THE BIOCHAR: an alternative energy for the development of the Sahel countries[1]

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INTRODUCTION

The amazing demand for energy that we have experienced, from the beginning of the industrial era to the 19th century, comes from the economic and political structure of society which has an unconditional threat of depletion of fossil energy resources. In one hundred and fifty years, the amount of energy available to us has been increased to 100% or even 1000%.

In such a situation, where warming of the climate system is unequivocal, the Sahel countries such as Senegal and Mali are stroke by a crisis that is felt in all sectors: economy, energy politics, environment, health, education and the lives of the people (power cuts, food crisis, high transportation costs and housing etc.). Two thirds of our energy needs come from oil and natural gas. For the most pessimistic, resource stocks should keep us going for another 75 years (VIE, 2009). And yet there is considerable pressure on forest resources 40,000 ha/ year (FAO, 2007) and a proposed progressive suppression of government subsidy on gas 36 ha/year billion, in 2007, for 148 000t of consumption).

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[1] Case study of Senegal and Mali

In the sub-region, the use of energy remains a component to be taken into consideration in the field of natural resource management. Financial constraints mean that over 85% of Senegalese or Malian energy consumed for cooking comes primarily from wood. Both countries have limited energy resources. Wood and charcoal represent 57% of the energy consumption of these two countries. The bulk of the oil consumed is imported. Petroleum products weigh heavily on the trade balance; in 2000, the bill, in Senegal, was $ 248 billion, amounting to 22,5% of all imports, and potential water power is estimated at 1,400 MW on River Gambia and River Senegal (Department of Energy, 2008). As far as Mali is concerned, all domestic fuels (wood and charcoal) come from the national forests. Consumption of these fuels is about 6 million tons in 2002. Consumption of firewood increases of about 2 to 3% per year for households. This growth reaches 20% for households in the capital Bamako. So the overall energy consumption of Mali was 3.212.559 ton oil equivalent (toe) in 2002. This energy comes mainly from biomass (81%), petroleum products (16%), electricity (3%) and renewable energy use to an insignificant level.

This energy imbalance becomes repetitive with population growth which in turn induces an increase of daily needs. Added to this are insufficient and erratic rainfalls. Water deficit, along with the poverty of vegetation and soil, is a major constraint to agricultural activities. Worst, Senegal and Mali are not well endowed with raw energy.

From this perspective, the expected risks will be not only a shortage or unavailability of gas especially in rural areas, but also a return to traditional fuels as well as administrative and technical constraints to the promotion of alternative fuels and new cooking stuffs. So, the limited reserves of fossil fuels compel us to reflect on our energy sources, despite the technical, economic and political challenge that it represents.

Renewable energy which contains considerable potential, just waiting to be exploited, then constitutes a lasting solution. For instance, we have the biochar or "Green Coal" which is a component of biomass energy and aims to foster its development in order to reduce CO2 emissions, facilitating carbon sequestration and ensure energy security through modes of transformation of existing biomass (*Typha australis*, rice husk, cotton, millet, sorghum and corn stalks and all agricultural residues and wastes). The valuation of biochar is a new alternative experimented in the Sahel. This area has very good potential and allows a particularly interesting area of study within the area covered by Senegal and Mali (respectively in the Senegal River Delta and the Niger Basin). Certainly one can legitimately wonder why a study of the strategies developed to enhance the biochar in Senegal and Mali was chosen. After all, these two West African countries share, to a large extent, the same socio-economic practices and policies. Apparent facts permit to understand the rationality of the formulation of the problem of the topic. Raw materials, consisting mainly of *Typha australis*, rice hulls and peanut hulls, are available at the area in all seasons. In fact, *Typha australis,* the aquatic perennial grass, covers an area of 6.500 hectares in Senegal, this represents an average potential of about 900.000 tons of fresh biomass. Energy recovery of this biomass could produce about 65,000 tons of biochar or 37.000 PET 18% of annual consumption of charcoal in Senegal (GIZ, 2009) also representing 940.000 tons of CO2 credit. This biomass which is considered a threat to ecological and social balance in the Sahel is a wealth of energy, after conversion to fuels and kindling charcoal briquettes, without binding substances. Thus, we must note, at this point, a 20 years availability of production sustained by a regeneration cycle of 8 months of *Typha*.

Keeping these assets in mind, the valuation of biochar helps to reduce logging energy in the Sahel and is an alternative energy source to traditional fuels.

EVALUATION OF DOMESTIC FUEL CONSUMPTION

National energy assessments (SENEGAL-MALI, 2008) confirm the main trends in the Sahel countries. There is a preponderance of biomass-energy in the supply and final energy consumption. The Malian national forest estate is about 100 million hectares, producing nearly 21 million ha (DNE, 2009) and the area is controlled by more than 350.000 ha. As for Senegal, forests in the public domain, composed of the classified area of the state covering an area of 7.143.579 ha plantations governed, totaling 11.941 ha (DEFCCS, 2005) and forests managed by local authorities cover an area of 6.525.324 ha (FRA, 2005). Forest area and productivity are in perpetual decline. Biomass accounts for more than 90% of domestic energy source of the territory «Senegal-Mali», suggesting that other conventional products still play a marginal role in the field. The approaches used to replace the fuel by other energy sources, particularly gas and oil, have not had the expected success to date, although just over 100.000 tons of liquefied gases are consumed each year in Senegal. Unlike Mali, consumption rose from 3.428 tons, in 2004, to 8.030 tons, in 2008, representing an increase of 134% although the share of this fuel in final energy consumption is still very low, 0,4 % (DNE, 2007). This significant deforestation in the Sahel is perceived by some authors as the most disturbing and most alarming of all anthropogenic causes. Until the advent of the great drought that began in the late 1960s, nobody was talking about shortages of firewood or wood energy crisis. The supply of

wood fuel was by far superior to the demand and the firewood was regarded as an infinite resource. Deadwood burned as firewood and charcoal provided the necessary energy for cooking food and agricultural processing. Wood fuel was virtually the only source of domestic and professional energy in rural and urban areas.

But the prolonged drought upset Sahelian society in many ways. Among others, it caused a massive rural exodus of so-called "drought" or "environmental refugees". While the average increase of urban population of the Sahel countries is estimated at 600% during the last forty years, this concentration of population in urban areas created a strong demand for wood energy. To meet this growing demand, an economic sector has made in professionalizing the operations of transport and trade of wood energy.

Currently, wood and its derivative, charcoal, still meet 70% of the needs of Senegalese and Malians. The use of gas, electricity and renewable energy is still too expensive. And as the populations of the Sahel are among the poorest on the planet, they are highly dependent on wood energy and grow exponentially. Under these conditions, local populations, woodcutters and charcoal makers exert virtually uncontrollable environmental pressure and destroy classified forests to feed the lucrative markets of Dakar, Saint-Louis, Thies, Bamako, Segou, Koulikoro, etc. Furthermore, it becomes a commercial product whose price is constantly increasing, while demand is steadily increasing, 1,6% per year for fuel wood and 4,1% for the charcoal. And as a result, an observation of family structure, consumption of 0,5 kg of wood per person per day in the families of more than twenty people and rises to more than 2kg of wood per person per day for nuclear families (household under 5 persons).

Various surveys have shown that the heat demand associated with the food were increasingly difficult to satisfy in the Sahelian

countries, and rural and urban households were spending a considerable time or budget to the satisfaction of these basic energy needs. In both countries, there were about 500 or 700 kg per capita per year, which represents the equivalent 1,9 to 3,3 kcal, 87 to 90% of this wood for cooking. The significantly higher consumption can be explained by the fact that in the Sahelian zone, the wood is usually free and is closer to the concessions. So the first question to be asked is what form of energy is the most "ecological economic"? Or what solutions need to be advocated to reduce deforestation? For example, a qualitative comparison is made between-individual domestic fuel alternatives, and it turns out that the biochar, or green charcoal, is best. It is a very effective substitute product which is much appreciated by Senegalese and Malian consumers. But what kind of biochar is it? Who are the promoters? And what are the manufacturing processes?

THE BIOCHAR AS A SOCIALLY DESIRABLE ENERGY EFFICIENT PRODUCT

The green charcoal, or biochar, is a solid fuel with properties similar to renewable fossil coal. Obtained by the transformation of *Typha australis*, rice husk, mud, or coal dust, in the form of sticks and briquettes. It is intended as a substitute for wood energy, currently provided by woody biomass. That is to say the biodegradable fraction of plant and animal products, waste and residues from agriculture, forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste – sludge STEP, to agribusiness, and biological sludge – (DAMIEN, 2008).

Presented in the form of granules, after carbonization, it is easy to use, smokeless and odorless, and offers an energy density of 22

GJ per ton. Given these properties, the biochar proves an interesting product, which is timely in the Sahel. A Sahel that is characterized by a change of climate, accelerated deforestation, depleted soils exposed to erosion, as well as recurrent floods, accompanied by difficult socio-economic conditions. The African political organizations and local public/private have understood that early on. And it is this perspective that family firms based respectively in Senegal and Mali are investing in this field for almost eight years. This is the *Bureau de Recherche/Action pour le Développement Solidaire* (BRADES) and the Economic Interest Group (GIE GREEN-AFO). The question that may be interesting here is why the choice of these two companies, knowing that there are ten units of biochar in both countries for at least 15 years. The reason for this is simple: these two companies are the only to produce a biochar which is similar to charcoal, at a very tolerable price, and which is adapted to the conditions of Sahelian households.

The Office of Research/Development Action Solidarity (BRADES) is a family business, based in St. Louis in Senegal. It was created in September 2007, by Nthié Diarra, economist specialized in the production and marketing of bio-coal briquettes made of clay and coal dust. Its objectives are around three points:

- Supplying household in Saint-Louis with good quality alternative domestic fuel at acceptableprices;
- Contribute to the preservation of forest environments by reducing the need to supply the city of St. Louis in charcoal;
- Creating jobs at the local level and especially among the youth and women.It is supported by *Crédit Mutuel* of Senegal, and the program PERRACOD/GIZ. This small company is registered in accordance with the recommendations of Rio and commitments to the Kyoto Protocols. Since 2007, it has produced at least 165

tons of dry bio-char, 92% of which were sold (BRADES, 2012). These results have earned him SEED AWARDS prize, in 2011.

The AFO-GREEN (AFOVERT GIE), as the BRADES, is a family business, based in Niono, in Mali. It was created in January 21, 2010, under references: NINA: 51009196199001K-TIN: 086122261M-RCCM MA.BKO.2010.C.274, by Ousmane S. SAMASSEKOU, engineer of Forestry Commission. He developed over 22 years of business outreach-energy substitutions and cheaper cooking equipment. The objective of this company is to help control energy demand, which is among the overall objectives of the implementation of the SDA Basin in Niono. Recent studies conducted as part of the development of the Master Supply (SDA) of the city of Niono, showed that the total annual production of wood energy amounts to 440,882 tons. This represents a total annual need of 56,545 tons of wood energy for the city of Niono, while the proliferation of *Typha australis* and water hyacinth in the irrigation canals of the Niger Office has always been an environmental problem while it is possible to replace traditional fuels. It is in this perspective that *Afo Vert* has set up a production dry twig and charcoal briquettes made from *Typha australis* and rice husks at the urban council of Niono.

PRODUCTION PROCESSES AND TECHNIQUES USED

The technologies used are simple and less cumbersome. BRADES uses the compaction system, while AFO Vert resolves to densification. The technique of simple brickwork (without charring), and the technique of bio-char is the most applied. And among agricultural residues and wastes used, rice hulls do not need any prior treatment, given their fluidity; simply compacting the hot

(200°C) for single briquettes. The cattail requires pre-hashing before briquetting. Coal dust requires some refinement before mixing. Carbonization is applicable to all wastes, but in the case of these two companies, technologies are different especially as the raw materials are not the same.

At the BRADES, we must remember that the dust consists of a poor quality coal from the bark, twigs and leaves, mixed with the soil sand. It has high ash content and a PCI lower than the charcoal quality (DAMIEN, 2008). So, it just needs to be agglomerated with a binder such as clay, as is the case here with 4 to 8% for briquettes that burn like charcoal. These two raw materials, mixed with water, are agglomerated using a rotor- Press Haiti type craft with a production capacity of 60kg/H.

After three days of aeration, the biochar is packaged in bags of 1kg, 5kg to 25kg. However, coal has a limit in relation to wood energy it uses in its production. It has been shown that 80% of fuel input is lost. The mean NCV of charcoal is 30 MJ/kg and density between 0.10 and 0.19 (DAMIEN, 2008). But for the biochar made by BRADES, cooking tests were made. The results are shown in Table 1 of Appendix 1.

As for the AFO-GREEN, its technology is more complex and requires more space for production. There are a chain of devices connected to each other in a particular order indicated after the production process. For the transformation of *Typha*, for example, the process begins with mowing at the areas of crops (irrigation canals). The rods are then put into the crusher after drying in the open air. Once the crushing completed, the product triturated passes through the conveyor to achieve the dryer, which is provided with an oven that provides heat. The temperature reaches 180°C ~ 250°C. Once dried, the product passes through another conveyor to finally find the

"Mixing storage" and the machine with toggle (Biomass Briquette mills) or screw press which transforms under a high temperature fuel shive (finished products). The charcoal briquettes are then electrically charred for the PC biochar of the value of 20,000 kJ / kg unlike charcoal which your PC is 29,000 KJ / kg (AFO VERT, 2010).

SOCIO-ECONOMIC AND ENVIRONMENTAL IMPLICATIONS

In Senegal and Mali, a large number of households are facing crippling inequalities in terms of supply and demand for energy, for health, environmental quality, economic and individual freedoms. Inequalities tend to be interrelated and therefore, many are forced to live in precarious conditions.

With the use of biochar, you can improve very quickly and at relatively low cost living conditions of the Sahelian population This observation is predictable, with the assessment of positive and negative impacts of the types of biochar presented by the BRADES and AFO-GREEN. It would be useful to note that, in general, the logs in the production of fuel briquettes and charcoal from *Typha australis* rice husk or coal dust have negative impacts on relatively minor scale on the physical environment, the biological and human aspects. These negative impacts are mostly reversible. And most of the positive impacts are both direct and indirect with some bearing on the short, medium and long term. These types of biochar, obtained by agglomeration of coal dust or agricultural residue (cattail and rice husks), are likely to occur in several areas.

ENVIRONMENT SECTOR

Apart from its function as a substitute for fossil fuels, the use of biochar plays a vital role in environmental conservation. Among these advantages:

● It reduces deforestation generated by excessive exploitation of forest resources;

● It helps in the fight against invasive plants (*Typha*). On the banks of the riverSenegal, the cattail has colonized more than 20.000 ha with the advent of the two dams. Several organizations, national and sub-regional, are increasingly interested in the possibilities of use and processing of this aquatic plant to control its proliferation. Reason why, the Office du Niger spends more than CFA 100 million/ year for cutting of *Typha australis* weeds). Operation could offer several potential uses in terms of energy, crafts, food, medicine etc. Since 2001, actions are developed for the recovery of this important biomass as an alternative energy source (Afo Vert). The amount of harvestable dry matter per hectare is estimated at a minimum of 25 tons.

● It allows the recycling of urban waste (dust coal) and very bulky agricultural residues. In the area of Saint-Louis, the maximum biomass potential is about 400 tons of coal residues available annually at the 95 "coal parks" and the average annual potential is 397 818Kg.

● It fertilizes highly degraded tropical soils through the use of natural fertilizers. Because this material is very effective for fixing soil nutrients, and allows a better flow of water.

● It has a storage capacity of carbon. According to PRONATURA, the emission of CH_4, avoided per ton of charcoal produced is 1,5 t CO_2 – equivalent. This value is

an average of emissions from the traditional carbonization techniques less sophisticated in the Sahel. Avoided burning of unused biomass reduces from 0,06 kg of CO_2 –equivalent per ton of biomass used in the production of green charcoal. In short, the biochar reduces CO_2, CH_4 and NO_2 from combustion of agricultural residues. At this point, it is worthwhile to note that it gives off no smoke, no odor in its application processor. In addition to these qualities restoration of the environment, the field operators as BRADES, reinvests a portion of profits obtained in reforestation.

SOCIO-ECONOMIC SECTOR

The use of biochar as an alternative has many advantages at the social level:- It may reduce the burden on women and children who must walk at least 20km in the Sahel to stock up on wood.

- It contributes to the creation of local jobs. The example of the two companies mentioned in this study, demonstrates this. The BRADES has 7 permanent employees and 13 in perspective.
- It is cheaper financially, because the observation has been made by households in Bamako and Saint-Louis. The same amount of charcoal used per day is equivalent to the same amount of biochar or even less with a 50% thrift corresponding to CFA 250 per meal. So in one year, it is possible to save FCFA 150,000 (€228).
- It allows the creation of income generating activities, youth and women groups are part of the distribution and sale of biochar to get back the 40% of the profit from each bag sold (1) or open an account saving (2) for other related activities.

These funds were used to finance income-generating activities such as sewing, dyeing, training etc.

ENERGY POLICY AND STRATEGIES FOR THE PROMOTION OF BIOCHAR

In the typology of our socio energy context, energy consumption depends on the Sahelian population, the distribution of income, their level of economic activity by sector, the level of prices and biogeography conditions.

Access to multiple technology products is greatly reduced with a very low purchasing power. In this regard, the biochar is an appropriate solution to meeting energy needs. The Senegalese and Malian states have subsidized gas to make it more accessible to households, but the rate of demand is increasing. In 1994, the demand was 14,48% and the consumption reached 68,250 tons, in 1997. Today, the growth rate is about 5%.

So, the problem is not necessarily to design a technological solution (in most cases, it exists) but to develop a set of measures to ensure appropriation of technological tools (technology transfer) that satisfies this need.

And it is in that sense that BRADES and AFO VERT have listed well founded objectives:

- Fight against climate change.
- Reduction of greenhouse gas emissions.
- Removing barriers to conservation and energy efficiency.
- Awareness on the use of Renewable Energy.
- Training in advocacy on climate change phenomena and their impact locally.
- Training on cooking techniques.

● Research and development in collaboration with NGOs, academia for inexpensive and efficient energy policies.

Thus, in the pursuit of their objectives, they have set up initiatives for the involvement and empowerment of local people, in partnership with public/private actors operating in that field such as the Energy Division of Senegal and Mali, AMADER (3), the World Bank, the PERACOD, SEED, PREDAS/CILSS, CERER, NWRC, SAED, PROGEDE, PRONATURA NGO etc. Together, they have taken a range of measures to promote their new alternative fuels through a range of incentives and profit sharing, but also broadcast by the organization of competitions in culinary days, commercials, to radio and television. The continuation of experiments to improve the quality of products, the extension and dissemination of results and achievements in the towns and villages will increase awareness of this fuel. In this context, the sale of briquettes and stoves at competitive prices compared to charcoal furnaces and related, will guarantee its acceptance and its generalization to the household level. A policy of encouraging small-scale briquetting rice husk, cattail, pulverized coal and stores for promotion must be established and developed.

But even better, a good legislation and regulation of products sold must be established, it is sufficient to simply remove the political obstacles, to regulate and legislate laws on domestic renewable energy for a better product distribution. Until then, introductions and guides were presented in the field of renewable energy, but it remains to specify biomass energy.

CONCLUSION

In the Sahel, beyond a fad, the biochar is more than one way as a power of great interest, as part of alternative strategies or diversification of energy supply. Its contribution to economic development and rational is undeniable. It not only contributes to the vulnerability of agricultural production systems and the fight against greenhouse gas emissions, but also promotes the proliferation and diversification of income generating activities, by providing, in a decentralized and flexible way, an energy that the current classical programs of rural electrification can consider improving significantly in the short to medium term. Given its multi-sectoral response, the development of biochar in the Sahel is an advantage to establish a favorable diversification of agricultural production in the service of food and energy self-sufficiency and contribute to the ecological balance in the Sahel. However, the successful implementation this project requires a strong involvement of public and private stakeholders to facilitate the flow, and allow access to the Sahelian households.

NOTES

1. In the procedures for sale of BRADES, 1kg bag costs CFA 100 to 150, but retailers such as women and youth take the credit, and only pay for 60 francs per bag to get a profit of 40 francs per bag
2. Some women's groups in St. Louis have come to an agreement with the BRADES, on the benefits of biochar sold locally. They are intended to manage their deposit account for joint projects or the effectiveness of other related activities
3. Malian Agency for the Development of Domestic Energy and

Rural Electrification (AMADER) is a public national institution of an administrative nature (EPA), governed by N° 90-110 Act establishing basic principles of creation of organization and functioning of public establishments of an administrative nature. It is created by the 03 06/ AN-RM Act of May 21, 2003. The AMADER is placed under the guardianship of the Minister for Energy. It does not have exclusive jurisdiction in the implementation of domestic energy policy in Mali. However, it centralizes all the achievements in the sector to inform the government of Mali. It monitors and supports the AFO – GREEN in all its activities.

REFERENCES

AMGLUNG, T.; DIEHL, M. *Deforestation of tropical rain forests*. J.C.B Moor, 1992.

BURCH, William; R JM**.** *Reading in ecology, energy an el human society couteux porary*. New York, 1977.

DAMIEN, Alain. *La Biomasse Energie*, DUNOD, 2008.

DIRECTION DE L'ENERGIE DU SÉNÉGAL. Rapport coopéré (ECONOTEC, gTz, PERACOD, Intelligent *Système d'information énergétique du Sénégal : un outil d'aide à la prise de décision* Energie, UEMOA, la Francophonie), 2007.

_____. *Bilan énergétique du Mali*, 2009.

DURANT, Berbard. *Energie et Environnement:* les risques et les enjeux d'une crise annoncée. France: EDP Sciences, 2007.

ENDA/Energie. *Rôle des énergies renouvelables sur le développement des activités productives en milieu rural oust Africain*: le cas du Sénégal. Rapport final mars, 2006.

FAO. *Forests and energy in developing countries*. Rome, 2007.

FELLOUS, Jean Louis; GAUTHIER, Catherine. *Comprendre le Changement climatique*. Jacof, 2007.

GOUDOJNIK, G. *La révolution scientifique et technique de l'écologie*. Moscou: Edition du progrès, 1980.

HAYES, Denis. *Quelle énergie pour le Tiers- monde*. Copyright Word Watch Institue, 1979.

KAMTO, Maurice. *Droit de L'environnement en Afrique*. Edicef/ AUPEFEL, 1996.

MATHIS, Paul. *Les énergies renouvelables ont-elles un avenir?* Paris: Le Pommier, 2004.

MEUNIER, Fracis. *Domestiquer L'effet de serre-énergie et développement durable.* Dunod, 2005.

N D O N G J-B. *L'évolution du climat du Sénégal et les conséquences de la sécheresse récente sur l'environnement*. Th. Doct. Univ. Lyon III, 1996.

THIOUNE, Lamine. *Le Biocharbon quelle opportunités pour le Sénégal*. Dossier Environnement, 2009.

APPENDICES

Appendix 1:

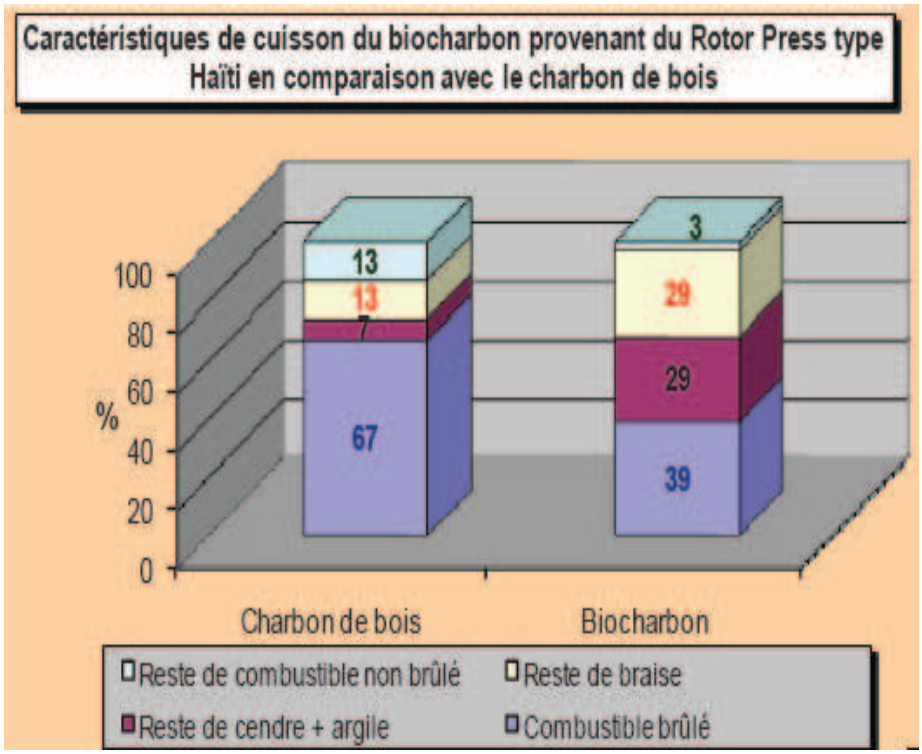

Diagram 1: source BRADES, 2011

Photo 1: Source BRADES, 2011

Photo 2: sticks of AFO VERT

ABSTRACT

For thirty years, the international energy situation has been characterized by a growing demand for domestic energy. The steady increase in world population has led to increased deforestation, strengthening then, climate change and pushing applicants to use the maximalist practices of natural resource use. Scenarios of the International Energy Agency showed that the actual energy demand will grow from 1,6% to 2% per year, and therefore it will increase by 50%, in 2030 (JLFELLOUS; GAUTIER, 2007). This crisis is not an exception in the Sahel region, which has considerable potential for biomass energy. Wood and coal, 89% of energy used in the Sahel, are currently available, but their energy is far from clean. So, to maintain a healthy environment, it is urgent to develop and popularize alternative energy sources such as bio-char, launched in Senegal and Mali since the 90's. Its development is a great interest in the framework of diversification strategies and energy supply in the Sahel. Its popularization would, moreover, reduce environmental costs, as well as the economic and social impacts of these environmental problems that limit the development capacity of the Sahel.

KEYWORDS: Biochar. Alternative energy. Development of the Sahel.

RESUMO

Por 30 anos, a situação energética internacional tem sido caracterizada por uma procura crescente de energia doméstica. O aumento constante da população mundial tem levado ao aumento do desmatamento, fortalecendo, em seguida, as alterações climáticas e empurrando os candidatos a usarem as práticas

maximalistas de uso dos recursos naturais. Cenários da Agência Internacional de Energia mostraram que a demanda real de energia vai crescer de 1,6% a 2% ao ano e, portanto, aumentará em 50% em 2030 (JLFELLOUS; GAUTIER, 2007). Essa crise não é uma exceção na região do Sahel, que tem considerável potencial para energia de biomassa. A madeira e o carvão, 89% da energia utilizada no Sahel, estão atualmente disponíveis, mas sua energia está longe de ser limpa. Assim, para manter um ambiente saudável, é urgente desenvolver e popularizar fontes alternativas de energia, tais como bio-carvão, lançado em Senegal e Mali desde os anos 1990. Seu desenvolvimento é um grande interesse no quadro das estratégias de diversificação e fornecimento de energia na região do Sahel. Sua popularização poderia, além disso, reduzir os custos ambientais, bem como os impactos econômicos e sociais desses problemas ambientais que limitam a capacidade de desenvolvimento do Sahel.

PALAVRAS-CHAVE: Biocarvão. Energia alternativa. Desenvolvimento do Sahel.