LIFE CYCLE ASSESSMENT OF THREE SCENARIOS OF CHARCOAL PRODUCTION IN THE EASTERN AMAZON

Rodrigues, Thiago[1]; Caldeira-Pires, Armando[2]; Rousset, Patrick[3]

[1] UnB, Forest Engineer Department – PhD candidate in Forest Sciences, Brasília, DF, Brazil – EFL/UnB
[2] UnB, Energy & Environment Laboratory, Brasília, DF, Brazil – LEA/ENM/UnB
[3] CIRAD, Biomass and energy Department, Brasília, DF, Brazil – CIRAD/SFB
thiagoefl@gmail.com

ABSTRACT

The Amazon forest is well known for its wealth of resources. There is a great abundance of iron ore and wood. This situation has promoted the development of pig iron industries based on charcoal for their thermal processes. The current scenario is a pig iron industry that uses charcoal produced in small brick kilns with biomass from sawmill residues. But there are other two potential scenarios that may develop, depending on economical, environmental, technical and political issues. The second is more technologic: charcoal production in big metallic kilns using wood from planted forests. The third is more social: charcoal production in bigger brick kilns using the mixture of wood from forest management residues and sawmill residues. So a Life Cycle Assessment is proposed to verify which scenario is better from an environmental viewpoint. The impact analysis showed that the most important impact categories are Global Warming Potential, Human Toxicity Potential and Terrestrial Ecotoxicity Potential. The second scenario causes less impact, due to sequestration of CO_2 during the development of trees and to lower emissions on carbonization.

Topic: LCA Industrial Applications – Waste management and recycling
Keywords: LCA, Charcoal, Forest Management, Amazon.

Introduction

In the southern Amazon, there are the greatest mineral resources of the world. The "Serra dos Carajás" (Mountains of Carajás), in the municipality of Parauapebas, state of Pará, is a large deposit of iron ore and other minerals. Due to this abundance, in the early 1970 a big project was implemented in the region: Projeto Grande Carajás (Great Carajás Project). This project has promoted a great transformation in the economy and logistics of the region [1]. In the city of Marabá, eastern of Pará, there was created an industrial district to smelt these iron ores into pig iron. Nowadays, there are about 17 industries that produces around 1.8 millions tons of pig iron per year or 25% of the whole brazilian production [2].

These numbers reflects the demand for energy inputs required for the thermal reduction of iron ore. The industries have defined the charcoal as the most important energy input, even if there is one that uses coke. The production of one ton of pig iron requires 0.8 tons of charcoal [3]. So for 1.8 millions of tons it is necessary, at least, 1.4 tons of charcoal per year.

In order to achieve this amount, industries are planting huge surfaces of *Eucalyptus sp.* for charcoal production. More than 60 thousand hectares are already deployed and industries intend to have 200 thousand hectares of energetic forests until 2015 [2].

Another way to have charcoal is the utilization of residues from the timber industry. The forest management in the state of Pará is a very important activity, it represents almost 40% of the 15.3 millions m^3 of logs extracted from natural forests in Brazil in 2009 [4]. This activity generates a great amount of residues, since the felling of trees in the deep forest to the cutting of logs into lumber in the sawmills, the average yield is 41% of processed wood, so 59% of residues [5].

The production of charcoal is realized mainly with brick kilns known as "rabo quente" or "half-orange" kilns. They are easy and relatively cheap to build, but the gravimetric yield does not reach more than 25%, the loading and unloading phase is performed manually, it has a small volume of charcoal per cycle and the whole cycle is long, at least seven days [6]. So to meet the demand it is necessary to build many kilns. On the other side, a more industrialized kiln is proposed. The DPC technology (Dry, Pyrolysis, and Cooling) utilizes a metallic kiln in a "closed" process. It means that all pyrolysis gases are burned to dry the biomass on another chamber, so there is no emission to the air [7].

Goal and scope

In this context of resources and carbonization technologies, there are several parallel activities to produce, prepare, recover and transport the biomass to the carbonization sites and then to transport the charcoal to the pig iron industries. So, there are important flows of energy and mass that must be assessed to verify which scenario is better, from an environmental perspective. Three scenarios were considered (Figure 1).

The project aimed to assess and compare the impacts associated with the production of charcoal in three different scenarios according to the biomass origins and the technologies adopted.

The principal scenario (base) is the production of charcoal in small brick kilns using sawmill residues. The second scenario is the production of charcoal in metallic kilns using wood from planted forests. And the third scenario is the production of charcoal in brick kilns with a mix of residues from forest exploitation and sawmills (Figure 2).

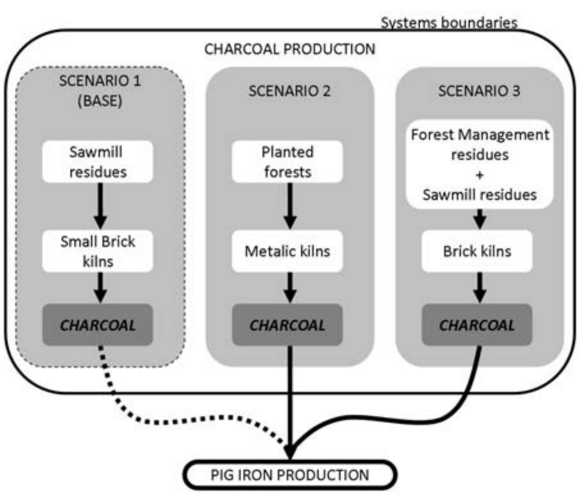

Figure 1 – Three scenarios for charcoal production in Pará, Brazil.

This research is limited to the state of Pará, Brazil. The time covered was the years before 2008, due to the economical crisis that happened that period and has strongly affected those industries. The functional unity is the production of 1000 m^3 of charcoal.

Life Cycle's Inventory

The elaboration of the inventory was initially based on the results of panoramic questionnaires applied on the production of biomass and the production of charcoal. Those questionnaires were answered with secondary informations obtained on scientific literature, industrial association's reports and governmental databases. The missing information was collected directly in the study area.

The sawmill residues are recovered right after the processing of logs and transported to the carbonization courtyard by truck. The wood from planted forests is produced in a seven year cycle and plantations are realized with seedlings of *Eucalyptus sp.* The harvest, bucking, storage and transport of logs to the carbonization courtyard are mechanized. The forest management residues are collected at least one year after logs extraction. The collection, bucking, storage and transport to the carbonization courtyard are mechanized. The site of carbonization is about 50 Km far from the biomass sources. The transportation and production of auxiliary materials processes were based on the information from the software database, GaBi 4.3.

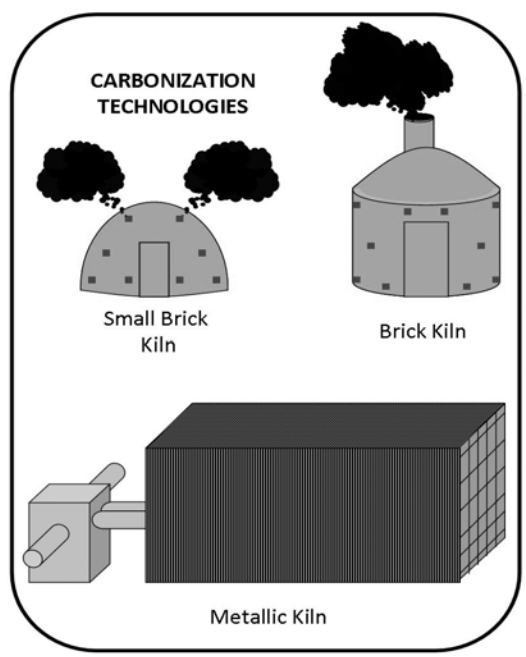

Figure 2 – Carbonization technologies.

For the SCENARIO 1, the usable (for carbonization) sawmill's residues are about 0,3m^3 for each cubic meter of log processed for lumber. The small brick kilns have a gravimetric yield of 25%.

In SCENARIO 2, one hectare produces about 300 m^3 of round wood per year. The metallic kilns used in this situation have a gravimetric yield of 35%.

In SCENARIO 3 the mixture proposed is 87% of sawmill residues and 13% of forest management (FM) residues. The FM residues are about 2 m^3 for each cubic meter of log extracted from forest. The brick kilns have a gravimetric yield of 25%.

The SCENARIO 1 is the most representative in the region, almost 85% of the biomass comes from sawmills and more than 90% of the charcoal is produced in small brick kilns. But several changes are taking place due to environmental, technical and economical issues and the plantation of energetic forests are increasing every year. The metallic kiln is a more industrial way to produce charcoal with greater yields, less pollution and less manpower. The FM residues are a promising alternative because the sustainable management is increasing in the northern region, so the availability of biomass for charcoal too. The transportation of biomass is realized by dump trucks that use diesel with 2000 ppm of sulphur.

Impact Analysis

After the measurement of all mass and energetic flows in three scenarios, an impact analysis was realized. For this task it was used the CML 96 methodology. This analysis showed up that there are three principal impact categories associated with the scenarios proposed: Global Warming Potential (GWP), Human Toxicity Potential (HTP) and Terrestrial Ecotoxicity Potential (TETP). Table 1 presents the values for the impact categories in each scenario.

The impact analysis showed that the technological increase in the charcoal production system has positive effects for the environment. Especially because of planted forests that remove the CO_2 from the atmosphere during seven years for tree development. Also the carbonization process in metallic kilns has low emissions due to its closed configuration, so less impacts on the workers health and on the soil. The three sequential graphics illustrates the impacts for each scenario.

The difference between SCENARIO TWO and the other scenarios is from the important consumption of fossil fuels during the activities of recovery and transport of biomass to the carbonization sites.

Table 1 – Main impact categories for the three scenarios (CML 96).

SCENARIOS	GWP *Kg CO_2-eq*	HTP *Kg DCB-eq*	TETP *Kg DCB-eq*
1	$3,10x10^6$	$1,40x10^5$	$5,87x10^8$
2	***$9,47x10^{-5}$***	$8,64x10^2$	$3,55x10^4$
3	$3,14x10^6$	$1,21x10^5$	$5,87x10^8$

Life Cycle Interpretation

The current carbonization system (sawmill residues + small brick kilns) has negative impacts on environment. But from another perspective it improves the supply chain of lumber because the residues become co-products.

The transition to the SCENARIO TWO is difficult, especially for economic aspects. Metallic kilns are expensive and they implicate in unemployment, in a region that there is a great lack of job. The carbonization is an activity for many people in the region, the huge demand on charcoal causes an improvement on the micro-economy.

There is a simple technical way to decrease the impacts of the current scenario: putting a chimney in small brick kilns and burning the gases that leave the carbonization. Among many gases, there is CH_4, known for being at least 20 times stronger as greenhouse gas than CO_2. Another improvable possibility is to use these burned gases for drying the wood or to begin pyrolysis in another kiln.

Another aspect that must be evaluated is the potential methane avoided emissions due to recovery of residues in the forest under sustainable management. Those residues are "artificially" added to the ground of forest at the moment of its exploitation. If they are left there to decompose, an extra volume of methane could be released to the atmosphere.

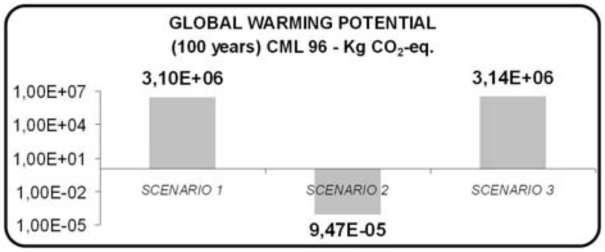

Figure 3 – Global Warming Potential for the three scenarios.

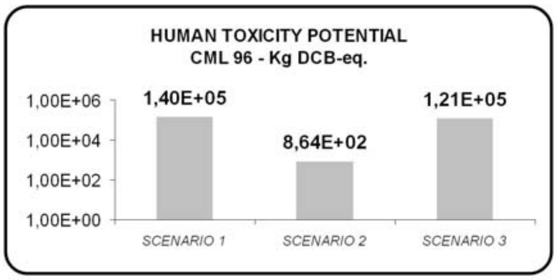

Figure 4 – Human Toxicity Potential for the three scenarios.

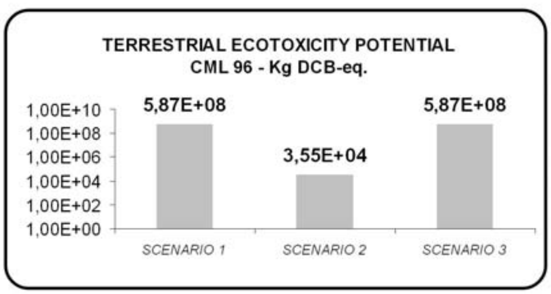

Figure 5 – Terrestrial Ecotoxicity Potential for the three scenarios.

Conclusions

The best environmental way to produce charcoal is using the wood from planted forests in metallic kilns. But this scenario is very difficult to implement in a small or medium term. It depends on several factors, mainly economic factors.

And this scenario does not have to be the only solution. As planted forests are increasing, improvements in recovering and transportation of biomass and carbonization processes can be done together. The utilization of forest management and sawmill residues must be encouraged, that could be a powerful tool to improve the efficiency of wood production chain.

More research must be done on those scenarios, especially on the recovery and the transport of residues from the forest management, in order to achieve most efficient ways. The aim of this industrial sector must be to find the best use of resources to ensure the sustainability of the activity.

Acknowledgments

This research was realized in a project financed by the French Development Agency (Agence Française de Développement - AFD) and it was coordinated by the International Center of Agricultural Research for Development (Centre International de Recherche Agronomique pour le Développement – CIRAD). The authors would like to thank the brazilian company CIKEL for hosting this research.

References

[1] Maurílio de Abreu Monteiro. 2005. Mineração industrial na Amazônia e suas implicações para o desenvolvimento regional. Novos Cadernos, Núcleo de Estudos Amazônicos – NAEA. v. 8, n. 1: 141-187.

[2] [SINDIFERPA] Sindicato das Indústrias de Ferro-Gusa do Estado do Pará. 2007. Eucalipto: Ouro verde para a sustentabillidade. Pólo Sustentável. n.1: 5 p.

[3] Maurílio de Abreu Monteiro. 2006. Em busca de carvão vegetal barato: o deslocamento de siderúrgicas para a Amazônia. Novos Cadernos, Núcleo de Estudos Amazônicos – NAEA. v. 9, n. 2: 55-97.

[4] [IBGE] Instituto Brasileiro de Geografia e Estatística. 2010. Produção da Extração Vegetal e da Silvicultura: 2009. Rio de Janeiro (RJ), Brazil: IBGE. v. 24: 45 p.

[5] Denys Pereira, Daniel Santos, Mariana Vedoveto, Jayne Guimarães, Adalberto Veríssimo. 2010. O setor madeireiro da Amazônia. In: Fatos Florestais da Amazônia. Belém (PA), Brazil: IMAZON. p. 31-37.

[6] Paulo César da Costa Pinheiro, Ronaldo Santos Sampaio, José Gonçalves Bastos Filho. 2005. Organização da Produção de Carvão Vegetal em Fornos de Alvenaria. Biomassa & Energia. v. 2, n. 3: 253-258.

[7] DPC Thermal Processing. 2010. O Processo DPC. http://www.dpcbiomassa.com.br/oprocesso.php. Accessed 17 december 2010.