



**CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 02 - in effect as of: 1 July 2004)**

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**SECTION A. General description of project activity****A.1. Title of the project activity**

ARAPUtanga Centrais ELétricas S. A. - ARAPUCCEL - Small Hydroelectric Power Plants Project (hereafter referred to as “Arapucel Project”).

A.2. Description of the project activity

The primary objective of the Arapucel Project is to help meet Brazil’s rising demand for energy due to economic growth and to improve the supply of electricity, while contributing to the environmental, social and economic sustainability by increasing renewable energy’s share of the total Brazilian (and the Latin America and the Caribbean region’s) electricity consumption.

The Latin America and the Caribbean region countries have expressed their commitment towards achieving a target of 10% renewable energy of the total energy use in the region. Through an initiative of the Ministers of the Environment in 2002 (UNEP-LAC, 2002), a preliminary meeting of the World Summit for Sustainable Development (WSSD) was held in Johannesburg in 1992. In the WSSD final Plan of Implementation no specific targets or timeframes were stated, however, their importance was recognized for achieving sustainability in accordance with the Millennium Development Goals¹.

The privatization process initiated in 1995 arrived with an expectation of adequate tariffs (less subsidies) and better prices for generators. It drew the attention of investors to possible alternatives not available in the centrally planned electricity market. Unfortunately the Brazilian energy market lacked a consistent expansion plan, with the biggest problems being political and regulatory uncertainties. At the end of the 1990’s a strong increase in demand in contrast with a less-than-average increase in installed capacity caused the supply crisis/rationing from 2001/2002. One of the solutions the government provided was flexible legislation favoring smaller independent energy producers. Furthermore the possible eligibility under the Clean Development Mechanism of the Kyoto Protocol drew the attention of investors in small hydropower projects.

In this scenario, *Brennand Energia Ltda.* began to consider investing in small renewable energy power projects (thermo and hydro) in Brazil. One of the main ventures of the company, the Arapucel Project, under development since 2001, explores the hydropower potential in three locations of the Jaurú River near the cities of Araputanga and Jaurú, in the State of Mato Grosso, Midwest of Brazil.

¹ WSSD Plan of Implementation, Paragraph 19 (e): "Diversify energy supply by developing advanced, cleaner, more efficient, affordable and cost-effective energy technologies, including fossil fuel technologies and renewable energy technologies, hydro included, and their transfer to developing countries on concessional terms as mutually agreed. With a sense of urgency, substantially increase the global share of renewable energy sources with the objective of increasing its contribution to total energy supply, recognizing the role of national and voluntary regional targets as well as initiatives, where they exist, and ensuring that energy policies are supportive to developing countries’ efforts to eradicate poverty, and regularly evaluate available data to review progress to this end."



The project consists of three small hydroelectric power plants (“PCH”, from the Portuguese, *Pequena Central Hidrelétrica*), PCH Alto Jauru (20.0 MW), PCH Indiavaí (28.0 MW) and PCH Ombreiras (26.0 MW), totalizing 74 MW installed capacity. The plants are located in the Jauru River in the state of Mato Grosso, Midwest region of Brazil. The project is being developed in three phases. The first phase was initiated in the first semester of 2001 and concluded in September 2002, when PCH Alto Jauru started operation. The second phase finished in July 2004 when PCH Indiavaí started to operate adding 28 MW to the Arapucel Project. The third phase of the project is the implementation of the PCH Ombreiras, which will add more 26 MW to project installed capacity. Ombreiras will be operational in September 2005. This PDD applies to the three phases.

This indigenous and cleaner source of electricity will also have an important contribution to environmental sustainability by reducing carbon dioxide emissions that would have occurred otherwise in the absence of the project. The project activity reduces emissions of greenhouse gas (GHG) by avoiding electricity generation by fossil fuel sources (and CO₂ emissions), which would be generating (and emitting) in the absence of the project.

The Arapucel Project improves the supply of electricity with clean, renewable hydroelectric power while contributing to the regional/local economic development. Small-scale hydropower run-of-river plants provide local distributed generation, in contrast with the business as usual large hydropower and natural gas fired plants built in the last 5 years, these small-scale projects provide site-specific reliability and transmission and distribution benefits including:

- increased reliability, shorter and less extensive outages
- lower reserve margin requirements
- improved power quality
- reduced lines losses
- reactive power control
- mitigation of transmission and distribution congestion, and
- increased system capacity with reduced T&D investments

It can be said that fair income distribution is achieved from job creation and an increase in people’s wages, however better income distribution in the region where the Arapucel Project is located is obtained from less expenditures and more income in the local municipalities. The surplus of capital that these municipalities will have could be translated into investments in education and health, which will directly benefit the local population and indirectly impact a more equitable income distribution. The lower expenditure is generated due to the fact that money will no longer be spent in the same amount to “import” electricity from other regions in the country through the grid. This money would stay in the region and be used for providing the population better services, which would improve the availability of basic needs. The local population will receive economic benefits from royalties paid to the municipalities for the water rights granted to Arapucel.

The Proinfa Program. Law # 10,438 enacted in April 2002, created the “Program of Incentives to Alternative Energy Sources” (Proinfa from the Portuguese *Programa de Incentivo as Fontes Alternativas de Energia Elétrica*). Among others, one of this initiative’s goals is to increase the renewable energy sources share in the Brazilian electricity market, thus contributing to a greater environmental sustainability. In order to achieve such goals, the Brazilian government has designated the federal state-



owned power utility (Centrais Elétricas Brasileiras S.A. – “Eletrobras”) to act as the primary off taker of electric energy generated by Alternative Energy facilities in Brazil, by entering into long-term power purchase agreements (“PPAs”) with Alternative Energy producers, at a guaranteed price of at least 80% of the average energy supply tariff charged to ultimate consumers in Brazil. The Arapucel Project began construction in 2001 prior to Proinfa’s legislation being in effect. Furthermore it was eligible in 2002 and it did not apply then due to certain uncertainties of the program. As such it does not have access to the financial advantages of the program. For that reason the project can be seen as an example of a solution by the private sector to the Brazilian electricity crisis of 2001, which contributes to the sustainable development of Brazil.

A.3. Project participants

- **Credit Owner and Project Operator:** Bioenergia Cogeneradora S.A. authorized by Interministerial Commission on Global Climate Change (Brazilian Designated National Authority of the CDM). Brazil ratified the Kyoto Protocol on 23rd August 2002.
- **Credit Buyer:** Corporación Andina de Fomento authorized by Ministry of Housing, Spatial Planning and Environment (VROM). The Netherlands ratified the Kyoto Protocol on 31st May 2002.

Contact information on party(ies) and private/public entities involved in the project activity listed in Annex 1.

A.4. Technical description of the project activity

The three facilities of the Arapucel Project utilize water from the Jauru River to generate electricity (total installed capacity of 74 MW). All the Arapucel Project facilities are run-of-river plants and have minimum diversion dams, which store water to generate electricity for short periods of time. Run-of-River schemes do not include significant water storage, and must therefore make complete use of the water flow. A typical run-of-river scheme involves a low-level diversion dam and is usually located on swift flowing streams (Figure 1). A low level diversion dam raises the water level of the river sufficiently to enable an intake structure to be located on the side of the river. The intake consists of a trash screen and a submerged opening with an intake gate. Water from the intake is normally taken through a pipe (called a penstock) downhill to a power station constructed downstream of the intake and at as low a level as possible to gain the maximum head on the turbine (Figure 2). According to Brazilian legislation (Eletrobrás, 1999), run-of-river projects are defined as “the projects where the river’s dry season flow rate is the same or higher than the minimum required for the turbines” and small hydropower projects the ones with installed capacity equal or smaller than 30 MW and reservoir area equal or smaller than 3 km².

A.4.1. Location of the project activity

**A.4.1.1. Host Party(ies)**

Brazil.

A.4.1.2. Region/State/Province etc.

Brazilian Midwest macro geographical region, state of Mato Grosso. (Figure 3)

A.4.1.3. City/Town/Community etc

Araputanga and Indiavaí (Figure 3).

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page)

The units of the project are located along the Jauru River in the state of Mato Grosso. The Jauru River forms part of the Paraguai river basin (Figure 4).

The region of the Arapucel Project, around the Jauru River, is comprised of several small cities in the State of Mato Grosso. The facilities are located in the southwest region of the State of Mato Grosso. The major city of the southwestern part of the state is Cáceres. The main economic activity is cattle breeding which has made the region one of the most important suppliers of meat to the Southeast and abroad. Although the region near the Jauru River, as well as the State of Mato Grosso, has high economic growing rates, there has been a lack of infrastructure development which has been a barrier to new investments in the region.

As soon as the Arapucel Project is fully operational, it will benefit approximately two-hundred-forty thousand inhabitants of the southwest of the State of Mato Grosso covering an area over 75 thousand km², and generating 350 direct jobs. This new, more reliable supply of electricity is the main social and economic catalyst in a region that shows substantial growth in farming and cattle breeding.

The exact geographical coordinate of the Arapucel Project plants are (Figure 5):

- Alto Jauru - 15° 02' 47'' south latitude, 58° 45' 09'' west longitude
- Indiavaí - 15° 15' 49'' south latitude, 58° 43' 12'' west longitude
- Ombreiras - 15° 02' 23'' south latitude, 58° 44' 03'' west longitude

A.4.2. Category(ies) of project activity



Renewable electricity generation for a grid

A.4.3. Technology to be employed by the project activity

The Francis turbine, used in the PCH Alto Jauru and PCH Indiavaí, is the most widely used among water turbines (Figure 6). This turbine is a type of hydraulic reactor turbine in which the flow exits the turbine blades in the radial direction. Francis turbines are common in power generation and are used in applications where high flow rates are available at medium hydraulic head. Water enters the turbine through a volute casing and is directed onto the blades by wicket gates. The low momentum water then exits the turbine through a draft tube. In the model, water flow is supplied by a variable speed centrifugal pump. A load is applied to the turbine by means of a magnetic brake, and torque is measured by observing the deflection of calibrated springs. The performance is calculated by comparing the output energy to the energy supplied.

PCH Ombreiras will use different turbine technology. Ombreiras will set up two Kaplan turbines to generate electricity (Figure 7). Kaplan turbines are well suited to situations in which there is a low head and a large amount of discharge. The adjustable runner blades enable high efficiency during partial load periods, and there is a very small decrease in efficiency due to head variation or load. As a result of recent developments, the range of Kaplan turbine applications have been greatly increased. They are being applied, for example, in exploiting many hydro sources previously discarded for economic or environmental reasons. The adjustable runner blades add to the complexity of the construction of a Kaplan turbine. The runner blade operating mechanism consists of a pressure oil head, a runner servomotor, and the blade operating rod inside the shaft.

The equipment and technology used in the Arapucel Project has been successfully applied to similar projects in Brazil and around the world. Technical description of the facilities follows.

PCH Alto Jauru:

- Average flow rate (critical period): 30.00 m³/s
- Average flow rate (long time period): 39.00 m³/s
- Reservoir area: 0.14 km²
- Useful reservoir volume (10³ m³): 0.38
- Maximum reservoir volume (10³ m³): 0.38
- Head: 44.70 m
- Installed capacity: 20 MW
- Turbine: 2 Vatech Francis Turbine, horizontal axis, 257 rpm
- Generator: 2 Toshiba synchronous, 11.7 MVA, 13.8 kV, 60 Hz
- Nominal Turbine flow rate: 26.00 m³/s

PCH Indiavaí:

- Average flow rate (critical period): 31.00 m³/s



- Average flow rate (long time period): 70.00 m³/s
- Reservoir area: 0.38 km²
- Useful reservoir volume (10³ m³): 3.45
- Maximum reservoir volume (10³ m³): 3.45
- Head: 32.10 m
- Installed capacity: 28 MW
- Turbine: 4 Vatech Francis Turbine, horizontal axis, 257 rpm
- Generator: 2 Toshiba synchronous generators 17.5 MVA, 13.8 kV, 60 Hz.
- Nominal Turbine flow rate: 24.3 m³/s

PCH Ombreiras:

- Average flow rate (critical period): 50.20 m³/s
- Average flow rate (long time period): 76.00 m³/s
- Reservoir area: 2.9 km²
- Useful reservoir volume (10³ m³): 14.83
- Maximum reservoir volume (10³ m³): 29.08
- Head: 31.92 m
- Installed capacity 26 MW
- Turbine: 2 Kaplan – Type S
- Nominal Turbine flow rate: 48.00 m³/s

The operation and maintenance of the facilities are administered by Alstom, a leading worldwide energy company. The activities managed by Alstom are divided in two sub-activities:

- Maintenance Support: Breakdown support and technical assistance
- Operations and Maintenance (O&M): Maintenance Engineering and Remote control implementation.

The company is training the local staff through a combination of theory instruction and practical training. By maintaining in-house O&M competence levels, Arapucel has developed preventive and condition-based maintenance.

Technical and operational personnel already employed:

- PCH Indiavaí: 5 operational technicians and 12 maintenance technicians
- PCH Alto Jauru: 5 operational technicians and 10 maintenance technicians

There are also staff employees working in both facilities: two engineers in the management of the power plants and five engineers at the technical support.

Of the total personnel working at the operational Arapucel Project power plants, 24 are from the region and 15 are from other parts of the country.



A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sector policies and circumstances

The Arapucel Project, a greenhouse (GHG) gas-free power generation project, will result in GHG emissions reductions as the result of the displacement of generation from fossil-fuel thermal plants that would have otherwise been delivered to the interconnected grid.

As Kartha et al. (2002) stated, “the crux of the baseline challenge for electricity projects clearly resides in determining the ‘avoided generation’, or what would have happened without the CDM or other GHG-mitigation project. The fundamental question is whether the avoided generation is on the ‘build margin’ (i.e. replacing a facility that would have otherwise been built) and/or ‘operating margin’ (i.e. affecting the operation of current and/or future power plants).”

The baseline emission factor is calculated as a combined margin consisting of the combination of operating margin and build margin factors. For the purpose of determining the build margin and the operating margin emission factors, a project electricity system is defined by the spatial extent of the power plants that can be dispatched without significant transmission constraints. Similarly a connected electricity system is defined as one which is connected by transmission lines to the project electricity system and in which power plants can dispatch without significant transmission constraints.

**A.4.4.1. Estimated amount of emission reductions over the chosen crediting period**

The full implementation of the Arapucel Project connected to the Brazilian South-Southeast-Midwest electricity interconnected grid will avoid a yearly estimated emission of around 227,000 tCO₂e (emission factor baseline of 452 kgCO₂e/MWh, detailed calculation in section E), and a total reduction of about 1,800,000 tCO₂e over 10 years (Table 2).

A.4.5. Public funding of the project activity

No public funding was and will be used in the present project.

**SECTION B. Application of a baseline methodology****B.1. Title and reference of the approved baseline methodology applied to the project activity**

ACM0002 - “Consolidated baseline methodology for grid-connected electricity generation from renewable sources”.

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity

The chosen methodology is applicable to grid-connected renewable power generation projects, under the condition of electricity capacity additions from run-of-river hydro power plants, as is the case with the Arapucel Project.

B.2. Description of how the methodology is applied in the context of the project activity

The Arapucel project is a renewable energy project connected to the electricity grid. The project fulfils all the “additionality” requisites (see application of the “additionality tool²” below) and demonstrates why the project would not occur in the absence of the CDM.

In a period of restructuring the entire electricity market, as is the current Brazilian situation, investment uncertainty is the main barrier for small renewable energy power projects. In this scenario these projects compete with existing plants (operating margin) and with new projects (build margin), which usually attract the attention of the financial market. Operating and Build Margins have been used to calculate the emission factor for the connected grid.

The methodology ACM0002 (2004), for grid-connected electricity generation from renewable sources, uses derived margins, which have been applied in the context of the project activity through the determination of the emissions factor for the South-Southeast-Midwest subsystem of the interconnected Brazilian grid (electricity system that is connected by transmission lines to the project electricity system and in which power plants can be dispatched without significant transmission constraints).

² Tool for the demonstration and assessment of additionality. UNFCCC, CDM Executive Board 16th Meeting Report, 22 October 2004, Annex 1. Web-site: <http://cdm.unfccc.int/>

**B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity**

To demonstrate additionality, the “tool to demonstrate and assess additionality” will be used.

Step 0. Preliminary screening based on the project start date:

- a) **Project Start date:** September 2002, Alto Jauru started its commission phase. Start-up occurred on October 2002 when the power plant delivered its first MWh to the interconnected grid.
- b) **Evidence demonstrates that CDM incentives were seriously considered in the development of The Arapucel project.** BK Energia Participações Ltda, a partnership between Koblitz Ltda. (Koblitz) and Brennand Group developed The Arapucel Project. Currently, the Brennand Energia, Ltda, a Brennand Group company owns the Arapucel Project.

Koblitz is a 100% Brazilian EPC³ contractor operating since 1975 in the area of energy systems, with solid know-how in industrial generation and cogeneration. Koblitz features a portfolio of over 200 projects in the areas of residual fuel oil, natural gas, coke oven gas, renewable energy sources (mainly agricultural residues as sugarcane bagasse, wood chips, rice straw and cashew nuts husks), and others.

Since 2000, Koblitz has formed several partnerships in order to invest in renewable energy projects throughout Brazil. In partnership with the Brennand Group, Koblitz developed the following renewable energy projects: Arapucel (small-hydro), Uruguaiana (rice husk fueled thermal power plant) and Itacoatiara (wood chips fueled thermal power plant). In another partnership with C.G.D.e, the Brazilian energy branch of the Portuguese bank Caixa Geral de Depósitos, the project developed was Piratini, C.G.D.e, Koblitz Energia S.A. (Piratini Project). In the second half of 2000, the Piratini project requested from the Brazilian government, through Ecoinvest, a position regarding its participation in the Clean Development Mechanism. In April 2001, the project received a non-objection letter from the Brazilian government (Figure 8) and in the beginning of 2002, Piratini, through Ecoinvest, negotiated 1,600 tCO₂e verified emission reductions with the Canadian government. The Piratini project, which is currently fully controlled by Koblitz, is the first project registered (V-AAA-001) in the Canadian GHG Reductions Registry (http://reductions.vcr-mvr.ca/er_masterprojects_e.cfm).

Through their experience with the Piratini project, Koblitz Ltda. developed the human capital and internal capabilities to apply CDM principles to future projects. By the end of 2000, all possible ventures by Koblitz Ltda. and the Brennand Group using renewable energy sources were analysed in order to evaluate their eligibility under the CDM. The impact of the CDM financial incentives was also considered in the development of the projects.

³ EPC – Engineering, Procurement and Construction

**Step 1. Identification of alternatives to the project activity consistent with current laws and Regulation****Sub-step 1a. Define alternatives to the project activity:**

1. The alternative to the project activity for the investors is the continuation of the current (previous) situation, with the investment of surplus capital in the financial market. The main project sponsor had no previous experience with the power market.

Sub-step 1b. Enforcement of applicable laws and regulations:

2. Not applicable.
3. Not applicable.
4. Non-applicable. Both the project activity and the alternative scenario are in compliance with all regulations.

Step 3. Barrier Analysis:

To substantiate the barrier analysis a brief overview of the Brazilian electricity market in the last years is first presented.

Until the beginning of the 1990's, the energy sector was composed almost exclusively of state-owned companies. From 1995 on, due to the increase of international interest rates and the lack of investment capacity of the State, the government was forced to look for alternatives. The solution recommended was to initiate a privatization process and the deregulation of the market.

The four pillars of the privatization process initiated in 1995 were:

- Building a competition friendly environment, with the gradual elimination of the captive consumer. The option to choose an electricity services supplier which began in 1998 for the largest consumers, and should be available to the entire market by 2006;
- Dismantling of the state monopolies, separating and privatizing the activities of generation, transmission and distribution;
- Allowing free access to the transmission lines, and
- Placing the operation and planning responsibilities to the private sector.

Three governmental entities were created: the Electricity Regulatory Agency, ANEEL set up to develop the legislation and to regulate the market; the National Electric System Operator, ONS, to supervise and control the generation, transmission and operation; and the Wholesale Electricity Market, MAE, to define rules and commercial procedures of the short-term market.

At the end of 2000, five years after privatization began, the results were modest (Figure 9). Despite high expectations, investments in new generation did not follow the increase in consumption.

The decoupling of GDP (average of 2% increase in the period of 1980 to 2000) from electricity consumption (average of 5% increase in the same period) is well known in developing countries, mainly due to the expansion of supply services to new areas and the growing infra-structure. The necessary measures to prevent bottlenecks in services were taken. These include an increase of generation capacity higher than GDP growth rates and strong investments in energy efficiency. In the Brazilian case, the



increase in the installed generation capacity (average of 4% in the same period) did not follow the growth of consumption as can be seen in Figure 10.

Without new installed capacity, the only alternatives were energy efficiency improvements or higher capacity utilization (capacity factor). Regarding energy efficiency, the government established in 1985 PROCEL (the National Electricity Conservation Program). Although the objectives of the program were commendable the results were limited, mainly due to insufficient investment and poorly managed strategies.

The remaining alternative, to increase the capacity factor of the older plants, was the most widely used, as can be seen in Figure 11. To understand if such increase in capacity factor brought positive or negative consequences one needs to analyze the availability and price of fuel. In the Brazilian electricity model the primary energy source is the water accumulated in reservoirs. Figure 12 shows what happened to the levels of “stored energy” in the reservoirs from January 1997 to January 2002. It can be seen that reservoirs which were planned to withstand 5 years of less-than-average rainy seasons, almost collapsed after a single season of low rainfall (2000/2001 experienced 74% of the historical average rain. This situation depicts a very intensive use of the country’s hydro resources to support the increase in demand without increase of installed capacity. Under the situation described there was still no long-term solution for the problems that finally caused shortage and rationing in 2001.

Aware of the difficulties since the end of the 1990’s, the Brazilian government signaled that it was strategically important for the country to increase thermoelectric generation and consequently be less dependent on hydropower. With that in mind the federal government launched at the beginning of the year of 2000 the *Thermoelectric Priority Plan (PPT, “Plano Prioritário de Termelétricas”*, Federal Decree 3,371 of February 24th, 2000, and Ministry of Mines and Energy Directive 43 of February 25th, 2000), originally planning the construction of 47 thermo plants using Bolivian natural gas, totaling 17,500 MW of new installed capacity to be completed by December 2003. During 2001 and the beginning of 2002 the plan was reduced to 40 plants and 13,637 MW to be installed by December 2004 (Federal Law 10,438 of April 26th, 2002, Article 29). As of December 2004, only 20 plants totaling around 9,700 MW were operational.

During the rationing of 2001 the government also launched the *Emergency Energy Program* with the short-term goal of building 58 small to medium thermal power plants until the end of 2002 (using mainly diesel oil, 76,9 %, and residual fuel oil, 21.1 %), totalizing 2,150 MW power capacity (CGE-CBEE, 2002).

It is clear that hydroelectricity is and will continue to be the main source for the electricity base load in Brazil. However, most if not all-hydro resources in the South and Southeast of the country have been exploited, and most of the remaining reserves are located in the Amazon basin, far from the industrial and population centers (OECD, 2001). Clearly, new additions to Brazil’s electric power sector are shifting from hydroelectricity to natural gas plants (Schaeffer *et al.*, 2000). With discoveries of vast reserves of natural gas in the Santos Basin in 2003 (Figure 13) the policy of using natural gas to generate electricity remains a possibility and will continue to have interest from private-sector investments in the Brazilian energy sector.

In power since January 2003, the newly elected government decided to fully review the electricity market institutional framework. A new model for the electricity sector was approved by Congress in March 2004. The new regulatory framework for the electricity sector has the following key features (OECD, 2005):



- Electricity demand and supply will be coordinated through a “Pool” Demand to be estimated by the distribution companies, which will have to contract 100 per cent of their projected electricity demand over the following 3 to 5 years. These projections will be submitted to a new institution (*Empresa de Planejamento Energético*, EPE), which will estimate the required expansion in supply capacity to be sold to the distribution companies through the Pool. The price at which electricity will be traded through the Pool is an average of all long-term contracted prices and will be the same for all distribution companies.
- In parallel to the “regulated” long-term Pool contracts, there will be a “free” market. Although in the future, large consumers (above 10 MW) will be required to give distribution companies a 3-year notice if they wish to switch from the Pool to the free market and a 5-year notice for those moving in the opposite direction a transition period is envisaged during which these conditions will be made more flexible. These measures should reduce market volatility and allow distribution companies to better estimate market size. If actual demand turns out to be higher than projected, distribution companies will have to buy electricity in the free market. In the opposite case, they will sell the excess supply in the free market. Distribution companies will be able to pass on to end consumers the difference between the costs of electricity purchased in the free market and through the Pool if the discrepancy between projected and actual demand is below 5 per cent. If it is above this threshold, the distribution company will bear the excess costs.
- The government opted for a more centralized institutional set-up, reinforcing the role of the Ministry of Mines and Energy in long-term planning. EPE will submit to the Ministry its desired technological portfolio and a list of strategic and non-strategic projects. In turn, the Ministry will submit this list of projects to the National Energy Policy Council (*Conselho Nacional de Política Energética*, CNPE). Once approved by CNPE, the strategic projects will be auctioned on a priority basis through the Pool. Companies can replace the non-strategic projects proposed by EPE, if their proposal offers the same capacity for a lower tariff. Another new institution is a committee (*Comitê de Monitoramento do Setor Elétrico*, CMSE), which will monitor trends in power supply and demand. If any problem is identified, CMSE will propose corrective measures to avoid energy shortages, such as special price conditions for new projects and reserve of generation capacity. The Ministry of Mines and Energy will host and chair this committee. No major further privatizations are expected in the sector.

Although the new model reduces market risk, its ability to encourage private investment in the electricity sector will depend on how the new regulatory framework is implemented. Several challenges are noteworthy in this regard. *First*, the risk of regulatory failure that might arise due to the fact that the government will have a considerable role to play in long-term planning should be avoided by enhancing the Ministry of Mines and Energy’s technical capabilities, while insulating the new institutions from political interference. *Second*, rules will need to be designed for the transition from the current to the new model to allow current investments to be rewarded adequately. *Third*, because of its small size, price volatility may increase in the short-term electricity market, in turn bringing about higher investment risk, albeit this risk will be attenuated by the role of large consumers. The high share of hydropower in Brazil’s energy mix and uncertainty over rainfall also contribute to higher volatility of the short-term electricity market. *Fourth*, although the new model will require total separation between generation and distribution, regulations for the unbundling of vertically-integrated companies still have to be defined. Distribution companies are currently allowed to buy up to 30 per cent of their electricity from their own subsidiaries



(self-dealing). *Finally*, the government's policy for the natural gas sector needs to be defined within a specific sectoral framework.

Sub-step 3a. Identify barriers that would prevent the implementation of type of the proposed project activity

Investment Barrier

In order to analyse accurately the investment environment in Brazil, the Brazilian Prime Rate, known, as SELIC rate, as well as the CDI – Interbank Deposit Certificate, which is the measure of value of value in the short-term credit market, need to be taken into account. Real interest rates have been extraordinarily high since the Real plan stabilized inflation in 1994.

As a consequence of the long period of inflation, the Brazilian currency experienced a strong devaluation, effectively precluding commercial banks from providing any long-term debt financing. The lack of a long-term debt market has caused a severe negative impact on the financing of energy projects in Brazil.

Interest rates for local currency financing are significantly higher than for US Dollar financing. The National Development Bank – BNDES is the only supplier of long-term loans. Debt financing from BNDES are made primarily through commercial banks. The credit market is dominated by shorter maturities (90-days to 1-year) and long-term credit lines are available only to the strongest corporate borrowers and for special government initiatives. Credit is restricted to the short-term in Brazil or the long-term in dollars offshore.

Financial domestic markets with a maturity of greater than 1 year are practically non-existent in Brazil. Experience has shown that in moments of financial stress the duration of savings instruments have contracted to levels close to one day with a massive concentration in overnight banking deposits. Savers do not hold long-term financial contracts due to the inability to price-in the uncertainty involved in the preservation of purchasing power value. (Arida et al., 2005).

The lack of a local long-term market results not from a disinterest of financial investment opportunities, but from the reluctance of creditors and savers to lengthen the term of their placements. It has made savers opt for the most liquid investments and to place their money in short-term government bonds instead of investing in long-term opportunities that could finance infrastructure projects.

The most liquid government bond is the LFT (floating rate bonds based on the daily Central Bank reference rate). As of January 2004, 51.1% of the domestic federal debt was in LFTs and had duration of one day. This bond rate is almost the same as the CDI - Interbank Deposit Certificate rate that is influenced by the SELIC rate, defined by COPOM⁴.

The SELIC Rate has been very volatile ranging from a minimum of 15% p.a. in January 2001 to a maximum of 45% p.a. in March 1999 (Figure 14).

The ARAPUCCEL project is being developed on a project finance basis. To finance construction, project sponsor (Brennand Energia) took advantage of the financing lines of BNDES. This financial support covers 80% of the project costs with a rate of TJLP (BNDES Long Term Interest Rate – 10%) plus a 5% spread risk for a term of 8-years and grace period of 1-year.

4 COPOM – Comitê de Política Monetária (Monetary Policy Committee).



As can be seen in the worksheet FCF_AltoJauru(CER).xls⁵ and FCF_Indiavai(CER), the facilities were set up with an expected financial ROE – Return on Equity of approximately 17% per year. The ROE is very similar to the SELIC rate in effect at the time of financing although the project is a riskier investment as compared to Brazilian government bonds. The inclusion of the revenues from CERs makes the investor's ROE increase by approximately 200 basis points, from 18% to 20% (Table 3, Table 4 and Table 5). Such increase in return would compensate for the additional risk investor would take with this project.

In addition to the increase of 200 basis points, CER revenues would bring the project additional benefits due to the fact that they are generated in hard currencies (USD or EUR). The CDM incentive allows Brennand Energia to hedge its debt cash flow against currency devaluation. Moreover, the CER Free Cash Flow, in US dollars or EURO, could be discounted at an applicable discount interest rate, thus increasing the project leverage.

The high level of guarantees required to finance an energy project in Brazil is a barrier for developing new projects. Insurance, financial guarantees, financial advisories are requirements which increase the cost of the project and are barriers to project achievability.

Other financial barriers are related to the power purchase agreement (PPA). The PPA is required in order to obtain long-term financing from a bank and the lack of adequate commercial agreements from the energy buyers may influence directly the negotiation between the bank and the project developer. Most of the utilities in Brazil do not have a satisfactory credit risk thus representing a barrier to obtain long-term funding.

The conclusion is that CDM incentives play a very important role in overcoming financial barriers.

Lack of Infrastructure

The region where the project is located is isolated and undeveloped. There is a lack of infrastructure such as roads, reliable electricity, communication and transportation. The project sponsors had to develop these facilities before the implementation of the project. In addition there were no qualified personnel available in the region due of the lack of schools and universities.

Institutional Barrier

As described above, since 1995 government electricity market policies have been continuously changing in Brazil. Too many laws and regulations were created to try to organize and to provide incentives for new investments in the energy sector. The results of such regulatory instability were the contrary to what was trying to be achieved. During the rationing period electricity prices surpassed BRL 600/MWh (around USD 200/MWh) and the forecasted marginal price of the new energy reached levels of BRL 120 – 150/MWh (around USD 45). In the middle of 2004 the average price was bellow BRL 50/MWh (less than USD 20/MWh). The high volatility of the electricity price in Brazil indicates an inconsistency in government policies and there is no guarantee that the project will operate in a secure regulatory energy market.

5 Available upon request.



Sub-step 3b. Show that the identified barriers would not prevent the implementation of at least one of the alternatives:

As described above, the main alternative to the project activity is to continue the status quo. The project sponsor could invest their resources in different financial market investments. Therefore the barriers above have not affected the investment in other opportunities. To the contrary Brazilian interest rates, which represent a barrier for the project activity, is a viable investment alternative.

Step 4. Common practice analysis:

One of the points to be considered when analyzing a small hydro project investment in the period (2001-2005) was the possibility to participate in the Proinfa Federal Government Program. Although some projects started construction independently from Proinfa, the program is considered one of the more viable financing alternatives for these projects, which will provide long-term PPAs and special financing conditions. Arapucel is not participating in the program and is addressing the market risk as it structures its projects.

Both processes of negotiating a PPA with utility companies and obtaining funding from BNDES have proved to be very cumbersome. BNDES also requires excessive guarantees in order to provide financing. Other risks and barriers are related to the operational and technical issues associated with small hydros, including their capability to comply with the PPA contract and the potential non-performance penalties.

Regardless of the risks and barriers mentioned above, the main reason for the reduced number of similar project activities is the economic cost. Project feasibility requires a PPA contract with a utility company, but the utilities do not have the incentives or motivation to buy electricity generated by small hydro projects.

Because of the reasons mentioned above, only 1.3% of installed capacity comes from small hydro sources (1.2 GW out of a total of 88.7 GW). Also, from the 6,934 MW under construction in the country, only 403 MW are small hydro. In 2004, only 9 small-hydro projects, a total of just 5.22 MW, were authorized by the regulatory agency⁶. Many other projects are still under development, waiting for better investment opportunities. Most of the developers which funded their projects outside of Proinfa have taken CDM as decisive factor for completing their projects. Therefore, to the best of our knowledge the vast majority of similar projects being developed in the country are participating in the Proinfa Program and those not are participating in the CDM. Additionally, the Brazilian government has stated that the projects under the Proinfa Program will also be eligible to participate in the CDM. The legislation which created Proinfa took into account possible revenues from the CDM in order to proceed with the program.

Step 5 – Impact of CDM Registration

According to Brazilian legislation⁷ small hydro power plants must have installed capacity greater than 1 MW but not more than 30 MW and with reservoir area less or equal to 3 km². Generally, it consists of a run-of-the-river hydro plant, with minimum environmental impact.

This project activity is not the business-as-usual scenario in the country where large hydro and natural gas fired thermal power projects represent the majority of new installed capacity. With the financial benefit derived from the CERs, it is anticipated that other project developers would benefit from this new source of revenue and then would decide to develop such projects. An increase of approximately

⁶ ANEEL – Agência Nacional de Energia Elétrica (National Power Regulatory Agency)

⁷ As defined by ANEEL Resolution n. 394, December 4th, 1998.



100 to 200 basis points, derived from CERs is an important factor in determination to implement the project.

CDM has made it possible for some investors to set up their small hydro plants and sell their electricity to the grid. The registration of the proposed project activity will have a strong impact in paving the way for similar projects to be implemented in Brazil.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity

The project boundaries are defined by the emissions targeted or directly affected by the project activities, construction and operation. It encompasses the physical, geographical site of the hydropower generation source, which is represented by the Jauru River basin close to the power plant facility and the interconnected grid.

Brazil is a large country and is divided in five macro-geographical regions, North, Northeast, Southeast, South and Midwest. The majority of the population is concentrated in the regions South, Southeast and Northeast regions. Thus the energy generation and, consequently, the transmission are concentrated in three subsystems. The energy expansion has concentrated in three specific areas:

- Northeast: The electricity for this region is basically supplied by the São Francisco River. There are seven hydro power plants on the river with total installed capacity of approximately 10.5 GW.
- South/Southeast/Midwest: The majority of the electricity generated in the country is concentrated in this subsystem. These regions also concentrate 70% of the GDP generation in Brazil. There are more than 50 hydro power plants generating electricity for this subsystem.
- North : 80% of the Northern region is supplied by diesel. However, in the city of Belém, capital of the state of Pará where the mining and aluminum industries are located, electricity is supplied by Tucuruí, the second biggest hydro plant in Brazil.

The boundaries of the subsystems are defined by the capacity of transmission. The transmission lines between the subsystems have a limited capacity and the exchange of electricity between those subsystems is difficult. The lack of transmission lines forces the concentration of the electricity generated in each own subsystem. Thus the South-Southeast-Midwest interconnected subsystem of the Brazilian grid where the project activity is located is considered as a boundary.

Part of the electricity consumed in the country is imported from other countries. Argentina, Uruguay and Paraguay supply a very small amount of the electricity consumed in Brazil. In 2003 around 0.1% of the electricity was imported from these countries. In 2004 Brazil exported electricity to Argentina which was experiencing a shortage period. The energy imported from other countries does not affect the boundary of the project and the baseline calculation.

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline



Mr. Ricardo Esparta, director of Ecoinvest (contact details listed in annex I).



SECTION C. Duration of the project activity / Crediting period

C.1. Duration of the project activity

C.1.1. Starting date of the project activity

September 2002

C.1.2. Expected operational lifetime of the project activity

20y-0m

C.2. Choice of the crediting period and related information

C.2.1. Renewable crediting period

Not applicable

C.2.1.1. Starting date of the first crediting period

Not applicable

C.2.1.2. Length of the first crediting period

Not applicable

C.2.2. Fixed crediting period

C.2.2.1. Starting date



September 2002

C.2.2.2. Length

10y-0m

**SECTION D. Application of a monitoring methodology and plan****D.1. Name and reference of approved monitoring methodology applied to the project activity**

Approved consolidated monitoring methodology ACM0002 – “Consolidated monitoring methodology for zero-emissions grid-connected electricity generation from renewable sources” (ACM0002, 2004).

D.2. Justification of the choice of the methodology and why it is applicable to the project activity

This monitoring methodology shall be used in conjunction with the approved baseline methodology ACM0002 (“Consolidated baseline methodology for grid-connected electricity generation from renewable sources”) and applies to electricity capacity additions from run-of-river hydro power plants

The methodology is applicable to the project activity. It consists in using meter equipment projected to registry and verify bi-directionally the energy generated by the facility. This energy measurement is fundamental to verify and monitor the GHG emission reductions. The Monitoring Plan permits the calculation of GHG emissions generated by the project activity in a straightforward manner, applying the baseline emission factor.

D.2.1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

Based on the hydropower technology, the project emissions (PE_y) are zero, therefore table D.2.1.1 below is empty.

**D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived**

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (Electronic/ paper)	Comment

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_{2e})

Based on the hydropower technology, the project emissions (PE_y) are zero, therefore no formula for calculation of direct emissions are necessary.

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (Electronic/ paper)	Comment
1. EG_y	Electricity generation of the Project delivered to grid	Energy metering connected to the grid and Receipt of Sales	MWh	M	15-minutes-measurement and Monthly recording	100%	Electronic and Paper	The electricity delivered to the grid is monitored by the Project as well as by the energy buyer.
2. EF_y	CO ₂ emission factor of the grid	Calculated	tCO ₂ /MWh	C	At the validation	n.a.	Electronic and Paper	Data will be archived during the credit period according to internal



								<i>procedures.</i>
3. $EF_{OM,y}$	<i>CO₂ Operating Margin emission factor of the grid</i>	<i>Data provided by ONS (National dispatch center). Calculated according the approved methodology – ACM0002</i>	tCO_2/MWh	<i>C</i>	<i>At the validation</i>	<i>n.a.</i>	<i>Electronic and Paper</i>	<i>Data will be archived during the credit period according to internal procedures.</i>
4. $EF_{BM,y}$	<i>CO₂ Build Margin emission factor of the grid</i>	<i>Data provided by ONS. Calculated according the approved methodology – ACM0002</i>	tCO_2/MWh	<i>C</i>	<i>At the validation</i>	<i>n.a.</i>	<i>Electronic and Paper</i>	<i>Data will be archived during the credit period according to internal procedures.</i>
5. λ_y	<i>Fraction of time during which low-cost/must-run sources are on the margin</i>	<i>Data provided by ONS. Calculated according the approved methodology – ACM0002</i>		<i>C</i>	<i>At the validation</i>	<i>n.a.</i>	<i>Electronic and Paper</i>	<i>Data will be archived during the credit period according to internal procedures.</i>

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_{2e})

According to the selected approved methodology (ACM0002, 2004), the baseline emission factor is calculated as (EF_y) is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors. For the purpose of determining the build margin and the operating margin emission factors, a project electricity system is defined by the spatial extent of the power plants that can be dispatched without significant transmission constraints. Similarly a connected electricity system is defined as an electricity system that is connected by transmission lines to the project electricity system and in which power plants can be dispatched without significant transmission constraints.

From ACM0002 (2002), a baseline emission factor (EF_y) is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors according to the following three steps:

- **STEP 1** - Calculate the operating margin emission factor(s), based on one of the following methods



- Simple operating margin
- Simple adjusted operating margin
- Dispatch data analysis operating margin
- Average operating margin.

The second alternative, simple adjusted operating margin, will be used here.

The simple adjusted operating margin emission factor ($EF_{OM,adjusted,y}$ in tCO₂/MWh) is a variation on the simple operating margin, where the power sources (including imports) are separated in low-cost/must-run power sources (k) and other power sources (j):

$$EF_{OM,simple-adjusted,y} = (1 - \lambda_y) \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_j GEN_{j,y}} + \lambda_y \cdot \frac{\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}}{\sum_k GEN_{k,y}}$$

Equation 1

Where:

- λ_y is the share of hours in year y (in %) for which low-cost/must-run sources are on the margin.
- $\sum_{i,j} F_{i,j,y}$ is the amount of fuel i (in mass or volume unit) consumed by relevant power sources j (analogous for sources k) in year(s) y ,
- $COEF_{i,j}$ is the CO_{2e} coefficient of fuel i (tCO_{2e}/mass or volume unit of the fuel), taking into account the carbon dioxide equivalent emission potential of the fuels used by relevant power sources j (analogous for sources k) and the percent oxidation of the fuel in year(s) y and,
- $\sum_j GEN_{j,y}$ is the electricity (MWh) delivered to the grid by source j (analogous for sources k),
- **STEP 2** – Calculate the build margin mission factor ($EF_{BM,y}$) as the generation weighted average emission factor (tCO_{2e}/MWh) of a sample of power plants m , as follows:



$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_m GEN_{m,y}}$$

Equation 2

Where $F_{i,m,y}$, $COEF_{i,m}$ and $GEN_{m,y}$ are analogous to the variables described for the simple OM method (ACM0002, 2004) for plants m , based on the most recent information available on plants already built. The sample group m consists of either

- The five power plants that have been built most recently, or
- The power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Project participants should use from these two options that sample group that comprises the larger annual generation.

- **STEP 3** – Calculate the baseline emission factor EF_y , as the weighted average of the operating margin factor ($EF_{OM,y}$) and the build margin factor ($EF_{BM,y}$):

$$EF_y = w_{OM} \cdot EF_{OM,y} + w_{BM} \cdot EF_{BM,y}$$

Equation 3

Where the weights are by w_{OM} and w_{BM} , by default, are 50% (i.e., $w_{OM} = w_{BM} = 0.5$). Alternative weights can be used, as long as $w_{OM} + w_{BM} = 1$, and appropriate evidence justifying the alternative weights is presented.

D.2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E)

Not applicable.

**D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived**

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (Electronic/paper)	Comment

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_{2e})

Not applicable.

D.2.3. Treatment of leakage in the monitoring plan

Indirect emissions can result from project construction, transportation of materials and fuel and other upstream activities. Nevertheless no significant net leakage from these activities was identified.

Project emissions in the form of methane can also result from the construction and operation of a water reservoir if biomass is permanently submerged in the process. The projects under the project activity are run-of-river hydropower plants, therefore only have minor reservoirs and no significant methane emissions from biomass decay.

**D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity**

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (Electronic/ paper)	Comment

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_{2e})

Not applicable.

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO₂ equivalent)

Based on the hydropower technology, the project emissions (PE_y) are zero, therefore no formula for calculation of direct emissions are necessary.

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored

Data (Indicate table and ID number e.g. 3.1; 3.2.)	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
D.2.1.3-1.	Low	These data will be used for calculate the emission reductions.



<i>D.2.1.3-2.</i>	<i>Low</i>	<i>Data does not need to be monitored</i>
<i>D.2.1.3-3.</i>	<i>Low</i>	<i>Data does not need to be monitored</i>
<i>D.2.1.3-4.</i>	<i>Low</i>	<i>Data does not need to be monitored</i>
<i>D.2.1.3-5.</i>	<i>Low</i>	<i>Data does not need to be monitored</i>

D.4. Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

Not applicable.

D.5. Name of person/entity determining the monitoring methodology

Mr. Ricardo Esparta, director of Ecoinvest (contact details listed in annex I).

**SECTION E. Estimation of GHG emissions by sources****E.1. Estimate of GHG emissions by sources**

Based on the hydropower technology, the project emissions (PE_v) are zero. Therefore, no calculation of estimate of GHG emissions is necessary.

E.2. Estimated leakage

Indirect emissions can result from project construction, transportation of materials and fuel and other upstream activities. Nevertheless no significant net leakage from these activities was identified.

Project emissions in the form of methane can also result from the construction and operation of a water reservoir if biomass is permanently submerged in the process. The projects under the project activity are run-of-river hydropower plants, therefore only have minor reservoirs and no significant methane emissions from biomass decay.

E.3. The sum of E.1 and E.2 representing the project activity emissions

Given there are no entries for both E.1 and E.2, the sum in E.3 is zero.

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline

According to the selected approved methodology (ACM0002, 2004), the baseline emission factor is defined as (EF_v) and is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors. For the purpose of determining the build margin and the operating margin emission factors, a project electricity system is defined by the spatial extent of the power plants that can be dispatched without significant transmission constraints. Similarly a connected electricity system is defined as an electricity system that is connected by transmission lines to the project electricity system and in which power plants can be dispatched without significant transmission constraints.

Brazil's electric power system is geographically divided in 5 macro-regions: South (S), Southeast (SE), Midwest (CO, from the Portuguese *Centro-Oeste*), North (N) and Northeast (NE). Regarding the electricity system, three different electric systems supply the five macro-regions of the country. The largest interconnected power transmission system, which includes the Southeast, South, and Mid-West regions, accounts for more than 70% of the Brazilian total installed capacity. It includes the hydroelectric power plant of Itaipu, and the only two nuclear power plants currently in operation in Brazil: Angra I (657 MW), and Angra II (1309 MW). The second interconnected grid system connects the north and



northeast regions, accounting for almost 25% of the Brazilian total installed capacity. Finally, the third system includes small, independent grids that are isolated in terms of electric power, largely in the northern region. These isolated systems accounted for less than 5% and are based mainly on thermal power plants (SIESE, 2002).

The Arapucel project is located in the State of Mato Grosso and is integrated to the South-Southeast-Midwest (S-SE-CO) connected electricity system.

From ACM0002 (2002), a baseline emission factor (EF_y) is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors according to the following three steps:

- **STEP 1** - Calculate the operating margin emission factor(s), based on one of the following methods
 - Simple operating margin
 - Simple adjusted operating margin
 - Dispatch data analysis operating margin
 - Average operating margin.

Dispatch data analysis operating margin should be the first methodological choice. Since not enough data was supplied by the Brazilian national dispatch center, the choice is not currently available. The simple operating margin can only be used where low-cost/must-run resources⁸ constitute less than 50% of total grid generation in: 1) average of 5 most recent years, or 2) based on long-term normals for hydroelectricity production. Table 10 shows the share of hydroelectricity in the total electricity production for the Brazilian S-SE-CO interconnected system. However, the results show the non-applicability of the simple operating margin to the Arapucel project.

The fourth alternative, an average operating margin, is an oversimplification and, due to the high share of a low operating cost/must run resource (hydro), does not reflect at all the impact of the project activity in the operating margin. Therefore, the simple adjusted operating margin will be used here.

The simple adjusted operating margin emission factor ($EF_{OM,adjusted,y}$ in tCO₂/MWh) is a variation on the simple operating margin, where the power sources (including imports) are separated in low-cost/must-run power sources (k) and other power sources (j):

$$EF_{OM,simple-adjusted,y} = (1 - \lambda_y) \cdot \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_j GEN_{j,y}} + \lambda_y \cdot \frac{\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}}{\sum_k GEN_{k,y}} \quad \text{Equation 4}$$

Where:

- λ_y is the share of hours in year y (in %) for which low-cost/must-run sources are on the margin.

⁸ Low operating cost and must run resources typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation (ACM0002, 2004).



- $\sum_{i,j} F_{i,j,y}$ is the amount of fuel i (in mass or volume unit) consumed by relevant power sources j (analogous for sources k) in year(s) y ,
- $COEF_{i,j}$ is the CO_{2e} coefficient of fuel i (tCO_{2e}/mass or volume unit of the fuel), taking into account the carbon dioxide equivalent emission potential of the fuels used by relevant power sources j (analogous for sources k) and the percent oxidation of the fuel in year(s) y and,
- $\sum_j GEN_{j,y}$ is the electricity (MWh) delivered to the grid by source j (analogous for sources k),

The most recent numbers for the interconnected S-SE-CO system were obtained from the Brazilian national dispatch center, ONS (from the Portuguese *Operador Nacional do Sistema Elétrico*) in the form of daily consolidated reports (ONS-ADO, 2004). Data from 120 power plants, comprising 63.6 GW installed capacity and around 828 TWh electricity generation over the 3-year period were considered. With the numbers from ONS, Equation 5 is calculated, as described below:

$$EF_{OM,y} = \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_j GEN_{j,y}} \quad \text{Equation 5}$$

Where:

- $EF_{OM,y}$ is the simple operating margin emission factor (in tCO₂/MWh), or the emission factor for low-cost/must-run resources by relevant power sources j in year(s) y .

Low-cost/must-run resources in Brazilian S-SE-CO interconnected system are hydro and thermonuclear power plants, considered free of greenhouse gases emissions, i.e., $COEF_{i,j}$ for these plants is zero. Hence, the emission factor for low-cost/must-run resources results, $EF_{OM,y} = 0$.

$$EF_{OM-non,y} = \frac{\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}}{\sum_k GEN_{j,k}} \quad \text{Equation 6}$$

Where:

- $EF_{OM-non,y}$ is emission factor for **non**-low-cost/must-run resources (in tCO₂/MWh) by relevant power sources k in year(s) y .

Non-low-cost/must-run resources in Brazilian S-SE-CO interconnected system are thermopower plants burning coal, fuel oil, natural gas and diesel oil. These plants result in non-balanced emissions of greenhouse gases, calculated as follows:

The product $\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}$ for each one of the plants was obtained from the following formulae:



$$F_{i,k,y} = \frac{GEN_{i,k,y} \cdot 3,6 \times 10^{-6}}{\eta_{i,k,y} \cdot NCV_i} \quad \text{Equation 7}$$

$$COEF_{i,k} = NCV_i \cdot EF_{CO2,i} \cdot 44/12 \cdot OXID_i \quad \text{Equation 8}$$

$$\text{Hence, } F_{i,k,y} \cdot COEF_{i,k} = \frac{GEN_{i,k,y} \cdot EF_{CO2,i} \cdot OXID_i \cdot 44/12 \cdot 3,6 \times 10^{-6}}{\eta_{i,k,y}} \quad \text{Equation 9}$$

Where variable and parameters used are:

- $\sum_{i,j} F_{i,j,y}$ is given in [kg], $COEF_{i,j}$ in [tCO₂e/kg] and $F_{i,k,y} \cdot COEF_{i,k}$ in [tCO₂e]
- $GEN_{i,k,y}$ is the electricity generation for plant k , with fuel i , in year y , obtained from the ONS database, in MWh
- $EF_{CO2,i}$ is the emission factor for fuel i , obtained from the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, in tC/TJ.
- $OXID_i$ is the oxidization factor for fuel i , obtained from the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, in %.
- 44/12 is the carbon conversion factor, from tC to tCO₂.
- $3,6 \times 10^{-6}$ is the energy conversion factor, from MWh to TJ.
- $\eta_{i,k,y}$ is the thermal efficiency of plant k , operating with fuel i , in year y , obtained from Bosi et al. (2002).
- NCV_i is the net calorific value of fuel i [TJ/kg].

$\sum_{k,y} GEN_{k,y}$ is obtained from the ONS database, as the summation of non-low-cost/must-run resources electricity generation, in MWh.

The λ_y factors are calculated as indicated in methodology ACM0002, with data obtained from the ONS database. Figures 16, 17 and 18 present the load duration curves and λ_y calculations for years 2001, 2002 and 2003, respectively.

The results for years 2001, 2002 and 2003 are presented in Table 7.

With the numbers from ONS, the first step was to calculate the lambda factors and the emission factors for the simple operating margin. The obtained values can be seen in Table 6, Figure 16, Figure 17 and Figure 18.

Finally, applying the obtained numbers to calculate $EF_{OM, \text{simple-adjusted}, 2001-2003}$ as the weighted average of $EF_{OM, \text{simple-adjusted}, 2001}$, $EF_{OM, \text{simple-adjusted}, 2002}$ and $EF_{OM, \text{simple-adjusted}, 2003}$ and λ_y to Equation 1:

$$\bullet \quad EF_{OM, \text{simple-adjusted}, 2001-2003} = 0.452 \text{ tCO}_2\text{e/MWh.}$$

- **STEP 2** – Calculate the build margin mission factor ($EF_{BM,y}$) as the generation weighted average emission factor (tCO₂e/MWh) of a sample of power plants m , as follows:



$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_m GEN_{m,y}} \quad \text{Equation 10}$$

Where $F_{i,m,y}$, $COEF_{i,m}$ and $GEN_{m,y}$ are analogous to the variables described for the simple OM method (ACM0002, 2004) for plants m , based on the most recent information available on plants already built. The sample group m consists of either

- The five power plants that have been built most recently, or
- The power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Project participants should use from these two options that sample group that comprises the larger annual generation.

Applying the data from the Brazilian national dispatch center to Equation 2:

$$\bullet \quad EF_{BM,2003} = 0.096 \text{ tCO}_2/\text{MWh}.$$

- **STEP 3** – Calculate the baseline emission factor EF_y , as the weighted average of the operating margin factor ($EF_{OM,y}$) and the build margin factor ($EF_{BM,y}$):

$$EF_y = w_{OM} \cdot EF_{OM,y} + w_{BM} \cdot EF_{BM,y} \quad \text{Equation 11}$$

Where the weights are by w_{OM} and w_{BM} , by default, are 50% (i.e., $w_{OM} = w_{BM} = 0.5$). Alternative weights can be used, as long as $w_{OM} + w_{BM} = 1$, and appropriate evidence justifying the alternative weights is presented.

The document which originated the proposition of the adjusted operating margin emission factor for the calculation of baselines in the power sector (Kantha et al., 2002) states: “The choice of baseline for electricity projects often revolves around the choice between *operating margin* versus *build margin*, and the question of which best represents the source(s) of avoided generation. Some baseline scenarios or methodologies reflect the belief that a given project will have no effect on other power sector investments, either because it is too small or because it brings additional investment to a sector that is short on capital for new power plant investments. These scenarios are *operating margin* scenarios, in that they assume the principal effect of a new project would be on the operation of current or future power plants”.

The three Arapucel projects together account for 74 MW, representing an increase of around 0.12 % in the S-SE-CO electric system installed power, and that is an initial indication that alternative weights must be considered. Renewable energy projects, such as Arapucel, will have little or no effect on which plants are built or retired, and thus avoid generation mainly, if not only, from existing plants. Such an argument suggests that for smaller projects the *operating margin* provides a more relevant baseline than the *build margin*. Indeed, in Brazil, capital availability and other intangible factors (e.g. public policy instability) are the principal drivers.

Alternative weights proposed here are based not only on the argumentation above but also and mainly on the evidence that a sector crisis occurred in 2001 and 2002, an extreme event to be considered. During that time a restriction was imposed on consumers: a compulsory reduction of 20% in relation to the average electricity consumption in the period of May to July 2000. Considering that between January



and May 2001, the period immediately preceding the shortage, the average demand was around 6% higher than that of the same period of the previous year, the actual rationing was much greater than the 20% announced. In other words, during the second half of 2001 and the beginning of 2002 there was a cut of about 24.5% compared to a “business-as-usual” scenario. The rationing plan lasted for ten months, from June 1, 2001 through February 28, 2002, causing a GDP growth reduction of 1.0 to 1.5% (Pinto Júnior, 2003).

It is interesting to compare the numbers that arose from the ex-post monitoring based on the national dispatch center data (ONS, 2004) obtained above and the ones from an ex-ante study by the International Energy Agency (Bosi et al., 2002), prepared without taking fully into account the impact of the rationing period of 2001-2002. The assumptions announced in the study were made specifically for private initiative and government investment plans in the power sector and a rationally operated system. The study represented at that time a very likely business as usual scenario, and it helped interested investors seriously considering the incentive from the CDM to evaluate the impact of the mechanism in their decision to proceed with their project activities, including among them the Arapucel Project investors (Table 8).

Also as an evidence of the impact it can be noted that in the analyzed period, 19 centrally dispatched plants started operation, totalizing 3,673.8 MW of installed power using natural gas and 2,436.5 MW of installed hydropower plants (Table 9).

In Table 09 it can be seen that the natural gas fired power plants operated at a capacity factor weighted average of around 21.3%, clearly a distortion when compared to business-as-usual investments in these kind of power plants, while the hydropower plants operated at 37.4% weighted average capacity factor. For specific plants the reasoning should be expanded, for example, the Araucária natural gas power plant almost did not operate in 2003 due to judicial dispute. Nevertheless the origin of the dispute can be traced to the extreme reduction in demand caused by the 2001-2002 crisis.

From the above mentioned evidence it is clear that the Arapucel project has practically no influence in the build margin and, therefore, the proposed weights to be applied in Equation 3 are, $w_{OM} = 1$ and $w_{BM} = 0$. With these numbers:

- $EF_{2003} = 0.452 \text{ tCO}_2\text{e/MWh}$.

E.5. Difference between E.4 and E.3 representing the emission reductions of the project activity

The emission reductions by the project activity (ER_y) during a given year y are the product of the baseline emissions factor (EF_y , in $\text{tCO}_2\text{e/MWh}$) times the electricity supplied by the project to the grid (EG_y , in MWh), as follows:

$$ER_y = EF_y \cdot EG_y \quad \text{Equation 12}$$

E.6. Table providing values obtained when applying formulae above

**ARAPUCEL Hydroelectric Project**

Facility	Alto Jaurú	Indiavaí	Ombreiras			
Installed power (MW)	20	28	26			
baseline (tCO ₂ /MWh)*	0,452	0,452	0,452			
				Total tCO ₂ abated (accumulated)		
	Generated energy (MWh)			tCO ₂ abated		
Total 2002	45.092	0	0	20.382	20.382	1st year
Total 2003	166.522	67.054	0	105.576	125.958	2nd year
Total 2004	167.326	178.428	0	156.281	282.239	3rd
Total 2005	157.680	176.602	39.312	168.864	451.103	4th
Total 2006	157.680	176.602	168.542	227.276	678.379	5th
Total 2007	157.680	176.602	168.542	227.276	905.656	6th
Total 2008	157.680	176.602	168.542	227.276	1.132.932	7th year
Total 2009	157.680	176.602	168.542	227.276	1.360.209	8th
Total 2010	157.680	176.602	168.542	227.276	1.587.485	9th
Total 2011	157.680	176.602	168.542	227.276	1.814.762	10th year
Total 2012	157.680	176.602	168.542	227.276	2.042.038	11th year
Total 2013	157.680	176.602	168.542	227.276	2.269.314	12th
Total 2014	157.680	176.602	168.542	227.276	2.496.591	13th
Total 2015	157.680	176.602	168.542	227.276	2.723.867	14th year

Table 1 – Estimated emission reductions of the project activity

**SECTION F. Environmental impacts****F.1. Documentation on the analysis of the environmental impacts, including trans-boundary impacts**

The growing global concern on sustainable use of resources is driving a requirement for more sensitive environmental management practices. Increasingly this is being reflected in countries' policies and legislation. In Brazil the situation is not different. Environmental rules and licensing policies are very demanding in line with the best international practices.

The environmental impact of the Project is considered small by the host country definition of small-hydro plants. By legal definition of the Brazilian Power Regulatory Agency (ANEEL), Resolution no. 394, December 4th, 1998, small hydro in Brazil is a hydro plant with installed capacity greater than 1 MW and up to 30 MW, with a reservoir area less or equal to 3 km². Generally, it consists of a run-of-the-river hydro plant, which results in having a minimum environmental impact.

The facilities of the ARAPUCCEL project possess all necessary environmental and construction licenses. All three environmental licenses (LP, LI and LO) were issued by the State of Mato Grosso Environmental Protection Foundation (*Fundação Estadual do Meio Ambiente*– FEMA).

As the ARAPUCCEL project is comprised of three small-hydro power plants, the fast-track procedure must be completed (Preparation of a Preliminary Environmental Report - “Relatório Ambiental Preliminar,” RAP). The process has been completed and a report containing an investigation of the following aspects has been produced:

- Resources usage
- Legislation to be observed
- Impacts to climate and air quality
- Geological and soil impacts
- Hydrological impacts (surface and groundwater)
- Impacts to the flora and animal life
- Socio-economical (necessary infra-structure, legal and institutional, etc.)
- Local stakeholders comments
- Mitigation measures
- Monitoring plan

In Brazil, the sponsor of any project that involves construction, installation, expansion or operation, even with no new significant environmental impact, new licenses are necessary.

The licenses required by the Brazilian environmental regulation are (Resolution CONAMA # 237 from 1997):

- The preliminary license (“*Licença Prévia*” or L.P.),



- The construction license (“*Licença de Instalação*” or L.I.); and
- The operating license (“*Licenca de Operacao*” or L.O.).

Alto Jauru and Indiavaí have all the three licenses necessary to operate as an electricity producer (Figure 20 and Figure 21 show the operation license for PCH Alto Jauru). Ombreiras has the preliminary license and the construction license (FEMA-MT 497/2004) and has already requested the “Operation License”.

The ARAPUCCEL project has an authorization issued by ANEEL to operate as an independent power producer (*ANEEL Resolution 334 of August 14th, 2001*).

Two other guidelines were used in order to evaluate the project with respect to environmental sustainability, the requirements of the Brazilian government to obtain the letter of approval and the recommendations checklist of the World Commission on Dams. The results of the evaluations follow.

Arapucel Project’s contribution to Sustainable Development (CDM letter or approval requirement)

a) Contribution to the local environmental sustainability

An April 2002 law # 10,438 created Proinfa (Programa de Incentivo as Fontes Alternativas de Energia Elétrica). Proinfa is a Brazilian federal program that gives incentive to alternative sources of electricity (wind energy, biomass cogeneration, and a small scale hydropower plant). Among other factors, this initiative’s goal is to increase the renewable energy source share in the Brazilian electricity matrix in order to contribute to a greater environmental sustainability through giving these renewable energy sources better economic advantages. The Brazilian government has committed a large monetary fund in order to develop this plan.

Although Arapucel is eligible for Proinfa, it has not applied for financing under Proinfa and therefore, does not have access to the advantages of the program. However, this project plays an important role in local environmental sustainability, specifically in superior air quality compared to an increase in natural gas which is part of the installed capacity of the country’s electricity matrix.

The Arapucel Project is located in three municipalities in the state of Mato Grosso. They are physically located at one of the ends of the interconnected sub-sector of the South-Southeast-Midwest electricity grid, which transports electricity from the installed capacity. This is further explained in the baseline scenario section in the Project Document Description that shows that the Brazilian electric matrix is roughly constituted mainly by electricity derived from large hydro plants and in part by thermal electricity derived from biomass, coal, and mainly natural gas, which has been increasing in use since the construction of GASBOL (the Brazil-Bolivia pipeline).

Although natural gas is the cleanest fossil fuel, the combustion in generating electricity in thermo plants emits greenhouse gases such as: carbon dioxide “CO₂”, methane “CH₄”, and nitrous oxide “N₂O”, which are, according to the Organization for Economic Cooperation and Development (OECD, 2004), the three greenhouse gases “GHGs” which account for the majority of human induced global warming effects.

Alto Jauru and Indiavaí, the municipalities where the project is located, currently use the electricity delivered by the grid. However, this supply of electricity has not been steadily delivered. These municipalities have been facing numerous electricity failures, which make



regional industries, such as local slaughterhouses use diesel generators as backups for the electricity system. The local air contamination from the combustion of this fuel is greater than those presented by natural gas.

A local, small-scale hydropower plant would supply a more constant energy flow that would discourage thermal generators. This indigenous and cleaner source of electricity would also have another contribution to environmental sustainability. It reduces technical losses occurred in the grids that deliver electricity to these distant communities.

b) Contribution to the development of the quantity and quality of jobs

The Arapucel Project is associated with large expenditures and significant employment demands. Indiavaí, one of the project locations has a population of 2,000 inhabitants according to IBGE (2004) and a significant portion is employed by the project.

Although not all employment is filled by the local population, a part of the demand for workers is absorbed by regional manpower.

The general employee profile for the project's type of construction is on average a person with few years of formal education. This profile would have difficulty finding a formal job in an informal economy, which is a common characteristic of this region's labor market.

The ARAPUCEL project provides its employees, and in some cases the entire community, many facilities which contribute to the quality of life of its workers such as housing, social security, health assistance, and life insurance.

One of the most important contributions from the construction of these three run-off-river hydro plants is that it can create the potential for the promotion of regional development which will generate a greater number of jobs and better living standards.

One of the factors which facilitate job creation is a more reliable energy supply. This is essential for making a decision between carrying-out or not an investment which creates jobs in the region.

Another important point to highlight is the Arapucel Project's contribution to the development of good quality jobs and the fact that the project has professionals responsible for educating the workers and population about environmental preservation and prevention of illness.

c) Contribution to the fair income distribution

It can be said that fair income distribution is achieved from job creation and an increase in people's wages, however better income distribution in the region where the Arapucel Project is located is obtained from less expenditures and more income in the local municipalities. The surplus of capital that these municipalities will have could be translated into investments in education and health which will directly benefit the local population and indirectly impact a more equitable income distribution. The lower expenditure is generated due to the fact that money will no longer be spent in the same amount to "import" electricity from other regions in the country through the grid. This money would stay in the region and be used for providing the population better services which would improve the availability of basic needs. The local population will receive economic benefits from royalties paid to the municipalities for the water rights granted to Arapucel.

d) Contribution to the technological development and capacity building



In the past Brazil protected its markets against external competition and as a consequence local technology did not develop at the same pace as compared to other countries. Brazil having one of the world's largest hydro capacity has invested heavily in large hydropower projects which make the country an authority in this field.

As Tolmasquim (2003) says, "the national industry is qualified to supply part of the electrical equipment and hydro-mechanisms for the small scale hydropower plants".

The project does not create new technology, however, it builds up the local capacity necessary for properly managing the project.

Another important contribution to the local capacity building is educational programs that are carried out (PCH Indiavaí, 2003) by technical professionals that teaches local educators the importance of the environment to their society. An example of topics covered are the 3Rs (Reduce, Reuse, and Recycle).

The educators are the bridge of this knowledge to the local children which are expected to have a better environmental consciousness as compared to the current knowledge about the environment.

e) Contribution to the regional integration and relationships among other sectors

Elliot (2000) in his article "Renewable Energy and Sustainable Futures" proposes the change from a conventional paradigm to a new energy paradigm, which is closely related to the proposal of the Arapucel Project, "to a world that is moving towards a sustainable approach to energy generation" that has enormous influence on, among other things, a better environment.

This new energy paradigm is the one that uses renewable fuels versus finite stock, smaller scale technology versus large scale, small and local environmental impacts versus large and global, and a liberalized market versus a monopoly.

Despite this, Elliot states that a decentralized generation of energy is a better contribution to sustainable development than a centralized one.

Currently this is the Brazilian tendency, because among other advantages, the electricity system has fewer losses, and local economies receive a greater income. Also, regional integration is developed since decentralized systems connected to the grid diminish the country's electricity system vulnerability and dependency on specific and limited electricity sources.

Therefore, decentralization of the electricity generation activity promotes integration and a higher degree of security for the other sectors of the economy to invest in an area which now has a better guarantee of electrical supply. This is the case of ARAPUCCEL. The local economy not only indirectly benefits during the construction, but also attracts new businesses after the construction period due to a more steady and reliable supply of electricity.

Conclusion

In conclusion, although the Arapucel Project does not have a large stake in the sustainability of the country, it is part of a greater idea (which the federal government supports through Proinfa) and it contributes to as the Brundland report (WCED, 1987) defines: the sustainable development which is the satisfaction of the present needs without compromising the ability of future generations to meet their own needs. In other words, by using run-of-river hydropower facilities, which are renewable sources of energy, to generate electricity for local use and for delivery to the grid, the Arapucel Project displaces part of the electricity derived from



natural gas, a finite fossil fuel, and gives less incentives for the construction of large hydro plants, which, although are considered renewable, can have major environmental, and social impacts.

Finally, the project has fewer impacts on the environment and it can boost the regional economy, therefore resulting in a better quality of life and social standards for the local people, in other words, the project contributes to the local sustainable development.

World Commission on Dams recommendations checklist

a) Gaining public acceptance

The projects are in different phases of development. Although civil works are underway, the project sponsor is working to gain public acceptance by developing environmental education projects, as well as other local activities, such as reforestation of degraded areas, regular water quality assessment, support to environmental parks, hiring of local manpower, erosion control, support to agriculture for the local community, among other initiatives. Therefore, significant modifications in the present environmental conditions are not expected.

b) Comprehensive options assessment

Various assessments were conducted in order to optimize the use of the water supply to increase the generating capacity, and to reduce the environmental impact.

c) Addressing existing dams

There are no existing dams in the region where the projects are located.

Regarding the construction requirements for the new generating units, the optimization of the river use is sufficient to increase the energy generation.

The reservoirs are considered to be of low impact.

d) Sustaining rivers and livelihoods

Although some environmental impact is expected from the projects, the project sponsor is committed to mitigating this with close cooperation from the local community. Mitigation and/or compensatory measures are to be considered to reduce any negative impacts to neighbouring communities or to the population in general.

It is not anticipated to cause any relevant impact to the aquatic ecosystems due to the mitigation measures as well as the optimization work.

e) Recognizing entitlements and sharing benefits

There is neither displacement of population nor a negative effect to its interests and rights related to the project.

As for sharing the benefits, funds are being structured to support local environmental parks. Also, degraded areas are being renovated, and reforestation work is underway for the 3 plants.

f) Ensuring compliance

The projects comply with the national and local environmental legislation, such as the CONAMA Resolution n° 237/97, Resolution 009/87, Resolution 006/86, Resolution 001/86, Law 6938/81, and the correspondent legislation. This legislation regulates the environmental licenses



and the public hearing procedures. Currently, the national environmental regulations include the mandate to promote sustainable development.

The projects comply with the electricity legislation, as well, such as the National Electricity Agency (ANEEL) Resolution nº 112/99 and related regulations. The electricity sector regulations include the mandate to comply with all the national environmental regulations, which for this case means environmental protection, mitigation and compensatory measures and social-economic concern.

g) Sharing rivers for peace, development and security

Protective installations on the shore of the river have been anticipated, and will not affect downstream waters.

An environmental impact evaluation was carried out for the project which explains in additional detail the relevant information about environmental and social impacts and mitigation measures.

F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party

The growing global concern on sustainable use of resources is driving the requirement for more sensitive environmental management practices. Increasingly this is being reflected in countries' policies and legislation. In Brazil the situation is not different; environmental rules and licensing process policy are very demanding in line with the best international practice.

After the assessment of the preliminary environmental report by the state environmental authority some minor requirements were made in order to issue the licenses (see Figure 21). All the requirements were and are being fulfilled by the project sponsors. As conclusion the environmental impact of the project activity is not considered significant and no full environmental impact assessment was demanded.

**SECTION G. Stakeholders' comments****G.1. Brief description how comments by local stakeholders have been invited and compiled**

Following the law established by FEMA - MT, the environmental agency, ARAPUCEL has published a public call for stakeholder's comments in a local newspaper while requesting the Operation License, LO.

The public call for the environmental licenses was published on July 27th of 2002.

Beside of the stakeholders comments requested for the environmental licenses, the Brazilian Designated National Authority, "Comissão Interministerial de Mudanças Globais de Clima", requests comments by local stakeholders and the validation report issued by an authorized DOE according to the 11th September 2003 resolution # 1 in order to provide the letter of approval.

The proponent of the project will send these letters to the stakeholders in order to invite their comments while the PDD of the project is open for comments in the validation stage in the United Nations Framework Convention on Climate Change "unfccc.int" website since anyone can have access to the mentioned document from a legitimate source.

G.2. Summary of the comments received

No comments were received on the licensing process.

Brazilian DNA requests that projects be open for comments prior to validation. Thus, in addition to UNFCCC global stakeholders comments this project will be open for inputs from locals at the same time. Any comments will be disclosed after validation.

G.3. Report on how due account was taken of any comments received

No comments were received. The project was developed as planned and following the requests made by the local environmental authority (FEMA – MT).

The research paper prepared by the Arapucel Project analyzing on the impact of the facilities in the region is available upon request.

Brazilian DNA requests that projects be open for comments prior to validation. Thus, in addition to UNFCCC global stakeholders comments this project will be open for inputs from locals at the same time. Any comments will be disclosed after validation.

SECTION H. Annexes

**Annex 1. Contact information on participants in the project activity**

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Telephone:	
FAX:	
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Represented by:	
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E-Mail:	
URL:	www.minvrom.nl
Represented by:	
Title:	Head of Clean Development Mechanism Division
Salutation:	Mr.
Last Name:	De Jonge
Middle Name:	



Annex 2. Information regarding public funding

No public funding was and will be used in the present project.



Annex 3. Baseline Information



Annex 4. Monitoring plan

Annex 5. Figures

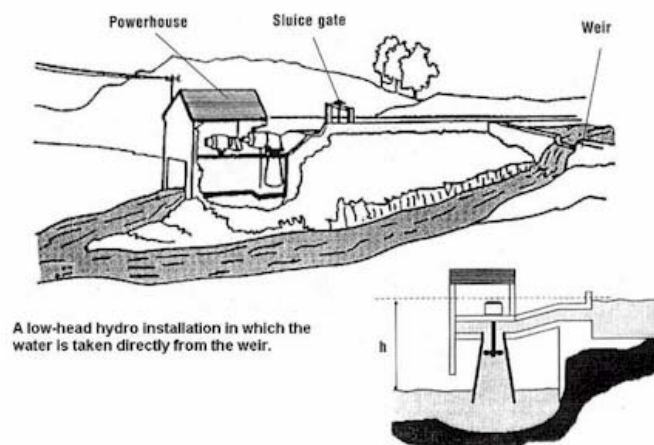


Figure 1 – Schematic view of a run-of-river power plan



Figure 2 – Power plants aerial view (Alto Jauru, left, and Indiavaí)

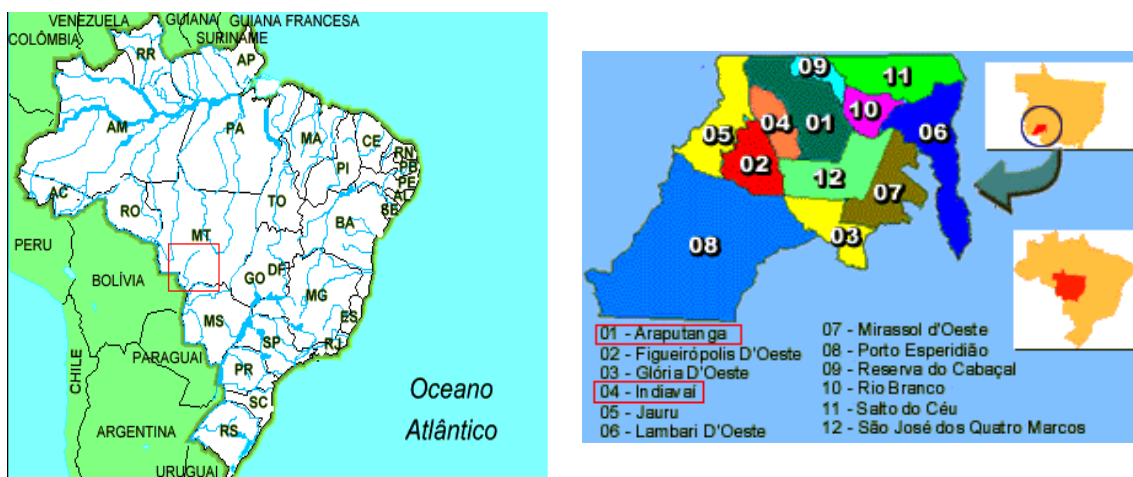


Figure 3 - Geographical position of the cities of Araputanga and Indiavaí
<http://www.citybrazil.com.br/>).

(Source:



Figure 4 – Major Brazilian river basins (Source: <http://www.portalbrasil.net/>).

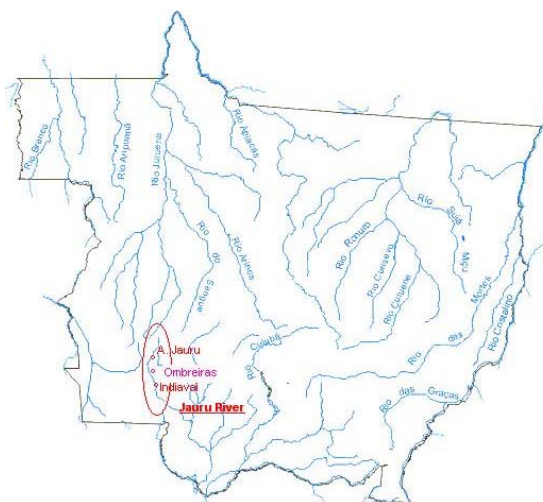


Figure 5 – Geographical location of the projects in the Jauru River
<http://www.citybrazil.com.br/>.

(Source:

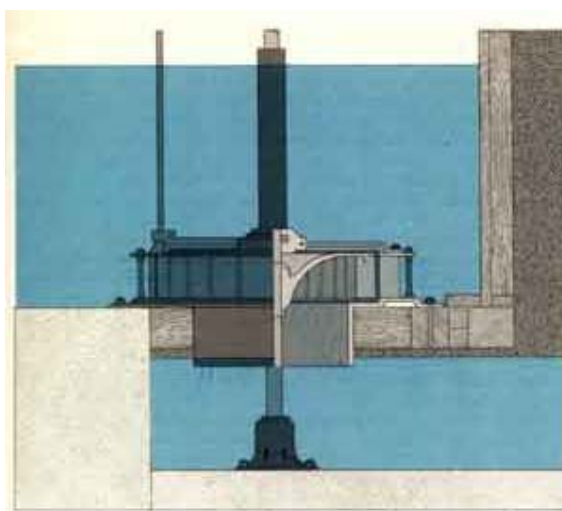


Figure 6 – Francis turbine
 Alstom, <http://www.alstom.com.br/> and Water Wheel Factory <http://www.waterwheelfactory.com/>).

(Sources:

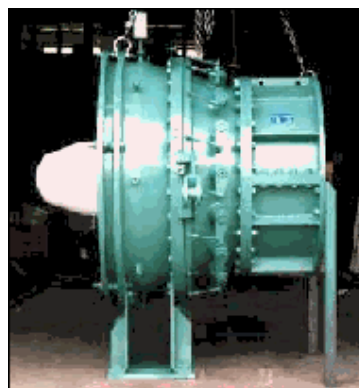
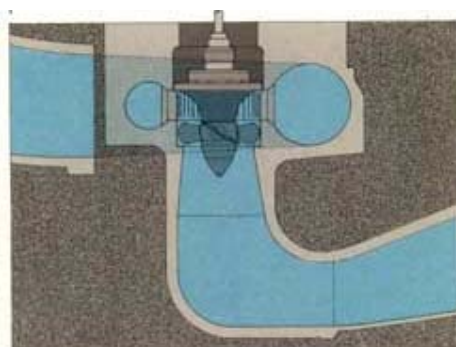


Figure 7 – Kaplan Turbine (Source: Water Wheel Factory, <http://www.waterwheelfactory.com/>).

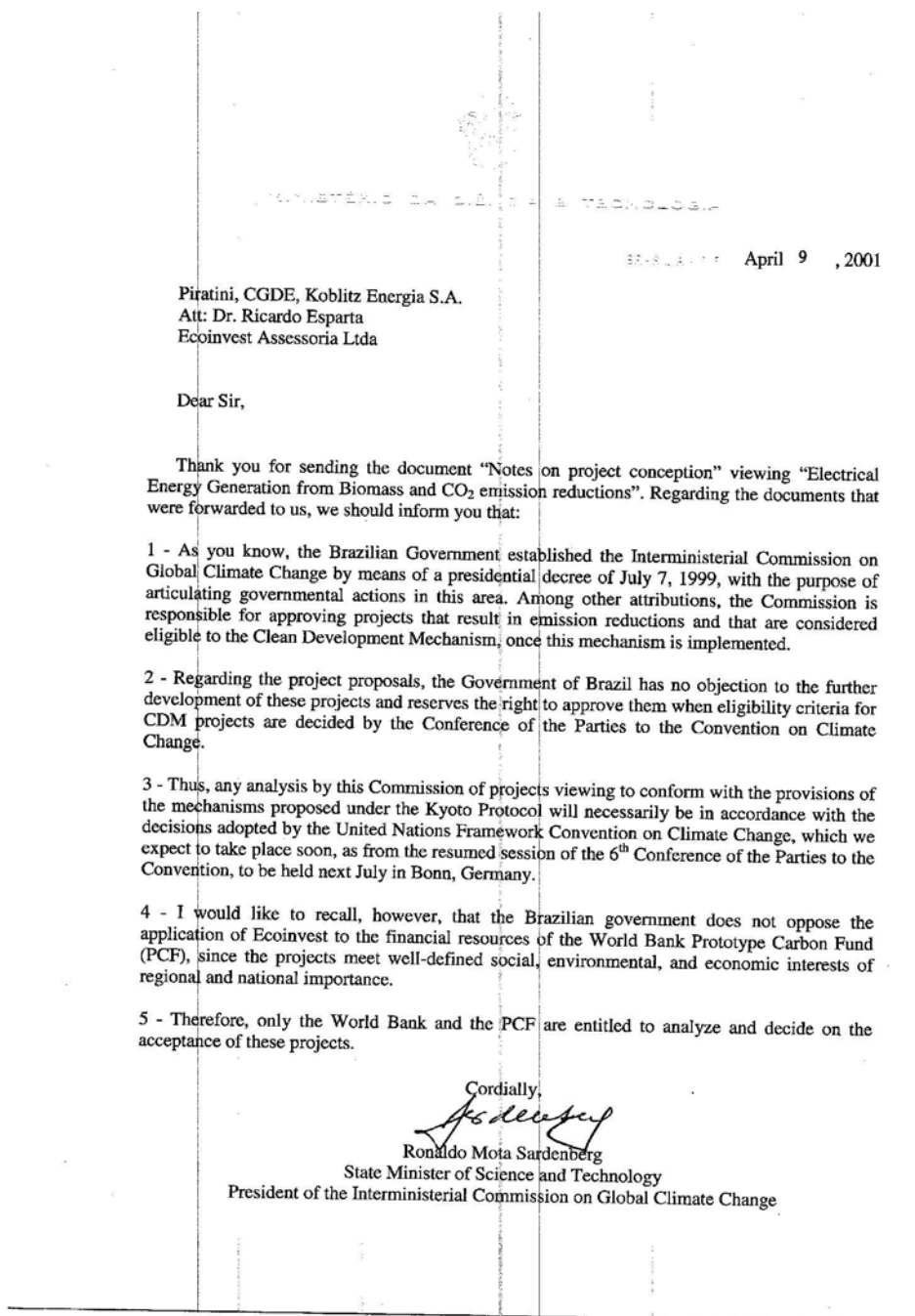


Figure 8 – Non-objection letter received by the Piratini, C.G.D.e., Koblitz Energia S.A. CDM Project from the Brazilian Interministerial Commission on Global Climate Change

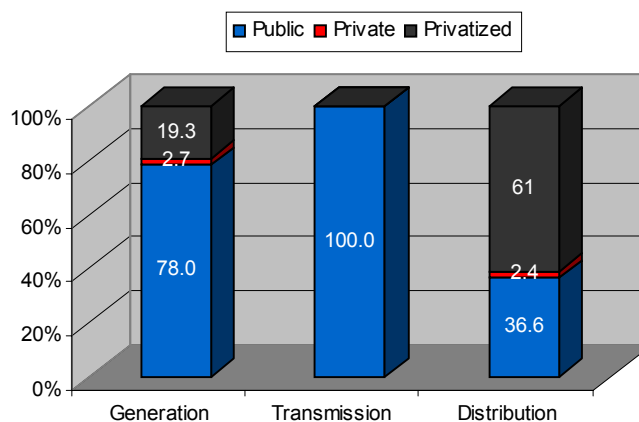


Figure 9 - Participation of private capital in the Brazilian electricity market in December 2000 (Source: BNDES, 2000).

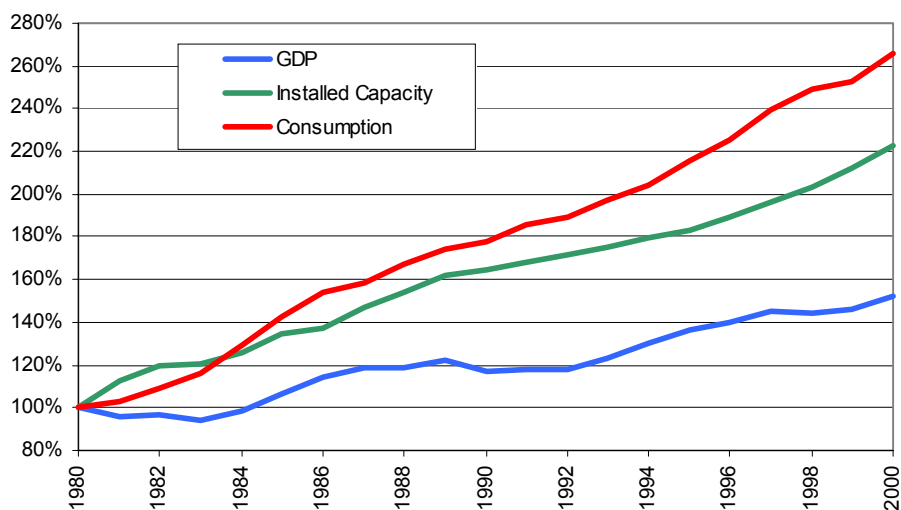


Figure 10 - Cumulated variation of GDP, electricity supply (installed capacity) and demand (consumption) (Source: Eletrobrás, <http://www.eletrobras.gov.br>; IBGE, <http://www.ibge.gov.br/>)

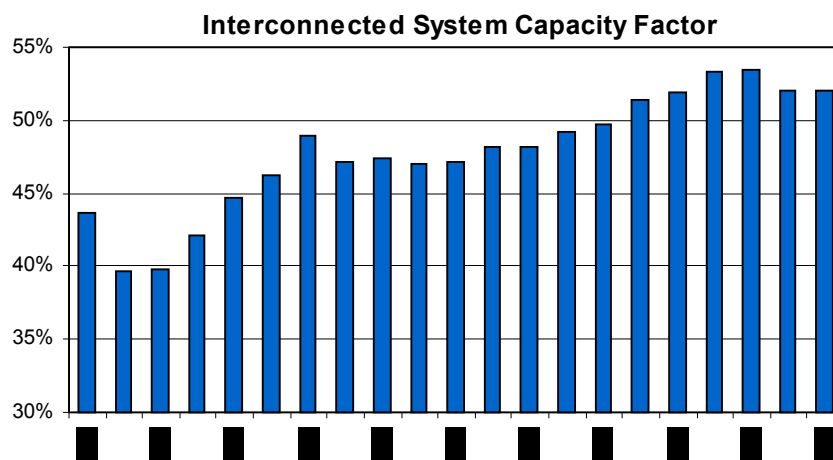


Figure 11 - Evolution of the rate of generated energy to installed capacity
Eletrobrás, <http://www.eletrobras.gov.br/>.

(Source:

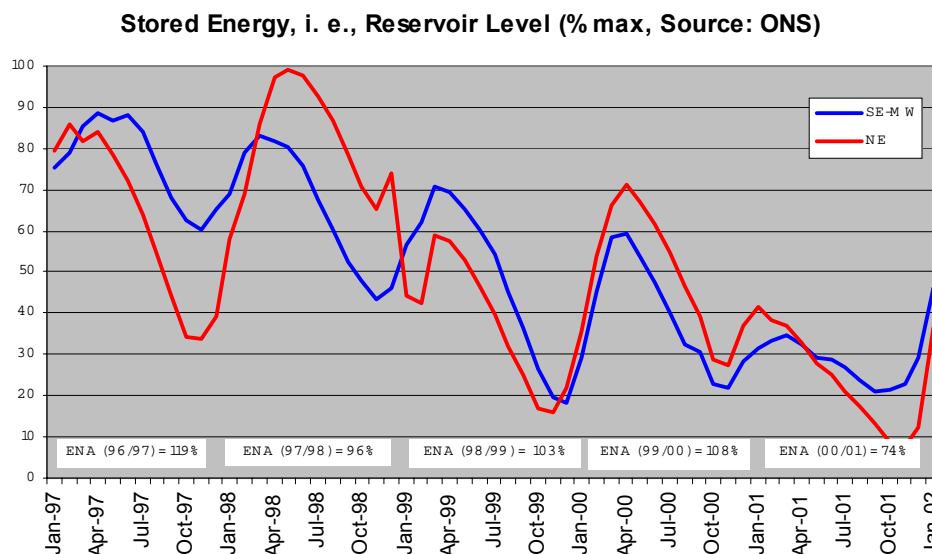


Figure 12 - Evolution of the water stored capacity for the Southeast/Midwest (SE-MW) and Northeast (NE) interconnected subsystems and intensity of precipitation in the rainy season (ENA) in the southeast region compared to the historic average (Source: ONS, <http://www.ons.org.br/>)

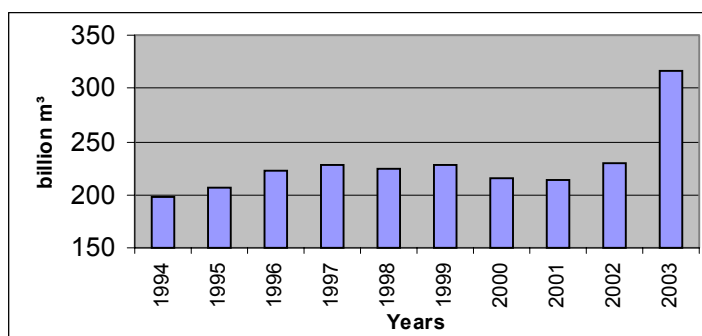


Figure 13 – Evolution of the Brazilian natural gas proved reserves
Petrobras, <http://www.petrobras.com.br/>)

(Source:

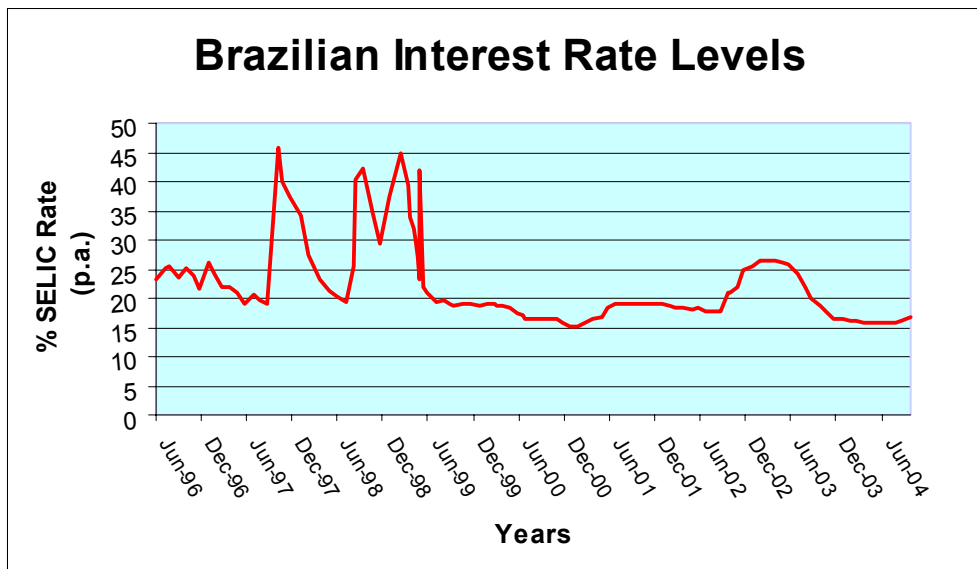


Figure 14 - SELIC rate (Source: Banco Central do Brasil, <http://www.bcb.gov.br/>)



Horizonte 2006

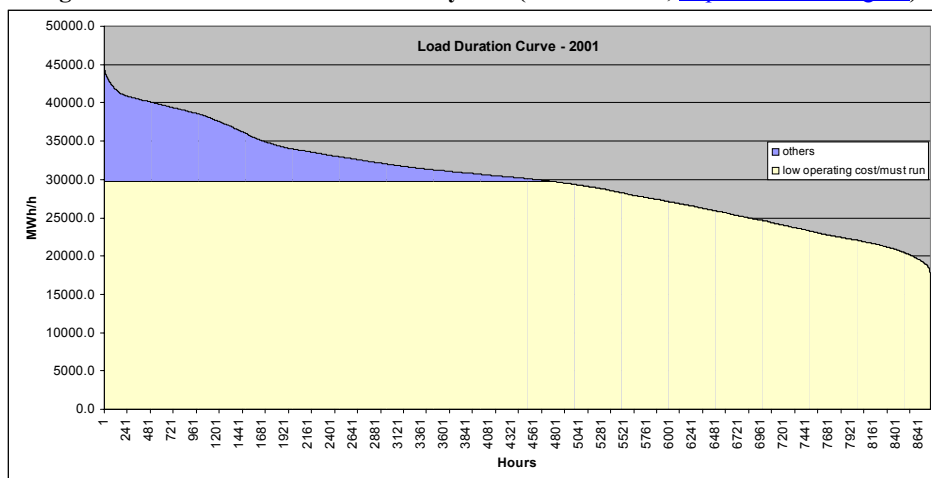
Figure 15 - Brazilian Interconnected System (Source: ONS, <http://www.ons.org.br/>)

Figure 16 - Load duration curve for the S-SE-CO system, 2001

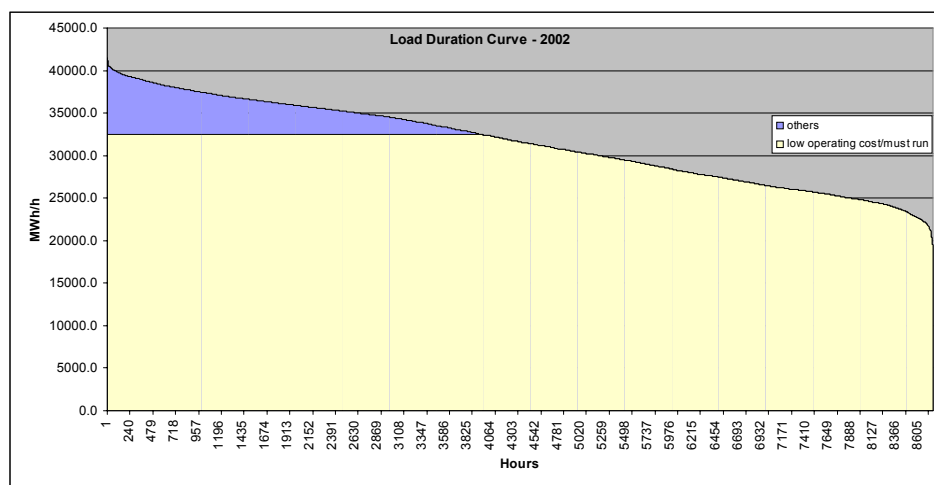


Figure 17 - Load duration curve for the S-SE-CO system, 2002

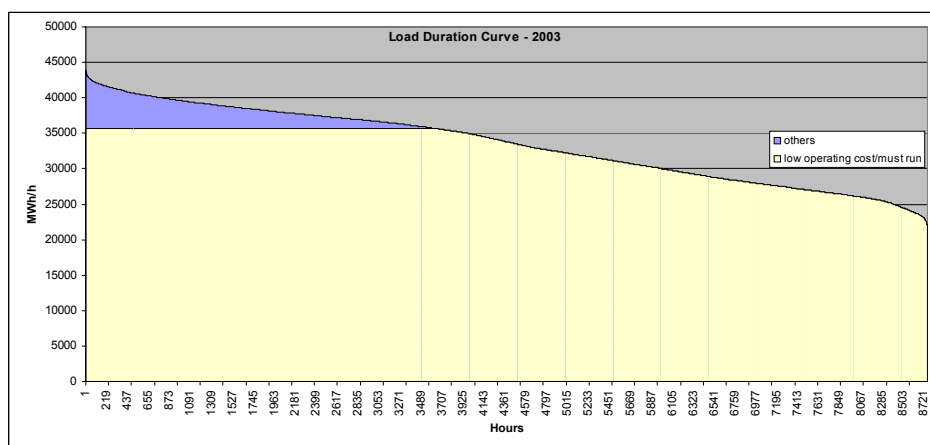


Figure 18 – Load duration curve for the S-SE-CO system, 2003

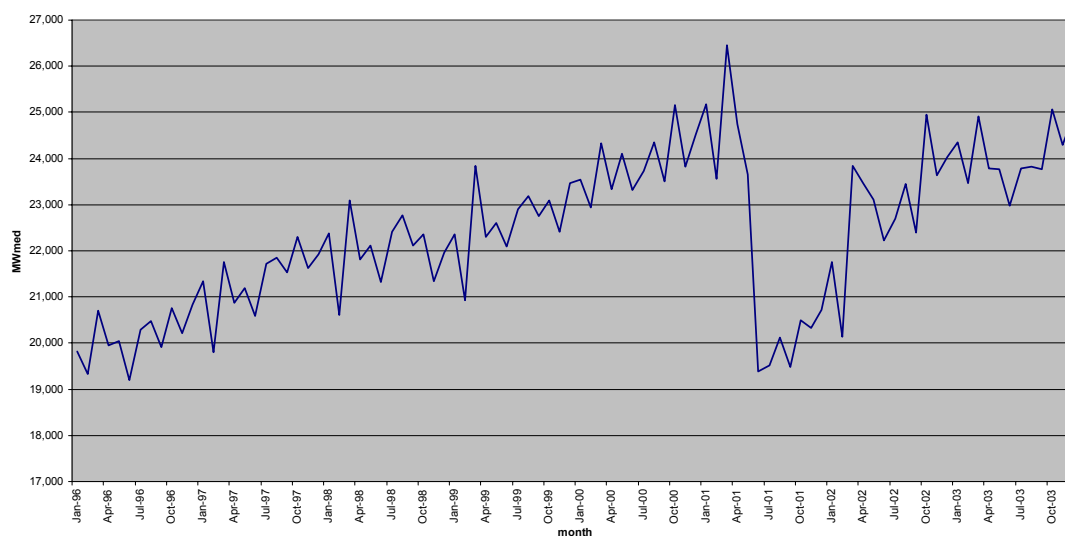


Figure 19 – Monthly load average in the Brazilian S-SE-CO interconnected electricity system from 1996 to 2003 (ONS, 2004)



GOVERNO DO ESTADO DE MATO GROSSO Fundação Estadual do Meio Ambiente - FEMAM Secretaria Especial do Meio Ambiente		
Licença de Operação N.1649/2002.		
A FUNDAÇÃO ESTADUAL DO MEIO AMBIENTE - FEMAM, no uso de suas atribuições que lhe são conferidas pela Lei Complementar n.º 38 de 21 de novembro de 1.995, que dispõe sobre o Código Estadual do Meio Ambiente, e dá providências, concede a presente Licença.		
RAZÃO SOCIAL ARAPUTANGA CENTRAIS ELÉTRICAS S/A - ARAPUCEL		
ENDEREÇO Rua Barão de Melgaço, nº 2350 - Sala 12.		
DISTRITO/BAIRRO. Centro Sul	MUNICÍPIO Cuiabá/MT	CEP 73.020 - 800
INSC. ESTADUAL	CNPJ/CPF 01.395.648/0001-77	PROCESSO 574/1997
ATIVIDADE Pequena Central Hidrelétrica - PCH Alto Jauru, potência instalada de 20 MW.		
LOCALIZAÇÃO Rio Jauru, Bacia do Paraguai, município de Araputanga/MT. Coordenadas Geográficas: 15°02'47"S e 58°45'07"W.		
RESTRIÇÕES As contidas no processo de licenciamento e na legislação em vigor.		
Esta Licença de Operação é válida até 14/10/03 conforme Processo de Licenciamento nº574/97, observadas as condições de validade no verso deste documento.		
LOCAL E DATA Cuiabá - MT, 14/10/2002	COORDENADOR DE INFRA-ESTRUTURA - em exercício. Maria de Gátima C. Tobias Coord. de Infra-Estrutura FEMAM / MT	DIRETOR DE INFRA-ESTRUTURA, MINERAÇÃO E INDÚSTRIA Doutor Luis Romão Eng.º Florestal - CREA 76.100/0 Diretor Infra-Estrutura, Mineração e Indústria - DMI/FEMAM/MT

Rua D, s/nº - Palácio Paiaguás - Centro Político Administrativo - Cuiabá - Mato Grosso
CEP 78050-970 - Fones: 0(xx)65 313-2212 / 2054 / 3296 - Fone/Fax: 0(xx)65 644-2584
E-mail: femam@bol.com.br

Figure 20 – PCH Alto Jauru operation license I



CONDIÇÕES DE VALIDADE DESTA LICENÇA
<p>As contidas no Parecer Técnico nº 387/COINF/DIMI/2002</p> <p><i>Serviço Notarial e Registro de Curitiba - Mt. Rua Comandante Costa, 683 - Centro - CEP: 75005-300 TEL: (0XX) 65 322-8609 - FAX: (0XX) 65 321-8054 Confere com o original, que me foi apresentado. Do que dou fé.</i></p> <p><i>15/09/2002</i></p> <p><i>Glória Alice Ferreira Brito, Notária e Registradora Iacy Auxiliadora Pereira Izar - 1ª. Tab. Substituta Pedro César Ferreira da Silva - 2ª. Tab. Substituta Edmundo Assunção Moraes Freitas - Escrivão Substituto Em Teste (assinatura e rubrica)</i></p> <ul style="list-style-type: none">- Apresentar o cronograma físico consolidado de continuidade dos programas ambientais, prevendo a periodicidade de emissão dos relatórios técnicos.- O PRAD deverá ter duração de 03 anos, com início do cronograma em Agosto/2002.- Apresentar o Termo de Compromisso para compatibilização da Defesa dos Direitos Indígenas, associado à FUNAI, ARAPUCEL, FEMA e Comunidade Indígena Figueira, em atendimento ao Parecer Técnico 241/COINF/TEC/2001 de 10/09/2001.- A vazão sanitária não deverá ser inferior a 3,96 m³/s durante a operação da usina.- O empreendedor deverá implantar uma ponte junto ao canal de adução, como forma de permitir a travessia de animais silvestres terrestres naquele trecho, além da implantação de uma cerca tipo alambrado para proteger o canal de adução quanto ao risco de entrada de animais silvestres.- Com a operação da usina deverá ser acrescida uma estação de amostragem junto a soleira vertente na área de remanso da usina, ficando 03 estações na fase de operação, conforme proposto no Plano de Monitoramento da Limnologia e Qualidade da Água.- O empreendedor deverá aplicar os recursos destinados para as atividades de comunicação social não executadas, no valor de R\$ 13.200,00, na unidade escolar do Distrito de Boias, com a implantação de uma biblioteca, em função do atraso na sua implantação, previsto no cronograma do Programa de Educação Ambiental e Comunicação Social.- O empreendedor deverá repassar os equipamentos referente a compensação ambiental, num prazo máximo de 30 (trinta) dias;- Apresentar documento de requerimento do DNPM das jazidas utilizadas na obra.
CONDIÇÕES GERAIS
<ol style="list-style-type: none">1 - A presente Licença não dispensa e nem substitui Alvarás ou Certidões de qualquer natureza exigidas pela Legislação Federal, Estadual ou Municipal.2 - Os equipamentos de controle ambiental existente, deverão ser mantidos e operados adequadamente de modo a obter a maior eficiência, sendo tal responsabilidade única e exclusiva da empresa.3 - Qualquer alteração ou ampliação no processo industrial e de controle ambiental, deverão ser precedidos de Licença da FEMA, de acordo com art. 18 da lei Complementar n.º 38 de 21/11/95.

Figure 21 – PCH Alto Jauru operation license II



Annex 6. Tables

<u>Year</u>	<u>Expected Generated energy (MWh)</u>	<u>tCO2 abated</u>	<u>Total tCO2 abated (accumulated)</u>	
2002	45.092	20.382	20.382	1st year
2003	233.576	105.576	125.958	2nd year
2004	345.754	156.281	282.239	3rd
2005	373.594	168.864	451.103	4th
2006	502.824	227.276	678.379	5th
2007	502.824	227.276	905.656	6th
2008	502.824	227.276	1.132.932	7th year
2009	502.824	227.276	1.360.209	8th
2010	502.824	227.276	1.587.485	9th
2011	502.824	227.276	1.814.762	10th year
2012	502.824	227.276	2.042.038	11th year
2013	502.824	227.276	2.269.314	12th
2014	502.824	227.276	2.496.591	13th
2015	502.824	227.276	2.723.867	14th year

Table 2 – Arapucel Project total estimated emission reductions

Cash Flow (R\$): ALTO JAURU

	2000	2001	2002	2003	2010	2011	2012
Net Income	(197,260)	(2,158,934)	(761,461)	4,969,901	4,873,695	4,981,088	6,821,433
(+) Depreciation	197,260	2,158,934	2,603,918	2,603,918	2,603,918	2,603,918	2,603,918
(-) Equity	(8,000,000)	(35,178,681)	(8,899,670)	0	0	0	0
(+) Funding	0	0	22,066,000	0	0	0	0
(-) Amortization	0	0	0	(596,378)	(2,385,514)	(2,385,514)	(2,385,514)
(+) Perpetuity							79,158,061
Investor Cash Flow	(8,000,000)	(35,178,681)	15,008,787	6,977,440	5,092,099	5,199,492	86,197,898
Return on Equity		18.4%					

Table 3 – ARAPUCEL (Alto Jauru) RoE without CER revenues



Cash Flow + CER(R\$): ALTO JAURU

	2001	2002	2003	2004	2011	2012	2013
Net Income	(197,260)	(2,158,934)	(761,461)	4,969,901	4,873,695	4,981,088	6,821,433
(+) Depreciation	197,260	2,158,934	2,603,918	2,603,918	2,603,918	2,603,918	2,603,918
(-) Equity	(8,000,000)	(35,178,681)	(8,899,670)	0	0	0	0
(+) Funding	0	0	22,066,000	0	0	0	0
(-) Amortization	0	0	0	(596,378)	(2,385,514)	(2,385,514)	(2,385,514)
(+) CER Revenues			1,042,500	1,042,500	1,042,500	1,042,500	1,042,500
(+) Perpetuity							79,158,061
Investor Cash Flow	(8,000,000)	(35,178,681)	16,051,287	8,019,940	6,134,599	6,241,992	87,240,398
Return on Equity + CER		20.6%					

Table 4 – ARAPUCEL (Alto Jauru) RoE with CER Revenues

Financial Sensitivity Analysis - PCH Alto Jauru			
SELIC rate* (1996 - 2004)	%	Project NPV	Project NPV with CER
Maximum Level	45.00%	(R\$ 12,846,099)	(R\$ 11,762,732)
Average	22.36%	(R\$ 4,940,469)	(R\$ 2,164,712)
Minimum Level	15.25%	R\$ 5,923,472	R\$ 9,989,993
Current Discount Rate	18.00%	R\$ 667,192	R\$ 4,153,177
Project IRR		18.42%	20.63%

* The SELIC rate was created in 1996.

Table 5 – Sensitivity analysis of the PCH Alto Jauru investment to the SELIC rate variations in the last 10 years.

Year	Share of hydroelectricity (%)
1999	94.0
2000	90.1
2001	86.2
2002	90.0
2003	92.9

Table 6 – Share of hydroelectricity production in the Brazilian S-SE-CO interconnected system from 1999 to 2003 (ONS, 2004).



<i>Year</i>	$\frac{\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}}{\sum_k GEN_{k,y}} \text{ [tCO}_2\text{/MWh]}$	λ_y
2001	0.948	0.457
2002	0.931	0.550
2003	0.969	0.582

Table 7 - Share of hours in year y (in %) for which low-cost/must-run sources are on the margin in the S-SE-CO system for the period 2001-2003 (ONS-ADO, 2004).

<i>Year</i>	EF _{OM non-low-cost/must-run} [tCO ₂ /MWh]		EF _{BM} [tCO ₂ /MWh]	
	Ex-ante	Ex-post	Ex-ante	Ex-post
2001-2003	0.719	0.950	0.569	0.096

**Table 8 – Ex ante and ex-post operating and build margin emission factors
ADO, 2004; Bosi *et al.*, 2002)**

(ONS-



	Plant	Energy source	Installed power (MW)	Capacity factor [%, forecasted]	Capacity factor [%, realized]
1	Três Lagoas	natural gas	306.00	75.0	25.5
2	Ibirité	natural gas	226.00	75.0	26.8
3	Jauru	hydro	121.5	56.0	25.0
4	Guaporé	hydro	120.00	56.0	27.7
5	Funil (MG)	hydro	180.0	56.0	23.7
6	Itiquira I	hydro	156.1	56.0	29.9
7	Araucária	natural gas	484.5	75.0	0.01
8	Canoas	natural gas	160.6	75.0	13.0
9	Piraju	Hydro	81.0	56.0	58.9
10	Nova Piratininga	natural gas	384.9	75.0	1.42
11	Cana Brava	hydro	465.9	56.0	53.9
12	Santa Clara	hydro	60.0	56.0	32.2
13	Machadinho	hydro	1,140.0	56.0	34.4
14	Juiz de Fora	natural gas	87.0	75.0	0.77
15	Macaé Mechant	natural gas	922.6	75.0	29.6
16	Eletrobolt	natural gas	379.0	75.0	7.30
17	Porto Estrela	hydro	112.0	56.0	41.8
18	W. Arjona	natural gas	194.0	75.0	32.4
19	Cuiabá	natural gas	529.2	75.0	48.0
	Total		6110.3		

Table 9 – Capacity factor for centrally dispatched power plants in the Brazilian S-SE-CO interconnected grid with operation start in the period 2001-2003
(Sources: forecasted, Bosi *et al.*, 2002; realized, ONS, 2004).

**Annex 7. Bibliography**

ACM0002 (2004). Approved Consolidated Baseline Methodology 0002 – Consolidated Methodology for grid-connected electricity generation from renewable sources. UNFCCC, CDM Executive Board 15th Meeting Report, 3 September 2004, Annex 2. Web-site: <http://cdm.unfccc.int/>

Arida, P. E. L. Bacha, and A. L. Resende (2005). *Credit, Interest, and Jurisdictional Uncertainty: Conjectures on the Case of Brazil.* In F. Giavazzi, I. Goldfajn e S. Herrera (orgs.), *Inflation Targeting, Debt, and the Brazilian Experience, 1999 to 2003*. Cambridge, MA: MIT Press.

Bosi, M., A. Laurence, P. Maldonado, R. Schaeffer, A. F. Simoes, H. Winkler and J.-M. Lukamba (2002). Road testing baselines for greenhouse gas mitigation projects in the electric power sector. OECD and IEA information paper.

BNDES (2000). O setor elétrico – Desempenho 1993/1999. Banco Nacional de Desenvolvimento Econômico e Social. Informe Infra-estrutura, nº 53. <http://www.bndes.gov.br/>

CGE/CBEE (2002). Programa de Energia Emergencial. Câmara de Gestão da Crise de Energia Elétrica – Comercializadora Brasileira de Energia Emergencial.

Eletrobrás (1999). Diretrizes para estudos e projetos de pequenas centrais hidrelétricas. Centrais Elétricas Brasileiras S.A. Web-site: <http://www.eletrobras.gov.br/>

Elliot, D. (2000). Renewable Energy and Sustainable Futures. Futures 32 CTS Special ‘Sustainable Futures’ Issue, pp261-274, April/May 2000

IBGE (2004). Banco de dados Cidades@,. Instituto Brasileiro de Geografia e Estatística (<http://www.ibge.gov.br/>).

Kartha, S., M. Lazarus and M. Bosi (2002). Practical baseline recommendations for greenhouse gas mitigation projects in the electric power sector. OECD and IEA information Paper.

OECD (2001). OECD Economic Surveys: Brazil. Organization for Economic Co-Operation and Development, Paris, France.

OECD (2004). Environmental Outlook. Organization for Economic Cooperation and Development. Web-site: <http://www.oecd.org/env/>



- OECD (2005).** OECD Economic Survey of Brazil 2005: Regulation of the electricity sector. Organization for Economic Co-Operation and Development, Paris, France
- ONS (2004).** De olho na energia: Histórico da energia, carga própria de energia 1999-2003. Operador Nacional do Sistema Elétrico Brasileiro. Web-site: <http://www.ons.gov.br/>
- ONS-ADO (2004).** Acompanhamento Diário da Operação do Sistema Interligado Nacional. ONS-CNOS, Centro Nacional de Operação do Sistema. Daily reports on the whole interconnected electricity system from Jan. 1, 2001 to Dec. 31, 2003. Web-site: <http://www.ons.gov.br/>
- PCH-Indiavaí (2003).** Relatório de Monitoramento de Qualidade D'Água e Limnologia do Rio Jauru. PCH Indiavaí, SEMA-MT Processo 2458/03.
- Pinto Júnior, H. (2003).** Les problèmes des réformes structurelles et institutionnelles inachevées: le cas de l'industrie électrique au Brésil. *Révue de l'Energie* **544**, 103-111.
- Schaeffer, R., J. Logan, A. S. Szklo, W. Chandler and J. C. de Souza (2000).** Electric Power Options in Brazil. Pew Center on Global Climate Change.
- SIESE (2002).** Sistema de Informações Empresariais do Setor de Energia Elétrica: Boletim Anual. Eletrobrás (Centrais Elétricas Brasileiras S.A.) - MME (Ministério de Minas e Energia do Brasil). Web-site: http://www.eletrobras.gov.br/IN_Informe_SIESE/
- Tolmasquim, M.T. (2003) [Ed.].** Fontes Renováveis de Energia no Brasil. Editora Interciência
- UNEP-LAC (2002).** Final Report of the 7th Meeting of the Inter-Sessional Committee of the Forum of Ministers of Environment of Latin America and the Caribbean. United Nations Environment Programme, Regional Office for Latin America and the Caribbean. 15 to 17 May, 2002, São Paulo (Brazil).
- WCED (1987).** Our Common Future. The World Commission on Environment and Development. Oxford University Press.