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Technical Article

Environmental and economic evaluation of coffee residues

Avaliação ambiental e econômica dos resíduos de café

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ABSTRACT

Brazil is a country of agricultural culture, and for over a hundred years has been the largest coffee producer. Thus, the work proposes alternatives for the use of agricultural residues from coffee production, analyzing them from an environmental and economic point of view. A coffee crop was selected from the municipality of Santa Rosa da Serra (Minas Gerais, Brazil), and three scenarios were established. Scenario 1: husk is discarded outdoors; scenario 2: energy use of the husk for gasification and subsequent production of electricity; scenario 3: use of the husk as an organic fertilizer. An economic and environmental analysis was conducted from these three scenarios. The gasification technology with the coffee husk, although technically feasible, according to the economic analysis becomes unfeasible, since the value of this electric generation was higher than the other generation values. Scenarios 2 and 3 that applied sustainable practices resulted in negative values for the environmental impacts of water depletion and depletion of fossil fuels, proving the benefits of such practices. The gasification process needs technological development to make the enterprise economically viable. Sustainable practices in coffee cultivation bring environmental benefits in the short and long terms.

Keywords: coffee production; life cycle assessment; residues.

RESUMO

O Brasil é um país de cultura agrícola, e há mais de cem anos é o maior produtor de café. Assim, o trabalho propõe alternativas para o aproveitamento dos resíduos agrícolas da produção de café, analisando-os do ponto de vista ambiental e econômico. Uma lavoura de café foi selecionada no município de Santa Rosa da Serra (Minas Gerais, Brasil), e três cenários foram estabelecidos. Cenário 1: a casca é descartada ao ar livre; cenário 2: uso energético da casca para gaseificação e posterior produção de eletricidade; cenário 3: uso da casca como adubo orgânico. Uma análise econômica e ambiental foi calculada com base nesses três cenários. A tecnologia de gaseificação com casca de café, embora tecnicamente viável, segundo a análise econômica se torna inviável, pois o valor dessa geração elétrica foi superior aos demais valores de geração. Os cenários 2 e 3, que aplicaram práticas sustentáveis, resultaram em valores negativos para os impactos ambientais de esgotamento de água e esgotamento de combustíveis fósseis, comprovando os benefícios de tais práticas. O processo de gaseificação necessita de desenvolvimento tecnológico para tornar o empreendimento economicamente viável. Práticas sustentáveis na cafeicultura trazem benefícios ambientais em curto e longo prazo.

Palavras-chave: produção de café; análise do ciclo de vida; resíduos.

INTRODUCTION

Coffee production is an important traded commodity in the world. Coffee is one of the most popular beverages in the world. On the supply side, it is a vital global commodity and contributes an important proportion of the export income of producing countries (PHROMMARAT, 2019).

Coffee involves activities ranging from cultivation, packaging, transporting, brewing and disposal, which causes harmful environmental impacts. In recent decades, coffee cropping systems have been transformed into more intensified systems of monoculture. These might lead to important losses of biodiversity (ACOSTA-ALBA *et al.*, 2020).

One of the effective environmental assessment tools is life cycle assessment (LCA); it is employed to assess the environmental impacts of the life cycle of coffee, from raw material extraction, to production processes, transportation, use and disposal. The results can be used to aid decision-making for stakeholders to improve their environmental performance. Several LCA studies have been published on coffee. Table 1 presents a summary of the literature review on LCA coffee production.

Büsser *et al.* (2009) showed that the most relevant environmental aspects for a cup of coffee are brewing (i.e. the heating of water) and coffee production. Brewing and coffee production had an impact share between 40 and 99%. The results indicated that the influence of coffee packaging disposal is very small due to the general low influence of packaging. In contrast, the brewing behavior is highly relevant for the environmental impact of a cup of coffee. The study highlights consumer behavior and packaging-related measures to reduce the

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environmental impact of a cup of coffee. The most relevant measure reducing the environmental impacts of butter production is the optimization of the milk and butter production. Besides, the consumer can influence the impacts of domestic storage using efficient and size-adequate appliances.

Coltro *et al.* (2012) assessed the regional differences of coffee cultivation for the reference crops 2001/2002 and 2002/2003 in order to create inventory data and quantify the potential environmental impacts of this crop. The study identified that some farms can reduce the amount of some input and enhance their environmental performance. The study indicated that 20% of the coffee growers showed a good performance, i.e. consumption of pesticides, fertilizers and correctives lower than the weighted averages.

Hicks (2017) presented a comparative midpoint LCA of different coffee brewing systems in order to explore the comparative impact of three different systems: drip filter, French press and pod style (a product of convenience). The drip filter system method was found to have the greatest environmental impact in all impact categories. The coffee pods had a significantly lower environmental impact when compared with the conventional drip filter method.

Humbert *et al.* (2009) evaluated the environmental burdens associated with spray dried soluble coffee over its entire life cycle and compared it with drip filter and capsule espresso coffee. The results indicated that spray dried soluble coffee uses less energy and has a lower environmental footprint than capsule espresso coffee or drip filter coffee. The latter had the highest environmental impacts on a per cup basis.

Salinas (2008) performed a LCA of green coffee production at Finca Vista Hermosa. The results showed that the majority of the impact in the production of coffee occurred during transportation. When compared to the impact due to other coffee processes, such as roasting and brewing coffee as espresso, the farming of coffee was determined to be a small percentage of the overall impact.

In Salomone (2003), the LCA methodology was applied to analyze the environmental impacts connected to a coffee business located in Sicily. The system boundaries included coffee growing through to its distribution to consumers, consumption and disposal. The results showed that the emissions are from fuel consumption of vehicles for local deliveries. The waste management was mainly related to coffee chaff. At present this solid waste is disposed of alongside other urban refuse.

This paper aimed to conduct an environmental and economic assessment of the coffee production chain for export in a specific region of Brazil, focusing on taking advantage of waste generated for use as organic fertilizer and for use as fuel in the gasification process.

METHOD

In this work the goals were to evaluate the potential environmental impact and to carry out an economic assessment of the coffee production chain for export in a specific region of Brazil, through three scenarios:

Scenario 1: considers the planting and cultivation of coffee, followed by drying, processing, classification and transportation for export. The residue generated in the coffee drying process (the husk) is discarded.

Scenario 2: represents the reality of most of the small properties that produce coffee. The residue (husk) is applied on crops as organic fertilizer.

Scenario 3: the residue (husk) is used as a source of biomass to feed the co-current gasifier, and the gas produced will feed an internal combustion engine for electricity production.

Life Cycle Impact Assessment

The scope of LCA study involves the coffee plantation stage through to the delivery of coffee for export. Figure 1 represents the boundary system for the three scenarios.

From Figure 1, it is observed that there are many common steps for the three scenarios: planting, cultivation, drying, processing, transport and delivery to export. Others steps are specified for scenario 2 (application of coffee husks as fertilizer) and scenario 3 (production of electricity from coffee husks).

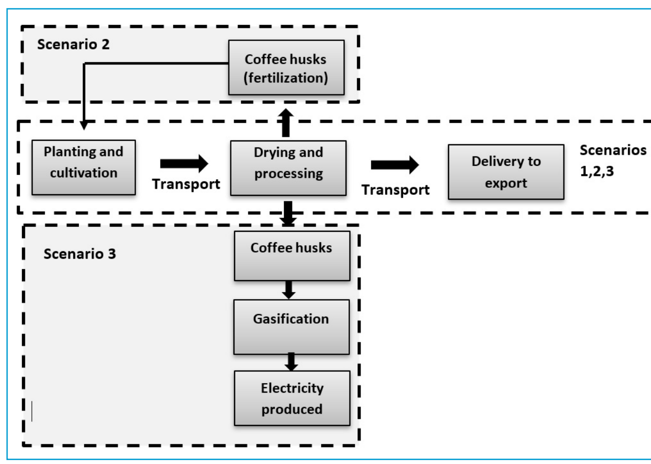


Figure 1 – Boundary systems of scenarios analyzed.

Table 1 – Summary of the literature review on life cycle assessment of coffee production.

Authors	Functional unit	Stages included	Software
Büsser *et al.* (2009)	A cup of coffee	Cradle to gate (cultivation and processing)	SIMAPRO
Coltro *et al.* (2012)	1,000 kg of green coffee	Cradle to gate (cultivation and processing)	PIRA Environmental Management System – PEMS4
Hicks (2017)	0.275 L of coffee (equivalent to a portion of the drink prepared with capsule)	Cradle to grave (cultivation, processing, packing, transport, consumption and final provision)	SIMAPRO/TRACI/ EARTHSHIFT 2015
Humbert *et al.* (2009)	A cup of coffee	Cradle to grave (cultivation, processing, packing, transport, consumption and final provision)	SIMAPRO
Salinas (2008)	1 kg of green coffee	Cradle to gate (cultivation, processing, transport)	SIMAPRO
Salomone (2003)	1 kg of packed coffee	Cradle to grave (cultivation, processing, packing, transport, consumption and final provision)	TEAM 3.0/ECOBILAN

The region chosen for analysis was the city of Santa Rosa da Serra, state of Minas Gerais, Brazil. Figure 2 shows the geographical location of the municipality.

The coffee produced in this region meets the quality required for export. Some considerations were taken to account:

- All data collected refer to the 2017/2018 crop.
- The transportation of agricultural inputs was considered from the production industry to the agricultural region. The production of agricultural inputs was also taken into account.
- Crop life was not considered, which varies significantly among regions.
- The manufacture of cultivation machinery was not considered in the system.

The functional unit established in the present work is 1,000 kg of coffee beans, also called dry coffee ready for export. Thus, the necessary data for the elaboration of the inventory refers to this functional unit. The Simapro software (8.0.3.14) was used to calculate environmental impacts applying the ReCiPe 2008 method. This method harmonizes the *Centrum voor Milieukunde Leiden* (CML) and Eco-indicator 99 methods into one all-inclusive methodology, and it was realized through a re-design of almost all midpoint and endpoint characterization models. It allows results on both midpoint and endpoint levels (Goedkoop *et al*., 2009).

Economic Analysis

The main parameters selected to investigate the investment project in this work are described below:

Net Present Value (NPV): This indicator makes it possible to know all the cash needs, or gains of the project in terms of today's money. The current value of the investment and its profitability are measured. The calculation is made by updating the cash flow of an investment to the value of the day, using the minimum attractiveness rate (MARR). Equation (1) represents this indicator:

$$NPV = \sum_{n=1}^{n=N} \frac{Cash\ flows}{(1+i)^n} \tag{1}$$

i=discount rate (MARR);
n=time period;
Cash flows=cash flows in the time period.

Internal Rate of Return (IRR): It is the minimum discount rate that management uses to identify what capital investments or future projects will yield an acceptable return and be worth pursuing. The IRR for a specific project is the rate that equates the net present value of future cash flows from the project to zero (Equation 2):

$$0 = NPV = \sum_{n=1}^{n=N} \frac{Cash\ flows}{(1+IRR)^n} \tag{2}$$

IRR=the internal rate of return;
n=time period;
Cash flows=cash flows in the time period.

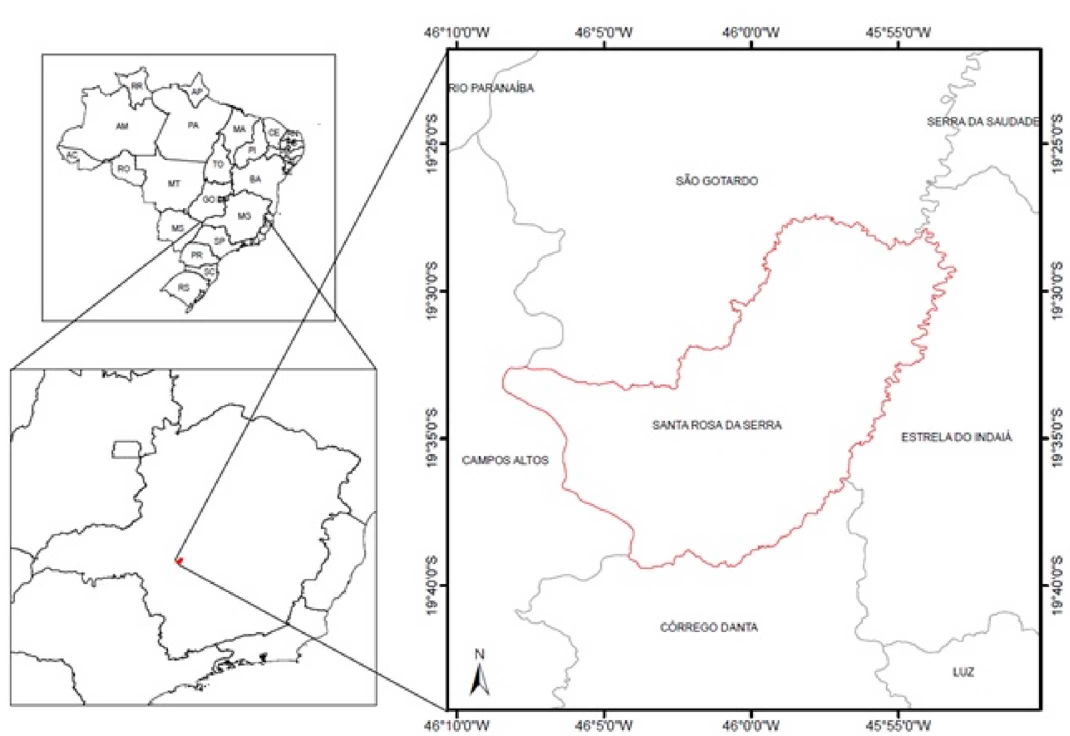


Figure 2 – Geographical location of the municipality.

The levelized cost of electricity (LCOE): It can be defined as a concept which accounts for all the resources and physical assets required to yield a stream of electricity output. The LCOE represents the value that a power provider would need to charge in order to justify an investment in a particular energy project. The LCOE can be expressed as the following (YANG, 2016):

$$LCOE = \frac{Total\ lifetime\ cost}{total\ lifetime\ energy\ production} \quad (3)$$

Where:

Total lifetime cost = (Initial investment + Operating & Maintaining + Depreciation) – Residual Value

RESULTS

Life Cycle Inventory

The data collected for the preparation of the inventory were classified as manual and mechanized, since two properties were analyzed operating manually (MAN) and the other mechanically (MEC). The main activities involving the production process are described below:

Plant nursery: This stage corresponds the preparation of the seedling and its subsequent transfer to the soil. It must follow the agronomic management guidelines. A closed and covered nursery is built with a shade screen. The seedling is mixed with sand, organic material (manure) and fertilizers. Table 2 presents the main items related to this stage per functional unit of 1,000 kg of coffee beans:

Soil preparation and planting: This preparation begins with the revolving of the soil with tractors, to clean the area, remove the undergrowth and promote the aeration of the soil. Liming of the soil is performed, which contributes to correct acidity, neutralizes toxic aluminum and manganese, provides calcium and magnesium and also improves the availability of nutrients. The inputs used in this step are shown in Table 3.

Cultivation: Cultivation includes the process of growth and maintenance according to the required productivity of the coffee plant. We emphasize the importance of analyzing the soil, which is done by a specialized technical group (of agronomists) before the start of cultivation. Actions taken incorrectly to treat the crop can impair productivity and product quality. The most relevant input for this stage is the amount of fertilizers applied, as shown in the Table 4.

Drying and processing: The present work considers drying combined with pre-drying in terraces and drying in mechanical dryers with a cleaning system. The mechanical dryer operates with heated air in a furnace. The processing unit contains a set of sieves with different sizes of holes that separates the coffee from light impurities. There is a ventilation system that removes the heaviest impurities, including metallic materials. Finally, the peeler that contains a set of knives and ventilation system removes the coffee husk. Table 5 presents the main inputs of theses stages.

Table 2 – Planting parameters of seedlings in a nursery.

Parameters	Unit	Amount	
		MAN	MEC
Sand	l	209.98	329.62
Humus (manure)	l	69.9	109.87
Phosphate	l	5.83	9.16

MAN: manually; MEC: mechanically.

Transport: The transport considered here occurred from the agricultural unit to the drying and processing unit, as well as from this unit to delivery for export, in this case at the seaport of Santos (state of São Paulo). The vehicle used was a heavy truck with specific diesel consumption of 1.6 km/L. Therefore, the total diesel consumption for the functional unit was approximately 18 liters. The main emissions from diesel combustion are presented in Table 6.

Table 3 – Main inputs of soil preparation and planting for functional unit.

Parameters	Unit	Amount	
		MAN	MEC
Diesel (tractor)	l	1.33	2.58
Limestone	kg	891	1,725
Phosphate	kg	297	575

MAN: manually; MEC: mechanically.

Table 4 – Main inputs of cultivation for functional unit.

Parameters	Unit	Amount	
		MAN	MEC
Water	l	534.60	920
Fuel (diesel)	l	55.45	106.55
Fuel (gasoline)	l	8.37	–
Fungicide	kg	3.31	1.30
Insecticide	kg	0.79	0.93
Herbicide	kg	–	4.27
Copper (Cu 5% – N 5% – S 3%)	kg	2.67	–
Zinc	kg	3.30	1.28
Manganese	kg	–	0.40
Magnesium	kg	–	0.74
Magnesium Sulfate	kg	–	81.84
Iron	kg	–	0.34
Boric acid	kg	–	5.52
Phosphate (P_2O_5 28% – K_2O 26%)	kg	–	0.67
Ammonium nitrate	kg	891	769.62
Nitrate (Mn 4% – Zn 6%)	kg	–	2.45
Nitrate (Mn 4% – Zn 6% – N 10%)	kg	3.61	–
Boron	kg	2.67	0.80
Phosphate (P_2O_5 8% – K_2O 8%)	kg	2.53	–
Phosphate (P_2O_5 8% – K_2O 5%)	kg	–	1.13
Phosphate (P_2O_5 30%)	kg	–	0.43
Calcium and magnesium carbonate	kg	–	371.54

MAN: manually; MEC: mechanically.

Table 5 – Main inputs of drying and processing stages for functional unit.

Parameters	Unit	Amount	
		MAN	MEC
Electricity – drying	MWh	0.6	4.06
Electricity – processing	MWh	1.92	1.92
Wood	kg	1,236.5	8,316.8
Liquefied petroleum gas (LPG)	kg	74.29	74.29
Water	L	1,000	1,000

MAN: manually; MEC: mechanically.

Gasification process: This stage refers only to scenario 2, and it was modelled in the AspenPlus® software. The reactor applied was a fixed bed (downdraft), which is the most suitable for the energy use of small-scale waste (for powers ranging between 10 kW and 10 MW). The coffee husk is then fed to the downdraft gasifier at a flow rate of 7 kg/h with air as an oxidizing agent. Both (air and biomass) are under atmospheric pressure (1 Bar). The air/fuel (husk) relation was 0.79 and the syngas produced was 13.58 kg/h. The ash generated was 0.15 kg/h and the tar was 2.57 kg/h.

The syngas is burned in an internal combustion engine (30% efficiency), producing electricity. The mechanical system produced electricity at a rate of 3.75 kW and the manual system produced 0.56 kW. Figure 3 shows a schematic of electricity produced from gasification process.

Fertilization: This stage refers only to scenario 3. It is the application of coffee husks as organic fertilizer in cultivation stage. To calculate the amount of organic fertilizer used, it is necessary to know the nutrient content in this solid fertilizer and the conversion rate from organic to mineral form. The conversion index represents the average percentage of transformation of the total amount of the nutrient from organic to mineral form. Therefore, it is used, multiplied by the amount of organic nutrient present. This amount was computed based on Furtini *et al.* (2001). The value achieved was 0.74 kg of organic fertilizer for each coffee plant.

Life Cycle Impact Assessment

Table 7 presents the 13 impact categories analyzed for scenarios 1, 2, and 3, with their manual (MAN) and mechanized (MEC) variations.

In the environmental study, it can be seen that the category of climate change was the most affected both in scenario 1 (manual and mechanized) and in scenario 3 (manual and mechanized). However, it was more expressive in mechanized scenario 1, due to a greater amount of inputs for each ton of coffee produced.

Another expressive impact category was human ecotoxicity and the formation of photochemical oxidants. Scenario 1 showed greater human ecotoxicity and case study 3 showed higher formation of photochemical oxidants. For the categories of water depletion and depletion of fossil fuel, scenarios 2 and 3 showed negative values, which indicates that these studies are sustainable alternatives and that they should be practiced to avoid and reduce the impacts caused by coffee production.

Economic Analysis

Scenario 3 was chosen for the economic analysis because it has significant costs due to the installation of the gasification system. For the initial investment, the sum of the costs of the individual components of the plant to be built was considered, including the gasification, cleaning and generation system.

The average cost considered for a Brazilian gasifier per KW produced was R$ 3,816 (year 2020), and this value was used for the analysis of the investment cost. As for the cleaning system, the average cost considered was R$ 495.2 per kW.

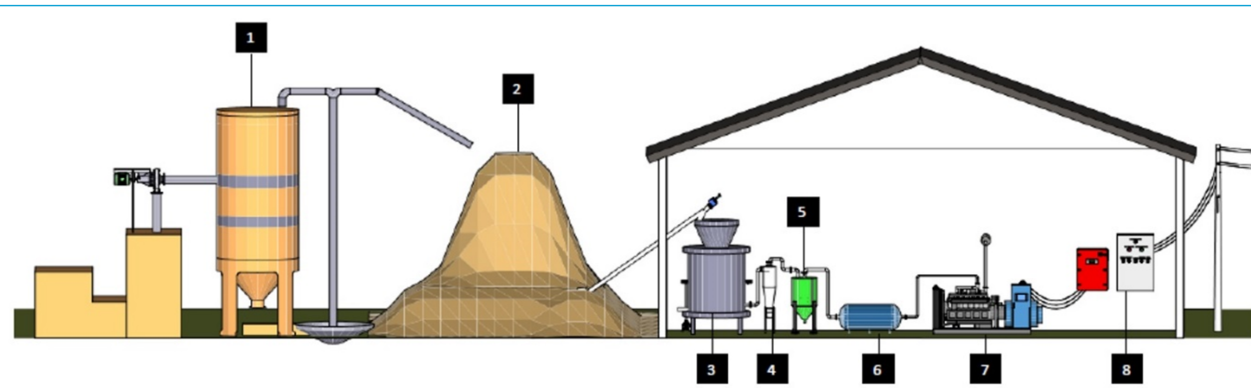
Other costs, called indirect ones, were included in the total cost for implementing the power generation unit. These generate percentage increases in investments, such as: engineering design (7.9%), civil works (14.64%), equipment assembly (5%), instrumentation and control (4.4%).

The economic model was based on the sale of electricity to properties that have the highest production of coffee and waste, so the five cities in the state of Minas Gerais that have the highest production of coffee were evaluated. Considering an interest rate of 8.81% per year, the sale price of electricity was 0.4590 R$/MWh, a minimum attractiveness rate of 10% and a useful life of the project of 20 years. Table 8 presents the economic results of the investment for the gasification plant, NPV and IRR for the cities studied.

For the five cities analyzed, only the city of Patrocínio had a positive NPV, despite its investment value being higher. With the highest energy production, Patrocínio also presents the highest revenue among the projects analyzed. For the other cities studied (Três Pontas, Alfenas, Nova Rezende and Manhuaçu),

Table 6 – Emissions from medium and heavy vehicles (LLOYD *et al.*, 2001).

	Emissions	Amount (g/km)
General	CO_2	935
	NO_X	7.69
	CO	1.76
Fine particulates	Organic carbon	0.0364
	Nitrate	0.0004
	Silicon	0.0012
	Carbon	0.057
	Ammonia	0.0013
	Sulfate	0.00185



1: coffee dryer; 2: residue generated by the dryer (coffee husk); 3: co-current gasifier; 4: cyclone; 5: granular filter (sand and charcoal); 6: gasometer; 7: internal combustion engine and generator; 8: network interconnection system.

Figure 3 – Electricity production from gasification process (LUZ, 2013).

Table 7 – Environmental impacts of scenarios.

Environmental Impact	SC1		SC2		SC3	
	MAN	MEC	MAN	MEC	MAN	MEC
Climate change (kg CO_{2eq})	$3.1x10^{2}$	$3.2x10^{2}$	$-1.0x10^{4}$	$-8.7x10^{3}$	$2.9x10^{2}$	$3.0x10^{2}$
Depletion of the ozone layer (kg CFC-11_{eq})	$2.7x10^{-7}$	$4.5x10^{-7}$	$-7.9x10^{-5}$	$-6.8x10^{-5}$	$-4.4x10^{-7}$	$-3.2x10^{-7}$
Terrestrial acidification (kg $SO_{2eq)}$	$1.8x10^{-1}$	$2.0x10^{-1}$	$-3.4x10^{1}$	$-3.0x10^{1}$	$6.9x10^{-2}$	$8.3x10^{-2}$
Freshwater eutrophication (kg P_{eq})	$1.6x10^{-4}$	$1.2x10^{-4}$	$-7.2x10^{-3}$	$2.8x10^{-2}$	$-1.1x10^{-3}$	$-1.2x10^{-3}$
Human toxicity (kg 1,4-DB_{eq})	$9.1x10^{4}$	$9.1x10^{4}$	$9.1x10^{4}$	$9.1x10^{4}$	$9.1x10^{4}$	$9.1x10^{4}$
Formation of photochemical oxidants (kg NMVOC)	$2.9x10^{3}$	$2.9x10^{3}$	$2.8x10^{3}$	$2.8x10^{3}$	$2.9x10^{3}$	$2.9x10^{3}$
Formation of particulate material (kg $PM10_{eq}$)	$7.4x10^{-2}$	$8.5x10^{-2}$	-7.8	-6.8	$4.2x10^{-2}$	$5.1x10^{-2}$
Terrestrial ecotoxicity (kg 1,4-DB_{eq})	$5.1x10^{1}$	$5.1x10^{1}$	$1.6x10^{1}$	$2.0x10^{1}$	$5.0x10^{1}$	$5.0x10^{1}$
Freshwater ecotoxicity (kg 1,4-DB_{eq})	$1.4x10^{1}$	$1.4x10^{1}$	3.9	5.3	$1.4x10^{1}$	$1.4x10^{1}$
Agricultural land occupation (m^2a)	$1.2x10^{-1}$	$1.2x10^{-1}$	$-1.7x10^{3}$	$-1.5x10^{3}$	-4.4	-4.8
Transformation of natural soil (m^2a)	$3.2x10^{-4}$	$3.2x10^{-4}$	$-1.5x10^{-2}$	$-1.3x10^{-2}$	$-1.2x10^{-2}$	$-1.3x10^{-2}$
Water depletion (m^3)	$1.4x10^{1}$	$1.3x10^{1}$	$-2.2x10^{3}$	$-1.9x10^{3}$	$-4.2x10^{2}$	$-4.6x10^{2}$
Depletion of fossil fuels (kg oil_{eq})	2.7	2.7	$-3.4x10^{2}$	$-3.0x10^{2}$	-1.3	-1.6

SC1: scenario 1; SC2: scenario 2; SC3: scenario 3; MAN: manually; MEC: mechanically.

Table 8 – Economic results for the gasification plant.

City	Revenue (R$/year)	O&M Cost (R$/year)	Investment Total (R$)	NPV (R$)	IRR (%)
Patrocínio	4,275,933.97	3,499,212.05	12,816,913.89	1,621,901.06	4.39
Três Pontas	2,007,105.36	1,642,286.20	6,015,365.88	-587,777.93	1.91
Alfenas	1,842,586.49	1,506,131.65	5,516,659.02	-511,060.68	1.97
Nova Rezende	1,622,522.25	1,325,507.15	4,855,067.60	-436,232.93	2.00
Manhuaçu	1,485,091.08	1,215,104.06	4,450,683.14	-433,957.97	1.92

O&M: operating and maintaining; NPV: net present value; IRR: internal rate of return

the NPV was negative. Another important result was the IRR, which was lower than the minimum attractiveness rate, proving that the investment is not economically attractive to any city.

Another result was the LCOE, which represents the minimum tariff for the economic viability of an energy project. Table 9 compares the results of the LCOE from other sources of energy generation with the present work. The cost of electrical generation with coffee husks can be seen to exceed all the sources considered.

Table 9 – The levelized cost of electricity of different sources of energy generation.

Source	Tariff (R$/MWh)	Reference
Small hydroelectric plant	227	ANEEL (2019)
Wind plant	247	ANEEL (2019)
Natural gas thermal plant	258	ANEEL (2019)
Hydrokinetic plant	308.75 – 406.25	ANEEL (2019)
Photovoltaic plant	320	ANEEL (2019)
Biogas plant	337	ANEEL (2019)
Coffee husk gasification	414.8 – 476.8	-

CONCLUSIONS

Analyzing the amount of energy and power produced with the coffee husk (available energy) for the Brazilian states in general, the total is 54,333.9 kW of power. However, it should be noted that this power would only be produced if all of the country's waste was directed to a single electrical production plant. In practical ways, this production would become unfeasible.

In the economic analysis, it was found that among the five municipalities verified, only that of Patrocínio presented a positive NPV, as it has the highest production of coffee and coffee residues in the state. Therefore, for the other municipalities, which presented negative NPV, it would not be economically viable to install an electricity generation plant using the gasifier. Also, in the economic analysis, it can be seen that only the municipality of Patrocínio presented an IRR of 4.39%, thus being the only viable enterprise in the state.

The analysis of the LCOE allows us to conclude that technologies using the gasification process with the coffee husk, although technically feasible, become unfeasible in the face of the results, since the value of this electric generation was higher than the other generation values practiced today.

In the environmental analysis, it was noted that scenario 1 had the greatest influence on impacts, because it did not present any sustainable practice. On the other hand, scenarios 2 and 3 reduced the environmental impacts caused.

AUTHORS' CONTRIBUTIONS

Freitas, L.C.F.: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources. Renó, M.L.G.: Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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