Production of ethanol from corn: Is it still a good investment in Brazil?

by

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ABSTRACT

The purpose of this thesis is to evaluate on the feasibility for company A to invest in a new ethanol plant in the Center-west of Brazil using corn as the main raw material.

Brazil is a large producer of ethanol and it has increased production over the past 5 years. The main contributor to ethanol growth has been government policies regulating greenhouse gases emissions through an increase of biofuels blended into gasoline and diesel. The mandate in Brazil states a blend of a maximum 13% for biofuels in diesel in 2021, of which 80% comes from the soybean feedstocks, and the Government plans to reach B15 by 2023. For ethanol, the mandate for blending in gasoline is 27% and may increase to 30% in 2022 and 40% in 2030. Due to low prices worldwide for sugar, Brazil reduced sugar production by 10% in 2018.

Ethanol production has increased by 45% from 2012 to 2019, 24 million m3 to 35 million m3. Ethanol consumption increased to 33 million m3 in 2019. The production of hybrid cars represented 96% of the 2.3 million cars produced during the same year.

Government policies and the demand for biofuels has resulted in ethanol representing 42.6% in 2019 of fuel use. More companies are investing in ethanol plants using corn as a feedstock with the majority in the state of Mato Grosso where corn price is lower.

The main reasons to locate plants in Mato Grosso are:

1) It is the biggest producer of corn in Brazil, about 30 million mt/year
2) Favorable weather and land for double cropping, which means planting beans and corn in the same crop year - September to August

3) Lower production costs due to double cropping
4) Strategically located in center area, so it can supply northern and northeastern states with lower logistic costs compared to Sao Paulo, the biggest producer of ethanol from sugar cane
5) Land availability to increase eucalyptus production, the main source of energy for the plant boilers
6) Infrastructure investment from the Government of the state of Mato Grosso or any other state to reduce high logistics costs to make Brazilian corn more competitive in the worldwide market
7) Large concentration of cattle for consumption of DDG – Dried Distilled Grains, the main byproduct derived from ethanol production using corn

This thesis analyzes if an investment in an ethanol plant in Mato Grosso using corn as the main raw material is profitable.

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CHAPTER I: INTRODUCTION

Ethanol consumption in Brazil was not strong before 1975 when the Brazilian Government, after the petroleum crisis in 1973 and to avoid its high dependency on imported fuel, launched in November 14th, 1975 the program "Pro Alcool". The program provided incentives to sugar cane plants to produce anhydrous ethanol with maximum of 0.7% of water in its composition, to be mixed into gasoline and methanol guaranteeing a minimum price for ethanol and subsidizing loans to invest in its production. This program was supported by the Brazilian Government, executives and universities desiring renewable energy to increase sugar cane production and provided protection against lower prices of sugar cane at that time.

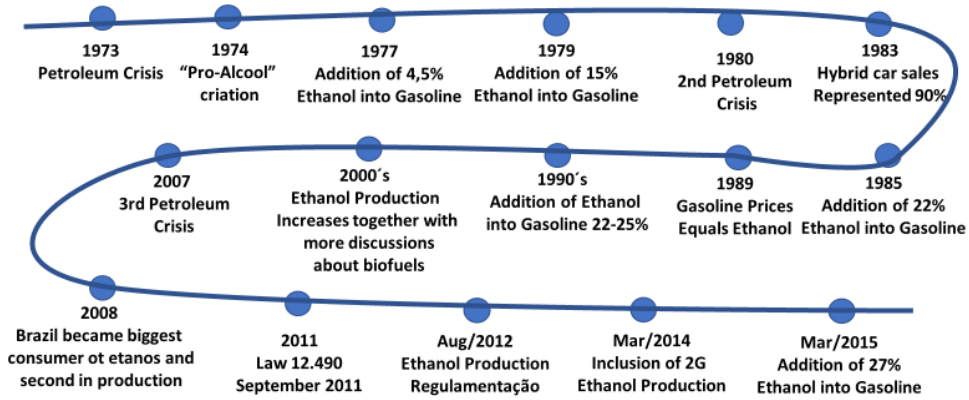
In early 1970s, the ethanol blend into the gasoline was only 1.1%, 550 billion liters. Figure 1 shows the history of ethanol in Brazil. Several events happened associated with three petroleum crises to make Brazil a larger producer and consumer of ethanol.

Fiat decided to invest in this new industry and launched the model FIAT 147 in 1976 in Brazil, with a motor engine running on 100% hydrous ethanol that has between 95.1% and 96% of ethanol and the balance in water. It was called "cachacinha" derived from the name "Cachaça", the main liquor produced in Brazil out of sugar cane. From 1976 to 1986, this type of car used hydrous ethanol only for fuel represented majority of cars produced in Brazil in this decade (Associação Nacional dos Fabricantes de Automoveis 2020). In 1993, cars using ethanol alone represented 60% of the Brazilian fleet, about 6 million cars (Wikipedia 2020). In the early 1990s, when petroleum prices fell to $12 per barrel, the use of ethanol lost its main purpose, and consumption decreased rapidly. The production of cars using only ethanol as fuel decreased and this type of car became expensive to reduce greenhouse gas emissions and to help the ethanol industry. In August, 1993, the

Brazilian Government launched a law stating a mandatory blend of anhydrous into gasoline at 22% (Figure 1).

In 2000, discussion of biofuels in Brazil entered the spotlight supported by the Brazilian Government and occurred in the automotive industry that launched the hybrid cars, called FLEX. The consumption of ethanol gained strength and consumers could opt to use gasoline with either an anhydrous ethanol blend or 100% ethanol depending on the price. Biofuel discussions and the reduction of greenhouse gases continued during the decade and in September 2011 a new law stated that any Brazilian company could produce biofuels (Figure 1.1).

Figure 1.1 Ethanol history in Brazil



Source: Ethanol History in Brazil by National Agency of Petroleum, Natural Gas, and Biofuels (anp)

In 2019, the Brazilian fleet of "flex" cars reached 79% (table 1.1) and the ethanol industry gained additional strength from environmentalists. As a renewable energy, ethanol gained attention because of CO_2 emissions, and demand increased exponentially. New raw materials were developed to produce ethanol, in states far from the Center-South region, where sugar cane production is concentrated. The first flex sugar mill was opened in 2015, in the state of Goias, using two different raw materials: sugar cane from April to August and corn from September to March. In 2016, the first

ethanol plant using 100% corn as the raw material was built in the state of Mato Grosso and began operations in 2017 and with the other five plants still being built.

Table 1.1 Brazilian vehicle fleet

Year	Total Fleet	Flex fuel	100% Gasoline	100% Ethanol	Electric
2007	21,517,698	4,586,512	15,085,856	1,845,330	
2008	23,104,220	6,878,189	14,555,523	1,670,508	
2009	24,967,140	9,467,825	13,991,052	1,508,263	
2010	27,058,723	12,244,937	13,455,428	1,358,358	
2011	29,160,425	14,944,734	12,995,272	1,220,419	
2012	31,410,752	17,895,425	12,421,215	1,093,995	117
2013	33,513,236	20,772,995	11,761,194	978,439	608
2014	35,307,138	23,328,161	11,104,282	873,232	1,463
2015	36,224,340	25,030,412	10,413,865	777,768	2,295
2016	36,557,411	26,172,750	9,689,901	691,398	3,362
2017	36,967,759	27,365,821	8,981,826	613,493	6,619
2018	37,542,095	28,669,505	8,318,551	543,449	10,590
2019	38,187,660	30,002,509	7,682,221	480,618	22,312
2020p	38,844,326	30,648,173	7,768,865	388,443	38,844

Source: Unica

The economic situation in Brazil in the past 5 years deteriorated with negative GDP growth. This was an important trigger for ethanol consumption growth, pushing the population to look for cheaper sources of fuel. Another important trigger that boosted ethanol consumption was the Brazilian culture. The Brazilian market for cars requires hybrid cars, Brazilians are used to ethanol as a source of fuel for more than 30 years and the majority understand the economics when comparing ethanol use to gasoline use.

In 2019, a record amount of ethanol was provided and consumbed, 35.6 and 32.8 billion liters respectively.

1.1 Ethanol Consumption and Prices Evolution

Ethanol consumption has grown more than 50% in the last decade, from 21 to 35 billion liters (figure 1.2). Its growth is associated primarily with the economic growth in Brazil adding purchasing power to the market, but also with local and worldwide economic instability and uncertainty impacting currencies, crude oil markets and, therefore, gasoline price. One example of this volatility in prices was during second quarter of 2014. Ethanol experienced a drastic decrease in use due to a drop in GDP, generating a negative growth in consumption during 2015 and 2016, and a poor recovery in 2017.

In 2018, with the expectation of a new Government and lower sugar cane production (Figure 1.3) and ethanol production, prices recovered to about R$2.0 liter until the end of 2019 (Figure 1.4).

Figure 1.2 Ethanol consumption in Brazil in the last decade

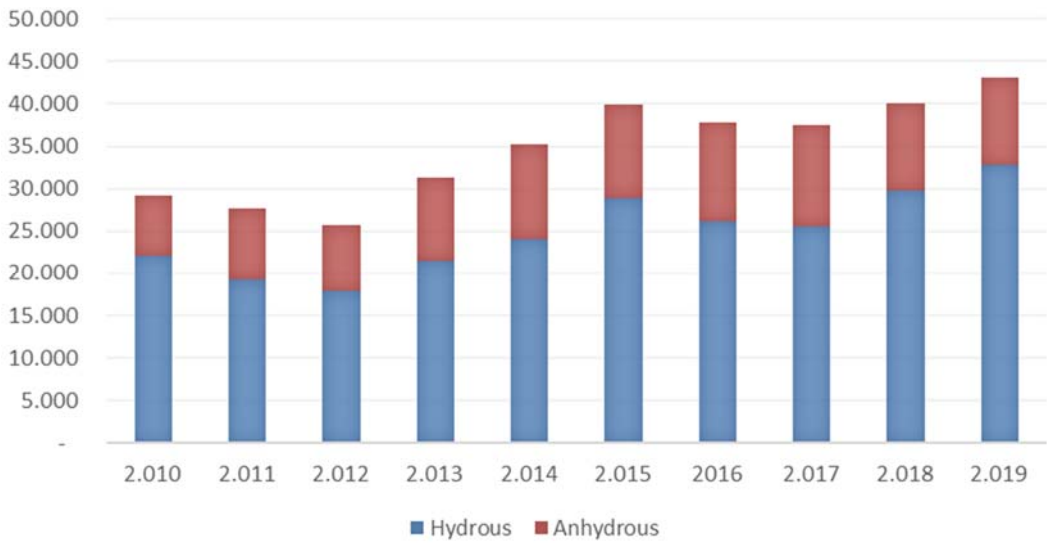


Figure 1.3 Sugar cane production in Brazil in million metric tonnes

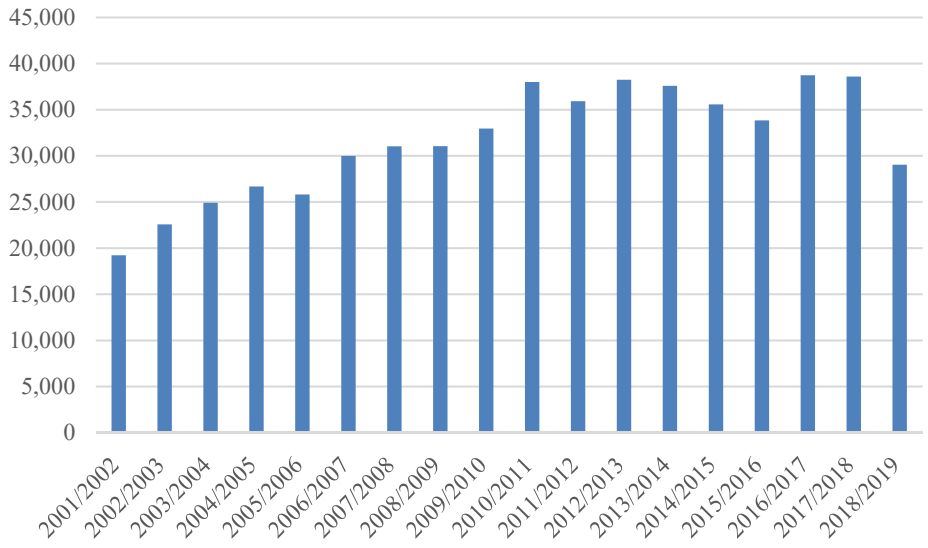


Figure 1.4 Ethanol hydrous prices ex-mill in Mato Grosso in R$/liter

1.2 Ethanol Industry

The ethanol industry has suffered for the past 20 years due to poor margins related to a strong currency, low sugar price as India expanded its production and the populist Brazilian Government freezing ethanol prices to control inflation during a poor period of economic growth. Several sugar mills entered Chapter 11 Bankruptcy during 2010 and 2016 due to the poor margins and a high debt. The giants of the agricultural sector such as Cargill, Bunge, Louis Dreyfus and ADM placed their sugar mill assets for sale, and/or were looking to find a partner to run such a business.

The start of a relief began in 2018 with the promise in the new President´s campaign to remove interventions in the energy sector. The sign of a new program designed to reduce greenhouse gases, and to some extent the currency depreciation versus the U.S. dollar caused gasoline prices to increase. Therefore, prices of ethanol increased, bringing sugar mills back to profitability but resulting in limitations to increase ethanol production, adding a new incentive for plants using 100% with corn being built.

Until 2017, the use of corn as a raw material for ethanol production was rare, as there were only few hybrid plants available that could use corn and/or sorghum during the off-season of the sugar cane crop.

In 2017, ethanol plants using 100% corn as raw material started to surge in Mato Grosso, where the cheapest corn is available. In Brazil, Mato Grosso is strategically closer to the North and Northeast fuel demand, compared to sugar mills located in central-south region. In 2020, the total number of ethanol plants corn based in Mato Grosso was expected to reach 14 units processing 6.4 million metric tons (Figure 1.5).

The data presented is based on the Brazilian metric system, but a comparison to the US system can be seen in table 1.3.

Table 1.2 Brazilian ethanol plants using corn as raw materials

Unit	City	State	Type	Status	Capacity (k cbm/year)	Corn (k tons)
Usimat	Campo de Julio	MT	Flex	Operating	200	476
FS Bioenergia	Lucas do Rio Verde	MT	Full	Operating	560	1,333
Usina Libra	S. Jose do Rio Claro	MT	Flex	Operating	120	286
Usina Porto Seguro	Jaciara	MT	Flex	Operating	60	143
Inpasa Brasil	Sinop	MT	Full	Operating	525	1,250
FS Bioenergia	Sorriso	MT	Full	Operating	560	1,333
Safras	Sorriso	MT	Full	Operating	50	119
SJC Bioenergia	Quirinopolis	GO	Flex	Operating	160	381
Usina Rio Verde	Rio Verde	GO	Flex	Operating	40	95
Usina Caçu	Vicentinopolis	GO	Flex	Operating	50	119
Santa Helena	Santa Helena de Goiás	GO	Flex	Operating	50	119
Usina Cooperval	Jandaia do Sul	PR	Flex	Operating	20	48
Inpasa (1ª fase)	Nova Mutum	MT	Full	Construction	201	479
Cerradinho Bio	Chapadão do Ceu	GO	Flex	Construction	102	243
Sub-total - OPERATING					2,698	6,424
Etamil Bioenergia	Campo Novo de Parecis	MT	Flex	Construction	100	238
Inpasa	Nova Mutum	MT	Full	Construction	603	1,436
Sub-total - CONSTRUCTION					703	1,674
FS Bioenergia	Campo Novo do Parecis	MT	Full	Project	530	1,262
FS Bioenergia	Nova Mutum	MT	Full	Project	530	1,262
FS Bioenergia	Primavera do Leste	MT	Full	Project	530	1,262
FS Bioenergia	Querência	MT	Full	Project		
Sta Clara Alcool Cereais	Vera	MT	Full	Project	17	40
Alcoaad	Nova Marilandia	MT	Full	Project	210	500
Millenium	Jaciara	MT	Full	Project	200	476
VMG Bioenergia	Jatai	GO	Full	Project	80	190
Sub-total - PROJECT					2,097	4,993

Table 1.3 Conversion table

Measure		Converted	
Cubic Meter	1	Gallon	264.17
Liter	1	Gallon	0.2642
Metric tonnes	1	Pounds	2204.620
Metric tonnes	1	Corn Bushel	39.368
Hectare	1	Acres	4.7105

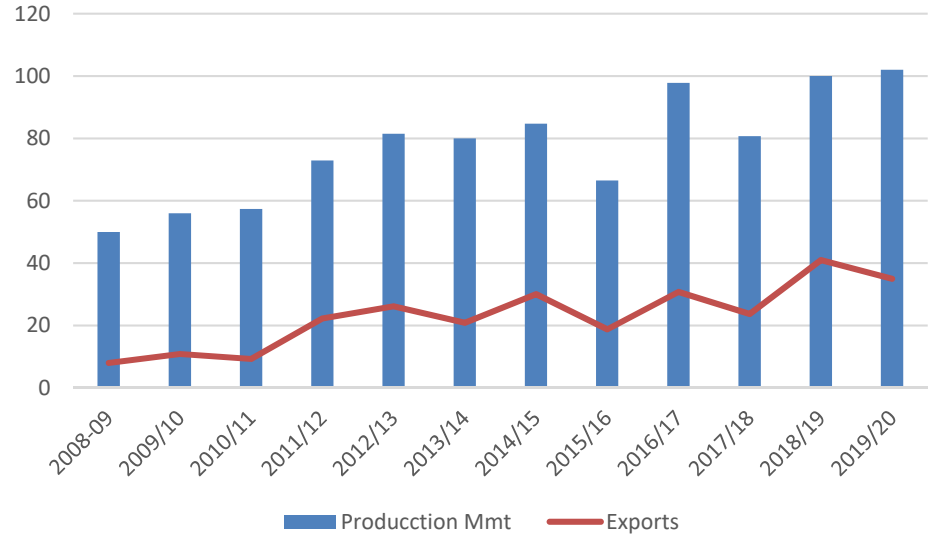
CHAPTER II: CORN MARKET IN BRAZIL

Brazil has become an important worldwide supplier of yellow corn in the last decade. In 2009, Brazil produced 50 million mt according to CONAB for the crop year 2008/2009, and it doubled production over the next 10 years reaching 102 million mt for the crop year 2019/20 (figure 2.1).

According to the latest World Agriculture Supply and Demand Estimates (2021) report released by United States Agriculture Department, Brazil has the 3rd largest corn crop in the world, behind the USA with 346 million metric tons and China with 261 million mt.

Brazil is the second largest corn exporter with 35 million mt, just 10 million behind the USA. Brazil has the potential to be the number one exporter in the next decade.

Figure 2.1 Brazilian corn crop in Brazil in the past 12 years in million metric tons



2.1 Corn production in Mato Grosso

Corn is produced in Mato Grosso, but several other states in Brazil have the right land and climate to double crop with soybeans planted during fall and harvested in summer and corn planted in summer and harvested in winter.

The ability to double crop is synonymous with a cost reduction, and many farmers argue that the soybean crop pays the bills, return to the land and other farming costs, so the corn crop is the profit. In 2020, production costs of corn in Mato Grosso, not including land depreciation, reached USD 75/mt. Land cost in Brazil is typically applied to the first crop, soybeans.

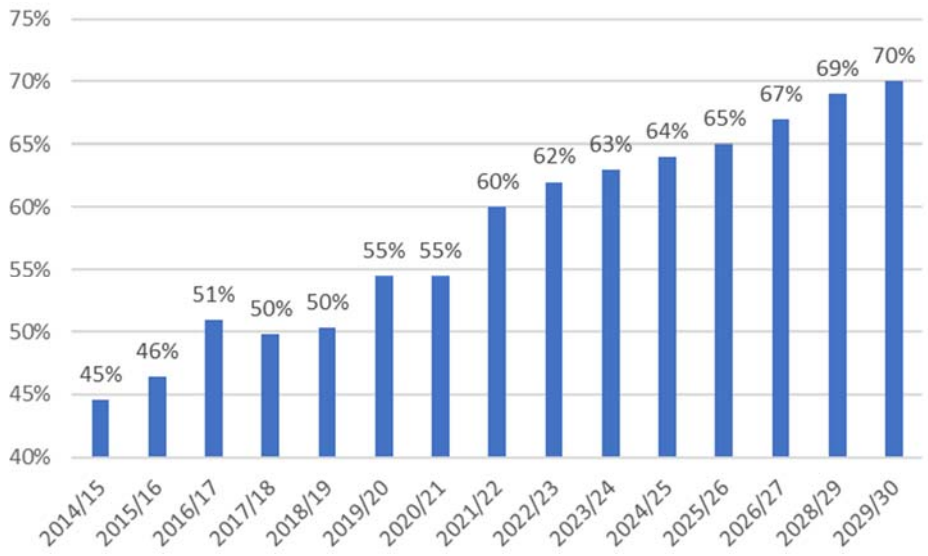
For this reason, the production of corn in Mato Grosso has grown exponentially in the past 10 years, from about 8 million metric tons for the 2008/2009 crop to 35 million metric tons for the 2019/2020 crop (CONAB). Roughly 34% of the Brazilian crop is produced in Mato Grosso that is considered as the corn belt in Brazil. The production increased due to a combination of new seed, new technology and farmers double cropping. In 2014, the total area in Mato Grosso for double cropping soybean/corn accounted 44%. For the 2019/2020 crop, it increased to 55% (Figure 2.2). This number is far from the potential of Mato Grosso, which is roughly 70% according to agronomists.

One of the reasons for the pace of the increase in double cropping is the financial power from farmers and high logistics costs to send production to the nearest ports due to lack of infrastructure. The average inland cost in 2018 to take corn from Mato Grosso to the port is about USD 65/mt compared to the U.S. where the cost is USD 20/mt. The main road linking the Brazilian corn belt to the nearest ports in the North of Brazil, called BR-163, has many kilometers unpaved. During the summer season, the peak of soybean harvest, the road is constantly blocked due to rain during this

period. In February 2020, BR-163 was finally completely paved and inland costs fell from USD 65/mt to USD 40/mt.

Facing the new scenario of lower transportation costs and higher demand for corn, it will be easier to double crop and reach the 70% estimate, boosting corn production in Mato Grosso to 7 million hectares and approximately 50 million metric tons of production in 2030.

Figure 2.2 Double crop estimates for Mato Grosso (%)



2.2 Corn Prices in Mato Grosso

A combination of local currency devaluation, better logistics costs and new local demand from ethanol plants, increased the corn prices to the farmers during the last two years that has incentivized more area for double cropping. The cost of production ten years ago, led to low incentives to produce corn besides the need for land rotation to achieve better results for soybeans. Today, revenues for farmers in Mato Grosso increased from R$261 (USD 52) per hectare in 2017/18 to R$1,618 (USD 324) in 2019/20. Corn prices to the farmer also increased with average prices

increasing from R$21.20 (USD 4.24) in 2017/18 to a record level in 2020 of R$70 (USD 14) a sac of 60kg (132 pounds). Looking at CME quotes for corn prices in Mato Grosso for one of the main cities, Sorriso, in the past 2 years (figure 2.3), price evolution motivated farmers to increase the production area in Mato Grosso.

Figure 2.3 Prices of corn 60kg sac at the city of Sorriso, MT

CHAPTER III: THE PROJECT

3.1 Location of the Plant

Mato Grosso is the location considered for an ethanol plant using corn due to the state's corn production capacity and potential growth from land availability. At this point, the plant is chosen to be in the region called BR 163, from Nova Mutum city to Sinop, which accounts for 40% of total corn production in this state and the price of main raw material varies little despite the distance between the cities, 240km. The main reason for this small variation is that the Sinop area has prices to ports located in Northern Arc: Port of Barcarena, Santana and Santarem. Nova Mutum prices to the main railroad hub of Rondonopolis that ships to the port of Santos, so both export corridors guarantee farmers can obtain similar prices for corn and biomass.

3.2 Size of the Plant and Investment

This project examines a plant with the capacity to process 250,000 metric tons of corn year, using a 100% dry milling process. It is able to produce:

- 107,500 cubic meters of ethanol/year,
- 72,500 metric tons of DDGs with 31% dry protein content and
- 4,500 metric tons of corn oil.

The total cost to build a plant of this size using ICM technology was quoted from a company based in Kansas City. It is known for producing machinery to produce ethanol. The cost is estimated at about USD 57 million, approximated R$ 285 million in Brazilian Reais. The components are as follows:

1. Pre-operational costs with project engineering, insurance, law and financing consulting, representing 7% of the project costs,
2. Machinery to produce ethanol including plant construction, warehouse, machinery, etc., are 70% of costs, and
3. Energy generation machinery and the site, 23% of costs.

This estimate was based on several interviews in 2019, but also used information from similar projects built in 2018 using the consulting company Datagro with the cost of USD 50 million, approximated R$250 million in Brazilian Reais and also several communications from companies operating the majority of ethanol plants in Mato Grosso: Impasa and FS energy. Impasa built its first plant in 2018 in the city of Sinop and spent R$700 million, and in 2019 its second plant in the city of Mutum with a cost of R$1 million (Canal Online 2018).

These two companies started investing in Mato Grosso in 2017, with plants of 1 million metric tons of corn and it has plans for plants to be built in 2020 at a cost of R$ 1 billion Brazilian Reais, about USD 192 million.

FS Bioenergia built its first plant in Lucas do Rio Verde in 2018 at estimated cost of R$800 million, with capacity for processing 1 million mt of corn. In 2020, it built its second plant with same capacity in the city on Sorriso with a total investment of R$1 billion (Minutomt 2018).

3.3 Labor Force

The direct labor force required to run a plant of 250 thousand metric tons/year is estimated as follows:

Group 1: Production, Laboratory and Material handling: 35 individuals and

Group 2: Administrative, Reception, Management, Sales: 30 individuals.

The salary for group 1 in Mato Grosso is R$ 6,800 (equivalent of USD 1,360) per month for the direct labor force and about R$8,150 (equivalent of USD 1,630) for group 2. These are net salaries and do not include benefits such as transport from home to work, meals, medical insurance, and taxes. These costs can reach a total of 80% of the base salary and it is assumed in this study as an HR factor of 80%. By Brazilian law, any employee has the right to earn additional salary if he/she works one full year, it is called 13o. salary and 30% bonus for the holidays period. For this reason, this study was 13.3 times the salary costs in an year.

The annual overhead total cost is R$6.4 million, equivalent to USD 1.3 million, not including any sales commission (Table 3.1).

Table 3.1 Labor cost estimates

Direct	**R$/million**	**U$/million**	**PS:**
Production, lab, and maintenance		**5.0**	**USD/R$ rate**
Number of employees	35		
Average salary	$6,800	$1,360	equal to about 3.6 minimum official salary removing taxes
HR factor (welfare + taxes)	0.80		
Year base salary number	13.30		13o. Salary included + 30% bonification over holidays
Total Direct Costs	$3,165,400	$633,080	
Indirect			
Administrative, reception, sales purchase			
Number of employees	$30		
Average salary	$8,150	$1,630	equal to about 4.5 minimum official salary removing taxes
HR factor (welfare + taxes)	0.80		
Year base salary number	13.30		13o. Salary included + 30% bonification over holidays
Total Indirect Costs	$3,251,850	$650,370	
TOTAL COSTS	$6,417,250	$1,283,450	
Overhead costs per Plant Capacity	$25.67	$5.13	in metric tons

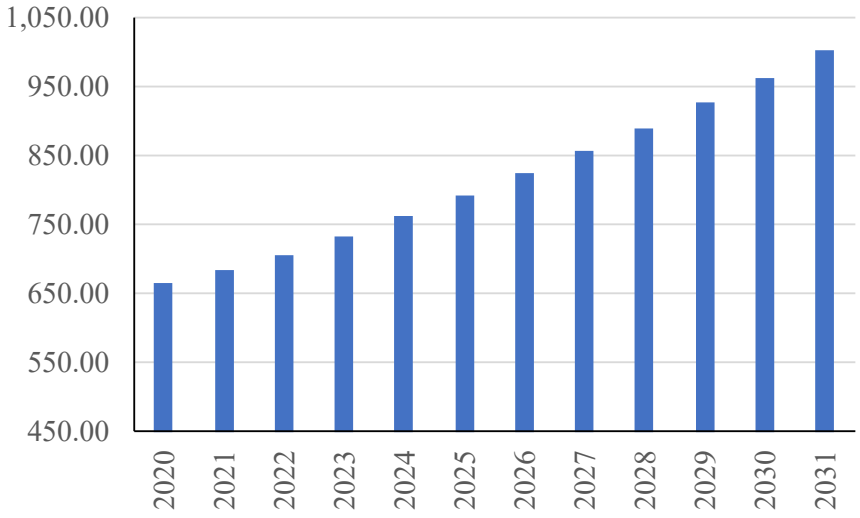
3.4 Economic Indexes

IPCA – "Indice Nacional de preços ao Consumidor Amplo" (Instituto Brasileiro de Geografia e Estatistica 2020) is the index from the Brazilian Government to measure inflation from services, wholesale markets, public services prices related to the consumption of Brazilian families from day 1 to day 30 of each month. It is used for price projections for this project. Based on the last report published by Brazilian Central Bank on January 15, 2021, the IPCA projections for 2021, 2022, 2023 and 2024 were 3.44%, 3.50% 3.25% and 3.22% respectively. For 2025 on it was 4%, based on the Brazilian Government expectations of a stable scenario. The local currency rate versus US dollar the same report indicated the Government projection for 2021, 2022, 2023 and 2024 at R$5, 4.98, 4.97 and 5 respectively and from 2025 it was assumed to be R$5. The cost of the main raw material corn and ethanol prices are the main drivers to make this project viable. High volatility can jeopardize the entire investment thus a sensitivity analysis is conducted on both factors.

3.5 Corn Cost

The actual cost of corn negotiated for 2021 is R$ 667/mt (R$41/60kg (sac). An estimated 10-year projection of costs using the IPCA Index is in Table 3.2.

Figure 3.1 Corn prices 10-year estimates for Mato Grosso (R$/MT)



3.6 Biomass

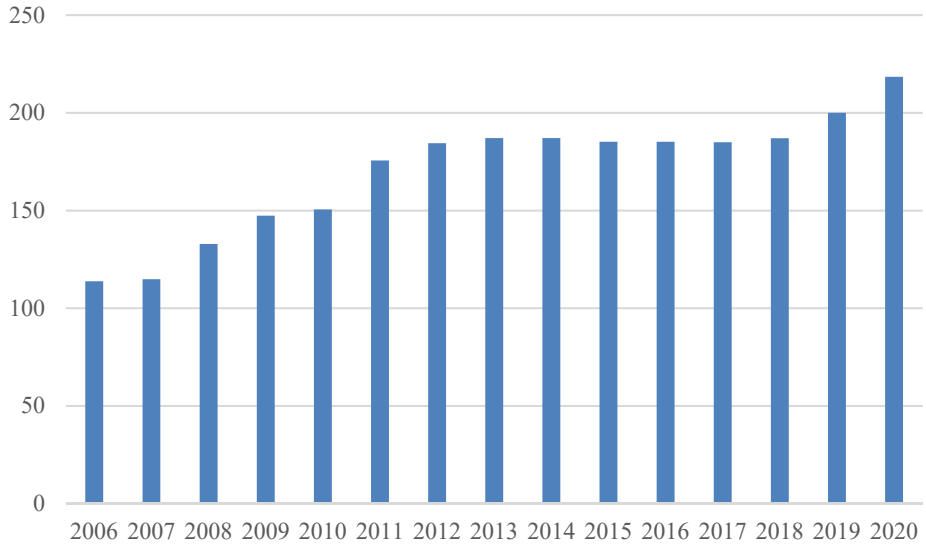
Energy is another of the main inputs needed to study the feasibility of building a plant. The majority of the ethanol plants generate energy from wood as it is the cheapest source. In Mato Grosso, eucalyptus production has grown 45% in the last decade reaching 218.5 thousand hectares of eucalyptus produced in 2020, to supply the actual demand coming from two large industries: ethanol and cellulose.

Increasing the number of eucalyptus farms brought several benefits to the state of Mato Grosso as production costs are lower compared to grains as it requires no more than 30% of the capital required for corn planting. There is a positive social impact for rural families, Eucalyptus farms bring the education of sustainability and environment protection, teaching farmers and Brazilian citizens that wood as a source of energy can be planted and it does not extract from the native forest (FIBRIA 2019).

For the next 2 years, a large increase in Eucalyptus production is expected reaching up to 500 thousand hectares to supply the ethanol plants plus all public projects. Most of the growth is driven

by the owners of the industry who invested in eucalyptus planting. Eucalyptus plantations are very profitable, about 23 bags of soybeans as net profits according to the local association for reforesting in Mato Grosso called ‘Associaçao de Reflorestamento no Mato Grosso
(Mato Grasso Tribune 2018).

Figure 3.2 Hectares (1000s) production of eucalyptus in Mato Grosso



Source: IBA

The actual cost of the biomass is about R$47 per stereo meter delivered to the ethanol plant. To process a metric ton of corn, 0.464 metric tons of biomass are needed that is equal to 1.36 stereo meter of biomass. The total cost in biomass to process 1 million metric tons of corn is R$64/mt.

3.7 Other Inputs

Other Materials such as yeast, chemicals and water are estimated to be R$17/mt of corn processed.

3.8 Total Material Costs

The total cost of materials used to process 1 metric ton of corn is estimated at R$730.67 or about USD 146 in 2020. The IPCA was used to forecast cost increase in the next 10 years (Table 3.2).

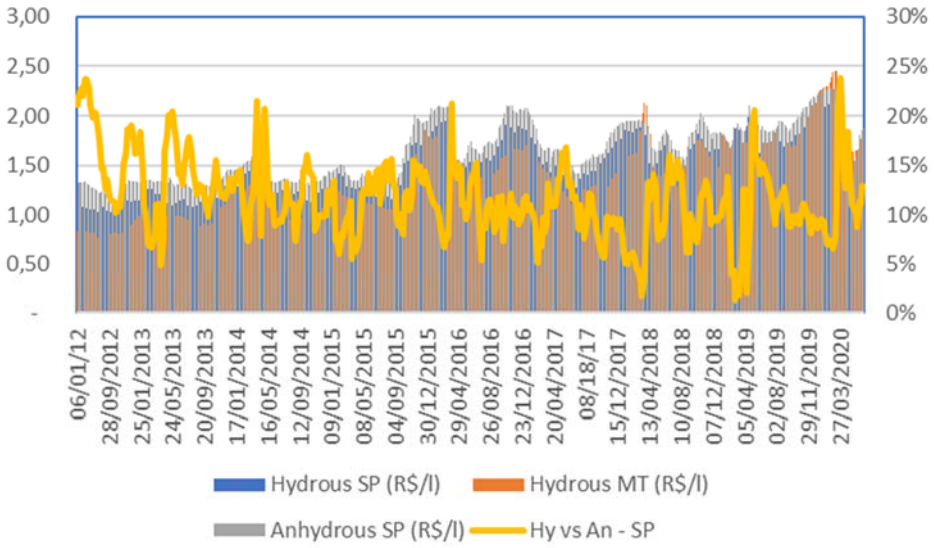
Table 3.2 Total material cost per metric ton of corn distilled.

Dollar		Economic Index		CORN		Biomass	Others	Total Material Cost	
	Projection	IPCA	Projection	R$/sac	R$/mt	R$/MT	R$/MT	R$/MT	USD/MT
2021	5.00	2021	3.37%	41.00	683.33	66.16	17.00	766.49	153.30
2022	4.98	2022	3.50%	42.44	707.25	68.47	17.60	793.32	159.30
2023	4.97	2023	3.25%	43.81	730.24	70.70	18.17	819.10	164.81
2024	5.00	2024	3.22%	45.22	753.75	72.97	18.75	845.48	169.10
2025	5.00	2025	4.00%	47.03	783.90	75.89	19.50	879.29	175.86
2026	5.00	2026	4.00%	48.92	815.26	78.93	20.28	814.47	182.89
2027	5.00	2027	4.00%	50.87	847.87	82.09	21.09	951.04	190.21
2028	5.00	2028	4.00%	52.91	881.78	85.37	21.94	989.09	197.82
2029	5.00	2029	4.00%	55.02	817.05	88.78	22.81	1,028.65	205.73
2030	5.00	2029	4.00%	57.22	953.73	92.34	23.73	1,069.80	213.96
2031	5.00	2030	4.00%	59.51	991.88	96.03	24.68	1,112.59	222.52

3.9 Ethanol Prices Projection

To estimate Ethanol prices for the next 10 years, an IPCA index was used. The expectation of hydrous ethanol prices are that they recover post Covid-19 and reach R$2,031 per cubic meter by the end of 2020. Anhydrous ethanol prices are projected to be 10% more expensive according to the last 8-year average prices at CEPEA database.

Figure 3.3 Price comparison of hydrous and anhydrous prices in Sao Paulo versus Mato Grosso (R$/l)



Source: CEPEA

3.10 Corn Oil and DDGs Prices Projections

Corn oil price was estimated at R$3,675/mt (USD 735) based on the average price of 2020 and FX rate for USD at R$5 in 2021. Corn oil prices increased in the first semester led by FX devaluation and at the end of the year due more demand overseas for Biodiesel as shown in Figure 3.4.

DDG prices were also highly volatile during 2020 with FX valuation associated with local demand learning how to use this product into feed as a replacer of soybean meal in some industries like dairy. Quotes ranged from R$600/mt (USD 120) in Jan/20 to

R$1,800/mt (USD 360) in Dec/20 (Figure 3.5). For this project, R$1,000/mt is used as average price for 2021. This is a USD 200/mt equivalent and about 40% above the corn prices. The supply of this product will increase in 2021 with new plants starting up in 2021 in a consumer market not mature enough for this type of product, but not sufficient to jeopardize the DDGs prices used in this project.

Corn oil and DDG prices were considered net of the sales commission of 1%, and from 2022 forward, those prices were adjusted by the IPCA index.

Figure 3.4 Corn oil prices

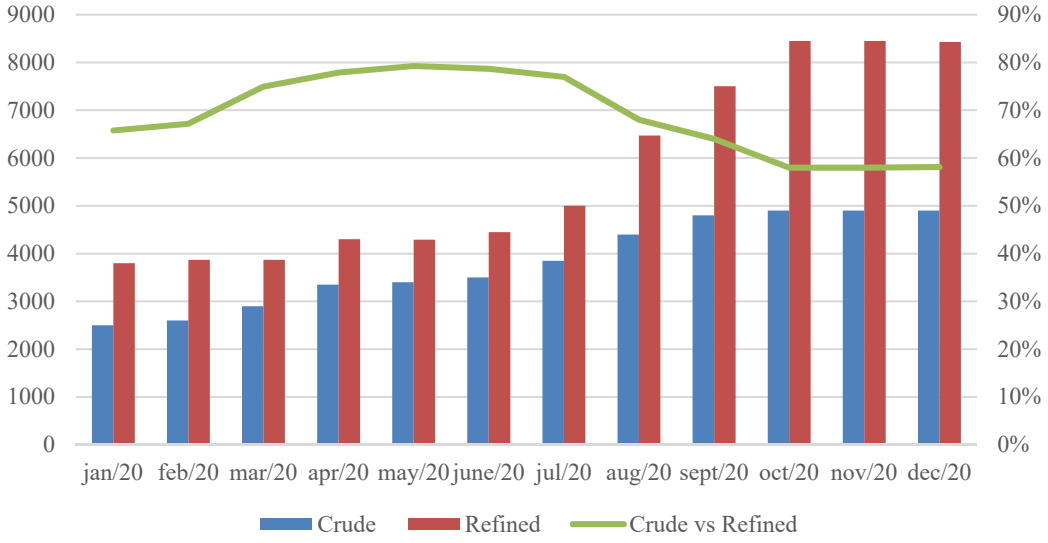
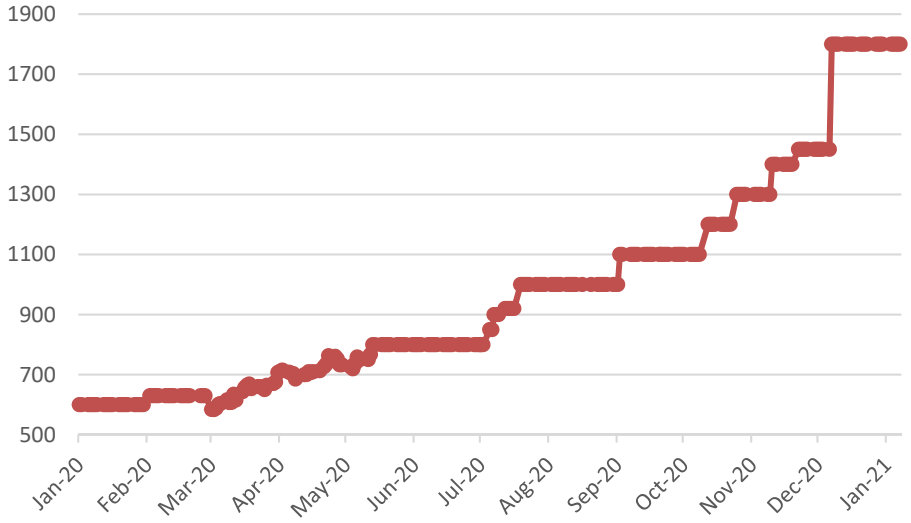


Figure 3.5 DDGs prices in Mato Grosso - Source: "Safras e Mercados"



The above assumptions result in total revenue (Table 3.3).

Table 3.3 Total revenue in R$

	Anhydrous	Hydrous	DDG	Corn Oil	Total Revenue	
YEAR	R$/cbm	R$/cbm	R$/MT	R$/MT	R$	USD
2021	2,341	2,090	1,000	3,675	321,800,800	64,360,160
2022	2,423	2,163	1,035	3,804	333,063,828	66,612,766
2023	2,501	2,233	1,069	3,927	343,888,402	68,777,680
2024	2,582	2,305	1,103	4,054	354,961,609	70,992,322
2025	2,685	2,398	1,147	4,216	369,160,073	73,832,015
2026	2,793	2,493	1,193	4,384	383,926,476	76,785,295
2027	2,904	2,593	1,241	4,560	399,283,535	79,856,707
2028	3,021	2,697	1,290	4,742	415,254,877	83,050,975
2029	3,141	2,805	1,342	4,932	431,865,072	86,373,014
2029	3,267	2,917	1,396	5,129	449,139,675	89,827,935
2030	3,398	3,034	1,452	5,334	467,105,262	93,421,052

3.11 Working Capital Costs and Interest Rates

The Brazilian Government Bank called BNDES offers financing lines for companies willing to invest. In 2020, the annual interest rates varied from 3.5% to 4.25% depending on the size of the investment. For this study, an annual rate of 4.25% was used

as this is the note expected by the Government until the end of 2021, the same rate company A charges for funding any of its 70 businesses units.

The working capital required in the first year of the plant operation is estimated to be about USD 24.6 million. This amount is enough to cover four months of raw material, two months of finish goods and one month of credit for the main customers (Table 3.4).

Table 3.4 Working capital estimates

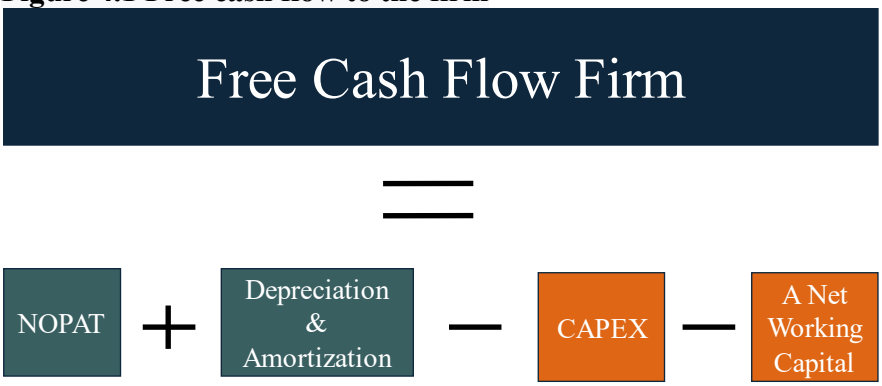
WC Estimates	Cycle Time	Year 1
Raw Material	120	12,602,137
Finished Goods	60	6,709,575
Debtors	30	5,276,931
Total WC USD		24,588,643

CHAPTER IV: ECONOMIC STUDIES

To value a firm, the first estimate used to measure the project viability is Free Cash Flow to the Firm (FCFF) that represents the cash available to the company after it pays all its business costs, invests in current assets including inventory and invests in long term assets (CAPEX).

FCFF is a good indicator of the expected operational performance of this project and the formula used is represented in figure 4.1, where NOPAT (net operating profits after taxes) is the Income from Operations x (1 – tax rate).

Figure 4.1 Free cash flow to the firm



Source: Corporate Finance Institute

The second estimate used was the Net Present Value (NPV) and the third was the Internal Rate of Return, IRR.

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. For this particular project, a 10-year period was used. The following formula is used to calculate NPV; $NPV = \sum_{t=1}^{T} R_t|(1+i)^t$, where R_t is Net cash inflow-outflows during a single period t, i is the Discount rate and t is the time period.

A positive net present value indicates that the projected earnings generated by a project or investment - in present dollars - exceeds the anticipated costs, also in present dollars. After calculating NPV, the Internal Rate of Return is estimated using the formula below. The NPV is set equal to zero to solve for the discount rate (i), which is the IRR. The higher the IRR, the higher will be the desire for the investor to put money in the project expansion. The formula and calculation used to determine the IRR is: $0 = \sum_{t=1}^{T}(R_t)(1 + IRR)^t - C_0$, where R_t is the net cash inflow during the period t, C_0 is the total initial investment costs, IRR is the internal rate of return and t is the number of time periods.

Any project to be sent to consideration for company A needs a minimum of 15% IRR given the Board of Director policy.

4.1 Main Results

The Net Present Value for this project is USD 104,936 with an IRR of 27% (Table 4.1). The production cost using corn as only raw material, was R$1.12/liter, which is 34% cheaper than sugar cane at R$1.50/liter. Sugar cane cost at the mills has been increasing since 2019 due to lower yields derived from non-favorable weather, age of the plantation, and lower rentability to the farmers compared to grains.

Table 4.1 Financial analysis

Dollar Rate			5	4.98	4.97	5	5	5	5	5	5	5
IPCA %			3.37%	3.50%	3.3%	3.2%	4%	4%	4%	4%	4%	4%
	2020	R$	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Production Volume Corn			250000									
Anhydrous cbm			32250									
Hydrous cbm			75250									
DDG HIPRO			72500									
Oil			4500									
Prices			USD									
Anhydrous		2341	468	485	500	516	537	559	581	604	628	653
Hydrous		2090	418	433	447	461	480	499	519	539	561	583
DDG HIPRO		1000	200	207	214	221	229	239	248	258	268	279
Oil		3675	735	761	785	811	843	877	912	948	986	1026
Total Revenue usd			**64,360,160**	**66,612,766**	**68,777,680**	**70,992,322**	**73,832,015**	**76,785,295**	**79,856,707**	**83,050,975**	**86,373,014**	**89,827,935**
Corn MT		683.47	137	141	146	151	157	163	170	176	183	191
Biomass mt corn destiled)		66	13	14	14	15	15	16	16	17	18	18
Others MT (base corn destilled)		17	3	4	4	4	4	4	4	4	5	5
Total Cost of Goods Sold			**38,331,500**	**39,673,103**	**40,962,478**	**42,281,470**	**43,972,729**	**45,731,638**	**47,560,904**	**49,463,340**	**51,441,873**	**53,499,548**
Contribution Margin			**26,028,660**	**26,939,663**	**27,815,202**	**28,710,852**	**29,859,286**	**31,053,657**	**32,295,803**	**33,587,636**	**34,931,141**	**36,328,387**
Overhead (Production)			**633,080**	655,238	676,533	698,317	726,250	755,300	785,512	816,933	849,610	883,594
Overhead (Adm)			**650,370**	673,133	695,010	717,389	746,085	775,928	806,965	839,244	872,814	907,726
Insurance			**66,000**	68,310	70,530	72,801	75,713	78,742	81,891	85,167	88,574	92,117
Maintenance			**860,000**	890,100	919,028	948,621	986,566	1,026,028	1,067,070	1,109,752	1,154,142	1,200,308
Others			**926,000**	958,410	989,558	1,021,422	1,062,279	1,104,770	1,148,961	1,194,919	1,242,716	1,292,425
EBITDA USD			**22,893,210**	**23,694,472**	**24,464,543**	**25,252,301**	**26,262,393**	**27,312,889**	**28,405,404**	**29,541,620**	**30,723,285**	**31,952,217**
Depreciation			5,690,227	5,690,227	5,690,227	5,690,227	5,690,227	5,690,227	5,690,227	5,690,227	5,690,227	5,690,227
Interest		1,209,173	2,820,213	3,119,459	2,913,507	2,707,247	2,506,467	2,311,688	2,118,791	1,927,851	1,738,947	822,507
EBIT USD			**14,382,770**	**14,884,786**	**15,860,808**	**16,854,827**	**18,065,699**	**19,310,974**	**20,596,387**	**21,923,543**	**23,294,112**	**25,439,483**
NOPAT			**14,622,536**	**15,303,609**	**15,958,168**	**16,627,763**	**17,486,341**	**18,379,263**	**19,307,901**	**20,273,685**	**21,278,100**	**22,322,691**
WC			23,338,543									
Investment		**-56,902,269**										
FCFL		-56,902,269	-3,025,780.5	20,993,836	21,648,395	22,317,990	23,176,568	24,069,489	24,998,128	25,963,911	26,968,327	28,012,918
Cumulative FCFL		-56,902,269	-59,928,049	-38,934,214	-17,285,819	5,032,171	28,208,739	52,278,229	77,276,357	103,240,268	130,208,594	158,221,513
IRR		27%										
NPV		104,936,126										
TAX		**4.25%**										

4.2 Sensitivity Analysis

There are two important variables in this project. One variable is the cost of the main raw material, corn that represents 79% of production costs, and the other variable is ethanol price that represents 77% of the total revenue.

The maximum price corn can reach to provide for a breakeven point for the project was calculated. Solver was applied and the result was R$68.6 per 60kg sac, equivalent to USD 228/mt in the BR-163 region of Mato Grosso, an increase of about 60%, if ethanol prices are unchanged.

The same analysis was made for ethanol and the minimum it can reach to provide a breakeven was R$1,062 the cubic meter, equivalent to USD 212.4 per cubic meter, a decrease of about 96%, if corn prices are unchanged.

It is very unlikely one of these variables suffer tremendous variance while the others remain unchanged (Figure 4.2). The prices of both variables are compared since 2013 with a correlation of 75%.

To better estimate the relationship of both variables: ethanol and corn prices in Mato Grosso, a regression was estimated. The results were a correlation of 0.75 and an R^2 of 0.55. There is a positive coefficient indicating that any increase in ethanol prices might result in an increase in corn prices (Table 4.2).

By using the regression analysis results, a 2-way table used to show the impact on NPV value at difference price levels of both variables (table 4.3). The breakeven point for this investment would be a corn price in Mato Grosso closer to USD 197. /mt, an increase of about 45% over the actual corn prices, with ethanol prices unchanged.

As April 14, 2021, corn prices in Mato Grosso reached USD 198, off season period, and hydrous ethanol was at USD 466, and the NPV still positive.

Figure 4.2 Prices comparison for ethanol and corn in Mato Grosso State

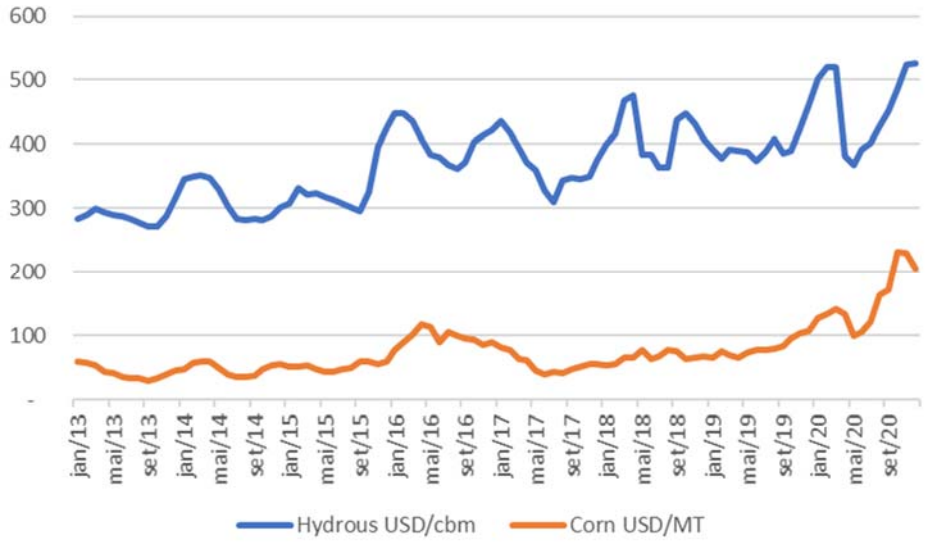


Table 4.2 Linear regression

Regression Statistics	
Multiple R	0.750
R Square	0.563
Adjusted R Square	0.558
Standard Error	43.078
Observations	96.000

ANOVA

	gl	*SQ*	*MQ*	*F*	*Significance F*
Regression	1.000	224,670.504	224,670.504	121.069	0.000
Residual	94.000	174,437.421	1,855.717		
Total	95.000	399,107.924			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	279.977	9.377	29.857	0.000	261.358	298.596	261.358	298.596
Variable X 1	1.227	0.112	11.003	0.000	1.006	1.448	1.006	1.448

Table 4.3 2-way table

Corn Prices USD/MT	Ethanol Hydrous Prices USD/cbm									
104,936,126	**417**	**423**	**429**	**435**	**442**	**448**	**472**	**497**	**521**	**546**
112	152,003,930	155,521,528	159,039,125	162,556,723	166,074,320	169,591,918	183,662,308	197,732,698	211,803,088	225,873,478
117	142,479,586	145,997,183	149,514,781	153,032,378	156,549,976	160,067,573	174,137,963	188,208,354	202,278,744	216,349,134
122	132,955,242	136,472,839	139,990,437	143,508,034	147,025,632	150,543,229	164,613,619	178,684,009	192,754,399	206,824,789
127	123,430,897	126,948,495	130,466,092	133,983,690	137,501,287	141,018,885	155,089,275	169,159,665	183,230,055	197,300,445
132	113,906,553	117,424,150	120,941,748	124,459,345	127,976,943	131,494,540	145,564,931	159,635,321	173,705,711	187,776,101
137	104,382,209	107,899,806	111,417,404	114,935,001	118,452,599	121,970,196	136,040,586	150,110,976	164,181,366	178,251,756
157	66,284,831	69,802,429	73,320,026	76,837,624	80,355,221	83,872,819	97,943,209	112,013,599	126,083,989	140,154,379
177	28,187,454	31,705,052	35,222,649	38,740,247	42,257,844	45,775,442	59,845,832	73,916,222	87,986,612	102,057,002
197	- 9,909,923	- 6,392,326	- 2,874,728	642,869	4,160,467	7,678,064	21,748,454	35,818,844	49,889,235	63,959,625
217	- 48,007,300	- 44,489,703	- 40,972,105	- 37,454,508	- 33,936,910	- 30,419,313	- 16,348,923	- 2,278,533	11,791,857	25,862,247
237	- 86,104,678	- 82,587,080	- 79,069,483	- 75,551,885	- 72,034,288	- 68,516,690	- 54,446,300	- 40,375,910	- 26,305,520	- 12,235,130
257	- 124,202,055	- 120,684,458	- 117,166,860	- 113,649,262	- 110,131,665	- 106,614,067	- 92,543,677	- 78,473,287	- 64,402,897	- 50,332,507

CHAPTER V: CONCLUSION

Considering the results achieved for this project with an IRR of 27%, which is above Company A Board of Directors requirement of 15% minimum, it is a good investment to consider. The location chosen to install and build a new plant to produce ethanol from corn is located in the Brazilian corn belt and provides the advantage of producing large amounts of corn. There is plenty of arable land to keep increasing the production of main raw materials: corn and eucalyptus, and to reduce production cost.

In addition to that, Brazilian culture and the car fleet associated with the new generation looks for products with less environmental impact. This is a positive environmental factor to increase ethanol consumption for the next decades.

The Brazilian Government also plays an important role in supporting the increase of ethanol demand by stablishing a new ethanol bend ratio into gasoline, as one of the initiatives to reduce greenhouse gas emissions.

The sensitivity analysis showed a positive correlation between corn and ethanol prices, so it is unlikely this project falls below breakeven. In summary, Company A is encouraged to invest in an ethanol plant in Mato Grosso using only corn as main raw material.

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