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TECHNOLOGICAL SCENARIOS TO THE DEMAND FOR SUGARCANE

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ABSTRACT

From the first decade of the 2000s, it is clear that there is an increase in discussions involving sustainability, including the bioenergy issue, to which Brazil has drawn the attention due to advances in the ethanol industry. Advances in engine technology reflected new opportunities for this industry and, according to the Ten-Year Energy Plan for 2019 developed by the Ministry of Mines and Energy, there is an expected increase in demand for ethanol of 90% by 2019 (Brazil, 2010). However, new technologies for the conversion and use of sugarcane and the complex context of this industry add uncertainties to this sector. Aiming to discuss and include the uncertainties on the agenda of this industry, this study proposes to elaborate and discuss prospective scenarios to the demand for sugarcane. Four scenarios with different perspectives of technological advance and market development were elaborated and discussed in the conclusion.

Keywords: Sugarcane. Scenarios. Ethanol. Demand.

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RESUMO

A partir da primeira década dos anos 2000, percebe-se um aumento das discussões a respeito do tema da sustentabilidade, em que se enquadra o tema da bioenergia, no qual o Brasil tem chamado atenção pelos avanços na indústria do etanol. Avanços na tecnologia de motores refletiram novas oportunidades para essa indústria e, de acordo com o Plano Decenal de Energia Elétrica para 2019 elaborado pelo Ministério de Minas e Energia, há uma expectativa de aumento na demanda de etanol em 90% até 2019 (Brasil, 2010). No entanto novas tecnologias de conversão e de uso da cana-de-açúcar e o contexto complexo no qual se insere essa indústria adicionam incertezas a esse setor. Foi com o objetivo de discutir e colocar as incertezas na agenda dessa indústria que neste trabalho se propôs elaborar e discutir cenários prospectivos para a demanda por cana-de-açúcar. Quatro cenários com diferentes perspectivas de avanço tecnológico e de desenvolvimento de mercados foram elaborados e discutidos na conclusão do trabalho.

Palavras-chave: Cana-de-açúcar. Cenários. Etanol. Demanda.

1 INTRODUCTION

The growth in demand for sugarcane is included in the Ten-Year Energy Plan, expected to increase approximately 90% in ethanol demand between 2010 and 2019 and 3% per year in sugar demand. In view of this scenario, it will be necessary to invest in new plants, in agriculture and infrastructure, thus leading to an investment plan of the sector.

However, the demand forecast does not present a discussion regarding the various prospective scenarios and with which it is possible to include the uncertainties in the agenda of the sector. This type of analysis considers the future marked by uncertainties and discontinuities and its

study can assist in the decision-making for choosing the best way to cope with uncertainty.

Technological innovation appears as an uncertainty that can cause major changes in the industry, and may influence a number of economic players in different ways (Abernathy, 1985). Although renewable energy still represents a small portion of the global demand (in the U.S. only 8% of energy comes from renewable sources, according to Figure 1), studies on energy efficiency and renewable energy are being conducted in several countries, with the participation of universities and companies. In the United States, for example, for the fiscal year of 2011, the budget for energy efficiency and energy accounted for approximately 56% of the budget on energy, reinforcing the strategic importance of this sector and the potential that significant advances are achieved. The success in these studies and the dissemination of various technologies may impact related sectors, such as the sugarcane producer, which may face competition with substitutes or even develop into new markets, depending on how the scenario evolves.

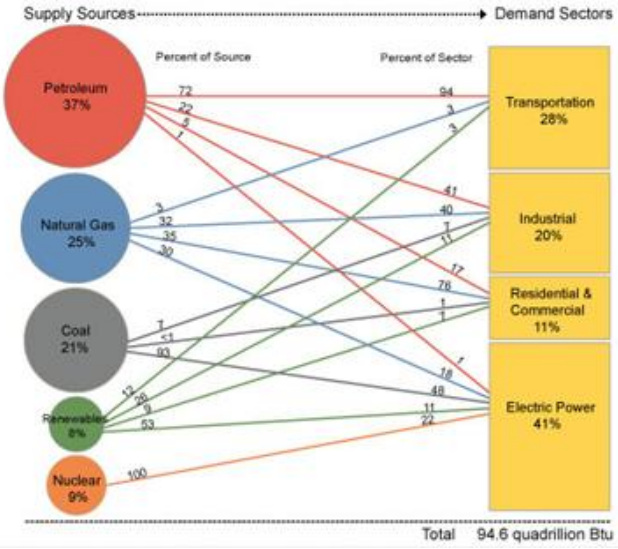

Figure 1: Flow of the primary energy source in the U.S. by source and sector in 2009
Source: Energy Information Administration – EIA (2010)

Using the theory of scenario structuring, this article aims to identify possible technological scenarios to the demand for sugarcane in 2020.

2 THE SUGAR AND ETHANOL INDUSTRY IN BRAZIL

Sugarcane is the raw material for several products, such as fuel ethanol (hydrous and anhydrous), non-fuel ethanol (used in pharmaceuticals, cosmetics, etc.), and ethanol and sugar stand out for the degree of participation in the consumption of this input.

Brazilian plants work in a flexible production model between sugar and ethanol products, where the driver for the production decision is related to, among other factors, the commercial strategy of mixed plants, which depends on the relationship between the prices of the two products. Chart 1 shows the projection of demand between these two main derivatives and indicates a decrease in the proportion of use of sugarcane for sugar in an expectation of lower growth of this market compared to the growth of the ethanol market. It is worth it to point out, however, the existence of competition between the derivatives, which can be demonstrated historically when, in the 1980s, the international price increase of sugar and the low price of domestic ethanol led to the ethanol crisis, causing a lack of the product in the domestic market and a confidence problem for the population regarding the ability to supply ethanol (Nascimento et al., 2010a).

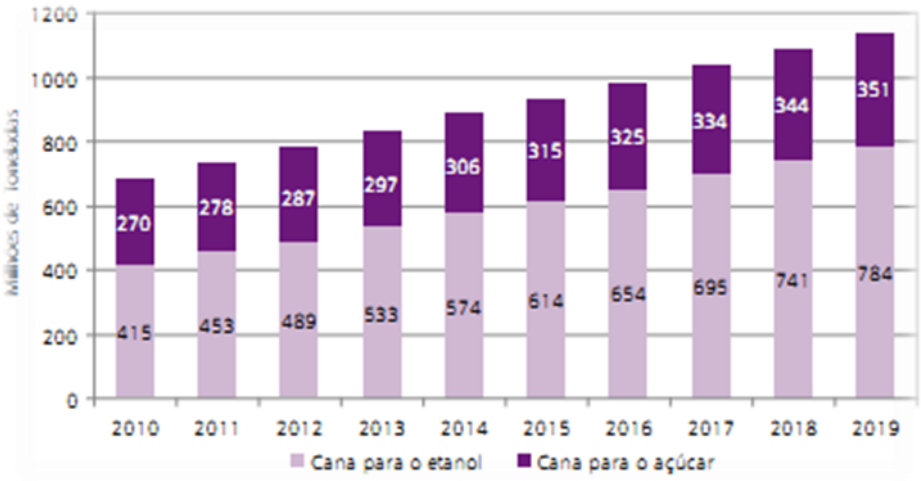

Chart 1: Projection of sugarcane use in Brazil
Source: Brazil (2010)

2.1 FUEL MARKET IN BRAZIL

Ethanol started being used as an automotive fuel on the 1930s, as a blend with gasoline in volumes defined by the law; it experiences a growth in production with the ethanol engine technology with the first car model produced in mass in 1978; it faces competition with the international price of sugar in the 1980s, causing the population to migrate to gasoline vehicles and with the flex fuel technology (ethanol and/or gasoline) the demand for ethanol grows again, which is set by a ratio of 70% of the gasoline price in the consumer preference. Charts 2 and 3 show, respectively, ethanol production in Brazil and the dominance of the architecture of flex-fuel vehicles, reflecting the impact of the new technology in the ethanol market.

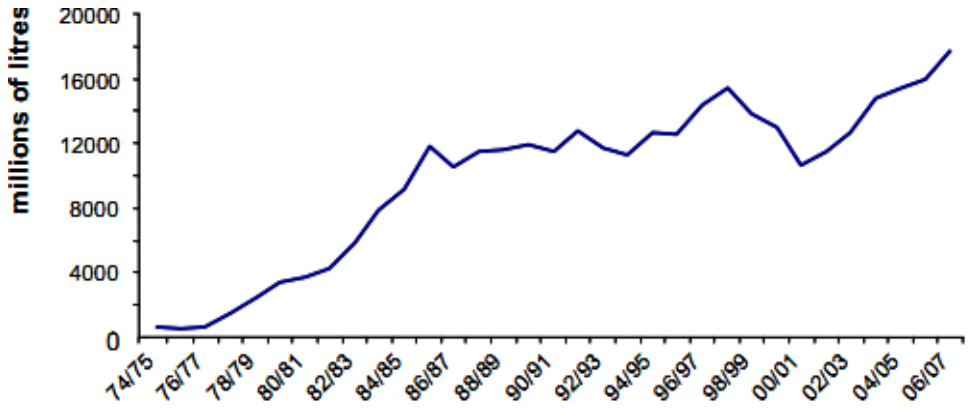

Chart 2: Ethanol production in Brazil
Source: Revista Exame (2008, quoted by Nascimento et al., 2010b)

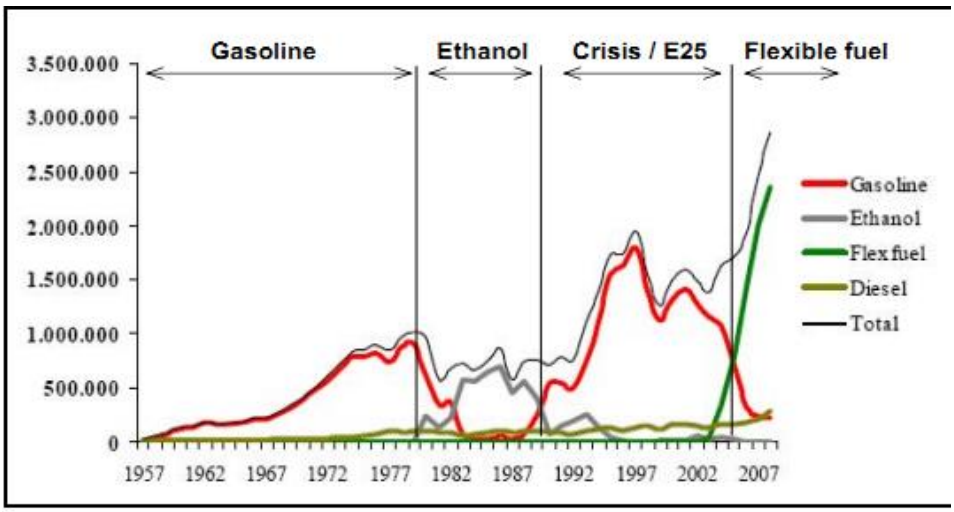

Chart 3: Dominance of the architecture of flex-fuel vehicles in Brazil
Source: Nascimento et al. (2010a)

The expectation for the next 10 years, according to data from Brazil (2010), is the continued growth of the participation of flex-fuel vehicles in the total Brazilian fleet, as shown in Chart 4.

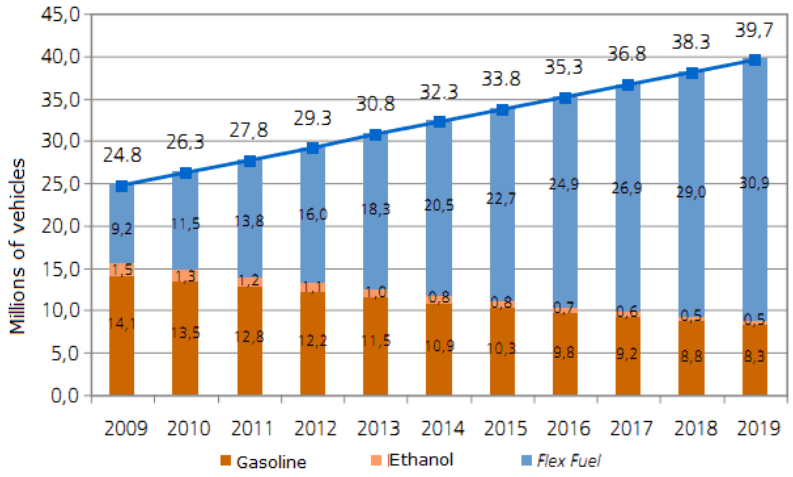

Chart 4: Profile of the fleet of light-duty vehicles by fuel in Brazil
Source: Brazil (2010)

In the demand projection by fuel type, it is expected that ethanol surpasses the use of gasoline, as shown in Chart 5. In this projection, we must not forget, however, the dependence of the price ratio of around 70% between ethanol and gasoline in consumer preference.

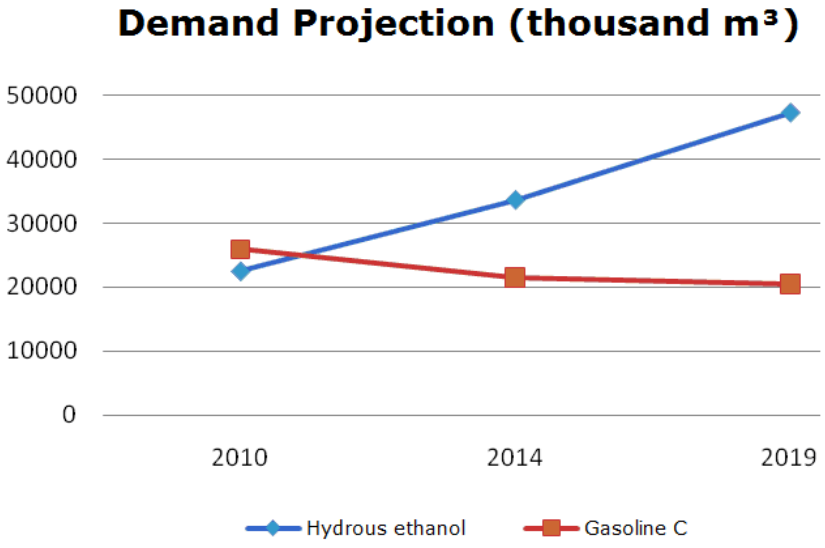

Chart 5: Demand projection (thousand m³)
Source: Brazil (2010), prepared by the author.

With this expectation of growth in the ethanol market, the production of sugarcane, which approximately 60% is currently intended for the production of ethanol, should reach approximately 70% for this use, 81% of which is allocated to fuel ethanol in the country and 15% for export.

2.2 ENGINE TECHNOLOGY

The engine technology development for the use of ethanol as fuel in markets hitherto concentrated in diesel and gasoline, as is the case of trucks, develops a new market niche by a technology refinement, impacting on an incremental demand in the production system. As shown in chart 3, the development of flex-fuel engines allowed the expansion of ethanol use in light-duty vehicles and is currently the major driver of the future demand growth for the fuel, but the engine technology evolution in other equipment and vehicles may lead to the expansion of the demand for the fuel.

On the other hand, the success in other vehicle technologies, such as electric cars, could negatively impact the future demand for ethanol. However, this technology is not considered to have a strong impact on the demand for ethanol to the horizon of this study.

2.3 IMPACT ON PRODUCTION

According to Table 1, meeting these growth projections in the demand for ethanol means to increase the production capacity currently available to approximately 11 new plants per year, between 2013 and 2019. This projection already considers an increase in the average production capacity in relation to the current plants. The investment order planned for the ten-year period totals R$ 58 billion, considering an average investment cost of R$ 150/tc (Brazil, 2010).

Year	Ethanol increase (billions of liters)	Number of plants required
2013*	2,54	9
2014	3,37	12
2015	3,28	11
2016	3,29	11
2017	3,29	9
2018	3,81	11
2019	3,36	10

Table 1: Forecast to meet the demand increase
Source: Brazil (2010)

In addition to increasing the number of plants, it is also necessary to increase the harvested area to approximately 50% in 10 years (Brazil, 2010). This projection already considers productivity gains of approximately 18%.

Therefore, there is a great prospect for the expansion of the ethanol market with a focus on the domestic fuel market. In this expectation, the expansion largely depends on an increased production of raw materials in the field, with the expansion of the Brazilian agriculture and the installed capacity of plants for the conversion of the raw material into the desired commodity.

3 THE INFLUENCE OF TECHNOLOGY IN THE DEVELOPMENT OF MARKETS

Studies related to technological innovation have been presented for decades in several theoretical excerpts. The importance of innovation is due to critical factors such as intense competition, the sophistication of markets and the rapid technological change (Clark & Wheelwright, 1993, quoted by Dacorso, 2000).

Among surveys of great recognition in the area there is a study on the life cycles of technology conducted by Abernathy and Utterback (1988), which shows the levels of innovation over time divided into product innovation, increasing until it reaches the dominant design, and process innovation, characterized by incremental improvements in productivity. This evolutionary path of technological innovation in the industry has

consequences both in the productive aspects of the organization (internal environment) (Clark & Wheelwright, 1993, quoted by Dacorso, 2000), and in the market in which it operates (Abernathy & Clark, 1985).

These consequences, however, differ by the type or degree of innovation, showing that its effects are not homogeneous. While some innovations make existing competences obsolete, others influence the improvement of performance. Thus, while an innovation contributes to the creation of new markets, others allow the expansion of the existing market. To illustrate the relationship between technology and the market, Abernathy and Clark (1985) proposed a typology of four divisions: architectural, niche creation, regular and revolutionary, which are shown in Figure 2.

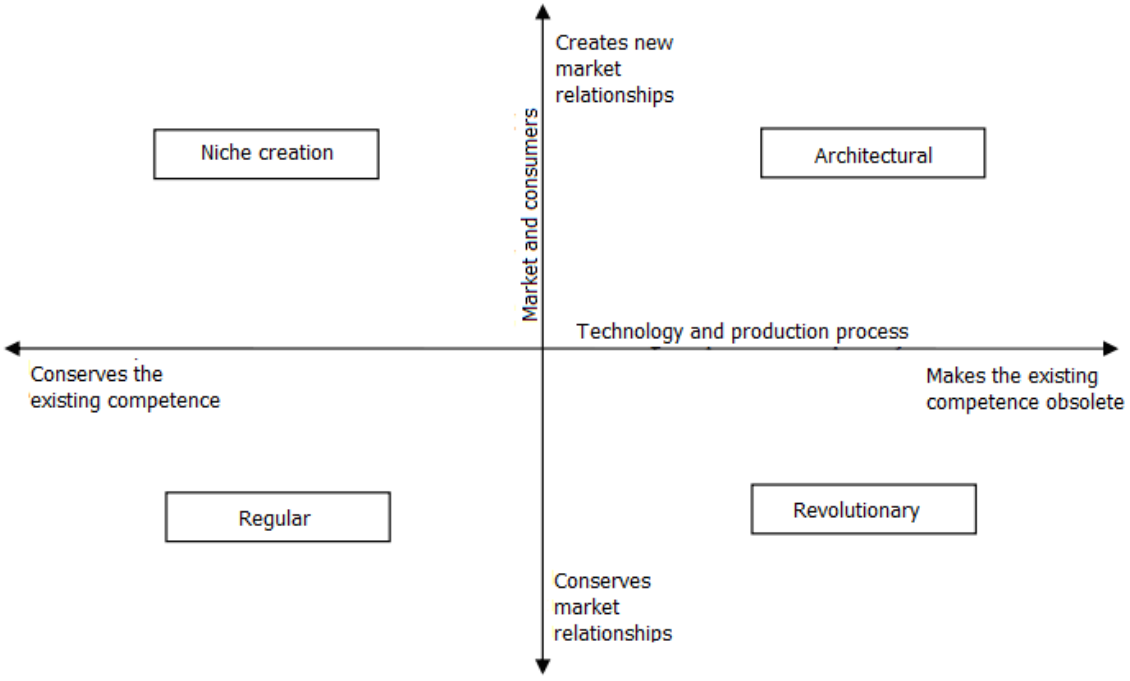

Figure 2: Transilience map
Source: Abernathy and Clark (1985)

In this model, the authors sought to point out the effects of innovation on the advantage of current and potential competitors by proposing a range that varies between two extremes, one conservative and

one radical, both for the degree of innovation in technology and for the innovation in the market.

At the extreme of creation of new market relationships are the architectural innovations and niche creation. In this range, new consumer groups are attracted and markets are created, but to meet these new needs, requiring new distribution channels, new services and new forms of communication (Abernathy & Clark, 1985).

At the extreme of innovation in technology and production process are the architectural and revolutionary innovations. In this range, new relationships are created with suppliers, there is an extensive replacement of materials, new production systems and new competences are required (Abernathy & Clark, 1985).

The architectural innovation is the one with the greatest degree of innovation in two variables, market and technology; therefore, it requires new technical skills and the development of new relationships with the market.

This structure proposed by Abernathy and Clark (1985) applied to the sugar and ethanol sector allows to point out two extremes of technological development (variable observed in this study), one radical that would lead to the modification of the existing competences and accordingly the research on 2nd generation (conversion of pulp) stand out, which allows the use of materials other than saccharose in the production of ethanol; and the other extreme, where the existing competences are conserved. On the other hand, in the market axis, the development of technology may allow the diversification of sugarcane markets, and where the alcohol chemistry gains greater relevance, there will be a growing importance in the development of new competences with the market.

4 METHODOLOGY FOR THE CONSTRUCTION OF SCENARIOS

Looking to the future and predict the events could assist in the decision-making by eliminating the uncertainties of the way. However, since

it is not possible to do it, the technique for building the scenarios assists in the description of future situations that are plausible and consistent (Wright & Spers, 2006) and that will help managers and leaders to plan actions and get ready for changes in direction.

For Alan Porter et al. (1991), scenarios are excerpts of some aspects of the future, and the focus should be the one that has greater relevance to the outcome desired. Goded (1993, quoted by Wright & Spers, 2006) understands the construction of scenarios as a detailed description of a future situation, which should consider the actions of key players and the estimated probability of uncertain events, which should be articulated in order to allow a transition from the current state to the future state.

Another important author in this subject is Schoemaker (1995) who shows the technique for the construction of scenarios as a structured process to imagine possible futures. For this structure, two key elements used by various authors are: the analysis of environmental trends and uncertainties, which would be the key variables for the construction of future plans (Raele, 2010).

The construction of a future vision may vary from an extrapolative structure, which uses quantitative tools that follow a natural evolution trend; it may adopt an exploratory format, such as consulting experts, or a normative model. The construction of scenarios proposes a pluralistic vision of the future. As shown in Figure 3, it is considered that the driving forces act on the system variables, and that there are natural or social limits (Wright & Spers, 2006, quoted by Silva, 2010).

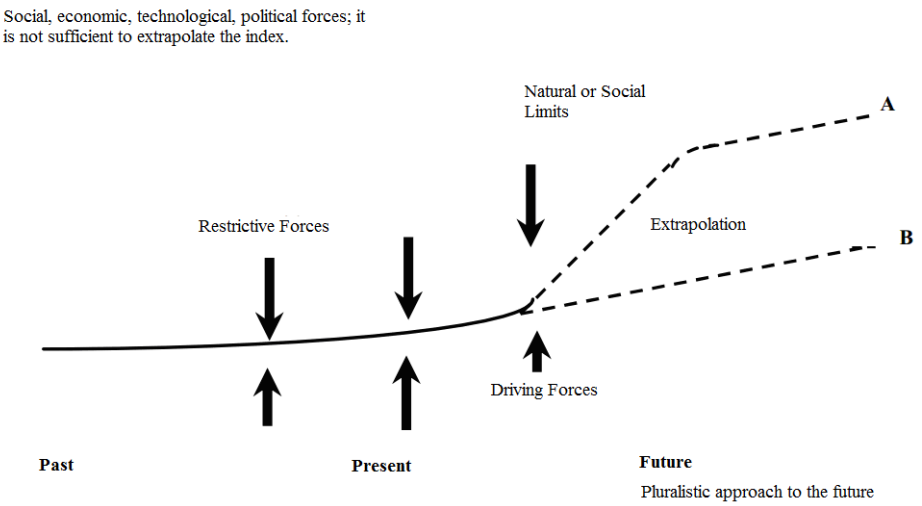

Figure 3: Schematic overview of the concept of scenarios
Source: Wright and Spers (2006, quoted by Silva, 2010)

5 THEORETICAL MODEL AND METHODOLOGY

The approach used considers that the scenarios do not focus on predicting the future, but aim to be a source of information and understanding for decisions to be made in the present so that the future goal is achieved.

The study was developed following the steps proposed by Wright and Spers (2006) for the construction of scenarios: 1) definition of the scope and purpose of the scenarios; 2) identification of variables, trends and key events; 3) structure of the variables of the scenarios; 4) projection of future states of the variables and their probability of occurrence; 5) identification of the driving themes of the scenarios; 6) assembling a morphological matrix for each scenario; 7) writing and validation of the scenarios.

As the demand for sugarcane is already a topic widely discussed in the literature, secondary data were used to identify the variables and study of trends. Likewise, several studies have been addressing the technological development for the energy sector, so there is plenty of information available in the literature. However, a joint study that discusses possible

technological scenarios that influence the demand for sugarcane is not yet exhausted and this study was conducted based on this approach.

Following the steps of the model of Wright and Spers (2006), defined as:

a) Scope and purpose of the scenarios: future implications in the demand for sugarcane arising from the technology development, with time horizon in 2020. With respect to stakeholders, we highlight the governments, industry (distilleries, alcohol chemistry and groups that produce ethanol), research institutes (national and international) and defense entities in the sector. The time horizon for this study is 2020, given that the last Ten-Year Energy Plan considers this date.

b) Variables, trends and key events: based on discussions with experts in the field of bioenergy and literature review, such as the research of Silva (2010), the following variables were listed as those that may impact the demand for sugarcane, considering the technology evolution:

- technological development in alcohol chemistry;
- development of engine technologies;
- technological development of other raw materials
- international oil prices;
- international sugar prices;
- price increase of other co-products;
- ethanol demand and price;
- energy policy of the countries;
- environmental policy;

c) Variables structure of the scenarios: the variables were structured demonstrating cause and effect relationship between them and they were identified in horizontal lines from bottom to top, in: causal, intermediate and resulting variables, respectively.

d) Projection of future states: for each variable, we evaluated four future states that will be the basis for the morphological analysis.

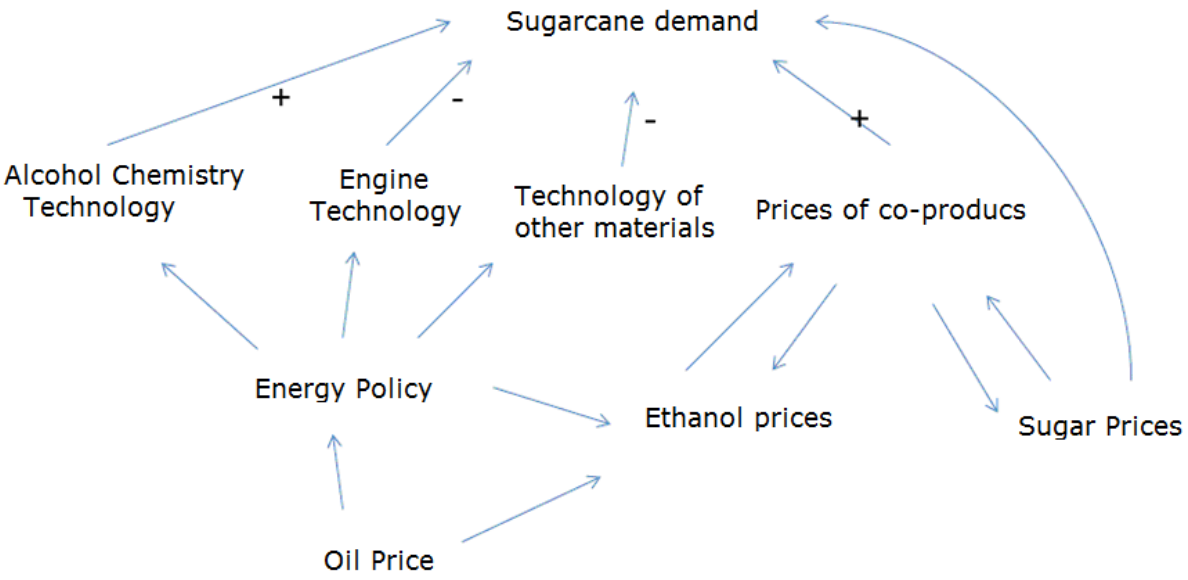

Figure 4: Variables structuring

	Future state 1	**Future state 2**	**Future state 3**	**Future state 4**
Development of alcohol chemistry technology	No evolution in the use of sugarcane in the alcohol chemistry industry	Few products using sugarcane in the alcohol chemistry industry	Reduced use of sugarcane in the alcohol chemistry industry	Many products using sugarcane in the alcohol chemistry industry
Development of engine technology	No evolution in engine technology for the use of sugarcane ethanol	Substitutes to the fuel ethanol technology gain market	Some evolution in ethanol-based engine technology	Great evolution in ethanol-based engine technology
Development of technology of other materials (raw materials: pulp)	No feasibility for new raw materials (substitutes)	Feasibility occurs in a moderate manner	Some feasibility in 2nd generation technology	Feasibility of other raw materials in the ethanol production
International oil prices	Current prices remain unchanged	Prices have small rise	Prices fall	Prices have great rise
International sugar prices	Current prices remain unchanged	Prices have small rise	Prices fall	Prices have great rise
Co-product prices	Current prices remain unchanged	Prices have small rise	Prices fall	Prices have great rise
Ethanol prices	Current prices remain unchanged	Price has small rise	Prices fall	Price has great rise
Energy policy of the countries (USA and EU)	The share of biofuels in the energy matrix remain in the current levels	Small increase of the share of biofuels in the energy matrix	Decrease of the share of biofuels in the energy matrix	Great increase of the share of biofuels in the energy matrix

Table 1: Future state of the variables

e) Identification of driving themes: themes were defined based on two key uncertainties: will technological development allow substitutes for sugarcane? and also in relation to technology, is alcohol chemistry a new market with great potential for sugarcane?

- Scenario 1: Sugarcane Multimarket
- Scenario 2: Sugarcane – a biofuel in expansion
- Scenario 3: Sugarcane - raw material for alcohol chemistry
- Scenario 4: Sugarcane – a raw material option

These four scenarios were developed, in this order, to identify a prescriptive scenario, a more likely scenario and two exploratory scenarios.

f) Assembly of the morphological matrix for each scenario

	Scenario 1: Multi-market	**Scenario 2: Biofuel in expansion**	**Scenario 3: Raw material for the alcohol chemistry industry**	**Scenario 4: A raw material option**
Technological development in the alcohol chemistry industry	Small increase in products using sugarcane in the alcohol chemistry industry	No evolution in the use of sugarcane in the alcohol chemistry industry	Many products using sugarcane in the alcohol chemistry industry	No evolution in the use of sugarcane in the alcohol chemistry industry
Development of engine technology	Some evolution in ethanol-based engine technology	Some evolution in ethanol-based engine technology	Substitutes to the fuel ethanol technology gain market	No evolution in engine technology for the use of sugarcane ethanol
Development of technology of other materials (raw materials: pulp)	No feasibility for new raw materials (substitutes)			Feasibility of other raw materials in the ethanol production
Oil prices	Current prices remain unchanged	Prices have great rise	Prices fall	Prices have great rise
Sugar prices	Current prices remain unchanged or Prices fall	Prices have small rise	Prices fall	Prices fall
Co-product prices	Current prices remain unchanged	Prices have great rise	Current prices remain unchanged	Current prices remain unchanged
Ethanol prices	Current prices remain unchanged	Price has great rise	Prices fall	Prices fall
Energy policy of the countries (USA and EU)	The share of biofuels in the energy matrix remain in the current levels	Great increase of the share of biofuels in the energy matrix	Decrease of the share of biofuels in the energy matrix	Great increase of the share of biofuels in the energy matrix

Table 2: Morphological matrix of scenarios

6 DISCUSSION OF SCENARIOS

6.1 SCENARIO 1: SUGARCANE AS MULTIMARKET RAW MATERIAL

The first scenario assumes that there will be some technological evolution in both alcohol chemistry and in the ethanol-based engine technology, which will lead to the expansion of the demand for sugarcane by both the new derivatives, and by the expansion of new engines suitable for the use of ethanol. However, there is no significant increase expected in oil prices so as to cause a change in the use of this fuel to ethanol. In this scenario, we considered that the United States and Europe will not make major changes in their energy policies, which should not, therefore, modify the relations of the use of current fuels. Knowing that liquid biofuels currently represent 1% of the energy used in transportation in the world (EIA, 2008, quoted by Rajagopal, 2009), it is expected that, in this first scenario, there is no change in this field of fossil fuels. Thus, the demand for sugarcane should continue to grow and follow the natural fluctuations in the price of oil and sugar, with some increase caused by market diversification and the sales of new vehicles with the flex technology.

6.2 SCENARIO 2: SUGARCANE AS RAW MATERIAL FOR BIOFUELS

A great driver of this scenario is the increase in oil prices, which will impact, as shown in the variables structuring, the price of ethanol and the energy policy of the countries. In this context, ethanol benefits from its price relation with gasoline (70%) and, given the large market of existing flex-fuel vehicles which part of the use of gasoline is due to ethanol, it is already possible to point to a considerable increase in the demand for sugarcane for the production of this product. In addition, the energy policy of the countries, by benefiting the use of renewable fuels, should also encourage an increased use of ethanol. Therefore, an increase in the production capacity becomes crucial to the viability and expansion of the

fuel, as a very strong pressure of demand without service capacity may impact the price of ethanol and limit its relation with gasoline.

In this scenario, considered as probable in the study, the technology that has influence in increasing the demand for sugarcane is the technology of engines that use ethanol fuel. It was precisely this technology that allowed the expansion of ethanol use in light-duty vehicles and it is currently the major driver of the future demand growth. As to the evolution in alcohol chemistry technology, we did not expect an advance in this scenario enough to change the primary use of sugarcane to ethanol.

It is worth considering that this scenario does not expect the evolution of the technology of new materials for ethanol production. The commercial viability of the second generation technology for the production of ethanol will reduce the pressure on the demand for sugarcane by allowing the availability of new raw materials.

6.3 SCENARIO 3: SUGARCANE AS RAW MATERIAL FOR ALCOHOL CHEMISTRY

The technology advance in the sugarcane use for the production of alcohol chemistry may cause significant impacts on the demand for raw materials. Some advances have been made in this new sector, such as the production of farnesene, a chemical intermediate for the production of various products, including diesel from sugarcane, and the commercial development of green ethylene. Given the global market size of these other co-products of sugarcane, this scenario leads to the possibility that technology advances cause a shit in the use of sugarcane, ethanol and sugar for incoming products.

6.4 SCENARIO 4: SUGARCANE AS A RAW MATERIAL OPTION

This scenario is strongly grounded in the success of studies using other materials for the production of ethanol. Studies in this area focus on the conversion of pulp (present in waste from agriculture, cities, and forests) into ethanol. The consequence of the success in this scenario is the

expansion of raw material options for fuel production and hence a negative impact on the demand for sugarcane. For the future distilleries, this scenario requires increasing the flexibility of production to a large number of raw materials.

7 CONCLUSION

The technological development may cause changes in the forecasts of the demand for sugarcane, causing both an increase higher than the levels estimated in the Ten-Year Energy Plan (Brazil, 2010) given the entry into new markets with great potential for consumption, and a large reduction in the demand for sugarcane due to a replacement for other materials. The definition of volumes of each scenario is given by factors that involve the markets to be opened and their ability to shift the use of the current raw material to its products, which involves the price ratio between these products.

The transilience map (Abernathy & Clark, 1985) illustrates the scenarios discussed and their relationship with the development of technology and the creation of new markets. It may be interesting to draw a parallel between the divisions niche creation, architectural, regular and revolutionary in the map and scenarios 1, 2, 3 and 4, respectively, which helps understanding the need to develop new competences according to the scenario that will become predominant.

Each scenario has specific consequences for the sector and, even if one of them presents itself as more likely to occur, it is important that all of them, as they are plausible, are included in the discussions regarding the actions to be taken for the development of the sugar and ethanol sector. Renewable energy is on the agenda of the major world powers and Brazil, which has been occupying a prominent position, should be aware of the technological changes, even and perhaps especially, observing those who are not in line with its current strategy.

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