

Developing Energy Profiles for Sawmills in the Amazon Region

First Field Visit to Rondolândia and Ji-Paraná

Alan Poole & Pericles Pinheiro; March 12, 2003

This field visit was made during December 3-6 as a contribution to the project *Generation from Sawmill Residues in the Northwest Region of Mato Grosso State* supported by the UNF/UNDP. This project seeks ways to exploit the energy potential of wood industry residues in ways that support sustainable forestry and contribute to the sustainable economic development of the frontier region.

By the time of this field visit the site for the pilot plant had been chosen – a cluster of nine sawmills in the municipality of Rondolândia, known as Pólo 70 - and two prior visits made. The cluster is isolated from the public service grid. All power is generated by the sawmills themselves. The cluster is relatively small by Amazonian standards. The local context for promoting sustainable forestry appears to be relatively favorable – a major factor in choosing the site for a pilot plant. More information on the project and the choice of the site can be found in the report: *The Energy Potential of Wood Industry Residues from Wood Produced with Sustainable Forest Management Practices – Executive Summary*.¹

Table 1: Characteristics of Rondolândia Pólo 70

Logs processed per year	49,600 m³
Residues generated per year	27,280 tons
Generation capacity in sawmills	1300 kW
Electricity consumption per year	1006 MWh
Capacity Factor	9%
Estimated cost of electricity (conservative)	US\$ 180/MWh

The primary objective of the field visit was to systematically accompany the steps of the industrial process and to make preliminary measurements of sawmills' electricity load profiles (both overall and for specific processes) in order to contribute to the dimensioning of the generation plant and to identify possible opportunities for energy saving and/or load management to reduce peak demand.

In planning for an isolated electrical system using renewable resources, special attention must be paid to maximum demand. Capital costs are much higher than with the "business as usual" diesel genset – where fuel alone costs for ~80% of the electricity generation cost.

The prevalence of the "diesel-low investment" energy supply approach and the "cowboy" business culture in the region means that there has rarely been given attention to capacity optimization or, consequently any interest in systematic measurements of energy use, such as load curves. This project is intended to bring attention to the usefulness of systematic measurements of consumers' energy use as a baseline for project development.

Another objective was to deepen understanding of the factors influencing wood drying in drying kilns – an energy intensive process which is a pre-requisite for new investments in the cluster to aggregate more value to the local timber resource. The issues concerned with drying are treated in another report.²

The team was led by Alan Poole and included Jandir Marinelli of Benecke - a company which manufactures and installs wood drying systems - and Pericles Pinheiro of INEE. Mr. Marinelli evaluated existing and potential sites for wood-drying systems designed by his firm. Mr. Pinheiro measured electrical loads.

This is a progress report based on this first visit. A second visit is scheduled in March. The plans to maximize the useful information obtained during the second visit are summarized at the end.

¹ The Executive Summary of the report is available in English and Portuguese on INEE's website: www.inee.org.br.

² See the technical report *Issues in Developing a Central Drying Unit for Wood – The Case of Rondolândia*, available on request from INEE.

Description of the Sawmill Process

The output of sawmills in the cluster is almost entirely limited to unseasoned planks of sawn timber. The basic process is very similar in all the mills.

The processing begins by loading a log on a rail wagon which feeds it to the bandsaw. The log grappling and aligning equipment on the wagon may be manually operated or have a hydraulic system. The hydraulic system permits a somewhat faster throughput of logs (10-15%) and reduces labor costs. Only one sawmill in the pole (Saga) has a hydraulic system. The sawdust is captured below the bandsaw and sent to a storage bin by exhaustor fans. Rough wastes (bark etc) are thrown to a nearby pile for transport later to a site for burning

The raw planks are piled and fed to a table saw for cutting lengthwise. A significant volume of large-sized residues (*aparas*) is produced in this step, as well as substantial sawdust.

The planks are then cut transversally to pre-determined lengths. A moderate quantity of medium-sized residues is produced in this step. Sawdust production is smaller than in the previous step.

This constitutes the first basic cycle of wood processing as practised throughout the region. The steps are illustrated in the photos in Annex A. At the end planks are piled for natural drying and/or transport. Significant stocks of piled planks are held at the sawmills. Most of the Pole's production is limited to this stage of processing. Further "beneficiation" of the wood is mostly done in Ji-Paraná, the sub-regional center about km distant.³ Where there is equipment for extra processing, its use is sporadic.

With drying and lower cost electricity available in the cluster significant additional processing capacity, especially planing, would be installed and used intensely. This is indeed a key objective of the pilot project.

The additional downstream "beneficiation" of the rough planks can greatly increase the sawmill's requirements for electricity per m³ of wood processed. Local estimates are that they can double, a value which needs confirmation by studying the processes currently used in Ji-Paraná.

This beneficiation also produces a significant volume of additional residues – one half the volume of wood in the rough planks becomes residue. In energy terms, these residues are of higher value than the residues produced by basic processing. The latter have a higher moisture content and the greater part are relatively large pieces which would need processing before introducing into the boiler.

In both cases, much of what is considered "waste wood" today (larger pieces) could become useful products.⁴ This means that the residues for energy generation (a relatively low value use) would be less.

Commercial project developers don't take the availability of residues as a constraint, because they are so obviously abundant today. However, within the time horizon of a bank loan for a power plant, today's abundance can become scarcity if "business as usual" continues in this region of Amazonia.⁵ We believe it is important to extract the maximum of value from the basic wood resource, so we must try to be efficient in our

³ Ji-Paraná is a city of inhabitants in the State of Rondônia. It has a large wood products industry providing semi-finished products. By comparison, Rondolândia has only inhabitants. The County Seat is a village elevated to new status by the subdivision of a larger *município* in Mato Grosso a few years ago. But they have ambition. This region is rocky, unusual in Amazônia, and has potential for quality granite besides forest products. The locals call themselves the "Alaska of Mato Grosso" because you have to go through Ji-Paraná, in another State, to get there from anywhere else in Mato Grosso by anything but jungle rally vehicles.

⁴ Artisans produce beautiful wooden plates from primary processing "residue". In a Ji-Paraná sawmill producing semi-finished products, the bin feeding "waste" to fuel the air drier furnaces would be perfect raw material for a high quality and very expensive "butcher block" tables.

⁵ Without the introduction of sustainable forestry commercial timber could be exhausted in eight years – as discussed in the main text.

use of the residues most appropriate for energy use. Efficient systems will be more robust – in terms of economics, politics (including the environment) and financing.

Case Study in Rondolândia - Polo 70

Two sawmills in the cluster were visited – Saga and J.G. Alfa. They are among the largest in Polo 70 and are considered to be among those most seriously interested in the pilot project. They certainly received the team well and did everything to facilitate our work.

Electricity measurements

Measurements and processing of the information were to be carried out principally with the Enforma ® kit of sensors, data loggers and software supplied by Architect Energy. A hand-held amperage meter was also taken for spot measurements.

Five battery powered data loggers were taken. They were charged and programmed in Rio de Janeiro on the eve of the trip. The programming foresaw measurements at 3 second intervals averaged over 30 seconds for each recorded reading. A dense recording strategy was indicated given the variable nature of the loads. Indeed, it was discovered later that the average period was far too long. An average of 5 seconds or less would have been more appropriate given the oscillating nature of the operations being measured.

Two mishaps limited the use that could be made of the loggers. First, Mr Pinheiro missed his airplane to Cuiabá due to a massive traffic jam on the Niteroi bridge and the access roads to the airport caused by an accident. Since there is only one flight per day from Cuiabá to Ji-Paraná this meant the loss of a day – or half the time available.

Second, it was not possible to reprogram the data loggers because the local computers at hand did not have the necessary ports or CD drives. When the team arrived in Rondolândia and the loggers were installed, it was discovered that all but one had “saturated” and could log no more measurements. This meant that only the overall use of the sawmill could be measured at the busbar of the diesel generator, for a relatively short period. Measurement of individual motors was limited to spot measurements with the amperage meter to obtain values for full load and when running idle

All this severely limited the data that could be collected. Even so, what could be measured proved to be very revealing and had an important impact on defining the current energy usage by the sawmills in the cluster.

The Saga Sawmill

The generating plant operates only during the hours of work of the sawmill (6:00 am to 7:00 pm). There is a smaller 30 kVA generator which provides electricity for the administrative/lodging buildings until 9:30 pm and can provide power for maintenance activities in the sawmill when the main generator is down.

Generating Plant			
Nameplate capacity	200 kVA	Date of fabrication	1980
	160 kW	Model	Maquigeral

The generating room is hot, which diminishes the performance of the diesel genset – which is 22 years old. The genset's ventilation was poorly conceived and could easily be improved.

The electric load varies substantially and rapidly as shown in Annex B. The figure underestimates the degree of fluctuation because the points represent averages of 30 seconds, during which motors' loads vary substantially.

The cycle of peaks of demand is strongly influenced by the size and species of the log. For example, a thick 6 m³ log of hard wood took almost an hour to saw, the cycle of cutting was about 55 seconds sawing and 10 seconds for repositioning with the bandsaw off-load. Smaller (3-3.5 m³) and thinner logs of a softer species took

10-12 minutes. The cycle of cutting was about 11 seconds for sawing and 7 seconds for repositioning the wagon.

The principal electric motors used are summarized in the table below, which shows rated horsepower and some measured amperages for operation when on full load or running off-load. The table is still preliminary, but is a starting point for the case studies to be developed in the second field visit, as described in the last section below.

Table 2: Installed Motors at the Saga Sawmill

Function of motor(s)	Rated Horsepower	Amperage Off-load	Amperage Full load	Observations Profile of operation
Basic process	195			
Traction for log feed wagon	10	20	50	
Wagon brake	10			Medium cycle, mostly offload
Crane for loading logs on wagon	10			Medium cycle, mostly offload
Compressor for hydraulic system	10			
Bandsaw	100	105	320	
Sawdust extraction	20			
Lengthwise cut radial saw	25	9	20	Frequent full load medium cycle
Cross cut radial saw	7,5	13,5	19,5	Frequent short cycle, mostly offload
Bandsaw sharpener	2,5			Intermittent use
Additional processing	77,5			
Cross cut radial saw	5			Inactive at time of visit
Planer and dust extractor (6 motors)	47,5			Inactive at time of visit
Other	25			Inactive at time of visit

The installed capacity of the motors for basic processing is covered by the generating plant, however the total capacity including additional processes of sawing and planing substantially exceeds the capacity of the plant. This additional processing is done only occasionally.

The cycle of operation of motors at different steps of the process is very different. Qualitative observations are made in the table. With actual load curves it will be possible to define them quantitatively. Besides helping to better define the maximum demand of the cluster, the additional round of measurements will help define the viability of measures to reduce demand or increase the energy efficiency of the motors. Two approaches appear promising:

- Most motors are old and rewound. New motors could do the same work with lower load.
- Frequency inverters or disconnect controls could be economic for some motors such as: (a) the traction for the log feed wagon, (b) the crosscut radial saw or even (c) the log bandsaw. A large share of energy is used running motors off-load.

If an “efficiency upgrade/process modernization” component were added to the energy supply project proposed for the cluster, these measures could become attractive to the sawmills. First, there would be financing available – something almost impossible for them until now. Second, new equipment could be purchased in greater scale for the cluster as a whole – diminishing the investment cost for the retrofit.

The Saga sawmill shows some particularities. It is perhaps the only sawmill in the cluster to use a hydraulic grappling system for the wagon feeding the bandsaw. This involves additional energy. The bandsaw is also more powerful than the usual, which is 75 horsepower.

Other than that, the basic processing is very similar with that in other sawmills in the cluster, as confirmed by a shorter visit to the sawmill J.G. Alfa. This means that in technical terms, it would be perfectly feasible to do “bulk” purchasing for the cluster as a whole, as suggested above.

Impact of the field visit on scenarios for the pilot plant

The field visit had an important impact on the development of the scenarios which dimensioned the pilot plant and underlay the economic calculations.

It suggested that the efficiency of the diesel generators is unlikely to be as high as had been assumed in the original analysis when translating reported diesel consumption into kWh of electricity generation. Most plants are quite old, operating rooms are hot and the load factor varies widely, often being too low for efficient generation. Lower efficiency implies a smaller existing electricity consumption than had been originally estimated. It also implies an even higher cost for the diesel generated electricity than previously estimated.

On the otherhand, the visit indicated that the growth in sawmills' electricity demand is likely to be faster than had been projected in the original scenario. A key reason for seeking lower cost power from residues and installing driers is the interviewed mills' objective to shift at least preliminary beneficiation capacity to the Polo 70 cluster. Preliminary observations indicate that the additional processing (excluding drying) could double a sawmill's electricity consumption. It is likely that the beneficiation capacity would be added quite soon after the energy project was implemented. Until then, demand is likely to remain flat – limited by the sawmills' existing diesel capacity and their reluctance to increase it at this time

The relation of average demand during full sawmill operation to peak demand was almost certainly underestimated in the original demand scenario. The recorded load profile suggest that, for individual plants, peak demand is 55-60% higher than average demand during sawmill operating hours.⁶ The peaks are driven primarily by variations in the load of the bandsaw – a thick dense log will push up demand. Beneficiation operations are unlikely to involve such large oscillations – so the ratio of peak to average demand should decline over time.

Attention to energy efficiency and load management can be an important option for a small isolated system – since maximum capacity is fixed until there are large new investments. While capacity would be ample in the beginning, constraints could be reached soon and become chronic. Opportunities exist for measures that reduce the maximum demand of a set of plants, as well as reducing the energy consumption, as was discussed above.

⁶ The measurement was taken every 3 seconds and averaged every 30 seconds. A shorter average period is likely to increase the peaks and valleys.

Preparations for the second field visit

The experience gained in the first field trip will be used to obtain much more information in the next field trip, scheduled for late March.

There are two broad complementary lines of work.

- I. Measure current loads in Rondolândia Polo 70 and specific loads in Ji-Paraná relevant to estimating the impact of beneficiation on future growth of demand in Polo 70.
- II. Accompany and systematically record industrial activities now used at Polo 70 and those that may be introduced

These lines of work combine to produce:

- A. An energy baseline, profiling current energy use – both generally and for a specific mill. This baseline will be valuable information for a vendor seeking to market more efficient motor systems. He can clearly and credibly show how much his new system has saved his client's costs.
- B. Information for projecting the expansion of the cluster's energy demand. This is of primordial importance for dimensioning the central energy utility plant.
 - o Estimate electricity peak demand and consumption in order to dimension the power plant;
 - o Estimate the demand for central wood drying services⁷

Below, we break down the two broad lines of work.

Electricity measurements

- An inventory of motors will be requested of each sawmill being measured.
- Very finegrained time discrimination will be used for most measurements – every 3-5 seconds. These fine measurements will be of relatively short duration to capture load profiles during periods of typical operation of specific processes and/or the plant.
- Another set of coarser-grained measurements will be used to measure loads over a longer period – both of the genset and several key processes. These will capture load factors and overall operating cycles.
- The operation of gensets supplying the administrative/dormitory centers will also be followed (coarse grained) during a day's operating cycle (lunch and evening).

A laptop computer is being purchased to allow necessary reprogramming on-site and also to permit processing of some data while still in the study area. The preliminary on-site analysis may suggest new measurements especially in interaction with vendors of new products.

Accompany industrial activity

- Photograph and video of processing steps being measured.
- During measurements of bandsaw operation, species and log size will be registered systematically.
- Characteristics and volumes of residues at each step of processing
- Operating hours of the main generators confirmed. At Polo 70 long (3 day) measurement site – record diesel fuel consumption over period. Volumetric measures.
- Information on projected use of central or other drying by the sawmills in the cluster.
- Information on projected beneficiation of sawmills.

A representative of a major motor manufacturer will be invited to participate in the field trip. This will help define more realistically the viable possibilities for measures to reduce specific loads and improve energy efficiency. The field trip is open to interested manufacturers and project developers, whose presence will add importance to the visit in the eyes of the local sawmills owners.

⁷ See the technical report *Issues in Developing a Central Drying Unit for Wood – The Case of Rondolândia*, available on request from INEE.

ANNEX A: Photographs of the Polo 70 Cluster and Basic Industrial Operations

Overview of the Saga Mill



Polo 70 – Loading Log on a Hydraulic Wagon



Introducing the log to the bandsaw



Cutting the log on the bandsaw



Repositioning partially cut log for bandsaw



Traction for wagon introducing log to bandsaw



Transfer to Longitudinal Cut Radial Saw



Longitudinal cut radial saw



First Cross Cut Radial Sawing



Output from basic processing



Second Cross Cut Radial Saw (after basic processing)



Approaches to stacking for open air drying – J.G. Alfa



Covered and open air natural drying at Saga mill



Disposal of Residues



Entering the town of Rondolândia –the infrastructure is not great



Saga Mill Proprietors (to whom much thanks) with Alan Poole, team leader



County Seat of Rondolândia (to the Mayor and Municipal Councillors, much thanks)



ANNEX B: Variation of Amperage at Busbar of Diesel Genset at Saga Sawmill

(Pericles – você consegue inserir o gráfico no Word?)