Metallurgy in the Brazilian Amazon: alternatives for ecologically imprudent activities

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Abstract

This study is an attempt to analyze a traditional model of development, aiming to economic growth and connected to the logic of immediate use of natural resources.

During the 80's, the eastern part of Amazonia was a strategic region for the Brazilian government to enhance a large industrialization process, focused on the implantation of pig iron plants on the energetic base of local made charcoal. According to official statements, these plants, located along the Carajás Railroad, should prepare the region for the future implantation of a great metallurgical industrial complex and a dynamic regional social and economic development. Contrary to any governmental claims, industrialization in eastern Amazonia is far from supporting a sustainable development of the region. There is no evidence of pig iron production overcoming environmental restrictions, mainly those related to the maintenance of energy and material flows, nor of pig iron production as a means to establish equal social relationships.

The analysis shows that such economic process is only possible through massive transference of private costs to the local society, which has no capacity to assume the ecological burden of this kind of production. The result is a constant social and environmental degradation.

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Introduction

Although the theories which supported intervention practices worldwide, linked to the so-called “development economy”, suffered increasing restrictions during the 80’s, the state’s perspective to transform the Carajas Railway Corridor into a giant mineral-metallurgical center at the beginning of that decade was still based on such theories, based on central concepts such as “unbalanced growth”, “linkage effects”, “motor industrial complexes”, etc.

The document on which the most important federal intervention program in the region, the Great Carajas Program - GCP -, was basead, pointed to a scenario where 3.5 million tons of pig iron, 10 million tons million tons of steel, 550 thousand tons of iron alloys, and 30 thousand tons of metallic silicon would be produced in the eastern Brazilian Amazon in the year 2000, in the fields of metallurgy and others (Companhia Vale do Rio Doce, 1981).

In terms of planning, this vision wasn’t abandoned during the 80’s. The Directive Plan for the Carajas Railroad Corridor, dated 1989, indicated that the industrialization in the region was linked to the “implementation of a progressive and varied industrial park, regionally and nationally linked, to be initially enhanced by the export base”, so that the region would not be transformed into a mere exportation platform for goods with low aggregate value” (Brasil, 1989: 7).

The official discourse announced the GCP as a program for regional development, which would industrialize and modernize the eastern part of the Brazilian Amazon due to the “dynamic linkage effects” and the “internalization of revenues” as a result of the mineral product “export base”. From such dynamics an “industrial metal-mechanics complex” would be created and its first stage would be the metallurgy industries. It was forecasted that the “forwarding motion set by metallurgic activities would propitiate the creation of a metal-mechanic industrial park, which would be responsible for at least 44,000 new jobs in the year 2010” (Brasil, 1989: 19). The base of this industrial metal-mechanic center would be metallurgic activities.

In a smaller number and in a slowlier rhythm than expected by the state planners, in the 80’s and 90’s some producers settled in the region, to produce pig iron — an intermediate form which the majority of iron components must go through before being transformed into steel. They were independent producers. The investments and output of these companies are small when compared to those made by integrated steelworks. Pig iron produced by the smaller companies is sold as an input for steelmaking plants or for casting. They were different from integrated steelworks, which operated on a larger scale working from iron ore until the final product, with all stages under their control, manufacturing steel products such as: dowels, plates, sheets, bobbins, bars and cables.

Integrated steelworks follow the technological route which dominates worldwide production of steel and is based on an industrial plant combining smelters for pig iron production and oxygen steel plant for steel production with machinery producing ingots and splinters. Such setup requires a minimum production of ten thousand tons per day, i.e. more than three million tons per year.

Nine independent pig iron producers have settled in the Eastern Amazon so far. The settlement of these companies in the region is not a result of capital invested in other activities in the region, but of corporate initiatives coming from other regions, mainly from the State of Minas Gerais.

Besides the possibility of easy and cheap access to biomass for charcoal production in the region, what that made companies settle down in the region were the credit, tributary and infrastructure facilities available.

Despite huge governmental efforts, the expected fast industrialization of the region has not materialized. Only the initial stages of the huge metal-mechanical complex intended for the region were implemented, with only a few metallurgical plants in operation, much less than originally planned. But still the production was increased year after year, causing significant destruction of the environment, as the metallurgical enterprises were neither able to stabilize and strengthen the social system in the region nor to use the natural resources involved in a prudent manner. This is not an isolated fact; the energy and material transfer from regions like Amazonia to industrialized countries has disastrous social and environmental impacts and is therefore incompatible with sustainable development strategies (Fenzl, Monteiro, 2000: 179).

Limitations of traditional development models and their indicators

The traditional development models which were the base of the State actions towards the implementation of metallurgy in the Brazilian Eastern Amazonia during the 80's, were based on the assumption that an immediate use of natural resources without any further thought as to its continuation in the future would be compensated by market mechanisms or by material or technological replacements. Such development strategies are based on theories stating that long term economic growth - beyond short-term unbalance - runs together with the possibility of reversing strategies. In other words, that the irreversibility will be overcome by the market (Boyer, Chavance, Godard, 1991: 16). Furthermore, models of this kind do not consider the limits of modernization and industrialization, in particular those related to social and environmental issues.

Economic activities produce irreversible changes in the quality of the available resources and even the possession of large quantities of low entropy resources cannot guarantee sustainable development by itself. The conversion of material and energy into goods involves complex relations between different technological, social, cultural, political and environmental elements and actors. These relations cannot be “regulated” only by the so-called free market dynamics, but need strategic social and political intervention.

The sustainability of complex open systems depends on the maintenance of their Energy-and-Material Metabolism (EMM) to sustain the coherence of their elements (Fenzl, 1997: 10). However, not all societies are able to have adequate material and energy transformation structures with the capacity of maintaining such coherence, thus enhancing sustainable development processes. The relationship between society and its energetic and material needs are subject to economic restrictions, to restrictions associated with the social organization of labor, technological know-how, institutional organization, cultural traditions, and to biophysical limits. That is why the concept of sustainable development is closely related to material and energy flows, which are ubiquitous in development processes[1].

Therefore, despite remarkable advances regarding neoclassical economics formulations, sustainability indicators which do not comprise material and energy references and are based only on the consumption of “natural capital” as suggested by Reppetto (1989), El Sarafy (1989), Peskin (1991), and Solow (1992), are insufficient and misleading[2]. This is even more relevant when dealing with activities introduced as part of a modernization strategy for an entire region like Amazonia.

The evaluation model underlying this study is the so-called enthalpic evaluation process, which expresses the various forms of energy in terms of heat equivalents, and measures the incorporated and the dissipated energy used in the production of a given good or service[3].

Energetic inefficiencies and transfer of private costs to society

It seems rather evident that alterations in the regional scenario as a result of metallurgy plants are very significant and very different from official estimations. Such changes are mainly linked to the production structure of the companies, characterized by charcoal demand and low energetic efficiency. The production of 16 tons of pig iron implies the destruction of

[1] See: Ayres and Ayres (1998); Czeskleba-Dupont (1999); Bossel (1996); Ryzhenkov (1999); Haberl (1997); Bossel (1999); and Moll (1999).

[2] See Fisher-Kowalski *et alli* (2000); Geissler and Todd (1999); Bringezu (1997); Adriaanse *et alli*. (1997); Femia (1996); Vellinga (1996); Leach, Bauen e Lucas (1996); and Wernick e Ausubel (1996).

[3] The most widely known models are: the *enthalpic* model, which expresses energetic forms in heat equivalents, generally based on *input-output* models; another one known as *exergy* model, aiming at expressing energetic equivalents in terms of feasible mechanical labor units; and a third energy evaluation technique, which goes back to the concept of *EMERGY*, trying to operate with only one kind of energy (for example solar energy) for calculating the (often multiply) transformed energy needed to provide a commodity. Regarding these methods, see, respectively, the pioneering works by Hannon (1972), by Pillet and Murota (1987) and by Odum and Odum (1981).

one hectare of forest, the dispersion of huge quantity of gases, the destruction of parts of the flora and fauna, etc., and this is usually not included in the economic analyses.

When we include elements of the energetic-material dynamics to the metallurgy industry analysis, we notice that to produce one ton of pig iron, 875 kg of charcoal is needed (CEMIG, 1988: 150) which requires at least 2,600 kg of dry wood, with an average density of 360 kg/m^3. In other words, if we use wood from primary forests, we need to deforest at least 600 m^2 considering that the forest has around 120 steres per hectare (st/ha) of useful wood potential for carbonization. The production of the amount of charcoal needed for the industrialization of one ton of pig iron uses the wood contained in at least 600 m^2 of primary forest.

There may be significant variations in the cited parameters. Literature indicates different wood potentials for carbonization in one hectare of forest, and this is more so due to the different kinds of tropical forests in Amazonia (SUDAM, 1974: 36). We are assuming that one hectare yields an average of 44 tons of dry timber for carbonization. Another parameter refers to the proportion of the conversion of timber into charcoal, which is linked to the humidity of the timber — with up to 25-30% of humidity, the wood has a calorific power of 3.5 Mcal/kg, while dry wood may reach 4.7 Mcal/kg (Martins, 1980: 20) — as well as the type of furnace used for carbonization. The type of furnace has a direct influence in the energetic efficiency of the carbonization process. There is a great number of ovens. However, there is no doubt that the most widely used furnace in the region is the “rabo-quente”.

The parameters adopted herein were obtained from various interviews made in factories using charcoal, in forest areas, and supported by related literature. According to the adopted techniques, only logs with diameters between 5 and 50 cm can be used for charcoal production. Such limitations are due to the fact that trees with more than 50 cm of diameter are difficult to transport and to cut into smaller pieces; this would consume energy and would make it too expensive. We have to keep in mind that all timber which may be useful for sawmills had been previously extracted from these areas.

Regarding sawmill waste, we can say that the production of 100m^3 of processed wood generates up to 24.7m^3 of waste (Vidal *et. al.*, 1997: 15), considering that only pieces of more than 5cm can be used to produce charcoal.

However, in both cases the main method of carbonization is based on the use of the so-called “*rabo-quente*” ovens, which means 3 t of wood for 1 t of charcoal.

Basically, charcoal production implies in large dispersion of material and energy, beginning with deforestation and continuing during the carbonization process, taking into consideration that the existent facilities are projected to use only charcoal, wasting the volatiles. During carbonization, the wood is decomposed, by the action of the temperature, into a solid product: the charcoal; plus volatile gases compounded by a fraction which can become liquid, and in a non-condensable fraction. Therefore, from the whole carbonization process, only the charcoal is used, and gases, water steam, organic liquids and tar are wasted (6,5 Mcal/kg). (Norbert; Monteiro, 2000: 181).

This process of carbonization is marked the low energetic efficiency, with significant losses of energy equivalent to 2.6 Gcal per ton of dry wood, for an average of 30% of charcoal (Martins, 1980: 20).

The energetic inefficiency of pig iron production is especially high due to its direct linkage to charcoal production, which is also marked by low energetic efficiency and the dispersion of huge amounts of material and energy. Production technology is similar in all plants of the region. The most remarkable difference is that some metallurgy companies installed in the region have an injection system of fine charcoal in the smelter, but the majority of the companies do not have this system.

The process is mainly based on the use of a smelter, where iron ore is reduced, together with the reduction agent: the charcoal. The melting products are loaded in the upper part of the smelter, leaving the device as a metallic alloy (Fe-C), in liquid state, used to produce solid pig iron. Through the lower part, the slag (sub-products generated by the process, mainly melting impurities) is drained. To initiate the charcoal combustion, which furnishes the necessary energy to the process, air is injected laterally in the lower part of the smelter while the gas formed during combustion leaves the furnace through the top, and is partially used (60%) for pre-heating. The charcoal has a double function: as chemical agent, eliminating oxygen from the iron oxides; and as thermal agent, providing heat to the process. Charcoal represents 99% of energy consumption in independent plants (CEMIG, 1988: II). Some companies operating in the eastern Brazilian Amazon, however, use also mineral coal in the smelter, but this is a residual participation when compared to charcoal. Coke importation is presently around 20,000 tons per year.

During charcoal combustion, energetic losses are very high. The energetic content of the liberated gases is higher than the sum of the energy consumed in the chemical reactions plus the heat absorbed by the pig iron and the slag (CEMIG, 1988: 157). The amount of energy actually used for iron reduction and fusion does not reach 40% of the total energy amount provided by the charcoal to the system (CEMIG, 1988: 187). Such process provides pig iron and slag as final commercial products. The pig iron produced with charcoal has an advantage (as opposed to the pig iron produced with coke): the quantity of sulfur is residual. It may be therefore added as part of the input needed to produce some types of steel, which require low levels of sulfur, reducing or even avoiding the use of secondary refinement to obtain low sulfur steel. This quality of the pig iron produced from charcoal will possibly compensate the energetic losses incurred by independent producers.

Evidently, there are losses caused by dissipation in all energetic-material transformation processes. However, the dimension of such losses depends on the intelligence of the system, on the degree of efficiency in the transformation processes and on energy use.

The production of pig iron requires the consumption of 5,688 Mcal included in 875 kg of charcoal, which in turn requires 12,200 Mcal bounded in the used wood. Including the large quantities of energy lost in non-carbonized wood, due to the technical limitations, we can show that the industrialization process implemented in the region is, from an energetic-material point of view, highly entropic. Taking into account the whole production process we find out that 12,200 Mcal are needed to produce one ton of pig iron.

Then, the biophysical dimension of this production process is marked by an intense use of natural resources and by the transfer of energy and material from the natural Amazon environment to other regions, in the form of charcoal/pig iron production, which results in the consumption of great amounts of vegetal biomass from the primary forests (from sawmill leftovers or from deforestation). Although the energy and material transformation processes have a very low efficiency, one ton of pig iron is sold at an average price of only US$ 125 (Fenzl, Monteiro, 2000: 183). Considering this process, Altvater (1993: 36) states that "...a sufficient sum of money [is not obtained] to compensate the increase of entropy ... the monetary compensation for entropy increase.... cannot be compensated by sintropy import”. It is clear that the industrialization process implemented in the region gives rise, already from a classical thermodynamic point of view, to a high increase of entropy .

Now the paradoxical fact is that this low energetic efficiency is by no means in conflict with the so-called economic efficiency. The reason for this is the transfer of costs to the society, thus making the physically inefficient processes of charcoal and pig iron production efficient and therefore acceptable from the traditional economic point of view. It is through this deficit of socialization of the market that the pig iron producers ensure their profits.

One cannot state that great part of the wood used in pig iron production is not wanted because there is a social manifestation, expressed in the legislation, restraining the percentage of the land used for deforestation in private estates in Amazonia. This is a clear indication that the majority of the society does not want the vegetation and ecosystems depleted in such areas. Actually, when deforestation is made aiming at private benefits, private costs are transferred to the society.

Private costs are also transferred to the society when ovens for charcoal production are installed in urban areas and when the pollution caused by them compromises the health and quality of life of the workers in the charcoal production and of the nearby population; this cost, in the bottom line, is also transferred to the society.

Independent producers and their demand for charcoal extracted from primary forest

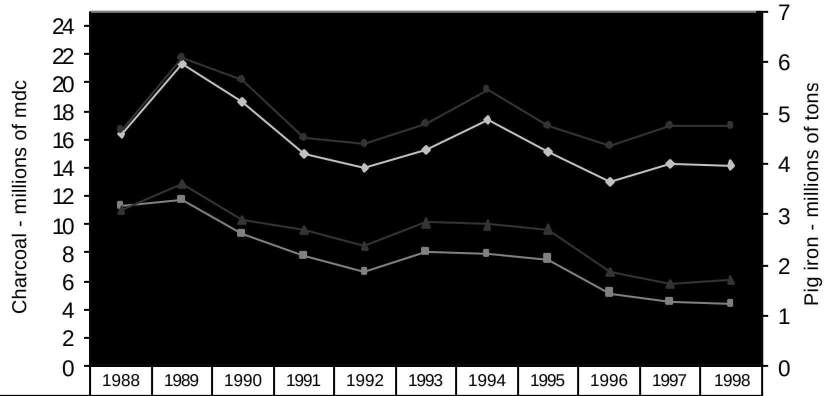
The state’s strategic attempts at modernizing the Amazon during the 80’s were of key importance for the launching of social actors in the region, among them the metallurgy industries. The consequences for the region depend on which social groups have access to natural resources and the way they use them, incorporating new dynamics and enlarging structural diversity of the region. Independent pig iron producers, using charcoal as input, relocated to the eastern Brazilian Amazon. Until then, such producers were almost exclusively located in the Brazilian southeast, specially in the State of Minas Gerais, where iron ore extraction dates back to last century.

There, too, the metallurgy industry has widely used charcoal as a reducer for pig iron production. However, a trend to reduce charcoal consumption is already perceived. In 1988, more than 36.3 million cubic meters were consumed, and in 1998 it dropped to 24.49 million cubic meters (Anuário Estatístico ABRACAVE, 1999).

Charcoal has basically two origins: it is either produced from primary forests, or comes from areas reforested exclusively for charcoal production. The charcoal from reforested areas has a significantly higher production cost than that coming from primary forests. The greatest consumers of charcoal from reforested areas are the integrated steelworks, with a vertical production clain. With all production stages under their own control, these companies can bear higher input costs, mainly that of charcoal coming from reforested areas.

Nevertheless, during the past decade the consumption of charcoal by these integrated steelworks has dropped. In 1988 they consumed 11.3 million cubic meters of charcoal; during the 90's consumption was constantly reduced and in 1998 it dropped to 4.4 million cubic meters (Fig. 1). The reduction in charcoal consumption by the integrated steelworks is linked to the increasing replacement of charcoal by coke as a reducer in the production process. The integrated steelworks using charcoal produced 3.1 million tons of pig iron, in 1988, and in 1998 this number was reduced to 1.7 million. On the other hand, within the same period, pig iron production by integrated steelworks using coke increased from 15.6 million to 18.6 million tons (Anuário Estatístico ABRACAVE, 1999). This is a result of the changes undergone by big integrated steelworks, such as Belgo-Mineira and Acessita, which have started to use smelters, where iron ore reduction is made through the use of coke, not charcoal.

FIGURE 1: CHARCOAL CONSUMPTION AND PIG IRON PRODUCTION IN BRAZIL, BY INTEGRATED STEELWORKS AND INDEPENDENT PRODUCERS (1988-1998).



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Charcoal consumed by integrated industries (millions of mdc)	11,30	11,70	9,40	7,80	6,70	8,00	7,90	7,60	5,20	4,50	4,40
Charcoal consumed by independent industries (millions of mdc)	16,40	21,30	18,60	14,90	14,00	15,30	17,30	15,10	13,00	14,30	14,19
Pig iron production by independent industries (millions of tons)	4,68	6,09	5,64	4,53	4,38	4,80	5,44	4,76	4,35	4,76	4,73
Pig iron production by integrated industries using charcoal (millions of tons)	3,11	3,61	2,90	2,70	2,38	2,84	2,80	2,72	1,87	1,61	1,69

Source: Anuário estatístico ABRAVACE (several years). Elaborated by the author.

The independent pig iron producers are, therefore, responsible for the maintenance of the high charcoal consumption as pig iron production reducer in Brazil. In 1998, these companies consumed 14.1 million cubic meters of charcoal, representing 58% of the total charcoal consumed by Brazilian industries.

It is evident that integrated steelworks tend to replace charcoal by coke and independent producers tend to maintain the use of charcoal as a reducer in their production processes. The problem is that, as opposed to integrated steelworks, the independent companies produce only pig iron, and, because charcoal is a considerable item on their production costs, they try to acquire charcoal from primary forests in order to decrease the costs of their inputs.

Currently, independent pig iron producers, in the Amazon, have a total output capacity of over 1.5 million tons/year, a potential production linked to the existent 18 smelters. In the State of Minas Gerais the output capacity is 5 million tons/year (Anuário Estatístico ABRACAVE, 1999). The pig iron currently in existence in the Amazon represents over 20% of the total output capacity of independent producers in Brazil.

There is now a situation in the eastern Brazilian Amazon, where pig iron production has increased year by year. This is very significant also means a considerable increaseing charcoal consumption. In terms of iron ore, however, the demand of these plants is residual when compared to the annual output of Serra Carajas. In 1997, for example, the pig iron companies located in the eastern Brazilian Amazon consumed 1.6 million tons, which corresponded only to 3.7% of the total iron ore extracted from Carajas in the same year (CVRD, 1998).

The regional production of pig iron will increase in the next years with the installation of new smelters in the companies already in operation.

Charcoal production: main link between pig iron production and regional economy

After almost one decade of operations, the primary metallurgy production is almost entirely sold in the international market. In 1999, 92% of the regional pig iron production was exported, mainly to the USA. And even the small part which is sold in the national market is processed in other regions and not in the eastern Brazilian Amazon. Therefore, until present date, the forecasts about these industries and their dynamic impacts on the regional economy creating a diverse industrial park, have not been fulfilled.

Regarding direct jobs, according to the characteristics of capital composition, the number of new jobs is small compared to the populations of the cities where the companies are located, and there are no significant changes in the job market of these cities. The generation of 1.6 thousand jobs is far from what had been forecasted in the Directive Plan for the Carajas Railroad Corridor: 21,658 direct jobs in the year 2000 in the metallurgy and iron alloy sectors (Monteiro, 1998: 126).

The wages generated by the operation of the companies have not been able to alter the income in the region. The salaries paid by metallurgy companies, besides being not in great number, are low; the average monthly salary for the jobs created by these companies is US$ 200 (Monteiro, 1998: 126).

Another key aspect of pig iron producers for the regional economy are the taxes that could be generated by the operations. However, the tributary exemptions of the profits generated by the trading of their products have significantly reduced taxes paid by these companies. In 1996, aiming at turning Brazilian products more competitive in the external markets, the federal government exempted several export products - among them pig iron - from the Merchandise and Services Tax — ICMS.

Thus, the main socio-economic changes in the region, caused by the operation of these companies, are linked one way or the other to operation inputs, namely charcoal. Therefore, the main link between the industrial plants and the regional socio-economy is the charcoal demand, not only due to the amounts operated - it is estimated that pig iron producers will buy approximately US$ 60 millions of charcoal in the year 2001 - but also due to the creation of several mechanisms for charcoal production, involving several social structures and relations.

Such demand changes the regional scenario; one of the changes is the formation of groups of workers dedicated to charcoal production. The monthly income of charcoal production workers ranges from US$ 52 to US$ 113 per month, corresponding to at least eight hours per day of work (usually 10-11 hours per day). Cosidering work conditions, stability, and the salary paid, there is no doubt that the jobs generated by charcoal production are of a very low quality; the working and housing conditions are extremely bad, jobs are temporary, there are no social or fringe benefits attached, the monthly wages are hardly higher than the national minimum salary, and workers are subject to coercible working capacity immobilization. Besides that, in most cases, workers get paid by the amount they produce; this induces workers to employ their families as helpers, sometimes even children, thus establishing a socially undesirable working relationship for these children, although this is not always perceived by the workers. Moreover, the extension and consequences of such unhealthy working conditions and the future effects on their health are not realized by the workers in its whole extent. One can add to this that even those family members who are not involved in the charcoal production are affected by it because the family houses are usually located near the ovens and all those who live there are impacted by the pollution originating from charcoal production (Monteiro, 1995: 89).

Metallurgy and the trend to consume charcoal of primary forest

In the 80's, the cost of one ton of charcoal from reforested areas in the eastern Brazilian Amazon was estimated between US$ 60 and US$ 75, excluding transport to the plants (Brasil, 1989: 308). However, calculations by Camargo Correa Metais — CCM —, a company which produces metallic silicon, has been reforesting, and has produced splinter and charcoal in the region for its own consumption, with wood originating from silviculture, indicate that in 1997 the production cost of one ton of timber from silviculture was around US$ 20 (Tab. 1) and that the cost of one ton of charcoal from the same biomass would come to US$ 100.

TABLE 1: PRODUCTION COST OF ONE TON OF TIMBER COMING FROM SILVICULTURE IN AMAZONIA.

Cost items	US$/t of timber
Land cost	1.9
Preparation, plantation	7.1
Forest maintenance	6.3
Silvicultural treatments	2.2
Administration	2.1
Total	19.6

Source: Research data obtained from CCM in 1997.

The production cost of US$ 19.6 per ton of timber, which is closer to the data provided by CVRD, means that even using an excellent conversion rate (2.7 t/timber for 1 t of charcoal), the cost of timber – excluding cut, transportation, carbonization, maintenance, etc., – represents, in the cost of one ton of charcoal coming from reforested areas, US$ 52.92/t. This cost item alone is higher than the regional price of one ton of charcoal coming from the primary forest, which is around US$ 45/t.

The acquisition of charcoal is the most representative cost item in pig iron production, representing approximately 40% of total costs. In the eastern Brazilian Amazon, the production cost of one ton of pig iron, before taxes, comes to US$ 107 (Tab. 2). Therefore, we can safely indicate that charcoal is the main input in pig iron production, and conclude that independent producers try to control their profit margins through it.

TABLE 2: PRODUCTION COST OF ONE TON OF PIG IRON IN THE EASTERN BRAZILIAN AMAZON.

Item	Unit	Cost (US$)	Consumption	Cost (US$)
Iron ore [(a)]	T	9.4	1.5	14.10
Mine/plant [(a)]	T	2.55	1.5	3.85
Charcoal	T	45.00	0.875[(b)]	39.37
Chalk	T	15.00	0.05	0.75
Dolomite	T	25.51	0.06	1.53
Quartzite	T	13.55	0.1	1.35
Electricity	MWh	40	0.1	4.00
Other inputs	-	-	-	2.53
Labor force	Man/hour	2.50	-	6.37
Maintenance	-	-	-	4.27
Administration	-	-	-	4.50
Transport and shipping	T	12.5	1	12.50
Capital costs	-	-	-	12.00
Total	-	-	-	107.12

(a) Items that the CVRD offers to independent producers, called “pig iron package”.
(b) Exclusive loss of charcoal, in an average of 15%.
Source: Monteiro (1998: 133), modified.

As the price of charcoal produced from reforested areas, over US$ 100/t, is significantly higher than that of charcoal produced from primary forests, the charcoal from reforestation is not compatible with the cost structure of pig iron production in the independent producers. Since one ton of pig iron is sold, in average terms, for US$ 125 (Fenzl, Monteiro, 2000: 183), the use of charcoal coming from silviculture would increase the production costs of pig iron. This could not be absorbed by these companies or markets, and would be contrary to their economic logic, which is to try to acquire charcoal at the lowest price in order to mantain or increase profit margnis.

Therefore, both in southeastern Brazil and in the Amazon, independent producers turn to charcoal from primary forests under of pressue of economic factors. This is the reason why the discourses of the companies on the polemic issue of big reforestation areas in the region, to meet the demand for charcoal, were buried during the first decade of operation of the metallurgy projects in the Amazon. The metallurgy industries in the region have not accomplished any of the Integrated Forest/Industry Plans — PIFI— which established goals and directives regarding the origin of the material to be carbonized, mainly the implementation of silviculture. According to official reports, in the southeast of the country, the demands of the Brazilian Institute of the Environment and Natural Resources — IBAMA — requiring metallurgy companies to assure that until 1992 70% of charcoal should come from reforested areas and that until 1995 this ratio should be 100%, were totally disregarded (Brasil, 1995: 25).

The biomass used to supply the pig iron producers in the eastern Brazilian Amazon comes almost entirely from the primary forest. The portion coming from silviculture or from *babaçu* coconut carbonization is not significant. The timber which feeds the thousands of ovens where charcoal is produced has several origins: deforestation for pasture or farming purposes; leftovers from sawmills; and the so-called "plans for sustainable forest management".

For charcoal production, network of varied social relations has been created. When the timber comes from deforestation for pasture or farming purposes, the land owners do not charge for the timber taken, asking only that the charcoal producers render the area "clean", mainly for planting grass.

That is why it is not possible to establish an equality between small charcoal producers and small farmers or squatters because in most of the cases the charcoal suppliers use timber from different landowners. A small charcoal supplier almost always uses timber coming from a big estate and not necessarily from a small farm.

When the biomass to be burned comes from sawmill leftovers, the sawmill owner usually allows the ovens to be installed within the sawmill premises and gives away the leftovers, asking that the sawmill staging area be cleaned. In some cases, the sawmill owners get 10 or 20% of the amount of the charcoal produced.

In some cases, the large estate owners or the sawmill owners are directly in charge of the charcoal production, but this is not the usual pattern.

In July 1995, Monteiro (1998: 149) estimated that the operation costs – excluding capital costs – involved in the production of one ton of charcoal supplied by sawmill leftovers were around US$ 30 and the production costs of those who used timber from deforested areas were around US$ 36. Such cost composition resulted in the establishment of a competitive charcoal market in the eastern Brazilian Amazon where prices were lower than those in the State of Minas Gerais, where pig iron industries are located.

Babaçu coconut as a source of biomass for charcoal production

Since the beginning of metallurgy implementation in the eastern Brazilian Amazon, the biomass of *babaçu* coconut had been indicated as an ecologically prudent alternative for charcoal suppl for pig iron industry in the region (Brasil, 1989: 77). The use of charcoal made from this fruit is an old alternative, as per a report made in 1953. This report indicated that charcoal made from *babaçu* coconut was technically acceptable (Leite, 1953: 43-48). Regional initiatives in carbonization of *babaçu* coconut have confirmed the good quality of this input and that it can be used in smelters.

Government forecasts - currently outdated - indicated that in the early 80's there was an area of over 4.7 million of hectares covered with babaçu palm trees in the State of Maranhao, producing an average of 1.6 tons of coconuts per hectare. This meant a potential volume of 7.7 million of vegetal biomass, which could be burned (Brasil, 1982).

Metallurgy companies in the eastern Brazilian Amazon include in their PIFI that one of the biomass sources to produce charcoal is the *babaçu* coconut. Besides including this source of energy in their PIFI they disseminate the idea that it will be a significant source of charcoal for their smelters. Althought this is not true, it is considered a way to diminish the pressure over the primary forest in the eyes of the control agencies and public opinion.

Therefore, up to now, charcoal produced from *babaçu* coconut to supply metallurgy companies in the region is extremely residual. They are limited to a few pilot programs, such as the one managed by Mr. Luiz Amaral, supportet by the State Government in the southwest of the State of Maranhao. The Pro-Natura Institute proposes that this experience should get institutional support in order to become a general activity, receiving credit for carbon sequestration (Instituto Pro-Natura, 2000: 5).

A study by SUDAM/PNUD states that supplying charcoal industries through carbonization of babaçu coconut "is not free of rather political than natural problems". According to said document, "in the *babaçu* coconut process there is an archaic social relation which some political segments would like to preserve" and concludes that "the use of *babaçu* coconut in the pig iron production is merely a matter of political and corporative initiative" (SUDAM/PNUD, 1997: 94-5).

This is not a good explanation for not using babaçu coconut to produce charcoal. The reasons for not using it are probably different, possibly purely economic. Both in the leftover carbonization and the carbonization of timber coming from deforestation, the costs for gathering, preparation and transportation of biomass are the highest ones. In the case of timber from deforestation, it is over 50% of the total operational costs involving charcoal production (Monteiro, 1998: 154). When using babaçu to produce charcoal, the great dispersion of biomass - only 1.6 t/ha - dramatically increases the costs of gathering and transportation to the carbonization site. Apparently, this does not make babaçu competitive in view of the low prices of charcoal produced from sawmill leftovers or from deforestation.

The use of babaçu as biomass source for charcoal production has not become popular, although it is an ecologically prudent alternative, mainly because pig iron producers induce their suppliers to use the less expensive biomass, disregarding social and ecological concerns. Therefore, environmental prudence is relegated to a mere rhetorical element.

Charcoal production and pressure on the Amazon primary forest

It is estimated that from 1999 on, 1.3 million tons of charcoal will be consumed. Supposing that 40% of it is produced with timber coming from deforestation or with timber coming from sustainable forest management - remembering that big metallurgy companies use this label only as a means to obtain legal authorization to deforest large areas - and that 60% is produced with timber coming from sawmill leftovers (as other biomass forms, in practical terms, do not exist), we can roughly deduct that part of the biomass gathered in a deforested area of approximately 425,000 hectares per year is carried to the metallurgy industries smelters. Even considering that there might be an intersection between areas where timber is extracted by sawmills and areas deforested for farming purposes, in both cases what is carried to charcoal production comes from areas reaching a total of 390,000 hectares (Fenzl, Monteiro, 2000: 184). Certainly, in the process of forest destruction in these areas, charcoal is a secondary drive, but its importance can never be overemphasized.

The pressure on the primary forest, the industries installed in the eastern Brazilian Amazon have also favored the onset of huge land properties through two ways: one is that charcoal production significantly reduces costs with cleaning the areas for pasture; the other one is that all companies acquired large estates for their sustainable forest management projects or reforestation.

Besides that, in certain areas where wood resources are scarce due to predatory use, charcoal production in sawmills has become an important factor in the maintenance of sawmill activities. In the last decade, revenues coming from charcoal production formed a significant portion of the sawmill workers wages. Therefore, one cannot say that “charcoal producers serve as mere recyclers or down-cyclers”.

Possible alternatives for metallurgy production in the Brazilian Amazon

The main problem involving iron production with charcoal as primary input is of a social and environmental nature. The pressure caused by the demand of this input on the primary forest results in imprudent environmental practices as well as in charcoal production supported by precarious labor conditions, unhealthy working environment and low wages.

One of the solutions to solve the problem is silviculture. However, the plantation of forests to produce biomass for charcoal production requires a cycle of at least two decades. The first cut is generally made in the seventh year, followed by regeneration and eventual re-planting of part of the areas. The second cut is made in the 14th year and the last one in the 21st year. It is therefore a long-term investment, requiring great amounts of capital. The investment of great amounts of capital for such a long time and mainly — as already indicated — the high costs of charcoal production with timber coming from silviculture are not assimilated by pig iron companies.

A study made by the Ministry of Environment of Brazil (Brasil, 1995: 53), referring to charcoal supply for pig iron industry in the State of Minas Gerais, recognizes that the custom of using biomass from primary forests without ecological prudence, existent for decades, tends to remain so in that region. According to this study, things have remained so because charcoal from primary forest biomass is significantly less expensive than that from reforested areas, and also because control mechanisms are inefficient. Such statements are correct and very similar to what is happening in the eastern Brazilian Amazon.

Even applications for non-refundable public financing to buy land to be used for reforestation to supply the metallurgy industry in the eastern Brazilian Amazon, as suggested by CVRD, would not solve the case. As already mentioned, it is not only the high cost of the land which makes charcoal from reforestation so expensive, and unable to compete with charcoal illegally extracted from primary forest. This is mainly caused by society's incapacity to stop illegal deforestation, which is even more dramatic when it happens in ecosystems not very well known, such as those in the Amazon.

The document issued by the Ministry of Environment of Brazil (Brasil, 1995: 25), based on experiences in the southeast of Brazil in a pilot program, suggests that changes in technology - with more sophisticated processes to carbonize wood, capable of using pyrolysis gas, methanol, tar and acetic acid - would make biomass from reforested areas economically feasible for charcoal production.

This was also present in the government plans, in the 80's, for charcoal production in the eastern Brazilian Amazon (Brasil, 1989: 272). Despite the existence of more advanced technologies, which add efficiency and re-usage of several wood carbonization by-products, the unsophisticated carbonization methods are still used both in Amazonia and in the southeast of Brazil. Such outdated techniques seem to be still in use due to the strategies of pig iron industries, which transfer charcoal production to a wide network of hundreds of suppliers lacking capital to invest in carbonization equipment in order to use technologies which allow more efficiency and better use of all possible by-products of wood pyrolysis.

Another perspective of metallurgy production in Amazonia is present in studies made by SUDAM and by the United Nations Development Program – UNDP –, which try to identify the main dynamics resulting from industrial extraction and transformation of minerals in the region, pointing out evaluation criteria for development policies, financing and concession of tax incentives. Such studies greatly emphasize pig iron production, reporting it as "reasonably well succeeded activity" (SUDAM/ PNUD, 1997: 89).

With respect to formulation of development policies, the studies state that the timber sector deserves the attention of regional financing agencies and support the allocation of public funds for primary metallurgy due to the potential for generating productive links from pig iron industries already operating in the region. They are convinced that in the medium term such activities could form the base of a metallurgic activity complex for semi-finished products. They base this argument on the fact that the rather recently installed pig iron park in the region is the "first expression of a transformation process and a favorable condition to induce, in the production process, activities resulting from the second generation of metallurgy production in Amazonia" (SUDAM/PNUD, 1997: 58).

The studies recommend the maintenance of primary iron production using the current patterns, i.e. with smelters using charcoal as reductant, indicating that electrical smelters could be attached to the existent industrial plants in order to produce steel. Therefore, the metallurgy companies already installed could use the high furnace structures to manufacture primary iron (pig iron), which would - in its liquid state - be carried to the electrical smelters for steel production. Such companies would then become small producers of steel. They would produce at a significantly lower scale than the integrated steelworks, but would enjoy a guaranteed competitiveness for their product because, according to the study, production in such patterns would demand investments compatible with the company's dimension and the energy consumption of the electrical smelters would not be very high: less than 300 kWh for each ton of steel (SUDAM/PNUD, 1997: 58).

The study recommends that agencies supporting regional development programs, responsible for the allocation of public funds, take into consideration the necessity of actions aiming at the implementation of small steel factories in the region, in the medium term, when analyzing projects applying for tax and credit concessions (SUDAM/PNUD, 1997: 141).

The construction of small steel factories is an idea that will probably be pursued by the metallurgy industry in the region. And as already indicated, it seems evident that in order to bear the costs of charcoal produced under ecologically prudent bases and sustained by social relations which respect the labor protection laws, pig iron companies will have to advance in the direction of producing goods with higher aggregate value. This may be done through the operation of small steel factories, operating with electrical smelter. However, it is not a good idea to add to this alternative the indication that an environmentally prudent solution for charcoal production would be biomass from babaçu coconut, as suggested by the SUDAM/UNDP studies (SUDAM/PNUD, 1999: 71).

The suggestion of installing small steel factories does not solve the main socio-environmental problem in the region: the iron ore processing in the region, linked, as already mentioned, to the harmful effects caused by charcoal production. On the contrary, they can be even worsened. Such indication does not take into consideration the social dynamics, which enhances the fact that no efficient measures are taken to prevent illegal deforestation for farming as well as for timber extraction to supply sawmills, the Amazon forest and the savannah in the State of Maranhao will be largely explored as sources of biomass for regional charcoal production, even when this charcoal is used to support an activity which will produce merchandises with more aggregate value than pig iron.

The lack of attention to this fact is also one of the greatest limitations of the proposal submitted by the Pro-Natura Institute to establish a sustainable supply of charcoal for regional metallurgy industries. The proposal suggests charcoal production in a large scale from *babaçu* coconut. This would be financed by public funds and possibly a credit for carbon sequestration (Instituto Pró-Natura, 2000: 7). However, with the public administration lacking power to control illegal deforestation, this alternative will have to compete with charcoal produced from other biomass sources, spatially concentrated and produced without any environmental prudence, using sawmill leftovers as well as deforestation for farming. Therefore, the economic feasibility is based on the overexploitation of labor force, disseminating undesirable labor relationships, which are so common in charcoal production from primary forests. Besides that, within this context, charcoal production from *babaçu* coconut may represent a risk for environmentally prudent and well-succeeded extractive activities, related to babaçu use for other purposes, such as oil and soap.

Therefore, the pressure over the vegetation cover would be reinforced by the metallurgy industries, without any ecological prudence and with undesirable labor relationships. The main factor that would break such practices would be the non-acceptance of the division between charcoal production and metallurgy production. These businesses must not be treated nor controlled as independent businesses. Metallurgy industries must be held responsible for the origin of the charcoal consumed by them and be fined for not abiding by the environmental rules regarding access to primary forests biomass.

It is not enough that metallurgy industries indicate that the charcoal comes from sawmill leftovers or from deforestation for farming purposes, assuming - very conveniently - that these are environmentally legal activities. They do not take responsibility for verifying the origin of the biomass which is supplying charcoal production and constantly postpone the terms to make their charcoal supply a sustainable one.

Only a very severe public control of the origin of the biomass and labor relationships supporting charcoal production may help to revert the social dynamics reinforcing the predatory exploitation of the natural resources of the eastern Brazilian Amazon, the chaos in the several urban spaces, the conflicts in the hinterland and land conflicts, intensifying low wages and unhealthy working conditions. Such dynamics allows a cheap charcoal production, which is of fundamental importance for independent pig iron producers, and represents a cruel transfer of private costs to the society.

However, public capacity to control socio-economic conditions which form the base of charcoal production is something that was not historically possible in the southeast of Brazil and there are no indications that it will be possible in the eastern Brazilian Amazon.

The historical incapacity of public administration to control charcoal production in Brazil; the increasing demand for charcoal by pig iron industries producing undesirable labor relationships and environmental impacts which may compromise the functional integrity of several ecosystems in eastern Brazilian Amazon; plus the metallurgy industries trend in the southeast of Brazil to replace charcoal by new energy sources makes us think that there are feasible alternatives on the medium term for regional production of primary iron. Such alternatives may be effective with the introduction of production techniques not linked to charcoal as the only energy source, which would benefit the Amazon region as an alternative for primary iron production and processing.

Such alternatives for primary iron production without charcoal became even more attractive when Petrobras announced that the largest natural gas reserve of the country is located in Amazonia, in the basins of the Jurua and Urucu rivers, in the State of Amazonas, where the gas piping system between Urucu and Coari is already operational and the gas piping system between Coari and the capital of the State of Amazonas is being projected, with a possible extension to Maraba, in the State of Para. Such reality justifies the introduction of possible alternative paths for primary metallurgy production in the eastern Brazilian Amazon, replacing charcoal by natural gas in the primary iron production. The result of primary iron production with natural gas is a product called foam iron. This type of primary iron is used, just like pig iron, by the small electrical steel factories.

Obviously, the mere substitution of charcoal by natural gas could important, but not sufficient to achieve sustainability.To induce sustainable economic processes need to establish a new vision of the relationship between material and energy flows, their conversion into values of use and the intervention of social institutions in a framework of indicator systems which include at least four main dimensions: social, ecological (considering energy and material flows), economic and institutional. If we disregard only one of these dimensions, we run high risks to fail in our intentions to project future sustainable societies.

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