INSTITUTO NACIONAL DE EFICIÊNCIA ENERGÉTICA

THE ENERGY POTENTIAL OF WOOD INDUSTRY RESIDUES FROM WOOD PRODUCED WITH SUSTAINABLE FOREST MANAGEMENT PRACTICES

EXECUTIVE SUMMARY

The Global Environment Facility (GEF), through the *Instituto Pró-Natura*, has been developing a program whose purpose is to implement Sustainable Forest Management (SFM) in the northwest region of Mato Grosso State, which includes the following municipalities: Juína, Castanheira, Juruena, Cotriguaçú, Aripuanã, Colniza and Rondolândia. With the intention of supporting and complementing Pro-Natura's activities, the present project, funded by the United Nations Fund (UNF) and coordinated by the *Instituto Nacional de Eficiência Energética* (INEE), aims to assess the technical, economic and financial feasibility of electricity generation in the above-mentioned region from residues derived from SFM practices in the wood products industry. It also seeks to study possible obstacles and opportunities as well as to propose the necessary measures for its future replication in other localities in the Amazon region that do not expect to be connected to the Brazilian National Interconnected System (SIN).

Pro-Natura's surveys and research demonstrated that the practice of Sustainable Forest Management is still incipient in the studied region, where timber is predominantly harvested without proper management and lumber is widely used from both legal (up to 20% of property areas in the Amazon region) and illegal logging. In a pessimistic scenario, the previously cited GEF project would not achieve its objectives and the situation would remain largely unchanged, i.e., the prevalence of a frontier culture, characterized by the search for high short-term gains at the expense of forest resource degradation. In such a scenario, the project would be unfeasible due to the unavailability of residues produced from SFM practices.

An assessment of the electricity infrastructure in the region showed that presently these systems are all isolated from the national network. Only the Juína and Castanheira municipalities are in the process of being interconnected by 2004 and are thus excluded from the present study's scope.

At that point, five wood products industry clusters and sub-clusters were identified and confirmed as potential sites for a Pilot Plant. The "Mulitattribute Utility Function" methodology was used to rank these areas based on fundamental premises (native forest preservation, human settlement, replication), quantitative criteria (quantity of substitutable diesel oil, quantity of residues from SFM practices, net electricity estimate) and qualitative criteria (local government support, presence of a wood products industry association, space availability for the project). These criteria were developed based on interviews with project team members while taking into consideration the above-mentioned premises. As a result, Rondolândia – Pólo 70 ranked first, followed by Juruena-Cotriguaçú[1], Colniza, Aripuanã-IMADEX and lastly, Aripuanã – the municipal seat.

Additional research and surveys related to Pólo 70 revealed drying to be an important factor in characterizing electricity consumption, and consequently, in making electricity generation from residues an economically and financially feasible activity. It must be noted that the Pólo 70 sawmills do not use kiln driers since timber is only sawn locally, and later shipped in planks to Ji-Paraná, a municipality in the neighboring state of Rondônia. Once dried, the wood is subject to the production and complementary finishing processes for eventual sale. Nonetheless, most of the sawmills in the area support the idea of building a Central Drying Plant (CDP).

[1] Both municipal seats were considered as a single cluster from the electricity perspective, due to the interconnection planned by the local utility company, CEMAT.

It was also shown that installing a Central Drying Plant together with the Power Generation Plant offers the enterprise a greater return and permits leveraging long-term financial resources to provide that service as well. This would give local sawmills the opportunity to begin a cycle of modernization and verticalization while using a smaller initial amount of their own resources. Without the drying plant, sawmill owners would have to bear expenses and investments far greater than the amount paid to the CDP for the service in order to reach the same objectives individually. Moreover, with the drying plant, the project's profitability will offer the participating sawmill owners an additional gain for investment in their business development. Hence, the Pilot Plant was defined as a Utility Plant that includes a Power Generation Plant (Electricity and Steam) and a Central Drying Plant.

The Power Generation Plant´s dimensioning was based on estimates of the maximum and average demands; the annual energy consumption of the sawmills, the CDP and the municipal seat (Rondolândia), and the Central Drying Plant's steam consumption based on the Reference Energy Scenario[2]. After the available technologies were analyzed and the budgets for the various technical options estimated, the following configuration was established:

Power and Steam Plant:	Boiler -15ts/h, Extraction Condensing Turbine –1250 kW Elevating Substation - 440/13.800 V. Residue Collection Equipment
Central Drying Plant:	22 50 m^3 dryers (Reference Scenario only) Supply shed Stackers

Cluster's Electricity Distribution Network

Considering that none of the sawmills in Rondolândia could undertake this project alone, that the participation of institutional agents in the company owning the Utility Plant is highly encouraged from the social environmental points of view, and further considering the possibility of attracting venture capital, this study recommends that a joint stock corporation be formed to build and operate the plant. The plant's private shareholders, preferably the sawmills themselves, should hold the controlling interest. The company's articles of incorporation, including shareholder agreements, if necessary, will define the organization's main objectives, and the participation of representatives from the various interested parties in the Board of Directors will ensure that these objectives are fulfilled.

The following main parameters were determined for the projects' economic and financial assessment:

- Variable assumptions: energy sales price, drying service price, amortization periods, interest rates, purchase price of residues from SFM, Value-Added Tax on Sales and Services (ICMS), investment values and cost of diesel-based self-generation;

[2] Reference Scenario: assumes growth in the volume of sawn timber due to the increase in sawmill operating hours; 50% of the sawn wood is dried in the first year, increasing to 80% by the third year.

- Fixed assumptions: Exchange Rate (US$1.00 = R$3.60), inflation (0%), resource structure (20% capital, 80% funding), discount rate from sawmill cash flow (25% per year), additional payment by sawmills for SFM-based timber (R$ 15,00/m^3), CCC resources[3] (R$ 0) and grace period for loans (2 years).

Based on the Reference Scenario, alternative scenarios representing a variety of possible situations were analyzed to ensure an adequate economic and financial assessment. These include:

- Scenario with Accelerated Drying (reaching 100% by the third year);
- Reference Scenario with no increase in operating time of the sawmills;
- Reference Scenario with no drying plant (electricity production only).

The following aspects were considered as baseline hypotheses: energy sales price - R$350.00/Mwh; price of drying - R$70.00/$m^3$; interest rates and amortization period[4] - Eletrobrás and others - 10% per year and 10 years/ BNDES/Agents and others 8% and 8 years; residue purchase price - R$ 0.00/m^3, ICMS tax rate -25%; investment – estimated budget value[5]; cost of self-generation - R$ 600.00/MWh.

Considering the above-mentioned basic hypotheses and a financial structure geared towards the conservative scenario described below, the following table summarizes the results of the above scenarios, from the point of view of sawmills, project investors, financial agents and governments:

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[3] CCC: Portuguese acronym for Fuel Consumption Account (*Conta de Consumo de Combustíveis*): In isolated systems CCC resources may be applied for investments in undertakings that aim to substitute fossil fuel-based generation, upon authorization or concession. However, ANEEL only authorizes in the case of installed power above 5 MW .

[4] Interest Rates and Amortization Periods: the conditions in the conservative financial model were applied to the No-Increase-in-Time Scenario; the Conservative and Intermediate models were applied to the Reference Scenario; and all three models were applied to the Optimistic Scenario. The Conservative scenario was adopted to determine the reference hypothesis.

[5] Estimated Investment Value: Reference Scenario, Accelerated Drying and No Increase in Operating Time - R$9,932,831; No Drying – R$6,514,226.

Table 1

RESULTS OF ECONOMIC AND FINANCIAL ASSESSMENT

Results	Baseline Reference	Accelerated Drying	No Increase in Operating Time	No Central Drying Plant
Plant:				
Internal Rate of Return – IRR (12 years)	31.7%	43.3%	17.4%	8.1%
Payback Period - years	1.6	1.6	7.7	>12
Debt Service Coverage Ratio (year 1) - years	2.8	4.2	2.0	1.5
Debt Service Coverage Ratio (average) – years [6]	1.6	1.8	2.2	1.3
Sawmills (in R$):				
Net Present Value – NPV (25% per year),w/ share interest	1,628,360	2,696,528	1,983,001	1,334,197
Net Present Value – NPV (25% per year), no share interest	1,589,756	2,479,416	2,369,200	1,758,289
Difference (Basic w/ share interest)	0	1,068,168	354,641	(294,162)
Governments (in R$):				
Service Tax - ISS (Municipal)	691,187	708,732	523,404	0
Value-Added Tax on Sales and Services - ICMS (State)	3,644,848	3,428,104	2,933,040	6,239,006
Income Tax + Social Security Contribution (National)	5,212,469	5,173,458	3,218,631	1,807,612

From the shareholder/investor point of view, the first three scenarios are all feasible (the second one is more optimistic and the third is more conservative compared to the Baseline scenario). For the sawmills holding a share interest in the plant, the best scenario among these is that of a Accelerated Dring. All of the above scenarios, however, under the reference hypotheses, would offer shareholders significant results as compared to the alternative of investing their own resources in individual drying units in Rondolândia. The table also shows the municipal, state and federal government gains from the respective taxes accumulated during the first 12 years of operation.

The following table shows the variations in project´s financial result due to changes in the variable assumptions, compared to the Baseline scenario.

[6] For the Debt Service Coverage Ratio in Table 1, the term “average” refers to the arithmetic mean of the values from year 2 to the last debt payment.

Table 2

SENSITIVITY ANALYSIS

Simulated Parameters		Central Plant Results			Sawmill Results (R$)		
Description	Value	IRR (% py)	Period (years)	Coverage Ratio	NPV w/share int.	NPV no share int.	NPV Difference
Energy (R$/MWh)	385	34.5%	1.8	1.8	1,403,187	1,284,917	118,269
	350	31.7%	1.7	1.7	2,317,127	2,278,523	38,603
	315	28.8%	1.7	1.7	1,853,533	1,894,595	(41,063)
Seasoning (R$/m^3)	77	38.0%	1.9	1.9	1,294,486	1,077,151	217,335
	70	31.7%	1.7	1.7	2,317,127	2,278,523	38,603
	63	25.3%	1.6	1.6	1,962,234	2,102,361	(140,128)
ICMS (%)	25	31.7%	1.7	1.7	2,317,127	2,278,523	38,603
	20	31.7%	1.7	1.7	1,818,884	1,780,280	38,603
Investments (R$ mil)	9833	39.2%	1.9	1.9	1,815,859	1,589,756	226,103
	10925	31.7%	1.7	1.7	2,317,127	2,278,523	38,603
	12018	25.2%	1.5	1.5	1,434,074	1,589,756	(155,682)
ELB Funding	10%-10 years	31.7%	1.7	1.7	2,317,127	2,278,523	38,603
Other Funding	12%-6 years	25.2%	2.7	2.7	2,135,913	2,278,523	(142,610)
Diesel Generation (R$/MWh)	660	31.7%	1.7	1.7	3,005,894	2,967,290	38,603
	600	31.7%	1.7	1.7	2,317,127	2,278,523	38,603
	540	31.7%	1.7	1.7	1,628,360	1,589,756	38,603
SFM Residues (R$/m^3)	0	31.7%	1.7	1.7	2,317,127	2,278,523	38,603
	15	27.4%	1.6	1.6	2,527,130	2,610,734	(83,603)
	30	22.9%	1.5	1.5	2,737,134	2,942,944	(205,810)
		31.7%	1.7	1.7	2,317,127	2,278,523	38,603

Table 2 shows that the results obtained by the plant are more sensitive to variations in drying prices and investments than in energy prices. The sawmill IRR (at a 25% annual discount rate) shows a sharper variance with the avoided self-generation cost. Occasional tax reductions linked to SFM may contribute to the project's feasibility, and indirectly, to SFM itself.

The greatest obstacles to the implementation and replication of the project – aside from the inherent cultural difficulties of the Brazilian business environment and especially of the local industry executives – are concentrated in the financial, environmental and regulatory areas, as well as in the electricity sector. Among the impediments to financing small-sized cogeneration projects in Brazil are the currently high interest rates, a high relative transaction cost and the regulatory risks inherent in the electricity and environmental sectors, particularly when associated with logging, in addition to the conservative character of the country's commercial bank sector. These risks increase due to the low capitalization rate of the wood products industry and the consequent difficulty of firms to participate in projects with a more significant share of their own capital.

The three scenarios considered when choosing the Project's funding and structure are summarized below:

I. ***Conservative****:* although moderate (greater than 15% per year, discounting inflation), the internal rate of return would be adequate for the minority participation (<50%) of Eletrobrás, which could also act as a source of loan financing. The principal equity share would be held by the actual sawmills in the cluster and complementary credit would come from the BNDES/Agents. The feasibility of the project for these federal institutions is justified not only by the demonstrated return, but also and notably by the goal of universalizing electricity services and implementing sustainable development in isolated areas of the Amazon region, where widespread replication is possible.

II. ***Intermediate***: Once an adequate medium return has been assured (greater than 25% per year), the project may attract the GEF Guarantee Fund, which guarantees 50 to 75% of the funding. Complementary guarantees would be constituted of energy and drying plant assets. Through this model, a project portfolio could be developed to guarantee financing from BNDES/Agents and other banks.

III. ***Optimistic***: The return (over 40% per year) is considered high and is compatible with the risks – that alone will attract private venture capital. Share interest would be divided between the sawmills and a strategic partner in order to allow financing from BNDES and others.

The environmental legislation related to forest resources is considered adequate enough to ensure sustainable economic use and conservation of the forest. The problem, however, lies in how to apply these laws, as the Amazon region makes it difficult for various reasons, including the size of the region to be monitored, the high value of the tree species found there and the low cost of extraction through deforestation, in addition to the high value of cleared areas for cattle raising. The Pilot Plant's implementation, together with the GEF-Pronatura Project, may contribute to revert this current picture, as it will prove that SFM residue-based generation in conjunction with local drying is feasible, and will develop the necessary mechanisms for the its replication in other wood products industry clusters in the Amazon region.

In the electricity sector, Law #10.438/2002 and the associated Decree #4.541/2002 created incentive mechanisms for using alternative energy sources and for universalizing electricity services that may contribute to disseminating electricity generation from wood residues in the Amazon region. However, the isolated systems' CCC, a potentially important source of financing for the project, benefits only those projects authorized by ANEEL, which, according the interpretation of the sector's legislation, only grants authorizations for thermalelectric plants that produce more than 5 MW of power. Yet in the isolated systems of the Amazon region most of the thermalelectric power generation falls under this limit. Eletrobrás minority interest in generation projects, according to Article 22 of Law #10.438/2002, also depends on ANEEL's authorization.

In sum, despite the identified risks, it is clear that generation from wood residues produced from SFM practices in the Amazon can be made feasible. The following actions are recommended towards this end:

- ♦ Detailing and implementing the Pilot Plant with the greatest interest possible from wood products industry owners and institutional investors;
- ♦ Carry out the necessary regulatory measures in order to extend the benefits created for alternative sources and service universalization to projects of less thano 5 MW in the isolated systems of the Amazon region.
- ♦ Bring together the Ministry of Mines and Energy and the Ministry of the Environment to ensure the link between residues for generation and electricity generation, on the one hand, and to speed up the environmental licensing process on the other.
- ♦ Ensure support specifically for SFM implementation in the pilot project's area of influence.

The resulting social benefits are:

- ♦ Reinforcement of the use of sustainable forest management in conjunction with local timber production, the only possible way to link economic activity with forest conservation.
- ♦ The self-sustained economic activity will lead to permanent settlement of the population.
- ♦ With the population's permanent settlement, the creation of schools and urban structures will increase as the presence of the industrial activity increases in the region.
- ♦ The verticalization of local industries, which is only possible with proper electricity supply and wood drying services, will necessarily lead to technological improvement in the industrial process and consequently, a need to cultivate manpower and improve the economic situation of the population as a whole.
- ♦ The relationship between the population's permanent settlement and sustainable management will halt the process of predatory exploitation, whether from timber companies not dedicated to sustainable management or from cattle ranchers and farming activities, the latter being significantly more predatory than the first source of deforestation.
- ♦ Barriers to transforming the region into a coca-producing area, as has already occurred in the Bolivian, Peruvian and Colombian Amazon.

As an overall result, the problems caused today by the unused potential of wood residues will disappear, and this currently negative externality will be transformed into a positive gain for the region.

ANNEX

SUSTAINABLE FOREST MANAGEMENT IN THE REGIONAL CONTEXT

1. SUBJECT

The present Annex offers a summary of the conclusions drawn from the technical, economic and financial feasibility study undertaken for the proposed electric power and central drying plant project. The plant will have the capability to burn residues derived from industrial processes of the wood products industry , assuming the timber extracted is a result of sustainable forest management practices. This study was developed with funds from the United Nations Foundation.

Currently on the production side, wood residues still represent a burden for most of the industries established in the studied region. They are disposed of by uncontrolled burning which maximizes local pollution..

On the electricity supply side, the referred region (see item 2 below) lacks adequate supply since it contains only isolated systems operating on diesel oil, with no connection to the National Interconnected Power System (SIN). Only two municipalities, Juína and Castanheira, are scheduled to be interconnected to the System by 2004. No other connections to the basic national electric network are expected. An inter-municipal connection between the isolated systems of Cotriguaçu and Juruena is being made.

The inadequate supply of electricity, both in quality and in quantity, restricts the possibilities of the wood processing industries to add value in the region. As a result, most manufacturers – with few exceptions – are forced to limit their local activities to timber extraction and sawing. The sawed timber – frequently still unseasoned in its green state – is then shipped to the respective industrial centers where final processing takes place, including drying and final production. In addition, this combination of circumstances has forced some industries to come up with their own energy solutions, whether diesel-based or through combustion of their own residues. Some of these industries, moreover, act as Independent Energy Producers and sell energy to other nearby sawmills or to the small communities formed by their employees.

Summarizing, the study's main emphasis is on forest conservation. Undoubtedly, logging is a predatory activity in its essence as it requires cutting down trees, and can only change in character if it is reinvented under an extensive sustainable forest management program.

Sustainable forest management is a practice that uses a set of techniques to map harvesting areas, identify an area's timber and other resources, and outline a rotational program in which the harvesting area is divided into quadrants and felling takes place sequentially: after the first quadrant is exhausted, the next quadrant is logged while the first is reforested and so forth, until the cycle is completed. This technique prevents the forest from disappearing or losing much of its biodiversity, in addition to keeping it economically active and ensuring the long-term survival of industrial activity. It also offers an alternative solution to the constant migration of businesses searching for new areas with standing trees – a migration that is motivated by the rapid depletion of good-quality timber.

Consequently, the study seeks to show sawmill owners who practice sustainable forest management that they can take advantage of the residues generated from their own production by using it as raw material to generate electricity - a process that will not only eliminate a burden, but will transform it into a source of more income, insomuch as:

- the current energy shortage will be resolved since electricity may be both produced and consumed by the same facility;
- electricity and steam used for drying and cutting the harvested timber can be cogenerated, an important basis for increasing the processing the industry's wood production;
- it promotes additional revenue when surplus electricity can be produced and sold. Whether it is sold to CEMAT or to nearby sawmills, the surplus gives industry owners the possibility to become Independent Energy Producers.

2. AREA OF INFLUENCE

The project's area of influence was divided into two parts according to type of influence (direct and indirect). The area of direct influence, in which the entire study was developed, corresponds to the extended region and includes the following municipalities: Juína, Castanheira, Juruena, Cotriguaçú, Aripuanã, Colniza and Rondolândia. The second part, the area of indirect influence, comprehends the remainder of the Amazon Region, in which the project may be reapplied in areas that are predominantly used for logging and that at the same time suffer a shortage of electricity supply. This shortage is compensated, furthermore, by the combustion of diesel oil within isolated systems.

The area of direct influence was sub-divided into 4 clusters and 3 sub-clusters, as follows:

- The Juína – Castanheira Cluster;
- The Juruena – Cotriguaçú Cluster;
- The Aripuanã – Colniza Cluster, which is further divided into three sub-clusters (Aripuanã – municipal headquarters, Aripuanã - IMADEX and Colniza);
- The Rondolândia Cluster.

The sub-cluster Aripuanã – IMADEX includes the area occupied by the timber company IMADEX, located 80 km from municipal headquarters. In addition to the IMADEX sawmill, there are two other sawmills in the sub-cluster, with a community of approximately 1000 people. All of the electricity supply is based on diesel.

3. SUMMARY DESCRIPTION OF THE AREA OF DIRECT INFLUENCE

The following aspects provide a basic description of the area of direct influence:

- ♦ Local population growth is a direct function of the wood products industry , and is especially significant in the municipalities located near the expanding frontier of harvesting areas (Aripuanã, still including the Colniza and Rondolândia municipalities, and Cotriguaçú). Conversely, in areas where the industry begins to decline, so does the resident population. (See Castanheira and Juruena in Table 3.1);

- ♦ The wood products industry stands out since it dominates economic activity in the entire region;

- The transport infrastructure in the study area is precarious. Unpaved roads offer the only option for circulating goods and passengers, which becomes difficult or impossible during the rainy season (see Table 3.2).

Published in 2001 by the Department of Planning and General Coordination of Mato Grosso State, the study entitled "Diagnóstico Sócio Econômico Ecológico do Estado de Mato Grosso"[7] offers a significant contribution with regard to the area's main economic activity: timber extraction. The report presents a worrisome picture in terms of the activity's sustainability, since it shows that most industry executives seek short-term gains, are uncommitted to the forest's conservation and are responsible for the rapid depletion of the raw material (wood). In summary, this official document reveals the following situations:

- Intense migration due to the relatively low investment needed for tree felling, on the one hand, and because of the high sales value of timber, on the other. This situation offers fast gains at the same time that it provokes premature exhaustion of the exploited area, followed by immediate relocation to new areas rich in raw material;

- A predominance of industries engaged in logging through unorganized forest clearings, an activity that predominates over other industries that use their own native forests;

- The presence of a service provider called *extrator de toras* – literally, a "log extractor" – who, when not engaged in illegal felling, takes advantage of any legislation that may allow clearing of substantial parts of a determined forested area's vegetative cover to sell felled timber to lumber companies. This kind of service provider is more common than the "forest producer", who, although also fells timber as a service provision, respects and practices sustainable forest management;

- A gradual reduction of the number of extractive activities based on sustainable management;

- Sixty-four percent of industry wood suppliers are engaged in predatory practices (46.4% are farmers and 17.6% are "log extractors") and only 11.4% supply timber from owned properties, though not necessarily based on adequate management.

- The average time estimated for maintaining logging activities at a commercial scale in the area of influence is no more than 8 years;

[7] *The Mato Grosso State Ecological and Socioeconomic Diagnostic*

TABLE 3.1 - POPULATION GROWTH

MUNICIPALITIES	POPULATION IN 1991	POPULATION IN 1996	CENSUS RESULT	POPULATION GROWTH (%per year)
Aripuanã	13,614	16,764	27,493	8.122
Castanheira	8,362	8,294	7,756	- 0.832
Colniza*				
Cotriguaçú		4,758	8,481	15.546**
Juína	36,581	32,221	38,026	0.431
Juruena	5,956	4,468	5,464	- 0.953
Rondolândia*				
REGION TOTAL	64,513	66,505	87,220	3.407
STATE TOTAL	2,027,231	2,235,832	2,498,150	2.348

Source: *Mato Grosso Annual Statistic Report – 2000*   *Included with Aripuanã   **From 1996 to 2000

TABLE 3.2 - ROAD TRANSPORT

a) **Road Conditions (km)**

ROUTE	LENGTH	PAVED	BASE COURSE
Juruena-Cotriguaçú	52	0	52
Juruena-Colniza	145	0	145
Juruena-Aripuanã	105	0	105
Juruena-Juína	105	0	105
Juruena-Castanheira	90	0	90
Juruena-Cuiabá	680	20	660

b) Approximate istance to Cuiabá (km)

MUNICIPALITIES	DISTANCE
Aripuanã	1,195
Castanheira	825
Colniza	695
Cotriguaçú	562
Juína	805
Juruena	637
Rondolândia	1,395

Source: Road Map of Mato Grosso - 2001

4. ENERGY INFRASTRUCTURE

Within the area of direct influence, only Juína and Castanheira will be connected to the national grid by 2004. All other municipalities consist of isolated systems based on diesel generation. Except for Juruena and Cotriguaçú, between which CEMAT is implementing a line to form a larger isolated system, all other municipalities supply only their respective municipal seats. The Eletrobrás Ten-Year Plan (*Plano Decenal*) foresees a connection between Juruena and Aripuanã that would create an isolated macro-system (Juruena-Cotriguaçú-Aripuanã). Although such connection is included in CEMAT's current plans, there is no starting date scheduled as yet.

The tables provided below outline the regional energy supply and diesel oil consumption:

- Table 4.1 - Increase of electricity consumption by CEMAT customers;
- Table 4.2 - CEMAT energy supply capacity;
- Table 4.3 – Sawmill self-generated electricity supplies, whether for own use or third-party consumption in cases of surplus;
- Table 4.4 - Diesel oil consumption by CEMAT and the sawmill industries.

TABLE 4.1 - AREA OF DIRECT INFLUENCE
ELECTRICITY CONSUMPTION INCREASE
1998 / 2001

(kWh)

MUNICIPALITY	1998	1999	2000	2001	GROWTH RATE (% per year)
Aripuanã	7,425,772	9,146,673	11,025,981	15,246,993	27.10
Castanheira	2,901,303	2,633,037	2,689,151	2,952,554	0.58
Colniza*	N/A	N/A	1,075,948	2,060,630	97.50
Cotriguaçú**	N/A	1,595,289	2,198,202	2,653,797	28.98
Juína	23,072,895	24,109,084	27,567,395	31,853,140	11.35
Juruena	3,439,068	3,413,787	3,470,929	3,951,880	4.74
Rondolândia*					

Source: CEMAT * The Colniza and Rondolândia municipalities were not included with Aripuanã.
**The Cotriguaçú municipality was not included with Juruena.

TABLE 4.2 - AREA OF DIRECT INFLUENCE CEMAT ELECTRICITY SUPPLIES*

MUNICIPALITY	ENERGY SOURCE	COMPOSITION	CAPACITY (kVA)	COMMENTS
Juruena	Diesel oil	7 units	250 each	4 units support the current load; 1 unit operates during peak hour
Cotriguaçú	Diesel oil	1 unit 3 units 2 units	405 375 each 325 each	Maximum demand 1,340 kVA Maximum demand 1,060 kVA
Aripuanã	Diesel oil Small Hydro Plant (SHP)	1 unit 2 units 2 owned units Surplus from the Madeireira Faxinal timber company	1,800 250 each 450 each (600 kW during the day 300 kW at night)	
Colniza	Diesel oil	6 units	375 kVA each	Operating 200 kVA: 3 units permanently operating, 1 unit on at 3 p.m., another at 6 p.m.
Rondolândia	Diesel oil	4 units	260 kw 100 kw 80 kw 300 kw	Serves only the municipal headquarters; does not supply the two industrial clusters (Pólo 70 and Paralelo 100)

*Since Juína and Castanheira will soon be connected to the South-Southeast-Middle West Interconnected System (*Sistema Interligado Sul-Sudeste-Centro Oeste*), these two municipalities are not shown in the Table.
SOURCE: CEMAT

TABLE 4.3 - AREA OF DIRECT INFLUENCE ELECTRICITY SELF-PRODUCED ENERGY SUPPLIES*

MUNICIPALITY	PRIMARY SOURCE	INSTALLED CAPACITY (1000 kVA)
Juruena	Fuel wood and wood residues	**4.25**
Cotriguaçú	Diesel oil and wood residues	**0.82****
Aripuanã	Diesel oil and small hydro plant	**3.26**
Colniza	Diesel oil and wood residues	**1.43*****
Rondolândia	Diesel oil	**1.86**

* Information obtained only from companies visited. ** The main self-producing facility refused to provide data; it supplies about 10 timber companies and a small community. *** Includes the single Independent Producer of the municipality.

TABLE 4.4 - DIESEL OIL CONSUMPTION
(1iters / year)

LOCATION	CEMAT	SAWMILLS	TOTAL
Juruena - Cotriguaçú	**2,654,996**	**357,333**	**3,012,329**
Aripuanã - IMADEX	**0**	**250,133**	**250,133**
Aripuanã – municipal headquarters	**362,843***	**296,587**	**659,430**
Colniza	**789,118**	**357,333**	**1,146,451**
Rondolândia – Paralelo 10	**0**	**321,600****	**321,600**
Rondolândia – Pólo 70	**0**	**554,921****	**554,921**
Total	**3,806,957**	**2,137,907**	**5,944,864**

* Annual consumption levels considered (in 2001, there were only 9 months of consumption).
** The evacuation of Paralelo 10 was considered in the value estimates.

5. RESIDUE PRODUCTION

The *Instituto Pró-Natura* (IPN), a co-participant of the present project responsible for the forest-related assessments, is developing an extensive study in the area of direct influence with the support of funds from the Global Environmental Facility (GEF). The study aims to advise regional timber industry owners on the practice of sustainable forest management, and also hopes to create a conservation awareness that will bring together various stakeholders who, given the possibility to generate energy from residues, will effectively complement each other:

- on a global scale, towards the goal of preserving the last tropical forest on the planet that has not yet been completely destroyed by human activity;
- on a national scale, towards the same goal;
- in benefit of the wood products industry owners who are committed to the long term survival their enterprises - by eventually transforming it into a sustainable activity that will prevent the premature exhaustion of resources and create the necessary conditions to allow its continuous operation;
- in benefit of local inhabitants - by supporting their livelihoods; the possibility of verticalizing local industries and hence increasing employment levels, which will help the local population establish itself and evolve economically;
- in favor of the state – including the municipal, State and Federal levels – through sustainable and tax revenue increases resulting from the continuity and the possible verticalization of the wood products industry.

In its study, IPN developed diagnostics for the wood products industry in 7 municipalities included in the area of direct influence. As a result, the organization was able to evaluate the different perspectives of wood residue production derived from sustainable forest management practices during a 5-year span, as shown in Table 5.1.

To prepare estimates for the next 5 years, two scenarios were considered. The first assumed the entire project elaborated by IPN in the region to be unsuccessful, and thus maintained the current situation described in the Diagnostic published by the Department of Planning and General Coordination of Mato Grosso State (see item 3 of this document). The second scenario was more optimistic and considered the GEF Program objectives – as described in this item – fulfilled. The values presented in the Table obviously represent results obtained through the second, more optimistic scenario, since the first approach, if realized, would effectively cancel out the present project as it does not permit the supply of residues to be derived from sustainable management practices.

The following conclusions were drawn from upon considering the possibility of the first scenario taking place:

a. In Aripuanã

There will be an increase in the number of Sustainable Forest Management Plans (PMFS's) in the municipality with the addition of two more companies (total of seven). These two timber companies are currently logging without a PMFS, each exploiting an area of 1000 ha per year. This addition will consequently increase the volume of timber extracted through sustainable forest management plans to a total of 44,000 m³ of logs per year, or 22,000 m³ of supplementary residue.

As for IMADEX, if the company began to rely on other sources of energy from local residue-based electricity generators, it would be able to increase its industrial wood processing capacity. The company, however, has no access to other forest resources that would allow expansion of its own property under sustainable management. The other companies located in its proximities do not have their own forest properties and obtain their wood from clearings made by surrounding settlements. It is therefore unrealistic to expect an increase in volume of residues from sustainable forest management practices in the short term.

b. In Castanheira

There is no possibility of increase under managed areas. Only one company operates in the area and it has no plans to expand its volume since the municipality's forest resources have been exhausted.

c. In Colniza:

The number of Sustainable Forest Management Plans is expected to double to a total of four. The new additions include Lunardelli, with an area of 1800 ha per year under a PMFS (in preparation) and another company with 1000 ha per year (under consideration). These additions will cause an increase in the volume produced through sustainable forest management plans of 61,600 m³ in logs, or 30,800 m³ of residue.

d. In Cotriguaçú:

There will be an additional three areas under PMFS (total of eight), including a project in the indigenous area Escondido, with 1500 ha per year, and two other PMFS's each of 800 ha per year. This will lead to a 68,200-m³ increase in the volume of managed raw material

(3100 ha at 22 m³/ha), which translates into about 34,100 m³ of residue.

e. In Juína:

The implementation of a PMFS in an indigenous area (still under discussion and currently in technical bid) will permit 2000 ha per year to be harvested under the PMFS. This addition will increase the volume of managed raw material by 44,000 m³ of logs, or 22,000 m³ of residue.

f. In Juruena:

No increase is expected in number of PMFS's. Yet if the main local company, Rohden, focuses its commercial strategies on obtaining FSC certification, there may be an increase in the volume of managed raw material through third-party PMFS's (which includes community management), with an increase in log volume of 20,000 m³ (which will generate an increase of 10,000 m³ of residue).

g. In Rondolândia:

At the present moment, activities in Rondolândia boil down to mere log-sawing sheds, from which planks are shipped to Ji Paraná for other applications. With improved energy availability and the installation of drying equipment, sawmills are likely to verticalize with more processing in the cluster. In such context, the industries established in Rondolândia will begin absorbing the total volume of logs extracted from local PMFS's, which are also expected to increase in number.

An increase in the volume of raw material derived from managed sources of 85,000 m³ of logs (or 42,500 m³ of residue), may occur if assets are transferred to Pólo 70, where the increase would actually take place.

h. Residue availability:

In order to estimate the potential availability of residues for energy generation, a 50% rate was applied generically to the log volumes estimated above. The results are shown in Table 5.1.

**TABLE 5.1 - AREA OF DIRECT INFLUENCE
ESTIMATES OF RESIDUE VOLUME PRODUCED BY THE WOOD PRODUCTS INDUSTRY THROUGH SUSTAINABLE FOREST MANAGEMENT**

LOCALITY	CURRENT	ESTIMATED (5 years)	INCREASE
Aripuanã	**16,070**	**38,070**	**136%**
Colniza	**7,850**	**38,650**	**392%**
Cotriguaçú	**33,460**	**67,560**	**102%**
Juína	**15,683**	**37,682**	**140%**
Juruena	**15,100**	**25,100**	**66%**
Rondolândia	**10,700**	**53,200**	**397%**
TOTAL	**98,863**	**260,262**	**163%**

Calculations of the values expressed in Table 5.1 were based on surveys undertaken by IPN. The volumes were also evaluated during site visits that revealed consistently greater quantities of total residue (in Rondolândia, up to 28,000 tons per year, which is compatible with the estimated difference from its current volume to the volume in 5 years as shown in Table 5.1). This shows that a large part of the residues are still produced from other extractive – though not necessarily illegal – activities.

ANNEX

CHOOSING THE LOCATION

1. PURPOSE

The purpose of this annex is to offer a methodology for choosing the thermalelectric plant's site. It concludes by proposing a location for the plant's installation.

2. PREMISES

Objectives:

a- to choose one of the six locations considered in the main Report. The preferred location must permit quick implementation of the thermalelectric plant;

b- to ensure objectivity by establishing levels of priority while seeking to verify if the conclusions reached are sustainable in when subjected to a methodology which is not subjective

The following locations were considered:

- Juruena – Cotriguaçú;
- Aripuanã – IMADEX;
- Aripuanã (municipal headquarters);
- Colniza;
- Rondolândia (Pólo 70).

A sixth location, Rondolândia (Paralelo 10), was evacuated during the course of the study, as its main sawmills have re-located or are in the process of re-locating their properties, plants and equipment to Pólo 70 or elsewhere

To this end, the project must satisfy the following assumptions:

- It must represent an opportunity that will motivate businesses and the community to opt for native forest conservation;
- It must promote the permanent establishment of people in the region as the motivating factor for creating an infrastructure for electricity distribution;
- It must be easily replicated in other localities in which there is forest exploitation.

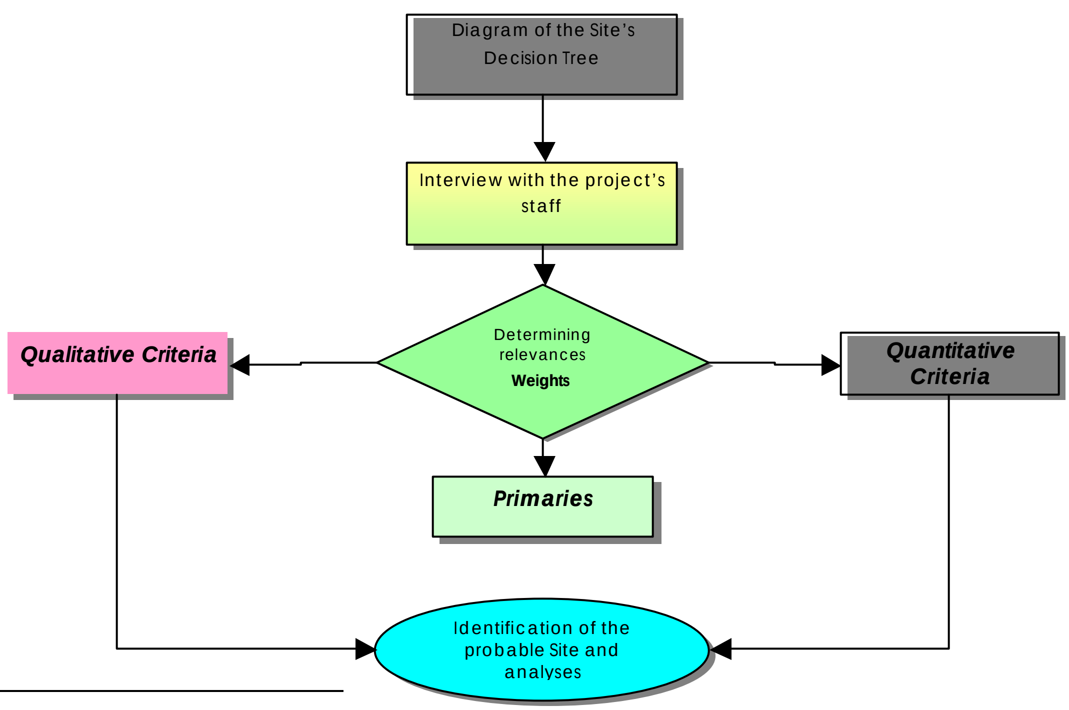
The criteria for choosing the location were divided into two groups (quantitative and qualitative), as follows:

– **Quantitative or numeric criteria:**
  - Quantity of diesel oil that can be substitued by the new technology;
  - Quantity of forest residues derived from sustainable management practices;
  - Estimated net load (in MVA) in the region.
– **Qualitative criteria:**
  - Support from the local government;
  - Presence of a local wood products industry association;
  - Space availability for the project.

3. METHODOLOGY

Based on the "Multiattribute Utility Function" theory[8], the various options were compared and ranked through "utility functions" that were created from the opinions presented by the various technical experts as well as from the quantitative data collected from each visited site. These values were then applied to a decision tree.

In order to apply this methodology, the following framework was used as a guide in the decision-making process.



[8] Gomes, L.F.A..M.; Gomes, C.F.S. & de Almeida, A. *Tomada de Decisão Gerencial Enfoque Multicritério*, São Paulo: Atlas (www.editora-atlas.com.br), 2002.
Clemen, Robert T. & Reilly, Terence. Making Hard Decision with Decision Tools, Pacific Grove: Duxbury (www.duxbury.com), 2001.

4. CHOOSING THE LOCATION

4.1 PRELIMINARIES

The team visited a total of 6 sites, however one of them, although it participated in the election, will be dismissed at the outset due to its evacuation (Paralelo 10, em Rondolândia). See item 2 for a detailed list.

The quantitative data were collected through local research, statistics and interviews. The following variables were found to be relevant in the final decision:

- Quantity of diesel oil already in use by the established industry that may be substituted by the new technology;
- Quantity of forest residues (stocked and produced) from already-established activities;
- Electrical load defined in MVA.

As already mentioned, when choosing the location, it is important, on the one hand, to evaluate the quantity of diesel oil consumption used to generate electricity for the wood products industry, whether burned in CEMAT or sawmill equipment, and on the other, to estimate the net demand for electricity to be satisfied by the thermalelectric plant. Thus, the following observations apply:

a- it is important to keep in mind that the desired implementation, derived from the present study, must be able to fulfill all of the requirements considered (residue availability, lack of electricity supply and concentration of timber industries in one location) in a short period of time;

b- diesel oil consumption, at the same time that it is presently responsible for generating electricity, may be effectively substituted;

c- the net electrical demand will be derived from the algebraic sum of the load from sawmills to be supplied, from CEMAT's ability to supply them and from the presence of other nearby plants with surplus productions, preferably based on non-fossil sources.

Therefore:

i- The net electrical demands of the IMADEX and Rondolândia clusters will be equal to the consumption required by the industries in those clusters, since there are no other available sources of energy supply; the same rationale serves for fuel consumption.

ii- Because of already-existing supplies, the Juruena-Cotriguaçú and Aripuanã-municipal headquarters clusters present near-zero or even negative net demands, as is the case with the latter, which has some hydro supply.

iii- Due to the presence of an Independent Producer (Amóz), the estimated value for the Colniza cluster will be 0.2 MVA, obtained from the algebraic sum of the loads from sawmills (São Paulo), their self-productions, from Amóz supplies and from CEMAT, although the latter is based on fossil fuels (scheduled expansions that have not yet been implemented were not considered).

Finally, it is important to note that the values presented were derived from information obtained from sawmill industry owners and were not measured, except in the case of CEMAT, which was able to supply statistically compiled data. Equally important is the fact that CEMAT's supply was only considered in cases where it actually exists, since in many locations (the Juruena-Cotriguaçú Cluster, for example) most of the timber companies visited are independent of external supplies.

The Table below shows the values found for each of the localities considered.

Locality	Diesel Substitution m3/year		Quantity of residues from sustainable management		Load in MVA	
	original	relative	original	relative	original	relative
Juruena-Cotriguaçú	3012	**1.0000**	48,560	**1.0000**	1.0	**0.8718**
Aripuanã -Imadex	250	**0.0000**	2,450	**0.0000**	0.7	**0.7949**
Aripuanã – Municipal headquarters	659	**0.1481**	13,620	**0.2422**	-2.4	**0.0000**
Colniza	1146	**0.3244**	7,850	**0.1171**	0.2	**0.6667**
Rondo-10	321	**0.0257**	3,400	**0.0206**	0.9	**0.8462**
Rondo-70	554	**0.1101**	7,300	**0.1052**	1.5	**1.0000**

The column of the above table entitled "relative" shows the quantitative values in a relative order, so that the greatest value assumes a unitary value and the smallest is equal to the scale value of zero (reference). The intermediate values are presented in relation to the reference. These values will be used later to set up the utility function table.

The relevance for each criterion was determined based on interviews with the technical staff involved, who were asked to classify, using an arbitrary scale, each criterion in terms of its relative importance among the other two. An average was then calculated and the relative weight for each of the criteria was determined.

The following table presents the utilized criteria in detail.

<table>
<tr><th colspan="2">Level of relative importance</th></tr>
<tr><td rowspan="5">Criterion</td><td>1 X = not important</td></tr>
<tr><td>2 X = important</td></tr>
<tr><td>3 X = indifferent</td></tr>
<tr><td>4 X = very important</td></tr>
<tr><td>5 X = extremely important</td></tr>
</table>

The table below was created as an example to demonstrate the selective process. The tables immediately following were actually used.

Relative importance, Numeric x Qualitative criterion

Type	Average weight		Interviewee 1		Interviewee 2		Interviewee 3		Interviewee 4	
	average	%	original	relative	original	relative	original	relative	original	relative
Numeric	**4.000**	53.3%	4	1.0	3	0.8	4	1.0	5	1.0
Qualitative	**3.500**	46.7%	3	0.8	4	1.0	3	0.8	4	0.8

Relative importance, Quantitative criterion

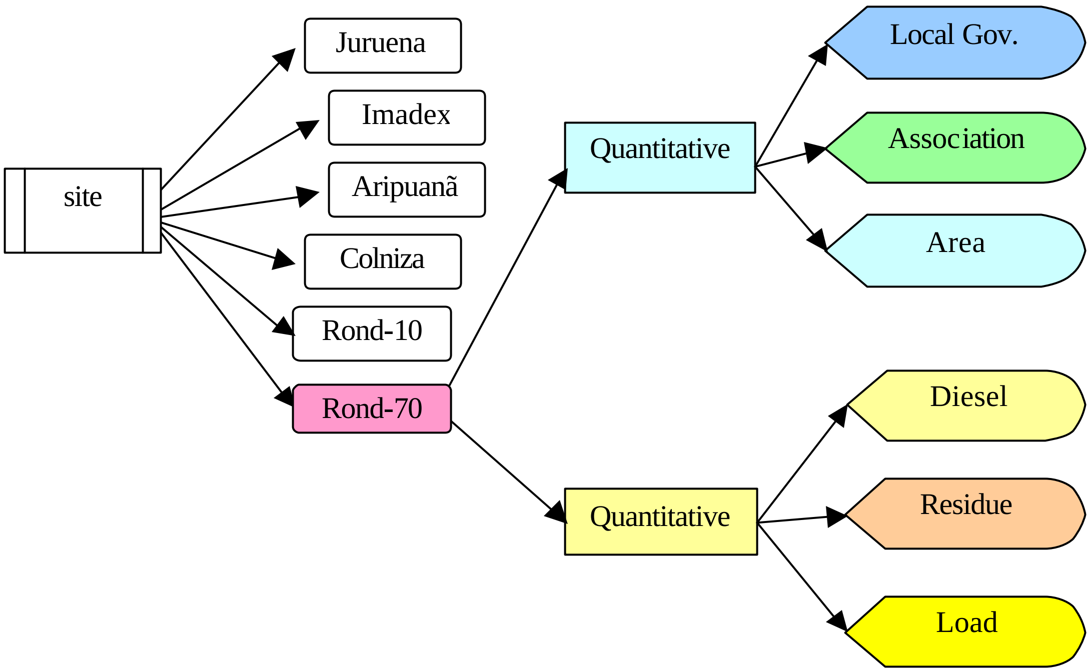
Quantitative	Average weight		Interviewee 1		Interviewee 2		Interviewee 3		Interviewee 4	
	average	%	original	relative	original	average	original	relative	original	relative
Diesel Oil Substitution	**4.250**	45.9%	5	1.0	3	0.3	5	1.0	4	1.0
Quantity of Residue from Sustainable Management	**3.250**	35.1%	4	0.7	5	1.0	3	0.5	1	0.0
Load in MVA	**1.750**	18.9%	2	0.0	2	0.0	1	0.0	2	0.3

Relative importance, Qualitative criterion

Qualitative	Average weight		Interviewee 1		Interviewee 2		Interviewee 3		Interviewee 4	
	average	%	original	relative	original	average	original	relative	original	relative
Local Government Interest	**2.750**	29.7%	5	1.0	1	0.0	4	1.0	1	0.0
Presence of a Wood Products Industry Association	**3.250**	35.1%	4	0.7	2	0.3	2	0.0	5	1.0
Space availability for plant	**3.250**	35.1%		0.0	5	1.0	3	0.5	3	0.5

4.2 DECISION TREE

In order to determine the plant's site, the following decision tree was organized through the software"Precision Tree", developed by the Palisade Corporation. The diagram below is only a synthesis and gives a structural idea of the original tree, since its actual size would exceed a page of this annex.



SUMMARY TABLE OF THE PARAMETERS ESTABLISHED AND USED IN THE DECISION TREE

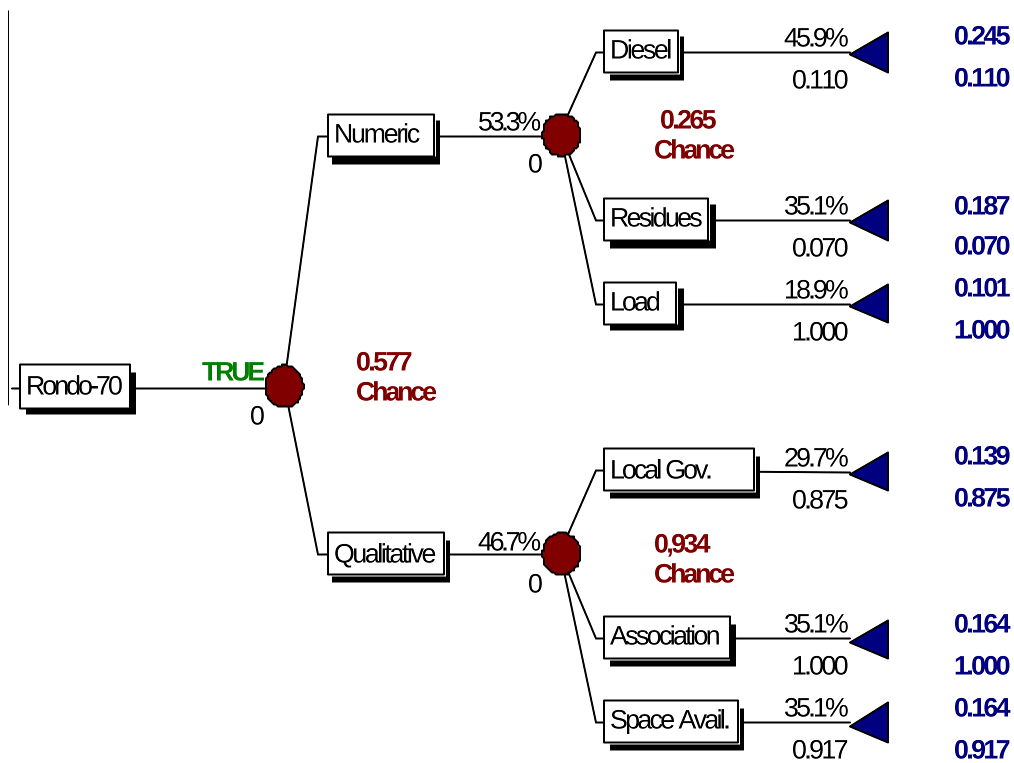
	Numeric			Qualitative		
Weight I		**53.33%**		46.67%		
	Diesel Oil Substitution m3/year	Quantity of Residue from Sustainable Management	Load in MVA	Local Gov. Interest	Presence of a Wood Products Industry Association	Space Availability for Plant
Weight II	**45.95%**	**35.14%**	18.92%	**29.73%**	**35.14%**	35.14%
Juruena	1.000	1.000	0.872	0.250	0.000	0.083
Imadex	0.000	0.000	0.795	0.938	0.375	0.333
Aripuana	0.148	0.242	0.000	0.563	0.271	0.063
Colniza	0.324	0.117	0.667	0.313	0.417	0.625
Rondo-10	0.026	0.021	0.846	0.125	0.188	0.667
Rondo-70	0.110	0.105	1.000	0.875	1.000	0.917

5. CONCLUSION:

The utility function applied from the decision tree ranked the sites as follows:

		Ranking
Juruena-Cotriguaçú	0.57	2
Aripuanã -Imadex	0.33	4
Aripuanã – municipal headquarters	0.21	Last
Colniza	0.38	3
Rondo-10	0.25	5
Rondo-70	0.58	First

The diagram below shows the branch in which the chosen site appears.



	Qualitative Votes - Summary		
Location	**Local Government Interest**	**Presence of a Wood Products Industry Association**	**Space Availability for Plant**
	average	average	average
Juruena-Cotriguaçú	0.3	0.0	0.1
Imadex	0.9	0.4	0.3
Aripuanã-municipal headquarters	0.6	0.3	0.1
Colniza	0.3	0.4	0.6
Rondo-10	0.1	0.2	0.7
Rondo-70	0.9	1.0	0.9

	Qualitative Votes - Interviewee 1					
Location	Local Government Interest		Presence of a Wood Product Industry Association		Space Availability for Plant	
	original	relative	original	relative	original	relative
Juruena-Cotriguaçú	**2**	0.3	**1**	0.0	**2**	0.0
Imadex	**5**	1.0	**3**	0.5	**4**	0.7
Aripuanã-municipal headquartes	**4**	0.8	**2**	0.3	**2**	0.0
Colniza	**1**	0.0	**3**	0.5	**5**	1.0
Rondo-10	**2**	0.3	**3**	0.5	**3**	0.3
Rondo-70	**5**	1.0	**5**	1.0	**4**	0.7

	Qualitative Votes - Interviewee 2					
Site	Local Government Interest		Presence of a Wood products industry association		Space Availability for Plant	
	original	relative	original	relative	original	relative
Juruena-Cotriguaçú	2	0.3	1	0.0	1	0.0
Imadex	5	1.0	1	0.0	1	0.0
Aripuanã-municipal headquarters	5	1.0	3	0.5	2	0.3
Colniza	2	0.3	3	0.5	3	0.5
Rondo-10	1	0.0	2	0.3	5	1.0
Rondo-70	3	0.5	5	1.0	5	1.0

	Qualitative Votes - Interviewee 3					
Location	Local Government Interest		Presence of a Wood products industry association		Space availability for Plant	
	original	relative	original	relative	original	relative
Juruena-Cotriguaçú	1	0.0	2	0.0	2	0.0
Imadex	5	1.0	3	0.3	2	0.0
Aripuanã-municipal headquarters	3	0.5	3	0.3	2	0.0
Colniza	3	0.5	3	0.3	4	0.7
Rondo-10	2	0.3	2	0.0	4	0.7
Rondo-70	5	1.0	5	1.0	5	1.0
	Qualitative Votes – Interviewee 4					
Site	Local Government Interest		Presence of a Wood products industry association		Space Availability for Plant	
	original	relative	original	relative	original	relative
Juruena-Cotriguaçú	3	0.5	2	0.0	3	0.3
Imadex	4	0.8	4	0.7	4	0.7
Aripuanã-municipal headquarters	1	0.0	2	0.0	2	0.0
Colniza	3	0.5	3	0.3	3	0.3
Rondo-10	1	0.0	2	0.0	4	0.7
Rondo-70	5	1.0	5	1.0	5	1.0

ANNEX

DIMENSIONING THE THERMALELECTRIC PLANT

1. THERMALELECTRIC PLANT CONCEPTUAL DESIGN

1.1 TECHNICAL ALTERNATIVES

1.1.1 General Aspects

The technical analysis will determine the technology to be used in the present project by taking the following factors into account:

- Type of biomass: wood residues;
- Cost of biomass (purchase and transport);
- Current and potential energy market;
- Current cost of purchased energy;
- Current quality of energy;
- Availability of manpower for implementation, operation and maintenance;
- Domestic manufacture and the Brazilian trade balance;
- Efficiency;
- Implementation cost;
- Cost of generating energy.

1.1.2 Available Technologies

Table 1.1.2.1 offers a brief description for each technology analyzed. The preferred technology (chosen for reasons presented in the table) will indicate a sub-item for further details.

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TABLE 1.1.2.1

TECHNOLOGIES ANALYZED

TYPE OF TECHNOLOGY	MAJOR CHARACTERISTICS	STATE OF THE ART	SPECIFIC COMMENTS
Steam Turbine (Rankine Cycle)	Boilers can use all residue fuels; robust; heat rate of electricity improves w/ steam pressure in plants >3 MW	Many domestic manufacturers & engineering firms	Chosen for the pilot project.
Steam Engine ^Locomóvel`	A steam piston variant of the Rankine cycle. W/ domestic technology it is impossible to recycle water, since it is contaminated by lubricant oil.	Technology widely used in Amazonia due to low investment and operations & maintenance costs.	Not considered since is very low-efficiency with a high level of water consumption.
Steam motor generators	A more sophisticated steam piston variant of the Rankine cycle with hiher efficiency. Requires more careful maintenance.	Entirely imported, no domestic commercilaization.	Not considered since is. entirely imported, w/o service support.
Gasification (conversion of biomass into low Btu fuel gas).	Process produces a fuel gas which can be used by gas turbines & internal combustion engines). Gas is low-quality and maintenance.costs high.	Still in development	Not recommended because of the lack of experience with this technology
Gas Turbine with gasification	Gasifier gas goes to an open cycle gas turbine. More kWh per ton steam in cogen mode	Still in development	Lack of experience. Only appropriate for larger scales
Internal combustion engine with gasification	Gasifier gas goes to an IC engine. Most kWh/t steam in cogen mode below 2 bar	Still in development	Lack of experience. Temperature for drying thermal base too high.
Closed-cycle gas turbine.	Use almost all fuels. Compact & robust configuration. Fast response to load alterations	No longer commercialized?.	Lack of vendor.

1.1.3 The Rankine Cycle

A determined quantity of fuel is burned in a steam generator (boiler), which in turn produces a given quantity of steam at designed pressure and temperature levels. This steam feeds into a prime mover (the steam turbine), expands, and activates a synchronous electric generator by producing mechanical movements on the turbine's shaft. The generator, attached to the turbine's shaft, produces electricity.

The same quantity of steam that feeds into the turbine is in turn condensed in a vacuum and returns to the boiler in liquid state. During this condensation process, the vacuum steam passes through a heat exchanger, where it releases heat and becomes pressurized hot water. The hot water is then stored in a deaerator and pumped back to the steam generator, a final step that ensures efficiency to the process and closes the cycle.

The Rankine cycle is composed of the following equipment:

***a-* Boiler**

This is the equipment responsible for generating steam from the combustion of fuels – in this case, wood residue. The boiler produces steam at predefined pressure and temperature levels. The steam in turn activates the turbine and later passes through a condenser, as already described, where it is transformed into hot water in order to return to the boiler and close the cycle.

The boiler's main parts include: a condensing tank, an economizer, steam pipes, feeding systems and corresponding instrumentation.

***b-* Condensing Turbine**

Activated by steam produced in the boiler, this device is responsible for converting part of the thermal energy contained in the steam into mechanical energy by rotating its shaft. The turbine is attached to a speed reducer, which is coupled to a synchronous electricity generator.

Once it activates the turbine, the steam is driven by vacuum pressure into the condenser. This latter device contains a water circuit where centrifugal pumps bring in colder water from the cooling tower basins to condense the steam and transform it into hot water. The exchange water, which gained the heat lost by the steam, is then returned to the top of the towers to be cooled, thereby closing the cooling tower cycle.

The turbine's main parts include: a speed reducer, a heat exchanger, the corresponding instrumentation, special pipelines, a vacuum pump, a speed governer and security valves.

***c-* Synchronous Electric Generator**

This device is responsible for electromechanical conversion – in other words, for transforming mechanical energy into electricity. Its exciter system controls the voltage produced, and its activation speed determines the frequency of this voltage. Therefore, the power it supplies in its terminals is related to the proper control of these two parameters: excitement and speed on the shaft. Finally, it is important to note that the generator can be air or water- cooled.

The generator's main parts include: a cooling system, a dehumidifying system and a brushless exciter.

***d-* Cooling Towers**

The cooling towers are essentially heat exchangers responsible for water circulation in the condenser. They obey a predetermined temperature differential in order to cool the steam flow. The towers are equipped with closed-rotor single-suction centrifugal pumps that are submersed as they pump out return water and complete the tower cycle.

e- **Electromechanical system**

This system consists of a set of devices, panels and materials that command, control, protect and distribute the electricity produced.

The scheme of the thermalelectric cycle described herein - duly adapted to the solutions for the conditions under study – is presented below.

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1250kW EXTRACTION CONDENSING COGENERATION

YEAR 1

	SAWMILL / KILN DRIER / CITY DATA		
SAWMILLS	Operating Regime	2,088	h/year
	Maximum Demand	739.00	kW
	Average Demand	592.00	kW
	Load Factor	80.11%	
	Energy Consumption	1,236.10	MWh/year
KILN DRIERS	Operating Regime	8,760	h/year
	Maximum Demand	146.00	kW
	Average Demand	107.19	kW
	Load Factor	73.42%	
	Energy Consumption	939.00	MWh/year
CITY	Operating Regime	8,760	h/year
	Maximum Demand	86.00	kW
	Average Demand	38.13	kW
	Load Factor	44.33%	
	Energy Consumption	334.00	MWh/year
TOTAL	Operating Regime	8,760	h/year
	Average Demand	286.43	kW
	Energy Consumption	2,509.10	MWh/year
	Steam Consumption	3.87	ts/h
	Annual Steam Consumption	33,927.48	ts/year

COGENERATION PLANT DATA		
Operating Regime	8,500	h/year
Power Rating	1,250.00	kW
Generating Capacity	10,625.00	MWh/year
Steam Production	13.19	ts/h
Fuel Consumption	3.27	t/h
MAX. AVG. FOR SIMULTANEOUS OPERATION OF SAWMILLS, KILN DRIER, CITY & PARASITIC ENERGY		
Maximum Average Power	774.56	kW
Utilization Factor	61.96%	
Steam Production	7.42	ts/h
Fuel Consumption	1.84	t/h
GENERAL BALANCE		
Energy Generated	2,751.13	MWh/year
Parasitic Energy	316.50	MWh/year
Net Energy Generated	2,434.63	MWh/year
Surplus Energy	-	MWh/year
Energy Deficit	74.47	MWh/year
Annual Fuel Consumption	10,237.05	t/year
Annual Steam Production	41,351.31	ts/year
Steam Deficit	-	ts/year

YEAR 2

	SAWMILL / KILN DRIER / CITY DATA		
SAWMILLS	Operating Regime	2,088	h/year
	Maximum Demand	887.00	kW
	Average Demand	710.00	kW
	Load Factor	80.05%	
	Energy Consumption	1,482.48	MWh/year
KILN DRIERS	Operating Regime	8,760	h/year
	Maximum Demand	198.00	kW
	Average Demand	147.37	kW
	Load Factor	74.43%	
	Energy Consumption	1,291.00	MWh/year
CITY	Operating Regime	8,760	h/year
	Maximum Demand	96.00	kW
	Average Demand	42.69	kW
	Load Factor	44.47%	
	Energy Consumption	374.00	MWh/year
TOTAL	Operating Regime	8,760	h/year
	Average Demand	359.30	kW
	Energy Consumption	3,147.48	MWh/year
	Steam Consumption	5.33	ts/h
	Annual Steam Consumption	46,647.00	ts/year

COGENERATION PLANT DATA		
Operating Regime	8,500	h/year
Power Rating	1,250.00	kW
Generating Capacity	10,625.00	MWh/year
Steam Production	13.19	ts/h
Fuel Consumption	3.27	t/h
MAX. AVG. FOR SIMULTANEOUS OPERATION OF SAWMILLS, KILN DRIER, CITY & PARASITIC ENERGY		
Maximum Average Power	943.18	kW
Utilization Factor	75.45%	
Steam Production	9.52	MWh/year
Fuel Consumption	2.36	MWh/year
GENERAL BALANCE		
Energy Generated	3,420.55	MWh/year
Parasitic Energy	366.49	MWh/year
Net Energy Generated	3,054.06	MWh/year
Surplus Energy	-	MWh/year
Energy Deficit	93.42	MWh/year
Annual Fuel Combustion	13,566.20	t/year
Annual Steam Production	54,799.02	ts/year
Steam Deficit	-	ts/year

YEAR 3

	SAWMILL / KILN DRIER / CITY DATA		
SAWMILLS	Operating Regime	2,088	h/year
	Maximum Demand	1,035.00	kW
	Average Demand	828.00	kW
	Load Factor	80.00%	
	Energy Consumption	1,728.86	MWh/year
KILN DRIERS	Operating Regime	8.760	h/ano
	Maximum Demand	265,00	kW
	Average Demand	192,92	kW
	Load Factor	72,80%	
	Energy Consumption	1.690,00	MWh/ano
CITY	Operating Regime	8,760	h/year
	Maximum Demand	106.00	kW
	Average Demand	46.92	kW
	Load Factor	44.26%	
	Energy Consumption	411.00	MWh/year
TOTAL	Operating Regime	8,760	h/year
	Average Demand	437.20	kW
	Energy Consumption	3,829.86	MWh/year
	Steam Consumption	6.97	ts/h
	Annual Steam Consumption	61,065.96	ts/year

COGENERATION PLANT DATA		
Operating Regime	8,500	h/year
Power Rating	1,250.00	kW
Generating Capacity	10,625.00	MWh/ year
Steam Production	13.19	ts/h
Fuel Consumption	3.27	t/h
MAX. AVG. FOR SIMULTANEIOUS OPERATION OF SAWMILLS, KILN DRIERS, CITY & PARASITIC ENERGY		
Maximum Average Power	1,111.56	kW
Utilization Factor	88.92%	
Steam Production	11.76	ts/h
Fuel Consumption	2.91	t/h
GENERAL BALANCE		
Energy Generated	4,087.81	MWh/year
Parasitic Energy	371.62	MWh/year
Net Energy Generated	3,716.19	MWh/year
Surplus Energy	-	MWh/year
Energy Deficit	113.67	MWh/year
Annual Fuel Combustion	17,211.41	t/year
Annual Steam Production	69,523.42	ts/year
Steam Deficit	-	ts/year

1000kW PURE CONDENSATION + 300kW BACK-PRESSURE GENERATION

Year	Section	SAWMILL / KILN DRIER / CITY DATA			COGENERATION PLANT DATA		
YEAR 1	SAWMILLS	Operating Regime	2,088	h/year	Operating Regime	8,500	h/year
		Maximum Demand	739.00	kW	Power Rating	1,300.00	kW
		Average Demand	592.00	kW	Generating Capacity	11,050.00	MWh/year
		Load Factor	80.11%		Ste	16.10	ts/h
		Energy Consumption	1,236.10	MWh/year	Fuel Consumption	3.98	t/h
	KILN DRIERS	Operating Regime	8,760	h/year	**MAX. AVG. FOR SIMULTANEIOUS OPERATION OF SAWMILLS, KILN DRIERS, CITY & PARASITIC ENERGY**		
		Maximum Demand	146.00	kW			
		Average Demand	107.19	kW	Maximum Average Power	780.28	kW
		Load Factor	73.42%		Utilization Factor	60.02%	
		Energy Consumption	939.00	MWh/year	Steam Production	7.46	ts/h
	CITY	Operating Regime	8,760	h/year	Fuel Consumption	1.85	t/h
		Maximum Demand	86.00	kW	**GENERAL BALANCE**		
		Average Demand	38.13	kW	Energy Generated	2,799.82	MWh/year
		Load Factor	44.33%		Parasitic Energy	365.19	MWh/year
		Energy Consumption	334.00	MWh/year	Net Energy Generated	2,434.63	MWh/year
	TOTAL	Operating Regime	8,760	h/year	Surplus Energy	-	MWh/year
		Average Demand	286.43	kW	Energy Deficit	74.47	MWh/year
		Energy Consumption	2,509.10	MWh/year	Annual Fuel Consumption	10,305.48	t/year
		Steam Consumption	3.87	ts/h	Annual Steam Production	41,627.75	ts/year
		Annual Steam Consumption	33,927.48	ts/year	Steam Deficit	-	ts/year
		SAWMILL / KILN DRIER / CITY DATA			**COGENERATION PLANT DATA**		
YEAR 2	SAWMILLS	Operating Regime	2,088	h/year	Operating Regime	8,500	h/year
		Maximum Demand	887.00	kW	Power Rating	1,300.00	kW
		Average Demand	710.00	kW	Generating Capacity	11,050.00	MWh/year
		Load Factor	80.05%		Steam Production	16.10	ts/h
		Energy Consumption	1,482.48	MWh/year	Fuel Consumption	3.98	t/h
	KILN DRIERS	Operating Regime	8,760	h/year	**MAX. AVG. FOR SIMULTANEIOUS OPERATION OF SAWMILLS, KILN DRIERS, CITY & PARASITIC ENERGY**		
		Maximum Demand	198.00	kW			
		Average Demand	147.37	kW	Maximum Average Power	944.98	kW
		Load Factor	74.43%		Utilization Factor	72.69%	
		Energy Consumption	1,291.00	MWh/year	Steam Production	9.53	MWh/year
	CITY	Operating Regime	8,760	h/year	Fuel Consumption	2.36	MWh/year
		Maximum Demand	96.00	kW	**GENERAL BALANCE**		
		Average Demand	42.69	kW	Energy Generated	3,435.82	MWh/year
		Load Factor	44.47%		Parasitic Energy	381.76	MWh/year
		Energy Consumption	374.00	MWh/year	Net Energy Generated	3,054.06	MWh/year
	TOTAL	Operating Regime	8,760	h/year	Surplus Energy	-	MWh/year
		Average Demand	359.30	kW	Energy Deficit	93.42	MWh/year
		Energy Consumption	3,147.48	MWh/year	Annual Fuel Consumption	13,587.66	t/year
		Steam Consumption	5.33	ts/h	Annual Steam Production	54,885.71	ts/year
		Annual Steam Consumption	46,647.00	ts/year	Steam Deficit	-	ts/year
		SAWMILLS / KILN DRIER / CITY DATA			**COGENERATION PLANT DATA**		
YEAR 3	SAWMILLS	Operating Regime	2,088	h/year	Operating Regime	8,500	h/year
		Maximum Demand	1,035.00	kW	Power Rating	1,300.00	kW
		Average Demand	828.00	kW	Generating Capacity	11,050.00	MWh/year
		Load Factor	80.00%		Steam Production	16.10	ts/h
		Energy Consumption	1,728.86	MWh/year	Fuel Consumption	3.98	t/h
	KILN DRIER	Operating Regime	8,760	h/year	**MAX. AVG. FOR SIMULTANEIOUS OPERATION OF SAWMILLS, KILN DRIERS, CITY & PARASITIC ENERGY**		
		Maximum Demand	265.00	kW			
		Average Demand	192.92	kW	Maximum Average Power	1,115.93	kW
		Load Factor	72.80%		Utilization Factor	85.84%	
		Energy Consumption	1,690.00	MWh/year	Steam Production	11.78	ts/h
	CITY	Operating Regime	8,760	h/ year	Fuel Consumption	2.92	t/h
		Maximum Demand	106.00	kW	**GENERAL BALANCE**		
		Average Demand	46.92	kW	Energy Generated	4,124.97	MWh/year
		Load Factor	44.26%		Parasitic Energy	408.78	MWh/year
		Energy Consumption	411.00	MWh/year	Net Energy Generated	3,716.19	MWh/year
	TOTAL	Operating Regime	8,760	h/year	Surplus Energy	-	MWh/year
		Average Demand	437.20	kW	Energy Deficit	113.67	MWh/year
		Energy Consumption	3,829.86	MWh/ano	Annual Fuel Consumption	17,263.64	t/year
		Steam Consumption	6.97	ts/h	Annual Steam Production	69,734.39	ts/year
		Annual Steam Consumption	61,065.96	ts/year	Steam Deficit	-	ts/year

SUMMARY OF INVESTMENTS

	UNDP Thermoelectric Plant Project															
	Electric Power - 1250kW															
Item	**Description**	**Qty**	**Supplier**	**Sales Price**	**ICMS Tax Deduction at Source**		**IPI (Excise Tax)**	**ISS (Service Tax)**	**Invoice amount in R$**	**ICMS (V.added Tax)**	**Total Cost**	**Freight**	**Delivery Time (days)**	**Tariff Classification**	**Code**	**Nat'l Ind**
				(Taxes: ICMS at source + ISS)	**%**	**R$**	**R$**	**R$**	**(Taxes: ICMS at source + IPI+ISS)**	**Destination**	**(R$)**				**FINAME**	
	EQUIPMENT															
1	Boiler	1	H. Bremer	1,159,118.40	5.14	56,666.05	57,955.92	-	1,217,074.32	144,345.01	1,361,419.33	CIF	300	8402.12.00	117512-2	100
2	Biomass Patio	1	Dujua	242,784.00	5.14	11,869.03	12,139.20	-	254,923.20	30,233.89	285,157.09	CIF	240	XXXXX	XXXX	XX
3	Water Treatment System	1	Estimate	50,000.00	7.00	3,271.03	2,500.00	-	52,500.00	5,250.00	57,750.00	FOT	120	XXXXX	XXXX	XX
4	Turbine	1	Estimate	700,000.00	5.14	34,221.04	35,000.00	-	735,000.00	87,171.00	822,171.00	FOT	240	8406.82.00	061162-0	100
5	Generator	1	Estimate	250,000.00	12.00	26,785.71	12,500.00	-	262,500.00	13,125.00	275,625.00	EX-Work	240	8501.64.00	132446-2	97
6	Cooling Towers	1	Estimate	85,000.00	5.14	4,155.41	6,800.00	-	91,800.00	10,887.48	102,687.48	-	-	-	-	-
7	Sewage Treatment Plant	1	Estimate	60,000.00	7.00	3,925.23	3,000.00	-	63,000.00	6,300.00	69,300.00	FOT	120	XXXX	XXXX	XX
8	Chemical Products Tank	2	Estimate	44,000.00	7.00	2,878.50	2,200.00	-	46,200.00	4,620.00	50,820.00	FOT	30	XXXX	XXXX	XX
9	Compressor / Compressed Air Vessel	1	Estimate	33,000.00	7.00	2,158.88	1,650.00	-	34,650.00	3,465.00	38,115.00	FOT	60	XXXX	XXXX	XX
10	Electric Overhead Traveling Crane	1	Estimate	43,000.00	5.14	2,102.15	2,150.00	-	45,150.00	5,354.79	50,504.79	FOT	120	8426.11.00	030887-0	100
11	ScaleN	1	Estimate	36,000.00	17.00	5,230.77	1,800.00	-	37,800.00	-	37,800.00	FOT	60	XXXX	XXXX	XX
12	13.8 kV Power Transformers	1	Estimate	25,000.00	12.00	2,678.57	1,250.00	-	26,250.00	1,312.50	27,562.50	FOT	180	8504.22.00	XXXX	XX
13	Médium-Voltage Electric Panels	-	Estimate	130,000.00	12.00	13,928.57	6,500.00	-	136,500.00	6,825.00	143,325.00	FOT	150	8537.20.00	037041-0	100
14	Low-Voltage Electric Panels	-	Estimate	280,000.00	12.00	30,000.00	14,000.00	-	294,000.00	14,700.00	308,700.00	FOT	150	8537.10.19	065114-5	100
15	Project Coordination and Management	1	Estimate	158,220.00	-	-	-	7,911.00	158,220.00	-	158,220.00	-	360	-	-	-
16	Selectivity and Short Circuit Study	1	Estimate	23,430.00	-	-	-	1,171.50	23,430.00	-	23,430.00	-	120	-	-	-
17	Agreements with CREA, ANEEL and ONS	1	Estimate	18,350.00	-	-	-	917.50	18,350.00	-	18,350.00	-	120	-	-	-
18	Electrical, Mechanical and Basic Civil Project	1	Estimate	200,000.00	-	-	-	10,000.00	200,000.00	-	200,000.00	-	180	-	-	-
19	Electrical Installation and Instrumentation	1	Estimate	318,000.00	-	-	-	15,900.00	318,000.00	-	318,000.00	-	120	-	-	-
20	Mechanical Installation	1	Estimate	265,000.00	-	-	-	13,250.00	265,000.00	-	265,000.00	FOT	120	-	-	-
21	Electrical Material and Instrumentation	1	Estimate	340,000.00	12.00	36,428.57	-	-	340,000.00	17,000.00	357,000.00	FOT	120	-	-	-
22	Mechanical Material	1	Estimate	380,000.00	12.00	40,714.29	-	-	380,000.00	19,000.00	399,000.00	FOT	120	-	-	-
23	Automation System	N/A	Estimate	125,880.00	-	-	-	6,294.00	125,880.00	-	125,880.00	FOT	180	-	-	-
24	Environmental Project + Fees	N/A	Estimate	35,000.00	-	-	-	1,750.00	35,000.00	-	35,000.00	-	120	-	-	-
25	Civil Works	-		-	-	-	-	-	-	-	-	-	-	-	-	-
	Earthwork	N/A	Estimate	100,000.00	-	-	-	5,000.00	100,000.00	-	100,000.00	-	30	-	-	-
	Well	1	Estimate	65,000.00	-	-	-	3,250.00	65,000.00	-	65,000.00	-	60	-	-	-
	Cistern	1	Estimate	50,000.00	-	-	-	2,500.00	50,000.00	-	50,000.00	-	60	-	-	-
	Construction	N/A	Estimate	388,000.00	-	-	-	19,400.00	388,000.00	-	388,000.00	-	120	-	-	-
	Structural Calculation Project	N/A	Estimate	12,000.00	-	-	-	600.00	12,000.00	-	12,000.00	-	60	-	-	-
	Materials – Metal Structure - Powerhouse	N/A	Estimate	74,185.63	7.00	4,853.27	-	-	74,185.63	7,418.56	81,604.19	FOT	150	-	-	-
	Assembly – Metal Structur e - Powerhouse	N/A	Estimate	48,000.00	-	-	-	2,400.00	48,000.00	-	48,000.00	-	120	-	-	-
26	Financial Consulting	N/A	Estimate	150,000.00	-	-	-	7,500.00	150,000.00	-	150,000.00	-	120	-	-	-
27	Furniture and Appliances	N/A	Estimate	20,000.00	17.00	2,905.98	-	-	20,000.00	-	20,000.00	-	30	-	-	-
28	Training	N/A	Estimate	80,000.00	-	-	-	4,000.00	80,000.00	-	80,000.00	-	30	-	-	-
29	Freights	N/A	Estimate	150,000.00	-	-	-	7,500.00	150,000.00	-	150,000.00	-	-	-	-	-
	EPC SUB-TOTAL			6,138,968.03		284,773.06	159,445.12	109,344.00	6,298,413.15	377,008.24	6,675,421.39					
-	Contingencies (5%)			306,948.40												

	EPC FINAL TOTAL			6,445,916.43		284,773.06	159,445.12	109,344.00	6,605,361.55	377,008.24	6,982,369.79					
	Pre-Operational Expenditures			200,000.00												
	Working Capital			250,000.00												
	TOTAL COST OF PROJECT			**6,895,916.43**		**284,773.06**	**159,445.12**	**109,344.00**	**7,055,361.55**	**377,008.24**	**7,432,369.79**					

	UNDP Thermoelectric Plant Project															
	Electric Power - 1250kW															
Item	Description	Qty	Supplier	Sales Price	ICMS Tax Deduction at Source		IPI (Excise Tax)	ISS (Svc. Tax)	Invoice amount in R$	ICMS (V.Added Tx)	Total Cost	Freight	Delivery Time (days)	Tariff Classification	Code	Nat'l Ind
				(Taxes: ICMS at source + ISS)	%	R$	R$	R$	(Taxes: ICMS at source + IPI+ISS)	Destination	(R$)				FINAME	
	EQUIPMENT															
1	Boiler	1	H. Bremer	1,159,118.40	5.14	56,666.05	57,955.92	-	1,217,074.32	144,345.01	1,361,419.33	CIF	300	8402.12.00	117512-2	100
2	Biomass Patio	1	Dujua	242,784.00	5.14	11,869.03	12,139.20	-	254,923.20	30,233.89	285,157.09	CIF	240	XXXXX	XXXX	XX
3	Water Treatment System	1	Estimate	50,000.00	7.00	3,271.03	2,500.00	-	52,500.00	5,250.00	57,750.00	FOT	120	XXXXX	XXXX	XX
4	Condensing Turbine	1	Estimate	800,000.00	5.14	39,109.76	40,000.00	-	840,000.00	99,624.00	939,624.00	FOT	240			
5	Back-pressure Turbine	1	Estimate	250,000.00	12.00	26,785.71	12,500.00	-	262,500.00	13,125.00	275,625.00	EX-Work	240			
6	Generator	1	Estimate	250,000.00	12.00	26,785.71	12,500.00	-	262,500.00	13,125.00	275,625.00	EX-Work	240			
7	Generator	1	Estimate	120,000.00	12.00	12,857.14	6,000.00	-	126,000.00	6,300.00	132,300.00	EX-Work	240			
6	Cooling Towers	2	Estimate	85,000.00	5.14	4,155.41	6,800.00	-	91,800.00	10,887.48	102,687.48	-	-	-	-	-
7	Sewage Treatment Plant	1	Estimate	60,000.00	7.00	3,925.23	3,000.00	-	63,000.00	6,300.00	69,300.00	FOT	120	XXXX	XXXX	XX
9	Compressor / Compressed Air Vessel	1	Atlas Copco	37,000.00	7.00	2,420.56	1,850.00	-	38,850.00	3,885.00	42,735.00	FOT	60	XXXX	XXXX	XX
10	Electric Overhead Traveling Crane	1	Estimate	43,000.00	5.14	2,102.15	2,150.00	-	45,150.00	5,354.79	50,504.79	FOT	120	8426.11.00	030887-0	100
11	Scale	1	Toledo	56,000.00	17.00	8,136.75	2,800.00	-	58,800.00	-	58,800.00	FOT	60	XXXX	XXXX	XX
12	13.8 kV Power Transformers	1	Estimate	25,000.00	12.00	2,678.57	1,250.00	-	26,250.00	1,312.50	27,562.50	FOT	180	8504.22.00	XXXX	XX
13	Médium-Voltage Electric Panels	-	Koblitz	130,000.00	12.00	13,928.57	6,500.00	-	136,500.00	6,825.00	143,325.00	FOT	150	8537.20.00	037041-0	100
14	Low-Voltage Electric Panels	-	Koblitz	360,000.00	12.00	38,571.43	18,000.00	-	378,000.00	18,900.00	396,900.00	FOT	150	8537.10.19	065114-5	100
15	Project Coordination and Management	1	Koblitz	158,220.00	-	-	-	7,911.00	158,220.00	-	158,220.00	-	360	-	-	-
16	Selectivity and Short Circuit Study	1	Koblitz	23,430.00	-	-	-	1,171.50	23,430.00	-	23,430.00	-	120	-	-	-
17	Agreements with CREA, ANEEL and ONS	1	Koblitz	18,350.00	-	-	-	917.50	18,350.00	-	18,350.00	-	120	-	-	-
18	Electrical, Mechanical and Basic Civil Project	1	Koblitz	200,000.00	-	-	-	10,000.00	200,000.00	-	200,000.00	-	180	-	-	-
19	Electrical Installation and Instrumentation	1	Koblitz	318,000.00	-	-	-	15,900.00	318,000.00	-	318,000.00	-	120	-	-	-
20	Mechanical Installation	1	Koblitz	325,000.00	-	-	-	16,250.00	325,000.00	-	325,000.00	FOT	120	-	-	-
21	Electrical Material and Instrumentation	1	Koblitz	400,000.00	12.00	42,857.14	-	-	400,000.00	20,000.00	420,000.00	FOT	120	-	-	-
22	Mechanical Material	1	Koblitz	450,000.00	12.00	48,214.29	-	-	450,000.00	22,500.00	472,500.00	FOT	120	-	-	-
23	Automation System	N/A	Koblitz	180,000.00	-	-	-	9,000.00	180,000.00	-	180,000.00	FOT	180	-	-	-
24	Environmental Project + Fees	N/A	Estimate	35,000.00	-	-	-	1,750.00	35,000.00	-	35,000.00	-	120	-	-	-
25	Civil Works	-		-	-	-	-	-	-	-	-	-	-	-	-	-
	Earthwork	N/A	Estimate	100,000.00	-	-	-	5,000.00	100,000.00	-	100,000.00	-	30	-	-	-
	Well	1	Estimate	65,000.00	-	-	-	3,250.00	65,000.00	-	65,000.00	-	60	-	-	-
	Cistern	1	Estimate	50,000.00	-	-	-	2,500.00	50,000.00	-	50,000.00	-	60	-	-	-
	Construction	N/A	Estimate	388,000.00	-	-	-	19,400.00	388,000.00	-	388,000.00	-	120	-	-	-
	Structural Calculation Project	N/A	Estimate	18,000.00	-	-	-	900.00	18,000.00	-	18,000.00	-	60	-	-	-
	Materials – Metal Structure - Powerhouse	N/A	Estimate	95,000.00	7.00	6,214.95	-	-	95,000.00	9,500.00	104,500.00	FOT	150	-	-	-
	Assembly – Metal Structure - Powerhouse	N/A	Estimate	64,000.00	-	-	-	3,200.00	64,000.00	-	64,000.00	-	120	-	-	-
26	Financial Consulting	N/A	Estimate	150,000.00	-	-	-	7,500.00	150,000.00	-	150,000.00	-	120	-	-	-
27	Furniture and Appliances	N/A	Estimate	20,000.00	17.00	2,905.98	-	-	20,000.00	-	20,000.00	-	30	-	-	-
28	Training	N/A	Estimate	80,000.00	-	-	-	4,000.00	80,000.00	-	80,000.00	-	30	-	-	-
29	Freights	N/A	Estimate	150,000.00	-	-	-	7,500.00	150,000.00	-	150,000.00	-	-	-	-	-

	EPC SUB-TOTAL			6,955,902.40		353,455.48	185,945.12	116,150.00	7,141,847.52	417,467.68	7,559,315.20					
-	Contingencies (5%)			347,795.12												
	EPC FINAL TOTAL			7,303,697.52		353,455.48	185,945.12	116,150.00	7,489,642.64	417,467.68	7,907,110.32					
	Pre-Operational Expenditures			200,000.00												
	Working Capital			250,000.00												
	TOTAL COST OF PROJECT			**7,753,697.52**		**353,455.48**	**185,945.12**	**116,150.00**	**7,939,642.64**	**417,467.68**	**8,357,110.32**					

PROJECT SCHEDULE

INSTITUTO NACIONAL DE EFICIÊNCIA ENERGÉTICA

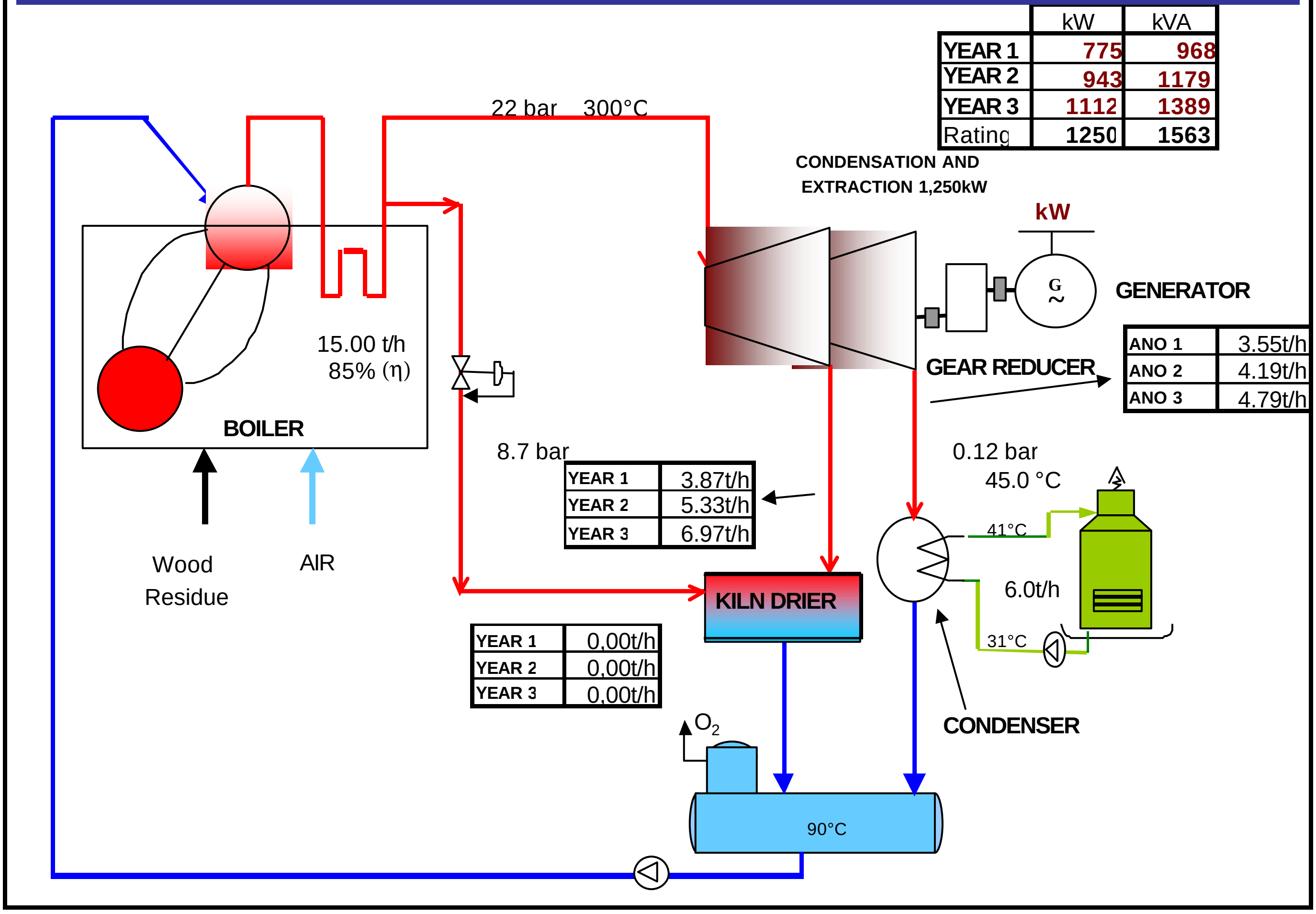
BASIC SCHEDULE

JOB: ELECTRIC POWER PLANT INSTALLATION

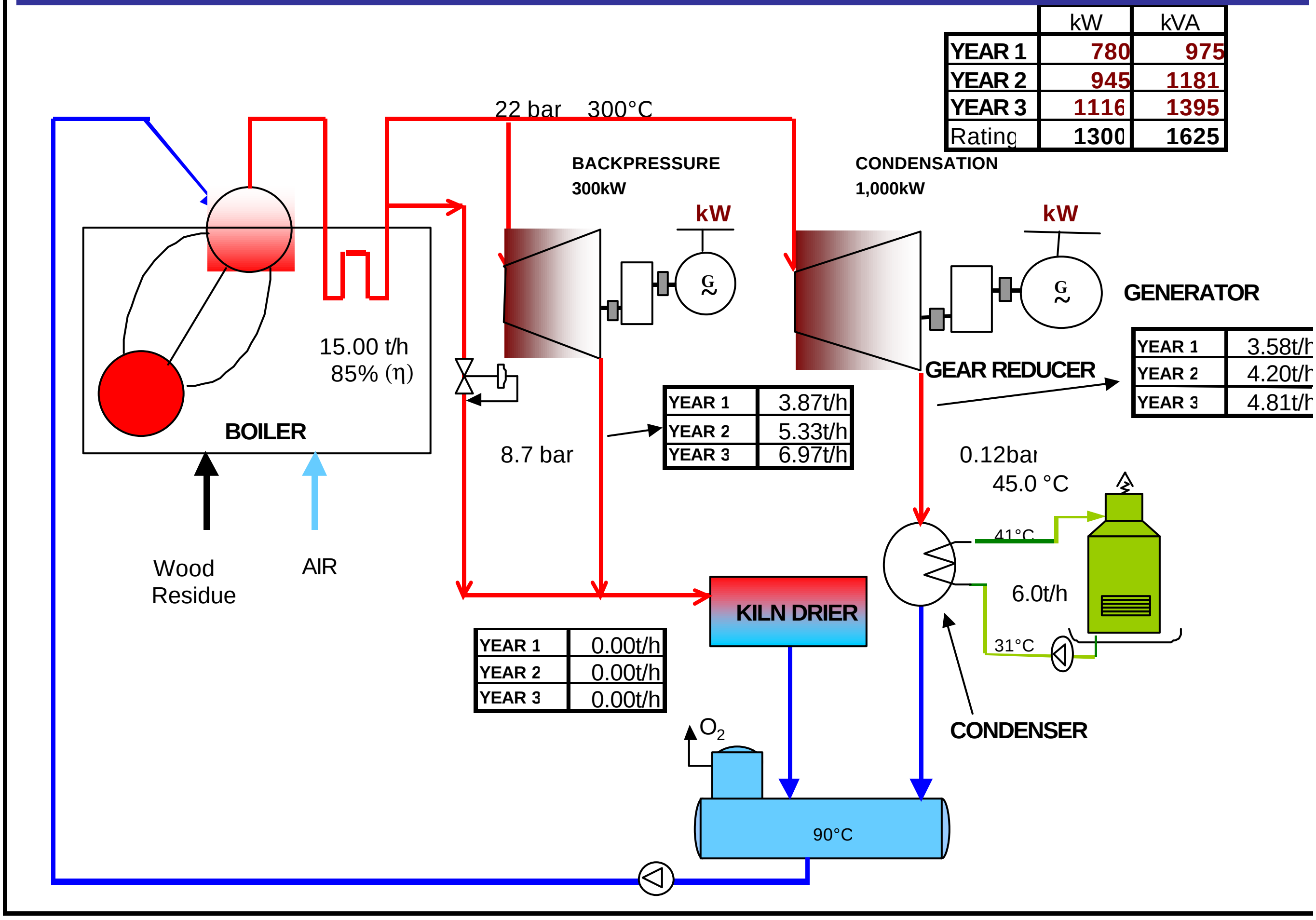
DESCRIPTION	DAYS	START	END	TEAM	MONTHS 1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Creation of an SPC	60				XXXX	XXXX										
Data Collection	30				XXXX											
Letter of Intent	30					XXXX										
Execution of Contracts	30						XXXX									
Study Development	15						XX									
Executive Project	169							XXXX	XXXX	XXXX	XXXX	XXXX	XXX			
Civil Project	62								XXXX	XXXX	X					
Metal Structures Project	75								XXX	XXXX	XXX					
Mechanical Project	169							XXXX	XXXX	XXXX	XXXX	XXXX	XXX			
Electrical Project	104									XX	XXXX	XXXX	XXXX			
Environmental Permit	240							XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
Prior license	30							XXXX								
Installation	45								XXXX	XX						
Operation	165									XX	XXXX	XXXX	XXXX	XXXX	XXXX	
ANEEL AUTHORIZATION	60						XXXX	XXXX								
Procurement	180								XX	XXXX	XXXX	XXXX	XXXX	XXXX	XX	
Boiler	135								XX	XXXX	XXXX	XXXX	XXXX			
Specification/ purchase	15								XX							
Production	120									XXXX	XXXX	XXXX	XXXX			
Transport	15															
Cooling Towers	109								X	XXXX	XXXX	XXXX	XX			
Specification/ purchase	35								X	XXXX						
Production	74										XXXX	XXXX	XX			
Transport	16												XX			
Electric Panels	105											XXXX	XXXX	XXXX	XX	
Specification/ purchase	10											XX				
Production	85											XXX	XXXX	XXXX		
Transport	40													XXX	XX	
Electrical Material	82										XXXX	XXXX	XXX			
Cables	60										XXXX	XXXX				
Wireways	40										XXXX	X				
Conduits	40										XXXX	X				
Other	80										XXXX	XXXX	XXX			
Mechanical Material	90									XXX	XXXX	XXXX	X			
Plates/ Profiles	45									XXX	XXX					
Pipes	74									XXX	XXXX	XXX				
Unions	80									XXX	XXXX	XXXX				
Valves	90									XXX	XXXX	XXXX	X			
Thermal Insulation	45									XXX	XXX					
Paint/ solvents	45									XX	XXXX					
Pipe rack/ supports	16									XXX						
Civil Construction	117								XX	XXXX	XXXX	XX				
Civil Construction	30									XXX	X					

FLOWCHARTS

PLANT FLOWCHART : CONDESATION/EXTRACTION TURBINE 1250 kW

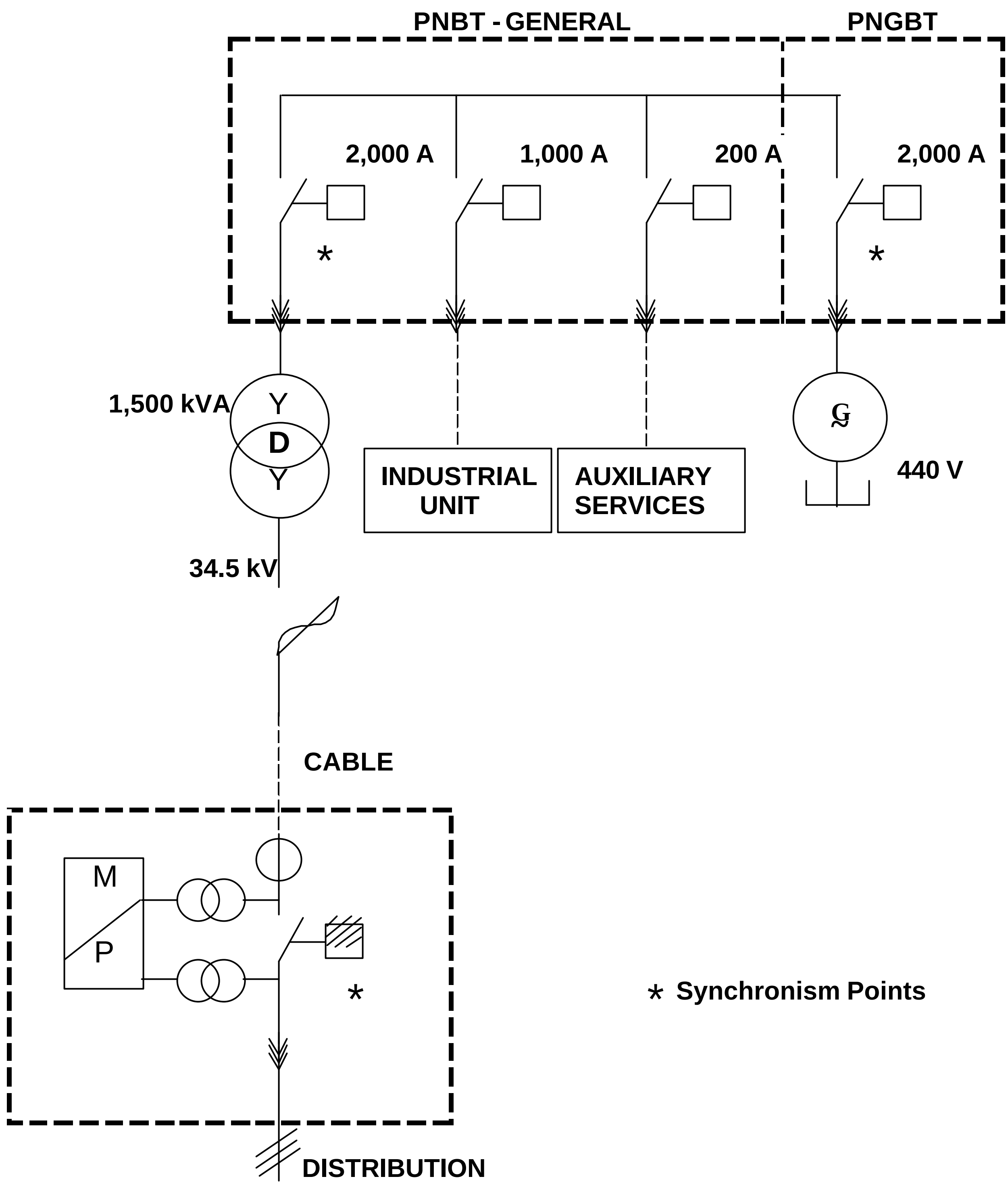


PLANT FLOWCHART: CONDENSATION TURBINE 1000 kW-BACKPRESSURE 300 kW



SINGLE WIRE ELECTRICAL DIAGRAM

BASIC SINGLE WIRE ELECTRICAL DIAGRAM



* Synchronism Points

ANNEX

INSTITUTIONAL ASPECTS AND FUNDING SOURCES

1. INSTITUTIONAL ARRANGEMENT

The study recommends the establishment of a joint-stock corporation that would include equity participation by sawmills in the cluster and institutional investors, among others. The participation of institutional players is crucial for the Plant's feasibility. Generation through residues, when not linked to sustainable forest management, is extremely profitable and enjoys a high level of replicability. It is, however, illegal and economically unsustainable, and therefore constitutes one more factor of forest resource depletion and deforestation.

This point is crucial since without the development of public policies focussed on forest conservation and public awareness of the need for conservationist practices, it will be difficult to avoid the presence of opportunistic "rent seekers" and encourage instead wood products industry representatives who understand the need for a longer term vision, know how to employ sustainable forest management and want to use wood residues effectively.

With 80% of the project's funds accounted for (by BNDES or its agents and/or Eletrobrás), sawmill owners´ equity participation would be around 10% of the initial investment expenditures (equivalent to 50% of the SPE's capital).

The future corporation must include a wide array of stakeholders to ensure not only the Plant's feasibility but also to develop and consolidate a model for future replication in other isolated locations throughout the Amazon Region. In addition to the aforementioned investors, other possible partners may be considered, including project developers, equipment manufacturers and independent energy producers already active in isolated systems.

The corporation would be controlled by private investors through a shareholder agreement that would ensure fulfillment of the institutional investors' objectives. Such agreement would also formalize the communion of interests needed to guarantee freedom of choice for energy consumers (Law N° 10.438 of 2002), as well as the commitment to make the transition to sustainable management.

From the Electricity Sector's regulatory point of view, the corporation would not qualify for the incentives offered by the fuel consumption subsidy program for the Amazon region known as the CCC (*Conta de Consumo de Combustíveis*), since it would own an electricity generation plant with less than 5 MW of power.

From the consultants' point of view, this restriction contradicts the spirit of Law N° 10.438/2002, since most isolated systems in Amazonia are below the 5 MW threshold (which does not apply for utilities receiving the subsidy). Indeed, most are far smaller. If this distortion were corrected, with the support of the environmental authorities, the plant could be implemented wioth the same CCC subsidies that the local utility enjoys (but rarely uses to substitute diesel). A 1 MW threshold has already been allowed for Small Hydro Plants. Such authorization, in turn, should be conditioned to the use of sustainable forest management.

This correction, if made in a relatively short term, could constitute the loan's collateral. The funds extended through such incentive would be further conditioned to fulfillment of reduction targets for use of wood from legal clearings as well as to sustainable management practices, at ANEEL's discretion and with the cooperation of environmental agencies.

Residue use is another important issue. All of the companies joining this enterprise should enter into a supply contract for the wood residue generated from their own productions, assuming it is generated with zero cost and in quantities proportional to the volume of the sawed and dried wood. Also, residue generation should not deplete the fuel used as raw material, and residue use should remain proportional to final product quantities. It is essential that residues never acquire market values that may be manipulated by their producers in times of scarcity. Today, residues represent a burden and may result in heavy fines if disposed of through open-pit burning, which is why granting it a zero cost is appropriate. It is also important to inspect the delivery of the timber to both plants and of the residue for combustion, since it must fulfill a determined proportion of biomass (in its various forms).

2. FINANCIAL MECHANISMS

2.1 INTERNATIONAL FUNDS

Regardless of the chosen financial arrangement, there are other possibilities that may be considered as alternatives, as shown in Table 2.1.

TABLE 2.1

INTERNATIONAL FINANCING FUNDS
a- MULTILATERAL INSTITUTIONS

INSTITUTION	FUND	CHARACTERISTICS
IBRD – (World Bank)	PCF (Prototype Carbon Fund)	Embraces projects that aim to reduce carbon emissions; it acts within the framework of the Convention on Climate Change (CCC), in accordance with the Kyoto Protocol. Dedicates itself to long-term projects demonstrating great carbon capture capacity.
IBRD / IFC - International Finance Corporation	EOF (Environmental Opportunities Facility) - embraces projects that fight against pollution and promote environmental sustainability and renewable energies; covers up to US$120,000 for projects and up to US$600,000 for implementations, whether through funds or shares. SME (Small and Medium Scale Enterprise Program) – Projects up to US$5 million in shares: conservation and sustainable use of biodiversity and reduction of carbon emissions; up to US$100,000 in loans.	Embraces private projects, with no government guarantees, and covers funds as well as equities; limits itself to 25% of project costs but may increase to 35% for small projects.
IADB - Inter-American Development Bank	IIC (Inter-American Investment Corporation) MIF (Multilateral Investment Fund) HSET (Hemispheric Sustainable Energy and Transportation Funds)	Finances medium-sized private companies, which must produce revenues ranging from US$5 million to US$35 million per year Focuses on small-sized projects; finances other funds provided they are directed to Latin American ESCOs (Energy Service Companies), clean technology and the like. Provides support to prepare sustainable energy and urban transport projects; specific to Latin America and the Caribbean
CAT -Corporacion Andina de Fomento		Promotes sustainable development and includes private companies and government entities. In the energy field, it concentrates on carbon capture projects.

b- BILATERAL INSTITUTIONS

INSTITUTION	ORIGIN	CHARACTERISTICS
DCA - Development Credit Authority	US Government (USAID)	Guarantee fund – up to 50% of financing.
OPIC - Overseas Private Investment Corporation	Independent US Government Agency	Provides support for US investments in renewable energy projects in developing countries; provides funds and guarantees up to US$200 million.
TDA - US Trade and Development Agency	US Government Agency	Supports feasibility studies for projects in the public sector (up to 100%) that reflect significant export opportunities for US products; may cover from US$30,000 to US$2 million.
IFU - The Industrialization Fund for Developing Countries and IFV - Investment Fund for Emerging Markets	Danish Government	Usually participates as equity partner with up to 30%; may finance up to 25% of the total cost. Encompasses the entire array of project sizes, provided they are "clean energy" projects.
EXIMBANK – Export-Import Bank of USA	Official Export Credit Agency of the US Government	Finances projects of any size as long as they include export of products and services from the United States. Pays special attention to "clean projects."
FMO - Netherlands Development Finance Company	Dutch Government's Development Bank	Finances private projects in emerging markets. Although it does not require participation from Dutch partners, it includes several government programs from the Netherlands.

c- TRADE INITIATIVES

NAME	CHARACTERISTICS
E&Co	A non-profit organization that aims to fund self-sustainable energy projects in developing countries; provides financing through loans or equity investments. Its limits range from US$50,000 to US$250,000 and cover investments in renewable energy and energy efficiency enterprises.
Latin American Energy Services Company Investment Fund	This fund provides equity investments to small- and medium-sized ESCOs and offers this type of company the possibility to access performance contracts in Latin America; it also covers alternative methods of electricity generation and generation from renewable energy sources. Its capital ranges from US$25 to US$50 million.
The Clean Tech Fund	Also equity-based (capital ranges from US$20 to US$35 million); provides support for investments in small- and medium-sized companies in 5 industry sectors, which currently include: effluent treatment; residue use; recycling; energy efficiency; renewable energy; and transport efficiency. Its activities are limited to Latin America.
NUON	Dutch private fund that participates in projects related to energy and water use. Based on equity participation, its work is not limited to Latin America; for example, it owns investment shares in South Africa (rural electricity systems based on photovoltaic energy), in the US (NUON invested US$53.5 million in Green Mountain Energy Company), and in China (wind energy in farms).
Global Environment Fund	The fund manages about US$ 250 million through 4 other funds (two of these funds, Emerging Markets Funds I and II, invest in renewable energy); Works through equities and embraces the full range of companies and organizations in emerging markets.
Triodos Bank	Dutch bank that finances socially- or environmentally- oriented undertakings; encompasses all organizations worldwide, whether public or private. Holds shares in the Solar Investment Fund (SIF), in Fundo Eólico and in Triodos Greenfunds.

2.2 NATIONAL FINANCING

For strategic reasons, and in accordance with Law N° 10.438/02, Eletrobrás may currently hold a minority interest in the capital of a company that will be created to generate energy from residues and/or to finance the project. This possibility favours the referred undertaking since it is a project that promotes “clean energy” generated from biomass, and uses local sources to supply raw material at the same time that it replaces the use of diesel oil by supplying isolated systems.

BNDES is the only Brazilian bank that provides financing for energy efficiency improvement in facilities and renewable energy sources (see Table 2.2). It is also the only Brazilian development bank that acts through financial agents including private and public sector banks. Public sector banks include the BRDE (in the Southern Region) and BNB (for Brazil’s Northeastern region). Banco do Brasil, however, cannot be considered an official bank from the commercial point of view, except when it manages official funds.

BNDES funds are loans with similar characteristics in terms of the guarantee requirements for commercial loans. The interest terms, however, are incomparably lower than those exercised by private banks. Consequently, the present Report does not consider hese funds due to the high cost of money involved; even when re-lending the BNDES funds, these banks are not competitive with the official re-lending banks for BNDES funds.

It should be noted that BNDES administers other energy funds for small hydro plants and fossil fuels, which are not included in the following Tables as they do not fall directly into the objectives of the present Document.

In addition to the BNDES, the Banco do Brasil and BASA (Banco da Amazônia) manage development funds for the Middle-West and Northern regions (both include areas with Amazônia), respectively. Although these funds are not specific to energy production or energy efficiency, they include projects that focus on regional development, such as the one described herein. The funds are:

- The “Fundo Constitucional do Centro Oeste (FCO Empresarial),” which covers programs focused on economic infrastructure;
- The “Fundo Constitucional do Norte (FNO),” which provides financing in special situations for projects in the Northern Region (in this case, it would only include replication projects).

TABLE 2.2

NATIONAL FINANCING: BNDES-MANAGED FUNDS

NAME	CHARACTERISTICS
1. *Programa para Investimentos em Conservação e Fontes Alternativas de Energia Elétrica* (Conservation and Alternative Electricity Sources Investment Program)	Interests: Long-Term Interest Rate (TJLP) + basic spread + risk or underwriting spread. Basic spread: 1% per year (in the Amazon Region and in the Middle West); risk or underwriting spread: depends on each project or agent (when there is no agent, it varies between 0.5% and 2.5% per year). If FGPC* is used, up to 4% per year. Maturity: to be defined as up to a maximum grace period of 6 months and a twelve-year amortization period. Participation Level: up to 80%.
2. *Programa de Apoio à Cogeração de Energia Elétrica a Partir de Resíduos de Biomassa* (Support Program for Electricity Cogeneration from Biomass Residues)	Interests: Long-Term Interest Rate (TJLP) + basic spread + risk or underwriting spread Basic spread: TJLP. Risk or underwriting spread: 0.5 % to 2.5 % per year (if no intervening agent); under R$10 million, under "BNDES Automático"; above this value, up to 2.5 % per year; if FGPC* is used, up to 4 % per year. Maturity: same as above. Participation Level: up to 80%.
3. *BNDES Automático*	Participation Level: up to R$10 million in investments in energy efficiency projects. Interests: same as above. Basic spread: 1% per year (in the Amazon Region and in the Middle West); risk or underwriting spread: depends on each project or agent (BNDES does not act directly); if FGPC* is used, up to 4 % per year. Maturity: per project. Participation Level: up to 100%. Does not finance implementation projects and may include working capital.
4. FINEM – *Programa Regional do Centro Oeste* (Middle West Regional Program)	Finances projects located in the Middle West Region starting from R$1 million.
5. FINAME – *Fundo de Financiamento para Aquisição de Máquinas e Equipamentos Industriais* (Government Agency for Machinery and Equipment Financing)	The fund is not specific to energy projects put covers the entire range of equipment purchases; interest rate is equivalent to this table's Program 1 and applicable to microcompanies. Maturity: up to 72 months. Participation Level: up to 100 %. Includes working capital associated with equipment purchases.

* FGPC - *Fundo de Garantia para a Promoção da Competitividade* (Guarantee Fund for the Promotion of Competition)

ANNEX

TRAINING

Considering the Generation Plant's suggested organization, there are two possible alternatives for its design:

a- outsourcing the plant's operation;

b- maintaining the operation under the plant's own administrative structure.

The first alternative is considered more feasible and will govern the training structure described below. The training framework, outlined in this sub-item, is divided into three different modules directed to specific audiences. These are:

a- Module A – Trains timber industry owners and/or their principal managers.

b- Module B – Trains an intermediate team that will manage and inspect the outsourced party or parties.

c- Module C –Trains the team that will be responsible for undertaking the actual inspection process

Although the second alternative is presented herein, building an operative structure entirely separate from the core business of a sawmill may be considered an inadequate option. If this is the case, the training framework presented in this Report will require that Modules B and C be replaced by a course specifically geared towards training future operators. Such a course would offer a more in-depth approach to the disciplines at issue and would require basic prerequisites from the trainees.