Using biomass for power generation: case study of a timber industry Aripuanã-MT

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Abstract: Nowadays, the concern for environmental management is increasingly becoming part of everyday business. The timber industries, for example, in its production process, generate a lot of waste requiring proper management of these wastes to reduce their environmental impacts. The study aimed to identify the main advantages that the timber industry can get to the reuse of manufacturing waste to generate energy. The methodology used for data collection was simple observation on site, implementation of a structured interview with the owner, as well as literature. The research showed that after the implementation of the power plant at the company, to generate energy for their own consumption and sale of surplus costs decreased significantly, and also highlights the importance of revenue from the sale of electricity.

Keywords: environmental management; solid waste; biomass; timber industry.

Reference to this paper should be made as follows: Justen, G.S., Froehlich, A.G., Luppi, L. and de Moraes, S. (2014) 'Using biomass for power generation: case study of a timber industry Aripuanã-MT', *Int. J. Environment and Sustainable Development*, Vol. 13, No. 4, pp.382–394.

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1 Introduction

Currently in Brazil environmental issues are being addressed more rigorously compared to the past. The coming of the international recovery is intensifying in relation to the preservation of natural resources in the countries, especially in the case of forest resources, in the case of Brazil, have in abundance. Besides the natural resources that are marketed nationally and internationally, the country is a major generator of forest residues that most often receive inadequate treatment, being exposed to the environment.

Studies have shown that approximately 40–60% of the total volume of a log is tapped, that is, ten cut trees only five are utilised in their entirety. The waste of raw material is very large. Leftovers are the untapped called waste in the timber sector can be: sawdust, shavings, slabs, chips, refilos, bark and others.

The state of Mato Grosso has great potential commercial products originating in the timber sector, is one of the states that has one of the highest levels of deforestation in Brazil, behind only the state of Pará Data System reports Deforestation Detection Real Time (DETER) of the National Institute for Space Research (INPE) show that in 2010, the State of Pará deforested an area equivalent to 981.6 km^2. Mato Grosso got 645.8 square kilometres deforested area followed by the State of Rondonia which in turn cut down the equivalent of 287.6 km^2.

According to data from the Environmental Secretariat (SEMA), the period between February 2006 and November 2010, the timber industry in the state Mato Grosso obtained a total of R$7,720,621,024.73 in sales. The trade of wood waste generated revenue of R$48,623,164.15. These values correspond to both internal and external sales.

The city of Aripuana is located in the northwest region of the state of Mato Grosso, Brazil, and most of its economy is originally from the extraction, processing and marketing of timber. The waste generated during processing of the wood most often are not reused. The difficulty in marketing these leftovers due to issues like logistics makes this waste to be stored in the open or are burned bringing more harm to the environment.

The city is located in a region where natural resources, in this case, the wood, are plentiful. This is one of the reasons that often wastes are not being wasted reused or discarded into the environment.

Currently, many studies have been directed to seek viable options to reduce waste and reuse natural resources that are becoming increasingly scarce and distant, making indispensable the need for effective management in the treatment of such wastes.

In this context, the present study aimed to identify the main benefits that a timber industry can get to the reuse of waste from its production to power generation. Therefore, it was necessary to establish whether there is a reduction of energy costs from the implementation of thermoelectric; see if the company could get an additional revenue if commercialise surplus energy, and analyse the main environmental benefits of reusing waste wood to generate energy.

This research was carried out in a company of wood industry in the city of Aripuana/MT, which makes the management of solid waste using them as biomass for power generation.

The main data form provided by the manager of the company through an interview. The study was conducted in only one company because this is the only one that has its own generation of energy from biomass use in the locality in which it is.

According to the proposed objectives for the research, it is classified as exploratory, because it was held in a context in which we have little systematic knowledge, in this case providing a challenge to explore certain reality to fetch data relevant studies. By favouring the description of a fact, such as the use of biomass for power generation, enabling the knowledge of something unknown, research is also descriptive in character. (Gil, 2006).

The fieldwork was carried out from in situ observations in the studied company, comprising also the application of the interview with the manager of the timber, all in order to gather as much relevant data as possible to validate the proposed objectives. The interview was structured with open questions, in which the researcher asked the interviewee and he answered with his own words. All stages of the research are also backed up by its mintage literature from the analysis of already published material in books, magazines and papers, which address the subject of the work (Marconi and Lakatos, 2009).

The collected data were discussed in a qualitative way, i.e., analysed thoroughly, without statistical analysis, because they are coming from a single interview with the manager of the company and also observations. In this sense, the data were treated from their analysis, interpretation and description.

2 Review of literature

2.1 Environmental management

Currently, environmental management has been widely discussed in various business sectors about the importance and the need for efficient management regarding the reduction of environmental impacts caused by the development.

Tinoco and Kraemer (2008) define as the environmental management system which includes organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy. It’s what the company does to minimise or eliminate the negative effects on the environment caused by its activities.

Describe environmental management as: "the way in which the organization is mobilized internally and externally, for the achievement of desired environmental quality." Emphasise that "it consists of a set of measures to have control over the environmental impact of an activity."

These concepts of environmental management show that this is a process that involves all activities of the organisation, from planning to final execution of the processes. For this it is necessary that the political business is facing issues related to the environment.

For Vilela and Demajorovic (2006) environmental management can be understood as the application of the principles of planning and control in the identification, assessment, control, monitoring and reducing environmental impacts at present levels.

Already Tinoco and Kraemer (2008) state that environmental management can be conceptualised as systems integration and organisational programs that allow you to: control and reduce environmental impacts; meet environmental laws and regulations; develop and use technologies to minimise or eliminate industrial waste; monitor and evaluate the processes and environmental parameters; eliminate or reduce risks to the environment and to humans; using clean technologies in order to minimise the costs of energy and materials; improve the relationship between the community and government, and anticipate environmental issues that may cause problems to the environment and especially to human health.

Notable are the benefits that effective environmental management can bring, both for the environment and for society, for this is that companies need to change their practices and adopt environmental management as a philosophy of life of the organisation.

Moreover, Tinoco and Kraemer (2008) highlight some benefits of environmental management, including: reducing the consumption of water, energy and other inputs, recycling, sale and use of waste and effluent reduction, reduction of fines and penalties for pollution; increased demand for products that contribute to the reduction of pollution, increase productivity, improved relations with government agencies, communities and environmental groups, among others.

The use of waste is one of the important factors that can and should be worked in environmental management.

2.2 Solid waste

Vilela and Demajorovic (2006) describe that waste should be understood as liquid effluents, air emissions and solid waste.

The Department of the Environment of the State of Mato Grosso defines solid waste as the remains of human activity, considered by managers as useless, unwanted or disposable. Usually present in solid, semi-solid or semi-liquid. They can be classified by their physical nature: dry and wet, for their chemical composition: organic matter and inorganic matter, and the potential risks to the environment: hazardous, non-inert and inert.

According to the Secretariat industrial waste is originating from different industrial activities, and may be composed of: ash, sludge, oils, acids or alkalines, plastic, paper, wood, fibers, rubber, metal, slag, glass, ceramics, etc.

According Colonel et al. (2007), the main waste from wood industries are: sawdust, originally from wood sawing process, which represents about 12% of the total volume of

raw materials; cepilhos or the planer shavings derivatives that can reach 20% of the total raw material; firewood or chips and composed slabs, chips, refilos, shells amongst others, reaching 50% of total raw material in sawmills and veneer. It is estimated that the total volume of a log around 40% to 60% is passed, i.e., ten cut trees only five are utilised in their entirety.

In this context it can be said that despite existing technologies there are still plenty of waste raw material in this industry. So there is lots of studies that address this problem in order to reduce waste and add value to the industry generates waste.

According Dolens et al. (2010) the recovery of waste can bring some financial benefits to lumber companies, as lower expenses on raw materials, energy and waste disposal, reduction or elimination of future costs of remediation processes caused by such waste; minor legal complications with the unpaid environmental fines, lower operating costs for maintenance, lower current and future risks to employees, the public and environment and hence lower costs.

Thus, the solid waste management becomes paramount when it comes to the use of waste production.

2.3 Biomass as an alternative use of forest residues

The energy use of firewood and charcoal is part of the social history of mankind. Cavalcanti (2009) states that the first use of hydraulic force by aqueducts and canals, then by water wheels and mills, comes the most important civilisations of all continents, for example, the Aztec empire, Mesopotamia, the Romans, the Chinese. Also discusses that nowadays use those resources in a very specific manner, in large amounts and dimensions, but based on the following elementary processes: the burning of wood as a source of heat for melting metals; burning fuel ethanol ; wheel hydraulic and mechanical energy available for other purposes.

From the nineteenth century began the era of electricity and oil, creating conditions never experienced before, for transport, for communication and for the manufacture of products. Cavalcanti (2009) describes the perception that the relationship between human activities and nature was predominantly one type of vision scanning of the set of natural resources, increasing increasingly scale, the dimensions and powers of the outputs materials, both Constructive as the destructive.

According to the author, social and environmental history of capitalism, of which we are part, has been a history of intensification of production and use of energy. Electricity and fuel are not merely new forms of energy, and are becoming increasingly valuable commodities energetic, strategic, relevant elements of the business cycle, the realisation of profits and capital accumulation.

According to Cortez et al. (2008) most countries, developed or not, is promoting actions for the renewable energy alternatives have meaningful participation in their energy matrixes. According to the author, the motivation for this change in attitude is the need to reduce the use of petroleum products, since these emit gases that promote global warming, and also by reducing energy dependence of these countries for oil exporting countries.

In this work, approach was given to biomass as a form of energy generation both for own consumption of timber, as well as for marketing the surplus generated by the industry.

According Cortes et al. (2008) biomass comes from municipal solid waste, whether they are animal, vegetable, industrial and forestry, and which are meant for energy purposes, covers the use of these various waste for the generation of alternative energy sources.

According Decicino (2007), biomass is a material composed of substances of organic origin (plants, animals and microorganisms). Plants, animals and their derivatives are biomass. The use of these materials as a fuel can be made from its raw form, such as wood products and agricultural waste, forestry waste, livestock waste, animal droppings and garbage.

According to the author, one of the first uses of biomass by man to obtain energy was through the use of fire. Wood has long been the main source of energy used by man followed by vegetable and animal oils.

By 1850, biomass accounted for about 85% of global energy consumption, before that, was the only form of energy used by man, and the force of winds and small amounts of coal for residential use (Goldemberg, 2009). From this period on oil and gas became dominant.

Goldemberg (2009) states that there are a number of technologies for energy conversion of biomass for use in small and large scale. This includes gasification method of producing heat and electricity, energy recovery from municipal solid waste, landfill gas, and biofuels for the transportation sector, namely ethanol and biodiesel.

Due to the increasing prices of oil and natural gas, landfill gas, bagasse from sugar cane, biodiesel, wood reforestation are becoming attractive options for biomass. According to Goldemberg (2009), based on current trends in technological development, it is estimated that the costs of energy recovery from biomass are reduced by two-thirds in 20 years.

Peixer (2011) makes a brief overview on biomass, stating that forest biomass (waste from sawmills), is the most promising potential at the moment, because it is an alternative and renewable source of energy is available locally. The residue is an environmental problem to be solved properly, their use for co-generation of energy (electrical and thermal) is appropriate and necessary for the segment of sawmills and for society in general, contributes to reducing the CO2 concentration in atmosphere, is based on a system of sustainable forest production, generate employment and regional locations, among others.

The surplus generated in the split wood when used for power generation can bring great benefits to the company, as this will become self-sufficient and become more competitive in the market and will further reduce its costs in relation to energy.

2.3.1 Types of biomass in Brazil

According Cortez et al. (2008), the first biomass in Brazil are: vegetable waste, municipal solid waste, industrial waste, animal waste and forest residues. Plant residues are produced in the field, derived from the activities of harvesting agricultural products. Agricultural waste are made of straw, leaves and stems. Municipal solid waste are derived from household and commercial activities.

Already industrial waste, are those from the processing of agricultural and forestry products, the use of charcoal in steel and blast furnace gas to charcoal.

Cortez et al. (2008) describes that the timber industry produces waste from the processing of logs. The types of waste are produced peel, chip, riverside, sawdust,

shavings and chips. As for the food and beverage industries produce waste in the manufacture of juices and brandy, processing rice, coffee, wheat, corn, coconut Bahia, peanuts, cashew nuts, etc. from.

Animal waste is determined by the capacity of droppings creations. According to Cortez et al. (2008), the most important waste generated by biological activity are those of cattle, pigs, goats and sheep, which are creations relevant and justify its energy use. Apart from energy uses, the pig manure is used as fertiliser, reducing pollution and improving the physical, chemical and biological soil properties.

And lastly, forest residues, which according Cortez et al. (2008), consist of all that material left behind in collecting wood in both natural forests and woodlands as reforestation, and the sawdust and shavings produced in wood processing.

Many wastes are generated from the beginning of the process until the final step, i.e., from the cutting of the tree until the transformation of the raw material in the finished product ready for commercialisation. Much of this waste can be used for power generation, especially those generated in the processing of wood, i.e., the timber, usually because these residues are closer to the plants generating power than those generated in the extraction site the timber.

2.3.2 Electricity generation from biomass

Data Center Management and Strategic Studies (CGEE) indicate that biomass has been used increasingly as a source of energy in the world, widely used for end-users such as thermal energy, but also in a very meaningful as generating electricity.

In Brazil the production of electricity from biomass is estimated at about 3% of the total electricity, research conducted in 1999. According CGEE the production of electricity from biomass has two important characteristics: the energy content of biomass collection and transportation demands for the input focus, so the input costs increase with unit capacity conversion and conversion technologies electricity for conventional thermoelectric essentially, have strong economies of scale, thus the investment per unit of input falls and conversion efficiencies increase with capacity.

Investments in technology have sought to increase efficiency in the use of biomass to reduce costs of collection and transportation. To reduce the cost of transport may be used: other uses waste biomass that are already concentrated at point of use and the cost of transportation absorbed by the cost of the main product (bagasse, rice straw, remains in sawmills, bark in the pulp industry, etc.); residues other uses of biomass that can be collected and transported at low cost example, part of the straw, and plantations specific energy production, e.g., forestry trade.

According to CGEE the main types of biomass available in greater quantities in Brazil are: bagasse cane sugar, wood bark, straw.

The wood waste can be used by burning in power plants with the purpose of generating electricity in the timber industry itself.

2.3.3 Thermoelectric power plants

According to Costa (2009) are considered the power plants that use as fuel for power generation: coal, oil, gas, nuclear and biomass, where the operating procedure is based on the transformation of thermal energy into mechanical energy which in time is transformed into electrical energy.

However, according to Costa (2009) biomass is one of the sources with the highest growth potential in the coming years and despite good flexibility, it is still an option maturing with little significant representation in the national matrix.

According to information from Companhia Paranaense de Energia (COPEL), the power plants can operate in simple cycle, combined cycle or cogeneration:

- cycle simple: burning a given fuel in boilers simple, turbines or engines, provides the mechanical energy to electrical energy generator
- combined cycle: fuel combustion provides the mechanical energy to electrical energy generator and the gases from the burning fuel is directed to a heat recovery boiler to produce steam, and this steam will drive a steam turbine that will be linked the other power generator
- co-generation, is similar to the combined system, in which the steam produced in the recovery boiler heat is also used in industrial food, paper, beverage, space heating, etc.

The fuel used for obtaining the necessary heat for the process can be: natural gas, petroleum, coal and vegetable, wood waste and agricultural production, bagasse from sugar cane, household waste and uranium.

Thus, the wood waste generated by the company are used in the power plant for power generation itself.

3 Results and discussions

The company studied is in the market since 2004, is composed of two members, has 55 employees in total, and administrative workers. The production sector operates in two shifts. Its production capacity is 600 m³ of timber monthly benefit.

The company's production is totally sold to a company in the city, however, 70% of production is targeted for export. The timber purchaser undertakes to sell the products for foreign trade. The main products exported are: S4S and decking. The S4S are shorter wood decking and timber are longer than are normally used to make floors. Thus, 30% of products are sold for use in the domestic market.

The waste generated in production are recycled in the company for power generation. The wastes are reused casqueiros, or leftover wood in the production process and shavings which is a residue much like sawdust, is derived from the process aplainagem wood widely used for export. The sawdust is a waste which the plant generates great heat being very important for power generation. Only the sawdust generated in production is not reused by the company. This waste is stored at a location on own timber.

The waste generated vary from a total of 9 m³ to 18 m³ per day depending on the species of wood being sawn. Waste is placed directly in the plant, does not require any processing before being used for power generation.

The company has a mechanism of power generation using waste from their own production, however, it uses waste wood from two other wood industries in the region. The capacity of power generated in the company is 1,500 KVA, enough to meet the demand of timber and a surplus that can meet eleven more companies of the same size timber. With this surplus, the company already sells the power generated to eight other

timber. Therefore, for a company commercialising energy is necessary to obtain the permission of the National Agency of Electric Energy (ANEEL).

In the case of the studied company that already has a license for generation and sale of electricity since June 14, 2009.

The production process begins with the arrival of the log in the lumber yard. The following log is unloaded from the truck and then is forwarded to the local storage of timber on the patio. To initiate the transformation of the log in the final product, this is forwarded to the mill where the sawing process occurs timber. After sawdust, wood passes through alinhadeira process by which withdraws the defects on the sides and perform the alignment thereof. It is then routed to destopadeira where the wood is cut also removing defective parts at the ends of the workpiece and so it is the desired size. In the processes of sawing, alignment and estopo are generated waste will be conveyed directly to the boiler of thermal power plant, part of waste, saw dust, is taken from the place of sawdust and deposited near the timber and then is forwarded to the storage location on the timber itself.

After benefit, the timber passes through the packing process, and then is stored. Thereafter the product is ready for shipment and marketing.

The power generation process starts with the arrival of the waste from the sawing process, alignment and destopo timber, and these are deposited in front of the boiler, which is fed manually by two officials.

The wood shavings, waste generated in the process of processing the wood is put through a machine on a thread that has a motor attached. This motor rotates the screw and pushes the waste into the furnace, according to the need for heating.

After burning the waste water which circulates through pipes inside the boiler is heated to steam generation occurs. This steam spins a turbine, which in turn drives a generator turning the steam into electricity. After this process, the energy passes through the transformer, according to the control panel, where it is distributed to both the company itself, as for the other three timber.

For the operation of a thermoelectric power is necessary to have a reservoir of water for steam generation in the boiler. The vapor is a condition that drives the turbine drives the generator and generating energy. After this process, the last step is the distribution of electricity.

Given the above, for the operation of the power plant is required large water availability. In the power plant of the company, are used daily around 30,000 litres of water. Therefore, the company has a large reservoir with a capacity of 65,000 litres, as shown in figure 05 and 06.

This reservoir is stocked well with water from an artesian well built as close to the power plant with water from the municipal supply. They are used in borehole approximately 18,000 litres of water and municipal supply, 12,000 litres of water.

Before deploying the system of power generation, the timber had a spending power equivalent to R$45,000.00 monthly. After deployment, this cost has ceased to exist, because from there the company uses only the energy produced in thermoelectric own. However, for the permanent operation of the plant is needed constant maintenance, and staff working around the clock so that the process flows smoothly. Because of this, the timber had to hire 13 employees, being an incumbent, six operators and six auxiliary operators. They work in pairs, each shift working six hours a day. Besides hiring, the company needed to enable them to exercise their functions. Thus, the company has no

energy costs, but on the other hand, has spending on plant maintenance and staffing, which equals approximately 50% of the energy costs of thermoelectric before deployment. According to the owner, the investments made by the company to deploy the system of power generation with the reuse of wood waste accounted for 50% of the current assets of the same.

Moreover, the company has plans to alter the machine to also reuse the sawdust, which so far is stored in the company. This residue has no other utility company and is visible in the large amount stored making necessary a suitable location and extremely large for storage.

When installing the power plant the company's main objective was to minimise the cost of electricity, but should consider the financial benefits that could be achieved through revenue from sales of its surplus. Another no less important is the disposal of waste that would no longer be a problem both for the company and for the environment.

The timber generates roughly about 310m ^{3} of waste monthly. With the exception of sawdust, which corresponds to 15% of this total, the remaining residues are all used in thermal power plant. In addition to consuming the waste, the plant still takes 25% of other waste timber. Given this, we can consider that the company is contributing to reduced waste of these inputs. In addition to diminish the problems that might have with storage of the waste, further contributing to which they are not exposed to the environment.

As Tinoco and Kraemer (2008, p.114) is the environmental management system that includes the entire structure of an organisation, encompassing planning, responsibilities, practices, procedures, processes to develop, implement, achieve and maintain environmental policy. It further emphasises, is what the company does to minimise or eliminate the negative effects on the environment caused by its activities.

Also highlight some benefits of environmental management, including: reducing the consumption of water, energy and other inputs, recycling, sale and use of waste and effluent reduction, reduction of fines and penalties for pollution, increased demand for products that contribute for the reduction of pollution, increase productivity, improved relations with government agencies, communities and environmental groups, among others.

The author describes that one of the benefits of environmental management is to reduce water consumption, this is a factor that can be considered as a disadvantage from an environmental standpoint, as to the operation of a power plant requires a large volume of water is consumed daily.

Thus, the environmental impact caused by the operation of power plants is much lower compared to hydropower, and in return, the power plants help to reduce the waste of waste production in various sectors such as agriculture that can be used as straw, bagasse of cane sugar, industrial, wood waste, etc.

Tinoco and Kraemer (2008), emphasise that the goal of environmental management is to minimise the environmental impact and social enterprises, and make all their operations as environmentally friendly as possible.

According to information from the owner of the timber, the company has been constantly seeking to decrease these impacts to the environment by reusing the waste at the plant, and with it still obtains additional revenue by selling its surplus, and that approximately 27% of revenue company's net income.

According to Savitz and Karl (2007), a sustainable company conducts its business so as to obtain benefits naturally to everyone, including employees, customers, business partners, shareholders and the community.

The term sustainability is linked to the achievement of various dimensions, involves all human activities. According to Dias (2009), sustainable consumption means providing products and services that meet basic needs and provide a better quality of life, while reducing the use of natural resources and toxic materials, minimising waste emissions and pollutants over the life cycle of the product and service, in order not to threaten the needs of future generations.

Thus, one can say that the main benefits that a company can get the lumber business with the implementation of a system of recovery of waste generated in its production for power generation are as follows:

a reduction of energy costs to maintain its production

b increasing revenue through marketing the surplus to others

c eliminates problems with the storage of such waste

d decreases the environmental impacts caused by waste

e contributes to the rationalisation of the raw material, wood.

Dolens et al. (2010) states that the recovery of waste can bring some financial benefits to lumber companies, as lower expenses on raw materials, energy and waste disposal, reduction or elimination of future costs of remediation processes caused by such waste; smaller legal complications, with the unpaid environmental fines, lower operating costs for maintenance, lower current and future risks to employees, the public and the environment and, consequently, lower expenses.

Given the above, are notorious the numerous advantages a company can get to reuse the waste generated in its production, be it a timber, or any other company that produces waste to develop their activities.

And if the company studied, the benefits of the use of waste for energy production are: reduction of energy costs to maintain its production, increasing revenue through marketing surplus for others, elimination of problems with the storage of such waste, reduction of environmental impacts caused by waste, and contribution to the rationalisation of the raw material, wood.

4 Conclusions

One can understand that environmental management is linked to all sectors of any company, is a process that involves all activities of the organisation, from planning to final execution of the processes. One of the important factors related to environmental management, is the recovery of waste generated in its production.

Before the question can highlight the key benefits that the timber industry studied can get with the reuse of waste from its production to power generation, being: reduction of energy costs to maintain its production, increasing revenue through marketing surplus for others, elimination of problems with the storage of such waste; reduced waste, and contribution to the rationalisation of the raw material, wood.

The company can obtain additional revenue to provide the surplus to others, because the timber and producing enough energy to keep their activities still have a capacity to supply over eleven companies of the same size timber, including already sells part of its surplus for eight other timber. After the implementation of the plant and the sale of energy, the company started to get about 27% more revenue on net income.

Also noteworthy is that the reuse of waste for power generation contributes to reduce the environmental impact in the city, because the company, in addition to using all its waste except sawdust, uses waste wood from two other city. Despite this statement, there was a study on environmental impact to detect the percentage that this action contributes to the reduction. The lack of this study, not diminish, so the contribution that this action taken by the company behind the benefit to the environment.

It was found that by reusing the waste for energy generation itself, the company had a 100% decrease in energy costs. However, there are costs for maintenance and operation of the plant, whose numbers were not informed by the respondent, which others deserve further study.

However, a research had some limitations, mostly not obtain data regarding the value of the investment made by the company to implement the power plant, since this information is important to do a more complete analysis of the advantages and disadvantages of deploying this system lumber industries.

This study brings the suggestion of future research studies on the detailed values of investment for implementation of a power plant based on the recovery of waste generated by the timber industry, as well as research in the area to ascertain the financial costs of that process, order to determine whether such practices are sustainable or not.

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