A perspective on competitiveness of Brazil in the global supply of biomass

Javier Cárcel Carrasco
Professor/Investigador de la Universidad Politécnica de Valencia; Doctor Ingeniero Industrial; Doctor en Ciencias Económicas y Empresariales; Ingeniero Industrial y Ingeniero en Electrónica; Ingeniero Técnico en Electricidad. Valencia [Comunidad Valenciana], España. <fracarc1@csa.upv.es>.

Cassiano Augusto Agapito
Mestre em Engenharia Civil. Especialização em Análise Organizacional. BTG Pactual, Energy Desk, Head of Comoditties Energy Services. São Paulo [SP], Brasil. <cassiano.agapito@btgpactual.com>.

Carlos Alberto Mariotoni
Professor Titular da FEC/UNICAMP, Ph.D., e Mestre em Engenharia Elétrica, Engenheiro Eletricista. Campinas [SP], Brasil. <cam@fec.unicamp.br>.

Abstract
In this paper we intend to present an integrated view of biomass production in Brazil. By analyzing biomass potential and biomass production costs we seek to present a broad view of Brazilian competitiveness in the domestic and global energy markets. By mapping out this potential, we want to present the main opportunities for Brazil in its quest for cleaner, more competitive and more sustainable fuel sources. Our estimate of the potential represents almost double the volume that the country produced in 2010. This should enable Brazil to meet 30% of global demand for biomass by 2035. As regards production costs and profits, dedicated biomass has trading conditions to yield the same or more than the most profitable products in the sector such as sugarcane, soybeans or wood. Compared with fossil fuels, the cost of biomass is equivalent to an oil barrel below R$ 40.00, although adequate logistics is crucial for the economic feasibility of biomass utilization. Global demand for biomass will increase in the coming years, both for conventional and modern uses, such as second generation biofuels or biomass gasification. Due to its agricultural potential, Brazil could become a major biomass producer, with great economic and environmental advantages in a world increasingly concerned with sustainability and climate change.

Keywords
Biomass, energy, Brazilian Agriculture, global markets, sustainability.

Una perspectiva sobre la competitividad de Brasil en el oferta mundial de biomassa

Resumen
Se muestra un enfoque integrado de la producción de biomasa en Brasil. Con el análisis del potencial brasileño de la biomasa y también con su los costos de producción se busca presentar una perspectiva más amplia de su competitividad en los mercados internos de Brasil e internacionales de energía renovable. Así, considerándose la distribución de este potencial, queremos mostrar las principales oportunidades para el Brasil en su búsqueda de fuentes de energía más limpia, más competitiva y más sostenible. El potencial estimado significa casi el doble del volumen que el país produjo en 2010. Esto deberá permitir a Brasil contribuir con el 10% de la demanda global de la biomasa para el año 2030. Considerando los costos de producción y los ingresos, la biomasa ha permitido condiciones de comercio para obtener el mismo o más que los productos más rentables en el sector como la caña de azúcar, la madera o la soja. En comparación con los combustibles fósiles, el costo de la biomasa es equivalente a un barril de petróleo por debajo de $ 40.00, aunque la logística adecuada es crucial para la viabilidad económica de la utilización de la biomasa.

CÁRCEL CARRASCO, J.; AGAPITO, C. A.; MARIOTONI, C. A. A perspective on competitiveness of Brazil in the global supply of biomass. **Labor & Engenho**, Campinas [Brasil] v. 6, n. 4, p. 46-52, 2012. Disponível em: <www.conpadre.org> e <www.labore.fec.unicamp.br>.

Palabras clave
Biomassa; energía renovable; Agricultura de Brasil; mercados globales; sostenibilidad.

Biomass as an energy source

Biomass is any type of renewable resource derived from organic matter that can be used to produce energy. Its classifications are forestry biomass, agricultural biomass from agroenergy crops, and biomass from agricultural, industrial or urban waste. The energy contained in biomass is chemical, associated with carbon and hydrogen atoms present in oxidizable organic molecules. The organization and assimilation of these organic molecules and subsequent production of vegetable biomass is the result of a natural conversion of carbon dioxide and water into a type of organic fuel. This process is called photosynthesis and requires the exposure of photosynthetic tissue to solar energy.

When it comes to primary energy output from biomass there is little variation between the available sources, as quantitative mass is based on the dry basis of biomass and therefore has an equivalent calorific value for all types of cellulose matter. There can be significant variations because of water content, however, which has a significant impact on preparation, transport and costs.

The method for measuring the calorific value of fuel is based on energy balance and on the sample's full combustion, which in general takes place with pure oxygen, under a constant volume and upon the transfer of heat to the calorimeter's water. The difference between higher heating value (HHV) and lower heating value (LHV) lies in the final stage of a mix between combustion gas and vapor released during the combustion of hydrogenated substances. If the thermal equilibrium state of the products obtained from the combustion of the calorimeter's water occurs without vapor condensation, the heating value is lower; if the vapor is condensed and the mix is cooled down to its initial temperature (usually room temperature of 25°C), more heat is released to the calorimeter, thus resulting in a higher heating value. Another very important aspect in the use of biomass as fuel is the energy conversion process.

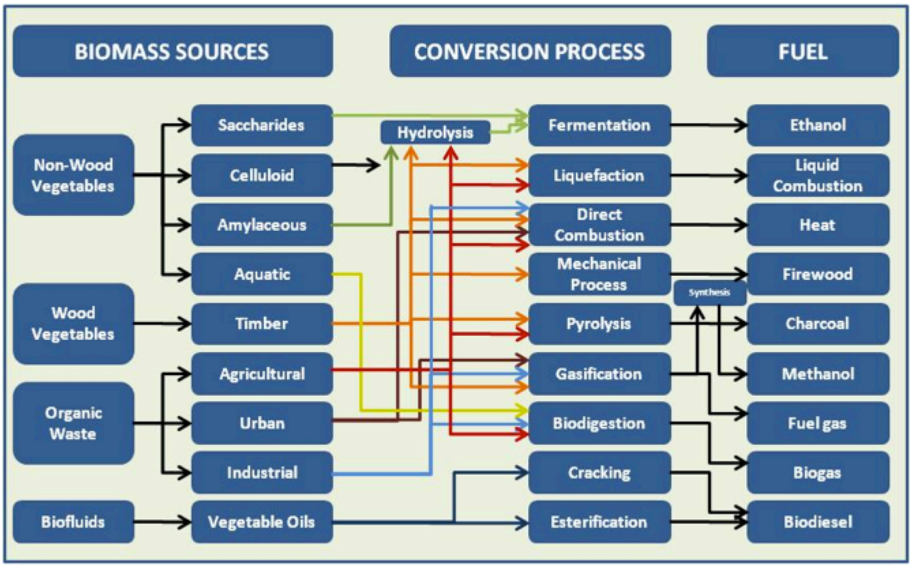

Figure 1. Biomass energy conversion processes.

This process relies on its final utilization purpose – heat, electricity or transport fuel – and on the technological possibilities that vary both in terms of duration and energy conversion efficiency.

CÁRCEL CARRASCO, J.; AGAPITO, C. A.; MARIOTONI, C. A. A perspective on competitiveness of Brazil in the global supply of biomass. **Labor & Engenho**, Campinas [Brasil] v. 6, n. 4, p. 46-52, 2012. Disponível em: <www.conpadre.org> e <www.labore.fec.unicamp.br>.

Biomass availability in Brazil

Brazil is a continental country with innumerous advantages that make it a global leader in the agricultural, agribusiness and wood markets, especially when it comes to products used as energy sources. Among its advantages are large arable areas within socially acceptable standards of environmental impact; the ability to plant multiple crops throughout the year; intense solar radiation; a diverse climate; exuberant biodiversity; a mix of agricultural scientific and technological knowhow specially developed for tropical regions; and a solid and productive agribusiness.

Brazil has a large quantity of unused land and degraded pastures with great economic potential. Another important aspect is crop yields, which have grown continuously due to technological advances.

Table 1. Brazilian land uses.

Land Uses	hectare
Amazon Forest and Protected Areas	405.000.000
Cities, Roads, Water bodies and others	20.000.000
Temporary and permanent crop land	66.000.000
Pasture	210.000.000
Available lands	90.000.000
Other uses	60.000.000

In order to estimate available biomass volume, we need to focus on crops with current and future growth potential, including waste from food crops, energy crops and forestry, as well as agribusiness waste.

Based on this, we will focus on the crops supplied in the Brazilian Agriculture Ministry's Livestock and Food Supply of Brazil Agribusiness Projections for 2010-2021, more specifically on those crops with considerable biomass potential.

Table 2. Brazilian crop production.

Crop	Plantation (ha/ano)		Harvest (ton/year)	
	2010	2020	2010	2020
cotton	910.000	890.000	1.588.300	2.422.900
soybean	24.740.000	30.020.000	68.721.900	86.526.200
corn	12.910.000	13.380.000	52.853.700	65.540.900
rice	2.560.000	1.610.000	12.503.100	13.738.200
sugarcane	9.400.000	11.500.000	624.990.000	1.025.800.000
Wood	6.973.000	9.473.000	250.273.000	340.001.456

Each of these resources presents distinctive availability, production and access characteristics. Estimates about the availability of wood and forest residues are very inaccurate and rely on local circumstances. The availability of crop field and process waste can be more accurately estimated, although field residues rely on harvest patterns and environmental limitations. It should be borne in mind that our biomass availability estimates do not include the use of foodstuffs in biofuel production, but is considering the associated waste.

CÁRCEL CARRASCO, J.; AGAPITO, C. A.; MARIOTONI, C. A. A perspective on competitiveness of Brazil in the global supply of biomass. **Labor & Engenho**, Campinas [Brasil] v. 6, n. 4, p. 46-52, 2012. Disponível em: <www.conpadre.org> e <www.labore.fec.unicamp.br>.

After estimating the available biomass volume in fields and its harvest conditions, we calculated a technical coefficient for dry material production and the technical characteristics for an estimate of the primary energy content of these biomass fuel sources, which enabled us to estimate the physical availability potential and the primary energy content.

Table 3. Biomass availability in the field.

Crop	Biomass availability	Energy Availability	
	Dry ton / ton harvested	GJ/dry ton	boe/dry ton
cotton	1,43	16,00	2,69
soybean	2,13	14,60	2,45
corn	2,00	17,70	2,97
rice	1,82	16,00	2,69
sugarcane	0,40	16,50	2,77
Wood	0,30	19,40	3,26

The dry mass in a specific crop consider the biomass left in the field on harvest and biomass as industrial waste. For wood, we consider only partial destination for energy, using a waste average availability from commonwood processing industries.

Table 4. Brazilian biomass availability.

Crop	Energy Availability			
	(GJ/year)		(boe/year)	
	2010	2020	2010	2020
cotton	36.304.000	55.380.571	6.101.513	9.307.659
soybean	2.132.096.948	2.684.475.355	358.335.621	451.172.329
corn	1.871.020.980	2.320.147.860	314.457.308	389.940.817
rice	363.250.064	399.133.177	61.050.431	67.081.206
sugarcane	4.124.934.000	6.770.280.000	693.266.218	1.137.862.185
Wood	1.456.588.860	1.978.808.474	244.804.850	332.572.853
Total	**9.984.194.851**	**14.208.225.438**	**1.678.015.941**	**2.387.937.048**

Biomass production costs and farmers' remuneration

The use of biomass as an economically viable energy source depends on a valuation of production costs and on competition with other energy sources. An analysis of existing processes in Brazil showed that biomass is mostly used to produce electricity in thermal power plants, heat and power in industrial boilers and to produce biofuels such as ethanol and biodiesel.

The production costs of these processes depend on efficiency and on the type of technology used. However, this is not the focus of this paper, as we intend to analyze the costs of biomass production in the rural areas and for delivery to industries. Our analysis is solely based on biomass produced for energy purposes, known as agroenergy crops – more specifically wood and grass, focusing sugar cane. We believe that an adequate industrial infrastructure for the use of dedicated biomass enables industrial centers to incorporate biomass easily from agricultural and agroindustrial wastes – provided the acquisition costs are lower than dedicated biomass production costs – thus enabling a reduction in the energy industry's costs.

CÁRCEL CARRASCO, J.; AGAPITO, C. A.; MARIOTONI, C. A. A perspective on competitiveness of Brazil in the global supply of biomass. **Labor & Engenho**, Campinas [Brasil] v. 6, n. 4, p. 46-52, 2012. Disponível em: <www.conpadre.org> e <www.labore.fec.unicamp.br>.

Wood and grass crops – especially sugar cane – are mature, large-scale and traditional in Brazil. Therefore, we will use these crops as a basis to identify productivity levels and production costs in rural areas.

Sugar cane production costs are a good point of reference for biomass production from agroenergy crops, as sugar cane is a consolidated and booming sector in Brazil, with good average productivity levels. The prices of sugarcane in "reais" per ton in Brazilian ethanol and sugar market is driven by the amount of recoverable sugar in sugarcane, and the average price over the last three years has averaged at $ 0.30 per kilogram of total recoverable sugar, or the methodology CONSECANA SP – we can say that the average crop was trading at R$ 43.50 per ton. These prices are referred to the state of Sao Paulo for the sugarcane delivered at the mill. This value indicates the farm revenue linked to the sugarcane crop, which can be considered one of the most profitable activities in Brazilian agribusiness.

In our pricing analysis of the energy contained in sugar cane just considered the energy contained in its dry matter biomass. In the opposite direction of the sugar & ethanol industry practices, we disregard the economic value of sugar content of sugarcane. Nevertheless, prices are very competitive and adequate to reward the producer. If we consider a grass crop without the focus on reaching the highest sugar yields, we could easily achieve greater volume of dry mass per hectare, increasing the energy availability without major changes in production costs and harvest. It can be at other grasses crops as elephant grass or even in other species of sugarcane crops with low sugar yield.

Analyzing the forestry sector, among its many purposes, we see that it provides relevant portion of its offer for the energy sector. It basically presents the consumption of woodchips, firewood and charcoal in kilns and boilers for a variety of functions. That usage leads to direct formation of planted forests specifically for energy use, so-called energy forests. These forests often meant 100% of its production to energy production, being well paid for that. In regions with specific agro-industrial or steel industry vocation, the charcoal or firewood markets take significant proportions. USP-CEPEA monitors eucalyptus prices on São Paulo market. Prices are in reais per cubic meters of production and can be easily converted to reais per ton.

Table 5. Equivalent energy costs for biomass at industry.

Agroenergy crop	R$ / ton	R$/GJ	R$/boe
Sugar cane	43,54	6,60	39,25
Eucalyptus Wood	117,40	7,56	45,01

Although dedicated biomass from forestry is not as competitive as that from sugarcane crop, the forestry sector has an interesting characteristic: due to harvesting flexibility and the type of raw material used, standing forests are a live energy reserve which can grow in field even when it is not used. This aspect drastically reduces the risk of supply shortages in the eventuality of crop failure, thus having a positive influence on biomass short term prices and on national energy security.

Results

The biomass available in the Brazilian fields in 2010 was really near of the total national energy demandin that year. The grains crop had a relevant share on that availability but it was almost consisting of sugarcane and wood wastes.

CÁRCEL CARRASCO, J.; AGAPITO, C. A.; MARIOTONI, C. A. A perspective on competitiveness of Brazil in the global supply of biomass. **Labor & Engenho**, Campinas [Brasil] v. 6, n. 4, p. 46-52, 2012. Disponível em: <www.conpadre.org> e <www.labore.fec.unicamp.br>.

Based on biomass production from consolidated agroenergy crops, building on sugar cane current production, and growth projections for the agroenergy sector of up to 30% use of available cropland with 30.000.000 hectare, we estimate a biomass supply potential of 15 x 109 GJ a year, which represents 18% of the global biomass market projected for 2035.

This potential does not include biomass from agricultural residues available in the rural areas, whose inclusion could raise the projection to 25 x 109 GJ a year, thus supplying 30% of global biomass demand. Brazil can explore more than 100 million hectare of unproductive land, including degraded pasture, to food crop. The biomass harvest profits derived from that can support food prices lower. Although a complete exploration of available biomass might not be feasible due to collection and processing costs, a warming-up of this market could enable the use of a large portion of this energy source which is currently wasted in rural areas.

Conclusions

If we consider the total biomass available in the field, we get impressed with the fact that the amount of available energy today in Brazil would be enough to supply practically all the national primary energy demand, with a 100% renewable fuel source and very low CO_2 emissions.

The current challenge is the logistics theme that often prevents the commercial use of this fuel in the field. The transportation costs incurred on carry the biomass to the consumption point and the energy conversion costs would raise the total cost of biomass to be above the price of fossil fuels, reducing its competitiveness and its share on national energy supply matrix.

The biomass industry deployment can be the solution for a more expressive use of this energy source. The biggest challenge to increase theavailable biomass use in the rural areas is the development of an active market, based on dedicated biomass production from agro-energy crops It Ensures the constant and steady supply, combined with the reduction in production costs guaranteed by the use of agricultural wastes biomass.

Among the technologies to convert biomass into fuel suitable for consumption, we have those that now are in commercial use as the pellets industries that can directly replace coal for heat and electricity production. The second generation biofuels and biomass gasification can be future solutions for the biomass use in transportation, enabling the replacement of fossil fuels more effectively.

References

ASSOCIAÇÃO BRASILEIRA DE PRODUTORES DE FLORESTAS PLANTADAS. **Indicadores do Setor de Florestas Plantadas**. Available in: <http://www.abraflor.org.br>. 2010.

BRASIL, Ministério de Minas e Energia. **Plano Nacional de Energia 2030**. Available in: <http://www.epe.gov.br/PNE/Forms/Empreendimento.aspx>. 2007.

BRASIL, Ministério da Agricultura, Pecuaria e Abastecimento. **Anuário Estatístico da Agroenergia, 2010**. Available in: <http://www.agricultura.gov.br/images/MAPA/arquivos_portal/anuario_cana.pdf>.

CÁRCEL CARRASCO, J.; AGAPITO, C. A.; MARIOTONI, C. A. A perspective on competitiveness of Brazil in the global supply of biomass. **Labor & Engenho**, Campinas [Brasil] v. 6, n. 4, p. 46-52, 2012. Disponível em: <www.conpadre.org> e <www.labore.fec.unicamp.br>.

BRASIL, Ministério da Agricultura Pecuaria e Abastecimento. **Projeções do Agronegócio Brasil 2010/2011 a 2020/2021**. Available in: <http://www.agricultura.gov.br/arq_editor/file/Ministerio/gestao/projecao/PROJECOES%20DO%20AGRONEGOCIO%202010-11%20a%202020-21%20-%202_0.pdf>. 2010.

BRASIL, Ministério de Minas e Energia, 2009, Balanço Energético Nacional 2010. Available in: <http://www.mme.gov.br/mme/galerias/arquivos/publicacoes/BEN/2_-_BEN_-_Ano_Base/1_-_BEN_2010_Portugues_-_Inglxs_-_Completo.pdf>. 2009.

BRASIL, Ministério de Minas e Energia, Empresa de Pesquisa Energética. **Plano Decenal da Expansão de Energia 2019**. Available in: <http://www.epe.gov.br/PDEE/20101129_1.pdf>. 2010.

INTERNATIONAL ENERGY AGENCY. **World Energy Outlook 2010**. 2010.

LABOR & ENGENHO. **Revista Labor & Engenho (2007-2012)**. Avaiable in: <www.conpadre.org> and <www.labore.fec.unicamp.br>.

CÁRCEL CARRASCO, J.; AGAPITO, C. A.; MARIOTONI, C. A. A perspective on competitiveness of Brazil in the global supply of biomass. **Labor & Engenho**, Campinas [Brasil] v. 6, n. 4, p. 46-52, 2012. Disponível em: <www.conpadre.org> e <www.labore.fec.unicamp.br>.