

Article

Technical and Economic Analysis of the Implementation of a Self-Sustainable Briquetting Process for Electric Generation

Rosa Martins ^{1,2}, Haylemar de Nazaret Cardenas-Rodriguez ¹, Levy Ely Lacerda Oliveira ¹, Erik Leandro Bonaldi ¹, Frederico de Oliveira Assuncao ¹, Germano Lambert-Torres ^{1,*} , Helcio Francisco Villa-Nova ³, Wilson Cesar Sant'Ana ¹ , Luiz Eduardo Borges-da-Silva ¹, Clodoaldo Barboza Bomfin ⁴, Jamil Haddad ¹ and Afonso Henriques Moreira Santos ¹

- ¹ Gnarus Institute, Itajuba 37500-052, MG, Brazil; rosa.martins@suapeenergia.com.br (R.M.); haylemar@institutognarus.com.br (H.d.N.C.-R.); levy@institutognarus.com.br (L.E.L.O.); erik@institutognarus.com.br (E.L.B.); fredeoa@gmail.com (F.d.O.A.); wilson_santana@ieee.org (W.C.S.); leborgess@gmail.com (L.E.B.-d.-S.); jamil@excen.com.br (J.H.); afonsohms@gmail.com (A.H.M.S.)
- ² Energética SUAPE II S.A., Cabo de Santo Agostinho 54590-000, PE, Brazil
- ³ Pro-Reitoria de Pesquisa e Pos-Graduacao (PRPPG), Itajuba Federal University, Itajuba 37500-903, MG, Brazil; helcio.villanova@unifei.edu.br
- ⁴ Guaçu Geração de Energia S.A., Aripuanã 78325-000, MT, Brazil; clodoaldo@guacuenergia.com.br
- * Correspondence: germanoltorres@gmail.com



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Abstract: The wood industry is an essential part of the economy of some regions in Brazil. Although the excess of wood residue is an environmental concern, it is also an alternative source for electricity generation. This allows for compliance with current legislation to minimize environmental impacts such as strategies to control the emission of pollutants and the decarbonization in the wood exploration activity. Despite this, the thermoelectric plants based on wood residues face problems associated with the low efficiency in generation due to the high moisture content of the residues, and challenges related to transport and storage. In this sense, this work is to evaluate the application of a self-sustainable briquetting plant as an alternative for solving the problems associated with the high moisture content, transport, and storage of wood residues. The aspects related to the construction of the briquetting plant and economic indicators associated with the economic feasibility, such as, the estimation of the net present value over the project lifecycle, internal rate of return and pay-back period, are also presented and discussed. The results demonstrated the feasibility of the plant mainly due to the better energy/volume ratio of the briquette (drying and compaction) and the transportation cost savings associated to the density of the compacted material.

Keywords: briquettes; economic feasibility; wood residues

1. Introduction

The use of wood biomass for energy production still has some limitations, mainly due to the physical properties of the wood itself [1]. The presence of moisture in the biomass causes a reduction in its heating value and an increase in transport costs and a decrease in burning performance [2]. Low bulk density and low energy density are also major barriers to valorization of woody biomass residues as renewable energy, particularly forest residues. Thus, transportation tends to be a limiting economic factor when hauling woody biomass, as low bulk density results in high transportation costs [3].

Despite the great potential for use, forest residues are not yet fully utilized due to gathering and transport costs, which results in the smaller economic attractiveness of forest biomass for energy purposes [4]. By a report from the Michigan Department of Labor and Economic Growth [5], the transportation of wood fuels over long distances is usually not economically prudent due to its handling and storage requirements. Besides handling and storage limitations, according to Muniz [6], the use of wood residue in the generation of heat energy, without receiving prior processing or preparation, becomes inefficient due

to moisture content, which can often harm the combustion capacity. Raw biomass tends to absorb moisture from the environment due to its fibrous structure, and the presence of hydroxyl groups on polysaccharides [7,8], part of the heat generated during burning is consumed by the evaporation of the absorbed water [2]. Different studies recommend a moisture content between 5% and 12%, depending on the nature of biomass [8].

Densification technologies are used to overcome the challenges of high cost of forest residues, offering a sustainable alternative to the use of these resources as a solid bioenergy product [9]. Among these densification technologies, it can be highlighted the briquetting process. Briquetting requires less power/energy and is more flexible in terms of the input raw material quality (size and moisture content – and it can also handle the bark of forest residues) [9].

By Tenu [8], due to the concerns of greenhouse gas emissions and air and soil pollution from biomass combustion, it is worth considering the use of briquettes, as they may increase the heating value by 2–5% through torrefaction before briquetting [8,10]. This indicates that the use of briquettes to replace the wood in heat energy generation minimizes the negative environmental impacts, reducing the emission of pollutants into the air by up to 50% and minimizes the need for deforestation [6]. Briquettes can be used domestically or industrially for heat or power generation [11]. Also, the use of biomass is one of the few proven and cost-effective technologies that can reduce emissions from CO₂ [11,12].

Briquettes provide a more significant energy concentration per volume unit [13], which allows economy in transportation, given that the same volume of briquettes can have five times more energy than *in natura* wood [13,14]. The use of briquettes in industrial boilers allows a more uniform combustion and better conditions of transport, handling, storage and supply of boilers. [13,15].

As per with Filippetto [16] and Figueira [17], to assess the economic feasibility of a briquetting plant, some aspects must be considered, such as the price of the fuel for which the briquette will be a substitute, production costs, characteristics of the biomass and transport. The plant's complexity significantly interferes with costs and for this reason, it must be evaluated in the expected production volume.

The economic viability of briquette production can be reached through an economic study that is based mainly on four elements, such as the type of biomass used, investment capital, human resource skills and the type of equipment used [18]. The economic analysis is performed by deploying certain basic economic indicators of net present value (NPV), internal rate of return (IRR) and payback period (PBP) [11].

In this context, the objective of this work is the technical-economic analysis of the implementation of a self-sustaining briquette plant based on the assessment of the energy potential of wood residues used as fuel in the generation of electric energy, through the characterization of biomass and computation of the high, low and useful calorific value. In addition, it is evaluated the feasibility of the plant based on the reduction of costs associated with transportation. It is important to highlight that the objective of the briquetting plant considered in the present work is not to commercialize the densified fuel, the main idea is to use it to improve the electricity generation of a thermoelectric plant and reduce the transportation costs. The transportation cost savings are considered as the cost benefits in the cashflow computation, then, by mean of the estimation of economic indicators as NPV, IRR and PBP the economic feasibility of the briquetting plant is demonstrated. Previous efforts as is [19] also demonstrated the energy potential of briquetting in thermoelectric generation improvement and the present work, in part, is developed in order to economically justify the investment on this type of technology which in addition, is adapted to the particular characteristics of the region, such as poor road condition, high moisture content and low proximity among several raw material resources.

2. Materials and Methods

Aripuanã is a location that has a high potential for the production of wood residues, allowing such residues to be used in the generation of electric energy in the region, however,

this location has prolonged periods of rain that increase humidity and directly affects the energy properties of the forest biomass. Hence, it has been considered the study of the characterization of residual biomass as one of the main steps to investigate the energy potential of the region [19], considering the briquette production process as a better alternative for the use of the energy contained in the wood residues to producing bigger amounts of electric energy inside of a power plant.

The study will be carried out considering the Guacu power plant, (see Figure 1) located in the state of Aripuanã, Mato Grosso (MT), Brazil. This plant which is based on forest residues and has a generation capacity installed of 30 MWh. The main characteristics of this plant are:

- Turbo Condenser Generator of 33 MVA.
- Boiler (130 TVH rotary grill boiler with a pressure of 67 kgf/cm, heating temperature of 2495 °C with an average consumption of wood residue—46,000 kg/h or 144 m³/h and maximum consumption—55,000 kg/h or 172 m³/h).
- Interconnection pipes for high and low pressure steam lines.



Figure 1. The Guacu Power Plant.

Despite having an installed generation capacity of 30 MWh (720 MW per day), that amount is not produced. To generate this amount, an average of 1340 tons/day is needed, however, the plant does not receive that proportion of waste per day, due to the precarious road infrastructure in the region (see Figure 2) that makes it difficult to transport the wood residues. Poor road conditions are related to heavy rains and lack of maintenance on them [19].



Figure 2. Poor road conditions in the Aripuanã region.

Currently, this plant receives an average of 800 tons of residues per day. These residues are stored in a storage silo to be then used for the generation of electricity. However, such

residues have a high moisture content, which lowers the energy contained in the fuel and consequently increases the costs related to transport as larger quantities of raw material must be transported to comply with the established generation amount, which is 18 MWh.

The Guacu power plant, currently, uses as fuel the wood residues gathered in nearby locations such as Conselvan (at a distance of 80 km), Conilza (at a distance of 95 km) and Juruena (at a distance of 120 km)—which are transported to the Guacu plant using dump trucks of 100 m³ capacity. Hence, the following analysis is performed in order to obtain the amount of raw material that could be transported in such trucks, considering the granulometry of the residues used as fuel in the plant (wood chips and sawdust).

A rough estimation of the amount of raw material that could be transported by a dump truck with a capacity for 100 m³ volume can be obtained by proportionality, based on the mass that could be stored in a box of known dimensions. Figure 3 presents a box with dimensions 210 mm × 141 mm × 81 mm (which results in a total volume of 0.002398 m³) over a scale. The samples were placed in the box, and the respective masses have been obtained—751 g for the wood chips and 546 g for the sawdust. By proportionality, Table 1 presents the maximum mass that could be stored in a 100 m³.



Figure 3. Measurement of the mass of residues of different dimensions.

Table 1. Estimated maximum mass of wood residues (according to different dimensions) that could be stored in a 100 m³ dump truck.

Granulometry	Mass
wood chips	31.3 ton
sawdust	22.76 ton

2.1. Energetic Properties of in Natura Residues

As the residues will be used to generate of electric energy, it is necessary to estimate the equivalent amount of energy that could be transported in a dump truck with 100 m³ capacity. In the process of converting biomass energy to electricity, it is necessary to consider the physical and chemical characteristics of the residues, as they can directly influence the performance and maintenance of equipment, especially those that carry out the combustion processes [20].

Determination of the Heating Value of the Residues

The heating value (or calorific value) of a material/fuel is the amount of heat released when the mass unit of that material is wholly burned under certain conditions [21]. It indicates the amount of energy that could be obtained from the fuel combustion [22]. The greater the heating value, the greater the energy contained in the fuel [23,24]. The heating value is usually defined in terms of a Higher Heating Value (HHV) and a Lower Heating Value (LHV) [22], where the difference between them is caused by the heat of evaporation of the water formed from the hydrogen in the material [25]. An additional differentiation for the heating value, is called Useful Heating Value (UHV). In the UHV, the energy required to evaporate the water from the material is discounted [24].

In the present work, the HHV is obtained with a laboratory test. The calorific value of wood residues was determined in duplicate, using the IKA300 adiabatic calorimeter bomb and according to the methodology described by ABNT NBR 8633 (1984) norm [26]. The analysis was performed with previously selected wood samples that passed through a sieve with a mesh of 40 mesh and were retained in a sieve with a mesh of 60 mesh. These samples were dried in an oven at 103 ± 2 °C and burned under controlled conditions by a predefined time. Finally, the lower heating value (LHV) is obtained by calculation, taking into account the samples' moisture, hydrogen, and ash content.

The determination of the HHV of the briquettes was carried out in an analogous way.

2.2. Production Process of Briquettes

For the briquettes manufacturing process, a self-sustainable plant in Conselvan was considered. It is because this location is located close to the different wood residue collection poles, which facilitates the transport of biomass for the compaction procedure, as well as the subsequent transfer of the briquettes to the Guaçu Power Plant.

The self-sustainable compaction plant is composed of its own electric power generation system that guarantees the operation of the equipment. This system is based on the Rankine cycle, where wood residues are placed in a boiler for the combustion process with a constant flow of water to generate steam, which allows the movement of a turbine that, together with a generator, transforms mechanical energy into electrical energy. In other words, it will not be necessary to use external electrical energy for the compaction process.

In this context, compaction begins with sieving the wood residues to remove impurities. They are transported using screws to the dryer where the moisture is removed, after drying the gases are filtered and released into the atmosphere using the cyclone and the residues are sent to the briquette machine silo where they are later compacted as briquettes and subsequently stored in the silo. Figures 4 and 5 illustrate the compaction plant component location.

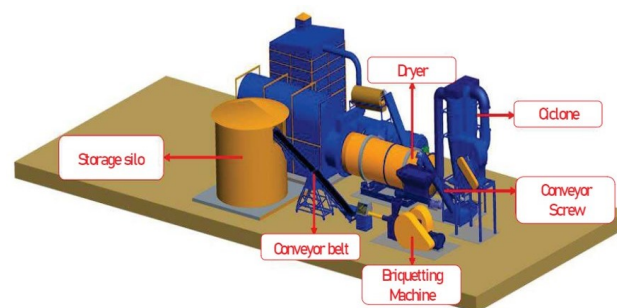


Figure 4. Scheme of the self-sustaining compaction plant (part 1).

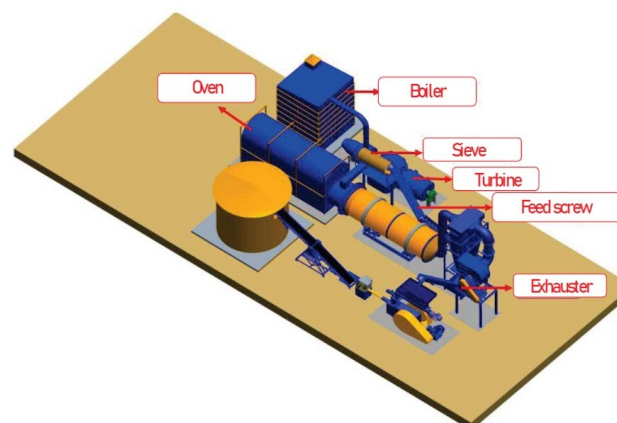


Figure 5. Scheme of the self-sustaining compaction plant (part 2).

The equipment that makes up the self-sustaining plant was designed with the aim of better adapting to the conditions in the locality of Conselvan and the needs of the Guaçu Power Plant. In order to produce the electrical necessary energy provided to the motors of the main equipments of the briquetting plant, an turbo-generator was established, fed by means of wood residues. The turbo-generator is equipped by a vacuum pump condenser and a synchronic generator of 4 poles of 60 Hz, 380 Hz, 188 kVA, connected to a rotating grill boiler with an average consumption of 6000 kg/h.

A Ø¾ mesh sieve was designed with the purpose of classifying the wood residues before being inserted into the drying system. This system consists of a furnace that allows the dryer with dimensions of 2 m in diameter and 6 m long to be heated by burning wood residues, consisting of conduction hangers on the inside, thermal insulation of the external parts and connection to an exhaust transport system. The transport by exhaustion of wood residues is carried out using 2 cyclone filters of the conventional swift type, with a flow of 28,000 m³/h, the flow velocity of 30 m/s, and a rotary valve with a nominal capacity of 2 tons. Other characteristics of the equipment are listed in Table 2.

Table 2. Technical characteristics of the briquette plant.

Equipments	Units	Capacity [ton/h]	Power [CV]
Briquetting machine (B 95/210)	1	2	75
Oven (1,000,000) Kcal/h	1	0.166	-
Dryer	1	2	2 × 7.5
Ciclone	1	2	-
Exhauster	1	2	30
Feed screw	4	-	2 × 3
Sieve	1	4	2
turbo-generator	1	-	201
Boiler	1	6	-

The compaction of the residues after leaving the cyclone is done using a BIOMAX model B 95/210 briquette machine with a capacity of 2 ton/h. After briquetting the briquettes are stored inside a silo. The main characteristics of the briquette machine can be seen in the Table 3.

Table 3. Characteristics of the B 95/210 briquette machine.

Productive capacity	2 ton/h
Equipment weight	7.6 ton
Diameter of the matrix	93 mm
Main engine power	75 CV–380 V three-phase
vertical propeller power	7.5 CV
Dimensions	2840 mm × 1170 mm × 1830 mm
Flywheel diameter	1390 mm (2 units)

2.3. Evaluation of Briquettes Apparent Density

The briquettes density calculation was performed directly by measuring the volume and weigh of several samples of the manufactured briquettes and computes an average of the density value. In this sense, a rectangular container (with dimensions 0.35 m × 0.49 m × 0.202 m) was used. Briquettes were placed with a uniform accommodation that considers the empty spaces inside the truck caused by the geometry of the briquettes. Obtaining 750.5 kg/m³ as the density of the briquettes, which means that 75.05 tons can be transported in a 100 m³ truck.

3. Results and Discussion

3.1. Heating Value of the Wood Residues and Briquettes

To obtain the HHV of the samples with the same granulometry as presented in Figure 3, a laboratory test was performed (at the LAPEM—Wood Panels and Energy Laboratory in the city of Vicosa, Brazil) following the procedure described at Section 2.

From the HHV, the LHV can be calculated by the Equation (1), this equation considers the amount of hydrogen in the elemental composition of the wood sample [19]. 6% hydrogen content was considered.

$$\text{LHV} = \text{HHV} - 600 \cdot \frac{9 \cdot H}{100}, \quad (1)$$

where H is the hydrogen content, in %.

From the LHV, the UHV can be calculated using the Equation (2). This equation considers the moisture content of the material. Considering the LHV and 42% moisture content.

$$\text{UHV} = \text{LHV} \cdot (1 - \text{MC}) - 600 \cdot \text{MC}, \quad (2)$$

where MC is the moisture content.

Table 4 presents the calculated LHH, LHV and UHV of the samples with the same granulometry presented in Figure 3.

Table 4. Estimated masses and energy properties of wood residues.

Granulometry	HHV		LHV		UHV	
	[kcal/kg]	[kJ/kg]	[kcal/kg]	[kJ/kg]	[kcal/kg]	[kJ/kg]
wood chips	4742	19,847.6	4418	18,491.5	2310.44	9668.5
sawdust	4176	17,478.6	3852	16,122.5	1982.16	8295.6

In the case of manufactured briquettes, samples of briquettes manufactured in the town of Aripuanã were collected and sent to the LAPEM laboratory to obtain the high calorific value. HHV was determined using the method described in Section 2. Based on the HHV values and considering a 6% hydrogen content, the values for the LHV of the briquettes were obtained. Therefore, to calculate the useful calorific value of the briquettes, the moisture content (8%) [27] was considered. The Table 5 presents the calculated LHH, LHV and HHV of the briquettes.

Table 5. Estimated masses and energy properties of briquettes.

Granulometry	HHV		LHV		UHV	
	[kcal/kg]	[kJ/kg]	[kcal/kg]	[kJ/kg]	[kcal/kg]	[kJ/kg]
Briquette	4949	20,714	4625	19,358	4207	17,608.3

Once the UHV was known of “*in natural*” material and briquettes, the calculation of the necessary power for generation of 1 MW was made, as presented in Equation (3) (defined at [28]).

$$\text{Biomass (kg/h)} = \frac{\text{NP}}{\text{UHV}} \quad (3)$$

An operating efficiency of the Rankine steam cycle of 20% was considered for thermo-electric plants, where to generate 1000 kW of electricity, the fuel must provide a power of 5000 kW. For calculating the necessary power, a conversion unit was considered that 1 kW represents 860 kcal/h, as presented in Equation (4).

$$\text{NP} = (5000 \text{ kw}) \cdot (860 \text{ kcal/h}) \quad (4)$$

The result about comparison of the number of kilograms needed to generate 1 MW of electrical energy from the briquettes compared to “*in natural*” material is presented at Table 6.

Table 6. Comparison of the kilograms needed to generate 1 MW of briquettes against “*in natural*” material.

Granulometry	kg/h
briquette	1022
wood chips	1861.1
sawdust	1833.5

The results obtained allowed us to corroborate that the compaction of wood residues (briquettes) reduces the moisture content in the fuel thus increasing its calorific value for better energy use. In this way, such results demonstrated that compaction allows a better volume/energy ratio, since it reduces approximately 800 kg of wood residues to generate 1 MW of electrical energy compared to wood chips and sawdust, making viable the use of briquettes for power generation from the point of view of energy performance.

3.2. Electrical Energy Storage

Using the energy per mass unit value for raw residues and briquettes previously presented, it can be verified that, to generate 1 MW of energy, 1.861 tons of chips or 1.833 tons of sawdust must be burned. Considering the estimated maximum mass of wood residues (according to granulometry) that could be stored in a 100 m³ dump truck (Table 1), 16.8 MW of wood chips and 12.4 MW of sawdust can be transported in each truck freight.

As a result of the briquette density estimation, the briquette density obtained was 750.5 kg/m³, then approximately 75 tons can be “stored” in a dump truck. In terms of energy per mass unit 73.4 MW of energy can be stored at each truck freight. This means that at least five times of energy can be transported in the form of briquette when compared with the same material in raw form.

3.3. Case Study

Currently, in Brazil, manufacturers of equipment used in briquetting plants recommend having a minimum of 90 m² of available area for this application. In the case study, considered in the present work, this area’s located was strategically predefined in the city of Conselvan, due to its proximity among the different lumber companies in the region (wood residues providers). The construction of the compaction plant was proposed in a storage yard owned by Guaçu plant, then, it is not necessary to consider the cost of the land where the briquetting plant will be implemented, as well as the costs associated with electricity since the plant is considered a self-sustainable system. Only costs related to the transport of briquettes from the compacting plant (Conselvan) to the thermoelectric plant (Aripuanã), equipment, labor wages, and equipment maintenance will be considered. The Table 7 presents a detailed distribution of the investment cost of the plant.

Table 7. Investment cost of various equipment in the briquetting plant.

Equipment	Units	Unit Cost [USD]	Total Cost [USD]
B95/210 Briquetting machine	9	59,600	536,400
Sieve	9	9600	86,400
Oven	9	35,000	315,000
Drying system *	9	55,430	498,870
turbo-generator	1	400,000	400,000
Boiler	1	198,000	198,000
Briquette Plant Automation System	1	27,397	27,397
Total			2,061,667

* Drying system: storage silo, dryer, cyclone.

3.3.1. Investment Costs

The plant will produce 18 tons/h (nine briquetting machines) and will operate 24 h/day for 30 days/month, which determines a briquet production of 12,960 tons/month or 155,520 tons/year.

3.3.2. Operational/Production Costs

The production of densified material involves manufacturing costs that are not taking into account in the case of chips or sawdust. Then, all the costs regarding the production process of briquettes need to be considered to estimate its total cost. Among the production costs it can be mentioned: (i) the man workforce hours, (ii) the equipment maintenance costs (briquetting machine), and (iii) maintenance costs of the miscellaneous equipment (generation system)

It was considered nine B/95 briquette machines from the manufacturer BIOMAX[®] with a production capacity of 2 tons per hour/briquette machine, with 4 employees with a salary of USD340 plus USD272 of charges for 30 days of work per month and 24 h a day. Regarding maintenance, the data provided by the manufacturer was considered USD515 per year. Table 8 shows a summary of the main operating costs.

Table 8. Operating costs.

Item	Units	Unit Cost [USD/Year]	Total Cost [USD/Year]
Maintenance briquetting machine	1	515	515
Maintenance miscellaneous	1	12,000	12,000
Cost of manpower	4	7354	29,417
Total set-up			41,932

3.3.3. Transportation Costs

The costs associated with transport are estimated by the distance traveled by the dump truck between the thermoelectric and the compaction plant (in the case of briquettes) or from thermoelectric plant to lumber companies (in the case of residues). The last ones are currently pre-established by shipping companies depending on the granulometry of the residues. For the present case study, the briquette transportation cost will be depending on the transported residue. The transportation costs per ton are summarized in Table 9.

Table 9. Costs per ton.

Granulometry	Cost [USD/ton]
wood chips	10.00
sawdust	7.5
briquette	10.00 or 7.5

3.3.4. Energy and Transport Savings

The main interest in the present case study is to estimate the total cost of transporting the necessary fuel (residues or briquettes) so that the mandatory minimum amount of energy of 18 MWh be achieved (432 MW must be generated per day). Considering Table 1 and briquette density calculated at Section 2, in a 100 m³ truck, 31.3 tons of chips or 22.8 tons sawdust or 75 tons briquettes can be transported by freight. Then, if we consider the number of trips necessary to obtain the amount of raw material for daily generation, it is obtained that 25.7 trucks of chips, 34.8 trucks of sawdust, and 5.8 trucks of briquettes are needed.

Following the same line of knowledge, the total costs, to generate 432 MWh per day, paid for truck freight (considering the values at Table 9) are USD8039 for chips, USD5938 for sawdust, and briquettes USD1842 (assuming chips transportation cost) or USD1006 (considering sawdust transportation cost). This result represents, at least, a monthly transportation cost reduction of USD185,909 (77%) and USD147,968 (83%) when compared to chips and sawdust respectively. Table 10 presents the transport savings per year depending on the wood type substituted by briquettes.

Table 10. Transport savings per year.

Granulometry	Residue/Briquette Qty [ton/Day]	Daily Transport Cost [USD/ton]	Cost Saving [USD/Month]	Cost Savings [USD/Year]
wood chips	803.952 (25.7 trucks)	8039	-	
sawdust	791,856 (34.8 trucks)	5939	-	
Briquette (chips transport cost)			185,909	2,230,911 (77 %)
Briquette (sawdust transport cost)	441,504 (5.8 trucks)	4415	147,968	1,775,624 (83 %)

3.3.5. NPV, IRR and Pay Back Period Estimation

In order to consolidate the economic analysis some basic economic indicators are estimated, the Net Present Value (NPV), the Internal Rate of Return (IRR) and the Pay back period (PBP). The NPV of the investment is calculated as the sum of the net cash flows along some period (n) minus the total investment cost. A positive NPV indicates that the investment cost was covered. The NPV is computed by means of Equation (5) [11]:

$$NPV = \sum_{t=0}^n (C_b - C_c)_t (1 + i)^{-t} \quad (5)$$

In the present work case C_b is the cost saving and C_c is the total cost per year (investment, operational and raw material costs). $(C_b - C_c)$ is the net cash flow in the year (t), n the calculation period during the project life cycle and i is the discount rate, assumed as $i = 30\%$. The NPV plot along 6 years is illustrated at Figure 6. It is easy to see that in both cases (briquette price assumption), the total investment costs are recovered at approximately 2–2.5 years (estimated PBP). After 6 years of project life cycle the accumulated NPV is almost equals to the initial investment cost.

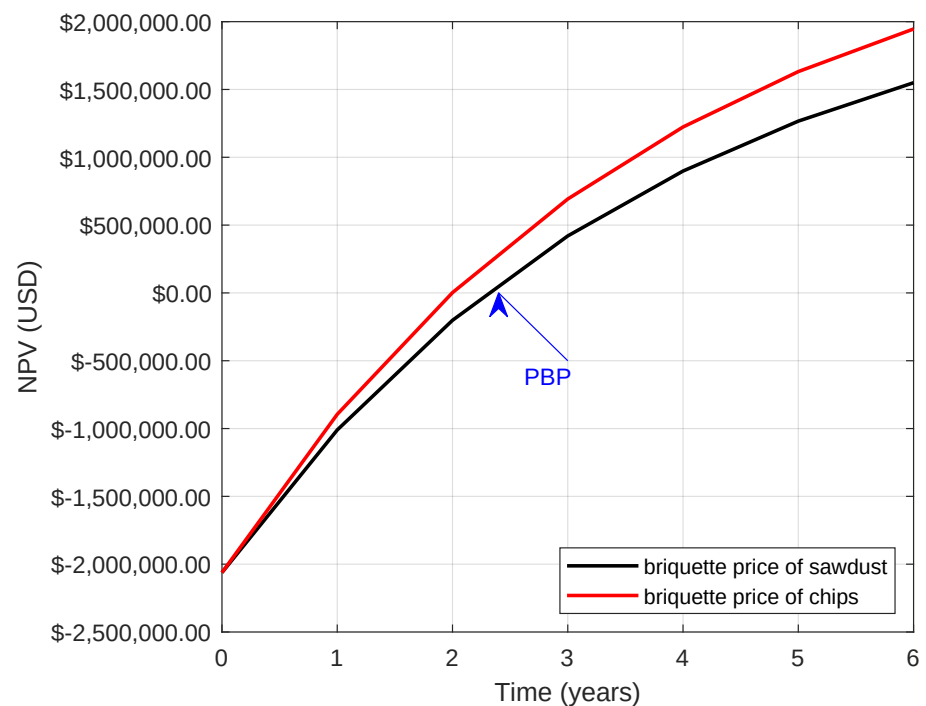


Figure 6. NPV along project life cycle.

According [29], the Internal Rate of Return (IRR) let determine the discounted rate at which the cumulative NPV of the project costs would exactly equal the cumulative NPV of all project benefits. The discount rate was varied from 10–80% and the NPV was calculated at the third year project (close to the estimated PBP) and the results indicated that the IRR is approximately 45–55% in both cases (see Figure 7).

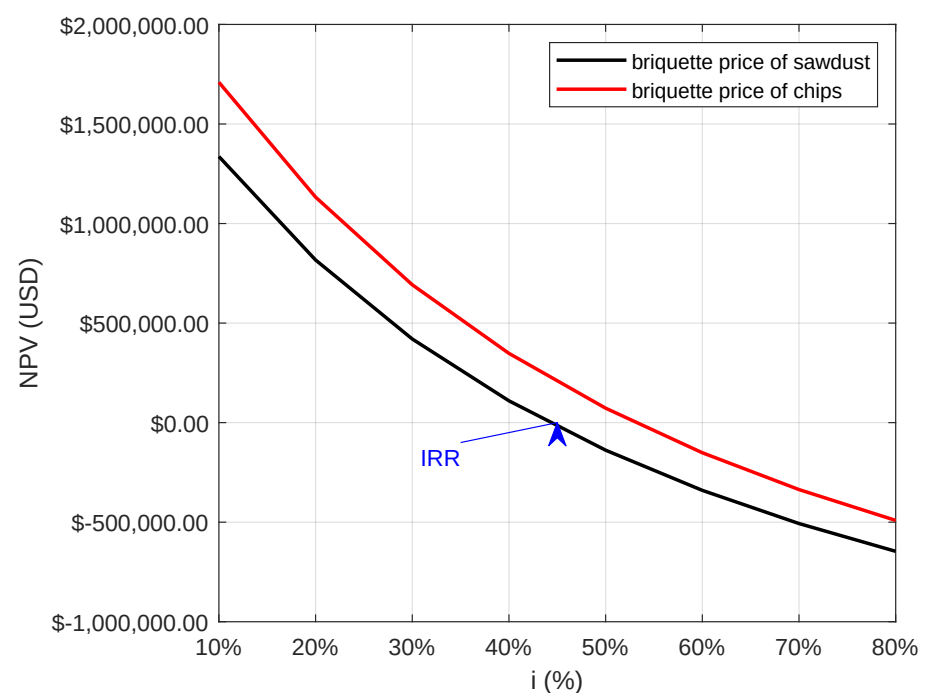


Figure 7. Internal Rate of Return for several discount rates (at third year).

To estimate the pay back period (PBP), that is, the number of years that it will take, from day one of compacting plant operation, before the investment cost is fully recovered [11], a simple computation needs to be done using Equation (6).

$$\text{PaybackPeriod}(\text{years}) = \frac{\text{Initial investment}(\text{R\$})}{\text{Cash inflow}(\text{R\$/year})} \quad (6)$$

The initial investment is computed by adding the equipment and operational costs (available on Tables 7 and 8). Cash inflow is considered the cost savings per year with implementing of the briquetting plant (See Table 10). The estimated pay-back period for the self-sustainable briquetting plant is about 1.93 years, considering wood chips transportation cost saving as a reference value and, 1.5 years in the case of sawdust. The difference between the PBP calculated by Equation (6) and by NPV graph is the consideration of a discount rate at the last one.

4. Conclusions

During the development of the work, energy properties of the *in natura* residues were collected around a thermoelectric power plant in the region of Aripuanã (Brazil) and nearby locations such as Conselvan, Conilza and Juruena. The collected data was used in order to estimate the energy advantages of compacting such residues and the density properties of the compacted material (briquettes) are used to determine the transport cost savings as a solution to the problems associated with the transport and storage of wood residues. Then, Taking into account the total costs of investment and operation of the self-sustainable briquetting plant responsible for doing the compaction process such as equipment, maintenance, etc. an economic analysis using indicators as NPV, IRR and PBP was performed.

The assessment of the collected information showed that the implementation of a self-sustainable plant of briquettes in the storage yard owned by Guaçu Power Plant in the city of Conselvan MT, indicates a reduction in the costs associated with transportation due to the better energy/volume ratio of the briquettes compared to the wood residues *in natura* and to the proximity of the location of the different wood resources in the region. The use of briquettes showed a reduction per day of 19.8 trips compared to chips and 28.8 trips considering sawdust as reference, which demonstrates a more efficient use of the energy contained in the residual biomass with easy transport and storage. Moreover, the use of briquettes represents an environmental advantage as they allow a reduction of greenhouse gases in energy generation.

The economic results, considering the total initial investment in equipment, maintenance, and human resources and using the transportation cost savings (based on two different scenarios) as benefit cost in cashflow computation concluded that total investment on a self-sustained briquetting plant is feasible. The analysis showed a positive net present value between two and three years of lifecycle project. It demonstrates the high gain in efficiency of compacting residues in the energy generation industry, not only by the thermal energy increment of compaction but also by the transport, storage, abundance of raw material resources advantages in the briquette plant location.

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Abbreviations

The following abbreviations are used in this manuscript:

LAPEM Laboratório de Painéis e Energia da Madeira (Wood Panels and Energy Laboratory)
NP Necessary power

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