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Environmental Energy Technologies Division

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November 2000

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November 2000

Final Report

This work was supported by the U.S. Environmental Protection Agency through the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

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Abstract

The Brazil/U.S. Aspen Global Forum on Climate Change Policies and Programs has facilitated a dialogue between key Brazil and U.S. public and private sector leaders on the subject of the Clean Development Mechanism (CDM). With support from the U.S. government, a cooperative effort between Lawrence Berkeley National Laboratory and the University of Sao Paulo conducted an assessment of a number of projects put forth by Brazilian sponsors. Initially, we gathered information and conducted a screening assessment for ten projects in the energy sector and six projects in the forestry sector. Some of the projects appeared to offer greater potential to be attractive for CDM, or had better information available. We then conducted a more detailed assessment of 12 of these projects, and two other projects that were submitted after the initial screening.

An important goal was to assess the potential impact of Certified Emission Reductions (CERs) on the financial performance of projects. With the exception of the two forestry-based fuel displacement projects, the impact of CERs on the internal rate of return (IRR) is fairly small. This is true for both the projects that displace grid electricity and those that displace local (diesel-based) electricity production. The relative effect of CERs is greater for projects whose IRR without CERs is low.

CERs have a substantial effect on the IRR of the two short-rotation forestry energy substitution projects. One reason is that the biofuel displaces coke and oil, both of which are carbon-intensive. Another factor is that the product of these projects (charcoal and woodfuel, respectively) is relatively low value, so the revenue from carbon credits has a strong relative impact. CERs also have a substantial effect on the NPV of the carbon sequestration projects.

Financial and other barriers pose a challenge for implementation of most of the projects. In most cases, the sponsor lacks sufficient capital, and loans are available only at high interest rate and with substantial guarantee. A few of the projects might go ahead without the benefit of CERs, but most probably would not. Whether the projected revenue from CERs would be sufficient to induce sponsors to proceed with the projects is an important issue that requires further investigation.

All of the projects contribute to economic development in Brazil. The forestry projects in particular would create a significant number of rural jobs, and contribute income to rural communities. Some of the carbon sequestration projects would provide environmental benefits with respect to protection of biodiversity and soil.

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I. Introduction

The Clean Development Mechanism (CDM) is provided for under Article 12 of the Kyoto Protocol, which was agreed at the Third Conference of the Parties to the UN Framework Convention on Climate Change in Japan in 1997. If the Kyoto Protocol is ratified, CDM will enable non-Annex I countries to benefit from project activities in their countries that result in certified greenhouse gas (GHG) emissions reductions. These emission reductions purchased by Annex I countries to contribute to their compliance with their emissions limitation obligations under the Protocol. Certified emission reduction units gained can be anytime after 2000 can be banked and used by Annex I countries to achieve compliance with their obligations beginning in 2008. For non-Annex I countries, CDM is intended to support technology transfer and sustainable development.

Beginning in 1998, the Brazil/U.S. Aspen Global Forum on Climate Change Policies and Programs has facilitated a dialogue between key Brazil and U.S. public and private sector leaders on the subject of CDM. Early on, it was recognized that experience with potential CDM projects would shed light on the critical issues concerning implementation of a successful CDM regime. The Forum asked for identification and assessment of projects in Brazil that might be eligible for CDM certification.

With support from the U.S. government, a cooperative effort between Lawrence Berkeley National Laboratory and the University of Sao Paulo (USP) conducted an assessment of a number of projects put forth by Brazilian sponsors. The project proposals were gathered from efforts by the American Chamber of Commerce (Brazil) and the USP. Initially, we gathered information and conducted a screening assessment for ten projects in the energy sector and six projects in the forestry sector. The main criteria used at this stage were:

- The project would provide real GHG emission reduction relative to a plausible baseline (it relied on proven technology);

- The project would support objectives associated with sustainable development (particularly economic development and environmental improvement).

Some of the projects appeared to offer greater potential to be attractive for CDM, or had better information available. We then conducted a more detailed assessment of 12 of these projects, and two other projects that were submitted after the initial screening. Wherever possible, we have gathered new and additional information from sponsors. In a few cases, they have reviewed our assessment and provided comments. The assessment should be regarded as preliminary in nature. Its goal was not to make a definitive judgement of the viability of the projects, but rather to provide sufficient analysis to inform the Forum's consideration of key issues related to the CDM.

II. Analytical Methods

Estimation of Avoided Carbon Emissions or Sequestered Carbon

Baselines. The amount of carbon emissions avoided or carbon sequestered by a project is estimated relative to a baseline that represents the likely situation in the absence of the project. The baseline is a hypothetical construct, but it is based on actual and expected conditions.

All projects need a baseline that is relevant at the project site. For some projects, such as those that avoid electricity generation away from the project site, it is also necessary to construct a baseline for the off-site system.

Energy projects. For many of the projects, reduction in emissions derives from electricity generation that will be avoided by the project's operation. The amount of avoided electricity generation can be estimated based on technical calculations of project performance. For projects that reduce grid electricity generation, estimating the fuel combustion that will be avoided is more complicated.

Estimating the carbon impacts of projects that reduce grid electricity generation can be done in various ways. In Brazil, over 95% of current electricity generation is from hydropower, but the majority of new power capacity is expected to use natural gas. Precise estimation of avoided fuel combustion on a project-specific basis is quite difficult. Instead, we used four types of multi-project baselines.[1] In each case, the baseline is expressed in terms of carbon intensity (kg C per MWh).

One multi-project baseline is based on national average carbon intensity of all existing grid electricity capacity in 1998. Another is based on the estimated carbon intensity of all recent capacity additions (1995-99).[2] The third approach relies on a projection of the configuration of the future electricity system and how it is likely to be operated with respect to dispatch of different power plant types. We approximated the future operation of the Brazilian electricity system using a technique similar to that employed in power system simulation models. This method involves estimating the total power load for future years, and then allocating the available generating resources according to their expected dispatch.[3] The Appendix gives further discussion on this method. As an average over the next 20 years, we estimated the marginal electricity generation that would be avoided by projects to be roughly 50% from natural gas combined cycle power plants and 50% from hydropower.

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[1] A multi-project baseline (or benchmark) is a standardized baseline designed to apply across a range of similar projects. Use of such baselines may reduce the transaction costs associated with CDM projects. See Lazarus, Kartha, and Bernow, Key Issues in Benchmark Baselines for the CDM, Tellus Institute, Boston, June 2000.

[2] The multi-project baseline for recent additions is based on installed capacity data for individual power plants/units commissioned in 1995-99. (Data are from: Bosi, M. An Initial View on Methodologies for Emissions Baselines: Electricity Generation Case Study, International Energy Agency, June 2000.) To estimate generation, load factors for the different types of plants were assumed. To estimate fuel consumption, fuel conversion efficiency was estimated.

[3] S. Meyers, C. Marnay, K. Schumacher, J. Sathaye. Establishing Benchmarks for Estimating Carbon Emissions Avoided by Electricity Generation and Efficiency Projects: A Standardized Method. LBNL-46063. Lawrence Berkeley Natl Lab. (May 2000).

The above approach assumes that projects have a relatively small impact on the power system, and affect operation at the margin. The final approach assumes that a project (or set of projects) might be large enough to displace construction of an entire power plant. In Brazil, the most likely plant type that would be displaced is natural gas combined cycle.

The avoided carbon values used for multi-project baselines are as follows:

National average carbon intensity of all utility electricity generation in 1998:	15 kgC/MWh
Carbon intensity of all recent capacity additions (1995-99):	25 kgC/MWh
Projected future operation of power system (marginal impact):	68 kgC/MWh
Natural gas combined cycle (40% efficiency):	137 kgC/MWh

For projects that displace electricity generation not from the central system or displace fossil fuels, we used project-specific assumptions, as described in each case. The nature of these projects argues against the use of multi-project baselines.

Carbon sequestration projects. Projects may store carbon in (1) above- and below-ground biomass, (2) soils, (3) decomposing matter (detritus), and (4) products. The available data allowed us only to account for carbon sequestration in above-ground biomass and products. Of the omitted carbon pools, below-ground biomass is by far the most significant. The pace of decomposition of below-ground biomass after harvesting is uncertain, however. At some point, most of the carbon would probably return to the atmosphere.

Different approaches have been proposed for accounting for changes in carbon stocks in forestry projects.[4] One approach assumes perpetual rotation in which the project is maintained in perpetuity through replanting. The second approach -- limited period C sink -- assumes that the trees remaining at the end of the project life are cut down, and most or all of the carbon sequestered in them is released to the atmosphere. We accounted for annual changes in carbon stock using both of these approaches. In the case of limited period C sink, we allow the project to gain carbon credits for sequestration, but then require the project to purchase credits at the prevailing price when carbon is released. Because of the relatively high discount rate used, the present value of the credits gained in the early years outweighs the present value of the credits purchased in later years (even assuming a high price for carbon credits in the 2030-40 period).

In each case, we considered the fate of the products (and the stored carbon in them) after they leave the project site. We also accounted for land use changes expected to take place without the project (the baseline), and considered the potential for "leakage" (impacts on biomass stocks away from the project site that may result from the project). The project description provides the details of carbon accounting in each case.

Scenarios of Price of Certified Emissions Reductions

In addition to a case without Certified Emission Reduction (CERs), we used three scenarios of CER price (Figure 1). Each scenario assumes that the Kyoto Protocol takes effect in 2003, resulting in a significant increase in the value of CERs compared to the current price.

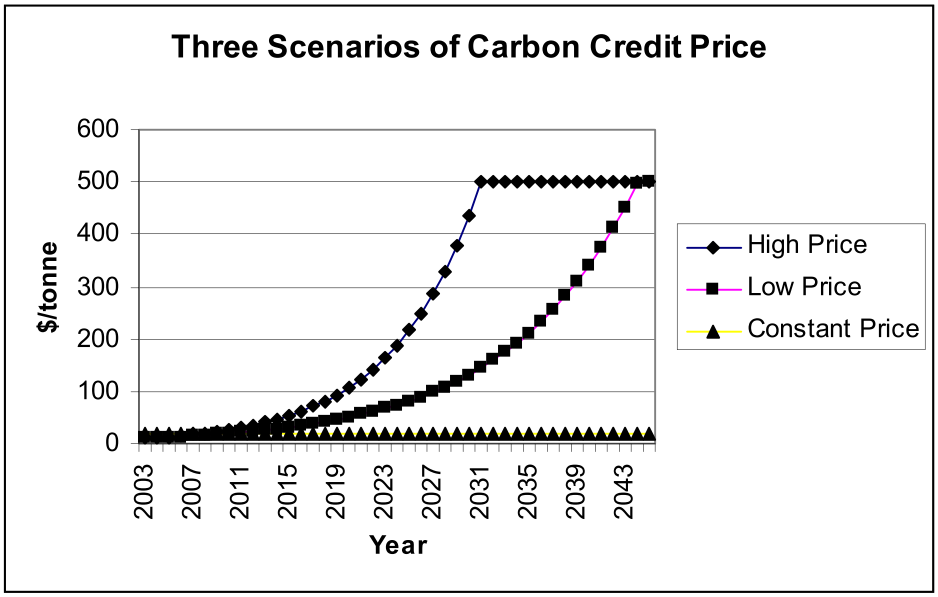
[4] Tipper, R. and De Jong, B. 1998. Quantification of carbon offsets from forestry: comparison of alternative methodologies. Commonwealth Forestry Review 77:219-228.

- Low Price: The price of CERs is $10/tC in 2003, and rises thereafter at 10% per year.

- High Price: The price of CERs is $10/tC in 2003, and rises thereafter at 15% per year, leveling off at $500/tC.

- Constant at $20/tC.

Figure 1. Three Scenarios of Carbon Credit Price



Financial Assessment

The financial analysis uses data on capital investment and projected operating costs and revenues over the expected lifetime for each project. Most of the data on project costs were obtained from the project sponsors. The projects are assumed to commence operation in January 2003. In most cases the capital investment is assumed to take place in the preceding year. Revenue from CERs is received on an annual basis.

For the electricity supply projects, the revenue derives from sale of electricity to utilities or industry. (Electricity sale to private parties is now possible according to the new legislation of the electric sector.) For the grid-connected projects, we assumed that the projects will receive a somewhat higher price than Brazilian utilities currently pay to independent power producers using natural gas.[5] For the forestry projects, the revenue derives from sale of specific products. The sale price was estimated by the project sponsors in most cases.

[5] Recent legislation allows Brazilian utilities to pay a higher price for electricity generated from renewable sources compared to the price paid for electricity from natural gas, and to recover the additional cost in the tariffs. Considering the emerging competition from sector deregulation, however, some resistance to paying the highest allowable price is anticipated. Thus, we use prices below the allowable price, as described in the descriptions.

With the perpetual rotation case, we assume additional investment in the later years of the project for replanting. We count the revenue from CERs gained from this new planting, as well as revenue from sale of products, for seven years after the assumed project lifetime.

To make the results more comparable, we assume that all of the projects are fully financed with equity of the sponsors. Availability of low-interest loans would change the results.

The costs associated with registration, monitoring, and certification of CDM projects are uncertain. Preparation of required documentation will take some time. For the energy projects, monitoring of the energy production or savings will be done as a normal part of project management. Conversion of energy impacts into carbon impacts will depend on the framework that is established for such. A system of multi-project baselines would reduce costs incurred by project sponsors, but it may be that the cost of establishing such a system would be spread over projects. For the forestry projects, basic monitoring of tree growth occurs as a normal part of the project operations, but some additional monitoring may be required to assess sequestration and loss of carbon. Because of the considerable uncertainty regarding CDM transaction costs, we elected to not include such costs in this assessment. Nor did we include any "tax" on projects that may be collected to support a fund to address climate change adaptation efforts in vulnerable countries. Thus, the positive benefits of carbon credits shown here are somewhat overstated.

The results presented are after taxes, which for these projects would be approximately 20% of the net annual income. For the energy projects, we present the Internal Rate of Return. For the carbon sequestration projects, we do not present the IRR because the uneven stream of cash flow for these projects renders its estimation problematic. The net cash flow is negative for the first few years and then becomes positive, as the revenue from carbon credits becomes substantial prior to harvest. Once the harvest begins, the first year of the harvest has a net loss of C and hence revenue, which is sufficiently large to make the net cash flow negative. The NPV provides a more reliable indicator. The NPV for forestry projects is very sensitive to the discount rate used, so we present it using real discount rates of 15% and 20%. The return desired by the sponsors is believed to be within this range.

III. Overview of Projects

The projects fall into four general categories with respect to their GHG impact:

1. Displacement of central grid electricity,
2. Displacement of local (remote) electricity production,
3. Direct displacement of fossil fuel,
4. Carbon sequestration in biomass.

The size and investment needs of the projects vary greatly (Tables 1-3). A few projects require less than US$ 1 million, while one requires US$ 110 million. One of the projects derives the bulk of its carbon benefits from avoidance of deforestation. As the eligibility of this type of benefit for CDM credits is rather uncertain, we present results with and without inclusion of this benefit.

IV. Projected Emissions Reductions or Carbon Sequestration

All of the projects would provide C emissions reduction or sequestration over their lifetime. As one would expect given the range of project size, the magnitude of estimated lifetime carbon impact varies greatly. Among the energy projects, those that displace central grid electricity have a lower emissions reduction impact per kwh relative to those that displace local (remote) electricity production or fossil fuel. This results reflects the low carbon intensity of central grid electricity generation.

An important feature of most of the sequestration projects is the time distribution of their carbon impacts. In the early stages of the plantation, the growing trees will sequester considerable quantities of carbon.
The likely fate of this carbon varies among the projects. In each case, we assume that the original plantation is cut at the end of productive life. For the rubber plantation, some of the wood is assumed to go into long-lived products, while some is assumed to be sold as fuelwood. For the oil palm plantation, it is assumed that nearly half of the wood is used for electricity generation (sold to the grid), some is turned into durable products, and some becomes residue and decomposes. For the teak plantation, all of the wood goes into long-lived products. In the perpetual rotation case, there is further sequestration from a new plantation cycle, and thus greater overall sequestration compared to the limited period sink case.

V. Impact of CERs on Financial Performance of Projects

Tables 1-3 show results concerning the impact of CERs (constant price scenario) on the financial performance of projects. More detailed results are given in each project description. For the electricity and fuel displacement projects, the IRR without CERs ranges between 7% and 31%. With the exception of the two forestry-based fuel displacement projects, the impact of CERs on the IRR is fairly small. This is true for both the projects that displace grid electricity and those that displace local (diesel-based) electricity production. While the amount of avoided carbon per kWh is much higher for the latter projects than for those that displace grid electricity, the revenue received per kWh by the "off-grid" projects is much higher, so the relative effect of CERs on the IRR is similar in both types of projects. The relative effect of CERs is greater for projects whose IRR without CERs is low.

CERs have a substantial effect on the IRR of the two short-rotation forestry energy substitution projects. One reason is that the biofuel displaces coke and oil, both of which are carbon-intensive. Another factor is that the product of these projects (charcoal and woodfuel, respectively) is relatively low value, so the revenue from carbon credits has a strong relative impact.

CERs also have a substantial effect on the NPV of the carbon sequestration projects (Table 3). As one would expect, the perpetual rotation approach for carbon accounting results in a higher NPV than does the limited period C sink approach (not shown in Table 3; see project descriptions).

Table 1. Potential "Early Start" CDM Projects In Brazil Assessed By LBNL/USP--Central Grid Electricity Displacement.

PROJECT	INVESTMENT (US$ mn)	ESTIMATED C OFFSET ('000 tC)*	ESTIMATED IRR W/OUT CREDITS	ESTIMATED IRR WITH CREDITS AT $20/tC
SMALL HYDRO IN GOIAS	12	97	12%	13%
WIND FARMS	50	221	6.7%	7.3%
BAGASSE ELECTRICITY GENERATION	12.9	168	31%	33%
LIGHTING RETROFIT	1.0	6	27%	28%

* Using project future operation for baseline estimating avoided carbon.

Table 2. Potential "Early Start" CDM Projects In Brazil Assessed By LBNL/USP- Local Electricity Production and Fuel Displacement.

PROJECT	INVESTMENT (US$ mn)	ESTIMATED C OFFSET ('000 tC)	ESTIMATED IRR W/OUT CREDITS	ESTIMATED IRR WITH CREDITS AT $20/tC
SAWMILL RESIDUES FOR ELEC GENERATION	7.5	112	16%	18%
HYDROELECTRICITY IN AMAPA	110	1400	18%	19%
ALCOHOL/DIESEL MIX FOR MUNICIPAL BUSES	0.16	7	Negative	Negative
VILLAGE ELECTRICITY GENERATION -- PALM OIL	0.1	1	Negative	Negative
EUCALYPTUS-BASED CHARCOAL FOR PIG IRON PRODUCTION	7.5	650	13%	17%
EUCALYPTUS WOODFUEL FOR CERAMICS	0.24	40	25%	31%

Table 3. Potential "Early Start" CDM Projects In Brazil Assessed By LBNL/USP--Carbon Sequestration

PROJECT	INVESTMENT (mn US$)	ESTIMATED C OFFSET* ('000 t)		ESTIMATED NPV W/OUT CREDITS (000 US$)**		ESTIMATED NPV WITH CREDITS AT $20/tC (000 US$)**	
		Limited Period	Perpetual Rotation	Perpetual Rotation		Perpetual Rotation	
				15%	20%	15%	20%
RUBBER PLANTATION	3	107	239	2220	381	3378	1257
OIL PALM PLANTATION	15	504	649	-465	-4910	305	-4756
TEAKWOOD PLANTATION	8	178	325	2059	-1211	3538	-76
BABAÇU PLANTATION	11.6	7941	2274	-3574	-3349		
Counting Avoided Deforestation						36202	25484
Not Counting Avoided Deforest.						8878	5877

* First value assumes "Limited period C sink" approach for carbon accounting, second value assumes "Perpetual rotation"

** Using "perpetual rotation" approach for carbon accounting; 15 and 20% discount rates, respectively.

VI. Impact of Alternative Baselines on Performance of Projects that Affect Power Grid

The use of alternative baselines for calculating avoided carbon emissions for projects that reduce grid electricity generation has a relatively small effect on the IRR. For the small hydro project, for example, the IRR (with CERs at $20/tC) ranges from 12% in the lowest case to 14% in the highest (assuming generation from natural gas combined cycle is avoided by the project).

VII. Project Status Without CDM

Article 12.5 of the Kyoto Protocol states that emissions reductions from project activities conducted within the context of the CDM shall be certified on the basis of reductions in emissions that are additional to any that would occur in the absence of the certified project activity. A key issue is how likely it is that the project will take place without the benefits of CDM certification. The Kyoto Protocol language suggests that if a project would likely take place without CDM, then the associated emissions reduction should not be certified. Some have argued that a looser interpretation is warranted, in part because judging whether a particular project would likely take place without CDM is problematic.

We did not try to judge the likelihood of project implementation without CDM. In general, financial and other barriers pose a challenge for implementation of most of the projects described here. In most cases, the sponsor lacks sufficient capital, and loans are available only at high interest rate and with substantial guarantee. A few of the projects we analyzed might go ahead without the benefit of CERs, but most probably would not (unless loans at well below market interest were available). Whether the projected revenue from CERs or other benefits associated with CDM certification would be sufficient to induce sponsors to proceed with the projects is an important issue that requires further investigation.

VIII. Contribution to Sustainable Development

All of the projects contribute to economic development in Brazil. The forestry projects in particular would create a significant number of rural jobs, and contribute income to rural communities.

The local-grid electricity generation projects will reduce local air pollution from diesel power generation. The grid-connected electricity projects will have a more modest effect on reducing air pollution from natural gas-fired power plants.

Some of the carbon sequestration projects would provide environmental benefits with respect to protection of biodiversity and soil. One of the projects would reduce deforestation of native palm stands.

IX. Lessons Learned Concerning the Project Assessment Process

Construction of a reasonable baseline proved fairly straightforward in most cases. The development and use of multi-project baselines proved feasible for projects that affect the central electricity grid.

Carbon accounting for carbon sequestration projects can be complex. Results are sensitive to assumptions regarding the eventual fate of the products and the disposition of the trees at the end of plantation lifetime. Our assumption that project sponsors would be required to purchase CERs when carbon is released may be difficult to enforce in practice, as this purchase would occur some 30 years in the future.

X. Small Hydro in the State of Goiás

Background

Small hydro plants are very common in Brazil. An accounting done in 1997 identified 1878 units with a total installed capacity of 1111MW. Of these, 331 with an installed operational capacity of 605 MW were in operation, 428 were out of operation, 10 were being retrofitted, and 1089 have no description of operational conditions. In this same year, 346 new units were being considered for installation with a total capacity of 1044MW, but only 20 were under construction.

According to electricity sector legislation, small hydroelectric plants are defined as the ones with installed capacity of 30 MW and less. Units under this category have special incentives:

- Permission for construction and operation depends only on the regulatory agency ANEEL.
- Wheeling prices qualify for at least 50% cost abatement.
- Technical and economic advantages regarding its dispatch in the interconnected electric grid.
- No payment of royalties due to the use of natural resources.
- Permission to sell electricity to consumers with demand of 500 kW or more.
- They can apply for low cost financial resources.

Legislation also allows small hydroelectric plants to sell electricity to utilities at a better price than conventional generated electricity. With such advantages and the growing demand for electricity, an increase in interest for small hydro is expected.

Project Description

The state of Goiás, situated in the center/west part of Brazil, has several regions that are short of electricity supply. This project plans to offer 10 MW of installed power to the existing utility owned grid. The energy would be supplied by a small hydroelectric plant, Mambai II, which would be installed in Sitio D'Abadia and will be operated by the natural flow of a river that is part of the Rio Tocantins basin, without the necessity of a water reservoir. The plant will utilize two generators and will need a 24 km transmission line to enable interconnection to the existing distribution grid. Assuming a capacity factor of 70%, 61,300 MWh/year will be generated. The project has already been approved by ANEEL, the Brazilian regulatory authority. As the project will not need a water reservoir, there will be no land flooding and therefore it will not affect the local landscape and the people settled nearby. The assumed project lifetime is 25 years.

Project Sponsor

Consórcio de Produtores de Energia (CPE) is the main sponsor. CPE is a civil engineering company and is working to establish the basis for a Power Purchase Agreement (PPA) with CELG, which is the utility that has the responsibility for supplying electrical energy to the consumers of the region. The PPA should have at least 14 years total term in order to warrant operation. In case CPE does not succeed with this PPA, it will look to establish one with private consumers that lack sufficient energy.

Costs and Revenues

The total expected investment is US$ 12 million, to be applied over three years of the construction period. Estimated operation and maintenance costs are US$ 10/MWh. CPE hopes to sell all the generated electricity to the utility at US$36/MWh. For private customers, the price could be somewhat higher. Assuming a capacity factor of 70%, total annual revenue would be US$ 2.2 million.

Financing

CPE will welcome partners and is willing to discuss the shares of equity and CERs.

Carbon Accounting

Baseline Condition without Project: Electricity is generated by the central grid.

Carbon Reduction by Project: The project's generation displaces grid electricity. Assuming Projected Future Operation for the grid, the estimated lifetime reduction is 97,000 tC.

Internal Rate of Return (after taxes) (%)

	Basis for Value for Avoided Carbon from Grid Electricity Generation			
	Avg C Intensity, 1998	**Avg C Intensity of Recent Additions**	**Projected Future Operation**	**Natural Gas Combined Cycle**
Without sale of CERs	12	12	12	12
With sale of CERs at $20/tC	12	12	13	14
With sale of CERs, Low Price	12	13	13	14
With sale of CERs, High Price	12	13	14	15

Contribution to Sustainable Development

The project will enhance development of a clean, renewable energy source in Brazil.

Contact

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XI. Wind Farms in Northeast Brazil

Background

Total installed windpower capacity connected to the grid in Brazil at the end of 1999 was 20 MW. According to CRESESB (Brazilian Reference Center on Solar and Wind Energy) there are good sites where electricity can be generated at US$ 70-80/MWh.

Project Description

The project consists of two wind farms of 30 MW and 10 MW to be built near industrial centers of Macao and Araripina in the Northeast Brazilian states of Rio Grande do Norte and Pernambuco, respectively. Electricity from the wind farms will be sold to the state electric utilities. The assumed project lifetime is 25 years.

Project Sponsor

The project sponsor is a consortium of private companies currently in the process of being formed. The consortium, coordinated by EOLICA (the Brazilian Wind Energy Centre, incorporated as a private foundation), consists of two European wind turbine manufacturers, a British design firm, two Brazilian electric utilities, a Brazilian engineering firm, and EOLICA itself.

Costs and Revenues

Construction of the wind farms will require approximately $50 million. Estimated O&M cost is $10/MWh. In the North/Northeast integrated system, a purchase power agreement under special price conditions (US$65/MWh) has occurred for a biomass-based power plant. We assume the project receives $40/MWh for its output.

Financing

The wind turbine manufacturers are willing to provide equity equivalent to the cost of the equipment they supply -- roughly 70% of the total installation cost. Sponsor is seeking the balance of the required investment – US$ 15 million – from private and/or multilateral investors.

Carbon Accounting

*Baseline Condition without Project***:** Electricity is generated by the central grid. We assume that the North/Northeast grid is interconnected with the rest of the Brazilian system for most of the project's lifetime.

Carbon Reduction by Project: The project's generation displaces grid electricity. Assuming Projected Future Operation for the grid, the estimated lifetime emissions reduction is 221,000 tC.

Internal Rate of Return (after taxes) (%)

	Basis for Value for Avoided Carbon from Grid Electricity Generation			
	Avg C Intensity, 1998	**Avg C Intensity of Recent Additions**	**Projected Future Operation**	**Natural Gas Combined Cycle**
Without sale of CERs	6.7	6.7	6.7	6.7
With sale of CERs at $20/tC	6.8	6.9	7.3	7.8
With sale of CERs, Low Price	6.9	7.0	7.5	8.3
With sale of CERs, High Price	7.1	7.3	8.2	9.5

Contribution to Sustainable Development

The project will enhance development of a clean, renewable energy source in Brazil.

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XII. Lighting Efficiency Improvement in Supermarkets

Background

Since 1985 the official agency PROCEL has been responsible for energy conservation activities in Brazil. Lighting has been one of the sectors where end-use efficiency savings has been substantial.

The private sector has also been quite active in this area and several light-fixture manufacturers offer efficient equipment since the end of the 1980s. Furthermore, ESCO activity is well developed and the Brazilian Association of Energy Saving Companies (ABESCO) has 30 members, a few of them specialized in lighting. Quantified information from private activities is difficulty to obtain, but a study carried out in 1997 showed that a few hundred thousand efficient light fixtures were sold every year.

Energy saving projects are more feasible in the commercial sector, as electricity tariffs are two times higher for this sector than for average industries.

Project Description

The project aims to cut 50% to 60% of electricity expenditures for lighting in a chain of commercial stores via utilization of efficient lighting techniques. As lighting can represent around 40% of the total electric consumption, this means a reduction on the electricity bill of around 20%.

Several small-scale projects already implemented by the sponsor in supermarkets show that the utilization of specular reflectors with tri-phosphor fluorescent lamps maintains the level of lighting while cutting to half the number of fluorescent lamps in use. The reflector is especially designed and produced in each case to suit the light fixture and at the same time provide an efficient light distribution. Illuminance is kept on the original level and the power demand of the light fixtures is cut by 50%. By cutting to half the quantity of lamps, half of the ballasts are deactivated and can be used for further maintenance. With only half of the lamps and ballasts in use, there is an additional saving from reduction of maintenance costs. In case the facility uses air conditioning, an additional reduction on the power demand is obtained via reduction of the thermal load. The project lifetime is 10 years.

The project targets CBD, the second biggest supermarket chain in São Paulo with more than 300 stores. Lighting retrofit would be applied to 80 stores over a four-year period. After appraisal of the results, the project could be replicated to other stores or customers.

Project Sponsor

The sponsor of this project is NEGAWATT- Projetos, Engenharia e Comércio Ltda., a Brazilian private company active since 1992 in several energy-related projects. A main area of business is lighting projects, which can include all related activities from design to final installation. The company has already accomplished several similar projects on a smaller scale, in some of them acting as an energy services company. In this case, services are paid for out of the monthly savings, avoiding the necessity for the customer to use its financial resources.

Costs and Revenues

Total investment for the CBD project involving 80 stores would be around US$ 1 million. CBD pays a relatively high electricity tariff ($US 0.07/kWh) and stores operate a significant number of hours a day. The sponsor will claim the monitored utility bill savings during the first three years. After this period, the clients will retain all savings.

Financing

NEGAWATT is ready to contribute around US$ 50,000, and seeks either equity investors or financing.

Carbon Accounting

*Baseline Condition without Project***:** The existing lighting system in the supermarkets is maintained without improvement. Electricity is generated by the central grid.

Carbon Reduction by Project: The reduction in electricity generation is based on estimated decrease in electricity consumption and associated T&D losses. Assuming Projected Future Operation for the grid, the estimated lifetime reduction is 6,000 tC.

Internal Rate of Return (after taxes) (%)

	Basis for Value for Avoided Carbon from Grid Electricity Generation			
	Avg C Intensity, 1998	**Avg C Intensity of Recent Additions**	**Projected Future Operation**	**Natural Gas Combined Cycle**
Without sale of CERs	27	27	27	27
With sale of CERs at $20/tC	28	28	28	32
With sale of CERs, Low Price	28	28	28	31
With sale of CERs, High Price	28	28	28	32

Contribution to Sustainable Development

The project will help to establish the viability of Energy Service Companies as agents to deliver electricity efficiency in Brazil. It will also employ skilled labor.

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XIII. Electricity Cogeneration from Sugarcane Bagasse in São Paulo State

Background

Approximately 4.5 million ha of land is used for cultivation of sugarcane in Brazil, yielding a volume of more than 300 million tonnes of harvested sugarcane per year. Pressing of sugarcane at the mill produces bagasse as a by-product. The bagasse is typically incinerated in inefficient low pressure boilers, producing steam to generate electricity and heat for the mill's operation.

The total amount of sugarcane bagasse is significant (≅50 million tonnes/dry basis). Potential power generation from the use of sugarcane bagasse was evaluated by several authors as ranging from 1,000 to 9,000 MW, depending on the technology used and the use of trash associated with mechanical harvesting. The higher value requires biomass gasification and gas turbine system.

The heat value of bagasse has been poorly used because of lack of opportunity to sell surplus electricity to the grid. The electric sector legislation now recognizes the role of independent power producers, which has triggered interest in improving boiler efficiency and increasing electricity generation at mills for sale to the grid. One of the utilities serving the state of São Paulo is buying more than 1% of its electricity from sugar mills, and the self-sufficient capacity of the mills (600 MW) has already been increased by 100 MW for power sale to third parties.

In the same way as small hydro plants, electricity generated from biomass qualifies to receive a better price than electricity from conventional sources.

Project Description

Vale do Rosário, one of the largest sugar/alcohol producers in Brazil, currently sells surplus electricity to the local utility, but it still has a significant bagasse surplus. The project aims to increase the surplus of electricity to be sold. Electricity generation from sugarcane origin in Southern region is during the dry season when electricity from hydro is reduced. This feature makes the electricity from the project attractive to potential purchasers.

The project is proceeding in three stages. The first involved installation of higher-efficiency steam turbines. The second (1995-97) involved acquisition of two new boilers and a 12 MW turbo-generator. The third phase (1998-2001) involves acquisition of a 15 MW turbo-generator with condenser and replacement of two 4 MW generators with two 6 MW ones. The total installed power available for sale will be 25 MW. Assuming capacity factor of 63%, total annual generation for sale could be 137,000 MWh. The assumed project lifetime is 20 years.

Project Sponsor

Vale do Rosário is a Brazilian private company with 104 shareholders, mostly farmers and sugarcane producers. Founded in 1964, it has 800 employees. During 1998 harvesting season, its production was 4.4 million tonnes of sugarcane, 159,000 cubic meters of ethanol and 330,000 tonnes of sugar. The company currently sells surplus electricity to the utility during the season.

Costs and Revenues

The total investment for the project is estimated at US$ 11.5 million. Estimated O&M cost is $5/MWh.

We estimate the future purchase price for the electricity by the local utility at US$36/MWh. For private customers, the price could be somewhat higher.

Financing

The sponsor plans to implement part of this project with its own resources. It is hoped that revenue from carbon credits, perhaps combined with a loan, may allow the full project to be implemented.

Carbon Accounting

*Baseline Condition without Project***:** Electricity is generated by the central grid.

Carbon Reduction by Project: The project's generation displaces grid electricity. Assuming Projected Future Operation for the grid, the estimated lifetime reduction is 168,000 tC.

Internal Rate of Return (after taxes) (%)

	Basis for Value for Avoided Carbon from Grid Electricity Generation			
	Avg C Intensity, 1998	**Avg C Intensity of Recent Additions**	**Projected Future Operation**	**Natural Gas Combined Cycle**
Without sale of CERs	31	31	31	31
With sale of CERs at $20/tC	32	32	33	34
With sale of CERs, Low Price	32	32	33	35
With sale of CERs, High Price	32	32	33	35

Contribution to Sustainable Development

The project will enhance development of a renewable energy source that has significant potential in Brazil. Sugarcane bagasse cogeneration can help to diversify the products of sugar/alcohol industries in a moment when the Brazilian Alcohol Program faces economic difficulties. The project will help to demonstrate the viability of electricity generation as a source of revenue for the sugar industry.

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XIV. Hydroelectricity Generation in the State of Amapá

Background

Hydroelectricity historically has been the most used primary energy source in Brazil due to the availability of large rivers and a moderate hilly land. Financial conditions up to 10 years ago were favourable to its implementation by the government. Since 1997, the electric sector has undergone privatization and several utilities are now owned by private investors. These investors look for return on investments much higher than the government and prefer to invest in natural gas plants due to the lower investment required and the existent infrastructure. Even so, more than half of the new capacity that will be installed in the next 5 years will be hydro.

A few areas of the country are not yet covered by the national grid and rely on local generation, most of it dependent on small thermal units. One of these areas is the state of Amapa, where the state government does not have enough revenue to construct a medium-size hydro plant, but is very much interested in replacing the thermal system with a much lower operational cost hydro unit.

Project Description

In the state of Amapá most of the electricity is consumed in the cities of Macapá and Santana, which are 20 km apart. These cities are served by ELETRONORTE through a hydro plant (40MW) and by gas turbines (4 x 17 MW). The hydro plant cannot be expanded, since large land areas would have to be flooded, and the gas turbines are at the end of their lifetime.

In the border of the state of Amapá there is a convenient site for a run-of-river hydro facility. The project foresees the installation of 2 units of 33 MW, which can be built at different phases. The run of river plant has the capacity to generate 60 MW year around. The assumed lifetime is 30 years.

The sponsor's mill has interest to use 33 MW from the proposed hydro plant, and a small amount would be sold to Companhia Energética do Amapá (CEA), which supplies electricity to a small city near the Jari factory. The remaining power could be sold to ELETRONORTE for use in Macapá/Santana cities. This would require the construction of a 200 km transmission line. The estimated capacity factor is 80% because the JARI factory runs 24 hours/day.

Project Sponsor

The major interested partner is JARI CELULOSE, which has a pulp and paper mill and a large tree plantation nearby and owns the rights for water use. JARI is approved by ANEEL as an Independent Power Producer. It is looking for a partner, possibly to form a new company which would be in charge of the new hydrogeneration facility and the transmission lines.

Financing

Uncertain.

Costs and Revenues

The proposed hydroelectric power plant requires around US$ 100 million for the generating facility (US$ 1500/installed kW), and another US$ 10 million for the 200 km long transmission line. Operation and maintenance cost is US$10/MWh.

We estimate that 40% of the project electricity will be sold to ELETRONORTE for $70/MWh, and 10% will be sold to CEA for $70/MWh. Both of these utilities qualify for the CCC subsidy, which allows them to sell electricity for $40/MWh and also receive $70/MWh from the Federal government, so they can pay a high price for the hydro electricity. The estimated value of the electricity that JARI would use (half of the total) is $40/MWh (currently they purchase some of the fuel used for on-site generation).

Carbon Accounting

Baseline Condition without Project: ELETRONORTE continues to use diesel generation at 30% efficiency, and CEA continues to use diesel generation at 25%. JARI generates its electricity using forestry residues, fuel oil and pulp process residues.

Carbon Reduction by Project: The project's generation displaces utility generation as described above. Total estimated carbon reduction for project lifetime is 1.4 million tC.

Internal Rate of Return
(after taxes of 20% on the earnings)

Without sale of CERs	18%
With sale of CERs, Low Price	19%
With sale of CERs, High Price	20%
With sale of CERs at $20/tC	19%

Contribution to Sustainable Development

The project will enhance development of a clean, renewable energy source in Brazil. The hydro facility does not require a dam, avoiding flooding land, and will not interfere with the present river landscape. Local air pollution (in Macapá and JARI factory) will be reduced.

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XV. Electricity Cogeneration from Sawmill Residues in Itacoatiara, Amazonas State

Background

A significant share of Amazonia is not served by the national grid due to the large land area and the small population density. Excluding the capitals and the most populated cities, Amazonia is served by electricity generated by small and local supply plants mostly consuming diesel oil. There are more than 500 units with less than 500 kW. Operation with diesel oil is very expensive and a significant amount of money is collected from electricity clients served by the national grid to be transferred as a subsidy to electricity consumers living in isolated areas of Amazonia.

Considering that biomass derived fuels or biomass residues are available in large amounts from commercial activities occurring in the area, it is reasonable to use them as a source of electricity or electricity and heat to replace or complement diesel generation.

Project Description

The electric power supply in Itacoatiara, the second largest city in Amazonas State, depends on diesel generators operated by CEAM (the local utility) and a private company from whom CEAM buys power. Forecasts show electricity demand increasing by three-fold between 1998 and 2009.

Four sawmills in and near Itacoatiara (Gethal, Mil Madeireira, Braspor, and Carolina) produce some electricity for self-use from biomass residues and also purchase electricity from CEAM. Existing boilers are quite old. Other smaller mills in the neighborhood produce waste that is either burned or simply piled up in huge waste dumps.

The project proposes to utilize all available wood residues from the existing sawmills to co-generate electricity and process steam. A 5 MW power plant would be located at Gethal sawmill, and residues from other sawmills would be purchased. Some of the output will be used to provide on-site power needs at Gethal (replacing the old equipment currently used), while the rest will be sold to CEAM. Process steam would be used by Gethal to dry the processed wood, as they currently do. We assume that a capacity factor of 60% can be achieved, as the sawmill operates 75% of the time. The assumed lifetime is 20 years.

Project Sponsor

The project is still at a concept stage and WINROCK is the present sponsor.

Financing

Winrock is currently working with Banco Axial to determine funding options.

Costs and Revenues

The estimated installed cost for 40-bar boiler and steam turbine with 3-bar extraction and atmospheric condenser (efficiency of 15.8%) is US$ 8.25 million (1,650/kW). The estimated cost for wood residue from other mills, which is roughly half of the total, is $2.00/GJ. Residue on the site is assumed to be free.

We estimate that CEAM would pay $15/MWh, and the project would be eligible for a CCC subsidy from the Federal government of $65/MWh. The on-site electricity (25% of the total generation) has an estimated value to Gethal of $25/MWh.* We assume that Gethal will pay $4/ton for the cogenerated steam.

* With the project, Gethal will not need to purchase any electricity. In the baseline condition, they would continue to purchase 25% of their needs.

Carbon Accounting

*Baseline Condition without Project***:** CEAM continues to generate with diesel power plant at 25% efficiency. The Gethal mill continues to rely on wood residues and some electricity purchased from CEAM.

Carbon Reduction by Project: We assume that 75% of the electricity is sold to CEAM and displaces utility generation as described above. The other 25% displaces electricity purchased from CEAM by Gethal, and also electricity generation from wood residues at Gethal (for which there is no net carbon effect). Total estimated carbon reduction for project lifetime is 112,000 tC.

Internal Rate of Return
(after tax of 20% of profit)

Without sale of CERs	16%
With sale of CERs, Low Price	18%
With sale of CERs, High Price	18%
With sale of CERs at $20/tC	18%

Contribution to Sustainable Development

The project will demonstrate the viability of an energy source with much potential in the Amazon region.

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XVI. Village Electricity Generation Using Palm Oil

Background

In the State of Pará in Amazonia there are more than 20,000 villages with populations between 50 and 200 inhabitants. Most of these villages are far from the grid and do not have any local supply of electricity. It is possible to install small (up to 75 HP) internal combustion engines coupled with electric generators to provide electricity. Many experiments and trials have been performed in Brazil and in other countries for the use of vegetable oil as a diesel substitute in internal combustion engines.

Project Description

This project intends to install a 50 kW electricity generator that will run on palm oil. Along with the electric generator it is also necessary to build a local electricity distribution network, which would include a step-up and step-down transformer. Electricity will be sold to the 50 houses (average monthly consumption is 100 kWh, so monthly domestic electricity demand is 5.0 MWh). Including the operation of the oil extraction facility and public lighting, total village electricity demand should be 20 MWh/month. Assumed lifetime for one diesel set is 15 years.

For the first few years, the project can obtain palm oil from EMBRAPA, a federal-owned agricultural company that has 500 ha of oil palm plantation. The company is unable to sell palm oil due to difficulties imposed by federal regulation and the 70 km of bad road connection. The state government of Manaus has negotiated with EMBRAPA to allow villagers to exploit the existing plantation for some time without cost. There would be a future need for a nearby small palm oil plantation to easily obtain the fuel. Near EMBRAPA plantation are several villages that can be involved in the future in similar projects. For purposes of analysis, we consider the palm oil plantation as a separate project that will sell palm oil to the electricity enterprise.

Considering the small size of the installation, the electric plant must be locally administered. With proper training to the local community it is possible to qualify people for system operation. Maintenance service can be provided by a qualified organization.

Project Sponsor

PROMAK Indústrias Mecânicas Ltda. already installed an electric system using palm oil in Boa Esperança village. PROMAK received grants from the Federal Government to cover the installation costs. Boa Esperança village has received electricity from an Esbelt type diesel engine for a year. The motor-electric set has accumulated more than 2,000 hrs of operation without any major problems. Maintenance is being carried with parts acquired in the city of Belém, since most of the parts are common to diesel engines used in trucks. The service is provided by PROMAK for a fee.

Costs and Revenue

Total installation cost of all equipment (motor-generator plus electric grid) is approximately US$ 60,000. Considering the earlier experience with Boa Esperança village, estimated maintenance and operation cost is US$ 20/MWh. The cost of palm oil for the first few years is estimated at $200/t. Estimated fuel cost from the local palm oil plantation is US$ 350/t. (US$ 40,000 will be needed to establish an oil palm plantation of 20 ha.)

The assumed tariff for all electricity sales (including the palm oil extraction plant) is US$ 0.04/kWh. The project qualifies for receiving CCC subsidy payment at a rate of US$ 65/MWh. Assuming a price to final users of $40/MWh, total revenue for the supplied electricity would be US$ 105/MWh.

Financing

The sponsor is ready to provide the labor to install the system and is seeking funds for the equipment costs. The sponsor anticipates the possibility of getting US$50,000 in grants from the Federal government, which is the value obtained for the Boa Esperança village.

Carbon Accounting

Baseline Condition without Project: Electricity is generated by a new diesel generator at efficiency of 30%, yielding emission of 54 tC/year.

Carbon Reduction by Project: The project avoids use of a diesel set.

Internal Rate of Return

Even with a grant of US$ 50,000, the project has a negative IRR with or without carbon credits. It appears the project will need to charge a higher price for electricity to be viable.

Contribution to Sustainable Development

This project is an opportunity to supply clean electricity to areas which would otherwise have diesel oil as the only alternative. Furthermore, with electricity locally generated with fuel locally produced, the money involved with these activities will stay in the area. It is expected that commercial activities triggered by the availability of electricity will help the village development. With improvement in their life standard, the village inhabitants will be less interested in the sale of native wood, reducing the pressure on the forest.

Contact

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XVII. Alcohol-Diesel Mix for Municipal Buses in Campo Grande City

Background

Diesel oil is the major fuel in Brazil's transport sector since a significant share of freight is handled by trucks powered by diesel engines. The use of ethanol (neat or blended to gasoline) since 1975 has reduced the relative demand for gasoline as compared with diesel. Ethanol continues to displace a significant share of the gasoline market (approximately 200,00 barrels/day). This fact and the lack of flexibility in the oil refinery profile has created a situation where surplus gasoline is exported while diesel fuel is imported. The export market for gasoline is very competitive and prices received by the national producer – PETROBRAS – are much lower than what can be obtained for sale in the national market. Thus, if a market is developed for the use of ethanol in a diesel blend several synergisms will be obtained: ethanol demand increases, diesel demand declines, and less oil will have to be processed, reducing the over supply of gasoline.

Experimental tests have been conducted in São Paulo and Paraná, under the coordination of Brazilian Ministry of Science and Technology, for the introduction of an ethanol-diesel oil mix to replace diesel oil in urban buses. Preliminary results seem positive regarding technical and environmental aspects. In 1999, the National Oil Agency has authorized the use of a 3% alcohol-diesel oil mix for urban buses in Curitiba, Paraná State in an experimental phase.

Project Description

This project aims to introduce a 8% ethanol-diesel oil mix in municipal buses in the city of Campo Grande, the Capital of Mato Grosso do Sul State. The bus fleet in Campo Grande has 420 buses. Tests of this mix were conducted recently. Alcohol fuel, as well as the vegetable oil based additive AEP (2.6% in the mix), will be provided by sugar/alcohol producers.

Project Sponsor

Project sponsors are the Municipality of Campo Grande and Sindálcool-MS, the sugar and alcohol syndicate of Mato Grosso do Sul.

Costs

Estimated consumption of diesel fuel by the bus fleet is 12 million liters per year. The mid-2000 price of diesel is $ 0.272 per liter. The estimated price of the mix is $0.279 per liter with present technology. A greater quantity of the mix is required since it has a lower energy content compared with diesel. Assuming energy content of the additive is the same as ethanol per unit of volume (5100 kcal/liter), to replace 12 million liters of diesel (8000 kcal/l) requires 12.48 million liters of the mix. This increase in volume costs $134,000/yr. The difference between the price of diesel and ethanol-diesel mix costs $92,000/yr. The total additional annual cost of the alcohol/diesel mix is [US$239,000]. Assuming the additive production cost will be reduced by 30% due to mass production, the alcohol-diesel mix will require $160,000/yr. more than diesel. The NPV results below assume an additional cost of $167,000/yr.

Carbon Accounting

*Baseline Condition without Project***:** The buses continue to run on diesel fuel.

Carbon Reduction by Project: The use of alcohol fuel displaces some of the diesel fuel, resulting in a reduction in carbon emissions of 7000 tC (assuming C content of the additive is the same as ethanol).

Net Present Value (US$ 000)
(10% discount rate, no taxes)*

Without sale of CERs	(144)
With sale of CERs at $20/tC	(90)
With sale of CERs, Low Price	(91)
With sale of CERs, High Price	(67)

The project NPV is negative in all of the scenarios. (Note: since there is no capital investment for the project, the IRR is not relevant.) This calculation does not include the value of reducing air pollution in the city.

* Since the sponsor is a municipal government, we use a low discount rate and assume no taxes.

Contribution to Sustainable Development

The Government considers this project quite important. Proalcool - the Brazilian Alcohol Program - faces significant difficulties mainly related to the large amount of alcohol surplus currently existing. Alcohol production is expected to rise due to the growth in sugarcane production, but the fleet of (hydrated) ethanol fueled cars is declining because the production of new ethanol vehicles is almost zero. Hydrated ethanol can be converted into anhydrous ethanol, and its utilization in an ethanol-diesel mix can help to equilibrate the supply. The utilization of the ethanol-diesel mix in large Brazilian cities can also reduce pollutant emissions, especially particulates.

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XVIII. Promotion of Energy-Efficient Refrigerators

Project Description

The project intends to encourage consumers to purchase energy-efficient refrigerators. The project will collect the old refrigerators, which often would continue to be used for a number of years, and dismantle and recycle them. Through recovery and recycling of CFCs, the project will prevent their eventual release from the old refrigerators.

The project is conceived as having a pilot phase to be followed by a nationwide program. The pilot phase will test procedures and establish solid partnerships with municipal authorities, appliance dealers, and the recycling industry. It would take place in two Brazilian cities and involve a three-month marketing campaign, with a target of selling 8000 units. Along with an advertising campaign, the sponsor would offer a rebate of 10% on the purchase price.

For a nationwide program, the sponsor envisions a potential for sale of 500,000 units per year.

Project Sponsor

The sponsor of this project is Whirlpool Corp./Multibras S.A, the largest producer of major home appliances in Brazil. It is envisioned that other manufacturers would participate in the nationwide program.

Costs and Revenues

For the pilot project, the costs to the sponsor are:

- A rebate of $44 per unit x 8000 units = $352,000
- Transportation and dismantling of old refrigerators = $55 per unit x 8000 units = $440,000
- Advertising campaign = $190,000

The revenue to the sponsor, not including that from sale of CERs, consists of:

- Salvage value of recycled units = $8 per unit x 8000 units = $64,000

The total program-related costs would be $982,000, and the net cost would be $918,000. Whirlpool hopes that another party (such as a utility) would contribute some part of the rebate cost.

Due to the project, Whirlpool will gain some sales that might have gone to other companies, and some purchases will occur sooner than otherwise, so there would be some additional profits. Presumably the profit on an efficient refrigerator is similar to that for a standard refrigerator.

Financing

The sponsor hopes that funds for half of the net project cost would come from electric utility programs to conserve electricity.

Carbon Accounting

We consider the pilot project, which targets sale of 8000 refrigerators. Whirlpool estimates that 7000 families would purchase a refrigerator without the project, but we assume it would not be an energy-efficient refrigerator. The other 1000 families are not yet looking for a new refrigerator, but Whirlpool believes they would decide to buy an energy-efficient refrigerator because of the project. The estimated lifetime for a project refrigerator is 11 years.

For the 7000 families, the electricity savings from the project are equal to the difference in consumption between a standard new refrigerator (the baseline case) and the project refrigerator, which is approximately 36 kWh/year.

For the 1000 families, the situation is more complicated. Without the project, they would continue to use their existing refrigerator for some time, but then buy a new one. For the baseline case, we assume that on average, these 1000 families would continue to use their existing refrigerator for 5 years, and then would buy a new standard refrigerator. Thus, the electricity savings due to the project are partially equal to the difference in consumption between an average existing refrigerator and the project refrigerator, which is estimated to be 180 kWh/year, and partially equal to the difference in consumption between a standard new refrigerator and the project refrigerator.[6]

Additional electricity savings come from avoiding continued use of the old units after purchase of a new unit. In most cases (Whirlpool estimates 80%), the old refrigerators would continue to be used by the original household (as a second unit) or by another household who purchases or receives the old unit for free.[7] By collecting and dismantling these units, the project would avoid their electricity use. How many years the old units would continue to operate is uncertain; we assume five years.

Based on the above assumptions, the electricity savings attributable to the project over an 11-year period are as follows:

Class of Family (number)	Savings from New Refrigerator (GWh)	Savings from Recycling Old Refrigerator (GWh)*	Total Savings (GWh)
Would have bought a new refrigerator (7000)	2.77	13.44	16.21
Would have kept old refrigerator for 5 more years (1000)	1.12	2.30	3.42
Total	3.89	15.74	19.63

* We assume that 20% of the old units would get discarded (and not used by anyone) without the project.

The majority of the total savings are attributable to recycling of the old units rather than to the better efficiency of the project refrigerators.

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[6] In reality, it is likely that the efficiency of a standard new fridge will improve over the next five years, so using the value for today's standard new fridge overstates the savings due to the project for the 1000 families.
[7] For the 1000 families, without the project, we assume that they would replace their existing fridge in five years. So the project would avoid further use of these fridges for a few years (we assume five).

The avoided carbon emissions under alternative power system baseline cases and the revenue from sale of carbon credits in different scenarios are as follows.

	Basis for Value for Avoided Carbon from Grid Electricity Generation	
	Projected Future Operation	**Natural Gas Combined Cycle**
Avoided Carbon Emissions by Project	2763	2763
NPV of CER revenue at $20/tC	21	42
NPV of CER revenue, Low Price	18	35
NPV of CER revenue, High Price	24	48

* NPV assumes 15% discount rate.

The above calculation does not account for avoided release of CFCs from old refrigerators, which Whirlpool estimates at 200 grams of CFC-12 per fridge. CFC-12 is an extremely potent greenhouse gas with an atmospheric lifetime of approximately 100 years. The total quantity of CFC-12 whose release would be avoided, 1.6 tons, has a direct Global Warming Potential of 13,600 tons CO2-equivalent, or 3,700 tC-equivalent. The timing of the avoided release is uncertain, however, since the eventual fate of the old fridges in the absence of the project is not well determined. If we assume that the project avoids 370 tC-equivalent in each of 10 years, the NPV of CERs from avoided CFC-12 would be $23,000 with CERs at $20/tC. Verifying the avoidance of these emissions could be somewhat costly, however.

The NPV of potential CER revenue from both avoided carbon and CFC-12 emissions would be $44,000 using Projected Future Operation of the electricity grid as a baseline. This amounts to only 5% of the net project cost. If Whirlpool only has to assume half of the total cost, the CER revenue would be about 10% of their cost.

If the pilot project were expanded into a larger program, the program cost per participating family would be lower.

Contribution to Sustainable Development

The recycling of old refrigerators will reduce problems related to disposal of old refrigerators. The avoidance of CFC release will be beneficial with respect to the ozone layer. The project would also create business opportunities related to the collection and recycling of old units.

XIX. Eucalyptus Charcoal for Pig Iron Industry

Background

Traditionally Brazil has been one of the few countries using a large amount of charcoal in the pig-iron industry (6.7 million tonnes/yr). Several small and medium size plants using charcoal for iron-ore reduction exist in the States of Minas Gerais and Para. These producers in the past bought low cost charcoal produced from native forest cut for expansion of the agricultural area. This practice continued for several decades in the State of Minas Gerais, but the availability of native forest decreased, requiring transportation of charcoal from distances over 600 km. Simultaneously, environmental legislation was gradually introduced that restricted deforestation. Today all the charcoal used in pig-iron factories must come from human-made forests. The situation is similar in the State of Para, where legislation started to be enforced more strongly in the last 5 years. There, a share of charcoal is still derived from the use of native vegetation.

Charcoal obtained from plantation forestry is more expensive, but when long distance transportation costs are added, it becomes more competitive. The major competitor to charcoal is metallurgical coal. Such coal is essentially imported to be transformed into coke. Several mid-size pig-iron plants have been converted to coke use in the last 5 years. The remaining ones using charcoal are searching for all possible co-benefits to keep their process competitive with coke-based pig-iron producers.

Project Description

The project intends to produce charcoal for use in the pig iron industry in Minas Gerais. The sponsor has a eucalyptus plantation that is at the end of its economic cycle and must be fully reformed. Investments are required for a plantation of 9600 ha and for the transformation of wood into charcoal. It is hoped that the value of carbon offsets will make it possible to sell charcoal at a competitive price.

A eucalyptus plantation for charcoal production provides the maximum economic return when cut at 7 and 14 years. After the second cut it is better to initiate a new plantation at the same site. The new plantation is carried out in the space between the old trees and it is not necessary to disturb the soil for the removal of the old trees. The new plantation very quickly will shade sunlight to the old one, disabling it to compete with the new plantation. Assumed productivity is 17.5 m^3/ha/year, which means a total amount of harvested wood of 245 m^3/ha per harvest. We assume that the entire stock is cut and converted to charcoal in the final seven years, and there is no replanting.

Plantar Siderurgica will purchase all of the project's charcoal production.

Project Sponsor

PLANTAR S/A–Reflorestamentos, is a Brazilian company based in Belo Horizonte, Minas Gerais. It has been operational in reforestation since 1967. Plantar owns 103,000 ha in forests, another 281,000 ha in rural real estate, as well as agricultural machinery and vehicles. The company has done projects for many clients in the pulp and paper sector and in the pig iron/steel sector. Projects already implemented cover a planted area of 380,000 ha.

Financing

Precise needs for financing are uncertain.

Costs and Revenue

The initial investment for the plantation is US$ 7.5 million. The charcoal conversion oven requires an additional US$ 400,000. Annual operational costs for harvesting and processing the wood are US$ 891,000. The plantation is replanted after two cutting cycles. Projected revenue from the sales of charcoal is US$ 60/ton.

Carbon Accounting

Baseline Condition of Land Without Project: If the project does not occur, the existing plantation would be abandoned. There would be some growth from coppices, and some decay of dead trees. The net effect is minimal.

Carbon Emissions Avoided by Project: Each ton of charcoal will avoid use of ~1 ton of coke by the pig iron enterprise, avoiding emission of approximately 0.83 tC (coke is ~92% carbon, and ~90% of the carbon is released in the blast furnace).

Note: We have not accounted for any carbon sequestration and carbon loss at the plantation that is in addition to the wood that is harvested.

Potential for Carbon Leakage: There is no expectation that the project would cause any change in biomass stocks away from the site. In the baseline condition, the workers currently employed might engage in slash-and-burn agriculture. By employing these workers (and others), the project would prevent this loss of biomass. The magnitude of this positive effect is very uncertain.

Internal Rate of Return
(After tax of 20% on profit)

Without sale of CERs	13%
With sale of CERs at $20/tC	17%
With sale of CERs, Low Price	18%
With sale of CERs, High Price	21%

Contribution to Sustainable Development

This project will create 1900 jobs for rural workers, thus benefiting the local economy. There is potential to replicate the project throughout the pig iron industry, with a potential for creating more than 100,000 jobs. The use of charcoal will also displace imported coke, providing savings of foreign exchange.

Contact

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XX. Eucalyptus Woodfuel for Ceramics Industry

Background

The ceramic industry in Brazil often uses firewood for the thermal treatment of its product since the absence of sulfur in the fuel improves the physical appearance of the product.

Project Description

The project intends to reform a eucalyptus plantation that will be used as a source of fuel for industrial processing of ceramics. An area of 240 ha will be used for the plantation. Eucalyptus will be cut at 6 and 12 years and fully harvested at 18 years. The expected annual yield is 30 m^3/ha. We assume there is no replanting after the last harvest. The sponsor will also be the user of the firewood. While this project is small, there is potential for other plantations to serve the rural ceramics industry.

Project Sponsor

FORNARI & DENARDI is a ceramic products manufacturer in the city of Rio Verde – state of Mato Grosso do Sul – South West of Brazil.

Costs and Revenues

The investment required for establishment is US$ 120,000 (US$ 500/ha), which would be used over two years. Firewood has a value of US$ 10/m^3. First revenue will occur after 6 years. Income is US$ 1,800/ha in the sixth, twelfth, and eighteenth years.

Financing

The sponsor is looking for a partner able to provide 50% of the initial investment through equity.

Carbon Accounting

Baseline Condition Without Project: In the absence of the project, the ceramics facility would use diesel oil as an energy source. There would be minimal net change in biomass stock on the project site.

Carbon Reduction by Project: The wood from the plantation substitutes for diesel fuel at the ceramics facility.

Note: We have not accounted for any carbon sequestration and carbon loss at the plantation that is in addition to the wood that is harvested.

Potential for Carbon Leakage: There is currently minimal activity on the land that could be displaced to another location.

Internal Rate of Return
(After tax of 20% on profit)

Without sale of CERs	25%
With sale of CERs at $20/tC	31%
With sale of CERs, Low Price	32%
With sale of CERs, High Price	35%

Contribution to Sustainable Development

This project will create 20 jobs for rural workers, thus benefiting the local economy. The use of charcoal will also displace imported oil, and thus provide savings of foreign exchange.

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XXI. Rubber Plantation in Mato Grosso State

Project Description

The project involves establishment of a rubber plantation “hevea brasiliensis” of 1,000 ha. The plantation starts to produce latex in commercial scale four years after planting, with full production two years later. Latex is collected continuously from the trees during the productive life of the plantation at an annual rate of 2 tons/ha. Expected production life is 30 years.

Project Sponsor

Companhia Comercial OMB, a private Brazilian company, has one rubber plantation in Acará, state of Pará and another one in the state of Espirito Santo.

Financing

The National Development Bank (BNDES) provides loans which cover up to 60% of the project cost at real interest rate of 15%/yr and a grace period of 2 years. The money is available only with real guarantees, however, which can exceed the value of project land and plantation. It is estimated that half of the total guarantee must be derived from other corporation assets. It is hoped that a partner can provide equity financing.

Costs and Revenue

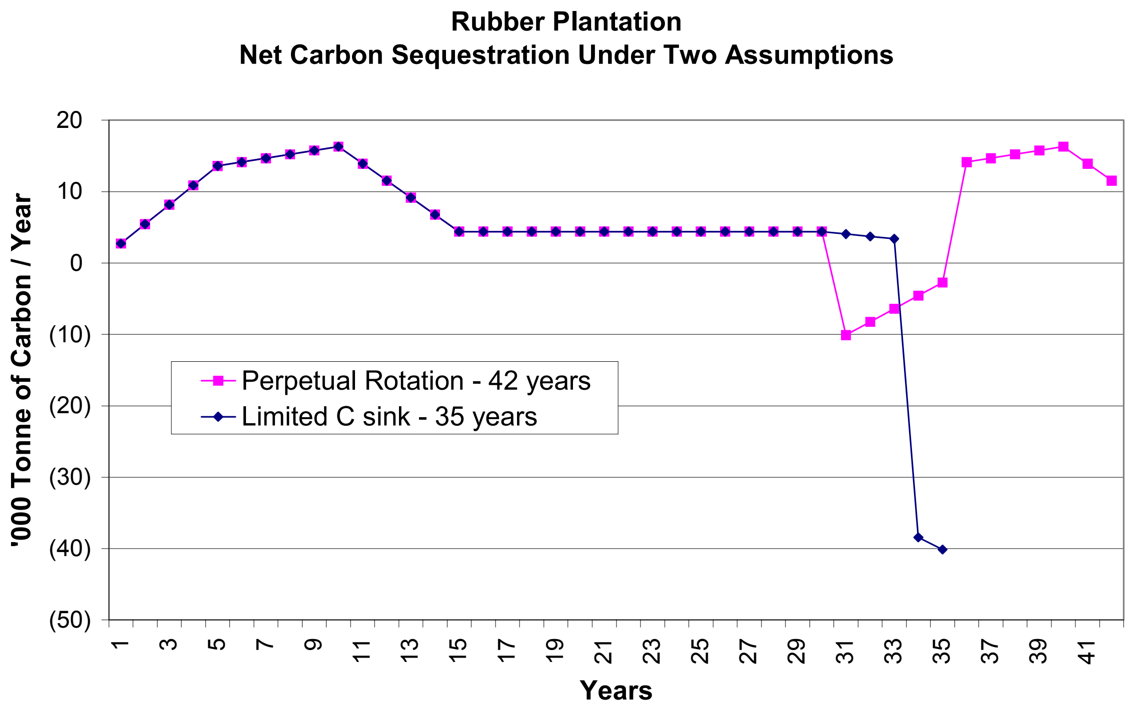
Plantation establishment cost is approximately US$3 million (US$3,000/ha). The only operational cost is for labor; total annual expense is US$ 514 / ha (3.5 ha / worker). Latex has a market value of US$ 1,300/t in Brazil. After production begins, projected annual revenue is US$ 2,086/ha. We assume that the trees are cut after production life is over and long-lived products are sold.

Carbon Accounting

Baseline Condition without Project: The current state of the land and the likely evolution of the biomass stock in the absence of the project needs to be determined.

Carbon Sequestration by Project: A "hevea" plantation on degraded land can store over 200 tons of carbon per hectare and could be considered a carbon sink similar to recovery of that land by natural forests or eucalyptus plantation. Much carbon sequestration occurs early on in the project as the rubber trees grow fast at first, and then slower after the first decade. Under perpetual rotation assumption, the plantation is replanted at the end of the project. This leads to additional sequestration and revenue. Under limited period C sink assumption, there is no replanting. In both cases, the original trees are cut down at project end and sold for manufacture of durable wood products. The wood residues are used for firewood, releasing most of the stored carbon.

Net carbon sequestration (ktons)	
Perpetual rotation	239
Limited period C sink	107



Potential for Carbon Leakage

There is currently minimal activity on the land that could be displaced to another location.

Net Present Value of Benefits ('000 US$)
(After tax of 20% on profit)

	Perpetual Rotation		Limited Period C Sink	
	15% d.r.	**20% d.r**	**15% d.r.**	**20% d.r**
Without carbon credits	2,220	381	2,176	368
With carbon credits, $20 Constant	3,378	1,257	3,323	1,242
With carbon credits, Low Price	3,394	1,164	3,134	1,111
With carbon credits, High Price	3,868	1,455	3,542	1,393

Contribution to Sustainable Development

Extraction of latex creates 1 job per 3.5 hectare of plantation, and the activity can be carried out year around. Latex has an international market and can be used as a hard currency cash crop, or further processed in Brazil to yield higher value added products. Regarding local environment effects, the rubber plantation will recover wasted land, increasing protection of biodiversity.

XXII. Oil Palm Plantation in State of Pará

Background

Palm oil is the second most used vegetable oil in Brazil. Plantation of oil palm trees started at the beginning of the 20th century in Brazil in the State of Bahia. The commercial activity declined around 1960 due to international competition and poor regional management. By 1970 the activity had been transferred to the state of Para in Amazonia, where climatic conditions are even more favourable than in Bahia. Such plantations were carried out with better management and by more professional companies.

Presently, oil palm production is carried out in 5 or 6 larger areas. The level of production is lower than the national demand. The commercial activity is recognized as very profitable, but the high cost of capital reduces interest of investors. The possibility of adding financial value by carbon storage is being considered as a potential way of fostering palm oil production in Brazil

The high oil yield obtained from palm oil plantation makes it possible to consider this plant as a source of liquid fuel. Many experiments and trials have been performed in Brazil and other countries for the use of vegetable oil as a diesel substitute in internal combustion engines.

Project Description

The project intends to establish an oil palm plantation of 5,000 ha in state of Pará. Oil palm plantation requires 5 years of growth before full commercial exploitation, and can be used as a source of palm oil for another 25 years. The expected average productivity is around 4 t palm oil / ha.

The oil-processing factory is 100% self-sufficient in electricity and steam, which is obtained from the burning of the by-product biomass in boilers. Further residues are left in the field. To utilize these, the project plans to retrofit the existing system through the installation of high-pressure steam boilers, and thereby produce excess electricity for sale to third parties.

Project Sponsor

Dendê do Pará S/A. (DENPASA) is a Brazilian private company involved with oil palm plantation and the extraction of palm oil for food purpose. The company has 2 plantations with several thousand ha in production and is in the market since the 1970s. The sponsor has suitable land in Acará, state of Pará, and seeks to expand its oil palm plantation with equity investment of a foreign partner.

Costs and Revenue

The investment in agricultural and industrial facilities is US$ 3,000/ha; total investment is US$ 15 million. The assumed value of palm oil is US$ 480/t for regular palm oil and US$ 640/t for palm kernel oil, which is produced in lesser quantity. The cogeneration equipment requires an investment of US$ 3.3 million in the first year (2.2 MW) and another US$ 3.0 million in the fifth year. Revenue from sale of surplus electricity is assumed to be US$ 0.04/kWh.

Financing

The National Development Bank and other regional agencies can provide financing for up to 80% of the investment, but real guarantees must be provided. Land value covers a fraction of the guarantee. DENPASA is looking for a partner able to provide equity to guarantee possible loans.

Carbon Accounting

Baseline Condition without Project: The project site is second-growth rainforest of some 20 years of age. Assumed biomass density is 25 tC/ha. In the absence of the project, some further growth would occur. We subtract the estimated baseline biomass stock from the project's gross carbon sequestration.

*Carbon Sequestration and Offset***:** Under perpetual rotation assumption, the plantation is replanted after 30 years. This gives rise to some additional sequestration and revenue. Under limited period C sink assumption, there is no replanting. At the end of their lifetime, the original trees are assumed to be cut down in both cases; we assume that 45% of the wood is used for electricity generation (sold to grid) and 15% is put into durable products. The remainder becomes residue and decomposes.

Half of the by-product residues from processing of the palm "bundles" will be used to generate electricity, which is assumed sold to the central grid.

Net carbon sequestration and offset (ktons)
Perpetual rotation 649
Limited period C sink 504

Potential for Carbon Leakage: There is currently minimal activity on the land that could be displaced to another location.

Net Present Value of Benefits ('000 US$)
(After tax of 20% on profit)

	Perpetual Rotation		**Limited Period C Sink**	
	15% d.r.	**20% d.r**	**15% d.r.**	**20% d.r**
Without carbon credits	-465	-4,910	-555	-4,927
With carbon credits, $20 Constant	305	-4,756	197	-4,777
With carbon credits, Low Price	1,973	-3,824	1,622	-3,897
With carbon credits, High Price	4,494	-2,629	3,945	-2,745

Contribution to Sustainable Development

The plantation will provide approximately 400 job opportunities. This would reduce some of the present activities in the region responsible for deforestation. Being a permanent crop, palm oil plantation causes much less soil erosion compared with annual crops.

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XXIII. Teakwood Plantation in Mato Grosso

Project Description

The teak tree produces a very valuable variety of wood especially suited for long lasting furniture and other residential wood products. The project plans to use an area of 3,000 ha of flat and slightly undulating land for a plantation of teakwood in the state of Mato Grosso.

The plantation will last for at least 25 years and soil tillage will be carried out only at the very beginning. The density of trees (initially 1600/ha and after 3rd year, 1000/ha) is enough to protect the soil from heavy water run-off. After 3 years from the tree planting, 40% of the trees are eliminated; after 7 years half of the remaining are cut and left on the soil since they have no commercial value. At year 12 and 18 there is commercial thinning and most of it is sold as a high value wood. After 24 years, the last cut occurs.

Project Sponsor

TECTONA is a company that owns land in Mato Grosso.

Costs and Revenue

The cost for the plantation, including administration and harvesting costs, is US$ 2,500 / ha. For 3,000 ha the full project cost is US$ 8 million. The wood has a market value of US$ 400/m^3, and an even higher price is expected in the future.

Financing

The project requires long term financing. Sponsor is willing to participate with 40% of the investment and is trying to sell shares to potential investors.

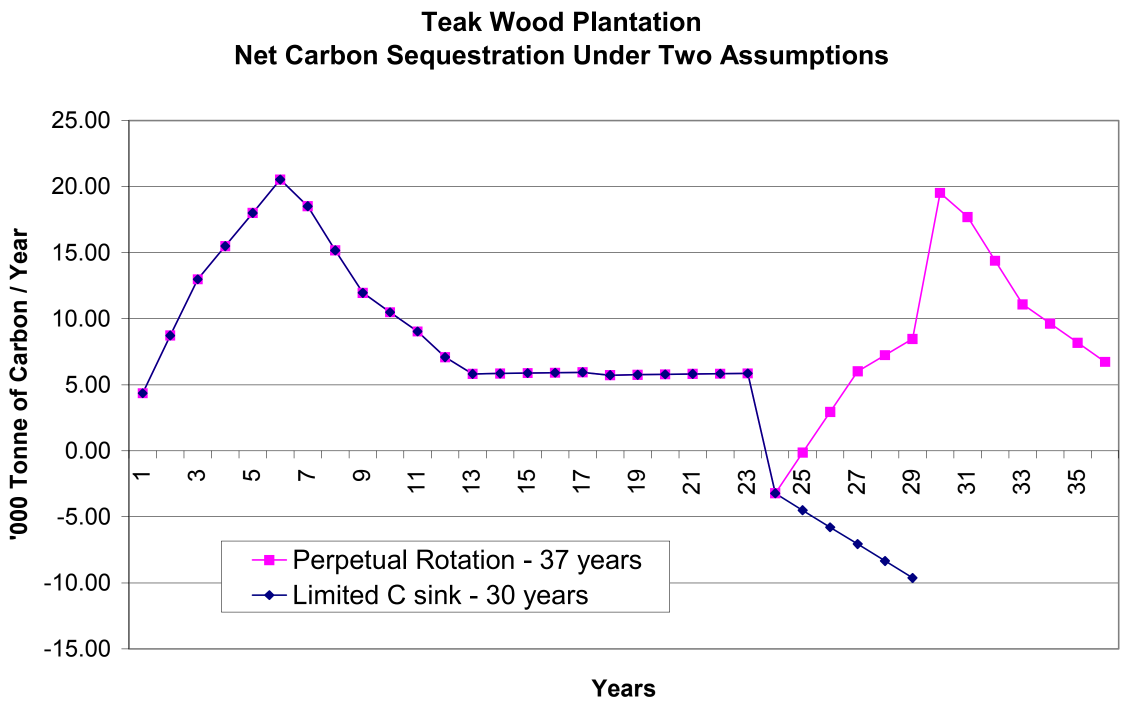
Carbon Accounting

Baseline Condition without Project. The land is currently being used for pasture (two head of cattle per ha). The only maintenance practice consists of burning the vegetation every 3 to 5 years to eliminate weeds and fertilize the soil. Thus, there would be little growth of biomass in absence of the project.

Carbon Sequestration by Project. It takes 25 years for the trees to mature to full commercial value. Carbon content in the trunk of mature trees is 95 tC/ha.[8] As the thinning progresses, the number of trees that are growing will diminish, and with it the rate of carbon sequestration. Around 70% of the commercial wood will be used for furniture or other long-lived products; the remaining 30% is burned. Under perpetual rotation assumption, there is replanting in the end years of the project, and some additional sequestration. Under limited period C sink assumption, there is no replanting, and all of the stock is harvested and sold.

[8] Including below-ground biomass and other above-ground biomass in the trees, the estimated carbon content is 147 tC/ha.

Net carbon sequestration (ktons)[9]
Perpetual rotation 325
Limited period C sink 178



Potential for Carbon Leakage: There is currently minimal activity on the land that could be displaced to another location.

Net Present Value of Benefits ('000 US$)[10]
(After tax of 20% on profit)

	Perpetual Rotation		Limited Period C Sink	
	15% d.r.	**20% d.r**	**15% d.r.**	**20% d.r**
Without carbon credits	2,059	-1,211	2,092	-1,203
With carbon credits, $20 Constant	3,587	-76	3,574	-81
With carbon credits, Low Price	3,592	-227	3,275	-317
With carbon credits, High Price	4,624	249	3,640	-33

[9] Including other biomass outside the trunk, the value would be 464 tC for perpetual rotation.
[10] Including other biomass outside the trunk, the value for $20 Constant scenario and 15% discount rate would be 4139 '000 US$ (16% higher) for perpetual rotation.

Sustainability Issues

Sustainability benefits from this project include soil preservation, job creation and the generation of hard currency. Together these benefits can promote regional development. TECTONA also preserves the legal forest reserves in 20% of its forested area beside rivers, creeks and springs. Re-establishment of a forest cover between the forest reserve areas and water areas creates opportunities for the wildlife to migrate between the native forest areas, thus improving the survival of many species.

Contact

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XXIV. Babaçu Plantation for Charcoal Manufacture in Maranhão

Project Description

Babaçu palm (*Orbignya* spp.) is a very fast pioneering species with a high density that grows even on poor soils. The fruit can used to produce palm oil, soap, feedmeal and fiber. Part of the fruit can be converted to a superior quality charcoal. The project plans to collect babaçu fruit from an area of 100,000 ha and convert these to charcoal in portable kilns. This charcoal will be used for fuel in pig iron plants. Through management of this area, the project expects to avoid deforestation that has been ongoing.

The project will last for 20 years and will include management thinning in some of the area and the introduction of a hybrid species that has been shown to increase productivity. Currently, only an estimated 25% of the native babaçu stand is extracted efficiently and this would be improved. Other forms of carbon sequestration may be included in the project in later stages. The owners of the land will receive 15% of the proceeds from the fruit sales in exchange for a usufruct and management agreement. A pilot phase of this project is already underway in the Tocantine Zone of southern Maranhão.

Project Sponsor

The project is to be carried out by Pro Natura, an organization that works with communities and enterprises in rural areas throughout the developing world to conserve tropical biodiversity, and Estrela do Norte, a private company, with support from the Maranhão State Government.

Costs and Revenue

The project will require an investment of US$ 11.6 million over a four-year startup period. Charcoal production is projected at 178,000 m^3 per year, with a market value of $20/$m^3$. Additional revenue will be generated through the sale of palm oil and other products as technological improvements allow the extraction of other components of the fruit.

Financing

Counterpart financing is currently available for $2.1 million. The World Bank, through the state government of Maranhao, assured financing for the initial six operational units. Additional financing was provided through the Banco do Nordeste. For the scaled-up project, co-financing for a share of fixed capital investment is anticipated from the State of Maranhao, the Banco do Nordeste and charcoal buyers in the pig iron industry. The state government supports this project, but unless it received further World Bank funding, the government will probably not invest directly. The sponsor is currently exploring other sources of financing.

Carbon Accounting

Baseline Condition without Project: In the last 20 years, 20% of babaçu palm stands have been removed by mechanical and herbicidal means. Without the project, this trend would continue. We assume a gradual loss of 20% of the current stand over the next 20 years. The remaining babaçu trees would grow normally.

Carbon Benefits from Project: Babaçu palms can sequester over 11 tC/ha/yr, primarily through leaf biomass, but most of this growth also occurs under baseline conditions. Improved management results in higher carbon sequestration rates (by approximately 1 tC/ha/yr) than under baseline conditions, however. Charcoal from the project would substitute for coke and charcoal produced by other means. We assume that half of the charcoal substitutes for coke and half for other charcoal. Up to 30% of the latter is taken from unsustainably managed forests, so the project could avoid loss of this biomass carbon. Management practices are expected to increase sequestration.

If one counts avoided deforestation due to the project, the carbon benefit is vastly greater.

Net carbon benefit (ktons)	
Counting avoided deforestation	7,941
Not counting avoided deforestation	2,274

Potential for Carbon Leakage: If the project prevents removal of trees, it seems possible that the people responsible might move their activity to another area. Thus, some of the benefit from avoided deforestation might be lost.

Net Present Value of Benefits ('000 US$)
(After tax of 20% on profit)

	Counting Avoided Deforestation		**Not Counting Avoided Deforestation**	
	15% d.r.	**20% d.r**	**15% d.r.**	**20% d.r**
Without carbon credits	-3,574	-3,349	-3,574	-3,349
With carbon credits, $20 Constant	36,202	25,484	8,878	5,877
With carbon credits, Low Price	40,223	25,272	9,348	5,333
With carbon credits, High Price	65,477	39,395	16,201	9,246

Sustainability Issues

The project has an elaborate plan to involve local stakeholders. It will stimulate regional spin-off enterprises and improve conditions for local gatherers and the niche palm oil industry. The investment also includes training program for local workers. The project would supply jobs for 4,500 fruit gatherers for 8 months per year. It would also protect biodiversity and soil quality.

XXV. Acknowledgements

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John Mein and Dr. José Goldemberg were also instrumental in encouraging parties in Brazil to come forward with potential projects. We also wish to acknowledge the assistance of the project sponsors who generously provided the information that made our analysis possible.

XXVI. Appendix

Establishing Benchmarks for Estimating Carbon Emissions Avoided by Electricity Generation and Efficiency Projects

Introduction

Estimation of the GHG emissions that are avoided by projects that supply electricity to the grid or reduce electricity demand requires a baseline emissions rate for the electricity system. Ideally, this baseline should reflect how the system would normally be operated. Estimating the effect of projects hinges upon finding the type of power plants whose use would be avoided by the projects, and the carbon emissions avoided by their reduced operation.

Baseline setting and determination of additionality has taken place on an ad hoc, case-by-case basis. This approach has required project developers to expend significant time and resources in preparing projects and moving them through a review process. In response to this situation, there has been interest in simple methods for setting a baseline that could apply to all projects in a given sector and country.

Establishing an "official" baseline (benchmark) for the power system would provide project developers with avoided-carbon factors that they could use in calculating the carbon emissions expected to be avoided by a project, and the number of carbon credits claimed after the project has been underway. A benchmark for a power system could be expressed in terms of kg C per kWh avoided. All projects affecting the electricity system in a given country (or region in a country) would be using the same values, and project developers would not have to make an estimation on their own.

This Appendix describes a simple approach for establishing a power system benchmark that strikes a balance between simplicity of use and the desire for accuracy in granting carbon credits.

Overview of the Method

Independent electricity generation projects and electricity efficiency improvement projects both result in a reduction in the residual load that the electricity system needs to meet. The approach described here provides a method for estimating the types of electricity generation that are expected to be the marginal source during a given period. It provides a reasonable estimate of which source(s) are likely to be curtailed in response to the load reduction from projects.

Using an emission factor based on marginal impacts will produce much more accurate estimates of emissions reductions than applying an average rate. For small projects, this approach is also more accurate than one which relates avoided generation and emissions to a specific type of new power plant, since new capacity is often low cost and thus is not frequently dispatched as the marginal source.

The load of an electricity generation system during a given period can be represented in a diagram that plots system power output as a function of time (Figure 2). In order to clarify the respective roles of different power sources in meeting the load, chronological load data can be converted into a load duration curve. A load duration curve is a reordering of chronological load data into the form of Figure 3, in which the x-axis shows how many hours the load was equal to or greater than the power level shown on the y-axis. For each hour in the period, there is a particular cost-minimizing dispatch of power sources to meet the demand. The basic goal of the method is to approximate this dispatch, by filling in the area underneath the load duration curve, which represents the total energy requirement. In so doing, one can estimate which sources operate at the margin, and for how long.

Once one has such an approximation, deriving a factor for avoided carbon emissions in a given period is straightforward. If only one source is marginal for the entire period, the appropriate factor is simply the emissions factor for that source. If two or more sources are marginal, the factor is the average of the respective emission factors for each source, weighted by the percentage of hours in the period for which each source is marginal.

Steps in the Method

The method makes use of an Excel spreadsheet.

Step 1: Draw a Load Duration Curve

- Data requirement: Chronological load data (typically in MW) for each hour of a year (or other period).

- Sort load data (only) from highest to lowest MW level. Leave hourly data unchanged. Plot load data against hours of the period. *Automatically performed by LBNL spreadsheet model.*

Step 2: Organize Data on Generating Sources

- Data requirement: Available capacity and projected generation in year (or other period) by source.

- The suggested approach for approximating the dispatch of the generating sources is to stack the sources according to their marginal cost of generation. In normal operations, the sources with the lowest marginal cost are used as much as possible, while more expensive sources are used as needed. In actual operation, the dispatch does not conform to simple economic rules, but for purposes of approximation using such criteria is reasonable. For a system with only a few sources, one can approximate the dispatch based on expert judgement of how the system operates.

This approach treats each power source as if it were a single homogenous unit. There is no attempt to depict the system operation with respect to dispatch of individual units.[11] The EF used for each source would normally be the average value, unless there is good reason to use a different value.

[11] The carbon emitting characteristics of various fuels differ considerably, whereas the difference between plants burning the same fuels is less dramatic.

Step 3: Stack ("Dispatch") Sources to Meet the Load

- *Automatically performed by LBNL spreadsheet model*. Model calculates how many hours a year (or other period) each source was active at an average capacity of *xy* MW. Model determines how many hours in a year (or other period) the non-baseload sources were at the margin.[12]

Step 4: Calculate Carbon Emissions Factor for the System for Relevant Period

- Data Requirements: For each source, information on the type of fuel used, the conversion efficiency (in %), the carbon content of the fuel used (in tC/TJ), and the combustion efficiency of this fuel (in %).

- The model computes the Marginal Carbon Emissions Factor as the average of the respective emissions factors, weighted by the percentage of hours for which each source is marginal.

Results for Brazil

The projections for Brazil were based on official plans of Elotrobras, supplemented with assumptions and calculations made by USP.

Figures 4 and 5 depict the projected operation of the Brazilian electricity system (South/Southeast) for typical weeks in August 2003 and 2008. Since there is little seasonal variation in operation, a typical week is assumed to be applicable for the entire year. Nuclear and coal-fired units are assumed to run as base load all the time.[13] Above these sources, the stacking of the other sources is based on their marginal cost of generation. The system emissions factor (EF) is the average of the respective EFs, weighted by the percentage of hours for which each source is marginal.

[12] The model algorithm advances in discrete steps (by the hour) starting at the last hour. Going backwards along the load curve, in each step it determines the area under the load curve for the relevant source subject to the total generation and available capacity constraints. It stops at the hour and capacity where the generation constraint is fulfilled and the available capacity is not exceeded. For baseload sources, the algorithm only calculates the average capacity usage given the information on total electricity generation from these sources.

[13] In reality there would be some down time for the nuclear and coal plants over the course of a year, but it is simpler to model their operation as if it were constant.

Figure 2. Chronological Annual Load Curve.

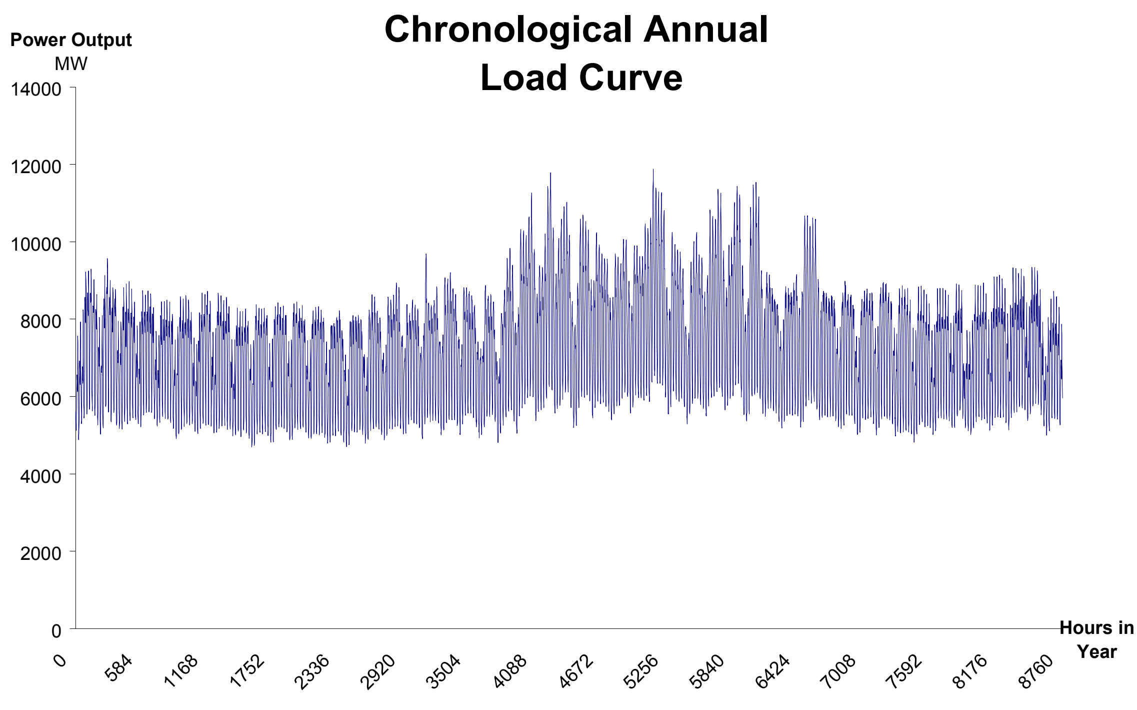


Figure 3. Annual Load Duration Curve

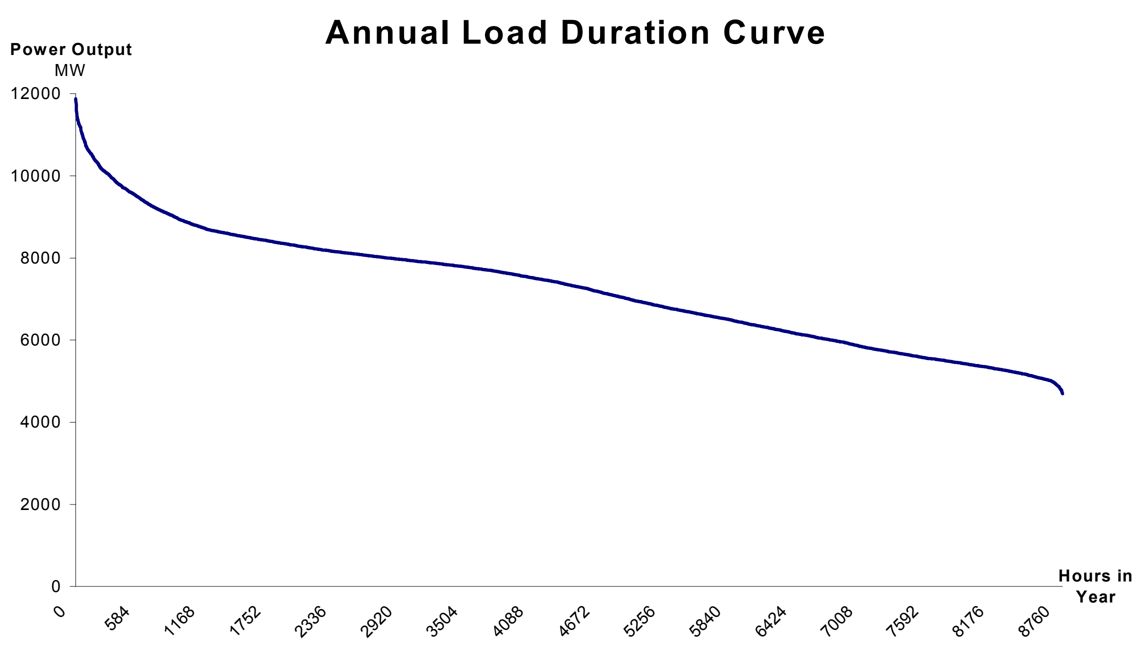
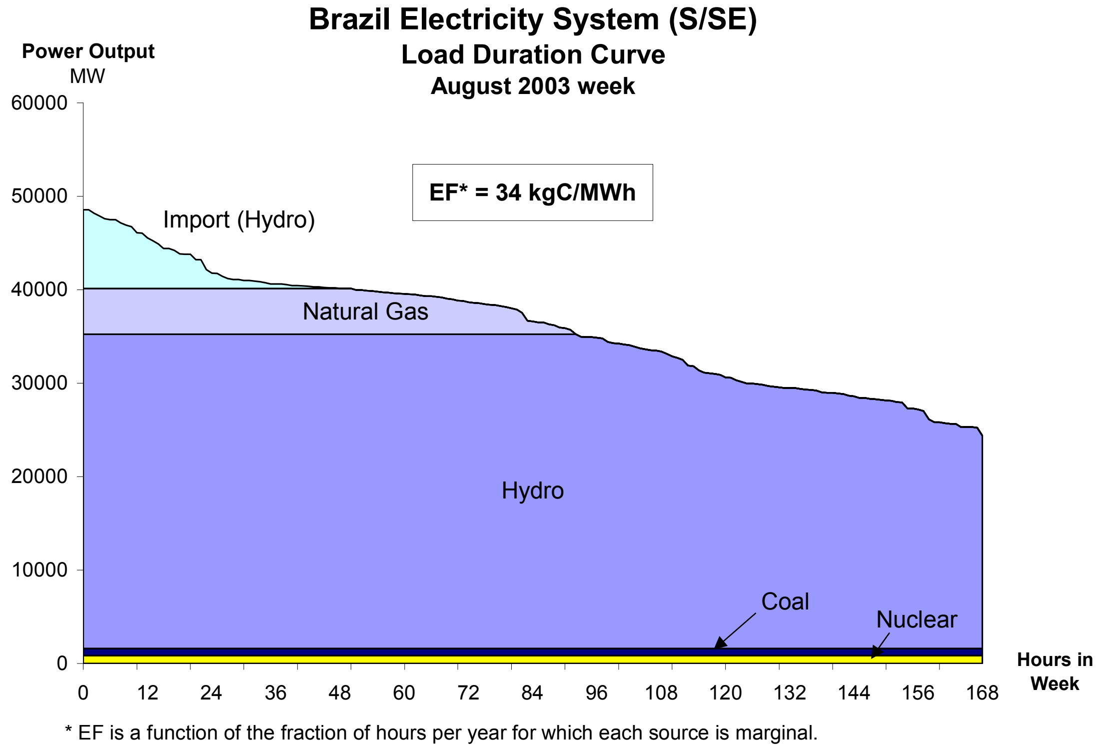


Figure 4. Brazil Electricity System: Load Duration Curve, 2003



Plant and Fuel Characteristics

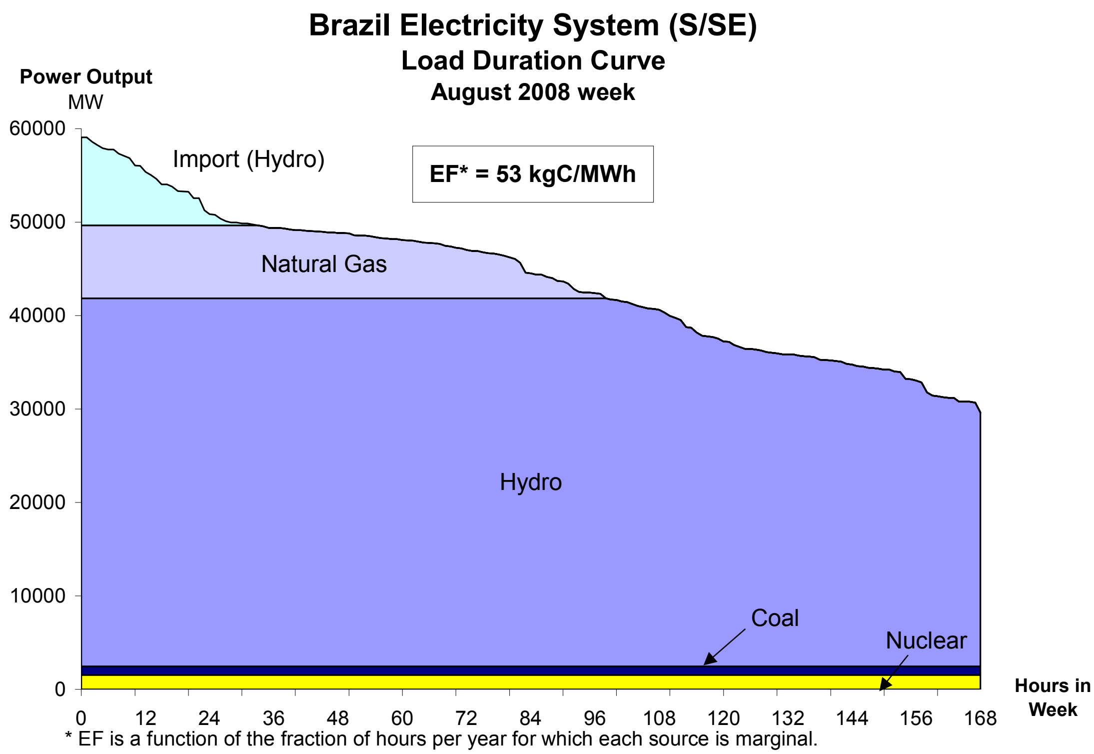
Type of Plant	Type of Fuel	Conversion Efficiency % A	Heat Rate MJ/MWh B=(1/A)*3.6*10^3	Carbon Content (unadjusted) tC/TJ C	Combustion Efficiency % D	Carbon Content (adjusted) tC/TJ E = C * D	Emissions Factor per fuel kgC/MWh F=B*E *10^3/10^6
Combined Cycle	Natural Gas	40%	9000	15.3	0.995	15.2	137

Marginal Power Source Displacement

	Hours of Source being marginal hours	Share of Marginal Hours %	Emissions Factor kgC/MWh	Weighted Emissions Factor kgC/MWh
Conv. Hydro	76	45%	0	0
Combined Cycle	42	25%	137	34
Import	50	30%	0	0
Sum	168	100%		34

Weighted Average Emissions Factor for Marginal Sources: 34 kgC/MWh

Figure 5. Brazil Electricity System Load Duration Curve, 2008



Plant and Fuel Characteristics

Type of Plant	Type of Fuel	Conversion Efficiency % A	Heat Rate MJ/MWh B=(1/A)*3.6*10^3	Carbon Content (unadjusted) tC/TJ C	Combustion Efficiency % D	Carbon Content (adjusted) tC/TJ E = C * D	Emissions Factor per fuel kgC/MWh F=B*E *10^3/10^6
Combined Cycle	Natural Gas	40%	9000	15.3	0.995	15.2	137

Marginal Power Source Displacement

	Hours of Source being marginal hours	Share of Marginal Hours %	Emissions Factor kgC/MWh	Weighted Emissions Factor kgC/MWh
Conv. Hydro	33	20%	0	0
Combined Cycle	65	39%	137	53
Import	70	42%	0	0
Sum	168	100%		53

Weighted Average Emissions Factor for Marginal Sources: 53 kgC/MWh