BX13 - Decarbonisation and Cost Reduction Obtained by Replacing Transit Vehicles in Bauxite Mining

Lincoln Felisardo[1], Eduardo Pedras[2], Brener Gomes[3], Gabriel Souza[4] and Agnaldo Souza[5]
1. Production engineer
2. Infrastructure Manager
3. Process Analyst
5. Infrastructure Supervisor
Hydro Paragominas, Paragominas, Brazil
4. Purchasing Specialist
Norsk Hydro Brazil, Belem, Brazil
Corresponding author: lincoln.felisardo@hydro.com

Abstract

This work aims to demonstrate a pioneering study implemented at Hydro Paragominas Bauxite Mine in Brazil, where 45 Four-Wheel Drive diesel pickups were replaced by Two-Wheel Drive vehicles powered by Ethanol (Biofuel obtained from sugar cane), and 10 vehicles 100 % electrical. This was possible due to constant infrastructure works at mine accesses in accordance with national safety standards, mechanical assessments of vehicles with better resources to meet the local scenario, enabling Hydro Paragominas to achieve a projected reduction of approximately 3 475 tonnes of CO_2, approximately 9 520 trees planted over a period of 5 years, in addition to savings for the company's cash of approximately 3 million US dollars.

Keywords: Decarbonization, Cost reduction, Vehicles, Access, Ethanol.

1. Introduction

Currently, bauxite mines in Brazil practice a culture for vehicle traffic within the mine areas, limited only to 4-wheel drive trucks, and Hydro Paragominas Bauxite Mine (MPSA - Mineração Paragominas) does not escape this culture. Since the implementation of the plant operation in August 2004, this model of vehicles has been adopted as necessary for internal displacements.

Today, MPSA has approximately 100 light vehicles working directly to support its service fronts, from mining, research, maintenance, pipeline, environment, safety and other support areas.

Until Dec/2022, 97 % of the number of vehicles consisted only of 4×4 diesel trucks, which in addition to having a high cost in OpEx for the company, contributed to environmental impacts by burning this fuel, releasing polluting gases into the atmosphere, especially monoxide of carbon, nitrogen oxide, sulfur, among others contributing to the global warming process.

The infrastructure support team in charge of inspecting the light vehicle rental contract began a study among other models seeking to replace this dominance of 4×4 diesel vehicles, since the roads and accesses in the mine areas were gradually improving within the mining area, increasing road safety, opening doors for new tests.

New utility trucks began to appear on the market with greater safety features, emphasizing the Fiat Strada, Oroch and Saveiro pickups, both with flex-fuel engines, making it possible to work with Ethanol fuel, less polluting than Diesel and Gasoline.

Figure 1. Location map of Hydro Paragominas.

2. Location of the Hydro Paragominas Bauxite Mine

The MPSA (M3 and M5 mines) is located in the municipality of Paragominas, in the northeast of Pará, 350 km from Belém, the capital of Pará state. Access to the unit from Belém is via BR 316, BR 010, PA 256, Estrada da Mineração at km 36, as shown in Figure 2 showing the project location map. Paragominas also has an airport with an asphalt runway of 1600 m capable of receiving large private planes.

MPSA is an integrated bauxite production system, which includes mining activities, processing and transportation by pipeline to the Northern Brazil Alumina Refinery (ALUNORTE), in Barcarena, in the State of Pará.

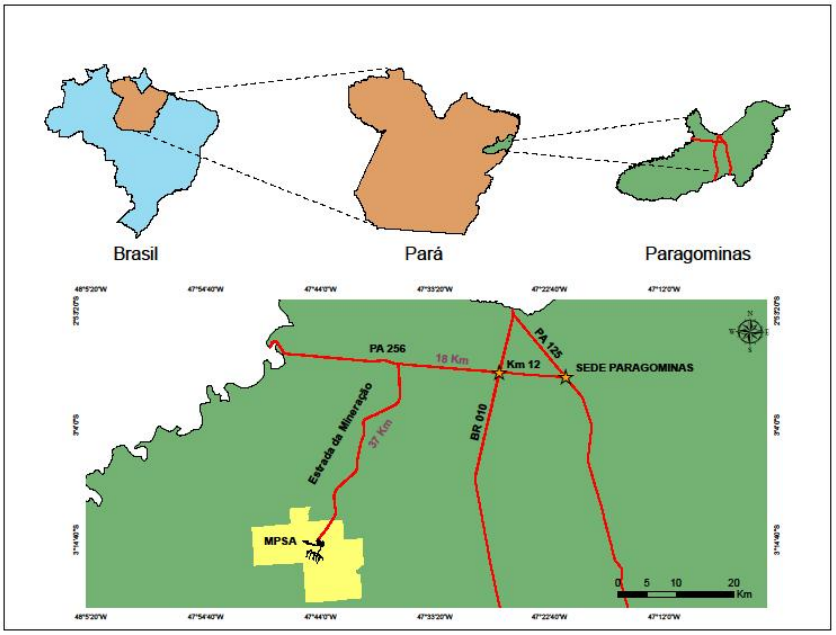

Figure 2. MPSA regional location map.

2.1. Climate

The climate of the municipality of Paragominas fits into the Ami category, for the humid equatorial climate type, with a relatively dry, well-defined season and another with high rainfall.

The average annual temperatures in Paragominas range from 25.5 ºC to 26.8 ºC, with the average being equal to 26.0 ºC, indicating that temperatures do not undergo very high variations. The annual maximum temperature is 32.7 ºC, with oscillations between 31.7 ºC and 33.8 ºC. The annual minimum temperature is 21.7 ºC, with variations between the extremes of 20.0 ºC and 22.5 ºC. The relative humidity of the air is high. On average, the humidity is around 80 %, and in the periods of greater precipitation the humidity reaches 87 % on average, and in the less rainy months it reaches 80 %.

2.2. Pluviometric Regime

The average annual rainfall in Paragominas is 1 781 mm for the period studied, with the wettest period (December to May) totaling 1 502 mm, representing 84.3 % of the annual average, while the least rainy period (June to November), with 279.3 mm, represented 15.7 % of the annual average.

This is an important factor, because when it comes to safety in vehicle traffic, rainy weather directly influences the operation, driving and maintenance of vehicles by requiring greater effort from components.

3. Mine Road Maintenance Plan

The Bauxite Mine of Mineração Paragominas is known for having an excellent maintenance plan on the roads and accesses as required by NR 22. These main lanes are maintained in the following specifications below:

- Uphill/downhill ramp maximum 6 %
- Transverse bulging of accesses -2 % from the axis
- Access width 20 meters, except service access on the 2nd floor
- Minimum width of 8 meters for service accesses (2nd floor) and mine edge
- Superelevation of accesses 2 %
- Minimum access curve radius of 80 meters
- Minimum lining with laterite in a minimum layer of 40 cm in the accesses
- Minimum height of the side swaths of accesses of 1 meter
- Internal inclination of the gutters at most 1 % (under special conditions, build an energy sink)
- Inversion of the drainage of the access in T of 1 %
- Drainage of the accesses in T and Parallel/Main Accesses must be treated in the space between these and the sterile deposits. For T-shaped accesses, the space intended for drainage is 10 meters on each side of the access and 40 meters on parallel/main accesses. The inversion of the drainage of the T-shaped accesses must be completed by December 15 of each year, to withstand the following rainy season.

In addition to the excellent maintenance plan presented above, allowing greater security for vehicle traffic, it has a 24 hour maintenance and signaling team for these accesses, in addition to other safety features on roads such as automatic water sprinklers, reducing dust in periods of drought.

On the other hand, a horizontal bauxite mine, with no risk of falls against slopes different from a pit mine, added even more to this work being approved, breaking paradigms of requirements only for 4×4 vehicles in mine areas.

Figure 3. Main access 1st floor.

Figure 4. Automatic water sprinkler system for dust control

4. Vehicle Model

Hydro Paragominas Bauxite Mine had the culture of traveling using only 4-wheel drive trucks to carry out essential operating services within the industrial areas, mine, right of way and other accesses. In Figure 5, a graph of the number of vehicles divided by model, which operated in the company's operation until 2022.

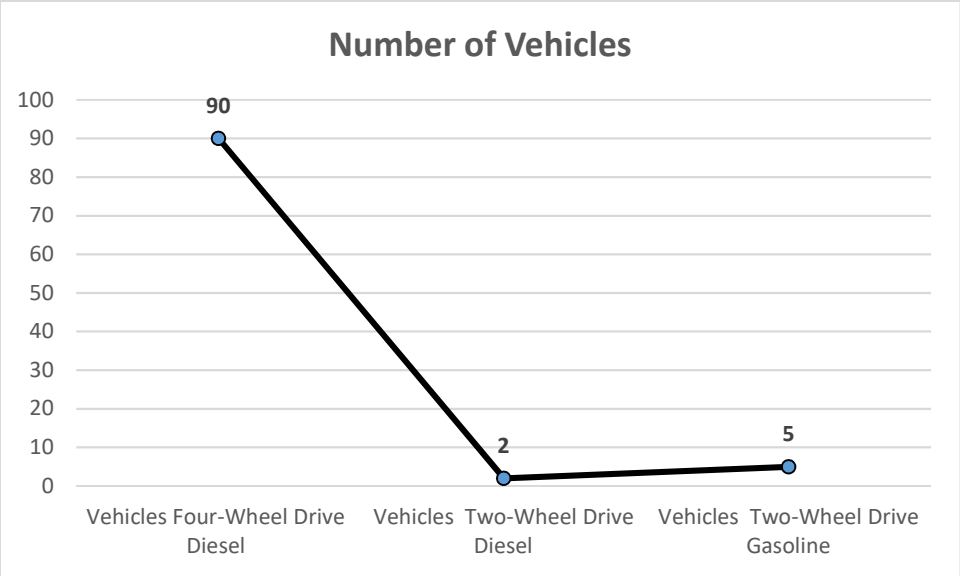

Figure 5. MPSA fleet - number of vehicles per model.

What draws attention is the dominance of 4×4 model vehicles, which in addition to a high cost for the operation, considerably impacts the environment by using Diesel, which when burned releases polluting gases into the atmosphere, especially carbon monoxide, nitrogen oxide, sulfur and among others, contributing to the global warming process.

Analyzing this scenario and the company's objectives, which is decarbonization by 2030, in line with the Paris agreement and reductions in environmental impacts around the world, the MPSA transport team began to study the change in the scenario of vehicles to transit within the company, seeking safety, lower GHG emissions (Greenhouse Gases), cost and technology.

In recent years, the Brazilian market has been increasing the amount of technologies used in the manufacture of vehicles, with greater emphasis on safety, whether in the manufacture of 4×4 or 4×2 pickup trucks. And within this sales scenario, we have 2 champions in the medium and small pickup categories, with Fiat Strada occupying the first position in the small pickup category and Toyota Hilux occupying the 2nd position in the medium/large pickup category, as shown in Tables 1 and 2.

Table 1. Best-selling small pickup trucks in 2021/2022 [1]

Small Pickup							
Position 2022	**Model**	**Total 2022**	**2022 %**	**Total 2021**	**2021 %**	**% Variation 2022/2021**	**Position 2021**
1st	FIAT STRADA	112 456	82.74 %	109 107	79.04 %	+3.1 %	1st
2nd	VW SAVEIRO	23 422	17.23 %	26 751	19.38 %	-12.4 %	2nd
3rd	CHEVROLET MONTANA	18	0.01 %	2 182	1.58 %	-99.2 %	3rd
4th	EFFA K01	16	0.01 %	6	0.00 %	167 %	4th
5th	EFFA K02	1	0.00 %	1	0.00 %	0.0 %	5th
Total		135 913	100 %	138 047	100 %	-1.55 %	-

Table 2. Best-selling medium/large pickups in 2021/2022 [1]

Medium/Large Pickup							
Position 2022	**Model**	**Total 2022**	**2022 %**	**Total 2021**	**% 2021**	**% Variation 2022/2021**	**Position 2021**
1st	FIAT TORO	49 567	26.12 %	70 890	32.09 %	-30.08 %	1st
2nd	TOYOTA HILUX	48 606	25.61 %	45 893	20.78 %	+5.91 %	2nd
3rd	CHEVROLET S10	27 128	14.30 %	35 046	15.86 %	-22.59 %	3rd
4th	MITSUBISHI L200	15 831	8.34 %	13 157	5.96 %	+20.32 %	5th
5th	FORD RANGER	14 302	7.54 %	20 499	9.28 %	-30.23 %	4th

Accompanying the evolution and quality of road maintenance within the mine area, which has the highest criticality pointed out by the Workplace Safety team within the company, the Fiat Strada vehicle, sales champion in the years 2021/2022, was presented to them, as shown in Table 1, and because it has greater safety features, work profile, on-board technology, consistent with mine operation and because it works with ethanol fuel, less polluting than diesel and gasoline.

5. Why Choose Fiat Strada?

- 4×2 vehicle, with the greatest amount of resources for OFF ROAD operation:
- Entry angle – 24°
- Departure angle – 28º
- Angle of back – 28º
- Ground Height – 214 millimeters
- Load capacity – 1 354 liters and 720 kg
- Suspension with parabolic springs
- E-Locker – advanced traction control system
- Front and side air bags
- The stability control
- Hill start assistant
- The Double Cab

Figure 6. Strada approach angles, departure, and ground clearance [2].

Figure 7. Air bags and internal part of the FIAT Strada [2].

Evaluating the need for the MPSA, the entry and exit angles are sufficient for FIAT STRADA's trafficability on mine roads that have quality infrastructure as shown in Figures 3 and 4, the load capacity of the bodywork that has a parabolic spring bundle with greater resistance, it is enough to withstand the need for loads of up to 600 kg with 1 354 liters, advanced stability and traction control that provides greater safety to drivers in off road terrain, in addition to having front and especially side air bags that in situations overturning devices are activated to protect the cabin, which makes it possible to transport up to 5 passengers.

A side curtain airbag used to meet the federal safety standard to prevent occupant ejection remains inflated for more than 10 seconds, covering multiple rolls of the vehicle, and keeps occupants contained inside.

Figure 8. Safety of the front and curtain air bags in rollover situations inside the FIAT Strada [3].

And finishing the positive characteristics, we do not mention one of the main ones, which is the flex engine that makes possible the realization of the combustion through the fuel ethanol.

6. Why Choose Ethanol?

This fuel called ethanol, also simply called alcohol, has one of the most important roles in the transition from combustion vehicles to electric vehicles. It is considered a type of biofuel, as it is obtained from plants such as sugar cane, corn, cassava, potatoes and other vegetables. In Brazil, production is divided between corn and sugarcane, with sugarcane production having greater dominance. And because it is a renewable substance, manufactured using natural resources that do not run out, ethanol is seen as positive from an environmental point of view.

Ethanol is an alternative to reduce environmental and energy problems in the world due to the scarcity and high prices of fossil fuels and the pollution caused by them [4]. Brazil is in a prominent position with regard to ethanol production, as it has advantages in production technology, leadership in energy agriculture and the biofuel market without increasing the area deforested or reducing the area destined for food production. In addition, the Brazilian energy matrix is already an example of sustainability, because while the world average is the use of only 14 % of renewable sources, Brazil uses 46.8 % of these sources. The positive externalities of ethanol were responsible for the increase in demand for the use of alcohol fuel, since alcohol-powered cars contribute to less atmospheric pollution, reducing CO_2 emissions, as it emits 73 % less CO_2 than regular gasoline and up to 68 % compared to diesel.

Faced with the new scenario that has been emerging with the end of the combustion engine and the arrival of electric vehicles, ethanol has been discussed as the best alternative in this transition to reduce environmental impacts. Ethanol will be an alternative to electric cars, even for the use of hybrid vehicles that will only work with ethanol fuel.

To justify this position on ethanol, Stellantis teamed up with Bosch to carry out dynamic tests with vehicles that use four different energy sources, to measure the total CO_2 emission. The choice was to use gasoline (E27 – including 27 % ethanol), ethanol (E100) and two electric cars, one fueled with European energy and the other with Brazilian energy – the difference between the two is in how much CO_2 is produced to generate the electricity needed for the car rotate all the way.

The test carried out in a simulator put the vehicles to travel 240.49 km, measuring CO_2 emissions (or CO_2 equivalent in the case of electric cars).

Table 3. Comparison of the amount of equivalent CO_2 emissions between fuels and electricity [5].

Fuel	Emission
Gasoline (E27)	60.64 kg CO_2eq
100 % electric (BEV) with European energy	30.41 kg CO_2eq
Ethanol (E100)	25.79 kg CO_2eq
100 % electric (BEV) with Brazilian energy	21.45 kg CO_2eq

With that, after deepening the subject, the MPSA, saw Fiat Strada flex Fuel (Ethanol), as the bet for the reduction of CO_2 emissions, aiming at the future scenario of transition to 100 % electric vehicles with low carbon emissions.

7. Bidding for Light Vehicle Fleet Renewal at MPSA

After the approved study, the transport and infrastructure team built the technical scope for a bidding process, seeking to hire a company to supply these vehicles through a 5-year lease contract, divided into 2 scenarios:

- Scenario 1- Hiring 90 diesel 4×4 trucks + 9 fossil fuel powered Hatchs/Sedams and Vans.
- Scenario 2- 42 4×4 vehicles, 45 4×2 vehicles, 10 100 % electric vehicles and 2 Vans.

After the end of the bidding process in the market, the supply sector returned the commercial proposal comparing both scenarios, with the values for validation and closing of the technical team that bet on choosing scenario 2, aiming at innovation, cost reduction and sustainability.

8. Results Achieved

The Norsk Hydro Mineração Paragominas strategy of adopting scenario 2 brought savings to the company of approximately 3 million dollars in OpEx, due to the cost of leasing 4×2 vehicles being lower than 4×4.

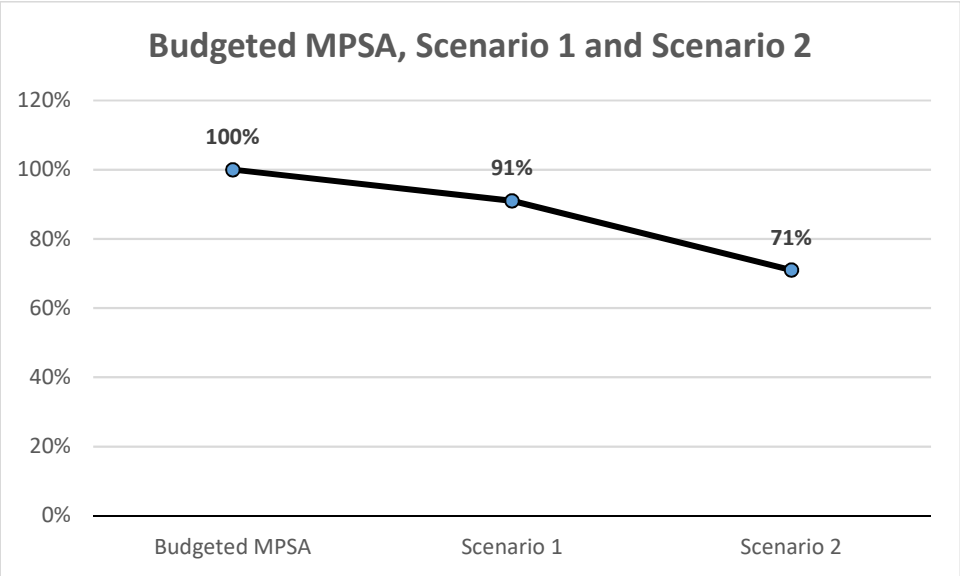

Figure 9. Comparison of percentage reduction between scenario 1 and 2.

With this economy, Mineração Paragominas was able to adopt a new scenario for light vehicles, being a pioneer in bauxite mining, deploying ten 100 % electric vehicles, further contributing to the company's decarbonization plans.

8.1. 100 % Electric Vehicles

With the opportunity obtained with the cost reduction in carrying out the bidding process in the renewal of the light vehicle fleet and seeking innovation and sustainability, the Infrastructure Management of Mineração Paragominas, proposed to replace 10 vehicles totally powered by fossil fuels, by electric cars with a low level of greenhouse gas emissions. The exchange of vehicles will reduce emissions by 120 tonnes of CO_2 per year, complying with the Hydro +30 sustainability policy and helping to reduce the MPSA's carbon footprint.

Figure 10. 100 % electric Renault KWID vehicle plotted to publicize Hydro's low carbon program

9. Conclusion

The choice of the support team in partnership with the other operational areas of the MPSA in scenario 2, was part of Hydro's strategy and the Paris agreement on decarbonization by 2030. Since most of these vehicles will use ethanol fuel, and electrical energy, which is more sustainable and greatly reduces the environmental impacts caused by the burning of fossil fuels (diesel and gasoline), releasing lower levels of polluting gases.

With this initiative to operate using vehicles with ethanol fuel and 100 % electric, it will reduce an approximate amount of 3 475 tonnes of CO_2, approximately 9 520 trees planted in a period of 5 years, in addition, an economy of approximately 3 million dollars in OpEx, demonstrating that it is possible to negotiate, make sustainability and innovate in contracts in the mining support area in atypical moments like the one we went through with the pandemic crisis with high prices for vehicle assemblers.

This good practice is already being sought and adopted by other units inside and outside the company, making it a reference contract in this segment.

Where it has already been negotiated with great success at the Hydro Alunorte unit, which adopted the same scenario for the bidding process for renewing the light vehicle fleet, further boosting sustainability and changing the culture of people and the company.

Figure 11. Benchmarking visiting the 100 % electric vehicles and charging stations – Alunorte visits MPSA

10. References

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