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ENERGETIC FORESTS

INNOVATION FOR SUSTAINABILITY

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Embrapa

Agrienergy
Forestry

Brazil has a public agenda for the agrienergy business[1].

The growing challenges in the areas of production, innovation and supply demand changes in the national agricultural policy. The opportunity for Brazil to lead the new energy matrix is based on biomass energy which brings together the platforms of ethanol, biodiesel, energetic forests and co-products & residues. With the recent benchmarks, the Brazilian agrienergy program focuses on the key challenges of the agricultural and industrial renewable energy production, supported by gains in technological innovation and sustainable production systems.

The achievement of the agrienergy expansion requires the alignment of various government policies such as tax policy, supply, agriculture, land, credit, energy, science and technology, environmental, industrial, international trade and foreign relations, and if required, a new specific legislation.

The agrienergy business is a typical public-private partnership and requires the development of new institutional, technical-scientific and production arrangements.

Forest plantations aim, mainly, at the production of biomass (firewood and charcoal) for energy conversion (heat, bioelectricity and new products) and to avoid the deforestation pressure on the natural vegetation of Brazilian terrestrial biomes (Cerrado, Caatinga, Atlantic Forest, Pantanal, Pampa, Amazon).

[1]Document elaborated in support to the Research, Development and Innovation platform of "Energy Forests", described in the Brazilian Agroenergy Plan (PNA 2006-2011).

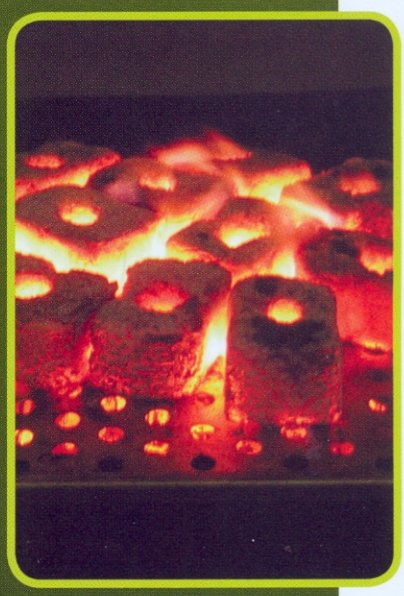
Brazilian challenges in the areas of production, innovation and supply.

The Brazilian challenges in the areas of food production, energetic biomass and forests (fiber/paper/pulp) are focused on five dimensions: economic, social, environmental, regional integration and globalization.

The Brazilian Agroenergy Plan (PNA 2006-2011), coordinated by the Ministry of Agriculture, Supply and Livestock and carried out with the support of Embrapa's RD&I agrienergy network, aims to "establish a framework and guidelines for public and private actions to generate knowledge and technologies that contribute to the sustainable production of the agriculture of energy and for the rational use of renewable energy. Its target is to turn the Brazilian agribusiness competitive as well as to support specific policies, such as social inclusion, regional and environmental sustainability".

The classical production factors (land, capital and labor), although necessary, are not enough to meet the criteria for a competitive and sustainable agriculture, forest and livestock activities. Accordingly, the socio-economic and environmental issues, as well as business opportunities, require the continuity of the agricultural policy as a provider of national guidelines.

The definition of priorities is powered by criteria which establish the sharing of actions, results and impacts of collective effort, based on the organization and integration of technological innovations in sustainable production systems.



Vision on Forest Energy - **World**

About 5% of global energy demand are met with the direct burning of wood. Two decades ago, from the total of 472.3 Mtoe produced from wood worldwide, the largest users were Asia (46.0%) and Africa (30.0%); North America (8.0%), South America (8.0%) and Europe (7.1%), occupied the intermediate range of consumers, and the Pacific (0.8%) and Middle East (0.1%) regions, the lowest users (IEA Statistics, 1999).

Although the data are imprecise due to regional variations, the annual world consumption of wood *per capita* is estimated at 0.3 to 0.4 m^3, equivalent to 0.1 toe. The rural sector is the largest consumer of wood for energy. It is estimated that the *per capita* consumption in rural areas is 1 t/year (15 GJ) and half of that in urban ones.

According to FAO (2009), the total area of forests in the world decreased by 125.2 million hectares in the period from 1990 to 2005, which means a 3.1% reduction, or an average annual rate of 0.2% (Table 1). This means that natural forests were cut for commercial or industrial purposes as well as for direct burning as a source of energy.

Table 1. Evolution of Worldwide Forest area.

Region	Area (10^3 ha)		
	1990	2000	2005
Europe	989.320	998.091	1.001.394
Latin America and Caribbean	923.807	882.339	859.925
África	699.361	655.613	635.412
North America	677.801	677.971	677.464
Ásia and Pacific	743.825	731.077	734.243
Mideast (Center Ásia)	43.176	43.519	43.588
TOTAL	**4.077.290**	**3.988.610**	**3.952.025**

Source: FAO, 2009.

Changes in energy consumption of wood in raw and residue forms are strongly associated with the country's development stage. Such use is especially common in rural areas of developing countries, accounting for almost all residential energy consumption. Commonly, the consumption occurs, almost in its entirety, in the production site. Meanwhile, charcoal is consumed in urban and suburban city areas, requiring about 6 m^3 of wood to produce one tonne of charcoal. Thus, this brings about costs incurred in the transportation of both raw material and charcoal, as well as in processing and storage.

A view on Energetic Forests - **Brazil**

Brazil is one of the largest producers and the world's largest consumer of forest products. Strategic sectors of the Brazilian economy, such as steel, paper industry and packaging, and construction, are highly dependent on the forest sector.

According to FAO, the Brazilian forest area is approximately 5.3 million km^2, about two-thirds of the country, being the second largest in the world, surpassed only by the Russian Federation (PNA, 2006).

Wood consumption in Brazil is about 300 million m^3/year, with some 100 million m^3/year of planted forests for industrial use.

The sectors of food and beverage, ceramic and paper production are the main industrial users of forest biomass in Brazil, especially firewood and charcoal. Regarding to charcoal, it is estimated an annual consumption of 6 million tones, especially in the industries of steel and other alloys. The extensive use of wood for energy, including charcoal, is due to its low cost and accessibility, particularly in rural areas. Generally, it is an extraction process, in which the costs of production and processing are negligible. The preference for charcoal refers to the ease of transport and combustion. In 2008, the use of wood (firewood and charcoal) was 29.2 million tonnes, representing 11.6% of total consumption, occupying the fourth place among the sources (Table 2)

Table 2. Brazilian final energy consumption per source - 2008.

Sources	Millions toe	%
Oil derivatives	92.5	36.7
Natural gas	25.9	10.3
Fossil coal (1)	15.7	6.2
Electricity	34.9	13.8
Wood (2)	29.2	11.6
Sugar Cane derivatives (3)	41.3	16.4
Nuclear sources (Uranium)	3.7	1.5
Other renewable sources	8.8	3.5
TOTAL	**252.2**	**100.00**

Source: BEN, 2009, Reference EPE/ MME, 2008

(1) Coal, coke and coke oven gas; (2) Wood and charcoal; (3) Ethanol and bagasse

The forest production converted to charcoal, wood and energy is intended for both domestic and industrial consumption. In assessing the consumption per user sector, the processing sector is responsible for 42% of the total (Table 3).

Table 3. Brazilian wood energy consumption per sector in 2008.

Sector	%
Processing (*)	41.8
Residential	27.1
Agricultural	8.6
Industrial	21.7
Others	0.8
Total	**100**

Source: BEN 2009, Reference EPE/MME, 2008

*mainly for charcoal and in small scale for electricity generation.

Of the 8.5 million square kilometers of Brazilian territory, approximately 63.7% are covered by native forests, 23.2% occupied by pastures, 6.8% by agriculture, 4.8% for infrastructure and urban areas networks, 0.9% for permanent crops and only 0.6% shelter planted forests (Brazilian Association of Producers of Planted Forests - ABRAF, 2005).The area of planted forests, around 5.2 million hectares, is planted with eucalyptus (3.4 million hectares, mainly for coal) and pine (1.8 million hectares).

The main areas of planted forests to be used as charcoal to attend the industrial segments of pulp & paper and steel are concentrated in Minas Gerais, São Paulo, Paraná, Santa Catarina and Bahia states. They account for 78.7% of the total area planted with eucalyptus and pine (Table 4). The state of Minas Gerais is the greatest producer and consumer of forest products.

Table 4. Distribution of Eucalyptus and Pine forest areas in Brazilian states in 2008.

State	Eucalyptus		Pinus		Total	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
MG	1.278.212	30,0	145.000	7,8	1.423.212	23
SP	934.360	21,9	207.840	11,1	1.142.199	18,6
PR	142.434	3,3	714.893	38,3	857.328	14
SC	77.436	1,8	551.219	29,5	628.655	10,3
BA	587.606	13,8	35.090	1,9	622.696	10,2
RS	277.316	6,5	173.163	9,3	450.480	7,4
MS	265.254	6,2	18.797	1	284.051	4,6
ES	210.409	4,9	3.991	0,2	214.399	3,5
PA	136.294	3,2	11	0,0	136.305	2,2
MA	111.117	2,6	0	0,0	111.117	1,8
AP	63.309	1,5	1.620	0,1	64.929	1,1
GO	56.881	1,3	15.198	0,8	72.079	1,2
MT	58.580	1,4	7	0,0	58.587	1,0
Outros	59.496	1,4	850	0,0	60.346	1,0
Total	**4.258.704**	**100,0**	**1.867.680**	**100,0**	**6.126.384**	**100,0**

Source: Statistical Yearbook, ABRAF/2009 – Year Base 2008.

In Brazil, the energy production from planted forests grew significantly in recent years, while the participation of native forests was reduced. The evolution of the traditional kiln furnaces to rectangular ones has contributed to greater efficiency in the use of raw materials. More efficient processes are being gradually adopted, adding value to planted forest products, which reduces transportation costs.

The prospects of using the Clean Development Mechanism (CDM) to reward the "green" steel production renewed the interest for the steel charcoal. There is a search for cleaner and more efficient technologies, including the use of co-products (tar and effluent gas). It is estimated that current production of pig iron (27 million tonnes) needs 17.5 million tons of charcoal, equivalent to a planted area of 3.3 million hectares.

The development of technologies the processing and use of residues, including those from the forest, aiming at reducing production costs and environmental pollution, is the today´s major challenge. The use of residues originated from the proper management of reforestation projects can increase the forest energetic productivity. Although the statistics are poor due to regional biodiversity, wildlife, technology, soil and climate, Woods et al (Environment and Energy, Paper 13, 1994) estimated at 35 EJ / yr (10 GW), the energy potential of residues from forest extraction in the world. Considerable portion of those residues is obtained from the wood-processing plants or from pulp and paper industry.

Brazilian Forest Program

The Brazilian forest activity is sheltered under the Brazilian Forest Program (FNP), established by the Decree Nº. 3420 of April 20, 2000, aiming at articulating the sector's public policy to promote sustainable development, balancing conservation with the use of Brazilian forests, and promoting reforestation activities, especially in small rural properties. It is a program that consolidates the Brazilian governmental actions on forest resources, coordinated by the Ministry of Environment and implemented with the support of CONAFLOR - the National Forest Committee, which is composed of members representing the public and private sectors. After the Decree Nº. 6101 of April 26, 2007, that defined the new regimental structure of the Ministry of Environment, the coordination of FNP was given to the Department of Forests (DFLOR).

PNF activities are important as mechanisms for maintaining and expanding the production base, which is necessary for the sustainability of the forestry sector.

In this context, most RD&I Embrapa's Units focus on the generation of knowledge for biomass production, while Embrapa Agrienergy searches for the processes of transformation of biomass into energy, seeking a more efficient conversion, contributing to the sustainability of the production systems.

The Brazilian Forest Program, seeking to implement the forestry sector, set in 2004 the strategies and targets for the period 2004 – 2007:

1) Expansion of planted forests associated with the recovery of degraded areas:

- Achievement of an annual planting of 600 thousands hectares of forests
- Increase to 30% the participation of small producers.

2) Expansion of the forest managed area associated with the protection of areas of high conservation value:

- Increase to 15 million hectares the area of sustainable managed natural forests in Brazil.
- Ensure that 30% of the managed area are considered as social forests. Decree Nº. 6101 of April 26, 2007.

Demands

The Brazilian productivity of wood in planted forests exceeds that of countries like Canada and the United States, giving to Brazil a distinct position and competitiveness in the global market for pulp and credentials to consolidate its role also in other fields of production of forest goods and environmental services. The country's high competitiveness in the forestry agribusiness is provided mainly by its soil and climatic characteristics as well as by the technological advance in the forestry field.

According to ABRAF (Statistical Yearbook, 2009) the area planted with industrial forests (eucalyptus and pine) is increasing, but not at the rates necessary to meet the demands of forest products. Considering that the assessments are measured by the area of expansion, the annual increases were below the targets set by the Brazilian Forest Program (PNF) of 600 thousand hectares for the period 2004-2007, generating an annual deficit in the demand by planted forest area (Table 5).

Table 5. Evolution of the total planted area in the period 2004 to 2008 and calculated deficit with respect to the goal of 600 thousand ha / year in new plantations[1].

	2004	2005	2006	2007	2008
Planted area (ha)	4.963.511	5.294.204	5.632.080	5.836.610	6.126.384
Annual Increase (ha)[2]	-	330.693	337.876	204.530	289.774
Annual deficit (ha)[3]	-	269.307	262.124	395.470	310.226
Cumulative deficit (ha)	-	269.307	531.431	926.901	1.237.127

[1]Data adapted from Table 1 of ABRAF Statistical Yearbook 2009.

[2]Difference between subsequent years.

[3]Difference between PNF goal and the calculated increase.

In this scenario, the possible resumption of the forest biomass market, will generate a deficit in timber supply over the next decade, due to the long maturation time of reforestation projects, and also to a rate of planting smaller than the rate of use. According to Table 5, the cumulative deficit from 2004 to 2007 is 926 thousand hectares, which if kept at this level, is a strong indication of a potential "forest blackout" in the next decade. It is therefore necessary to implement public policies to encourage the expansion of planted forests, and to increase investments in research, development and innovation (RD&I) to increase the efficiency of use of raw materials.

In the evaluation of the Department of Forests of the Ministry of Environment (DFLOR/MMA), the areas planted (in 10^3 ha) from 2002 to 2007 were 320, 425, 465, 553, 627 and 640, respectively. Numbers are very impressive; however, they took into account the sum of reformed and new planted areas (http://www.mma.gov.br/, accessed on 18/05/2009). The assessment of ABRAF (Statistical Yearbook, 2009) considered the total planted area.

Need for Innovation

The use of wood and wood residues still lacks the refinement of current techniques and development of new knowledge to increase the use efficiency of raw materials.

Innovation must be sought both in forestry and industrial technology as well as in transversal studies.

Forestry Technology

- To identify and to select forest species alternative to eucalyptus, with appropriate calorific value for forest biomass production in various regions of Brazil;
- To define more efficient production systems, considering forestry parameters, management practices, harvesting techniques, production arrangements and integrated planning models.

Industrial Technology

- To develop technologies for synthesis gas production using bio-pyrolysis oil in pressurized gasifiers;
- To develop clean and efficient charcoal combustion technologies as fluidized bed, and pressurized fluidized bed and gasification;
- To develop clean and efficient carbonization technologies and its application for charcoal briquettes from forest residues, to be used by the steel industry;
- To develop advanced and mixed combustion technologies and pyrolysis processes of biomass to produce bio oil;
- To develop more efficient combustion technologies for energy generation and cogeneration from forest biomass.

Transversal Studies

- To zone and delimit suitable areas for forest cultivation;
- To develop local production arrangements considering native and adapted species, and consortia with agriculture and livestock;
- To develop methods for measuring the carbon balance and environmental services;
- To enable development programs for small producers such as the forest farmer.

The contribution of tools such as genetic engineering in agronomic and forestry technologies, as well as those from industrial technologies for efficient use of forest biomass conversion into final products, demand new developments. For the forest biomass traditional uses such as firewood, charcoal, paper & pulp, lumber, sawn wood, resin and essential oils extraction and furniture manufacturing, there is, currently, the need to seek new markets and new products based on processes and innovative technologies.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Thermochemical and biochemical routes for forest biomass conversion into energy, fuels and renewable materials are feasible options to open these new markets providing the means for greater gain. Accordingly, the production of lignocellulosic ethanol by enzymatic hydrolysis, the gasification to produce synthesis gas as well as the synthesis of catalytic synthetic fuel and fertilizers, the fast pyrolysis to produce bio-oil, briquetting and pelleting compaction of biomass and charcoal for the production of solid fuel are potentially attractive.

The full use of the forest, including its residues in the field (thin trunks and branches) and those generated in the industries (sawdust, shavings, slivers and tips) will bring more sustainability and renewability for the forest activity. Forests have the potential for commercial exploitation, also in integrated crop-livestock-forestry production arrangements, which is a strategy for sustainability.

With regard to RD&I, Embrapa leads an ample research project that responds to one of the major Brazilian challenges. The Forest Energy project is carried out by a national research network (involving about 130 researchers from 17 Embrapa R&D Units, 15 Universities, 14 Research Institutes, 11 Forest Development Companies, 4 Cooperatives, 7 Industries and 2 Manufacturers Associations and other institutions) and has the following objectives: a) to establish the groundwork for the expansion of forest crops; b) to develop and optimize technologies for the traditional use of wood as an energy source, c) to develop high added value energy co-products, and d) to contribute to the sustainable increase of the productivity of the forestry chain and its share in the Brazilian energy matrix.

The development of forest production chain in Brazil requires local / regional adequate arrangements in Public - Private Partnerships (PPP), since the Brazilian forest sector is economically, socially and environmentally important to the country and it urgently needs new investment and new policy definitions to allow the introduction of innovative technologies.

Currently, in order to adjust the forest business to the peculiarities of each region of the country, a new forest policy is under discussion in Brazil, especially focusing on the adequacy of the Forest Code (Law 4771 of 15/09/1965) by harmonizing the production and environmental issues.


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