Scenarios for the Cellulosic Ethanol in Brazil

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Abstract

The present work aims to develop scenarios for the future of second generation ethanol (cellulosic) seeking a horizon of ten years. The universe studied is the Brazilian bioenergy industry that produces ethanol for use as vehicle fuel. The research is justified to the extent that the second-generation technology for ethanol production is an important aspect for the migration towards a renewable energy grid on a global scale. Allied to this is the fact that in Brazil, a leader in ethanol production technology of first generation, scenarios for cellulosic ethanol had not yet been built. The method used for the construction of the scenarios was the environmental analysis *(stakeholder analysis)* for the survey of variables that affect the future dynamics of the sector. In-depth and semi-structured interviews were conducted with experts in three stages. *Stakeholders* were identified and the variables studied were classified according to their importance and uncertainty. Next, these variables were analyzed in pairs, for the assignment of relationships of influence and dependence. The scenarios obtained with the interaction between the main variables showed contrast and logical consistency, forming the four plots obtained.

1. Introduction

In Brazil, in the 70s and 80s, the oil shocks led to a deficit in the balance of payments, causing the government to initiate a program to produce ethanol to replace the use of gasoline. The Pro-Alcohol program, as it was called, aimed to produce ethanol for use as vehicle fuel. The raw material selected to produce ethanol was the sugar cane , given the geographical conditions in Brazil. The program lasted three decades, and managed to create a market for ethanol, as well as a productive infrastructure of such importance and scale, which made ethanol production economically competitive with gasoline prices. Plants, research centers, universities, public and private companies, and a whole myriad of organizations were mobilized since the beginning of the Pro-Alcohol program, ultimately resulting in Sao Paulo bioenergy program, currently the largest renewable energy program in the world (in joules of energy produced).

The technological development necessary to establish this renewable energy matrix was massive, and proved crucial. In agriculture, genetic improvements ensured the production of varieties of sugar cane sugar that are more resistant and present more sucrose.

However, with advances in complex biochemistry in recent decades, a new way to produce ethanol was conceived It turnedot that there was a possibility of producing ethanol from cellulose in the plant, i.e. in this case not transforming the juice of sugar cane, but the wood itself (bagasse) into ethanol through enzymatic hydrolysis process.

The importance of taking the second generation ethanol (cellulosic) production to the productive scale in times of global warming is easy to recognize. But if many technical studies have been and are being made to the technical development of second generation ethanol, we could not find in the literature, studies that prospected the future of the second generation ethanol in Brazil in terms of industry. Thus, this work aims to fill this gap, building sector scenarios for the development of second generation (cellulosic) ethanol in Brazil with the 2020 horizon.

2. Theoretical Foundation

2.1 Definition

The definitions of what scenarios are do not show contradictions. To Mannerma [1] scenarios are studies of the future , which do not seek to predict events, but imagine future alternatives and their connections, rich in detail and logically consistent in their temporal evolution. Godet [2], in turn, explains that the future is multiple and diverse, ie, infinite futures are possible. The description of a possible future, desirable or undesirable and progressions necessary to achieve it constitutes a scenario. Schwartz [3], explains this point well. In fact, the author argues that it is not possible to predict the future with a degree of certainty and precision. However, he states that scenarios are a useful tool to learn about a social system.

2.2 Exploratory Scenarios and strategic scenarios

Wack [4] was one of the first authors to put forth the difference between strategic scenarios and exploratory scenarios. Georgantzas and Acar [5] also classify the scenarios in these two categories. Exploratory scenarios, or first-generation present trends and uncertainties without intending to support specific decisions, unlike the second generation strategic scenarios, that support risk taking. The exploratory scenarios have a sequential development criteria. They are the starting point for future studies, and are also called industrial settings. These are scenarios that seek to understand the economic sector environment of a given industry. As in the case of this study, which deals with scenarios for the ethanol industry. The two authors state that this type of scenario is particularly useful for managers to better understand their environment of operation, the influential factors and their consequences in the administrative field. Strategic scenarios, in turn, besides being a tool for environmental recognition, have their genesis in the concern to investigate specific issues including the environment, necessary to underpin certain decision-making.

2.3 Basic elements for the construction of scenarios

The basic elements for building scenarios are trends and uncertainties. The relationship between trends and uncertainties, in turn, reveal a portfolio of different scenarios. Trends are changes in the environment on which we expect a persistence of behavior, Costa [6]. Uncertainties for Ayres and Axtell [7] deal with variables that despite being known, can not be said to reveal the probabilities involved in their future behavior.

There are several methods to construct scenarios. Ringland p.248 [8] describes SRI - Stanford Research Institute and Impact Analysis of Trends, Schwartz p.200 [9] the GBN

- Global Business Network, Mason[10], Mapping the Future, Huss and Honton [11] write about the Battelle; Godet [12] on the Prospective Analysis and Georgantzas and Acar [13] talks about the Comprehensive Situation Mapping.

Currently the methods of scenario building got new scopes of analysis, not only in the techniques used to mine the driving forces of the social system in which form their framework, but more importantly, what terms were improved regarding consistency.

The consistency analysis proposed by Boaventura and Fischman [14] aims to address two aspects. Check the contents of scenarios, relating the key variables to the future vision of an organization that participates in this environment and consistency of the relationship between these variables in a matrix that evaluates the possibility of coexistence between them. They test the inconsistency and consistency of the assertions in order to validate the scenarios constructed.

2.5 Stakeholder Analysis

Studies of the organizational environment have in the theory of *stakeholders,* a solid foundation on how to identify and analyze the behavior of agents in a social system. This makes the *stakeholder analysis* a particularly interesting tool as a starting point for building scenarios. The key data for scenario building (identification of agents and conditioning variables) can be obtained through the stakeholder analysis.

There is a consensus among many authors on the concept of stakeholder. Stakeholder is defined as groups or individuals that may influence or be influenced by mutual interactions, policies and practices of an organization, Freeman [15], Goodpaster [16], Weiss [17], Frooman [18]. Therefore, stakeholders are actors in a social system that affects their behavior.

Several authors propose methods to analyze the stakeholders. Wood [19], Svendsen [20], Carroll and Buchholtz [21] have developed methodologies for stakeholder analysis. Models of stakeholder analysis, besides being useful for investigating the environment of an organization, can be used for the analysis of a sector.

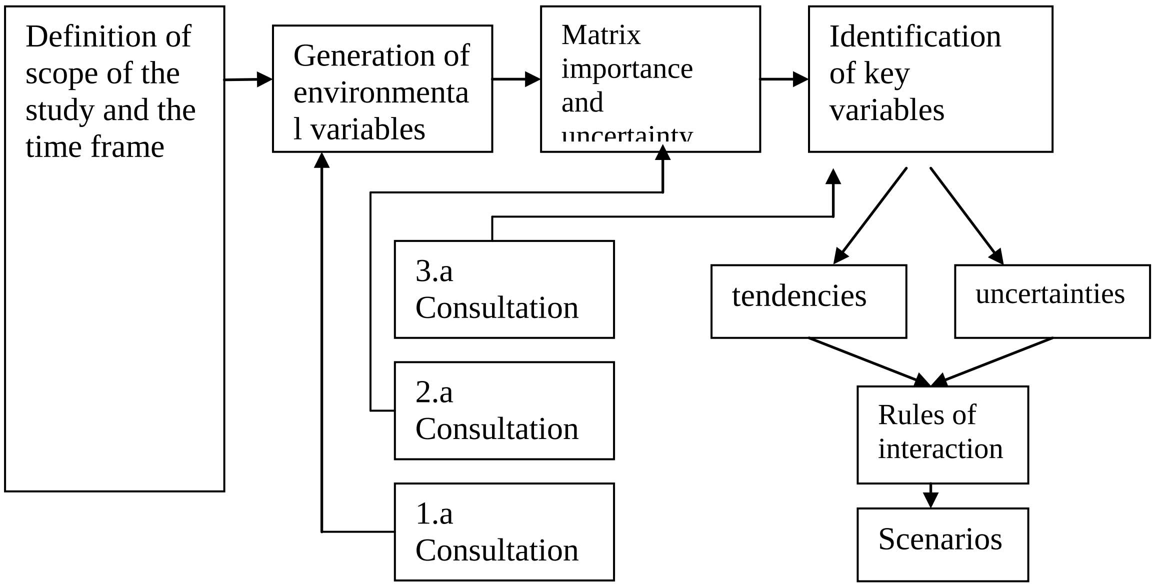
In general, the steps used in the stakeholder analysis begin with the obvious identification of stakeholders, namely a first phase, which involves an initial list of stakeholders. From that list we proceed to the identification and description of other stakeholders' interests, policies and behavior of each one of them.

Mitroff and Emshoff p.6 [22] developed a classic method of stakeholder analysis, widely used for dealing with environmental variables accurately, a method used by Boaventura and Fischmann [23], Gonçalves *et al.* [24] and Martins *et al.*[25] both for industry studies and for building scenarios.

3. Proposed Method

Methodologically, this study is characterized as a study of scenarios linked to the intuitive logic described by Wack [26] coupled with the processing of data proposed by Godet [27] and Georgantzas and Acar [28]. The method collects data in semi-structured, in-depth interviews to choose variables. Then the variables are measured on scales of importance and uncertainty. Finally, the dependencies and mutual influences between them are detected, in an attempt to elect the conditioning variables of the study. Therefore, the research is comprised of three phases. The first phase is to identify *stakeholders,* their variables and macro-environmental variables that influence the sector under study. The second phase assigns degrees of importance for variables with a view to selecting the most relevant for the next phase. Also, it sorts them according to the criterion of a trend or uncertainty. The third phase describes the variables according to their influence and dependence. With this, the most important variables are classified into categories of trend or uncertainty, and it is detected among them which ones condition the others in the system studied. Having such information as a base, scenarios are constructed from pairs of variables that affect the system (see Figure 5).

Figure 1 illustrates the proposed method: |



The modeling of the learning environment is developed through stakeholder analysis combined with analysis techniques to identify trends and uncertainties. Moreover, the method considers the prospect of macro-environmental elements. Aspects related to social, economic, political and technological circumstances (PTSS) were assessed, criteria adopted by Shoemaker [29]. In this particular research, we add to the situational aspects already mentioned the ecological situation, bringing to the analysis environmental issues that are relevant to the proposed problem.

3.1 Definition of the learning environment

The first step proposed for developing scenarios is to define the environment of the study, the object being studied and the time frame that you want to prospect.

3.2 Generation of environment variables studied

From the definition of the object, it is necessary to perform the identification of *stakeholders* that influence the environment in which the object of study is inserted. In addition to the stakeholders, the macro-environmental forces need to be investigated. The information about the *stakeholders* are obtained by consulting experts. At the end of this first step (of appointment of stakeholders) and survey variables, we must also make an analysis of the results to unify the vocabulary (some variables may have been cited with a different nomenclature). Therefore, it is necessary to unify and describe the variables found in interviews with experts in order to obtain the set union of the data collected. The next step is to qualify the environmental variables obtained.

3.3 Qualification of importance and uncertainty

The second stage of the study is to quantify the important variables in the question and classify them according to their uncertainty. Through structured interviews, where scales, graded variables of importance and uncertainty are applied.

Analyzing the importance of variables, allows to select a group of relevant variables, making the study operationally feasible. The assignment of degrees of uncertainty, in turn, creates two classes of variables, the classes of trend or uncertainty. This classification is crucial to choose the variables that give rise to scenarios.

Classification and qualification of the matrix employ variables of importance and uncertainty developed by Mitroff and Emshoff , p.9 [30].

3.4 Identification of key variables

The key-variables are the trends and uncertainties that affect the other variables of the Godet system [31] and are obtained by comparative analysis of the most important variables, ie, the variables obtained in the previous phase of the study.

The identification of influential or dependent variables takes place by administering a questionnaire to the experts. This is done by cross-comparison between the possible pairs of variables. Thus, experts are again consulted, this time about the influence and mutual dependence of the variables selected in the previous step.

Regarding the number of other variables that particular variable conditions - by comparing pairs of variables - points are awarded for this variable. The same is true for features of dependence. We reach the conclusive phase of identification. Based on the values obtained and standardized from variables, points are plotted in a matrix of influence and dependence. Boaventura, Costa and Fischmann [32] use in their method a matrix of influence and dependence proposed by Godet, as shown in Figure 2:

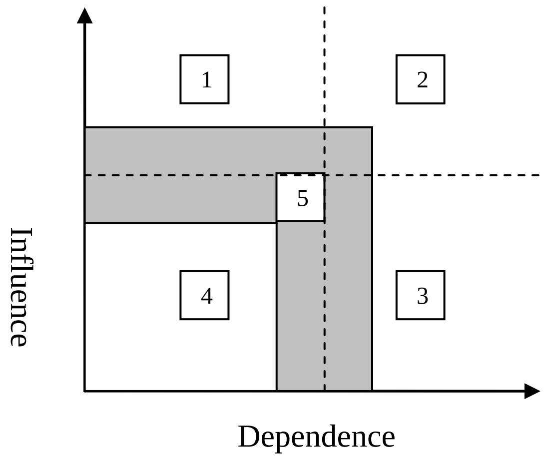


Figure 2: Chart Influence and Dependence

Sector 1 represents high influence and low dependence, belonging to this sector of the variables that influence the rest of the system, the key variables. Sector 2 represents the variables of transmission, of high dependence and influence, unstable by nature. Sector 3 represents the resulting variables, of low influence and high dependence, conditioned by sectors 1 and 2. Sector 4 represents the four variables to be excluded because they did not relate to the rest of the system. The Section 5 represents the mid-term variables.

3.5 Generation of Industrial Scenarios

The method used here is intended to generate scenarios starting from industrial environmental variables. Several methods of generating scenarios assume the analysis of environmental variables for their execution. Schoemaker p.196 [33] demonstrates this practice, arguing that the identification of major trends and uncertainties is the core, of the foremost methods of generating scenarios. In addition to the mining of the important variables, the uncertainty of their classification or trend and its influence or dependence, there is still a logical ordering of how trends and uncertainties relate Shoemaker p.35 [34]. From the analysis of interactions between the variables obtained and their characteristics the scenario plots are constructed.

4 Results

For the execution of this work we chose the ethanol production sector in Brazil as the setting for the study. The analysis is developed from the point of view of second-generation ethanol. The survey put the plants in the starting point of the analysis and mapped different types of organizations that interact with it to implement the technology of production of second generation ethanol over the next ten years. The scope of time for preparation of the scenarios covered ten years. In this survey, conducted in 2010, we aimed to understand how the problem would develop by 2020.

4.1 Generation of environmental variables

The consultation was made with a range of experts linked to the problem proposed and included engineers, scientists, administrators, politicians, journalists, i.e., a whole range of professionals who represent the *stakeholders* linked to the problem.

The choice of experts was made on the basis of two criteria. First the fact that the expert be linked to a relevant organization as part of *stakeholders*, the production of ethanol. Secondly, experience and expertise on the issue of second-generation ethanol.

The profile of the experts is as follows:

1 - Director of financial advisory firm
2 - Professor and researcher linked to public universities
3 - Manager of Technical Research Center of ethanol
4 - President of inputs manufacturing industry
5 - Consultant of professional association of sugar cane industry
6 - Production Manager for ethanol plant
7 - Advisor to the ethanol program in the State of São Paulo
8 - Technical Manager of equipment manufacturing company
9 - Technology Editor of specialized journal
10 - Director of the Bioenergy program of research funding agency

This first step aims to identify the variables that influence the learning environment.

Stakeholders have been identified and other stakeholders not previously identified may also be inserted. The variables of each one of them according to their political interests, behavior and power were described. In addition, experts also talked about the macro environment (social, economic, political, technological and ecological) of the problem.

Each specialist generated a list of different variables, averaging 32.4 each variable. A work of unification of vocabulary and repeated union of variables was employed. Experts from different organizations, all linked to the problem studied, added different shades and very different types of variables. Every expert described the system studied from a different point of view. This characteristic was important to conduct the study.

The total number of variables studied was 87. After the work of unification of the vocabulary, we came to 59 operational variables.

4.2 Qualification of importance and uncertainty

Starting from the 59 variables from the first phase of the study, we conducted a new round of interviews, whose purpose was to qualify each of them according to their importance and uncertainty. This was done through a questionnaire for the experts, which uses scales. Experts were asked about the importance of each variable on a scale from -5 to 5.

After raising the importance and uncertainty of variables, data were combined in the form of a matrix. When plotting the points for each variable, the value of the horizontal axis corresponded to the importance of the variable and the vertical axis to the degree of uncertainty.

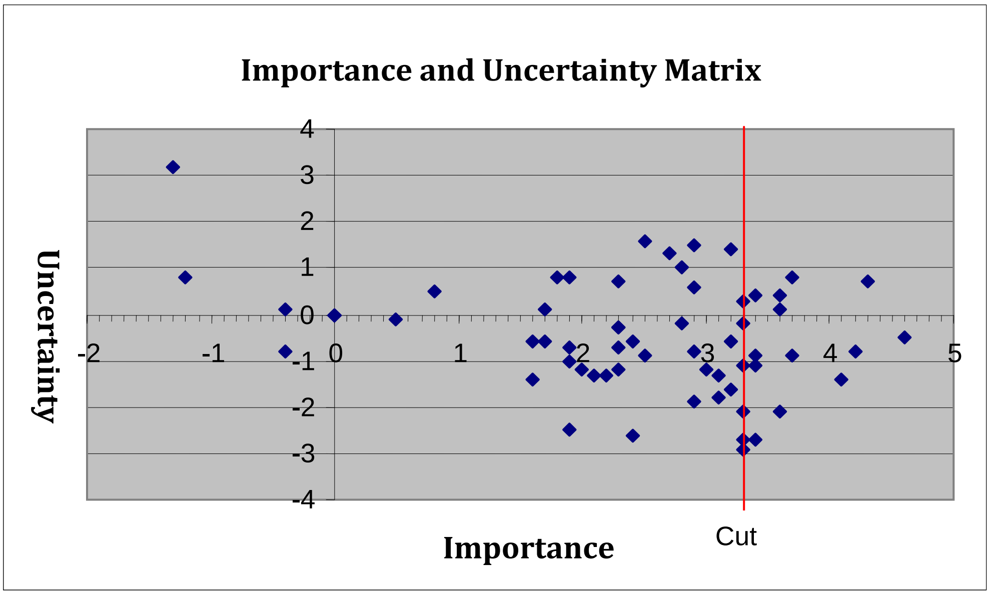


Figure 3 - Graph of the matrix of importance and uncertainty

Among the 59 variables analyzed, we selected the 21 most important for the next stage of the study. That is, the selection was made by cutting the right of the third quartile (3.3) on the horizontal axis (importance). Besides the election of nineteen variables which stood in the third quartile, two important variables whose average were below (3.3) were included in the next step; because they were new variables, not all specialists were aware of it; such variables,nonetheless, appear to be important for the experts who were aware of them. These are the variables "Plants 3 - Competition for mulch between second-generation ethanol and bioelectricity" and "research funding agencies 2 - physiological and genetic changes in sugarcane to pre hydrolyze the bagasse in the agricultural phase."

Table 1 shows the variables selected for analysis of the industry. These are the most important variables of the ethanol production sector, considering the next ten years of the issue of second-generation ethanol. The table also describes the categories of trend or uncertainty:

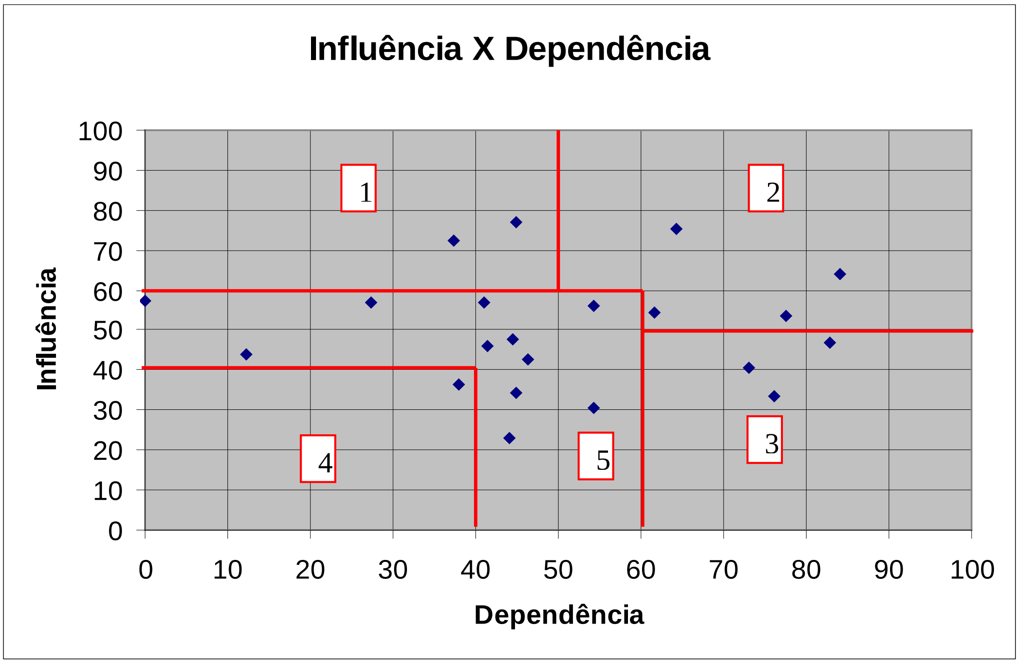
Variables	*Stakeholder* - variable number	Category
Adherence of industry to labor standards	Social Aspects - 1	Trend
Worsening climate change	Ecological Aspects - 2	Trend
High potential for biomass production in Brazil	Economic Aspects - 10	Trend
Strategic aspect in diversifying the energy matrix	Political Aspects - 4	Uncertainty
Commoditization of ethanol	Political Aspects - 1	Uncertainty
Competition between the bagasse and the second-generation ethanol and bioelectricity	Plants - 3	Trend
Creation of subsidies to consolidate the second-generation ethanol	Political Aspects - 2	Uncertainty
Funds research in the technical bottlenecks to consolidate the second-generation ethanol	Research Funding Agencies - 1	Trend
Forces training of HR	University - 2	Trend
Force the integration of technology between 1st generation 2nd generation technology	Plants - 2	Trend
Forces agricultural mechanization	Plants - 1	Trend
Forces the opening of national and international markets for Brazilian ethanol	Industry Association - 1	Trend
Forces the development of more efficient enzyme cocktails	Technology Center - 2	Uncertainty
Brazilian logistics favorable for the use of biomass (bagasse)	Economic Aspects - 5	Trend
Physiological and genetic changes in sugarcane to pre-hydrolyse bagasse in the agricultural phase	Research Funding Agencies - 2	Trend
Brazilian research in biofuels is internationalized and world-class	Technological Aspects - 5	Trend
Price of ethanol	Economic Aspects - 9	Trend
Oil Price	Economic Aspects - 2	Uncertainty
Trend of mergers and acquisitions in the sector	Economic Aspects - 7	Trend
End of burning and manual harvesting of sugarcane	Social Aspects - 2	Trend
Feasibility of hydrolyzing agricultural residues	Technological Aspects - 3	Uncertainty

Table 1 - Variables classified according to their importance and uncertainty

4.3 Identification of key variables of the study

Having obtained the most important variables and its nature as to uncertainty, the method used suggests discovering which are the conditioning variables of the system. For this, one must combine the variables selected in the previous step and analyze them in pairs. First by comparing their relative influence. Second, identifying whether there is dependence between them, which is the variable that causes addiction, and finally if the degree of this dependence is high, medium or low. Points were attributed to the influence and dependence of variables.

Below, follows Figure 4, the matrix of influence and dependence related to the third stage of this study:



The variables indicated in Figure 4 are presented in the table below:

Variable	Description	Category	Sector
Environmental Aspects - 2	Worsening climate change	Trend	5
Economic Aspects - 10	High potential for biomass production in Brazil	Trend	5
Economic Aspects - 2	Oil Price	Uncertainty	5
Economic Aspects - 5	Brazilian logistics favorable for the use of biomass (bagasse)	Trend	5
Economic Aspects - 7	Trend of mergers and acquisitions in the sector	Trend	5
Economic Aspects - 9	Price of ethanol	Trend	3
Political Aspects – 1	Commoditization of ethanol	Uncertainty	2
Political Aspects – 2	Creation of subsidies to consolidate the second-generation ethanol	Uncertainty	1
Political Aspects - 4	Strategic aspect in diversifying the energy matrix	Uncertainty	5
Social Aspects - 1	Adherence of industry to labor standards	Trend	5
Social Aspects - 2	End of burning and manual harvesting of sugarcane	Trend	5
Technological Aspects - 3	Feasibility of hydrolyzing agricultural residues	Uncertainty	3

Technological Aspects - 5	Brazilian research in biofuels is internationalized and world-class	Trend	5
Technology Center - 2	Forces the development of more efficient enzyme cocktails	Uncertainty	2
Industry Association - 1	Forces the opening of national and international markets for Brazilian ethanol	Trend	2
Research Funding Agencies - 1	Funds research in the technical bottlenecks to consolidate the second-generation ethanol	Trend	1

Table 2 - Classification of variables according to the matrix of influence and dependence

5. Generation of Industrial Scenarios

The generation of industrial scenarios has a peculiar characteristic regarding organizational settings. Because they deal with the economic-productive sectors, they have an extended time horizon, and a strong range of macro-environmental variables. For this study, four scenarios were constructed following the principle of generating scenarios of contrast, and thus, combining different variables of uncertainty.

The two variables were: "Creation of subsidies to consolidate the second-generation ethanol" (Political Aspects - 2) and the variable of high uncertainty "Oil prices" (Economic aspects - 2). The choice to take the "oil price" as a hub for building scenarios while not considered a key variable of the study is justified for two reasons.

The score that excluded it from the hall of key variables was minimal, its influence obtained an average standard of 57.2 points (only 2.7 points below the level necessary to achieve the key variable), second, and mainly because it was the less dependent variable of the study, indicating zero dependence for all other variables.

Figure 5 represents the vertical axis as representing the price of oil. The horizontal axis represents the creation of subsidies to consolidate the second-generation ethanol. We understand as subsidies the compulsory blending of ethanol from the second generation and first generation ethanol tax exemptions for the sale of second-generation ethanol.

5.1 The summary of the scenarios constructed

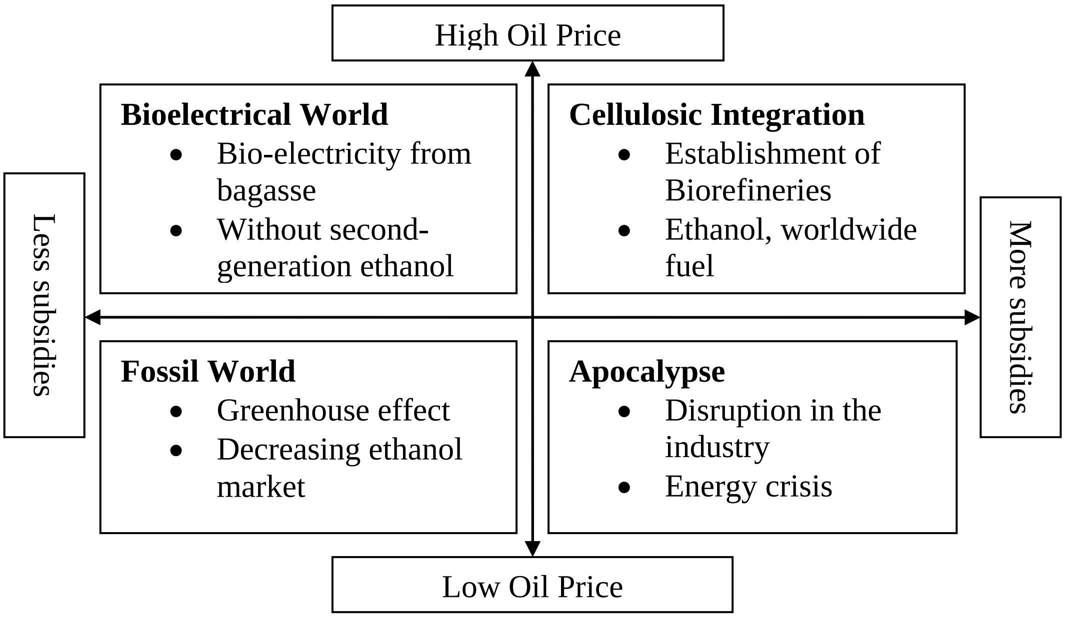
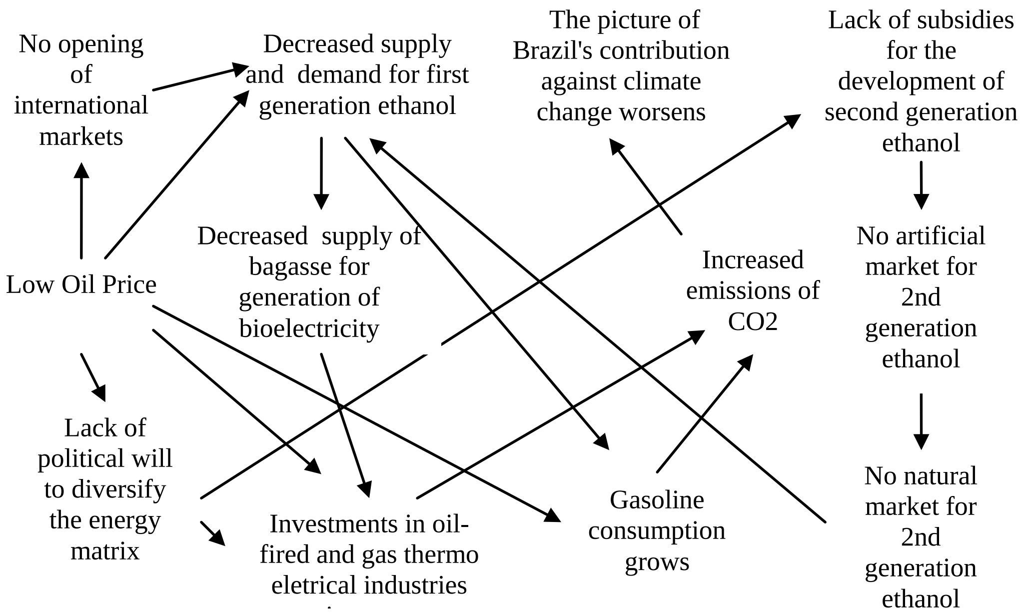


Figure 5 - Summary of scenarios constructed

5.2 Cellulosic Integration

The high price of oil drives the bioenergy sector comprehensively. The first direct unfold is the accretion in the policy of diversifying the Brazilian energy matrix. On the international scene the tendency to open international market for biofuels is also increased. Ethanol becomes a commodity further increasing the market and the production scale of first generation ethanol produced in Brazil. Given the price competitiveness of ethanol compared to gasoline, there has been a proliferation of investment in its production. Funding research for second generation ethanol increases constantly. The artificial market created by subsidies in Brazil with the compulsory addition of second-generation ethanol in the ethanol first generation and tax incentives for their marketing is born in 2015. Burning the sugarcane to generate electricity offers part of its space for the production of second generation ethanol from the conversion of biomass, since their value is greater than that of bioelectricity. Because it is a type of energy that can be stored , the first generation ethanol mixed with the second generation ethanol reaches the international market. In 2017 a happy reunion is consolidated. The continuous input of the government for the development of second generation ethanol meets a favorable environment for the market to adopt it widely. These factors, in 2020, generate a virtuous cycle. The learning curve for production of second generation ethanol reduces their costs, the market can absorb this supply, which increases the scale of production and makes the production costs decrease even further. The plants become biorefineries, integrating large-scale technologies first and second generation. Ethanol replaces the gasoline consumption, which improves the living landscape with respect to Brazil's contribution to global warming.

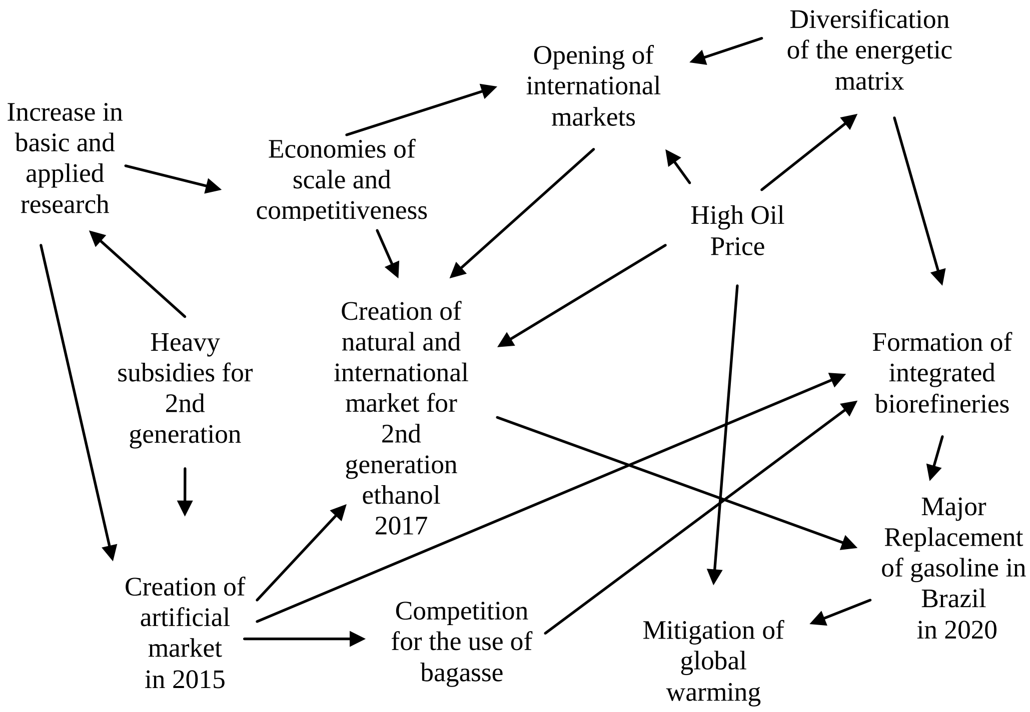
5.2.1 Logic Synthesis Integration scenario cellulosic



5.3 Bioelectrical World

For political reasons the Brazilian government does not implement subsidies programs for second-generation ethanol. There are no tax incentives for commercialization of second generation ethanol mixture and there is no compulsory second-generation ethanol in the first generation ethanol. There is no supply or demand for second generation ethanol. The high price of oil increases the demand for first generation ethanol, and forces the opening of the international market for biofuels. In view of that situation, the productive sector chooses to invest in expanding and developing the first generation ethanol. In 2013 ethanol becomes a commodity, reinforcing the dynamic investment, resulting in mergers and acquisitions in the sector. In 2015 investments in productive capacity, cause significant growth of the first generation ethanol and consequently increase the availability of bagasse in sugar mills. The favorable logistics for bagasse burning in power plants causes the generation of electricity from the burning of biomass in boilers to become an interesting option. There is a new wave of investments in high-pressure boilers and turbines for co-generation. The Brazilian government reviews regulation of the electricity market. The two factors together result in an increased offer of bioelectricity in 2017. Increasing economies of scale reduce the costs of bioelectricity which again increases the market for bioelectricity. The generation of bioelectricity inhibits the deployment of power plants to gas and oil. Gasoline consumption in Brazil and its trading partners is substantially replaced. In 2020, Brazil strengthens its position in the fight against global warming.

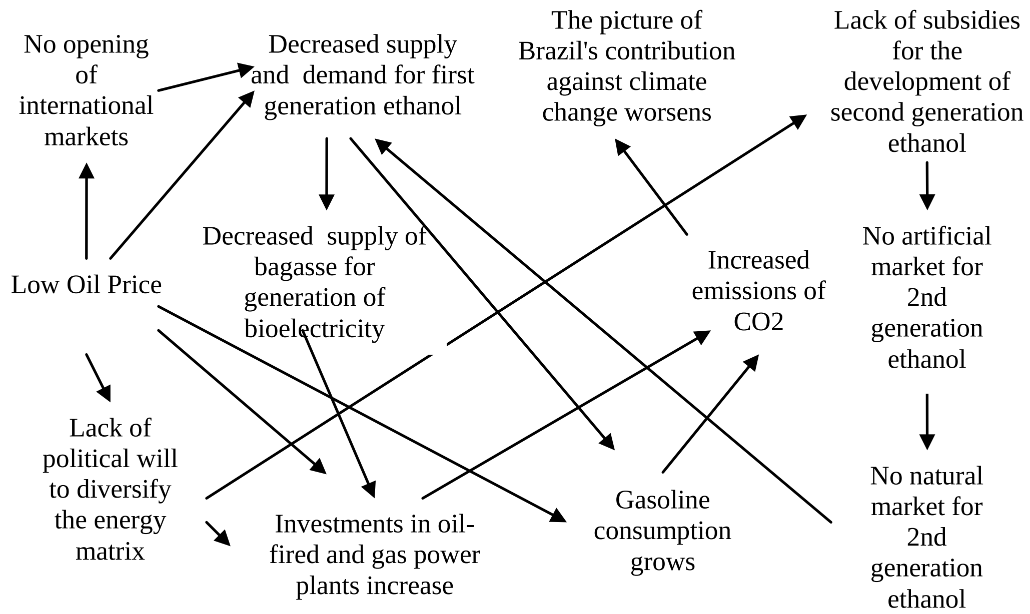
5.3.1 Logical Synthesis of the bioelectrical world scenario



5.4 Fossil World

With oil prices falling there is no political will to open markets for Brazilian ethanol. There is little incentive to diversify the energy mix and consumption of first generation ethanol in Brazil drops in 2012. Ethanol does not become a commodity. In view of such factors, in 2013, Brazil decides not to implement subsidies for cellulosic ethanol, since the demand for first generation ethanol is less than the supply of fuel. There are no tax incentives or compulsory blend for the second-generation ethanol. In 2015 there is not offer or artificial demand for second generation ethanol, because even without incentives, the technology did not migrate from the laboratory to the plants. The market for first generation ethanol decreases. The theoretical increase in the availability of biomass for co-generation of bioelectricity generated by the lack of demand for pulp for production of second generation ethanol, is not realized, because of reduced production of first generation ethanol resulting in decreased production of bagasse for co-generation. The investment in co-generation of electricity from biomass freezes. There is increased investment in gas-fired and oil thermo electrical industries in Brazil. In 2017 the price of oil hits its lowest level. The oil power plants operate at their maximum limit, as economic growth is driven by low oil prices. Gasoline consumption and growing carbon emissions in Brazil in 2020 point to a bleak outlook with regard to climate change.

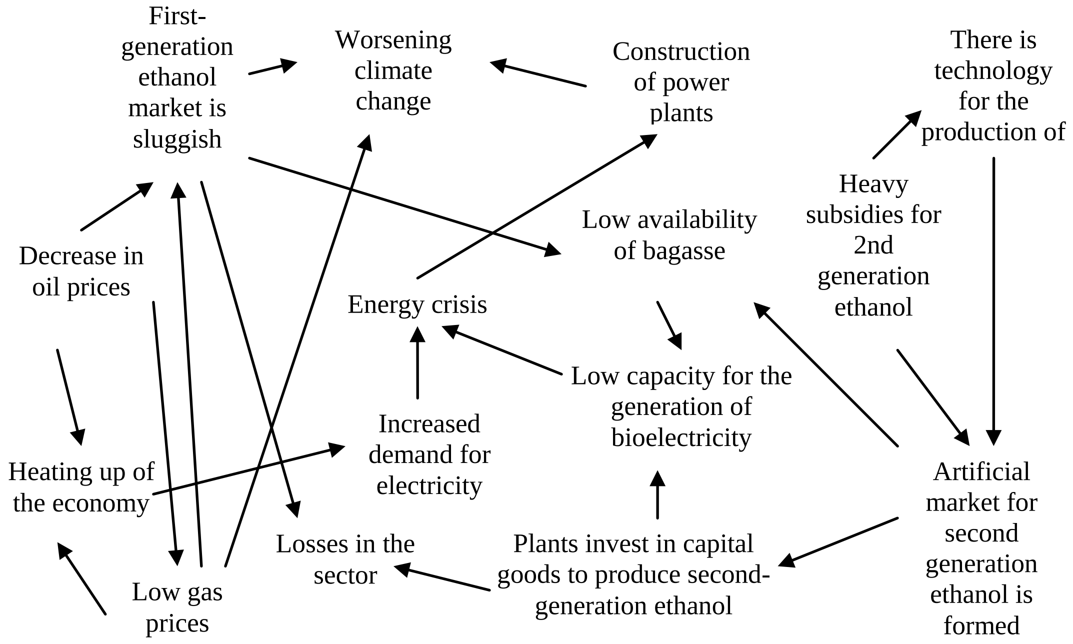
5.4.1 Logical Synthesis of the bioelectrical world scenario



5.5 Apocalypse

Even with oil prices at low levels in 2010, the Brazilian government invests heavily in second generation ethanol. The trend of investment in research is enhanced. The technical bottlenecks for the production of ethanol from cellulose are due and more efficient enzyme cocktails are developed, creating the possibility to produce cellulosic ethanol in pilot plants in 2013. Given the possibility of the existence of this offer, the Brazilian government implements subsidies for creating a market for second generation ethanol in 2015. The mandatory mixture is enforced by law. All first generation ethanol is now added with 5% of cellulosic ethanol and taxes on the sale of second-generation ethanol are eliminated. There is an artificial market for cellulosic ethanol at the government's expense. Brazilian plants, fueled by consumer safeguards provided by law, invest in second generation technology even if by 2015, the low price of oil keeps the natural market for ethanol sluggish. The co-generation of electricity from bagasse shows an attractive alternative to the plants, but these can not generate electricity by investing in capital goods to produce second-generation ethanol instead of investing in high-pressure boilers and turbines for the generation of bioelectricity. An asymmetry is created: The investment in cellulosic conversion technology does not meet the market demand for electricity and gasoline. Oil and gas power stations are built in haste. There is a strategic disruption in the bioenergy sector. In 2017 the incentives for production of second generation ethanol present heavy losses to both public and private sector. For plants the economical effect is devastating. The expectation of a large ethanol market does not materialize. The political damage of the government is immeasurable. There is a structural conflict among the low market demand for ethanol, a high capacity for installed ethanol production and high demand for power without possibilities of supply in the short term. Due to the increase in electricity consumption (coming from the heating of the economy, the result of low oil prices) and the impossibility of its production, there is an energy crisis. The high gasoline consumption and start-up of power plants in 2020 aggravate the carbon dioxide emissions into the atmosphere worsening the Brazilian performance in the mitigation of greenhouse gases and their detrimental effect on climate change.

5.4.1 Logical Synthesis of the bioelectrical world scenario



6 Conclusions

The first conclusion to be reached with the study was the recognition that the development of a new energy is not a purely technical problem. It is rather a complex problem that involves an articulated constellation of organizations , and macro-environmental conditions (social, economic, political, technological and ecological). The creation of a new source in the energy matrix is not the creation of a product, but is a social achievement in a civilizing process.

It is known that several countries have an interest in cleaning their energy matrices through the production of bioenergy. This study makes it clear that we need to create a web of interconnected organizations for a new energy matrix to be formed consistently and be sustainable in the long term. From this point of view, the present study becomes an interesting map of what Brazil has been building in this field, and is a contribution that shows some necessary steps in thinking about the future of the biofuels sector.

The scenarios constructed in this study enabled us to understand the dynamics of the sector and to imagine plausible futures, encouraging new studies and interpretations for decision making in the pursuit of materializing desired scenarios, or minimizing risks pointed out by unwanted scenarios. Although the objective of the study is not to build strategic scenarios, most certainly the scenarios constructed here may indicate pathways for further study so that it becomes possible.

The scenarios also present potential risks and opportunities potentially unrecognized so far. Overall, they showed that the development of second generation ethanol on an industrial scale depends more on political and market factors than technical ones. Indeed, while the technical part makes the industrial scale feasible, and constitutes an enormous challenge, the evolution of second generation ethanol in the sector as a whole depends crucially on policy and strategic decisions. Although basic research is a long-term trend, its migration to an industrial scale is a dependent variable of political and economic measures.

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