Promising resources and systems for producing bioenergy feedstocks

Short Rotation Eucalypt Plantations for Energy in Brazil

Brazil has over 4 million hectares of eucalypt plantations. Within that estate some plantations are dedicated to the production of charcoal while in some areas multiple land use includes forestry and agricultural production. Focus in recent years has been on very high initial stocking of eucalypts combined with short rotations. End use varies from bioenergy to pulp and reconstituted board companies who seek more efficient fibre production. The issue of cost effective harvesting machinery has yet to be solved although using new harvesting technologies developed for willow in the northern hemisphere and eucalypts in Australia provides concepts to be verified in Brazil.

Brazil has been a world leader in large scale eucalypt plantations with improved breeding material and now appear to be leading the world in new silvicultural options of very close spaced eucalypt plantations primarily for bioenergy production.

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Short Rotation Eucalypt Plantations for Energy in Brazil

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Summary report

KEY MESSAGES

- Eucalypts were introduced into Brazil in the 1940s.
- There has been a substantial expansion of plantations for a variety of uses, principally for pulp fibre and bioenergy.
- In 2009 Brazil had 6.3 million hectares of plantations, 70% eucalypt and 30% pine.
- Within the eucalypt estate there are plantations dedicated to the production of charcoal, sometimes associated with agroforestry systems.
- Research has led to significant gains in growth rates and yields which have been achieved from improvements in regimes, management and genetics.
- The majority of plantations are based on clonal material, often hybrids.
- Very short rotation (2 to 6 years) clonal eucalypt plantations are producing very high volumes (40-80 m^3/ha per annum), MAIs of 60 m^3/ha/yr have been reported. Volumes are over bark.
- Wood density basic / oven dry) varies with age and clone, but is between 0.45 and 0.5 tonnes per m^3
- Efficient harvesting of short rotation eucalypts remains a challenge but is an area of on-going R&D.

Cover Pictures: Eucalypt stand and charcoal processing facility, Itamarandiba, Minas Gerais Brazil (Laercio Couto)

INTRODUCTION

Eucalyptus species were introduced into Brazil in the early 1900s for forestry purposes. The intention was to use the timber for production of sleepers and firewood during construction of the São Paulo State railroad, thus conserving native tree species (Couto and Dubé, 2001).

Brazil has become known as growers of premier eucalypt plantations with fast growth rates and large scale clonal forestry. Much of this has been established for short fibre pulp production. What is less well known is that Brazil has some of the largest dedicated bioenergy forests of the world grown for charcoal production. Recent interest in very short rotations has seen new impetus in growing eucalypts for bioenergy (Couto et al. 2003).

BACKGROUND

In the 1940s, large eucalypt plantations were established in the Minas Gerais region (Southeastern Brazil). Wood was used mainly for production of charcoal, a substitute for coke fuel. By 1966 approximately 400,000 ha of eucalypt plantations had been established for industrial purposes mostly in Minas Gerais and São Paulo. At that time there was no clonal silviculture in Brazil and seedlings were produced from seeds imported from Australia, Timor islands and South Africa. Plantations were established at an initial spacing of 3 m x 2 m (1667 stems/ha) or 3 m x 3 m (1111 stems/ha) with the first harvest at age around 7 years with two subsequent coppicing cycles of 7 years in a 21 year rotation. With genetic improvement of seed and clonal silviculture, this rotation has reduced to 15 to 18 years with a 5 to 6 year cycle for each production period (Betters et al. 1991) (Figure 1).

Figure 1: Five year old *Eucalyptus urograndis* plantation in Mogi Guaçu, São Paulo, Brazil (Photo: Laércio Couto).

In 1966 the Brazilian Government provided fiscal incentives for afforestation and reforestation (Law 5106) which resulted in Cia Suzano de Papel e Celulose developing eucalypts for the production of short-fibre pulp and paper. Further plantation incentives were introduced by the Government in the 1970s. Examples were the Fundo de Investimentos Setoriais-Florestamento (FISET), the National Program for Pulp and Paper, and a national plan for the charcoal-based pig iron and steel industry. These programmes led to an increase in the number of short-rotation plantation forests, mainly eucalypts and pines. In 1989, when fiscal incentives for reforestation were removed, there were approximately 6 million ha of eucalypt and pine plantations. One of the largest and well known eucalypt forest companies is Aracruz (Couto et al. 1994), (Figure 2).

Figure 2: Aracruz mill and surrounding plantations, Brazil (photo Tom Baker).

The choice of *Eucalyptus* for plantation forestry was based on the number and variety of species within the genus; the potential for adaptation to soil and climatic conditions which vary widely throughout Brazil; the ready availability of genetically-improved seed and material for vegetative propagation; the existence of hybrids and clones ideally suited for different timber uses; and the availability of knowledge about silvicultural treatments and techniques. The main eucalypt species used for energy conversion in Brazil are *E. saligna, E. urophylla, E. grandis, E. cloeziana* and the hybrids *E. urophylla* x *E. grandis* known as "urograndis"; *E. grandis x E. camaldulensis* known as "grancam"; *E. tereticornis x E. camaldulensis* known as "tereticam"; and, *E. urophylla x E. camaldulensis* known as "urocam (AMS, 2004).

In the last five years the area established in eucalypts has doubled and the area in pine increased by 50%. Currently there is 6.3 million hectares of plantation forestry in Brazil (ABRAF, 2010), (Table 1).

Table 1: Brazilian eucalypt and pine resources in 2009 by state > 100,000ha

State	Eucalypt (1000s of ha)	Pine (1000s of ha)
Minas Gerais	1300	**140**
São Paulo	1030	**168**
Bahia	628	**31**
Mato Grosso do Sul	291	**17**
Espírito Santo	152	**4**
Rio Grande Do Sul	272	**171**
Paraná	140	**0**
Maranhão	137	**0**
Santa Catarina	100	**551**
Others	466	**713**
Total	**4516**	**1795**

UTILISATION OF EUCALYPTS

In Brazil, *Eucalyptus* wood is used in the production of pulp and paper, charcoal, solid wood items, medium-density fibreboard, particle board, oriented-strand board, plywood and veneer, poles, firewood, and biomass for energy conversion. Some species are also used in land reclamation, as wind-breaks, for stabilisation and control of sand dunes, and for reforestation of watersheds in order to reduce run-off. Essential oils are produced from the leaves of some species and tannin is extracted from bark (Couto 2002).

In the 1990s, interest in the use of eucalypt timber in Brazil stimulated Gutchess International and Aracruz, a pulp company, to start a joint venture called TECFLOR in Posto da Mata, South Bahia, to produce eucalypt sawn-timber for the domestic and international market. The new company developed and initiated the marketing and commercialisation of eucalypt solid wood under the "Lyptus" brand name. Later on, Gutchess International sold its participation in the business to Weyerhaueser which in 2004 had an annual production capacity of 44,000 m^3 of eucalypt sawn-timber (Couto et al. 2000a).

Soil and climatic conditions in Brazil are ideal for eucalypt-based forestry and agroforestry activities. Annual standing timber productivity in short-rotation plantations can reach 40-80 m^3/ha (over bark), whereas in other regions of the world it is around 25 m^3/ha/year. Most of the forestry companies have established eucalypt plantations, and this has reduced the exploitation of native forests mainly from the savanna like regions, to produce charcoal for the pig iron industry. Intensive studies have been undertaken, not only on the technical aspects of short-rotation cropping, but also on its economic, environmental and social consequences (Couto et al. 2000b).

Short-rotation eucalypt plantations do not have an adverse effect on local hydrology or water production. Water and plant nutrient requirements are similar to those for other Brazilian forest and agricultural crops. However, eucalypt forests seem to have greater water and nutrient use efficiency, indicating greater biomass production per unit water or nutrient uptake by this species than other species (Lima, 1993). Eucalypt plantations are valued for their efficient nutrient recycling, their protection of soil against erosion, and their contribution to biodiversity through provision of shelter for wildlife. Sustainability is taken into account in the establishment of short-rotation eucalypt plantations. Sound guidelines for fertiliser application are in place and these are constantly being improved as a result of research by research institutions, universities and affiliated forest companies (Couto et al. 2000c, Stape et al. 2010).

Forestry-related activities generate 4.5% of Brazil's National Gross Product (US$28 billion), providing two million jobs. In addition to the large companies, more than 100,000 small-scale farmers plant eucalypts. These family-based industries are major contributors to the economy and the stability of rural areas. Commitment to the Kyoto protocol and the advent of the Clean Development Mechanism activities in Brazil provide an opportunity for additional income to be gained from eucalypt plantations for sequestration of carbon dioxide. Companies such as PLANTAR and V & M Florestal have already initiated projects related to the commercialisation of carbon credits (ABRAF 2011).

EUCALYPT BASED CHARCOAL SYSTEMS

There are several companies in Brazil dedicated to growing eucalypt for charcoal, one of the recognised key products from eucalypt plantations, especially in the state of Minas Gerais (Table 2). One cubic metre of charcoal requires approximately 2.8m^3 of raw wood.

Table 2: Charcoal consumption in Minas Gerais (2004)

Industry	1000s of m^3
Integrated steel mills	3,383
Pig Iron plants	13,500
Ferroalloy plants	2,250
Domestic use (estimated)	200
Total consumption Minas Gerais	19,333
Total consumption in Brazil	29,200

One of the Minas Gerais companies; V & M FLORESTAL, was founded in 1969, its main activity is the planting of *Eucalyptus* forests for charcoal – one of the key inputs to V & M do BRASIL (former-Mannesmann S.A.) operations, used to feed its blast furnaces in the steel tube making process. V & M FLORESTAL is one of the Brazilian pioneers in eucalypt forest planting and management. It is also uses its own company CAPEF (Center for Support to Forestry Research and Development to develop new technologies to enable continuous improvement in planted forest yield and in wood carbonization processes, thus entailing the economical, environmental and social sustainability of its forestry undertaking. V&M FLORESTAL currently has around 40,000 ha in dedicated eucalypt forests for charcoal. Overall they use about 15 eucalypt species, but the main ones are *Eucalyptus camaldulensis*, *E. cloeziana, E. citriodora* and *E. deglupta*. Breeding emphasis is on clones selected for disease resistance and high lignin which is desired for charcoal production, and which is the opposite trait desired for pulp production which involves removal of lignin and prefers wood with high proportions of cellulose. The majority of clones are *E. urophylla* x *E. camaldulensis* and for seed they use *E. urophylla* x *E. cloeziana* crosses (AMS 2004).

In 2004 total production from V&M FLORESTAL was just over 1 million m^3 of charcoal, with about 80,000/m^3/month produced from its 21 furnaces (Figure 3). Wood tar is also collected from the furnaces and about 20 tonnes/month is exported to Japan and the USA for medicines. The plantations are generally felled on a 7 year cycle. Wood is usually harvested by modern processors, but stacked in the field to air dry for 3-5 months to around 30% moisture content before collection.

The wood is manually stacked, from truck loads (figure 4) in the furnaces over 2 days (Figure 5); each furnace has 4 chambers, lit, then sealed to heat without oxygen (around 600^oC), the fire is closed and monitored chamber by chamber. A load takes 11 days to process, 5 to burn and 6 to cool down. The charcoal (Figure 6) is then loaded (Figure 7) and transported to a blast furnace (Figure 8).

Figure 3: Bank of eucalypt charcoal furnaces;

Figure 4: Charcoal load ready for kiln

(Photos: Ian Nicholas)

Figure 5: Furnace loaded before firing;

Figure 6: The final product

Figure 7: Charcoal loaded for transport to furnace;

Figure 8: Pig iron furnace

(Photos: Ian Nicholas)

EUCALYPT BASED AGROFORESTRY SYSTEMS

Research on eucalypt-based agroforestry systems increased in the 1980s through the activities of the Department of Forestry of the Federal University of Viçosa (UFV). To disseminate the scientific and technical results the Brazilian Society of Agroforestry based in Viçosa was founded. This NGO, a non-profit organization, uses its scientific journal Agrossilvicultura to publish the findings of agroforestry research (Dubé et al. 2001).

Today, agroforestry systems are used in small-scale farm operations, in large plantations owned by large companies and in tree-farm extension programmes. They have been found to increase site utilisation and create job opportunities in rural areas. One of the best examples of the practice of eucalypt-based agroforestry in Brazil is the Cia Mineira de Metais (CMM), located in Vazante, Minas Gerais State where most of the eucalypt timber is converted to charcoal. In that region, eucalypt trees are planted at 10 x 4 m spacing (250 stems/ha) and intercropped with rice in the first year after establishment (Figure 9).

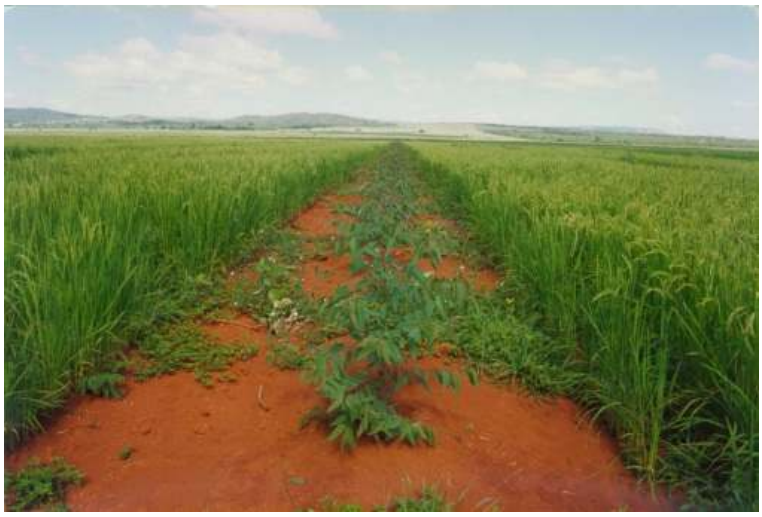

Figure 9: Five month old eucalypts intercropped with rice in Vazante, Minas Gerais, Brazil (Photo: Laércio Couto).

The variety of rice generally planted in these savannah areas are adapted to soils which are not hydromorphic (poorly-drained). The rice has a life cycle of 5 months from planting to harvesting. The rice is planted in the 8 m strip between the eucalypt lines leaving 1 metre each side from the eucalypt seedlings. Harvesting is mechanized by using a one-pass machine 4 or 8 metres in width leaving all the organic matter derived from the agricultural crop in the field.

The varieties of rice used are Carajás, Bonança and Aimorés with a total plantation and harvesting cost of US$532.00 and a yield of 1,800 kg/ha. In the second and third years, soybeans of the variety Vitória and Conquista are intercropped. The planting and harvesting total costs are US$ 750.00 and the yield is 1,920 kg/ha (Dubé et al. 2002), (Figure 10).

Figure 10: One year old eucalypts intercropped with soybean in Vazante, Minas Gerais, Brazil (Photo: Laércio Couto).

Finally, in years 4 to 12, pasture is established between the trees and cattle grazing becomes the agricultural component of the agroforestry system (Figure 11).

Figure 11: Five year old eucalypts intercropped with grasses in a silvo-pastoral system in Vazante, Minas Gerais, Brazil (Photo: Laércio Couto).

SHORT ROTATION DENSE CLONAL EUCALYPT PLANTATIONS

An increase in the demand for biomass for energy purposes during the last decade has stimulated researchers in the Brazilian Network of Biomass for Energy – RENABIO, to study the establishment and growth of very dense eucalypt plantations in short rotations. The objective is provision of economic, technical and environmental information for companies interested in electricity generation from eucalypt biomass. Sustainable use of these short-rotation eucalypt plantations is expected to make a major contribution to economic development in Brazil and to the protection of the native forest resource.

The study of short rotation dense clonal eucalypt plantations for energy started in 1982 when the timber production from *Eucalyptus grandis* in Brazil was studied at the University of Toronto. The hypothesis was that if we consider each seedling as a timber factory, the more timber factories we have in a hectare, the greater the production of eucalypt timber.

This hypotheses was tested in research work developed at Arcellor Mittal Bioenergia in Itamarandiba, Minas Gerais, financially supported by CEMIG, ANEEL, CNPq and Capes (Figure 12). The objective of the study, which resulted in a Ph.D. thesis at the Department of Forestry of the Federal University of Viçosa (Müller, 2005), was to find the optimum biomass production of eucalypts in a two year rotation under different initial planting spacing per hectare. It was expected that the biomass would be used for electricity generation in a 33 MW power plant.

Figure 12: Two year old clonal eucalypt plantation for energy in Itamarandiba, Minas Gerais (Photo: Laércio Couto).

The results of the Ph.D. thesis, confirmed the hypotheses and several other companies have expressed interest in the establishment of trials in their plantations (Couto 2011). These companies are:

- RAMIRES Reflorestamento Ltda of Ribas do Rio Pardo, Mato Grosso do Sul which established a similar research project but increased the number of clones tested and number of initial spacings (Figure 13).
- Usina Rio Pardo, sugar cane company and ethanol producer in Avaré, São Paulo which used sugar cane bagasse to supply its electricity cogeneration facility for seven months of the year and planted dense clonal eucalypt stands to supply biomass for that purpose in the remaining five months (Figure 14).
- Suzano Energia Renovável, which is establishing short rotation clonal eucalypt plantations to produce biomass to supply two one million ton pellet plants in Northeastern Brazil. Suzano Energia Renovável signed an agreement with Usina Rio Pardo to carry out the forest inventory of the 24 month old plantation in Avaré, São Paulo and to realize a field test of harvesting systems that could be suitable for those conditions. In general terms, a 24 month old dense plantation of clonal eucalypts in that region of São Paulo, has an average tree dbh of 7.5 cm and an average tree height of 13 metres with an average MAI of 60 m^3/ha/year.
- GMR Florestal, a forest company located in Tocantins, also established a pilot plantation in the Southern region of the state to analyse the use of the timber to generate electricity in the Termotins facility. The main objective of the company is to build a pulp plant called BraxCel with the forestry sector called BraxFlor which will supply the needed raw material to the industry. Current predictions are that eucalypt planting in Tocantins could rise from the 13,000 ha in 2006 to 530,000 ha by 2016! The total area of the investment is such a large scale that several kinds of eucalypt timber based industries can be installed in the region (Figure 15).
- COMAPI a company of the Bertin Group in Lins, Sao Paulo (Figure 16) has the biggest pilot area with clonal short rotation eucalypts to produce biomass for energy. The rationale of the Bertin Group is based on precision forestry and agriculture, establishing sugar cane in the better soils and eucalypt plantations in the marginal lands (Figure 17). The Bertin Group has a 27 MW electricity generation facility in Lins which at the moment is using sugar cane bagasse which later on will be replaced by eucalypt woodchips and/or grass biomass.
- Grupo Orsa which is the owner of the former Jari project located at the margins of the Jari river in the states of Pará and Amapá has also started to study short rotation clonal eucalypt plantations to produce biomass for energy. However this company is also looking to use part of the biomass for pulp production if it uses a 3.0 m x 1.0 m initial spacing and a 4 year rotation in three consecutive harvestings in a total of 12 years. The company has also forest activities in South São Paulo where pines are the raw material for the production of Kraft

pulp. This company might also test short rotation dense clonal eucalypt plantations in São Paulo to produce pellets for electricity generation in their facilities in this state.

- Duratex, the biggest particle board producer of Latin America has started the first studies of the use of the timber of the young dense clonal plantations of eucalypts in their industrial processes for particle board production. To save research time, Duratex has bought part of the plantations of Usina Rio Pardo from Avaré and have tested the biomass in their plants in Agudos and in a pellet plant in Porto Feliz called PelletBraz. Duratex is also establishing short rotation dense clonal eucalypt plantations in their areas in São Paulo and Minas Gerais. Depending on the results of these studies, Duratex may adopt these kind of eucalypt plantations for commercial purposes.

Interest in the short rotation eucalypt plantations has also resulted in study tours from Uruguay and Chile visiting the Brazil research sites. Universities such as the Federal University of Viçosa and the Federal University of the Valleys of Mucuri and Jequitinhonha are also studying these types of short rotation eucalypt plantations. Some of their professors in the areas of wood technology, silviculture and biometrics are just finishing three M. Sc. theses based on the original research plantations established in Itamarandiba, Minas Gerais in 2002.

Several other forest companies in Brazil such as International Paper and Energias Renováveis do Brasil, are devoting time and resources to study short rotation dense clonal eucalypt plantations aiming to produce not only biomass for energy but also for other purposes such as particle board production, pulp and charcoal for the pig iron industries.

Figure 13: Clonal eucalypt plantations for energy in Ribas do Rio Pardo, Mato Grosso do Sul (Photo: Laércio Couto).

Figure 14: Two years old 3.0 m x 0.5 m (3,667 stems/ha) clonal eucalypt plantations in Avaré, São Paulo (Photo: Laércio Couto).

Figure 15: Short rotation clonal eucalypt plantations for energy of the Bertin Group in Lins, São Paulo (Photo: Laércio Couto).

In Lins, the research team of the Bertin Group established a series of eucalypt clones planted in different initial spacings including the spacing used in Europe and USA for willows and poplars. These plantations are today about 24 months old and are expected to be used to produce biomass for pellet and electricity production by the company. Suzano Energia Renovável also made an agreement to carry out the forest inventory of those plantations to find the growth and yield of every eucalypt clone planted at different initial spacing (Figure 16).

Figure 16: One year old short rotation clonal eucalypt plantation for energy for the Bertin Group in Lins, São Paulo (Photo: Laércio Couto).

Figure 17: Precision forestry and agriculture with sugar cane, pasture and short rotation eucalypt plantations in Lins, São Paulo (Photo: Laércio Couto).

Biomass generated by short rotation dense clonal eucalypt plantations can also be used to produce charcoal that can be used by the pig iron and steel companies. This raw material is transformed to powder and can be used to mix with coke in the blast furnaces of the steel companies and also to produce briquettes for pig iron production or to be exported for domestic uses. Another sector in Brazil that is in high demand for biomass for energy is for tile, brick and gypsum production companies. Most of these companies are using native wood to supply their energy and the increasing legal restrictions on the use of these raw materials are making them investigate the short rotation eucalypt plantations as the best solution for this concern.

HARVESTING OF SHORT ROTATION CLONAL EUCALYPT PLANTATIONS

Harvesting short rotation dense clonal eucalypt plantations in Brazil to produce biomass for energy is considered a priority issue (Seixas and Couto 2005). One option for harvesting such plantations today in Brazil is the use of a small feller buncher, a skidder and a wood chipper. Therefore, to have woodchips for energy it would be necessary to use three different machines. This was the option used by Suzano's team in Avaré, São Paulo (Figure 9). New Holland is currently studying the use in Brazil of a one pass harvester with a cutting head developed by Chris Mell of Coppice Resources from the UK, which has been successfully used to harvest willow and poplar plantations in USA and Europe. Another option is the Australian Bionic Beaver developed by the Australian company Bioengineering systems (www.biosystems.com.au) which is participating in a joint venture project with John Deere, RENABIO and several forest companies in Brazil. The challenge will be the diameter and the height of the eucalypt trees at the age of 2, 3 and 4 years, the expected rotations of such dense clonal plantations for energy.

At the beginning of the studies in 2002 the aim was to copy the system already tested and used for willow and poplar short rotation energy crops s in several countries (Europe, USA and Canada). A cutting head was developed in the UK by Chris Mell of Coppice Resources which was initially adapted to several farm tractors such as New Holland, John Deere and Claas. This equipment worked very well for 3 to 4 years old willow and poplar energy plantations. In 2010 an international meeting was promoted by the State University of New York – College of Environmental Science and Forestry (SUNY-ESF) in Syracuse under the coordination of Professor Timothy A. Volk and Larry Abraham when two machines were demonstrated to the participants: a one-pass New Holland harvester (Figure 18) and the Bio Baler developed by the Anderson Group of Canada (Figure 19).

Figure 18: The New Holland one-pass wood harvester in a field demonstration in New York state, USA (Photos: Lynn L. Wright).

A key element with these machines is that the cutting has to be very clean to facilitate the sprouting of the stumps. This is important not only for the willow and poplar plantations but also for eucalypt and other genera tested in Brazil. The one-pass wood harvester produces woodchips which can be immediately transported to the consuming facilities such as pellet or electricity production plants. In the specific case of the Bio Baler, the equipment is able to produce 400 kg bales from wood crops, bushes and grasses that can be stored and later chipped for energy. The equipment is pulled and powered by by a farm tractor and does not produce as clean a cut of the stumps as the New Holland one-pass wood harvester tested in Syracuse.

Figure 19: The Bio Baler in a field demonstration in New York state, USA (Photo: Lynn L. Wright).

CONCLUSIONS

Brazil has 0.6% of its territory in forest plantations, mainly eucalypt and pines which totals 6.3 million hectares.

Wood products from these forests meet a wide range of end-products including bioenergy from charcoal.

Other than the plantations, the country has 200 million hectares of pasture land, a significant portion of which is degraded land. These areas are very suitable for reforestation projects since they do not need to be cleared for planting.

The establishment costs of eucalypt plantations in those pasture lands are lower than in other areas. Most of these lands are located in the savannah like regions where climatic and soil conditions allow the eucalypt plantations to have an average annual increment of 40 cubic metres per hectare per year.

These areas and the interest in new silvicultural options of close spaced eucalypt plantations on a short rotation may see a large increase in bioenergy eucalypt plantations in Brazil.

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IEA Bioenergy

IEA Bioenergy is an international collaboration set up in 1978 by the IEA to improve international co-operation and information exchange between national RD&D bioenergy programmes. IEA Bioenergy's vision is to achieve a substantial bioenergy contribution to future global energy demands by accelerating the production and use of environmentally sound, socially accepted and cost-competitive bioenergy on a sustainable basis, thus providing increased security of supply whilst reducing greenhouse gas emissions from energy use. Currently IEA Bioenergy has 22 Members and is operating on the basis of 13 Tasks covering all aspects of the bioenergy chain, from resource to the supply of energy services to the consumer.

IEA Bioenergy Task 43 – Biomass Feedstock for Energy Markets – seeks to promote sound bioenergy development that is driven by well-informed decisions in business, governments and elsewhere. This will be achieved by providing to relevant actors timely and topical analyses, syntheses and conclusions on all fields related to biomass feedstock, including biomass markets and the socioeconomic and environmental consequences of feedstock production. Task 43 currently (Jan 2011) has 14 participating countries: Australia, Canada, Denmark, European Commission - Joint Research Centre, Finland, Germany, Ireland, Italy, Netherlands, New Zealand, Norway, Sweden, UK, USA.

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