ABSTRACT – The ethanol market in Brazil has been driven by ups and downs related to political implications. Since the Pro-Alcool program to face the hydrocarbon market consequences in the aftermath of the Iran and Iraq War, the ethanol is strongly integrated to the fuel portfolio as a substitute of gasoline in Otto cycle engine fleets in Brazil. Different from other countries in Europe and North America, where the ethanol content in gasoline is around 10% in volume, the gasoline sold in the fuel stations of the Brazilian states is a mix of gasoline A (pure) and anhydrous ethanol to yield the so-called gasoline C with ethanol percentage in volume varying from 18% in 2006 to the current 27% in 2018. Studies evaluate up to 40% of anhydrous ethanol in gasoline C to decline the 30-40% levels of imports of gasoline A. Furthermore, the demands in ethanol stabilized to a new state of imports since 2017 and it currently represents 7% of the total ethanol consumed in the country. For this reason, the investments in the ethanol market are supposed to increase and there are discussions around the startup of new ethanol biorefineries by introducing the use of corn as biomass. Sugar cane based biorefineries for ethanol production dominates in Brazil, although the steady increase in ethanol demands and the corn market seasonality brings new figures for capacity planning of the ethanol production to achieve market equilibrium. In this direction, we calculate the net present value (NPV) in a strategic planning study of ethanol biorefineries considering the current ethanol imports and its expected increase.

1. INTRODUCTION

Brazil is facing an environment for investments in the production of ethanol due to the recent increase in its imports. Further demand of this biofuel is expected since Brazil is still recovering from the years of recession and the ethanol content in gasoline to be sold in the whole country (gasoline C) may be even higher than the current amount if state policies change again. Moreover, without governmental control, the gasoline C price is following the volatility of the international market, therefore the preferences of the flex-fuel fleet consumer are returning to gasoline as fuel, which in turn pushes the imports of ethanol beyond unprecedented levels nationwide.

Thereby, a strategic planning to equalize production and consumption of ethanol is important to guide public policies and private investments to start-up new ethanol biorefineries in
the country. Capacity planning studies to add ethanol in the market can be considered as in the proposition found in Menezes et al. (2014a) for the future of fuel market in Brazil.

2. ETHANOL INDUSTRY IN BRAZIL

The ethanol industry in Brazil is highly impacted by the automobile fleet evolution as there has been dramatic changes in the consumer behavior over the years (MENEZES et al., 2014b), largely catalysed by automobile fuel prices and consumers preferred choices as seen in Figure 1. Historically, as a response to import rises of petroleum products, ethanol became part of the fuel mix which has evolved from 4.5% ethanol content (in volume) in gasoline (E-4.5) in 1977 to the current 27% (E-27). Government studies to diminish the imports of gasoline A (pure gasoline) intend for the future years 40% of ethanol in the gasoline blend (E-40) (BARROS, 2016).

Sugar cane is the main feedstock for the production of ethanol in Brazil, although there is a potential for processing corn biomass as a complementary source of ethanol in the country. This enviroment involves the evaluation of the national production of sugarcane and corn considering both biomass seasonalities, the current and possibly the future state of ethanol imports and Brazil’s net export of corn with excess of production and its falling price. The advantage corn brings is its storability, multi-season production and higher yield per tonne compared to sugar cane. For example, Brazil already started-up the new flex model ethanol plants to process both sugar cane and corn. An example is the Distillery USIMAT which uses corn to meet its raw material need in the off-season of sugar cane, with ability to convert 400 t/day, producing up to 150,000 L of ethanol (ECKERT et al., 2018).

Corn production in Brazil has experienced significant increase in the last decade and curretly competes with United States (VALDES, 2016) and a comparison of production costs carried by Goldemberg (2008) shows a higher cost of production of USA corn ethanol than the Brazilian ethanol, which disincentives the import of corn ethanol from USA, the current practice to meet domestic demand of anhydrous ethanol for gasoline C blends.

3. PRODUCTION EVALUATION

There are 383 1st generation ethanol production plants in Brazil (an overall capacity of 39,650 million litres) with sugar cane as main feedstock and only 3 cellulosic plants with 127 million litres capacity (BARROS, 2016). Evaluation of ethanol market demand and supply
statistics shows a growth in production of ethanol in Brazil at an average rate of 3% p.a. (per annum). Likewise, it is considered a growth in the consumption of anhydrous ethanol of 2% p.a. as a consequence of imports of anhydrous ethanol started in 2012 to meet both increase in gasoline consumption and the additional ethanol content in gasoline formulation to the current 27% in volume.

The current and future situation of the fuel market for light vehicle shows a deficit in the domestic production of anhydrous ethanol. Furthermore, export of hydrous ethanol has also shown a decline since 2013. Forecasts predict that by maintaining the demand trends at the proposed rate (from 2012 to 2018), it will make the country a net importer of anhydrous ethanol in the long-term and can continually reduce its market share globally. At this possibilities, a shift in investments to install new process capacities may guarantee the equilibrium of the ethanol market in the country and further steps to achieve the national vision of replacing 5% of the world gasoline demand with ethanol (CERQUEIRA LEITE et al., 2009).

4. CAPACITY PLANNING RESULTS

The evaluation of the ethanol capacity planning considers an average plant capacity of 103,524 m³ to estimate requirements of biorefineries for market equilibrium without ethanol imports. The average import costs and export revenue per m³ considers US$ 491 and US$ 511, respectively, with 2017 as reference year. The import estimates and plants capacity were determined based on the current import demands and the considered forecast rates. The export potential also reveals the possibility of income to the country when this additional plant capacities are deployed to for the production of hydrous ethanol as well. The ratios of hydrous to anhydrous ethanol employed in the production scenario are 59%;49% considering production scenario from 2013-2017. Table 1 gives a summary of the evaluation.

| Year      | Actual        | Forecast       |             |             |             |             |
|-----------|---------------|----------------|-------------|-------------|-------------|-------------|
|           | 2017          | 2018           | 2019        | 2020        | 2021        | 2022        |
| Imports (m³) | 1,825,642     | 1,858,271     | 1,925,289   | 2,030,374   | 2,179,465   | 2,381,316   |
| Capacity requirement (in number of plant) | 18         | 18           | 19          | 20          | 21          | 23          |
| Net Import Savings per m³ (US$ x100) | 897,441     | 913,480       | 946,425     | 998,082     | 1,071,371   | 1,170,596   |
| Export potential (US$ x100) | 182,223     | 1,344,468     | 1,374,724   | 1,430,187   | 1,513,822   | 2,984,647   |

5. CONCLUSION

The evaluation of the current production scenario shows a deficit in current production
capacity and this will lead to making the country a net importer of ethanol. Additional 18 ethanol production plants will be required to ensure market equalization to cease ethanol imports (anhydrous) and maintain net exporter status (hydrous). Corn is an abundant non-competing viable alternative to meeting this need during sugar cane offseason production and also to increase total ethanol production for both domestic and export purposes. Investments in these additional plants will bring a net-savings of up to US$1.17 billion from import of anhydrous ethanol to the country and an export potential for hydrous ethanol of up to US$2.9 billion. In conclusion, investment in additional ethanol capacity promises a more economically viable path for sustainable ethanol production in Brazil.

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