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Evidence and lessons from Latin America

SPOTLIGHT ON PUBLICATIONS:
BRAZIL'S ETHANOL PROGRAMME

This Spotlight highlights some of the key publications that study, analyse and document Brazil's ethanol programme. The publications focus on the following specific issues: Brazilian government policies to promote the sector; sustainability issues; expansion, land use and agro-ecological zoning of sugarcane; bagasse, cogeneration and bioelectricity; and advanced biofuels. Together these resources highlight the current key issues surrounding the sector, offering a useful entry for readers from other regions who wish to understand the Brazilian experience with ethanol.

THE STORY OF BRAZILIAN ETHANOL: GOVERNMENT POLICIES AND LESSONS LEARNED

In addition to these publications, further information can be found in the ELLA Brief: Government Intervention to Strengthen the Ethanol Sector: Lessons from Brazil.

Brazil Alcohol National Program

The evolution of Brazil's National Ethanol Programme, *Proálcool*, tells an interesting story from the progressive construction of institutional infrastructure to the evolution of agro-industrial technology. In this comprehensive document, the author details all phases of *Proálcool*, the evolution and bottlenecks of ethanol production, the crises the sector faced, as well as government financial support such as subsides and taxes breaks. The conclusion argues that any attempted replication of the Brazilian model in other countries should consider the specific Brazilian context at the beginning of the programme, such as a military dictatorship which enabled centralised decisions, and a federal constitution that allowed direct government intervention in the economy.

Full citation: Moraes, M., Rodrigues, L. 2006. *Brazil Alcohol National Program*. Piracicaba.

The Brazilian Sugarcane Ethanol Experience

Biofuel enthusiasts frequently cite the Brazilian experience with ethanol from sugarcane as a success story and a model for diversifying energy matrices. Today, Brazil is the world's largest biofuel market, followed by the United States, where most ethanol is produced from corn. Ethanol production is more competitive in Brazil. This paper aims to review the conditions and policies that have contributed to the success of the Brazilian bioethanol industry. The paper also shows

that even in Brazil, ethanol is cost-competitive with gasoline only during periods when oil prices are high. It also compares the competitiveness of ethanol in Brazil and the US.

Full citation: Xavier, M.R.S. 2007. *The Brazilian Sugarcane Ethanol Experience*. Issue Analysis 3. Competitive Enterprise Institute, Washington, DC.

Ethanol: A Brazilian Successful Story

In 1975, Brazil launched a programme to boost ethanol production and consumption known as *Proálcool*, the world's largest renewable energy programme. Though successful, the development of large-scale production and use of ethanol in Brazil has always relied on proactive government policies. This paper explains all the stages of the *Proálcool* evolution, from up-take to the financial crisis and the introduction of flex-fuel technology in 2003. The paper also shows the rises and falls of ethanol production and analyses the most important policies and factors behind the successes and shortfalls of such a large-scale government programme.

Full citation: Carvalho, L.C.C. 2007. Ethanol: A Brazilian Successful Story. In: WROBEL, P. (eds). *Clean Energy: the Brazilian Ethanol Experience*. London, UK.

Ethanol Learning Curve - the Brazilian Experience

Brazilian government initiatives to expand the production and consumption of different renewable energies aim to reduce dependence on oil and work toward achieving sustainable development goals. However, a very common argument against renewables is their limited economic competitiveness against fossil fuels. Based on the Brazilian experience, this paper depicts how issues such as economies of scale and technological advances are important to reduce production costs of ethanol in comparison to conventional fossil fuels. According to the authors, such gains are results of the "learning curve effect", meaning, in this case, increase in productivity derived from the accumulation of experience in the production of ethanol. The evolution of this industry offers some valuable lessons for other countries considering ethanol production.

Full citation: Goldemberg, J. *et al.* 2006. Ethanol Learning Curve - the Brazilian Experience. *Biomass and Bioenergy* 26(3) 301-304.

Ethanol: Lessons from Brazil

Recently in Brazil, the volume of ethanol in the Otto Cycle fleet has reached more than 40%. This increase in ethanol demand is due to government policies such as the incentive to introduce flex-fuel vehicles in the Brazilian market. As the United States and many other countries explore ways to reduce oil dependency, policymakers are looking to Brazil for guidance. This paper summarises the history of the Brazilian ethanol programme and describes the programme's current successes and challenges. Finally, the publication explores lessons learned from the Brazilian experience.

Full citation: Sandalow, D.B. 2006. Ethanol: Lessons from Brazil. In: Monsma, D.W., Riggs, J.A. (eds). *A High Growth Strategy for Ethanol*. Aspen Institute, Washington, DC.

The Performance of Brazilian Biofuels: An Economic, Environmental and Social Analysis

More than 40 years have passed since the Brazilian ethanol programme was launched to boost ethanol production, reduce dependence on oil imports and increase energy security. The biodiesel programme, launched in 2005, is much newer and still faces some consolidation challenges. This report analyses the Brazilian ethanol and biodiesel programmes focusing on the potential competitiveness between biofuels and traditional fuels. This comprehensive document also depicts

the environmental and social impacts of the biofuels produced in Brazil, as well as their contribution to national energy security. Finally, it offers a prognosis of Brazil's potential to export biofuels.

Full citation: Almeida, E. F., Bomtempo, J. V., Silva, C.M.S. 2007. *The Performance of Brazilian Biofuels: An Economic, Environmental and Social Analysis*. Discussion Paper No 2007-5. OECD, International Transport Forum, Paris.

Sugarcane-based Bioethanol: Energy for Sustainable Development

The most sustainable way of replacing fossil fuels is using renewable organic matter, otherwise known as biomass. In Brazil, sugarcane-based ethanol is an excellent option and currently substitutes for almost half of the gasoline used in light vehicles. This book aims to provide a meaningful and objective discussion on the potential and constraints of producing bioethanol from sugarcane, especially in those countries where sugarcane is already being cultivated. The book also emphasises that many developing countries have adequate natural conditions to expand energy-orientated sugarcane production, but still depend on policies and incentives to create a competitive market. This is one of the most complete publications about Brazil's experience in the sugarcane ethanol sector.

Full citation: National Development Bank (BNDES) and Centre for Strategic Studies and Management in Science, Technology and Innovation (CGEE). 2008. *Sugarcane-based Bioethanol: Energy for Sustainable Development*. BNDES, Rio de Janeiro.

SUSTAINABILITY OF ETHANOL: IMPACTS AND POLICIES

In addition to these publications, issues related to the sustainability of ethanol are also explored in the ELLA Brief: Brazil's Efforts to Mitigate the Environmental Impacts of Ethanol Production.

Beyond Commonplace Biofuels: Social Aspects of Ethanol

Naturally, the production and use of biofuels generates environmental, economic and social impacts. Today, most studies that analyse biofuels focus on environmental and economic issues. This is also true for sustainability assessment studies of renewable fuels, with a limited appraisal of social aspects. In contrast, this study aims to develop a social framework in order to improve the impact assessments of ethanol. The author discusses the social constraints and strengths in the lifecycle of this biofuel, and overall asserts that there is little data accessible on the positive and negative social impacts of first generation ethanol.

Full citation: Ribeiro, B. 2013. Beyond Commonplace Biofuels: Social Aspects of Ethanol. *Energy Policy* 57 355-362.

Impacts on the Water Supply

The use of agricultural irrigation for sugarcane crops is relatively limited in Brazil. To better understand why, the author highlights the opinions of a number of specialists in water management to assess the use of water in sugarcane production in different regions in Brazil. The main conclusion is that water uptake for industrial ethanol processes has been reduced substantially in recent years, due to the development of technologies to reduce waste and increase the reuse of water. This paper is part of an important edited volume about the sustainability of ethanol production, written by leading experts on the issue.

Full citation: Neto, A. 2007. Impacts on the Water Supply (Chapter 5). In: Macedo, I. (eds). *Sugar Cane's Energy: Twelve Studies on Brazilian Sugar Cane Agribusiness and its Sustainability*. UNICA, São Paulo.

Sustainability, Certification and Internationalization of Brazilian Ethanol

Today the requirement for certification of biofuel production is a growing global movement, especially among purchasing countries. Certification is used as a market tool to promote sustainable production in different segments of agribusiness. This study aims to analyse the certification processes in the production and consumption of Brazil's ethanol supply by the most relevant players, such as Brazil, the European Union and the United States. According to the authors' argument, certification and regulatory initiatives are converging towards an "International Standard Certification".

Full citation: Padula, A. *et al.* 2011. *Sustainability, Certification and Internationalization of Brazilian Ethanol.* Paper presented at the International Food and Agribusiness Management Association (IFAMA) 2011 Annual World Symposium, 20-21 June 2011, Frankfurt.

The Sustainability of Brazilian Ethanol - an Assessment of the Possibilities of Certified Production

This article aims to assess the environmental and socio-economic impacts of ethanol production in the state of São Paulo in Brazil. To do so, the authors analyse 17 environmental and socio-economic issues. Their key conclusion is that the expansion of sugarcane production and the impacts on biodiversity as well as the competition with food production are the mains bottlenecks to achieving a certified sustainable ethanol production. The approach demonstrated in this report provides a useful framework for the development of a certification system applicable to other developing countries.

Full citation: Smeets, E. *et al.* 2008. The Sustainability of Brazilian Ethanol - an Assessment of the Possibilities of Certified Production. *Biomass and Bioenergy* 32(8) 781-813.

The Sustainability of Ethanol Production from Sugarcane

As the pace of Brazilian ethanol production has grown over the last decade, several questions have been raised with regard to the negative consequences of burning sugarcane before harvesting. Although burning facilitates manual harvesting, it also causes significant damage to the environment. This paper describes in detail both the negative and positive aspects of sugarcane production, focusing specifically on pre-harvest burning. It also analyses the consequences of mechanising harvesting. Overall, the authors find that while mechanisation reduces environmental impacts, it replaces workers with machines, thus creating social and economic challenges. Goldemberg, the primary author, is one of the most important Brazilian scientists currently working on energy and climate change issues.

Full citation: Goldemberg, J., Coelho, S., Guardabassi, P. 2008. The Sustainability of Ethanol Production from Sugarcane. *Energy Policy* 36 2086-2097.

The Quest for Eco-social Efficiency in Biofuel Production in Brazil

Eco-efficiency emerged as a solution to push sustainable development onto the corporate agenda. However, despite its ambition, the concept was reduced to the creation of more value with less environmental impacts, less natural resources and less cost. In this framework, the article compares the Brazilian ethanol programme *Proálcool* with the country's national biodiesel programme in the context of production and use of biofuels. Although the Brazilian ethanol industry has improved its eco-efficiency requirements, there are still several unsolved socio-environmental problems. Such important lessons, according to the author, do not seem to have been applied to the biodiesel programme.

Full citation: Schaffel, S., La Rovere, E. 2010. The Quest for Eco-social Efficiency in Biofuels Production in Brazil. *Journal of Cleaner Production* 18 1663-1670.

Use of Fertilisers

In this paper, the author analyses how Brazil's sugarcane agriculture has managed to reach a high level of competitiveness without the extensive use of fertilisers. The author compares the use of fertilisers for sugarcane with other Brazilian crops such as corn and cotton, as well as with sugarcane crops in other countries. According to the author, the application of industrial waste, such as vinasse and filtercake, is responsible for the increase in sugarcane productivity without wide use of fertilisers.

Full citation: Donzelli, L. 2007. Use of Fertilisers (Chapter 9). In: Macedo, I. (eds). *Sugar Cane's Energy: Twelve Studies on Brazilian Sugar Cane Agribusiness and its Sustainability*. UNICA, São Paulo.

SUGARCANE EXPANSION: LAND USE CHANGE, IMPACTS AND AGRO-ECOLOGICAL ZONING

In addition to these publications, agro-ecological zoning is explored in greater detail in the ELLA Brief: Sugarcane Agro-ecological Zoning: Greening the Expansion of Ethanol.

Analysing the Brazilian Sugarcane Agro-ecological Zoning: Is this Government Policy Capable of Avoiding Adverse Effects from Land-use Change?

There is a global debate about the reliability of ethanol in reducing greenhouse gas (GHG) emissions and conserving biodiversity. Although the use of ethanol does bring some environmental advantages, the expansion of sugarcane has caused and will continue to cause negative impacts on biodiversity. This dissertation analyses the efficiency of Brazilian sugarcane agro-ecological zoning, *ZAE Cana*, a federal policy developed in 2009 to reduce or avoid adverse environmental impacts in terms of GHG emissions and biodiversity degradation. In the analysis, the author takes into account both direct and indirect effects of land use change caused by the expansion of sugarcane in Brazil, and finds that *ZAE Cana* will be an important tool to enable the expansion of sugarcane crops more sustainably.

Full citation: Almeida, M. 2012. *Analysing the Brazilian Sugarcane Agroecological Zoning: Is This Government Policy Capable of Avoiding Adverse Effects from Land-use Change?* MSc dissertation. Victoria University of Wellington.

Brazilian Agriculture and Environmental Legislation: Status and Future Challenges

In Brazil, the area for agriculture has expanded substantially during recent decades and is expected to increase further in response to growing demand for food products and biofuel feedstock. Recently, this expansion has resulted in a large rise in output; however, it has also caused negative impacts on biodiversity and soil and water resources. In this paper, the authors assess the Brazilian agriculture sector's compliance with environmental legislation and identify challenges for agricultural development related to this legal framework. The conclusion suggests the need for a new Brazilian approach to environmental protection, including new legal and regulatory mechanisms, as well as voluntary commitments to avoid impacts from the expansion of agriculture into natural ecosystems.

Full citation: Sparovek, G. *et al.* 2010. Brazilian Agriculture and Environmental Legislation: Status and Future Challenges. *Environmental Science and Technology* 44 (16) 6046-6053.

Challenges and Opportunities for Biodiversity Conservation in the Atlantic Forest in Face of Bioethanol Expansion

The expansion of sugarcane crops in Brazil to supply the growing ethanol market is a reality that can be extremely harmful to the remaining biodiversity of the Brazilian Atlantic Forest. Regions where most forest fragments are smaller than 100 hectares will be the most severely hit. In this paper, the authors suggest that increasing crop productivity should be prioritised instead of expanding plantations. In particular, they argue that the number of sugar and ethanol companies following best management practices should increase in order to reduce environmental harm and restore ecosystems at risk of imminent collapse.

Full citation: Bernard, E., Melo, F., Pinto, S. 2011. Challenges and Opportunities for Biodiversity Conservation in the Atlantic Forest in Face of Bioethanol Expansion. *Tropical Conservation Science* 4 (3) 267-275.

Expansion of Sugarcane Ethanol Production in Brazil: Environmental and Social Challenges

The increasing demand for biofuels is likely to benefit the sugarcane ethanol industry in Brazil, especially because of economic, energy and environmental advantages such as low cost, good energy balance and low GHG emissions. On the other hand, sugarcane expansion and ethanol production generate negative impacts such as atmospheric pollution, soil degradation and exploitation of labourers. In this publication, the authors discuss environmental and social issues linked to the expansion of sugarcane in Brazil for ethanol production, and offer suggestions to policymakers, such as the implementation of a code for ethanol production that is environmentally sustainable and economically fair.

Full citation: Martinelli, L., Filoso, S. 2008. Expansion of Sugarcane Ethanol Production in Brazil: Environmental and Social Challenges. *Ecological Applications* 18 (4) 885-898.

Indirect Land-use Changes Can Overcome Carbon Savings from Biofuels in Brazil

The official forecasts for the next ten years show a large increase in the production of biofuels in Brazil. Although Brazilian sugarcane ethanol is an alternative to help reduce GHG emissions, the expansion of crop plantations for biofuel production can cause both direct and indirect land use changes. This paper uses an explicit model to project land use change caused by that expansion up to the year 2020. The simulations show that direct land use change will have a small impact on carbon emissions because most biofuel plantations will replace rangeland areas. However, indirect land use change, especially those in areas close to the border with the Amazon forest, could offset the carbon savings from biofuels.

Full citation: Lapola, D. *et al.* 2010. Indirect Land-use Changes Can Overcome Carbon Savings from Biofuels in Brazil. *PNAS* 107 (8) 3388-3393.

Land Use Competition for Production of Food and Liquid Biofuels: An Analysis of the Arguments in the Current Debate

Recently the expansion of feedstock production for energy purposes has raised an important dilemma: using agricultural land to feed people or to increase farmers' profitability through agro-energy production. This paper analyses the current debate over the competition for land use. It gathers arguments both for and against the use of land to grow biofuel crops, including the impacts on food production. The results show that agro-energy has changed the land use dynamic, though only modestly, pressuring a replacement of food crops with biofuel crops in traditional areas. The authors conclude by proposing a sustainable balance between biofuels and food production.

Full citation: Rathmann, R., Szklo, A. Schaeffer, R. 2010. Land Use Competition for Production of Food and Liquid Biofuels: An Analysis of the Arguments in the Current Debate. *Renewable Energy* 35 (1) 14-22.

Policies and Institutional and Legal Frameworks in the Expansion of Brazilian Biofuels

Sugarcane expansion in Brazil has been characterised by an array of government policies and private actions. Heavy private investment and public financing for infrastructure, as well as a strong focus on research and development, have underpinned the significant ethanol expansion in Brazil in recent years. This paper identifies and analyses the wide range of policies and players and the institutional and political frameworks that have shaped the phenomenal rise of biofuels in Brazil. It also considers questions that are currently being raised about the potential social, economic and environmental impacts of biofuel production. The paper provides important information about the efficiency of the policies implemented in Brazil and thus might be useful for policymakers who are in charge of biofuels promotion and regulation in developing countries.

Full citation: Andrade, R., Miccolis, A. 2011. *Policies and Institutional and Legal Frameworks in the Expansion of Brazilian Biofuels*. Working paper 71. Center for International Forestry Research, Bogor.

Simulating Land Use and Agriculture Expansion in Brazil: Food, Energy, Agro-industrial and Environmental Impacts

Since 2007, the Institute for International Trade Negotiations (ICONE) has been developing methodologies for measuring the impacts of the expansion of the agricultural sector on land use in Brazil. In partnership with the Center for Agricultural and Rural Development (CARD) of Iowa State University, ICONE developed an economic model called the Brazilian Land Use Model (BLUM) to simulate supply and demand of agricultural products produced in Brazil and their impacts on demand for land. This work seeks to quantify direct and indirect land use changes from agricultural-based biofuels in general, and for sugarcane ethanol in particular.

Full citation: Institute for International Trade Negotiations - ICONE. 2011. *Simulating Land Use and Agriculture Expansion in Brazil: Food, Energy, Agro-industrial and Environmental Impacts*. ICONE, São Paulo.

The Social and Environmental Impacts of Biofuel Feedstock Cultivation: Evidence from Multi-Site Research in the Forest Frontier

Energy supplies and climate change concerns boosted the development of biofuel markets in developing countries as a means to achieve energy security and stimulate rural economic development. However, the expansion of biofuel feedstock cultivation has caused some associated problems as a result of changes in land use, such as greenhouse gas emissions, and native forest degradation. This paper conducts a cost-benefit analysis of the expansion of biofuel feedstock cultivation in six countries in Asia, Africa and Latin America, including Brazil. The paper also maps the risks and local costs of biofuels, including how degradation of native forests offsets the global benefits of reducing greenhouse gases.

Full citation: German, L., Schoneveld, G., Pacheco, P. 2011. The Social and Environmental Impacts of Biofuel Feedstock Cultivation: Evidence from Multi-site Research in the Forest Frontier. *Ecology and Society* 16(3) 24.

Studies on the Rapid Expansion of Sugarcane for Ethanol Production in São Paulo State (Brazil) Using Landsat Data

In 2003, flexible fuel automobiles (FFVs) began to enter the Brazilian consumer market causing a dramatic increase in ethanol consumption. This rapid rise in domestic demand for ethanol caused an expansion in new areas for sugarcane cultivation. This paper aims to establish a correlation between the real impacts on land use change as a result of the increase in ethanol demand. Using Landsat-type remotely sensed data, the study assesses important characteristics of sugarcane cultivation and provides quantitative results that are relevant to the debate over sustainable ethanol production in Brazil.

Full citation: Rudorff, B. *et al.* 2010. Studies on the Rapid Expansion of Sugarcane for Ethanol Production in São Paulo State (Brazil) Using Landsat Data. *Remote Sensing* 2(4) 1057-1076.

SUGARCANE BAGASSE, COGENERATION AND BIOELECTRICITY

In addition to these publications, see the ELLA Brief: From Manual to Mechanical Harvesting: Reducing Environmental Impacts and Increasing Cogeneration Potential.

Brazilian Sugarcane Bagasse: Energy and Non-energy Consumption

Sugarcane has been a strategic and considerable economic resource for Brazil's development. Besides sugar and ethanol production for domestic and international consumption, the sector also produces biomass residue (bagasse) for electricity generation. This paper focuses on energy and non-energy consumption of sugarcane biomass. Using the Brazilian Energy Plan scenarios, the authors estimate an increasing amount of bagasse for producing second-generation ethanol through hydrolysis or gasification, or for generating electricity through cogeneration. Apart from producing energy for ethanol production, surplus electricity might also be sold to the grid. Finally, the authors predict that bagasse will play a key role in the global energy matrix overall.

Full citation: Hofsetz, K., Silva, M. 2012. Brazilian Sugarcane Bagasse: Energy and Non-energy Consumption. *Biomass and Bioenergy* 46 564-573.

The Development of the Brazilian Bio-electricity Market: An Historical Analysis of the Institutional Changes in the Sugarcane and Electricity Markets

Since the creation of Brazil's national ethanol programme, *Proálcool*, the country has gone through institutional and legal changes in both the sugarcane and electricity sector. Today, government policies are still being used as regulatory tools to promote bioenergy use, as well as to increase the share of cogeneration in the energy market. This paper describes the history of the sugarcane sector from a period of total government intervention, through deregulation in 1990s, to current public policies that promote alternative energy production. In this study, the authors analyse how the re-organisation of the electricity sector has brought opportunities for the sugarcane industry in relation to bio-electricity production and alternative energy diversification.

Full citation: Signorini, G., Gow, H., Peterson, C. 2010. *The Development of the Brazilian Bio-electricity Market: An Historical Analysis of the Institutional Changes in the Sugarcane and Electricity Markets*. Paper presented at the Agricultural & Applied Economics Association 2010 AAEA, CAES, & WAEA Joint Annual Meeting, Denver, Colorado, 25-27 July 2010.

Sugarcane Processing and Energy Generation from Fibre Resources

Sugarcane is a renewable resource that can be used for several ends, far beyond traditional sugar production. Bagasse, the fibrous residue that is left over after juice extraction, is now being used more efficiently to generate electricity. This paper describes the utilisation of biomass fibres in energy creation to support the entire industrial production process of sugar and ethanol and for sale to the national grid. The authors focus on productivity gains from the adoption of best practices and new technologies. Finally, they compare some indicators of industrial performance between southern Africa, Asia and Brazil.

Full citation: Seebaluck, V., Sobjanbabo, P.R.K. 2012. Sugarcane Processing and Energy Generation from Fibre Resources. In: Johnson, F., Seebaluck, V. (eds). *Bioenergy for Sustainable Development and International Competitiveness: The Role of Sugar Cane in Africa*. Routledge, Oxford.

Sweet Dreams are Made of This: Bioelectricity in Brazil

Sugarcane mills in Brazil have been seeking to reduce risk and diversify their portfolios by linking sugar and ethanol to electricity production. Bioelectricity not only supplies energy to the mills for their own consumption, but the surplus is also sold to the national grid through distribution companies. This publication highlights Brazil's bioelectricity achievements, emphasising the increase in efficiency gains and the changes in the electricity market which enabled bioelectricity from bagasse to become competitive against other power sources.

Full citation: Granville. S. *et al*. 2007. *Sweet Dreams are Made of This: Bioelectricity in Brazil*. Power Engineering Society General Meeting, Tampa.

ADVANCED BIOFUELS

From 1st- to 2nd-generation Biofuel Technologies: An Overview of Current Industry and R&D Activities

This publication is a rich and comprehensive report from IEA about biofuels, analysing ethanol, biodiesel and biogas. Additionally, it compares first and second generation biofuels, describing the limitations and advantages of each one. Due to the economic, social and environmental shortfalls of first generation biofuels, advanced biofuels have emerged as an option for supplying renewable energy more sustainably. However, as second generation biofuels also have economic and technological constraints, the report concludes by suggesting some policies that might overcome such constraints in the future.

Full citation: IEA. 2008. *From 1st- to 2nd-generation Biofuel Technologies: An Overview of Current Industry and RD&D Activities*. IEA, Paris.

An Overview of Second Generation Biofuel Technologies

It is commonly known that 1st-generation biofuels have economic limitations and cause environmental harm. Specific issues such as food competition, high production costs, declining productivity gains, both agricultural and industrial, and limited GHG emission reductions because of land use change have enhanced the development of 2nd-generation biofuels produced from ligno-cellulosic feedstocks. The authors analyse the present status of technological development of 2nd-generation biofuels in Brazil and elsewhere, focusing in particular on bioethanol. They assess production costs and outline the policies required to overcome the current environmental and economic constraints.

Full citation: Sims, R. *et al*. 2009. An Overview of Second Generation Biofuel Technologies. *Bioresource Technology* 101 1570-1580.

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To learn more about these and other key publications related to Brazil's ethanol programme, contact the author, Pedro Ninô de Carvalho, Researcher at the Environmental Sciences Laboratory (LIMA) of the Federal University of Rio de Janeiro, at pnino22@ppe.ufrj.br.

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