Rijksdienst voor Ondernemend Nederland

Biomass business opportunities in Brazil for the Dutch

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sustainable energy for everyone

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Executive summary

Brazil is a country with tremendous natural resources, and its economy already depends to a large extent on the exploitation of these resources. Biomass also plays an important role and is currently used, besides food and feed, for the production of electricity and biofuels for transportation.

Waste biomass streams from sugarcane (bagasse), forestry and agriculture are currently available in large quantities, and are even seen as environmental problems, so organisations are increasingly looking for better solutions for these streams.

The table below provides a summary of the identified opportunities for Dutch parties, and links to the relevant chapters in the report for further background and details of the respective sectors.

Sector	Opportunities	See further
Biomass power (bioelectricity)	• Research combustion properties of new feedstocks (new crops as well as new residues) • Optimisation of combustion processes • Technology supply/transfer in boilers • Technology supply/transfer in gasification (syngas) and fermentation (biogas) • Investment in independent power producers under RE auctions. (must be via joint ventures) • Technology supply and R&D in Pyrolysis oil production and upgrading (e.g. Dutch company BTG-BTL) • Technology supply, supply chain management for pre-treatment of biomass for internal market (pellets, briquettes and torrefaction) • Research and consultancy on biomass-to-power value chain (including off-grid solutions)	Chapter 4
Biofuels - Conventional	• Technology supply and R&D for biodiesel from vegetable oils waste streams (UCO etc.) • Logistics/collection of used cooking oil and tallow • R&D for engine technologies (e.g. TNO)	Chapter 5
Biofuels - Advanced	• Development of enzymes for second generation sugars and biofuels (DSM) • Research and development in advanced conversion processes and pre-treatment for lignocellulosic feedstocks • Biotechnology and Catalytic processes	Chapter 5

Sector	Opportunities	See further
Biogas	• Landfill gas management for municipalities • Technology supply – for landfill, animal manure, agricultural waste • Technology supply for infrastructure (pipes, pumps etc.) and biogas turbines (NL is preferred partner of COSAN along DE)	Chapter 7
Biowaste – MSW	• Developing and executing waste management policy (consultants) • Implementation of waste collection systems (bins, trucks, logistics) • Material Recovery Facilities • Engineering and planning waste treatment plants • Landfill gas recovery • Digestion of organic waste	Chapter 8
Biowaste – Waste Water	• Waste water treatment – gas cleaning (for energy use) • Microbial species for water reuse • Waste Water biological production	Chapter 9
Advanced biomaterials	• Develop plants for platform biochemicals and pyrolysis oil • Food and nutrition and cosmetics • Biofibre composites, bioceramics, biopolymers • R&D in field of bio-nano particles (NL Universities)	Chapter 10
Agriculture and forestry	• Genomics for plant breeding • Research in new energy crops for 2G biofuels • Agronomic capacities • Sustainable collecting, and on-site pre-processing of agricultural residues (for 2G biofuels) • Degraded land regeneration	Chapter 3

The **biofuels** sector (mainly first generation sugarcane ethanol) has suffered in recent years due to politically motivated low fuel prices but is now expected to slowly recover (experts estimate recovery will take from 2-5 years). The sectors' setbacks do not only affect the smaller businesses (family operated mills), but also big players like Granbio and ETH. The introduction of 2G bioethanol receives much competition from the current high electricity prices which makes the use of bagasse for power generation attractive.

The emerging **biogas** sector could become large and appears to be promising. Biogas does not compete with gas from the national grid, but the grid has a very limited reach. There is no national biogas policy but big players (like the Itaipu research center) are making a case (and running pilots) for its introduction as a transport fuel and power generation. Since the sector does not depend on subsidies, large players can draw their own roadmaps. Biogas is claimed to be already commercially viable when produced as landfill gas, and fermentation of agricultural waste and is seen as a good

option for rural energy development. The current scarcity of Brazilian players and the Dutch expertise in this field should make for interesting opportunities.

Large amounts of **bio-waste** are found in municipal solid waste and waste water streams. New waste laws mean that municipalities need to make proper waste plans and can no longer dump waste in open landfills. This provides opportunities for Dutch waste management parties. Other opportunities exist with less known waste producers like shopping malls, condominiums, hospitals etc. These players could use their waste streams to reduce environmental impact, but also to reduce their exposure to water rationing (through water re-use) and power rationing/cuts (increase energy self-sufficiency through waste-to-energy).

Advanced biomaterials. Most advanced biomaterials are in the stage of R&D or piloting phase. Brazil clearly lacks the academic and practical know-how to bring these projects to fruition. The Netherlands is well positioned to help fill specific knowledge gaps as it is doing already, for instance through the Be-Basic activities in Brazil, but also from the Dutch chemical sector that can help in developing new chemical value chains. The need for entrepreneurship and development of new business models has also been highlighted as an opportunity for Dutch parties, which can be developed in partnership with Brazilian incubators and start-up organisations

Apart from being an agricultural giant, Brazil also has significant resources and knowledge in the field of **agricultural research**. Its national agricultural research corporation EMBRAPA has strong research capacity, including in biomass for bioenergy applications. However the country is facing fast land degradation and the ministry of environment has identified 140 million hectares that need to be restored[1]. This offers many opportunities in terms of ecology and plant science that the Netherlands can provide. Yield improvements through shortening of the crop cycles and intercropping are also regarded as areas of interest. There is currently little research in the direct and indirect environmental impacts of various bioenergy and other crops which is crucial for the long term growth potential. Many policies and incentives are focussed on family and organic farms, which provide most of the food for local consumption. There are significant policy efforts from National and International parties to make these more efficient and sustainable.

[1] National Plan of Action of the Ministry of Environment (MMA) - Secretaria de Biodiversidade e Florestas

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1 Introduction

Brazil offers many opportunities in the field of biomass and bio-based value chains like biofuels, bioelectricity and high-value bio-based products like biochemicals. The Dutch government is supporting Dutch businesses in their efforts to enter this large market through the help of market studies, trade missions and its network of Science, Technology and Innovation Attaché Network. Consultancy Ecofys has performed this market study on behalf of the Netherlands Enterprise Agency (RVO) in order to provide a clear overview and concrete advice for Dutch companies and knowledge institutes interested to expand their biomass-related activities in Brazil.

Information and lessons learned were gathered through literature research complemented with interviews with Dutch and Brazilian companies with experience in the Brazilian Biobased market, as well as academic and research experts in these fields, both in the Netherlands and in Brazil. The details of the interviewees are available as an appendix. Opportunities were selected based on the needs in Brazil, and the positioning of the Netherlands (i.e. what are other countries doing in this field).

Reading guide

After a brief country profile, this report provides an overview of biomass sources (feedstocks), and then proceeds to explore the sectors that use the identified biomass streams. These sectors are bioelectricity, biofuels, other industrial uses, biogas, advanced biomaterials and waste (solid and waste water). In each of these sectors we provide a market overview, identify the main relevant policies and stakeholders, and identify opportunities for Dutch companies and knowledge organisations.

What is the Biobased Economy?
In this report we define biobased-activities as activities that transform biomass from agriculture and forestry (including residues) as well as solid and liquid organic waste streams into higher value-added products, including bioenergy (heat, electricity and transport fuels) and biomaterials (including biochemicals).

2 Brazil country profile

Brazil is South America's most influential country, an economic giant and one of the world's biggest democracies. Since the early 2000's it is named as one of the world's major emerging economies, known as the BRICS nations, together with Russia, India, China and South Africa. The official language is Portuguese which is spoken across its 27 states. These Estados are the 26 federal states, plus the Federal District which contains the capital city, Brasilia (see Figure 1). The country covers 8.5 million km^2, which is more than 200 times the size of the Netherlands. The president of the country is Dilma Rousseff, who has been in power since 2011 and who has started her second term (2015-2018) in January, though her presidency is currently under pressure.

Figure 1 Brazil Political divisions. Source: USDA GAIN 2014

Brazil's economy is characterized by large and well-developed agricultural, mining, manufacturing, and service sectors and has a middle class that is rapidly expanding. Recent discoveries of offshore oil reserves have also been hailed as an opportunity for growth and attracted investment. Brazil's biggest export partners are: China (17%), the United States (11.1%), Argentina (7.4%) and the Netherlands (6.2%). Over the last year however, the country has been plunged in an economic crisis which has affected the investment climate. In 2010, Brazil had a GDP growth rate of 7.5%, which

quickly dropped to 2.5% in 2013, 0.1% in 2014, and the economy is expected to shrink in 2015. Nevertheless, it is expected that economic recovery will occur over the next few years.

Renewables play an important role in Brazil's energy mix, with hydropower being dominant in the country's electricity consumption and modern biomass (from sugarcane) playing an increasingly important role. Figure 2 shows the total energy supply mix. The dominance of hydropower in the electricity mix also make the country more vulnerable to droughts, which have become more frequent in recent years. Expansion of hydropower capacity is also hampered by popular resistance, driven by social and environmental concerns. For these reasons Brazil is looking to diversify its energy mix, which offers opportunities for biomass power.

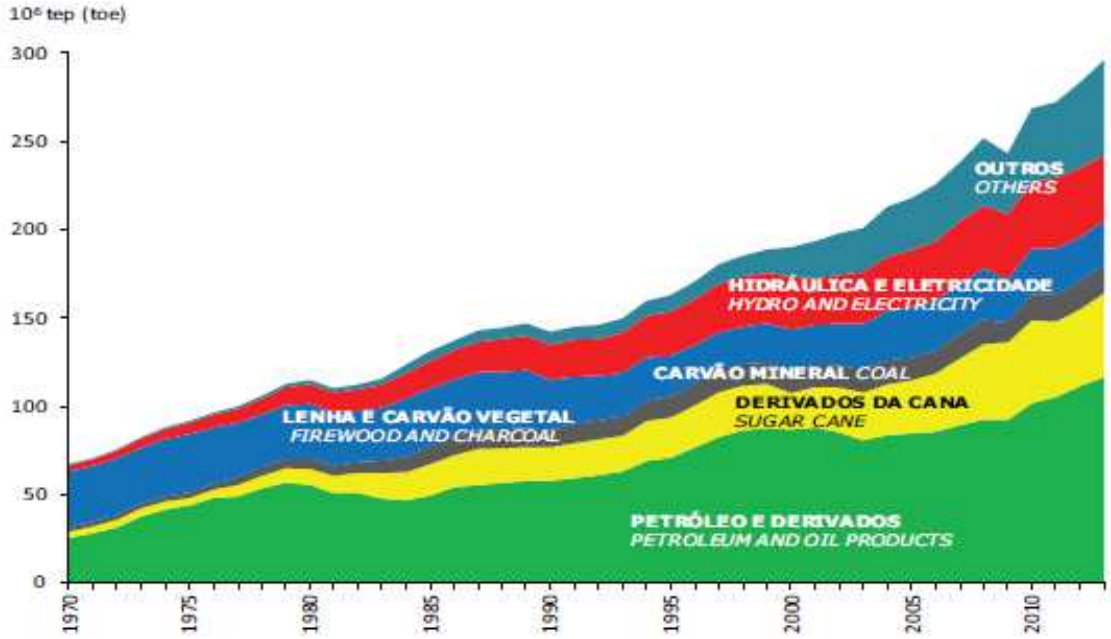

Figure 2 Brazil's domestic energy supply mix historical developments. Source: National Energy Balance 2014

Brazil is also a world leader in the area of agriculture and forestry. It is the world's largest sugarcane producer, and until recently the largest ethanol producer. It is the second largest soybean producer, and a major exporter of biodiesel. It is also the world's fourth largest pulp producer and a major timber producer. The abundance of biomass has spurred and attracted developments in biobased chemistry, mainly connected to the long established production chains of sugar and ethanol, such as the production of bio-ethylene and derived plastics (like poly-ethylene).

3 Availability of feedstocks

Because of its extensive agricultural land availability, Brazil is one of the world's largest producers of agricultural commodities. It is the world's largest sugarcane, orange juice, beef and coffee bean producer and increasingly large soybean and corn producer. With all the primary products of these crops come also large amounts of residues. A large part of these residues are currently not used, but they offer the potential for being transformed into useful products such as heat, power or energy carriers for other markets as well as biomaterials. Table 1 gives an overview of the volumes estimated for the main agricultural and forestry residues. More detailed descriptions of the industries that can use these residues is given in the sections below. The geographic distribution is shown in Figure 3.

Table 1 Agricultural and forestry residues available in Brazil. (see sources below).

Product	Production main crop (ktonne/year)	Residue-to-product ratios	Waste (ktonne/year)	Applications
Sugar cane	653,519 (fresh cane stalks)	0.27 t bagasse/t of crushed cane 0.3 t of straw /t of crushed cane	176 kton bagasse 196 kton straw	(advanced) biofuels
Maize	55,681 (grains)	2.2 to 2.9 t leaves and stems/t grains 0.3 to 0.9 t corncob	11,378 (straw) 3,793 (corncob)	Ethanol, food, feed, biochemical, biopower
Soy	68,479 (beans)	1t beans to 1,4t (straw and other waste)	95,871	Cogeneration, Fast Pyrolysis, Syngas and Electricity
Rice	11,235 (grains with husk)	1.3 to 1.8 t shoots/t grains with husk 0.22 t husks/t harvested grains	18,000 (straw)	CHP, Ethanol (2G), Fast-Pyrolysis (Bio-oil), Syngas (for electricity)
Wheat	6,171 (grains with husk)	1.4 t shoots/ t grains with husk	8,639 (straw)	Biopower, advanced ethanol
Coffee	2,906 (beans)	1 t husk/ t processed coffee 0.25 t endocarp-waste/ t processed coffee	2,688	Biopower, advanced ethanol

Product	Production main crop (ktonne/year)	Residue-to-product ratios	Waste (ktonne/year)	Applications
Cotton	2,949 (seeds)	0.04 t dry shoots/ ha	37	CHP, Ethanol (2G), Fast-Pyrolysis (Bio-oil), Syngas (for electricity)
Coconut	566 (green coconut)	0.85 t wastes/ t green coconut	481	Biopower, biomaterials
Beans	3,158 (beans)	0.53 t wastes/ t beans	1,674	Biopower, pellets
Wood	Plantation wood: 185 million m^3	Mechanical processed wastes (secondary residues)	50,100 (at least)	Biopower, pellets, pyrolysis oil
Brazil nut	40	1.4t husk and hard shell fruit/ t processed nut	56 (husk and shell)	Biopower, pellets
Babassu (kernel)	106	0.93 t waste/ t babassu coconut	50 (cake)	Biopower, pellets
Peanut	261	0.3 t wastes/ t peanut in husk	78 (husks)	Biopower, pellets
Barley	278 (grains)	7 t straw/ ton grain	2,000	Biopower, pellets
Oranges	17,000	0.5 ton peels/ton oranges	8,500 (peels)	Biochemicals, ethanol
Mandioca (cassava)	26,078	1t stems to 0,7t waste	17,237	Ethanol (1G) and biopower (use of stems)

Sources: (EMBRAPA Agroenergia, 2012); UNICADATA 2015; (Ferreira-Leitão, et al., 2010) Centro Nacional de Referência em Biomassa (2011), NA= not available or not applicable.

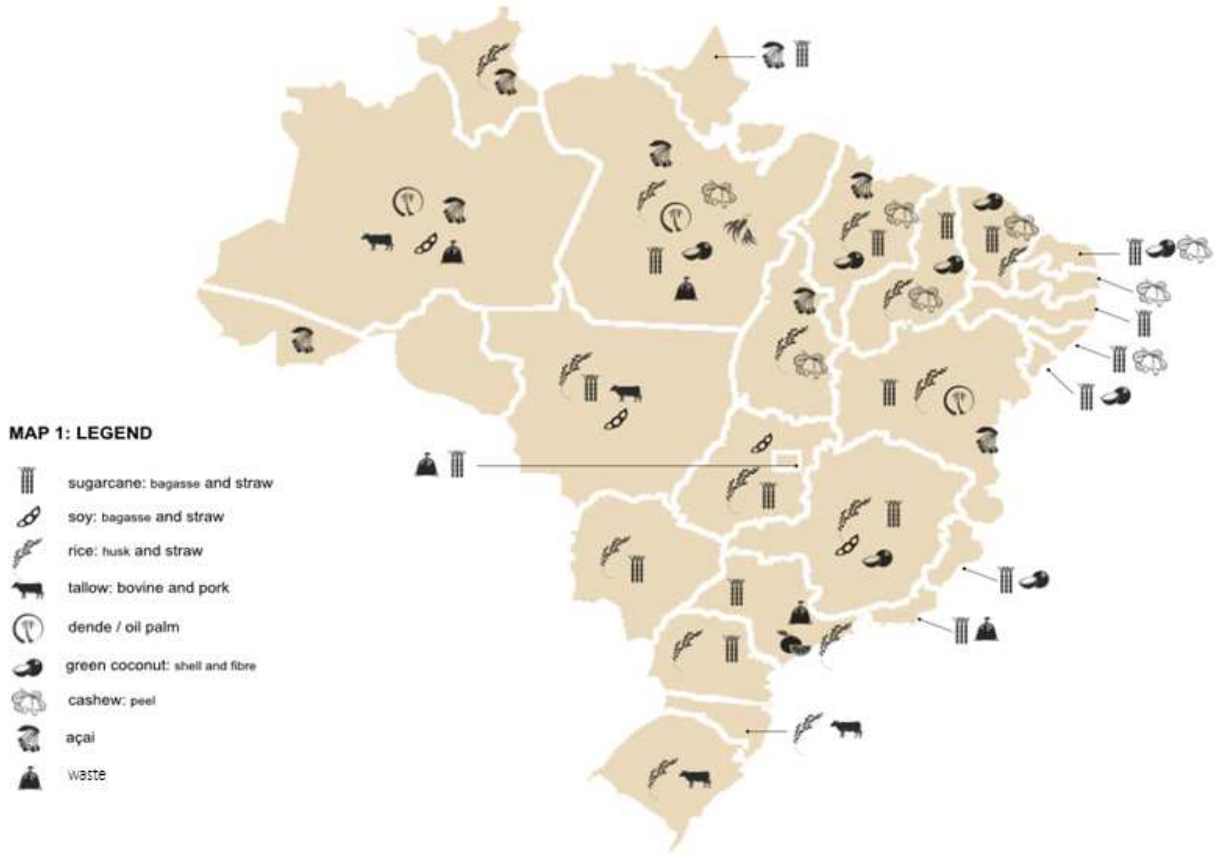

Figure 3 Distribution of main crops and feedstocks. Source: authors.

3.1 Sugarcane and co-products

Brazil is the world's largest sugarcane producer. The 2013/2014 harvest yielded no less than 653 million tonnes of sugarcane[2], with almost 600 million tonne coming from the Centre-South region (São Paulo and surrounding states).

Traditionally, the cane fields were burned before harvesting, mainly in order to speed up the manual harvesting. But this practice is being progressively phased out, because of its serious environmental consequences[3]. Without burning, the fields can no longer be harvested by hand, which leads to progressive mechanisation. With mechanical harvesting, residues like tops and leaves[4], are now becoming available for other uses. After the cane is pressed, the resulting product (called bagasse) is partially used for self-sustaining the plant processes in heat and power. However, because only a part

[2] Unicadata.com

[3] Burning has been phased out in the state of São Paulo in 2014, and should be phased out across all of Brazil by 2030

[4] These residues are collectively also called straw

of the bagasse was needed for self-sufficiency, the boilers and power equipment traditionally installed in sugar mills are very inefficient. With increased investment in plant equipment, larger amounts of bagasse could also be made available[5]. From the 9 million hectares of sugarcane grown in the country, some 100 million tons of biomass residue is estimated to be available (Ecofys, 2012).

Increases in yield of sugarcane are believed to be possible through improved agronomic practices and genetically improved plant varieties. New and improved varieties can be obtained through classical breeding, and though direct modifications to the plant genome (GMO's). The main objectives of breeding and genetic improvements are to produce plants with higher sucrose yields, higher resistance to pests, and improved suitability to new climatic regions (including resistance to drought, low temperatures etc.). For second generation biofuels, plants with higher fibre yields are also beind developed. De development of the Cana-Vertix (energy cane) by company GranBio is one example of this.

Opportunities for Dutch researchers and companies:
The available biomass at the sugar plants can be converted into electricity for power generation (see section on bioelectricity below), but also upgraded to higher value energy carriers (pellets, ethanol, pyrolysis oil) or biobased products like animal feed, fertiliser etc. (see Figure 4).

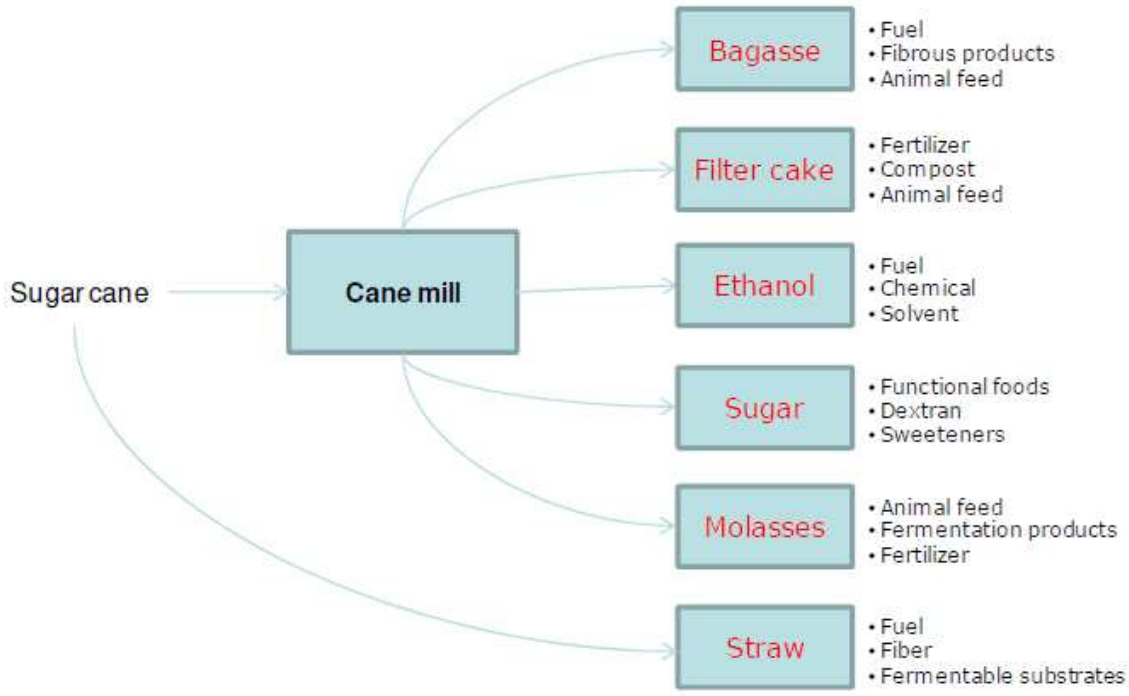

Figure 4 - By-products of sugarcane industry

[5] See also http://www.ifama.org/files/IFAMR/Vol%2017/Issue%202/320130111.pdf

Lignocellulosic materials obtained from processing sugarcane - bagasse and sugar cane straw - show a high potential for their use in energy production, either by means of biochemical (hydrolysis) or thermochemical treatments (combustion, pyrolysis and gasification).

Dutch companies are well-positioned for the development of these thermochemical conversions. For example, BTG-BTL has extensive experience in developing pyrolysis oil, and Torrgas has developed a technology that can gasify torrefied biomass material into a clean syngas for either local use or sales.

Main stakeholders in the sugarcane sector

The most important stakeholders in the Brazilian sugarcane industry are shown in Table 2.

Table 2 Main stakeholders in the sugarcane industry

Name	Description	Website
UNICA	The Brazilian Sugarcane Industry Association represents about 60% of Brazilian sugarcane production. They are also represented in Brussels and also represent the interests of ethanol in general.	www.unica.com.br
CTC	The centre for research in cane technology	www.ctc.com.br
Solidaridad	Dutch NGO with offices in São Paulo. They have worked with cane producers, certifiers and training programmes to make sugarcane harvesting more socially and environmentally friendly	www.solidaridad.nl
Copersucar	Brazil's largest ethanol producer, operating 48 mills in the states of São Paulo, Goiás, Paraná and Minas Gerais	www.copersucar.com.br
CTBE	National Laboratory that operates with the scientific and technological community and the Brazilian productive sector, aiming to contribute to the maintenance of competence of the Country in the production of sugarcane ethanol and other compounds from biomass	http://ctbe.cnpem.br/en
Raizen	Joint venture between Brazilian ethanol and sugar group COSAN and Shell	www.raizen.com.br
Odebrecht Agroindustrial (Previously ETH)	Large cane and ethanol producer	www.odebrechtagroindustrial.com

Name	Description	Website
Granbio	Biofuel producer and innovator. Granbio is developing energy cane as feedstock for advanced biofuels	www.granbio.com.br/en
IPT	Large research and technology company that research many conversion paths for biomass, including gasification.	www.ipt.br

3.2 Forestry and tree plantations

The Brazilian forestry sector can be split into forestry from trees from natural forests, and planted tree plantations. In this section we will focus on the latter, since it is a renewable form of biomass, which can be produced sustainably if managed properly, and when it does not come at the expense of natural forests.

Tree plantations

In 2013, the planted tree industry accounted for 5.5% of the Industrial GDP of Brazil. Brazil has 7.6 million hectares of planted trees, mostly eucalyptus (5.45 Mha) and pine (1.57Mha) with others species that include acacia, araucaria, paricá and teak (IBA, 2014).

60% of tree plantations have been certified by national sustainability certification schemes for sustainable management and limited negative social and environmental impacts. Industries involved in tree plantations either plant them themselves or work through outgrower programmes in which they establish long-term partnerships with local farmers who are thus included in the wood production supply chain.

The products of these plantations are used namely by the paper and pulp industry, the steel industry (for production of pig iron) followed by the construction, furniture, books, napkins etc.

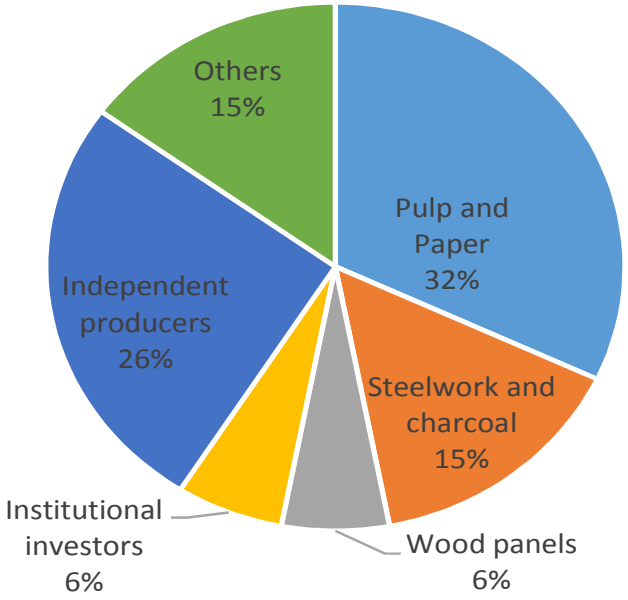

Figure 5 Share of production of planted trees per segment. Own production based on data from (IBA, 2014)

The main tree species used is Eucalyptus, for its fast growing properties, homogeneity and resistance to pests and diverse climates. Brazil has currently over 5.5 million hectares of industrial Eucalyptus plantations, which is more than the area of the Netherlands (around 4.1 million hectares).

Table 3 summarizes by-products of harvesting and processing planted trees with their main uses.

Table 3 Production of forestry residues and their applications

Product	Application
Pulp	• Papers requiring a high resistance (softwood pulp) • Papers for printing and writing as well as tissue products (hardwood pulp)
Industrialized wood panels	• Residential and commercial furniture (MDB) • Machined and embossed pieces, arts and crafts, construction for making flooring, skirting, doors and shaped pieces (MDF) • Residential and office furniture, cabinet and drawer backing, product packaging, arts and crafts, toys, construction for flooring, doors and walls (HDF) • Residential and office furniture, cabinet and drawer backing, in the automobile, packaging, toys, audio and video, produce and egg farms industries, as well as in construction (Hardboard)
Paper	• Printing and writing • Packaging • Paperboard • Tissues • Specialty paper
Forest biomass	• Burning for residential and commercial sectors, steelmaking industry

Forestry residues for bioenergy purposes

In Brazil, the main sources of biomass from natural forests and planted trees are firewood, charcoal, and wood pellets. Firewood is used in direct burning and combustion mostly for the residential and industrial sectors. 40% of firewood in Brazil is turned into charcoal, which is used as a fuel for heaters, fireplaces, barbecues and stoves for households, and in the steelmaking industry as a reducing agent of iron ore. Finally wood pellet production, in general used by the industrial sector for power generation, is still modest and at an experimental stage in Brazil.

Research in tree genetics, soil conditions and ecophysiology has proven to be a good way to increase productivity of tree plantations. Improvements in biotechnology are currently being discussed on a national scale. Future relevant areas could include R&D work on tree genetics to improve wood quality and resistance, the implementation of a robust regulatory framework and compliance with biosafety laws, biotechnology access and shared benefits throughout the country as well as increased knowledge sharing amongst relevant stakeholders.

Main stakeholders in the forestry sector

Table 4 Main stakeholders of the forestry sector in Brazil

Name	Description	Website
IBA	The Brazilian Tree Industry representing the planted tree production chain, from the field to the industry	www.iba.org
Bracelpa	Brazilian pulp and paper association.	http://bracelpa.org.br
Silviminas	Forestry association of Minas Gerais, where most of the plantations exist for the steel industry	www.silviminas.com.br
Fibria	Large forestry company with a strong presence in the global forest products market (mostly with Eucalyptus), investing in the cultivation of forests (plantations) as a renewable and sustainable source of life.	www.fibria.com.br/en
Suzano	Forestry based publicly held company. Present in pulp and paper market as well as which portfolio is composed by coated, uncoated and paperboard. We are the second largest eucalyptus pulp producer in the world and the fourth largest market pulp producer.	http://ri.suzano.com.br
Eldorado Brasil Celulose	Large Brazilian pulp producer (1.5 million tons of bleached kraft pulp/year) and the world's largest single-line pulp mill in the city of Três Lagoas (MS).	www.eldoradobrasil.com.br

Dutch parties who recognize opportunities and would like to enter in contact with stakeholders named above are encouraged to contact the Dutch support network in Brazil (See section 13.3) or in the Netherlands (RVO) when looking for Dutch partners in their sector.

3.3 Other agricultural products and residues

Agricultural residues

In Europe, discussions about the availability of cellulosic feedstocks from agricultural residues focus on how much of the straw can be removed from the field, while maintaining the soil quality and productivity, in other words, sustainability requirements will demand a minimum part of the residues to remain on the field.

In Brazil the situation is very different: agricultural waste from land that has been treated chemically (with pesticides, herbicides and fungicides, collectively known as 'agrotoxicos') needs to be removed and treated. If farmers fail to treat the residues, they face environmental fines[6]. This means large amounts of agricultural residues (as identified in Table 1) are now in need of cost-effective treatment options, where bioenergy applications can play a role.

The Brazilian government provides incentives for agricultural cooperatives to invest in decentralized agro waste processing technologies, including biogas production, through its national development bank (BNDES). In most cases the challenge is not technological, but organisational.

Energy crops

Jatropha Curcas (Pinha manso in Portuguese) has been hailed as an energy crop that could produce vegetable oil in low productivity lands, without competing with food. Jatropha cultivation has been stimulated in many regions throughout the world, but there are doubts about its economic feasibility due to low yields on poor soils (SCOPE, 2015). In Brazil, some notable developments are the research by Embrapa Bioenerga together with SGB biofuels, who are researching hybrids of Jatropha in Lucas do Rio Verde in Mato Grosso, where plants are being researched with the objective of bringing the maturity forward (from 5 years to less than 2 years before the plant starts producing oilseeds) (EMBRAPA, 2013). In general, the country lacks the infrastructure to turn the oil into fuels, and there are too few examples to inspire growth from other players.

Castor oil (Mamona in Portuguese) is a multipurpose plant oil, obtained by pressing the seed of the castor oil plant (Ricinus communis). Besides being a feedstock for the production of biodiesel, castor oil and its derivatives find uses in many industries such as cosmetics, food, lubricants, paints, agriculture, pharmaceuticals, plastics etc. Presently, castor is cultivated on approximately 100,000

[6] Monitoring is done by Anvisa (National Agency of Sanitary Surveillance) and IMA, federal agency in charge of evaluating pesticide health risks. Based on monitoring, Anvisa files reports for removal.

hectares in Brazil, an area that can increase with the introduction of advanced varieties and new-modern cultivation practices, like intercropping with soybean[7]. According to EMBRAPA and Evofuel the target area for this rotation system is in the region of MATOPIBA (States of Maranhao, Tocantins, Piaui, and Bahia) in the northeast and central regions of Brazil, where approximately five million hectares are estimated to be suitable for castor cultivation (Lane, 2014). The castor crop could also be used for bioremediation purposes.

Rice straw and husks

As indicated in Table 1, rice is a major Brazilian crop, with an output of over 11 million tons per year. The State of Rio Grande do Sul is responsible for over 50% of the rice harvest. The percentage of straw (stem or stalk of rice) in the total plant biomass ranges from 30 to 64 %. Therefore, an estimated 5 million tons of rice straw, consisting of 37% cellulose, 24% hemicellulose and 14% lignin, are produced yearly in Brazil (Ferreira-Leitão, et al., 2010). Farmers tend to burn the surplus rice straw, which is not used as compost for soil fertility, directly on the fields as the most economical method of disposal. This causes environmental and health hazards (smoke) and growers are looking at different ways of disposing of the rice residue in the field, in hopes of developing this ''waste'' into a potential resource. A unique feature of rice straw is its high silica content, which can be up to 18%. High silica content is problematic for combustion in boilers as it causes fouling, slagging and corrosion. These technical problems offer opportunities for research and technology cooperation.

Similar to rice straw, rice husk[8] has been put to use within the industrial sector for electricity generation. Among the crop residues, rice husk stands out for its highest ash content upon burning. Therefore, researchers have identified new uses for the recovered silica, which can be made into bricks, ceramic articles, and glassware, thus completing the recovery cycle. After burning, these materials can also be used as fertilizer or as raw material for foundries.

[7] Intercropping, also called 'second crop' or 'safrinha'in Portuguese, consists in planting the castor after harvesting the soybean crop.
[8] Rice husk, which yields about 25% of the weight of rice, presents an oven-dry solid with a weight composition of 34.4% cellulose, 16.2% xylan, 1.3% arabinan and 23.0% lignin.

Palm oil in the Amazon

Palm oil - also known as Dendê oil in Portuguese - is an edible vegetable oil derived from the pulp of the fruit of oil palms, primarily the African oil palm and to a lesser extent from the American oil palm and the Maripa palm. The Brazilian agricultural research company EMBRAPA estimates that 20 million hectares of deforested and degraded land are suitable for palm plantation. This is a very large area when compared to the 4 million hectares of palm oil plantations in Malaysia.

Developments have been slow initially, due to relatively high labour costs and limited government support. But this year INCRA (the federal institute for colonisation and agrarian reform) has come around to become supportive of palm oil expansion, and the national development bank has made funds available. An example of the largest company operating in this area is AGROPALMA SA which currently operates about 100.000 ha. They have proposed to follow the Malaysian model, based on family farms, organized in cooperatives, selling the raw oil to the refineries.

Orange peels

Brazil produces more than 17 million tons of oranges per year, representing almost 35% of all the oranges produced in the world. Brazil is also responsible for more than half of all the orange juice distributed throughout the world[9]. Adequate climate conditions and a large number of producers are some of the factors that help to sustain Brazil's position as market leader.

The main producing area in Brazil is known as the Citric Belt, a region that encloses mostly the state of São Paulo and the western portion of Minas Gerais, known as Triângulo Mineiro. This area alone is responsible for more than 80% of Brazil’s oranges. São Paulo, itself, has more than 10.1 thousand citrus producers, with crops distributed throughout nearly 500,000 hectares. The city of Itápolis is one of the main producers, as well as Casa Branca, Pirassununga, and Mogi Guaçu.

In the past years, an overproduction was seen among the Brazilian producers, making it necessary to establish measures in order to reduce the stocks. One of the biggest crisis of this sector happened in 2012, when the United States suspended the purchase of Brazilian oranges because of a certain pesticide used on the crop. Better results are expected for the next years, though[10].

DSM has developed a new process that creates a chemical compound traditionally produced from orange peels, but at a much lower cost. This means that orange peels will soon become available for other applications and markets.

[9] http://thebrazilbusiness.com/article/the-brazilian-orange-industry
[10] IBID

4 Electricity from biomass (bio-power)

4.1 Market overview

Brazil is a major producer of electricity from biomass. In 2013, with an installed capacity of 11.3 GW, biomass power represented 7.6% of the country's power supply, which is dominated by large hydroelectricity plants (at about 70%)(see Figure 6). In the country, bioelectricity is produced in 507 biomass plants throughout the country, which are mainly sugarcane mills (10 GW, over 389 plants), followed by black liquor[11] (1.8 GW in 17 plants) in the pulp and paper industry and smaller amounts of wood residues (360 MW in 47 plants) (ANEEL 2015).

Continued expansion of hydropower is limited and controversial. Technically the expansion is constrained by the remoteness of the hydro resources, and socially there is growing resistance to the displacement of indigenous people and the significant environmental sensitivity of a large part of the remaining resource, although 20 GW of hydropower capacity is under construction in the Amazon region (IEA, 2015). Furthermore, persistent droughts in the South-east region (São Paulo) have led to low utilisation rates of hydro resources in that region, and consequently higher electricity prices. These changes are believed to be structural, and will likely have impact over the next decade or more.

On the long term, the national planning agency expects demand for electricity to keep growing by 4.7% per year until 2022[12]. Instruments to develop renewable power generation (including biopower) include an incentive programme called Proinfa and a system of contract auctions since 2005. Besides Proinfa and the auction scheme, Net metering regulations have been introduced which allows consumers to directly feed electricity back into the grid.

[11] Black liquor is a by-product of the pulping process with a high energy content.
[12] Plano Decenal de Expansão

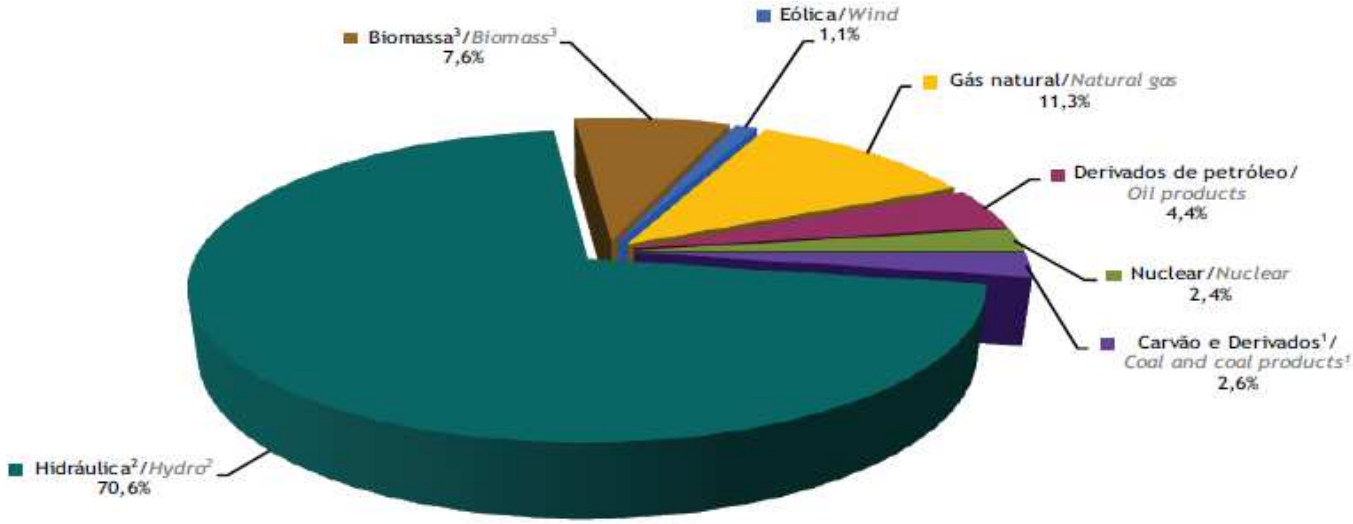

Figure 6 Primary energy use for electricity generation. Source: Balanço Energético Nacional 2014

Biopower from sugarcane mills

Over 98% of Brazilian sugar mills are electrically self-sufficient. They burn the bagasse (residue from the milling) in low-efficiency boilers/turbines in order to provide just enough steam and electricity to meet their own needs (Ecofys, 2012). However, mills are increasingly using surplus bagasse to produce excess electricity which is sold to the national grid. Of the 389 plants in operation last year, 160 were delivering power to the grid. The total installed capacity was about 9 GW, and the power delivered to the grid 1.4 GW (Jornal Biomassa BR, 2015). In order to produce marketable amounts of electricity, the sector is expected to invest in new technologies, including cogeneration equipment. There is a clear trend toward the implementation of boilers with higher steam-production capacity. New boilers and steam turbines with higher capacity and efficiency would substantially increase the electricity surplus that the mills would be able to sell.

According to UNICA - the Brazilian sugar and ethanol industry association - the national policy aims to use this residue to help increase the electricity from the overall cane industry to about 14 percent of the national requirements by 2020. The country still lacks a comprehensive long-term sectoral policy however, in order to secure investments and technological innovations needed for the current low-tech mills.

Biopower from rice

Though only a small part of the electric energy produced from biomass in Brazil comes from rice waste (36 MW, in 9 plants (Jornal Biomassa BR, 2015)), Ferreira & Leitao (2010) estimate the current technical potential at 200 MW, and an economic potential of 100 MW, due to logistical barriers.

A recent study by Tractebel and the university of Santa Catarina (Miyake, et al., 2012) identified co-firing rice straw in coal plants as a near term, low cost and low risk alternative for renewable energy production. A pilot was run in one unit of the Jorge Lacerda plant where rice straw is co-fired to 10% in a 50 MW power plant. The results showed a reduction up to 12% in CO_2 and SO_2 emissions and an increase up to 5% in gas temperatures.

However, there are many technical issues that may be studied for their sustainable use in power generation. Dutch research organisations could take a role into developing better boilers and biomass supply chains (see Table 5).

4.2 Main Policies

Proinfa – Incentive Programme

In 2002 the Brazilian government set up an incentive scheme called PROINFRA to support investments in wind power, bioelectricity and small-scale hydro. The initial target was for 3,300 MW capacity by 2009, however due to a slow start and implementation issues by 2011 an installed capacity of only 2,888 MW was achieved across 132 projects (60 projects 1,156.65 MW small-hydro; 51 projects 1,181.72 MW wind; and 21 projects 550.34 MW for biomass).

Auction Scheme

The Auction scheme was set-up to provide an efficient market for renewable power generation as alternative and complement to the dominating hydro-power sector. It plays an important role in stimulating biomass-power and has been significantly more effective in spurring deployment of renewable energy than the PROINFA Feed-in tariff.

There are two types of auctions for renewable electricity in Brazil:

- *New energy auctions* used to contract new capacity needed to meet the growth in electricity demand. Energy contracts are long-term and are auctioned in two markets:
    - The regulated market where 100% of the energy is bought in competitive bids with guaranteed revenue for generators. This type of auction is usually for large scale renewable electricity and conventional power.
    - The free market where contracts are freely agreed between consumers and independent power producers (IPPs). They are usually short to medium term bilateral contracts.
- *Reserve energy auctions*, which are organized at the discretion of the ministry and used to contract supplementary energy to increase the system's reserve margin. Using reserve energy auctions, the government can contract a given quantity of energy even if it was not considered in the demand forecasts prepared by the distribution companies. This type of auction is also used to contract renewable power (Batlle&Barroso, 2011).

The auction scheme is led by ANEEL under the guidelines of the ministry of mines and energy (MME). The Energy Research Company (EPE) which sits within the MME lists all energy auctions on its website, and real time auctions are managed through a web portal on the Energy Trade House (CCEE) website. There are technical pre-requisites to register a candidate project for the auction, including a prior environmental license, a grid access statement, financial qualifications, technology-dependent documents (such as a fuel supply agreement) (Cunha, 2012).

The auction system is intended to create competition between the different renewable power producers and sectors. However, the auction prices and volumes are strictly controlled by the government, and several interviewees have complained that the level playing field is tilted away from biomass power. Problems include the government distorting electricity prices (keeping them low) as a measure for combatting inflation[13] and the fact that other renewables also receive investment subsidies. These issues, combined with the unpredictability of government policies and strong lobby interests (from hydro, wind) make it a challenging environment to operate in.

The National Energy Plans to 2030 and 2050 (PNE)

The National Energy Plan 2030 (Plano Nacional de Energia - PNE 2030) was launched in 2007 and has been considered an important mark in the history of the energy sector[14]. The Energy Planning and Development Secretariat from the Energy Ministry (*MME)* was responsible for the coordination of the work executed by the public Energy Research Company (*EPE*) and Eletrobrás' Electric Energy Research Center (CEPEL). A new plan (PNE 2050) is expected to be published in the second semester of 2015.

The PNE 2030 puts a fair deal of emphasis on energy from biomass as one of the key-sources in reducing fossil fuel dependency, increasing energy security and diversification and preventing negative impacts of the supply-limitations of the hydropower infra (as a function of the increasing demand until 2050, especially during the dry seasons). To date it has become obvious that the policies are not sufficient to meet the growing needs for power, and more incentives are needed to reach any of the targets as formulated in the PNE 2030. This is mostly due to the fact that policies have, and are increasingly incentivizing thermoelectricity (natural gas, coal) nuclear power as well as big-wind and solar.

Current electricity prices

In Brazil, electricity tariffs are regulated, revised and published by the Agencia Nacional de Energia Electrica (ANEEL) every year. The country is divided into 63 'concessions' in which one or more utility companies, both national or local, are in charge of electricity distribution. A particularity of Brazil is that big discrepancies in wholesale electricity prices exist between the various regions.

[13] the same phenomenon is observed with biofuels
[14]It consists of an impressive 12 volumes pf studies and recommendations.

Electricity tariffs are divided in high and low voltage, and within each level, are further differentiated according to the contracted power and the sector. Since 2013, a system of "Bandeiras Tarifarias", which depend on the conditions of electricity generation and subsystems, has been created. Indeed Brazil has a Sistema Nacional Interconectado (SIN) of 4 subsystems: North, South, North-East and South-East. ANEEL announces on a monthly basis which 'banda' (green, yellow, red) is in operation for the month, 'green' being for favourable electricity conditions, yellow and red for less favourable conditions with higher generation prices per kWh consumed. Generally, in Brazil, three different electricity tariffs exist depending on the period of the day: Hora Ponta or peak hours (18h-21h), Intermediaria (16h-18h) and Fora da Punta or off-peak hours (21h-16h, week-ends and national holidays). Electricity prices include a variable component (BRL$/MWh) linked to electricity consumption, a price (BRL$/MWh) for the use of the electricity distribution system (Tarifa de Uso dos Sistemas elétricos de Distribuçao, TUSD) as well as a national and federal tax component.

In 2014, the average residential electricity price, as classified locally by regulators, was 132.404 USD/MWh, the average commercial price 103.667 USD/MWh and the average industrial price 125.215 USD/MWh. Overall the average retail electricity prices, calculated as the average of all three rates on a national scale, amounted to 120.43 USD/MWh[15].

The electricity sector in Brazil has been roiled by pricing constraints and rising costs. In March 2015, the Government has decided to stop funding an energy subsidy program, known as the CDE, forcing Brazilian utilities to increase costs by approximately 23%, on top of regular annual adjustments. Brazil's power generation capacity threatened to outstrip demand in most parts of the country due to delays in building new power plants and transmission lines. Moreover the recent heavy drought, especially in the South-East region, lowering dam levels of hydroelectric plants, worsened the scenario and contributed to further increase wholesale electricity prices. Earlier this year, ANEEL increased the tax component introduced by the 'Banderas Tarifarias' system (for example prices in the red banda increased from 0.03R$/kWh to 0.055R$/kWh, and in yellow from 0.015R$/kWh to 0.025R$/kWh) impacting all electricity tariffs.

The environmental licensing required for biopower operations are regulated by CONAMA law nº 237, (1997). Licencing is based on location and type of operation. Further aspects of licensing, but also incentives for social-environmental aspects of biopower are regulated through: Law Nº 12188 (11 January 2010), which created a national policy for technical assistance for family ariculture (known as PNATER[16]) which is important for incentives for smaller scale operations (for instance cooperatives operating biopower plants).

[15] http://global-climatescope.org/en/country/brazil/#/details
[16] Política Nacional de Assistência Técnica e Extensão Rural para a Agricultura Familiar e Reforma Agrária

4.3 SWOT

The strengths, weaknesses, opportunities and threats for the sector are shown in Figure 7

Strengths	**Weaknesses**
• Biomass in included in the proven power auction system in place • Expectations that policy will expand the role of auctions for biomass	• Not all users are connected to the grid • Value chains poorly integrated
Opportunities	**Threats**
• Technology gaps in: o Pre-processing o Logistics and infrastructure • Brazil wants to use alternative feedstocks for biopower • Lack of knowledge for R&D	• Electricity prices of other renewables (wind) could outcompete bioelectricity • Biopower potential is not fully exploited due to lack of coherent policy and incentives

Figure 7 SWOT for the Brazilian biopower sector.

4.4 Main stakeholders

Biopower mostly becomes economically viable when it can be done at a large scale and when it can be connected to the grid. As soon as one connects to the grid one has to be aware of the main stakeholders that regulate the national power system. These stakeholders and their roles are briefly explained below.

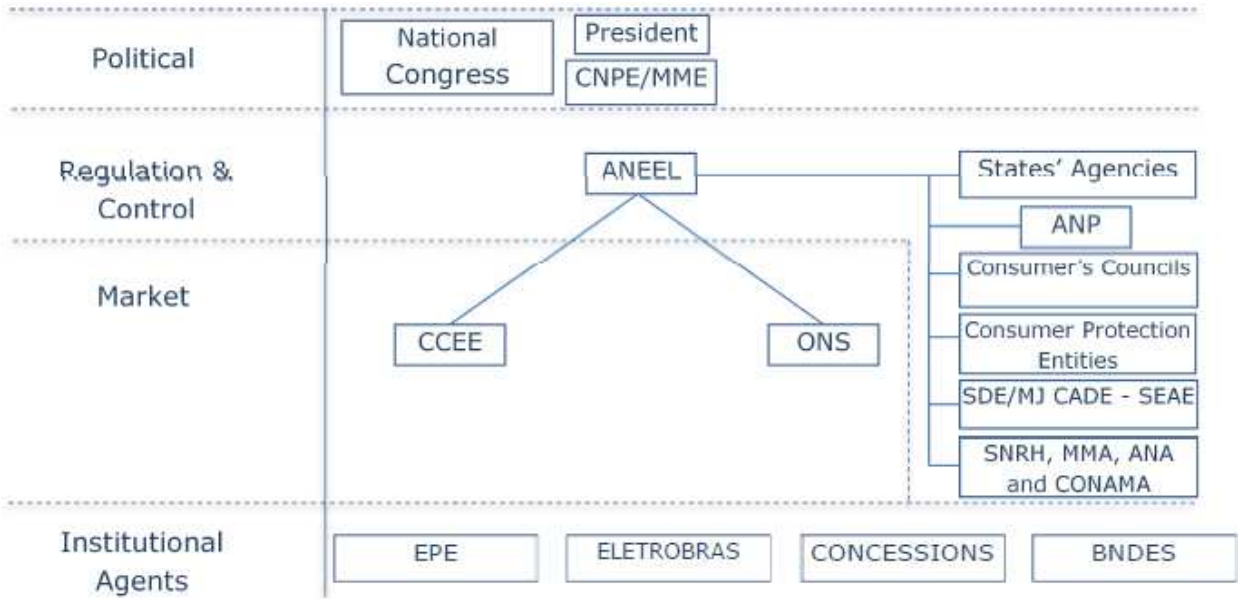

Figure 8 Institutional structure of the Brazilian electricity sector. Source: Transfer 2015

The government's influence in the energy sector is exclusive to the Ministry of Mines and Energy (MME) in combination with the National Council of Energetic Policy (CNPE), with support from the National Congress and the President. The policies developed by those bodies are regulated and controlled by the National Agency of Electric Energy (ANEEL). Financials are managed by the Chamber of Commerce of Electric Energy (CCEE) and operations are left to the National System Operator (ONS). ANEEL is under the oversight of representatives of the people, the federation's states, the National Oil Agency (ANP), and diverse public institutions. The authorized and regulated activities are then carried out by the Energy Research Company (EPE), ELETROBRAS, utility companies that hold concessions for their operations and the National Development Bank (BNDES) – all of which are either public-private partnerships with open capital or non-profit organizations. Utility companies dealing with electric energy usually do not participate in other markets (Transfer, 2015). Environmental licensing is particularly important for biopower, and is a legal obligation before any potentially polluting activity can take place. A framework has been created by the federal government called the National Environment System (SISNAMA), which includes local state government environment agencies, the National Environmental Council (CONAMA) and the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), in order to facilitate the licensing process.

4.5 Opportunities for Dutch players

Of the 507 bioelectricity plants in operation reported by ANEEL[17], the vast majority use old technologies that are enough for self-sufficiency of the cane mill, but not suited for multiple feedstocks and not optimised in terms of yield, which leaves large efficiency gains to be made when delivering power to the grid. Furthermore, with the effects of the drought expected to push electricity prices up on the long term, power production from biomass offers opportunities for growth, and for Dutch parties. Players like COSAN are already betting on it by developing their biomass power from sugarcane. Conversations with this party and other experts have lead us to identify opportunities for Dutch parties in the area of biomass power as shown in Table 5.

[17] http://www.aneel.gov.br/aplicacoes/capacidadebrasil/OperacaoCapacidadeBrasil.cfm

Table 5 Opportunities and relevant stakeholders in bioelectricity

Opportunities	Stakeholders	Indicative timeframe
• Research combustion properties of new feedstocks • Optimisation of combustion processes	SENAI Biomasa, EMBRAPA Agroenergia; ERB; IPT	1-5 years
• Prospecting new feedstocks (new plant varieties and species)	EMBRAPA Meio Norte, EMBRAPA Agroforestry, USP Biosciencias, Granbio	1-5 years
• Technology supply/transfer in gasification (syngas) and fermentation (biogas)	Mid- and large-scale agricultural producers, EMBRAPA Biomasa, CENBIO, ITAIPU research centre; GET2C	1-5 years
• Research and consultancy on biomass-to-power value chain (including off-grid solutions)	Odebrecht, Bardella SA	1-5 years
• Grid design and reinforcement, smart grids	EPE, UFRJ, Subcontractors, Ministry MME, DAEE (National water and power department)	1-5 years
• Investments in independent power producer under auctions	Eletrobras, Eletrosul, CPFL	1-5 years

Furthermore, Brazil needs to adapt its long-term energy planning to take into account the limited expansion possibilities of its hydropower, and the lessons learned from the renewable energy incentives. Brazil can also learn from other countries with highly diverse energy matrices. These lessons learned could very well be provided by Dutch knowledge and research institutes.

Next Steps

Dutch parties who recognize opportunities and would like to enter in contact with stakeholders named above are encouraged to contact the Dutch support network in Brazil (See section 13.3) or in the Netherlands (RVO) when looking for Dutch partners in their sector.

5 Biofuels – conventional and advanced

5.1 Market overview

Brazil has developed a sugarcane-based fuel infrastructure over the last decades, kick-started by its flagship ethanol programme 'Proalcool' that was launched in the 70s as a response to high oil prices (oil crises) and low sugar prices. Today, the country produces about 27 billion litres of ethanol from sugarcane. Depending on the production and demand volumes, the surplus is exported (USDA GAIN, 2014). Although the initial subsidies of the Proalcool programme have been phased out, today the biofuels industry operates in a highly regulated environment. For example, in order to fight inflation, the prices of fossil transportation fuels were kept artificially low in the last years, meaning that ethanol also had to sell at lower prices if it still wanted to be competitive. This has caused a crisis in the sugarcane ethanol sector in the last couple of years, from which the sector is only slowly starting to recover.

5.2 Main policies

Ethanol

Ethanol is sold as a vehicle fuel in either pure hydrated ethanol and brought on the transport market The percentage of ethanol blended in gasoline can vary from 18 to 25 percent according to the Provisional Measure #532 of April 2011. In 2011, the obligatory ethanol blend rate was dropped from E25 to E20 due to low availability. E27 is the norm as of August 2015. Virtually all bio-ethanol in Brazil is produced from domestically-grown sugarcane.

The use of ethanol is also stimulated through the large-scale deployment of flex-fuel vehicles. These are vehicles whose engines can run both on gasoline and ethanol. The sale of flex-fuel vehicles is stimulated through lower taxes, particularly lower IPI (Tax on Industrialized Products) (USDA GAIN, 2014).

Biodiesel

In December 2004, Brazil started the National Biodiesel Production and Use Program (Programa Nacional de Produção e uso do Biodiesel) (PNPB) to increase the uptake of biodiesel nationally. This program resulted in the 2005 law 11.097 mandating a minimum 2% biodiesel by 2008 and 5% by 2013. In May 2014, the Minister of Mines and Energy announced that the biodiesel requirement would increase to 6% on July 1, 2014 and 7% on November 1, 2014.

5.3 Aviation biofuels

Light aircraft have been flying on ethanol in Brazil for years, especially in the field of agricultural aviation. However, when we talk about aviation fuel, by far the largest market is jet-fuel, which is based on kerosene. Bio Jet fuel therefore has be designed as a drop-in fuel to be used with existing aircrafts and infrastructure, which are highly regulated. International standards are in place and several pathways to aviation biofuels have been certified by ASTM to be used in aircraft. Since 2011, airlines globally performed over 1500 commercial passenger flights with blends of up to 50% jet biofuel from used cooking oil, jatropha, camelina, and algae (SCOPE, 2015).

Feedstocks for these fuels are abundant in Brazil, but the production costs remain significantly higher than the costs for fossil jet fuels. A recent study by Cremonez et al (2014) concludes that "despite Brazil having vast farmland and several oilseed crops with potential for biofuel production, the high demand caused by the current use of biodiesel added to diesel oil in the Brazilian vehicle fleet compromises the use of these materials with other energy purposes".

Some developments are worth noting though. After 2010, a group of 10 companies related to aviation (Embraer, AIAB, TAM, Gol, Azul and Trip, UNICA, Amyris Brasil, Algae Biotecnologiae ABPM) founded the Brazilian Alliance for Aviation Biofuels (ABRABA), aiming to reduce the costs and improve energy security. Also worth mentioning is the SABB research project[18], which resulted in a report titled 'Flightpath to Aviation Biofuels in Brazil: Action Plan' in 2013. Recent developments include experiments with producing jet fuel from alcohol, as showcased by Californian company Byogy in partnership with Brazilian company Avianca Brasil.

In October 2014, Be - Basic, KLM and SkyNRG signed a Memorandum of Understanding with the Brazilian State Minas Gerais, to join forces in the development of an aviation biokerosene value chain, and becoming part of the Minas Gerais biokerosine platform (Plataforma Mineira de Bioquerosene). Activities within this platform cover the complete value chain, from innovation in feedstock to sustainable production technologies for bio jet fuels and to increase public awareness (Be-Basic, 2014).

From a Dutch perspective, the main ambition has been to look at potential for export of bio-oil for international use. Dutch biofuel company SkyNRG has been trying to develop new crops for producing low-cost feedstocks, but has encountered a number of barriers in importing new non-native varieties like Camelina into Brazil. Export of vegetable oil is discouraged by a tax that favours conversion of the oil in Brazil to final biodiesel.

[18] http://www.nipe.unicamp.br/sabb

5.4 Bioethanol from new feedstocks

The feedstocks identified in Chapter 3, as well as new – to be developed feedstocks offer prospects for reducing costs of ethanol in the long term. A recent report by Jonker et al (2015) estimates that and energy cane cultivation costs may be reduced for feedstocks like elephant grass, eucalyptus and sorghum as well as conversion technology advancements can be drivers of ethanol production cost reductions by 2030.

Rice residues

Similarly, Beta Renewables in Italy has also taken into production a plant to produce bioethanol, with a capacity of 75 Mlitre/yr, processing 275 thousand tonnes/yr of raw material including rice straw[19]

In Brazil, so far we have found only one example of a refinery plant, capable of processing rice-straw for ethanol production. This a venture of America Biomass Technologies in Piracicaba/SP, and includes on-site production of the required enzymes. It remains unclear what exact feedstock is processed, but the claim is to develop plants ranging from 1000 litre/yr up to 1 Mlitre/yr out of virtually any feedstock. The project was funded with BNDES financing[20].

For now, the rice-straw as a feedstock seems promising enough to investigate further, especially with regards to R&D in Brazil. Research will need to cover conversion technologies as well as field operations like rice-straw bailing, logistics etc. Similarly, it would be good to identify Dutch technological, operational and business expertise regarding this rice-straw for bioenergy and biofuel production.

5.5 SWOT

The strengths, weaknesses, opportunities and threats for the biofuels sector are shown in Figure 9.

Strengths	**Weaknesses**
• Historical experience in sector • Strong Branch organization (UNICA) • Clear policy and guaranteed market	• Low investment levels • Low efficiencies • Threshold in investment in new technologies • No guaranteed prices
Opportunities	**Threats**
• High electricity prices • Accumulation of technological experience • Strong track record with NL-BR cooperation (Be-Basic)	• Sector is in crisis • There is little funding available • Conservative attitude to innovation • Droughts becoming more frequent

Figure 9 SWOT for the conventional biofuels sector

19 UOL - Economia - Agronegocio - 14/10/2013

20 Produza etanol/álcool de segunda geração a partir de palha, casca de arroz outras biomassas. Produção: 200 litros de etanol por tonelada de biomassa seca - Newsitem/advertisement of 'Portal e-Usinas'

5.6 Main stakeholders

Table 6 Main stakeholders of the biofuels sector in Brazil

Name	Description	Website
ANP	ANP is the National Agency for Oil and Gas, linked to the Ministry of Mines and Energy responsible for the regulation of the oil sector. The agency that regulates the blending mandates and biofuels producers have to be registered with this agency in order to supply their fuels to the market.	http://www.anp.gov.br
UNICA	The Brazilian Sugarcane Industry Association represents about 60% of Brazilian sugarcane production. They are present in Brussels and lobby for the interests of cane ethanol.	http://unica.com.br
Copersucar	Brazil's largest ethanol producer, operating 48 mills in the states of São Paulo, Goiás, Paraná and Minas Gerais	www.copersucar.com.br
CTBE	National Laboratory that operates with the scientific and technological community and the Brazilian productive sector, aiming to contribute to the maintenance of competence of the Country in the production of sugarcane ethanol and other compounds from biomass	http://ctbe.cnpem.br/en
CTC	The centre for research in cane technology	www.ctc.com.br
Raizen	Joint venture between Brazilian ethanol and sugar group COSAN and Shell	www.raizen.com.br
Odebrecht Agroindustrial (Previously ETH)	Large ethanol producer	www.odebrechtagroindustrial.com
Brazilian Bio-jetfuel Platform	Formed in August 2013 as an open, collaborative platform to bring together key stakeholders to promote the implementation of a highly integrated biojetfuel and renewable value chain, "from R&D to the wing", to fill in the gaps identified by the Sustainable Alternative Biojetfuel study sponsored by Boeing, Fapesp and Embraer.	http://cdieselbr.com.br
Granbio	Biofuel producer and innovator. Granbio built the first advanced ethanol plant to operate on a commercial scale in Brazil.	www.granbio.com.br/en
Uabio	The Brazilian Union of Biodiesel and Biokerosine.	www.ubrabio.com.br

5.7 Opportunities for Dutch players

For conventional biofuels, opportunities exist in

- Technology supply and R&D for biodiesel from vegetable oils waste streams (UCO etc.);
- Logistics/collection of used cooking oil and tallow;
- R&D for engine technologies (e.g. TNO);

In the area of advanced (second generation biofuels) opportunities have been identified in the following areas:

- Development of enzymes for second generation sugars and biofuels (DSM);
- Research and development in advanced conversion processes and pre-treatment for lignocellulosic feedstocks;
- Biotechnology and Catalytic processes

Table 7 Opportunities and related stakeholders in biofuels

Opportunities	Stakeholders	Indicative timeframe
Technology supply/transfer for increased efficiency e.g. pre-treatment, gasification (syngas), pyrolysis, fermentation (biogas)	Abengoa, Raizen (Shell-Cosan), ETH, Odebrecht, Granbio, UNICA, Cosan, ERB, USP Biosciencia, IPT, Unicamp	1-5 years
Work on crop improvements, rotations and agronomy	Universities (ESALQ, UNICAMP, UFMG, IES), CTBE, CTC	5-10 years
Logistics/collection of used cooking oil and tallow	Biodiesel producers, Municipalities	1-5 years
R&D for vehicle engine technologies	IPT, Automotive research centres like INPE, ITA	5-10 years
Development of enzymes for second generation sugars and biofuels	CTBE, Universities, CENBIO, IPT	5-10 years
Engage with Jet fuel platform	Be-Basic, GOL Aerolineas, TAM, Azul-Avianza,	1-5 years
Engine technology	Embraer product development engineering	5-10 years
Pre-treatment for lignocellulosic feedstocks (pyrolysis, torrefaction, pelleting etc.)	Cosan, ERB, USP Biosciencia, IPT, Unicamp	1-5 years
Research and piloting on algae-based biofuels	SENAI Biomasa, UFC (University of Ceara)	5-10 years
Research in biotechnology and catalytic processes	USP Biosciencia, IPT, Unicamp	5-10 years

Next Steps

Dutch parties who recognize opportunities and would like to enter in contact with stakeholders named above are encouraged to contact the Dutch support network in Brazil (See section 13.3) or in the Netherlands (RVO) when looking for Dutch partners in their sector.

6 Biomass for other industrial uses

Besides the more known biofuel and bioelectricity applications, Brazil uses biomass in large-scale sectors like iron and steel, paper and pulp and cement and ceramics industries. Because biomass has been very low-cost, most of the processes are not very efficient, and opportunities lie in the expansion of biomass use, and improving efficiencies of biomass to heat value chains.

6.1 Market Overview

Iron and steel plants

Brazil is one of very few countries that uses biomass for heat in its iron and steel industry, with approximately 4 Mtoe of charcoal and biomass, supplying 31% of Brazil's iron and steel energy requirement in 2010 (IEA Bioenergy, 2013). Generally, plants that produce pig iron and steel in Brazil use charcoal, mostly emanating from forests and planted trees, as a thermal and reducing agent in their industrial processes, as an alternative to fossil coal. The iron and steel sector is predominantly situated in the state of Minas Gerais, where the high costs of logistics make the use of locally-produced charcoal relatively economical. Charcoal is also being investigated as a component for coke-making, tuyere injectant, steel recarburiser and foaming agent (all elements for the steelmaking process). (Bajay, Carvalho, & Ferreira, 2000). Even for large industrial applications, the charcoal making process is still based on traditional practices, which mean throwing biomass on a heap, covering it with bricks, and slowly heating it from below, without oxygen supply. This process is very inefficient from a resources perspective, very labour intensive and polluting the air.

An example of a steel company that uses charcoal extensively is ArcelorMittalBioEnergia, which manages eucalyptus plantations and charcoal manufacture in Brazil to produce 'green' steel.

Paper and pulp mills

The pulp and paper sub-sector is the fifth-largest industrial consumer of energy (Bajay, Carvalho, & Ferreira, 2000). The Brazilian pulp industry uses wood mostly derived from national tree plantations. Black liquor is a by-product of pulp production and is consumed as a fuel in the steam generators of the pulp plants themselves and others. When wood chips for pulping are produced in the mills, residues such as barks and fines are generated. In mills that produce pulp, they are typically burned in auxiliary boilers to generate surplus heat. However, these residues could also be converted to alternative fuels, which would allow pulp mills to export biofuels and in turn reduce the continuous demand for fossil fuels. Furthermore, depending on the profitability of the biofuel production, additional biomass could be brought from the forest specifically for this purpose (IEA Bioenergy, 2013) .

In 2012, BNDES approved 210 million Reais (US$104 mn) in funding for the construction of a steam and eucalyptus chip-fired cogeneration plant by company ERB Aratinga, headquartered in Bahia state. The facility produces 1.15Mt of industrial steam and 126MW of electricity per year and supplies

power for industrial units belonging to petrochemical firm Dow do Brasil. The investments include the plantation of 228Mt/y of eucalyptus across an area of 9,700 hectares (BNAmericas, 2012).

6.2 Main policies

During the 70's and 80's the Iron & Steel and Pulp & Paper industry were stimulated to plant trees for energy and fibre use through tax rebates. Today the use of wood is competitive with fossil fuels in many (remote) locations, and there are no clear policy incentives to increase this share.

6.3 SWOT

The threats, weaknesses, opportunities and threats for biomass use in other important industrial sectors is shown in Figure 10.

Strengths	**Weaknesses**
• Strong sectors: o Iron & Steel o Ceramics (bricks) o Cement o Pulp & Paper	• Outdated technology • Low thermal and material efficiencies • Logistical bottlenecks • Little experience working with foreign partners (in Cement and Ceramics industries)
Opportunities	**Threats**
• Large demand for industrial heat Need and experience with energy self-sufficiency • No dependence on policy • increased environmental legislation • End 2015 new budget is expected from BNDES to develop small-scale pyrolysis	• Collapse of construction sector • Increased environmental legislation • Conservative industries (cement and ceramics)

Figure 10 SWOT for biomass use in heavy industry sectors (iron & steel, pulp & paper)

6.4 Main stakeholders

Table 4 presents the main stakeholders for the industries of Iron & Steel, energy tree plantations, and paper and pulp.

Table 8 Main stakeholders of other industrial users of biomass for energy

Name	Description	Website
AMS – Associaçao Mineira de Silvicultura	The association for forest plantations of the Iron & Steel industry of the State Minas Gerais	http://silviminas.com.br
Renabio	Renabio is the Brazilian association of tree plantations for energy use. Renabio is looking for partners (incl. from abroad) for projects.	http://www.renabio.org.br/
Sindifer	Industry association for the Iron & Steel sector in Minas Gerais	www.sindifer.com.br
Bracelpa	Association of Brazilian pulp & paper industry.	http://bracelpa.org.br

6.5 Opportunities for Dutch players

Dutch parties can play a role in modernising the production of charcoal, or by researching the possibilities for introducing gasification technologies, thereby making the biomass supply chain more efficient.

Table 9 Opportunities in large industrial users of biomass

Opportunities	Stakeholders	Indicative timeframe
Iron & Steel: modernizing production of charcoal (R&D and technology supply in torrefaction, gasification, pre-treatment)	Sindifer, AMS (industry organisations)	1-5 years
Paper & Pulp: valorisation of residues (biorefinery)	Bracelpa (industry organization), Fibria, Suzano	1-5 years
Join bioenergy platform for joint development of opportunities in bioenergy for heat and power.	Renabio (industry organization for plantation wood energy)	1-5 years
Cement and ceramics: make use of new feedstocks available locally (see native species) (as a result of legislation)	Votorantim, smaller producers	1-5 years

Next Steps

Dutch parties who recognize opportunities and would like to enter in contact with stakeholders named above are encouraged to contact the Dutch support network in Brazil (See section 13.3) or in the Netherlands (RVO) when looking for Dutch partners in their sector.

7 Biogas

7.1 Market overview

The emerging **biogas** sector could become large and appears to be promising. Most of the biogas produced is used for electricity (700 GWh in 2013) and heat production (17 GWh in 2013) (IEA 2013) Its use as a vehicle fuel is only just being evaluated, but seems promising.

Biogas for energy

At present the biogas sector only accounts for a small part of the total renewable energy produced. In 2013, of the 11.337 MW electricity from biomass only 80 MW came from biogas power plants. However, we believe the biogas sector is a promising growth sector for decentralized energy generation[21]. The market is bound to increase in the short and medium term, and commitments by both the private and public sectors to facilitate this growth are solid[22].

In 2009, for the first time, biogas plants were allowed to tender for selling their electricity to public energy provider COPEL, in the state of Paraná where the development of the sector is most pronounced. Even though the feed-in tariff was not high enough to conclusively guarantee a profitable operation, it is was an important step forward in making the biomass plants more profitable.

Whilst in the past the primary purpose of such plants was sanitation and environmental protection, gas and electricity production for residential use and selling off excess electricity has only recently become economically viable. Brazil has now 22 biogas power plants connected to the electric grid. The majority of biogas plants are installed on agricultural properties, processing residues (including slaughterhouse waste), and at landfills. A few plants exist at farms and small industries generating electricity for their own use but are not connected to the grid. Moreover suppliers of small biogas motors are becoming more and more common in Brazil. Below is a summary of the types of plants that currently exist in Brazil.

Some international stakeholders have been contributing to the recent development of the biogas sector:

- GIZ, the German Association for International Cooperation, has set up a programme, as part of the German Climate Technology Initiative, to promote energy generation using biogas from sewage treatment, solid waste and agricultural residues in Brazil. It coordinates actors from the political sphere, the public sector, industry, and the academic and research community during the

[21] Based on literature and interviews at MME
[22] Interview with Dornelles, MME

period 2013 to 2018. Through close cooperation with the relevant regulatory authorities in the country and scientific cooperation, GIZ is helping in shaping processes and conditions for financing and support as well as providing training with leading sewage companies;

- SCANIA, a Swedish firm with a sales and service organisation in the truck and coach business, is actively involved in Brazil, It introduced a new technology for buses using biomethane in a pilot project. In this way, the aim is to demonstrate that this unconventional fuel can be of high value for the transportation sector.

Production of biogas

On the production side of biogas, the main stakeholders are mostly:

- Agricultural firms, using the fermentation of agro-waste from both crops and animal farming (manure) for biogas, energy and heat production;
- Meat processing industry (waste from slaughterhouses);
- Landfills;
- Wastewater treatment plants;
- Municipal and private operators of urban transportation;
- Hospital, shopping mall and hotel chains, project developers of condominiums for domestic, industrial and mixed uses.

Table 10 Status of biogas production used for electricity production in Brazil (values from 2013). Source: IEA 2013.

Plant type	Number of plants	Energy production (GWh/year)*
Sewage sludge	5	42
Bio waste	1	1
Agriculture	8	10
Industrial	2	249

* = Produced energy as electricity excluding efficiency losses

Bio waste – MSW & WWPT

Biogas from landfills for municipal solid waste (MSW) and from organic residues (sludge) from wastewater treatment plants (WWTP) are the other segments of this upcoming market. These topics are further discussed in Chapters 8 and 9.

Biogas for transport

Brazil has one of the world's largest gas-powered car fleets with over 1.7 million vehicles registered in 2014. Natural vehicular gas is sold in the country through more than 1,790 filling stations. Biogas can be upgraded to natural gas quality and can substitute natural gas as a vehicle fuel.

At the end of 2014, a partnership between Itaipu Binacional (a Brazilian hydroelectric giant) and Scania (Sweden) introduced the first bus running on biomethane from bird manure. Feasibility of biogas, especially in the southern states, is increasingly being discussed. Contrary to second

generation ethanol and bio-oil from fast-pyrolysis, the biogas fuel technology is mature and easy to implement in Brazil: there are no technological bottlenecks[23].

Another example of biogas for transport is found in the state of Paraná, where 33 small scale family farms are producing biogas through anaerobic digestion of manure and other residues. Each of the 33 family farms injects raw biogas into a 22 km-long pipeline to a central hub where it is used for electricity and heat and upgraded to biomethane to be used locally as a vehicle fuel. Through the anaerobic digestion process, the farmers also produce digestate that is used as a biofertilizer on their farms. (IEA 2013b)

Biogas can be produced through anaerobic digestion of various feedstock. Typically used for electricity of heat generation, biogas can also be upgraded to bio-methane by removing carbon dioxide and hydrogen sulphide. After this upgrading process, bio-methane can be injected into the natural gas grid and becomes fully compatible with natural gas vehicles and infrastructure (IEA, 2011).

7.2 Main Policies

As the biogas market is relatively new in Brazil, no specific policies have been developed to date, and in most cases, policies regarding renewable energy and biofuels equally apply to biogas.

In Brazil it is unlikely there will be subsidy levels for developing the biogas sector as it is the case in the EU. Nonetheless the federal government recognizes the need for specific legislation to incentivize the biogas sector and it is being increasingly discussed at ministry level. Some examples are provided here:

- The Low-Carbon Agriculture plan is facilitating the implementation of the NAMAs[24] related to agriculture, including the use of biogas. This plan translates the greenhouse gas reduction targets through the National Policy on Climate Change (Law no. 12.187/09), carried out by the Ministries of Agriculture, Livestock and Supply (MAPA) and Agrarian Development (MDA), also counting on the participation of organizations that represent the producers;
- The new legislation on solid waste (prohibiting waste-dumps, regulating controlled landfills and waste collection and processing) creates opportunities to significantly increase the number of landfill-biogas plants in the short-to-mid-term (see Chapter 8);
- In January 2015, for the first time, the ANP[25] published its Resolution N.8 setting specifications of bio-methane produced from organic waste and its application for natural gas vehicles, residences and businesses.

[23] Source: MME

[24] Nationally appropriate Mitigation Actions (Mechanism to fund climate projects in developing countries)

[25] http://nxt.anp.gov.br/NXT/gateway.dll/leg/resolucoes_anp/2015/janeiro/ranp%208%20-%202015.xml?f=templates$fn=document-frame.htm$3.0$q=$x=$nc=1926

7.3 SWOT

The strengths, weaknesses, opportunities and threats for the Brazilian biogas sector are shown in Figure 11.

Strengths	**Weaknesses**
• Local availability of feedstocks (e.g. animal farming) • New developments in waste management and energy security mean this is a promising sector • Largest gas-powered vehicle park • Biogas seen as solution for decentralized power generation	• Not much domestic experience • There is no biogas culture (awareness) in Brazil
Opportunities	**Threats**
• Agricultural residues need to be treated (lby law) • Strong interest to push biogas at ministerial level • High natural gas prices • Poorly developed natural gas infrastructure • Virtually no competition from other countries	• High level of complexity (many stakeholders involved)

Figure 11 SWOT for the Brazilian biogas sector

7.4 Main Stakeholders

Table 11 Main stakeholders of the biogas sector in Brazil

Name	Description	Website
Sbera	Brazilian Society of Agricultural and Agro-industrial Waste Management	http://sbera.org.br
ABBM	Brazilian Association of Biogas and Biomethane	www.abbiogasemetano.org.br
MME	Department for Renewable Fuels of the Ministry of Energy and Mines.	www.mme.gov.br/web/guest/secretarias/petroleo-gas-natural-e- combustiveis-renovaveis/publicacoes
MCIDADES	Ministry of cities: Department for Urban transport and Department for Urban Sanitation	http://www.cidades.gov.br

Name	Description	Website
MAPA	Ministry of Agriculture, Livestock and Supply	www.agricultura.gov.br
MDA	Ministry of agricultural development	www.mda.gov.br
EMBRAPA Agroenergia	National agricultural research corporation focused on agriculture and livestock. Together with GIZ, EMBRAPA has launched a network of five biogas laboratories equipped with standardized measuring technology for biogas to provide reliable input for feasibility studies and market opportunities.	https://www.embrapa.br/agroenergia
ITAIPU Binacional	ITAIPU Binacional is the world's largest generator of renewable energy and has created the Center for Studies of Biogas in order to serve as a source of information and technical reference data in the biogas supply chain. Moreover ITAIPU participated in the development of the biogas partnership with SARCIA for the biomethane bus	www.itaipu.gov.br/en

7.5 Opportunities for Dutch players

The current scarcity of Brazilian players and the Dutch expertise in this field should make for interesting opportunities. The added-value of potential Dutch actors would lie in supply of technology, transfer of knowledge and R&D. Key topics include:

- State-of the-art anaerobic digestion technology
- Co-fermentation technology
- Collaborative R&D in anaerobic digestion technology and innovation
- Gas motors for electricity generation
- Vehicle engines for biogas fuel
- Waste and Wastewater treatment technologies
- Technology for waste use as fertilizer
- Research on (monitoring) impacts of waste on air, soil, water and plant
- Solid waste to energy technologies
- Waste management know-how and technologies.

Table 12 Opportunities and related stakeholders in biogas

Opportunities	Stakeholders	Indicative timeframe
There is need for: • Purification and upgrade (to 80% methane) • Small scale digesters and integration in micro-grids	SENAI Biomass research centre, MAPA (ministry of agriculture) and MDA (agriculture)	1-5 years
Research in engine technologies (LPG vs CNG etc.)	SENAI, IPT, Universities (UFRG, UFSC)	1-5 years
Assist in developing value chains (waste-to-transport fuel)	Agricultural cooperatives	1-5 years
Joint research on algae-based biogas	SENAI Biomasa, UFC (University Ceara)	5-10 years
Develop (bio)gas pipeline infrastructure	ANP	1-5 years

Next Steps

Dutch parties who recognize opportunities and would like to enter in contact with stakeholders named above are encouraged to contact the Dutch support network in Brazil (See section 13.3) or in the Netherlands (RVO) when looking for Dutch partners in their sector.

8 Biowaste – Municipal Solid Waste (MSW)

8.1 Market overview

Municipal solid waste (MSW) and waste water (WW) are both large streams that contain significant shares of organic materials that can be used as feedstocks for energy and materials. Below we assess both these markets, developments and opportunities for Dutch players.

According to IBGE[26], 99.96% of the Brazilian municipalities, had some form of waste management plan in 2008, but more than half disposed their waste in open landfills without proper precautions. These areas are known as lixões. Also, less than 12% of the cities in Brazil have establishments that sort recyclable waste from organic waste. Composting of organic waste is also quite rare: only 0.61% of all Brazilian municipalities have a place to implement this practice.

The targets set in the Waste Law (see below) result in reducing/preventing greenhouse gas emissions because they lead to landfill gas recovery and a higher rate of recycling organic waste and dry recyclables. In addition to the large change in applying landfill gas recovery techniques and other measures to create sanitary landfill sites, other big transformations required for this scenario include the change to two bin collection (with all associated logistic issues related to distributing bins and implementing collection systems) and setting up an infrastructure of recycling facilities (Corsten, 2012).

To optimize the treatment of the organic fraction (kitchen and garden waste) digestion with gas and heat recovery is recommended (Corsten, 2012). The digestate can be composted and the compost can be used as fertilizer. The qualitative (legislative) demands of fertilizer determine the extends of contamination of the separate collected organic waste. Digestion and composting techniques are available in the Netherlands. The change to another collection system and to using recycling facilities also creates new employment opportunities. Because of the sanitation of landfills required by the Waste Law, the current 'wastepick' problem will turn to a 'labor-issue'. Both waste collection and waste treatment can play a role in providing work opportunities to waste pickers.

[26] Brazilian Institute of Geography and Statistics

8.2 Main policies

The 2010 waste management law[27] seeks to bring various improvements and sets targets (for 2031) to send about half of organic waste to be composted and the other half to be sent to sanitary landfills (Corsten, 2012). Important points of the 2010 waste law are:

- The division of responsibilities between consumers, sellers, distributors, importers, manufacturers, and government;
- Reverse logistics (one of the most controversial). All sectors believe it is crucial to collect used products and materials that can be repurposed. The challenge lies in agreeing on who should pay the bill;
- Selective collection of waste and materials, or recycling, which is growing, but needs to be widely expanded;
- An information system about solid waste management, known as SINIR, serves as a database for this subject.

The "Reverse Logistics" Issue

Since 2011, a commission formed by the federal government has the objective to implement a policy for the return of used packaging to industries and companies, in order to reutilize them in new manufacturing processes. The commission is composed of the Ministries of Environment, Health, Agriculture, and Industry. Other subgroups are responsible for different chains in the reverse logistics process, divided into five main categories (Disposal of medications, lubricants and its residuals, lamps, electronics and packaging in general). Each group is responsible for creating goals and action plans in order to establish an efficient program. Regarding the additional costs for recovering these products, industries claim that this extra cost would be passed on to the retailers, which means that the consumers will end up paying more for the products.

Recycling

Though the 2010 waste management law sets targets (for 2031) to send about half of organic waste to be composted, Corsten et al(2012) find in their modelling study that more ambitious scenarios are possible.

The selective collection generates more than BRL 12 billion per year, but this amount could be much higher (Utsumi, 2015). The federal government estimates that around BRL 8 billion are lost because of incorrect disposal.

The Ministry of Environment has defined a colour code to aid the garbage collection, which includes two organic (bio) components: blue indicates paper bins and brown for organic waste. However, according to IBGE, only 22 million people (out of about 200 million inhabitants) have access to recycling programs in the country.

[27] Law 12.305, of 2 August 2010; alters Law No. 9,605 of 12 February 1998.

LOIs with CETESB and FIESP and Rijkswaterstaat

In November 2012, a Letter of Intent (LoI) was signed with CETESB, the Environmental Agency of Sao Paulo State, and in October 2013 an LoI was signed with FIESP (the Federation of Industries of Sao Paulo).

Both LoIs aim at Exchange of Experience and practice with State and municipal authorities, Associations of Industry and Association of waste management companies in dealing with the new waste law management and introducing new recycling technology and Dutch companies in Brazil. During the project period (June 2013-June 2016), knowledge will be exchanged through:

- Workshops and teleconferences with Brazilian authorities
- Exchange of good practices with regard to waste management policies as well as methods and techniques
- Participating in trade missions and conferences
- Organising incoming missions of public authorities and private companies.

More information is available through the website of Rijkswaterstaat[28].

8.3 SWOT

The strengths, weaknesses, opportunities and threats for the sector are shown in Figure 12

Strengths	**Weaknesses**
• Increasing amounts of MSW are collected • High organic content of MSW • Coherent policy including incentives	• Waste processing not very developed • Technologically lagging • Low (knowledge) capacity at municipal level
Opportunities	**Threats**
• Legislation on banning open landfills needs implementation • Legislation largely copied from Dutch law • Seen as a problem that needs to be solved by many parties • Responsibilities lie with public and private sector	• Social aspects (high employment of 'catadores' (pickers)) • Informal practices

Figure 12 SWOT of Brazilian MSW sector

[28] http://rwsenvironment.eu/subjects/from-waste-resources/projects/brazil-waste

8.4 Main stakeholders

The main stakeholders in the solid waste sector are shown in Table 13.

Table 13 Main stakeholders in the Brazilian solid waste sector

Name	Description	Website
Abrelpe	The Brazilian Association of Urban Cleansing and Waste Management. Its annual survey is one of the sources that keeps track and gives insight into the volumes of waste generated in urban areas and the recycling of materials in Brazil. This includes waste from domestic activities in urban households, from sweeping and cleaning of public areas and public roads, and from other urban cleaning services	www.abrelpe.org.br
IBGE	The Brazilian Institute of Geography and Statistics publishes the National Survey of Basic Sanitation (IBGE, 2000). According to a study of the World Bank (2010) the data from Abrelpe is more reliable as these are based on surveys and studies undertaken by both the Ministry of Cities and the Ministry of Environment	www.sidra.ibge.gov.br/bda/pesquisas/pnsb
Municipalities	It is the municipalities who are responsible for managing the waste generated on their territory.	various

8.5 Opportunities for Dutch players

According to Corsten (2012), three elements of Dutch knowledge and experience can contribute to the shift from the current situation to a situation with traits from the Waste Law scenario. These elements are:

- Developing and executing waste management policy;
- Implementation of waste collection systems (bins, trucks, logistics);
- Engineering and planning waste treatment plants:
  - Landfill gas recovery;
  - Two bin separate collection;
  - Digestion of organic waste;
  - Material Recovery Facilities.

These, as well as other identified opportunities are summarized in Table 14.

Table 14 Opportunities and related stakeholders in MSW

Opportunities	Stakeholders	Indicative timeframe
Cooperation in research on processing biowaste (MSW)	SENAI, Universities	1-5 years
Demand for small-scale and decentralized solutions	Residences and Industrial estates (Condominiums); Hospitals, Shopping Malls, University Campuses etc.	1-5 years
Landfill gas recovery	Large municipalities	1-5 years
Waste collection (two bin separate collection)	Large municipalities	1-5 years
Waste processing (Digestion of organic waste, Material Recovery)	Research organizations, Large municipalities	1-5 years

Next Steps

Dutch parties who recognize opportunities and would like to enter in contact with stakeholders named above are encouraged to contact the Dutch support network in Brazil (See section 13.3) or in the Netherlands (RVO) when looking for Dutch partners in their sector.

9 Bio waste – waste water

9.1 Market overview

Waste water (WW) streams (mostly sewage water) contain large amounts of organic matter of biological origin, that can be converted to useful products through digestion (biogas) or other treatments, as for other forms of biomass.

In the last few years water supply and wastewater treatment has become an important focus area. Brazil is the seventh largest WW market in the world, representing 1.72 billion dollars in 2012. In Brazil, the sewage treatment rate is considerably low: approximately a third of sewage was treated and only 40% of households were connected to the sewage network in 2012. Water consumption per capita reached 190 litres per person per day in the southeast region of Brazil against 120 litres for northern Brazil. The municipal wastewater treatment plant market accounts for the majority of market demand compared to the industrial segment.

The current water crisis is exacerbated by regional droughts, leading to significant drop of the levels in the main reservoir system, known as the Cantareiera system, which reaches the *dead-volume*; the remaining water is stagnant and pollution is increasingly concentrated. Evacuating the city of Sao Paulo has even been discussed due to water shortages for households. The crisis is particularly dire in south-eastern states of Brazil, which are the most populated and industrialized areas. A solution to this crisis is better management of waste water, so it can be reused, and alleviate the demand from fresh water systems.

Besides the recent meteorological conditions, some major problems underlying the current water crisis have impeded the improvement of the WW sector:

- Insufficient and poor governance, lack of accountability;
- Derelict infrastructures and installations, outdated technology and an overburdened grid (for example, in Sao Paulo, 25% of all collected sewage is lost, through leaking pipes and outdated infrastructure whereas a substantial amount is not collected, ending up directly in the groundwater, soil and rivers) (SABESP, 2013);
- Low sewage collection and treatment rate, and poor connectivity of sewage with households Extreme pollution of the natural hydrological system, degradation of water related ecosystems and disproportionate dependency on the Cantareira reservoir system.

9.2 Main policies

The rising gap between water demand and supply has led to the recent implementation of stringent regulations for reuse of water. Laws and regulations in the WW sector include regulatory framework and quality regulations for drinking water, regulations for wastewater discharge and reuse, municipal and industrial wastewater quality regulations, as well as water regulations and compliance in

industry. The Brazilian Government has set a 2020 target of increasing the volume of treated sewage to 58% and access to sewage collection for 45% of the population.

The Government increasingly receives support from the private sector from PPP projects governed by federal law, mainly via investments and improvements of infrastructure. These Public-Private Partnerships are either sponsored, where the government subsidizes the tariff paid by the users of the services, or regulated, when the government pays a monthly fee to the supplier according to tendered conditions. From 2006 to 2013, drinking water supply and sewage collection and treatment concessions awarded to the private sector increased by 44% in Brazil and this trend is expected to continue at least until 2018. Moreover recent regulations and laws are promoting more competition with private WW companies, forcing public companies to modernize themselves.

Cooperation between the state of Sao Paulo and the Netherlands in the field of policy and regulations pertaining to the water, wastewater and solid waste treatment standards is already in place. The state agency for environmental licensing (CETESB) has adopted the Dutch standard as developed by RIVM. Missions, as recent as April 2014 and March 2015, contribute to an existing network that can be expanded upon.

9.3 SWOT

The strengths, weaknesses, opportunities and threats for the sector are shown in Figure 13

Strengths	**Weaknesses**
• Strong will and motivation to change status quo • Strong will to involve environmental aspects of water solutions • Democratization of decision making process	• Poor management • Informal practices • Insufficient treatment capacity • Outdated technology
Opportunities	**Threats**
• Funding from federal level and development bank available • Now decentralized solutions are being evaluated	• Water crisis (due to climate) • Environmental hazard (sewage load on rivers) • Not enough long-term planning

Figure 13 SWOT for the Brazilian Waste Water sector

9.4 Main stakeholders

In the water supply and wastewater treatment (WW) sector, the main stakeholders in Brazil are:

- Water utility companies, such as SABESP the largest one in Brazil operating the concession for the Cantareira system and most of the states' Waste water treatment plants, Foz do Brasil, CAB Ambiental, Aegea and Águas do Brasil (SAAB);
- Sewage utility companies, such as Copasa, SABESP, and Sanepar;
- Installers of WW treatment plants worldwide, such as Xylem, Acciona, Aqualia, GS Inima, Grupo Cobra, Marubeni, Miya Arizon Group, Siemens, Veolia, FOZ and Degremont.

9.5 Opportunities for Dutch Players

As the Netherlands is a leading country in water and sewage technology, some Dutch companies such as Deltares, Arcadis Logos and RoyalHaskoningDHV are contracted by SABESP for large infrastructure projects, for which a substantial budget has been made available to remediate the current economic crisis.

Market entry opportunities in Brazil can also arise for SME's, knowledge and research institutes and are listed in Table 15.

Table 15 Opportunities and related stakeholders in waste water

Opportunities	Stakeholders	Indicative timeframe
Supply decentralized waste water (WW)-treatment technology (WW-to-water-reuse, WW-to-energy, WW-to-biomaterials, biodigesters, bioreactors including processing sludge)	Water utility companies, such as Sabesp WW treatment plants, Foz do Brasil, CAB Ambiental, Aegea, Águas do Brasil (SAAB) Sewage utility companies, such as Copasa, Sabesp, and Sanepar	1-5 years
Gas cleaning of WW treatment installation; 'RWZI grondstoffenfabrieken' (WW treatment producing raw-materials)	Installers of WW treatment plants worldwide, such as Xylem, Acciona, Aqualia, GS Inima, Grupo Cobra, Marubeni, Miya Arizon Group, Siemens, Veolia, FOZ and Degremont	1-5 years
Supply wetland management technology Monitoring and improving water quality	State governments, IIE (institute for ecology)	1-5 years
Organization and structuring activities of the water sector.	State governments, IIE (institute for ecology)	5-10 years

Next steps

Overall opportunities for entry into the Brazilian WW treatment market for Dutch companies and organisations are numerous. These involve:

- Joining the initiative of the Ministry of Infrastructure and Environment to clean the Guanabara bay (see Clean & Circular Delta Challenge Rio de Janeiro) and the report on the Clean Urban Delta Initiative[29];
- Joining Brazilian parties that already have or are operating public commissions (municipal, or as subcontractors of water-utility) and participating in tenders;
- Commissions in the private sector (hospitals, shopping malls, university campuses, large industrial and domestic condominiums) for decentralized Waste water treatment, water-re-use and waste water and solid waste processing technologies and installations;
- Research and consultancy on crisis-remediation and policymaking, restructuring and reorganizing the water sector;
- Concessions, PPP and investments, and private equity funds investing in water and sanitation utilities in Brazil[30];
- The Netherlands Water Partnership (NWP) would be a good party which could provide a shortlist of its members interested in the Brazilian market, and successfully engage with the demand side; As 25,7% of all treated water is contaminated as soon as it hits the supply infrastructure[31], Waste water treatment for water re-use is a field opening up big opportunities for Dutch companies.

[29] Report available online: http://kunststofkringloop.nl/wp-content/uploads/2014/05/CleanUrbanDelta_English_full.compressed.compressed.pdf
Also the notes from the mission are available:
http://kunststofkringloop.nl/wp-content/uploads/2015/07/Terugkoppeling-Missie-Clean-Urban-Delta-Rio-de-Janeiro-v0407151.pdf

[30] BNAmericas 09/03/2015 http://www.bnamericas.com/news/waterandwaste/brazils-waterworks-industry-sees-private-sector-push1

[31] SVMA (Secretaria Municipal de Verde e Meio Ambiente), SABESP (Companhia de Saneamento Básico do Estado de São Paulo) 2013

10 Advanced biomaterials

Besides the use of biomass for energy (electricity, heat and biofuels), biomass can be used for creating higher value-added products like biochemicals. These can substitute petroleum-based chemicals. Advanced plant and micro-organism breeding can also be used to produce high value compounds for nutrition, pharmaceutical uses and cosmetics.

10.1 Market overview

As seen in earlier chapters, Brazil offers advantages in the availability and competitiveness of various renewable raw materials. Feedstocks of relevance for the biochemical industry are mainly carbohydrates (including sugars), and natural oils and fats. The competitive position of sugarcane has already attracted investments from foreign and domestic companies such as the joint venture between Solazyme and Bunge, Amyris and Braskem, mainly in the Southeast. The oleochemical sector is also based on fatty materials of plant and animal origin, such as soy, glycerine and beef tallow, in which Brazil also presents competitive costs.

In Brazil, the development of the biochemical sector is seen as important for international competitiveness, as well as an important diversification strategy for that sector. Industry experts[32] estimate that in 2020, the Brazilian market for chemicals produced from renewable sources could represent as much as 10% of the local chemical industry (Bain & Company, 2015).This will require large investments, estimated to be in the order of US$ 20 billion. The industry is very dynamic and complex, with many innovations occurring in products, processes and business models. For the country to reach its full potential, it needs to invest in the development of technologies, especially those related to the pre-treatment of biomass and its conversion into chemicals.

The main challenges that need to be overcome to allow the biochemical sector to scale up and become a success are:

1. Need for better technologies for pre-treatment of biomass such as thermolysis, enzymatic hydrolysis of cellulose, fractioning of pentoses and hexoses, purification of glycerin etc.;
2. Conversion technologies for the production of biochemicals (such as chemical conversion of sugars, heterogeneous catalysis, fermenting processes with genetically modified microorganisms, glycerine chlorination, chemical conversion of ethanol etc.);
3. New products (such as hydrogenous dehydrated sugars, glycerine derivatives, biodegradable polymers - PBS, PLA derived products etc.).

[32] Bain & Company 2015 cite USDA and ABIQUIM

Feedstocks

Vaz (2014) identified the need to setup strong actions to support the development of national technologies that take into account pre-treatments, catalysts, micro-organisms and logistics. Despite shortcomings and uncertainties, the author sees a large potential for Brazil to convert itself into a strong global player in the field of renewable chemistry." (Vaz, 2014)

Target compound	Precursor	Route	Status
Acrylic acid	Glycerin	Organic synthesis	In development: improvement of catalysts, yield, others
2,5-Furandicarboxylic acid	Glucose from celullose	Organic synthesis Fermentation	In development: improvement of catalysts, biocatalysts, micro-organisms, yield, others
Succinic acid	Xylose from hemicelullose	Fermentation	In development: improvement of micro-organisms and yields
Fuel additives	Glycerin	Organic synthesis	In development: improvement of catalysts, yield, others
Antioxidants	Lignin	Catalytic cracking	In development: improvement of catalysts, yield, others
Derivatives from celullose (acids, esters, nitrates, eters, etc.)	Celullose	Organic synthesis	Established industrial processes
2G ethanol	Glucose from celullose	Fermentation	In development: improvement of enzymes, micro-organisms, yields, and cost reduction
	Xylose from hemicelullose		
Phenols	Lignin	Catalytic cracking	In development: improvement of catalysts, yield, others
Furfural	Xylose from hemicelullose	Organic synthesis	Established industrial processes: still needing to improve catalysts, yields, others
Syngas ($CO + H_2$)	Lignocelullosic biomass	Gasification	Established industrial processes based on petroleum: still needing to improve yields
5-Hydroxymethylfurfural	Celullose	Organic synthesis	Established industrial processes: still needing to improve catalysts, yields, others
Sulfonated lignins	Lignin	Organic synthesis	Established industrial processes
Xylitol	Xylose from hemicelullose	Organic synthesis	In development: improvement of catalysts, yield, others

Figure 14 Target compounds from residues and co-products with high economic potential for a Brazilian renewable Chemistry. Source: (Vaz, 2014)

10.2 Main policies

There is currently no coherent cross-sector policy on bio-based products in Brazil. The federal government mainly stimulates and support R&D and innovation in biochemicals, both in products and processes. A recent study, commissioned by the Brazilian development bank (BNDES), and indented to help reverse the increasing trade deficit of the industry[33] (Bain & Company, 2015), identified opportunities to diversify the Brazilian chemical industry. The study identified opportunities in many subsectors, including oleochemicals and chemicals from renewable sources. In the sugarcane derivatives segment, the consortium identified opportunities in the construction of biorefineries in close proximity to existing sugarcane ethanol infrastructure and in new agricultural frontiers (new

[33] The Brazilian chemical industry was responsible for a trade deficit from between US$6 billion and US$9 billion between 2000-2006 and reached US$28 billion in 2012 (Bain & Company, 2015)

varieties). The authors also recommend the sector looks for other possible sources of biomass for chemicals, such as eucalyptus and pine pulp, orange, palm and others. The study recommends increased efforts in technological innovation with strategic priority given to bio-based chemicals.

For the required R&D, reaching sufficient technology readiness, industrial piloting and roll-out to market, FINEP & BNDES make available incentives and financing lines. Tax incentives are also available for companies and industries, active in this field, through the 'Lei do Bem' – the 'Goodwill Law'. This law enables the reduction of the tax burden for companies investing in Research, Development and Innovation (RD&I)

As biochemicals have priority in the field of technological innovation, funds from the National Fund for Scientific and Technological Development are made available through EMBRAPII – The Brazilian Research Enterprise for Industrial Innovation.

10.3 SWOT

The strengths, weaknesses, opportunities and threats for the advanced biofuels sector are shown in Figure 15.

Strengths	**Weaknesses**
• Large availability of feedstocks (conventional and new native species) • Experience with some pilot plants and recently first commercial scale 2nd generation ethanol plants • Expected new policy	• Pilots and commercial plants not very successful • Little commitment from industry • No integrated R&D infrastructure • No strategy or integration of value chain
Opportunities	**Threats**
• Policies and incentives for introduction of 2nd generation technologies • Interest in technological leapfrog • Know-how is present but not coordinated • Jet-fuel platform	• Low confidence in technological innovation • High electricity prices • Uncertain outlook on funding (from BNDES) • Technological lagging behind other countries

Figure 15 SWOT for the advanced biofuels sector

10.4 Main stakeholders

Table 16 Main stakeholders in the area of advanced biomaterials in Brazil

Name	Description	Website
ABIQUIM	The Brazilian chemical industry association.	www.abiquim.org.br
EMBRAPII	The national research and industrial innovation company was launched in 2013 to support Brazilian companies in developing high-skill, strategic products and technologies.	http://embrapii.org.br
CNPEM - Centro Nacional de Pesquisa em Energia e Materiais	The National Centre for Research in Energy and Materials operates on behalf of the ministry of science, technology and innovation (MCTI), and is responsible for managing the Biosciences Laboratory (LNBio), as well as the national research centre on bioethanol (CTBE). The laboratories have their own equipment that can be used for research by external parties	http://cnpem.br
Braskem	Brazilian chemicals company Braskem has been leading in developing drop-in biochemicals such as bio ethylene and bio-propylene, which can be fed directly into the existing oil-based chemical industry	www.braskem.com.br
LNNano	Brazilian Nanotechnology National Laboratory	http://lnnano.cnpem.br
CGEE	Centre for Management & Strategic Studies	www.cgee.org.br/sobre/english.php
SBPC	Brazilian Society for Scientific Advancement It represents over 100 associated scientific societies and over 6 thousand active members.	www.sbpcnet.org.br
USP - EESC	Institute of Engineering São Carlos – Department of Materials Engineering of the university of São Paulo	www.eesc.usp.br

Name	Description	Website
UNICAMP, institute of chemistry	Institute of Chemistry, Laboratory for Biological Chemistry of the university of UNICAMP (SP) Many laboratories available.	www.feq.unicamp.br/areas-de-pesquisa
REDEMAT – UFOP-CETEC	Programme for Material Engineering, Federal University of Minas Gerais Redemat specializes in R&D and industrial piloting in the fields of Physical, Chemical and microstructural Characterization, Design and Selection of Materials, Fatigue and Fracture of Materials, Modelling and Simulation, Physical and Transport Properties of materials.	www.redemat.ufop.br
BioPol Faculty of Department for Chemical Engineering, Federal University of Parana	Biopolymers Laboratory that works in R&D of systems based on biopolymers with emphasis on synthesis , chemical and enzymatic modification and chemical and physical chemistry of biopolymers for chemical, pharmaceutical and biotechnological uses.	www.biopol.ufpr.br

10.5 Opportunities for Dutch players

The Netherlands has a large chemical industry, with a turnover exceeding € 300 billion /year. The Netherlands has therefore a large knowledge base in chemical processes that can be sold to the Brazilian market.

Research
The biochemicals sector was already identified as one of the most promising sectors for the Netherlands to match with the Brazilian biofuel sector, and there is much demand for transfer of know-how, expertise and technology, both through collaborative R&D and joint ventures, as the potential absorption for these products by the Brazilian domestic market is very big.

R&D is carried out through the Brazilian Institutes for Science and Technology (ICT), with which Dutch institutes and companies can make partnerships.

Table 17 Opportunities and related stakeholders in advanced biomaterials

Opportunities	Stakeholders	Indicative timeframe
Supply technologies for pre-treatment of biomass (thermolysis, enzymatic hydrolysis of cellulose, fractioning of pentoses and hexoses, purification of glycerin etc.)	Petrobras, ABIQUIM (Chemical industry organization), CNPEM (Centro Nacional de Pesquisa em Energia e Materiais The National Centre for Research in Energy and Materials), Brazkem Pintec, ATS (association) FNDCT (fund), CTNBIO, NIT (technology innovation nuclei), EMPRAPII (institute for technological innovation)	1-5 years
Conversion technologies for biochemicals (chemical conversion of sugars, heterogeneous catalysis, fermenting processes with genetically modified microorganisms, glycerin chlorination, chemical conversion of ethanol etc.)		1-5 years
Joint developments and deployment of new products (such as hydrogenous dehydrated sugars, glycerin derivatives, biodegradable polymers - PBS, PLA derived products, , bio-adhesion, bio-adhesives and bio-polyphosphates etc.)		1-5 years
Value chains based on ligno-cellulose: • Chemical and physicochemical characterization of lignocellulosic materials; • Chemical modification of lignocellulosic materials aimed at creating hydrophobics;; • Microfibrils/nanofibres from cellulose; (applications in nanocomposites) • Delignification of sugarcane bagasse and straw through organosolv applications		1-5 years
Phase change biomaterials		1-5 years
Nanostructure reorganization of bacterial cellulose		1-5 years
Developing composite resin with unsaturated polyester from sugarcane bagasse;		1-5 years

Opportunities	Stakeholders	Indicative timeframe
Preparation, modification and characterization processes of biodegradable thermoplastic materials (such as starch, chitosan polylactic acid, hydroxy butyrate, etc.)		1-5 years
Nanocomposite particles prepared by alcoholic dispersion		1-5 years
Bioceramics,		1-5 years
Developing tools for macroscopy (based on anatomical modelling) and microscopy, (based on modelling of scaffolds)		1-5 years

Next Steps

Dutch parties who recognize opportunities and would like to enter in contact with stakeholders named above are encouraged to contact the Dutch support network in Brazil (See section 13.3) or in the Netherlands (RVO) when looking for Dutch partners in their sector.

11 Opportunities in new markets

Not all opportunities can be classified in sectors. In the sections below we list opportunities due to developments in areas that are new, or not sufficiently large to warrant an entire chapter.

11.1 Opportunities in agriculture

Apart from being an agricultural giant, Brazil also has significant resources and knowledge in the field of agricultural research. Its national agronomic research institute EMBRAPA has strong research capacity, including in biomass for bioenergy applications. However the country is facing fast land degradation and the ministry of environment[34] has identified 140 million hectares of land where biodiversity and fertility need to be restored. This offers many opportunities in terms of ecology and plant science that the Netherlands can provide. Yield improvements through shortening of the crop cycles and intercropping are also regarded as areas of interest. There is currently little research in the direct and indirect environmental impacts of various bioenergy and other crops which is crucial for the long term growth potential. Many policies and incentives are focussed on family and organic farms, which provide most of the food for local consumption. There are significant policy efforts from National and International parties to make these more efficient and sustainable (e.g. projects from the World Resource Institute).

11.2 Pre-treatment technologies

There is a clear desire to make better use of the agricultural residues identified in chapter 3 above. Bringing residues from the field to a location where they can be used is often problematic because of the large distances and corresponding high costs. In some cases the business case can be improved by pre-treating the low value products into high energy-density products, so that transport costs are reduced on energy basis. This is where pre-treatment options like pelletisation, torrefaction, and pyrolysis can play a role.

Discussions with experts have shown that there is indeed room for technology developments in this area. Specifically, areas where more research is needed include:

1. Pyrolysis products (syngas, bio-oil, biochar, acetic extracts, nitrogenous compounds etc.) for more high added value applications (i.e. bio-oil for bioplastics, resins next to use for biodiesel, biochar for upgrading into activated carbon, supplementary cement components, acetic extracts for the plastics and pharmaceutical industries etc.);
2. Optimization of the upgrading of bio-oil for biodiesel and bio jet fuel;
3. Downscaling and decentralizing available technologies;

[34] Departamento de Florestas do Ministério do Meio Ambiente

4. Adaptations of the mechanized sugarcane harvesting - cutting the tops and green leaves to leave in the field, cutting the stalk and dry leaves together and separate them at the mill/processing installation.

Dutch parties can play a role in points 1-3. It seems that for sugarcane harvesting operations and optimisation, Brazilians look to experience and technology providers from Australia, which is also a large sugarcane producer.

11.3 Bioprospecting and native species

Using native species for bioenergy and biomaterials is a relatively new phenomenon with little or no market players. It therefore shows little competition from other countries, and presents opportunities for Dutch knowledge institutes and companies to partake in the development of this fledgling sector.

A good example of recent research is the use of kernel oil from babassu palm in fast pyrolysis (Vinhal, 2014).The pyrolysis product of the oil contains 37 unidentified chemical compounds corresponding to 26% of the total pyrolysis product, and 19 others in pyrolysis products form the kernel (Vinhal, 2014).

Developing babassu exemplifies the combination of existing bioenergy activities, infrastructure and technology with the use of native species in the context of recovery of degraded areas (like *legal reserves*, degraded pastures and abandoned agricultural lands) as well as in the context of projects to compensate social debts, initiated by agro/bio-industrial companies (there are examples in combining bioenergy applications from different native palm-tree species with residuals from wood processing, food processing and agricultural residuals for bioenergy applications). As such, this approach, integrating the use of native species in regeneration and conservation (of biodiversity) with existing and upcoming, larger scale bioenergy production requires further collaborative R&D, highly specialized technological knowledge and technology transfers.

Some general characteristics, commonly found in the use of native species are:

- *Multiple applications:* for bioenergy, cosmetics, pharmaceuticals, food & beverage, cattle feed; biofuels - biodiesel; fertilizers, paints, resins, polymers and other biomaterials, etc.;
- *Decentralization;* because of the location of the feedstock there is a demand for downscaled fast-conversion technology e.g. fast pyrolysis and smaller scale pyrolysis upgrading installations.

Some of the challenges identified in this field are property issues; the access to biodiversity products and obtaining permits for bio-prospection. Very current changes in legislation (May 2015) will significantly simplify the latter.

Next to that, other research shows that the involved parties require better pyrolysis installations than currently used, better evaluations of product quality and yield, as well as expertise in better upgrading methods/technologies for the babassu bio-oil for biodiesel (Lappi & Alén, 2011). These findings are also relevant for other native bioenergy crops (see Appendix C).

Developing non-sugarcane biomass offers specifically opportunities for Dutch knowledge institutes like UR Wageningen and ECN and for Dutch SMEs who offer specialized technological expertise.

Biodiversity scouting

Like its predecessor, the new biodiversity law regulates research on genetic resources: an all-encompassing term covering everything from genes and proteins to oils and fragrances. It sets rules for sharing benefits with indigenous peoples when R&D leads to a product, such as a drug, shampoo, energy drink, or industrial enzyme, while eliminating bureaucratic hassles and encouraging biodiversity research (Herton, 2015).

11.4 Value chain integration & system design

As identified in the areas of feedstock, agriculture, biofuels, biogas, waste treatment etc, in many cases the challenges lie not only (or not at all) in technology development, but are more of an organisational nature. The opportunities therefore lie in developing integrated value chains, where the different actors and interests are coordinated to collect biomass, pre-treat it, and deliver it in a useful form to the diverse end-markets.

Concrete opportunities therefore lie in the inventory of chain inadequacies that lead to low efficiencies, for example harvesting techniques that are not in line with further processing. This work should at least involve the branch organisations, and the end-use markets, and could be assisted by Dutch consultancies, experienced in multi-stakeholder project management.

12 Research questions and technology status

Brazil does not have a coordinated research agenda for what we call the biobased economy. However, through our interviews, a number of technology gaps and research questions were identified in the various sectors that we consider to be part of the biobased economy.
An overview of these technology gaps, levels and related stakeholders is provided in Table 18 below.
Technology readiness levels (TRL) are used according to the following definitions:
TRL 1 – basic principles observed
TRL 2 – technology concept formulated
TRL 3 – experimental proof of concept
TRL 4 – technology validated in lab
TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7 – system prototype demonstration in operational environment
TRL 8 – system complete and qualified
TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Table 18 Overview of research questions and technology status for biobased sectors in Brazil

Sector	Research / technology question	TRL & Timeframe	BR stakeholders
Bioelectricity	• Research combustion properties of new feedstocks • Optimisation of combustion processes	TRL 4 Timeframe: 1-10	SENAI Biomasa, EMBRAPA Agroenergia; ERB; IPT
	Gasification (syngas)	TRL: 5,6 Timeframe: 1-5	Mid- and large-scale agricultural producers, EMBRAPA Biomasa, CENBIO, ITAIPU research center; GET2C
Conventional Biofuels	Technology for increased efficiency e.g. pre-treatment and pyrolysis	TRL: 3, 4, 5 Timeframe: 1-5	Abengoa, Raizen (Shell-Cosan), ETH, Odebrecht, Granbio, UNICA
	Work on crop improvements and agronomy	TRL: 3-7 Timeframe: 1-10	Universities (ESALQ, UNICAMP, UFMG, IES), CTBE, CTC

Sector	Research / technology question	TRL & Timeframe	BR stakeholders
Advanced biofuels	Biochemical conversion technologies	TRL: 4-9 Timeframe: 1-5	Abengoa, Raizen (Shell-Cosan), ETH, Odebrecht, Granbio, UNICA
	Pre-treatment for advanced conversions (torrefaction, pelleting etc.)	TRL: 5-9 Timeframe: 1-5	Abengoa, Raizen (Shell-Cosan), ETH, Odebrecht, Granbio, UNICA
	Thermochemical conversion technologies (Pyrolysis)	TRL: 5-7 Timeframe: 1-5	ETH, Odebrecht, Granbio, UNICA, FIBRIA, Suzano, Raizen
	Research in biotechnology and catalytic processes	TRL: 3-6 Timeframe: 1-10	USP Biosciencia, IPT, Unicamp
	Work on crop improvements and agronomy (for plants with higher cellulose content)	TRL: 4-6 Timeframe: 1-5	Universities (ESALQ, UNICAMP, UFMG, IES), CTBE, CTC
	Production of jet fuel	TRL: 4-7 Timeframe: 1-10	Be-Basic, bio jet fuel platform, GOL, Azul, TAM, Embraer, ITA/SP
Algae fuels	Development of micro and macro algae	TRL:1-3 -own technology (Some pilots) Timeframe: >10 years	SENAI Biomassa, UFC (University Ceara)
Industrial use of biomass - other	Iron, Steel & Ceramics: modernizing production of charcoal Technology needs are in pre-treatment (torrefaction, gasification) and alternative energy crops/heat-sources.	TRL: 4-7 Timeframe: 1-5	Sindifer, AMS (industry organisations)
	Paper & Pulp : valorization of residues (biorefinery concept)	TRL: 4-7 Timeframe: 1-5	Bracelpa (industry organization), Fibria, Suzano
Biogas	Biogas developments - Biogas upgrading - Infrastructure development	TRL: 5-9 Timeframe: 1-5 years	Mid- and large-scale agricultural producers, EMBRAPA Biomassa, CENBIO, ITAIPU research center; GET2C
Solid Waste	Processing biowaste (MSW)	TRL: 5, 6 Timeframe: 1-5	SENAI, Universities

Sector	Research / technology question	TRL & Timeframe	BR stakeholders
	Landfill gas recovery	TRL: 5, 6 Timeframe: 1-5	Large municipalities
Waste Water	Supply decentralized waste water (WW)-treatment technology (WW-to-water-reuse, WW-to-energy, WW-to-biomaterials, biodigesters, bioreactors including processing sludge)	TRL: 5-9 Timeframe: 1-5	Municipalities, watercompanies, industrial and large users
	Gas cleaning of WW treatment installation; 'RWZI grondstoffenfabrieken' (WW treatment producing raw-materials)	TRL: 5-9 Timeframe: 1-10	Municipalities, watercompanies, industrial and large users
Advanced biomaterials	Conversion technologies for the production of biochemicals (such as chemical conversion of sugars, heterogeneous catalysis, fermenting processes with genetically modified microorganisms, glycerin chlorination, chemical conversion of ethanol etc.) See also pre-treatment technologies	TRL: 5-7 Timeframe:1-5	Petrobras, ABIQUIM (Chemical industry organization), CNPEM (Centro Nacional de Pesquisa em Energia e Materiais The National Centre for Research in Energy and Materials), Brazkem Pintec, ATS (association) FNDCT (fund), CTNBIO, NIT (technology innovation nuclei), EMPRAPII (institute for technological innovation)

13 Doing Business in Brazil

Once business opportunities have been identified in terms of market, technology etc., the success of a venture will depend to a large extend on the ability to navigate the Brazilian bureaucracy, business culture and support channels. In this section we give an overview of these aspects, and provide advice on how to increase chances of success and avoid pitfalls.

13.1 Business culture

Some general practical recommendations are listed below. Based on the experience of the authors and input from interviews with experienced companies/organisations and literature.

Personal contacts are important
It is important to maximize the physical presence in Brazil. Personal relationships are important to Brazilians and building trust takes time. Doing business requires frequent in-person meetings.

Take initial enthusiasm with a healthy amount of scepticism
A 'partner' in Brazil often means someone you have a coffee with once in a while. If a counterparty talks about their network, many of the 'partners' may be just that. Similarly, a good client portfolio is a must in Brazil. For an SME it is helpful to have big names on the list of clients. It is also acceptable to inquire what exactly was performed for these clients, to get a better sense of the value of these references.

Be clear and specific
Define clear steps in the deal-making process on subjects such as timelines, actions, means of communication and accountability. Inquire about progress more often that you would do in a Dutch context.

Legal information
If information about legal situation comes from a business-partner, have it verified by a third party. See section 14.1 on laws and regulations.

Working with local partners
Avoid dependence on the Brazilian partner where this does not add obvious value. This can mean avoiding compromising on decision-making processes, and information and/or IP sharing, when this is not required for the business.

National and local holidays
Brazil has many holidays, and people are often completely unavailable during those periods. For many, working over the weekend is not common at all. Especially when deadlines for deliverables etc. are involved, plan well ahead and work with much larger margins when compared with Europe

13.2 Market entry strategies

There are several ways to enter the Brazilian market, namely greenfield, acquisition, joint venture, strategic alliance and participation in research programmes. In this section the first three of these market entry strategies is discussed briefly while participation in research and startup constructions is discussed in section 13.5.

Greenfield

Greenfield Investment is a form of foreign direct investment where a parent company starts a new venture in a foreign country, which in this case, would be a newly created entity in Brazil as a subsidiary of a Dutch company. Corporate entities can be set up in Brazil in one of two different structures: (1) by establishing a *limitada* (comparable with Dutch BV) or (2) an S.A. (comparable with Dutch NV). A *limitada* usually gives trading flexibility and ease of implementation. For more complex operations and limited liability, the S/A is the best choice. (Transfer, 2015). The benefits of this strategy are complete ownership and full control of all processes. There are, however, several disadvantages to this strategy: taking into account Brazil's bureaucracy, the establishment of the entity can be a cumbersome process (at least three months), and there is a high probability of making mistakes with forms and licenses. It also needs great commitment in capital and managerial effort, and the entity needs a native legal representative. (Transfer, 2015)

Acquisition

Brazil remains relatively open towards foreign investment, with low restrictions to investments in most industries. Thus, most activities may be freely executed by companies under the control of foreign citizens or foreign entities (there are few existing exceptions which are expressly determined by law). There is no difference in the treatment of foreign companies, from a legal standpoint, in all matters relating to tax, labour rights, social security, or civil and commercial law. A company incorporated in Brazil is Brazilian regardless of the nationality of its shareholders. However, take into account that local content requirements and import taxes still apply. In general an acquisition can be a jump-start for the industry, but in fact is a complicated and lengthy process in Brazil. It could also be challenging to integrate Brazilian and Western company culture (Transfer, 2015).

Examples of acquisitions in the field of biobased include the recent acquisition of Nutrifarma by Nuscience.

Joint Venture / Strategic Alliance

By setting up a joint venture with a Brazilian counterpart, bureaucratic hassle (native legal representative and knowledge on Brazilian laws, regulations and licenses) can be avoided. Furthermore, risks and rewards can be shared, and technological knowledge can be synergized. The downside of this market entry strategy is twofold. First the company is not wholly owned, and therefore not fully in control of the decision making process. Second, the Dutch company is partially liable for operative risks of the joint venture. (Transfer, 2015)

An interesting example of a large joint venture in the area of biobased in the US$12-billion joint venture between Shell and Brazilian sugarcane ethanol producer and distributor Cosan which gave Shell a distribution channel for its fuel, and also provided the Dutch oil conglomerate with sustainable fuel production assets.

13.3 Support from the Dutch government

The bilateral cooperation between the Netherlands and the Brazilians dates back centuries. Today, the Dutch government has a strong diplomatic presence in Brazil which can provide support for doing business in the country. The following governmental bodies are present in Brazil:

- **The Dutch Embassy,** located in the capital Brasilia, can provide detailed information and long-term support to companies and organisations entering the Brazilian market. The diplomatic body can also provide political assistance when needed, for example by negotiating trade deals.
- **Consulates General** are present in São Paulo and in Rio de Janeiro. They can help with procedural necessities and advice related to companies in their jurisdiction. Both consulates feature experienced economic departments and the consulate in São Paulo also hosts an innovation attaché.
- **NBSOs**. The Netherlands Business Support Offices are small offices located in strategic areas for foreign business in Brazil. These offices can assist Dutch parties in developing databases and getting in contact with local business and important networks. A new office opened in December of 2014 in Belo Horizonte, Minas Gerais which has a branch-office in Porto Alegre.
- **NL-Network for Innovation, Technology & Science**. In order to follow the developments in the area of science, technology and innovation, the IA-Network has offices in São Paulo and in Brasilia.

NWO

The Netherlands Organization for Scientific Research (NWO) and FAPESP (São Paulo region, Brazil) are collaborating in research on four topics related to the bio-based economy: crop improvement, sustainable agriculture, biorefinery processes, and hybrid catalytic conversion of biomass. The total budget is € 3.75 million. Support is given to researchers in the Netherlands and São Paulo to support research exchanges, workshops, equipment, and consumables. More information on the programme,

and examples of projects that have received grants in the past can be found on the (Dutch) website of NWO[35].

Government-to-government (G2G) and Knowledge-to-knowledge (K2K)

The ministry of foreign affairs wants to create good conditions for doing business with countries that are interesting for Dutch entrepreneurs.

Website: http://www.rvo.nl/subsidies-regelingen/government-government-g2g-en-knowledge-knowledge-k2k

Programmes from the Netherlands Enterprise Agency (RVO)

Partners for International Business

Partners for International Business (PIB) is a programme of the Netherlands Enterprise Agency (RVO), which is aimed at clusters of companies that jointly want to enter a foreign market. Knowledge institutes can be part of these clusters. The programme is demand-driven, flexible and result oriented. Next to that the programs include additional activities in the fields of promotion and matchmaking, government-to-government (G2) and programmes for the exchange of knowledge (K2K).

A group of minimum 3 Dutch companies active in one of the topsectors can apply for the program. These sectors are agri and food, chemicals, creative industry, energy, high-tech systems and materials, life sciences & health, logistics, horticulture and water. Brazil is one of the focus countries of the programme.

For 2015 the budget is € 6.305.000, and applications can be submitted throughout the whole year.

Website: http://www.rvo.nl/subsidies-regelingen/partners-international-business-pib

DHK

Subsidies for demonstration projects, feasibility studies and knowledge acquisition

Website: http://www.rvo.nl/subsidies-regelingen/aanvragen-dhk

[35] http://www.nwo.nl/actueel/nieuws/2014/cw/375-mln-voor-internationale-samenwerking-biobased-onderzoek-nederland-%E2%80%93-brazilie.html

Finance for International Business (FIB)

The Dutch state can provide co-financing up to 35% of a deal, on a case by case basis. The programme is valid for several countries, including Brazil. Investments can be made in company goods, startup or expansion of production facility, and sales offices and/or workcapital.

Website: http://www.rvo.nl/subsidies-regelingen/finance-for-international-business-fib

Zakenpartnerscan

RVO can help you finding the right business partner for doing business abroad.

Website: http://www.rvo.nl/onderwerpen/internationaal-ondernemen/hulp-bij-zakendoen-het-buitenland/zakenpartnerscan

Starters International Business (SIB)

Through this programme RVO offers coaching from third parties, that lead to an international plan of approach in three steps.

Website: http://www.rvo.nl/subsidies-regelingen/starters-international-business-sib

Other mechanisms

Other mechanisms through which the Dutch government helps Dutch entrepreneurs include:

- Trade Missions and Matchmaking;
- Trade Shows;
- Economic diplomacy;
- Kansendossier;
- Information meetings and content expertise of RVO advisors.

13.4 Support from the Brazilian government

Federal level

Financial support at the federal level is often channelled through the Brazilian development bank, the BNDES, and FINEP, the organisation that supports research projects. Because of the current economic crisis, the budgets at these institutions have been reduced, and money is spent more carefully than in previous years. In practice this means that projects have to provide a stronger business case.

BNDES[36]

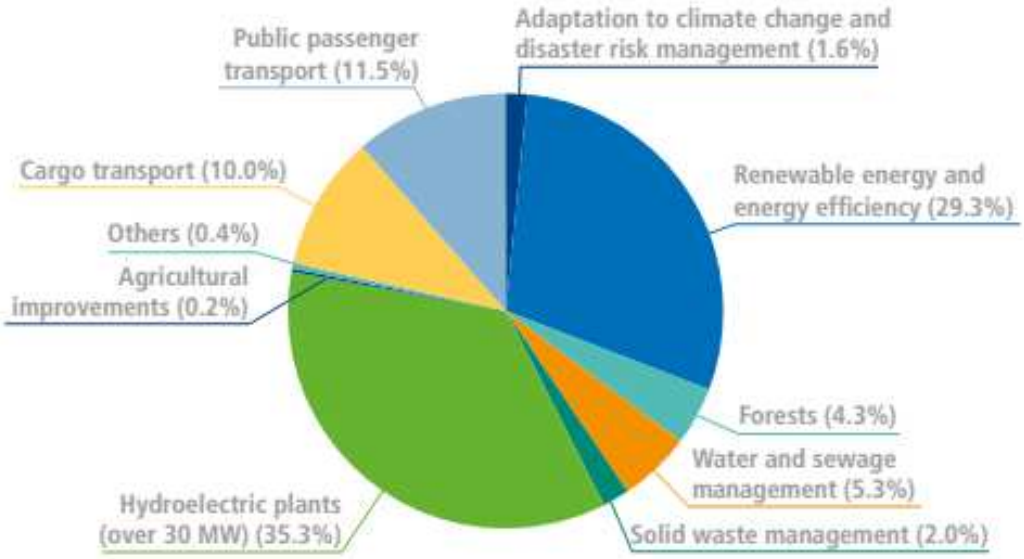

Figure 16 Breakdown of disbursements to the green economy in 2013 (BNDES, 2013)

The Brazilian Development Bank (BNDES) has opened special lines of financing for innovation and the green economy. The BNDES is a federally-owned company connected to the Ministry of Development, Industry and Foreign Trade and also reports to the Ministry of Finance, the Ministry of Planning and Budgeting, the Central Bank and National Congress. The Bank is the main instrument of execution of the investment policy of the Federal Government and has the primary objective to support programs, projects, works and services that relate to the long-term economic and social development. The bank also supports exports. The BNDES has assets of R$ 715.5 billion and a portfolio of credit and transfers of R$ 492.2 billion.

In the area of biobased economy the following funds are of interest:

- PAISS INDUSTRIA. Provides support to industrial-technological innovation in the sugar-based ethanol and chemical sectors. Some R$ 2.5 billion have been allocated to 35 projects.
- PAISS AGRICOLA - funding innovation in the SE & SE sectors' productive chain. Together with FINEP R$ 1.48 billion is made available for the 2014-2018 period.

[36] BNDES 2013

FINEP[37]

FINEP is a public company under the Ministry of Science, Technology and Innovation (MCTI). Currently, FINEP promotes economic and social development through public support in science, technology and innovation in companies, universities, technological institutes and other public and private institutions. The agency provides reimbursable and non-reimbursable funds to support projects and their initiatives are focused on:

- Sectoral funds for science and technology: tools for the financing of research, development and innovation. There are 16 investment funds of which 14 are related to specific sectors (including biomass) and 2 relate to two distinct areas;
- Business Incubators, science- & technology parks: through the National Program supporting business incubators and technological parks (PNi) supports the business sector in creating a favourable environment for the development of technological innovation.

INOVA AGRO

Programme from FINEP and BNDES that provides incentives for non-sugarcane productive chains, new products and investments in infrastructure, machinery, installations etc.

LEI DO BEM

The so-called 'Goodwill Law' enables the reduction of the tax burden for companies investing in Research, Development and Innovation (RD&I).

13.5 From research to business

In Brazil, the path from fundamental research to industrial roll-out is in general less well coordinated than in the Netherlands. However, some states offer support in this area as detailed below.

The Dutch Be-Basic programme is a good example of how companies can get involved in the Brazilian economy in an early stage trough research on the ground, which has proven to open the doors to further business on the long term. Collaborative research offers the advantage of establishing networks and partnerships on the ground that can scout opportunities from academia.

The Dutch presence in this field is not yet very well developed outside of the BE-Basic framework and exists as a strategy adhered by individual researchers and some universities (e.g. TU Delft in Be-Basic, Stenden with Instituto Federal do Ceará (IFCE), Avans Hogeschool with Living Lab and WUR).

[37] KPMG Auditores Independentes. Incentivos e Serviços de P&D - adicionando valor nas Américas. Edição de 2014 & FINEP. Inova Agro (19/02/2014)

Sao Paulo

FAPESP PIPE

The Sao Paulo research foundation (FAPESP) supports research and innovation for SMEs through its PIPE programme. The PIPE instrument is open to the participation of foreign partners, either academic and/or as a company, as long as the main applicant is from a Sao Paulo state university, and the company established for the commercialization of the IP, the technology etc. is (going to be) registered in SP state. The PIPE is a good and low risk route for Dutch SMEs to work in a joint venture with a Brazilian partner, or with the objective to create a Brazilian company/branch. The viability and business-development phases are (partially) financed and evaluated by Brazilians, for the Brazilian reality.

Minas Gerais

FAPEMIG

The Minas Gerais Research Foundation (Fundação de Amparo à Pesquisa do Estado de Minas Gerais - FAPEMIG) is a public foundation located in Belo Horizonte, Minas Gerais, with the aim of providing grants, funds and programs to support research, education and innovation of private and public institutions and companies in the state of São Paulo.

FAPEMIG has signed an MOU[38] declaring its intention to support the Dutch Initiative Living Lab, and to co-finance it with €50.000. With this investment the Living Lab intends to facilitate project management needed to support the coordination of future research, education and internships in the field of Biobased in the state of Minas Gerais.

BH-Tech

BH Tech is a public organisation formed by commercial, scientific, non-profit and public parties, with the intention to develop a 600.000 m^2 biotechnology-oriented research and business park in Belo Horizonte. It was founded by the Belo Horizonte's municipal government, Minas Gerais's state government, the University of MG, SEBRAE-MG and FIEMG (fededarion of MG industries).

Discussions are currently underway to sign an MOU with Living Lab. BH-Tec is interested to find international partners in the area of Biobased economy, and can help in connecting them to local parties in this field.

[38] Source: Prof Evakdim director Innovation with FAPEMIG

University Foundations

Most universities in Brazil have a foundation responsible for the administration and distributions of funds. The administration of foreign money streams, or the allocation of Brazilian moneys to foreign parties is extremely complex and time-consuming. The tax charged by these foundations to administer (research) funding can amount up to 30% of the overall total of any given funding for collaborative research with foreign parties. In certain cases[39] it is possible to negotiate this 'tax', and/or it will be possible to feature it as an expense on the project budget. In case of umbrella constructions (university-to-university MoU's pertaining to a general cooperation on research and exchange of students and staff – a so-called 'guarda chuva'), it needs to be decided upfront whether to include the foundation as an agent for administering funds or not. Once part of an umbrella agreement, every additional item also falls under the regulations of the universities' foundation for handling and administering funds.

Incubators & Start-ups

In Brazil, there is a diversified and extensive field of incubator- and start-up programmes that are mostly connected to public universities. Next to that, some municipalities have incubator programmes of their own (Sao Paulo, Campinas, Sao Jose dos Campos, Belo Horizonte, cities throughout the southern states etc.). To our knowledge, no other foreign country has yet set-up a cohesive strategy, targeting these incubator programs directly. The advantage of engaging with these incubators is that start-ups often need foreign technology, expertise etc. and are likely more open to share possible yields in the marketplace.

Both Dutch companies and the Dutch government could become directly involved with the programmatic aspects of the incubator programs, sharing experience and expertise, and thus stimulate hands-on matchmaking between Dutch and Brazilian start-ups and SMEs. Quite a number of these start-ups are recipients of funding from FAPESP PIPE (see above) of FINEP, state innovation funds and BNDES loans. This means that the risk and required investment level for Dutch partners is much better shared with the Brazilian partner.

[39] in the context of bilateral MoU's, joint research programs with BR science foundations

14 Lessons learned

The interviews with Dutch parties have led to several lessons learned that other Dutch companies and research organisations can learn from. They have been clustered by category below.

14.1 Brazilian laws and legislation

The Brazilian regulatory environment is complex and opaque. Brazil passes 8 laws per day on average and we found over 800 laws that are at least somewhat related to the biobased economy. Companies and knowledge institutes should inform extensively about relevant legislation, directives and programs with regard to their field of operation. Note that both state-level as well as federal-level legislation may be relevant, and that these are not always aligned. It is therefore highly advised to seek legal advice from either legal firms or experienced local partners. The Dutch diplomatic services (see 13.3) can help in finding a suitable partner or legal advisor.

14.2 For companies and research organisations

Exporting biomass for European energy use is not as interesting as previously thought

A few years ago it seemed that Brazil would be an interesting country for sourcing biomass for bioenergy use in Europe, and in the Netherlands in particular. However, although the country does feature many low-cost biomass (waste) streams, there are a number of barriers. Barriers mentioned in the interviews are:

1. The costs of logistics are prohibitive. The low cost biomass is often available in remote locations, far from railways, good motorways or navigable waterways[40].These costs are enough to kill most of the business cases for biomass export (even when pre-processed in the form of (torrefied) pellets), since distances are so large and the added value of the products is relatively low.
2. Brazil mostly lacks the technologies required for pre-processing, and when it has them, it cannot guarantee the quality standards required by European utilities.
3. Regarding pre-processing technologies, there is not much research into the matter.
4. The high electricity prices make the internal market more interesting.
5. The Brazilian market cannot fulfil the requirements for biomass certification demanded by the European market.[41].
6. For export of vegetable oils, Brazil maintains a protectionist attitude, and levies export duties on vegetable oils in the order of 100 USD/ton.

[40] Actually most existing that would have been suitable for this have been dammed off in the last 50 years with hydropower plants, making navigation impossible.
[41] Source: CENBIO/IE/Unicamp

Barriers 2, 3 and 5 simultaneously open opportunities for R&D, technology transfer, consultancies etc., by Dutch parties.

Logistics opportunities

The Dutch already play a role in developing the Brazilian infrastructure by developing ports[42].
The Dutch know-how in complex logistics questions could play a role in helping Brazil adjust to changing market environments. For example, the current economic slow-down has led to significant reduction of activities in the construction sector, a major domestic steel consumer. As many of the big steel firms have their own tree plantations, they now need to find alternative uses for their wood. A new market for these products could be the strong pulp industry, but this requires rerouting and logistical flexibility.

Requirements for local content

While there is no explicit local content[43] requirement for participation in Brazil's renewable energy power auctions, BNDES does use local content rules in determining which companies qualify for its low-cost credit. Since BNDES provides the most favourable financing terms, its financing creates a de facto local content requirement for the Brazilian market. To illustrate this point, out of the 81 wind farms operated in Brazil in 2014, only one had been developed without BNDES financing – a project financed instead by the Chinese Development Bank and that used Chinese manufactured turbines (USCS, 2014).

Dutch pyrolysis technology

BTG BTL has several years of experience developing pyrolysis technology with Brazilian partners. Though many applications of pyrolysis oil are possible, the company believes that it is important to first develop bulk production before looking at higher end materials[44]. They believe it might take another 5 years before technology and production is mature enough for high-end materials.
A recent breakthrough has been announced with partner Petrobras, who have managed to produce pyrolysis oil that can enter directly into the conventional chemical refining process (into the catalytic cracker) which means expensive upgrading of the pyrolysis oil is no longer needed.
The developments are currently slow in Brazil because of low oil prices and internal problems at Petrobras.

[42] The Port of Rotterdam is assisting TPK Logistica with knowledge and expertise in developing Porto Central, a deep sea harbor in Espirito Santo (north of Rio de Janerio)
[43] Local content means a minimum share of products/services used in a project are provided by domestic companies/organisations.
[44] Gerard Muggen, BTG-BTL

Working with Petrobras

Though technically speaking state-owned oil company Petrobras has no monopoly, it is a very dominant player in the market of fuels and chemicals. Experience shows that buy-in of Petrobras is key for successful deployment of product of technology in the Brazilian market[45].

SENAI

SENAI is the National Service for Industrial Training . All industries must contribute to it by a percentage of their revenue. Therefore large part of employee training is also done in partnership with SENAI. The organisation has a research and innovation centre for biomass.

14.3 For the Dutch Government

In general, Dutch companies and research institutes are satisfied, and sometimes delighted by the support the Dutch government is providing in Brazil.

Government to Government (G2G)

Government to government activities are seen as helpful, especially if market players are (partially) government owned. According to the interviewees, the Dutch government should have a facilitating role when supporting parties internationally. As an example, Brazil has a cooperation agreement with Germany for help in the development of Brazil's institutional organization and capacitation programs.

In Brazil, economic diplomacy is of high importance. Also, involvement of the sector in these studies is key, as there is a lot of international knowledge and expertise available.

Trade missions

Interviewed people had various reactions when asked about the success of previous trade missions. Some comments included:

- It would be better if the mission had a narrower focus
- It would be helpful if the government set the mission agenda in close cooperation with research institutes, universities, and companies to support matchmaking between Brazilian and Dutch parties (SME's).

[45] SkyNRG, BTG-BTL

Awareness about Dutch players is sometimes low

Most interviewed partners in Brazil were unaware of Dutch players in the area of biomass research or technology. There is clearly a role to play for the Netherlands on its visibility to research and professional organisations.

Follow-up of MOUs

Several interviewees have mentioned that though MOUs closed with various parties and with support of the Dutch government are useful for their visibility, the follow-up could be improved. For example, trade barriers are still in effect on the export of vegetable oils[46] biodiesel, which is hampering the development of business case for aviation fuels in the Netherlands based on Brazilian feedstock.

A Dutch Micro-Network in Brazil

A 'micro-network' of Dutch organizations, entrepreneurs and academics active in and/or connected to Brazil could greatly add to the scope, reach and bandwidth of the current Dutch network in Brazil. In many cases, Brazilian companies, organizations and institutions are approached by their Dutch counterparts - or through diplomatic channels - on just the top-tier level, in the context of scheduled, official visits and (trade-) missions. Even-though this leads to high-level bilateral MoU's and LoI's, many opportunities that may arise bottom-up from within Brazilian organizations and institutions are not being identified this way. The follow-up required to come from identification of a collaboration opportunity to actual collaboration is typically a lengthy and complex process. Therefore a stationary micro-network can also serve to fill the gaps that often occur along the different initiated trajectories.

Activities of the network would include, apart from communication between the members,:

- specific and targeted queries;
- frequently checking tenders;
- informing about R&D projects, incubators and start-up programmes;
- local brainstorm events.

Members of this micro-network can also be deployed to perform specific research, assessments, fact-finding and network and lobby activities, being able to act swift and flexible on both existing and arising Brazilian and Dutch requirements.

The coordination of this network can be carried out by the embassy, consulates and NSBO's in Brazil and RVO in the Netherlands.

Other countries like Germany, the UK and Canada, already have similar mechanisms in place.

[46] In the order of 100 Euro/ton

The required budget for maintaining and coordinating such a network are relatively low, and often only a fraction when compared to the required budgets for outgoing and incoming missions.

We highly recommend the formation of such a micro-network as a follow-up, and as part of creating additional tools for increasing the yield of results in terms of increasing order-portfolio's, R&B collaboration, joint ventures and joint start-ups etc.

Following the definition of the targets, pre-requirements and a preliminary road-map of this micro-network, a dedicated event about this subject, prepared by RVO and the issuers of this report could be feasible venture point.

15 Events

RWM Brasil - 29-30 September 2015 – São Paulo

Brazil's only focused event on solid waste management

Bringing together national and local government leaders, leading industry experts and key decision makers from Brazil and across the world.

Website: http://www.rwmbrasil.com.br/

Ethanol Summit – 22 September - São Paulo

Event for public, private and non-governmental stakeholders, with a focus on the state of São Paulo.

Website: http://anggulo.com.br/p+l/evento.html

Biogas Brazil Congress (7th Edition) – June 2016 - São Paulo

Website: http://www.informagroup.com.br/biogas

International Bioenergy Congress – Summer 2016 - São Paulo

Congress on renewable energy in Brazil and Latin America focusing on biomass, industrial, agricultural and urban waste, biofuels, new technologies and alternative energy sources. It includes a B2B programming as well as a trade fair for products and businesses. Together with the Congress several parallel events are scheduled such as the BIOTechFair, seminars, etc.

Website: http://www.bioenergia.net.br

Greenergy Expo Brasil – July/August 2016 – São Paulo

Trade fair for the renewable energy industry

Website: http://www.feiraecoenergy.com.br

International Fair for Bioenergy and Biofuels Technology – July/August 2016

On the use of industrial and agricultural waste and other alternative energy sources, focusing on the technological aspects in the field of biomass and biofuels from agricultural waste, forestry, sugarcane and urban waste.

Website: http://biotechfair.com.br

Greenbuilding Brasil (6th Edition) –July/Aug 2016 - São Paulo

"The Green Building Council Brasil is the leading institution in Brasil in terms of fostering Green Building. GBC Brasil hosts the Greenbuilding Brasil conference together with the WorldGBC congress which is an influential event for Green Building not only in Brasil but also for Latin America.

Website: www.expogbcbrasil.org.br

Brazilian Congress on Energy Efficiency COBEE – ABESCO – July 2016 – São Paulo

Structured around business development and networking, where sector agents, experts, service providers and suppliers can interact and exchange information through the various Congress' panels and through the exhibition/tradefair.

Website: http://www.cobee.com.br/

FENASUCRO & AGROCANA 2015 –August 2016 - Sertãozinho/SP
Major event on technology and trade for mills and sugarcane industry professionals. The main meeting-place for producers, traders, equipment manufacturers, producers and services suppliers for the sugarcane agro-industry. A comprehensive event that offers visitors the opportunity to explore the entire productive chain: soil preparation, planting, cultivation, harvest, industrialization, mechanization, use of derivatives transportation and logistics of sugarcane products and by-products.
Website: http://www.fenasucro.com.br

Dia de Campo Florestal (11th. Edition) - August 26st 2015 - Botucatu/ SP
Organized by the Faculty of Agricultural Sciences (FCA) - Unesp / Botucatu since 2004, the Forest Field Day takes place in 2015, in commemoration of the 50th anniversary of the FCA. In this edition programming will bring in an unprecedented manner the view of the main wood processing companies in the interior of São Paulo; traditional sectors such as panels, paper & pulp, energy, and treated lumber present of success stories for forestry professional
Website: http://www.fca.unesp.br/#!/evento/121

BW Conference - October, 20-22nd 2015 – São Paulo
High-end technical and scientific conference program with the main industry experts, including associations, universities and exhibitors. It will present extensive and detailed industry assessments, including: wastewater and sewage treatment; challenges of collection, treatment and water distribution; solid waste management; reverse logistics; solutions to major drainage, flood control and streams channelization; soil decontamination and treatment; etc.
Website: http://www.bwexpo.com.br/en/congress/180

Brazilian Biodiesel Conference - October, 26-27th 2015 – São Paulo
Largest biodiesel event in Latin America, bringing together government officials, power plant operators, manufacturers, fuel distributors, gasoline stations, producers and suppliers.
Website: https://conferencia.biodieselbr.com/2015/

Eucalipto 2015 - Forestry Production Technologies - November 20-22nd 2015 – Uberlândia/MG
The event will focus on policy, management and technology. The symposium also aims be a forum for discussion of all the aspects of the planted forest productive chain.
Website: http://www.sif.org.br/@eucalipto2015/

National Congress on Bioenergy - November 11-12nd 2015 - Araçatuba/SP
For new concepts, technologies and production systems applicable to the everyday operation of bioenergy plants, divided into the areas of greatest impact: agriculture; industry; administrative/financial; HR; communication; information technology; mechanization; new technologies; market, marketing and logistics; cost-control; health, safety and the work environment and sustainability.
Website: http://www.udop.com.br/index.php?item=congresso

16 Initiatives from the EU

16.1 From the Netherlands

Clean & Circular Delta Challenge Rio de Janeiro

This project aims to assist the State of Rio de Janeiro and municipalities, as a short term objective, with the ambition to clean up the Guanabara Bay before the start of the Olympic Games in 2016. Participating companies include Preventing further pollution by introducing the circular (green) economy and contributing (in)directly to foster and develop - as long term objective- the sustainability and economic potential of the Guanabara Bay.

16.2 Brazilian-European Projects

The CLIM-AMAZON joint Brazilian-European scientific initiative
Website: http://www.clim-amazon.eu/

The B-Bice+
Brazilian Bureau to Enhance the Bilateral Cooperation between Brazil and Europe project (2012) –
Website: http://pacenet.eu/inco/bbice

INCO-Net ALCUENET (2012-2016)
The project ALCUE NET, funded by the Seventh Framework Programme (FP7), is an initiative to support the political dialogue for Research and Innovation in order to establish a platform for EU-LAC that brings together the actors involved in R&D information, funding and implementation, as well as other relevant stakeholders in the public, private sectors and the civil society.
The Ministry of Science, Technology and Productive Innovation is the coordinator of a consortium of 19 institutions, 11 from Latin America and the Caribbean and 8 from Europe.
Website: http://alcuenet.eu/

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Appendix B – Characteristics of Electricity Auction scheme

Table 19 - Summary of major characteristics of auctions in Brazil (Ecofys own compilation, 2015)

Auction system in Brazil – Major characteristics	
Authorities in charge	Government: Ministério de Minas e Energia (MME) Executive body: Agência Nacional de Energia Elétrica (ANEEL)
Eligible technologies	Auctions can be technology specific, but in some cases are also open to more than one technology. For example, in 2008 biomass only auction, and 2009 wind only auction. ANEEL determines which technologies will be eligible in auctions and they can compete with conventional power as in the case of 2011 auction with wind, natural gas, biomass, and small scale hydro. Since 2004 auctions for wind, biomass, small scale hydro, natural gas From 2012 specific auctions for solar
Selection process	Pre-requisite for projects: prior environmental license; grid access statement; financial qualifications; technology specific documents (such as fuel contracts for biomass and certified production for wind) Selection in 2 phases based on price: Phase 1 descending price clock auction; Phase 2: final pay-as-bid auction
Agenda of auctions	New energy auctions annually based on forecast energy capacity needs in advance of one, three or five years (A-1, A-3, A-5 auctions). Reserve auctions when MME decides. One A-3 and A-5 auctions are held annually which are mix of conventional and RES-E technologies. In addition, typically at least one reserve energy auction is held for RES-E every year.
Volume contracted	2007 auction: 541.9MW (biomass); 96.74MW (small hydro) 2008 auction: 2379MW (biomass) 2009 auction: 1805.7MW (wind) 2010 auction: 809MW (hydro) (small and medium size) 2010 auctions (reserve & A3): 2.047.8MW (wind); 712.9MW (biomass); 131.5MW (small hydro) 2011 auctions (reserve & A3, A5): 2905.3MW (wind); 654.8MW (biomass)
Duration of tariff	Typically 20 years for wind; 15 years for biomass; 30 years hydro
Compliance	Penalties for delays. Contract termination for delay of more than one year. But no enforcement yet. Winning projects have to deposit several guarantees, including a bid bond of 1% of project's estimated investment cost and a project completion bond of 5% of project's estimated investment cost

Appendix C – Native plant species for conservation and biomass

Table 3. Examples of relevant species applicable in multipurpose biomass conversion, integrating economic interest with conservation of biodiversity, ecosystem services and land recovery

Brazilian native species	Relevance Brazil-Netherlands	Tech-nology	Products or applications
Babassu palm *Orbignya phalerata* (kernel and oil)	Feedstock to renewable energy and bio products. Native to Brazil and other LA countries (largely dispersed in northern and North-Eastern Brazil); Possibility to integrate with environmental and social projects (Sustainability and conservation certifications, PES etc.)	Fast Pyrolysis	Oil at 650°C: carboxylic acids (57.9%), alkenes (8.6%), aldehydes (2.5%), alkanes (2.3%), esters (1.7%), CO_2 (0.6%) and cyclic ketones (0.4%); Pyrolysis of kernel at 650°C: CO_2, alkanes, alkenes, alcohols, ketones, aldehydes, esters, amides and carboxylic acids.
Piqui *Caryocar coriaceum*		Fast Pyrolysis	Oil from mesocarp: straight-chain alkanes and 1-alkenes;
Palm tree *Elaeis guineensis*		Fast Pyrolysis	Palm oils from fruits: straight-chain alkanes and 1-alkenes; linear monoalkenes (up to C19) and alkanes (up to C17)
Macauba tree *Acrocomia sclerocarpa*	Feedstock to renewable energy and bio products. Native to Brazil, mainly in the center region, i.e. Minas Gerais State); Suitable for multipurpose projects	Fast Pyrolysis	Oil from fruits: carboxylic acid, aldehydes, alcohols, alkenes and alkadienes
Amazon tucumã *Astrocaryum aculeatum*	Feedstock to renewable energy and bio products. Native to Brazil (largely dispersed in northern region); Suitable for environmental and social projects (Sustainability and conservation certifications, Carbon Credits., PES etc.)	Fast Pyrolysis	Seeds residues at 550°C: to bio-oil (homogeneous fuel) and some high-value compounds, such as levoglucosan and guaiacol; also furans, phenols, some short-chain acidic compounds (acetic acid, propanoic acid)

Appendix D - Summary of main stakeholders

Name	Description	Website
Acende Brasil Institute	Non-profit organization that acts as watchdog of the energy sector. Mostly analyzes the market's developments and the results of policy changes and energy auctions.	www.acendebrasil.com.br/en/
ANEEL	Brazilian Electricity Regulatory Agency Created in 1996 to regulate and supervise the electricity service in Brazil. ANEEL's mission is to provide favourable conditions for the electric power market to develop a balance between the agents and the benefit of society.	www.aneel.gov.br/
BNDES	Brazilian development bank. The main financing agent for development in Brazil. Since its foundation, in 1952, the BNDES has played a fundamental role in stimulating the expansion of industry and infrastructure in the country	www.bndes.gov.br/
CEPEL	CEPEL is the Electric Power Research Center of Eletrobras and has over 30 years of research and development (R&D) experience regarding electric power generation	www.cepel.br
ELETROBRAS	Biggest electricity generator of Brazil, state-owned company with open capital that once was responsible for the entire electric sector. From its division that ANEEL, ONS, CCEE and EPE emerged. Now responsible for 164 plants with 42GW total capacity.	www.eletrobras.com
EPE	Energy Research Company The federal energy planning company was created in 2004 to help the government plan its energy supply. EPE is responsible for projecting energy supply and demand, supporting the government and power regulator ANEEL in implementing policies, as well as carrying out studies for new power projects to be offered at government auction.	www.epe.gov.br
IBGE	The Brazilian Institute of Geography and Statistics	www.ibge.gov.br/english/
MME	Ministry of Mines and Energy is at the top of the whole sector and is responsible for high level policy activities such as commissioning the energy auctions and changes in taxation.	www.mme.gov.br
SENAI	The National Service for Industrial Training All industries must contribute to it by a percentage of their revenue. Therefore large part of employee training is also done in partnership with SENAI.	www.portaldaindustria.com.br/senai
CTBE	National Laboratory that operates with the scientific and technological community and the Brazilian productive sector, aiming to contribute to the maintenance of competence of the Country in the production of sugarcane ethanol and other compounds from biomass.	http://ctbe.cnpem.br/en

Name	Description	Website
CNPEM	*National Centre for Research in Energy and Materials* A non-profit private institution whose goal is to manage four national laboratories for the Ministry of Science, Technology and Innovation (MCTI): Synchrotron Light (LNLS), Biosciences (LNBio), Science and Technology of Bioethanol (CTBE) and Nanotechnology (LNNano).	http://cnpem.br/
EMBRAPA	*Brazilian Agricultural Research Corporation* A technological innovation enterprise that is focused on generating knowledge and technology for Brazilian agriculture. The institution is under the aegis the Ministry of Agriculture, Livestock, and Food Supply (MAPA).	https://www.embrapa.br/
Raízen	Raizen is a joint venture of Shell with Brazilian company COSAN. It is one of the top five companies in terms of revenue and the third largest fuel distributor; leading manufacturer of sugarcane ethanol in the country and the single largest exporter of sugarcane to the international market. It operates 23 out of the 509 biomass power plants of the countries.	http://www.raizen.com.br/
GranBio	Brazilian biotech company that develops plants that transform biomass into renewable products such as biofuels, biochemicals, nano materials and nutrients. The only one in the sector to be active from start to finish in the chain of production – from raw material to distribution of the final product – integrating its own and third-party technologies.	http://www.granbio.com.br/en/
CENPES-Petrobras	Cenpes - the Petrobras Research and Development Center - is among the world's largest R&D centers dedicated to energy research. Located on the Ilha do Fundão in Rio de Janeiro. It includes more than 200 laboratories — their technologies equip Petrobras to be among the world's leaders.	http://www.petrobras.com.br/en/our-activities/technology-innovation/
Petrobras	Publicly traded corporation, the majority stockholder of which is the Federal Government (represented by the National Treasury), and we perform as an integrated energy company in the following sectors: exploration and production, refining, marketing, transportation, petrochemicals, oil product distribution, natural gas, electricity, chemical gas, and biofuels.	http://www.petrobras.com.br/en/
Fibria	Brazilian company with a strong presence in the global forest products market (mostly with Eucaliptus), investing in the cultivation of forests as a renewable and sustainable source of life.	http://www.fibria.com.br/en/
Suzano	Forestry based publicly held company, controlled by Suzano Holding and belonging to Group Suzano. present in two segments: market pulp and paper, which portfolio is composed by coated, uncoated and paperboard. We are the second largest eucalyptus pulp producer in the world and the fourth largest market pulp producer.	http://ri.suzano.com.br/
UNICA	*The Brazilian Sugarcane Industry Association* The organisation represents about 60% of Brazilian sugarcane production.	http://www.unica.com.br/

Name	Description	Website
UDOP	*Union of Bioenergy Producers* Brazilian union that represents the producers of ethanol, sugar, bioelectricity and biodiesel. UDOP maintains a list of its members, including ethanol mills and distilleries in at least six states in Brazil.	http://www.udop.com.br/index.php
APTA	*São Paulo's Agency for Agribusiness Technology* Linked to the Departament of Agriculture and Provision (SAA) to coordinate all agriculture and cattle raising research in the state of São Paulo, Brazil; to generate and transfer scientific and technological knowledge in agribusiness, thereby harmonizing the socio-economic development with environmental balance. 15 regional poles of development are spread throughout the state.	http://www.apta.sp.gov.br
ANP	*National Agency of Petroleum, Natural Gas and Biofuels* The federal government agency linked to the Ministry of Mines and Energy responsible for the regulation of the oil sector.	http://www.anp.gov.br
IBA	The Brazilian Tree Industry Association of tree plantations representing planted tree production chain, from the field to the industry.	http://www.iba.org
CENBIO / USP –	*The Brazilian Reference Center on Biomass* of the University of São Paulo Works on research and development of technological, economic, social, environmental and institutional studies related to biomass conversion and use, together with other (national and international) groups, in the scientific, technological, industrial and agricultural sectors.	http://cenbio.iee.usp.br
MAPA	*Ministry of Agriculture, Livestock and Food Supply* Federal department that formulates and implements policies for agribusiness development, integrating the aspects of market, technological, organizational and environmental care for the consumers of the country and abroad, promoting food security, income generation and employment, reducing inequalities and social inclusion.	http://www.agricultura.gov.br
Industry Association of Cogeneration COGEN	A non profit organisation based on the successful European COGEN initiative to promote integration and cooperation among its members in order to implement and strengthen the cogeneration industry in Brazil.	http://www.cogen.com.br
CONAB	*National Company of Food and Supply* Conducts surveys of agricultural crops in order to quantify and monitor the Brazilian production to MAPA [Brazilian Ministry of Agriculture, Livestock and Supply	http://www.conab.gov.br/
CCEE	*Câmera de comercialização de energia elétrica* Chamber of Commerce for Electric Energy is ANEEL's arm to regulate the financial aspects of the whole sector.	http://www.ccee.org.br
Odebrecht Agroindustrial (ETH Bioenergia)	Large industrial company controlled by the Odebrecht Group; it operates in the production and marketing of ethanol, electricity and sugar.	http://www.odebrechtagroindustrial.com
Bracelpa	*Brazilian Pulp and Paper Association* Association that represents the Brazilian pulp and paper industry	http://bracelpa.org.br

Name	Description	Website
Fundacao Getulio Vargas – Agro	Getulia Vargas Foundation . Economic research center specialised in agricultural businesses	http://www.eesp.fgv.br
Center for Sugarcane Technology CTC	Research and technology centre for research in the sugarcane industry.	http://www.ctcanavieira.com.br
CEPEA	*Center for Advanced Studies in Applied Economics* Agronomic research department of the University of São Paulo	www.cepea.esalq.usp.br
Centro de Gestão e Estudos Estratégicos CGEE	Center for Strategic Studies and Management Science, Technology and Innovation. Their studies have major impact on national policy making	http://www.cgee.org.br

Appendix E – List of interviewed people

Company/Organisation	Name	Function
Ministry of Mines and Energy (MME)	Ricardo de Gusmão Dornelles	Director Department of Energetic Planning and Development (DDE)
Shell/Raizen	Michiel Molenaar	Shell shareholder representative to Raizen at Shell brazil Petroleo ltda
Unicamp (university)	Prof. Dr. Waldir Bizzo	Prof in dept of Mechanical Engineering
USP Biologia	Prof.. Marie- Anne van Sluys	Prof in Biology
ERB (bioenergy company)	Nelson Amado	Director
Center of Research on Agricultural and Environmental Economics, IE/Unicamp & CENBIO	Jose Maria Ferreira Jardim da Silveira	Professor
Be-Basic	Ernst-Jan Bakker	BE-Basic Director Brazil
USP	Glaucia Mendes Souza	Associate professor, Biochemistry
EMBRAPA	Mariana Aparecida Carvalhaes	Specialist new biomass feedstock
COSAN	Mark Lyra	CEO Cosan Biomass
UNICAMP/CENBIO	José Maria de Silveira	Specialist in biotechnology for BBE/bioenergy
BIOWARE	Juan Miguel Mesa-Pérez	CEO
Unicamp/IE	Prof. Dr. Ademar Ribeiro Romeiro	Researcher/Consultant
SENAI Innovation Center for biomass	Carolina Andrade	Researcher
Torrgas (ex Topell)	Robin Post van der Burg	CEO
Toppell	Tom Kleingeld	Project Manager
DSM	Frank Nadimi	Business Development Director Biotech
TKI BBE	Dr. ir C.D. (Kees) de Gooijer	Directievoorzitter
BTG Biomass technology	Gerhard Muggen	Managing director BTG-BTL
Vattenfall	Bart Dehue	Biomass Sourcing
TNO	Laurens Steen	Business developer for TNO in Brazil
SkyNRG	Dirk Kronemeijer	CEO
AVEBE	Marco Giuseppin	Chief Technology Officer
Holland Brazil	Dirk Blom	Co founder

Company/Organisation	Name	Function
WRR Group	Jan Boone	CEO
NOST	Nico Schietekatte	Counsellor for Science, Technology & Innovation
TU Delft/BE-Basic Brazil	Patricia Ossewijer	Professor Biotechnology
Consulate Rio de Janeiro	Arie Plieger	Deputy Consul-General

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