POTENTIAL OF GENERATION OF ELECTRIC POWER IN THE STATE OF PARÁ USING SETOR LUMBERMAN'S BIOMASS.

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Abstract. *The Amazon region has an expressive potential for the supply of biomass, and the state of Pará is the third major processor of forest-derived products in Brazil. This activity generates a large amount of residue biomass with significant potential for the generation of energy. Many sawmills and similar factories are distributed throughout the state. This study surveys the localities where biomass is processed, with the use of GIS, in order to map where residues are produced and evaluate the energy-producing potential of municipalities. An estimate was also made of the costs involved in transporting biomass residues to communities that are not connected with the state electrical grid, where these materials could be used in generating electricity.*

Keywords*: GIS, Biomass, Electrical Generation, Production Potential.*

1. INTRODUCTION

The Amazon Basin, a major reservoir of the world's tropical forests, with many species of timber-yielding trees, has attracted attention as an important source of wood for both Brazilian and international markets.

Lumbering activity in the Brazilian north has increased with the exhaustion of native forests in the Brazilian south and southeast, as well as those of Africa and southeastern Asia. A major exporter of timber is the Brazilian state of Pará, with about 73% of the its area covered by native forests, low-lying relief, large navigable rivers, and well-developed roadways.

In 2002 the Pará timber industry generated approximately 5.4 billion reals (about 1.2 billion dollars), and in 2004, according to the wood exporters' association (Associação de Exportadores de Madeira, AIMEX), Pará exported about 109.000 tons of wood as finished products.

This production generates a considerable quantity of sawdust and wood scraps as residues that, if not properly handled and disposed, could be damaging to the forest environment.

The volume of these residues in the Amazon region is about 50% of the volume of processed logs. Besides the waste of a natural resource and impacts to the environment, traditional uses of these residues do not take into account their potential economic value. These residues are generally used as fuel, for producing charcoal, or as trash burned in the open.

Better use of wood scraps and sawdust can contribute to the rational use of a natural resource, as well as for generating a new source of income for lumber companies with consequent increase in employment and profits.

This study consisted of locating lumber companies, determining their production and use of wood scraps and sawdust, and analyzing their potential for using residues for generating electricity, especially for distribution to communities not connected to the power grid.

2. METHODS

Timber companies were surveyed according to their operating licenses throughout the state of Pará, by trained field workers. Among the collected information, the most relevant for this project were those related to production: the number of band saws, the average volume of wood sawn per year, most common types of wood, and the localization of sawmills.

This survey was undertaken from March 2004 to December 2005, using as a base the list of lumber companies registered with the Pará Industrial Federation (Federação das Indústrias do Estado do Pará, FIEPA).

After the field survey, research was undertaken to determine the thermo-physical properties of the utilized wood species. This was done using Brazilian norms for chemical characterization: volatile resin content, ash content, fixed carbon content, humidity, caloric content, and charcoal density. These values were applied to determine the energetic values of wood residues from sawmills.

Data from the field work and from the laboratory were entered into a data base and then filtered. Systems of electrical co-generation of were simulated in which vapor from a drying oven attached to a turbine was the fuel.

For this simulation, the following parameters of the thermo-physical properties of wood residues were used, along with information furnished by turbine manufacturer EBMA, for a unit operating at a pressure of 21 kg of vapor per hour.

Table 1 shows the constants used in the calculations. For vapor and charcoal density, the species average was used, as determined in the laboratory.

Table 1. Values of constants used in the calculations

Log Use Index	55%
Improvement Use Index	70%
Laminated Use Index	65%
Greenhouse Wood Volume	100%
Granary Density	200,00 kg / m³
PCI	3.200 kcal/ kg
Kettle Income	85 %
Sawdust x Log Relationship	5
Sawed Wood Humidity	30 %
Wood Final Humidity	10 %
Steam Entalpy at 21 bar	666 kcal/kg
Drying Efficiency	40 %
Turbine Specific Consumption	10 kg/kWh

Simulations using yearly amounts of processed wood gave results including: (1) amount of wood residue available, (2) total vapor generated, (3) vapor available for drying, (4) vapor available for electrical generation, (5) energetic balance, and (6) potential energy generation.

Another phase of this project used geo-referential data for the localization of the sawmills and potential consumers of generated electricity.

3. RESULTS AND DISCUSSION

Of the 143 researched municipalities in Pará, 88 showed a potential for electrical generation from wood residues, while the other municipalities did not have lumber mills registered with FIEPA and were therefore not considered in the study.

The following graph shows the types of lumber companies in the state, namely: (1) companies that cut logs into planks, (2) companies that produce finished plained lumber, (3) plywood companies, (4) companies that both cut planks and produced finished lumber, (5) companies that both cut planks and produce plywood, (6) companied that produced finished lumber and plywood and companies that cut planks and produce finished lumber and plywood, as shown in Figure 1.

Together, these companies process approximately 8.7 million cubic meters of wood per year (Figure 2), generating about 3.61 million cubic meters of residues per year (Figure 3), enough to generate approximately 160 MW of electricity per year (Figure 4).

It should be noted that most of the state’s lumber companies cut planks from logs, a poor situation because this activity shows the least efficient utilization of the resource as well as the least aggregated value.

Graphs of residues and cut planks demonstrate this great waste of wood, because the volume of the residues is greater than the cut planks.

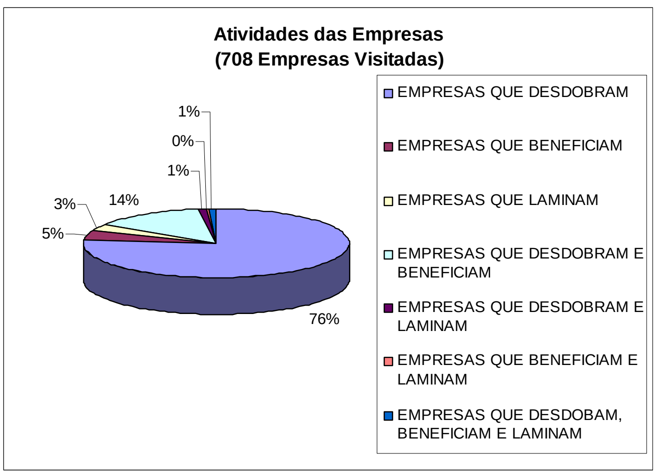

Figure 1 Companies

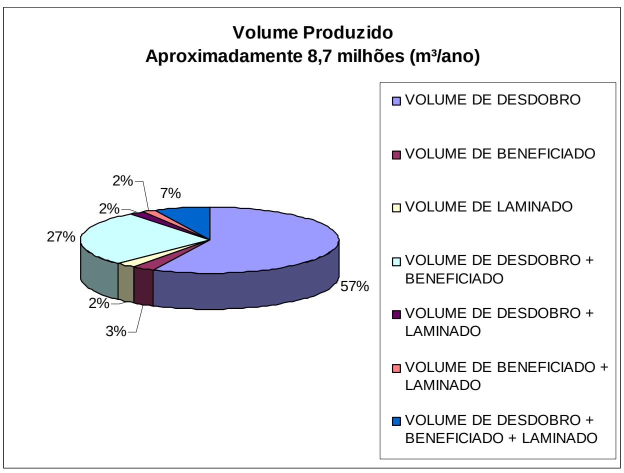

Figure 2 Volume

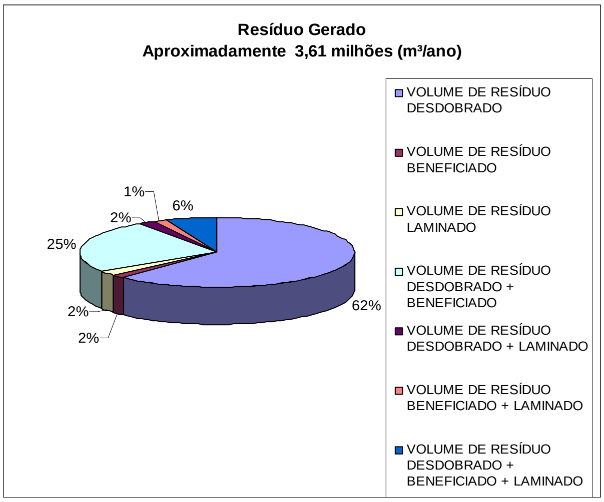

Figura 3 Residue

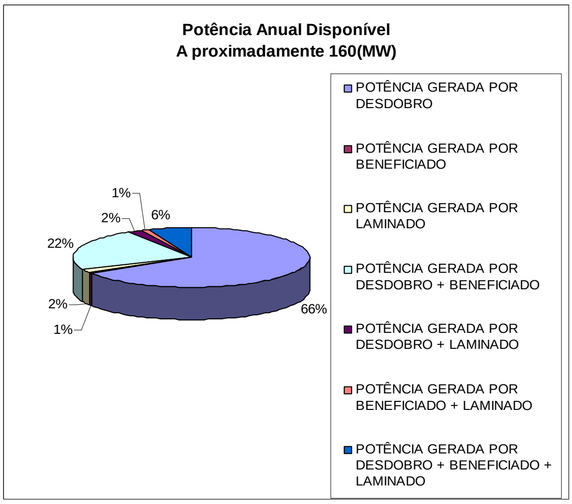

Figura 4 Eletrical Potencial

4.1 Histograms

Figure 5 shows clearly that most lumber companies process between 6000 and 12000 cubic meters of wood per year. This figure is reflected in the number of band saws since one band saw processes an average of 6000 cubic meters per year.

It can also be seen in Figure 6 that most of these companies generate, on average, between 3000 and 6000 cubic meters per year of residues (about 65% of these companies).

Approximately 70% of the lumber companies researched have the potential to generate individually from 200 to 300 kW per year of electricity (Figure 7).

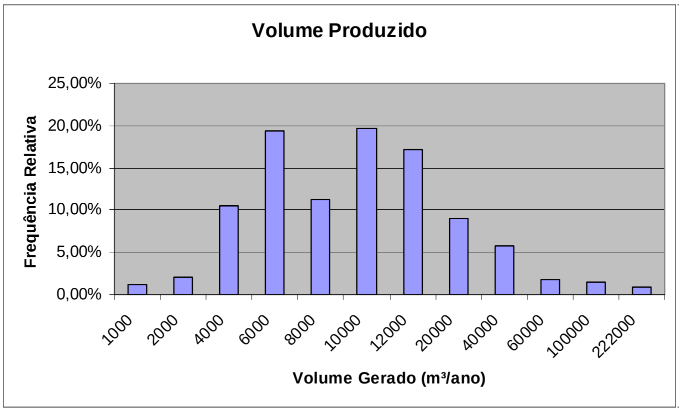

Figure 5 Volume histogram

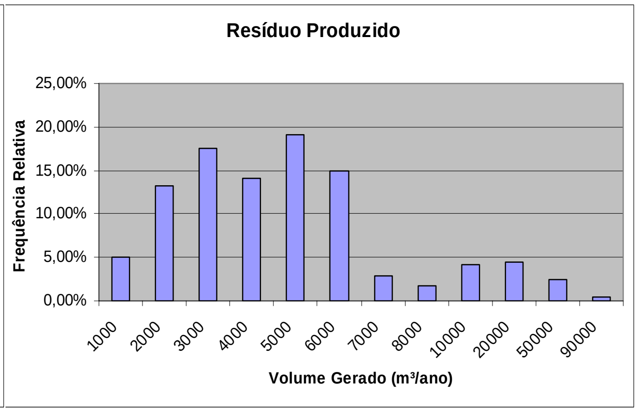

Figure 6 Residue histogram

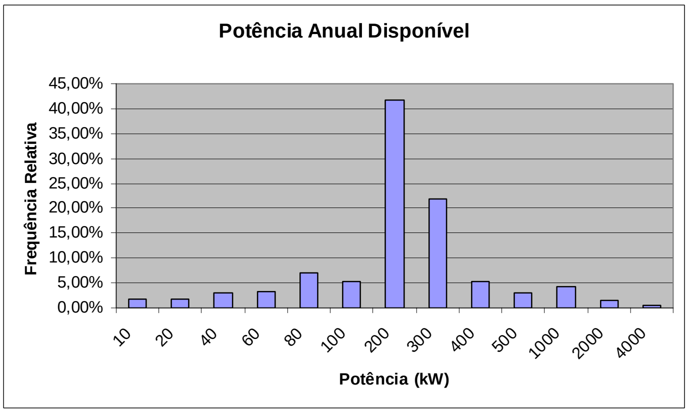

Figure 7 Eletrical potencial histogram

4.2 Local homogeneous regions

To aid in this study, Pará state's local homogeneous regions were considered (Figure X), as follows: (1) Lower Amazon River, (2) Metropolitan region of Belém (RMB), (3) Southeast, (4) Southwest, (5) Northeast, and (6) Marajó Island. The principal data of each local region are shown in Table 2.

Table 2 Companies/ Local homogeneous regions

LOCAL HOMOGENEOUS REGIONS	COMPANIES NUMBERS	VOLUME (m³/ano)	RESIDUE (m³/ano)	ELETRICAL POTENCIAL (kW)
BAIXO AMAZONAS	42	504.402	199.756,5	8.278
REGIÃO METROPOLITANA DE BELÉM	52	1.146.060	434.481	17.071
NORDESTE	107	1.031.717	449.022,3	20.450
SUDESTE	331	3.751.582	1.595.268	72.178
SUDOESTE	151	1.246.020	534.549	24.369
MARAJÓ	24	1.016.117	396.735	16.177

One interesting fact to be seen in Table 2 is that the metropolitan Belém region, although it has more lumber companies than the Northeast, shows a smaller volume of wood processed, less residue generated, and a smaller potential for electrical generation. This is because Belém houses mainly companies that produce finished, plained lumber, often from rough lumber cut in other parts of the state, including the Northeast.

In terms of potential for electrical generation, a highly relevant fact is the presence of drying ovens for lumber in companies in the metropolitan Belém region, where part of the generated vapor is used for drying, thus lessening the potential for electrical generation.

5. Electrical distribution to isolated communities

After considering local regions, municipalities with wood residues were divided according to their being linked to the state's power grid or not. Some municipalities with wood residues have the potential to generate electricity for distribution to nearby isolated municipalities.

Data provided by the local electrical company, Rede Celpa, were used to calculate the demand in municipalities not linked to the state power grid. To the most recent estimate, a correction factor of 30% was added.

To calculate installed potential, the lumber company's consumption was considered (basically the consumption of the most consuming piece of equipment in function of the volume of production), and the surplus that would be available for distribution. In the municipalities not linked with the power grid all sawmill residues would be used for electrical generation, and only the costs of transport from the mill to the thermoelectric plant are taken into account since the cost of the residue would be minimal.

For installed generation capacity, that used by the company, data were provided by EBMA as follows: (1) for cutting planks from logs, each 12.000 m³ of processed wood requires 70 kW/h, (2) for producing plained finished lumber, each 12.000 m³ of processed wood requires 70 kW/h, and (3) for plywood, each 9.000 m³ of processed wood requires 80 kW/h.

Surplus potential is given by the following formula:

$$ExcessPotencial = GeneratedPotencial - InstaletedPotencial \quad (1)$$

From this preliminary study, it can be concluded that the local homogeneous regions of the Northeast and the Belém metropolitan region do not need to receive wood residues from other regions since Belém does not have communities not linked to the state power grid and the Northeast is self-sufficient in wood residues to attend its communities that are unlinked with the state's power grid.

The nest step was to identify those municipalities with the potential to supply wood residues to municipalities not linked to the power grid, where the principal factor was distance.

EBMA also provided the information that for each 2.5 kg/h of consumed residue 1.0 kW of electricity would be generated, taking into account the efficiency of the generating unit. The generated potential is given by the following expression:

$$QTD_{res.} = ExcessPotencial x \tfrac{1000}{2,5} \quad (2)$$

Where:

$QTD_{res.}$ = Total quantity of residue [kg/h]

To calculate transportation costs of residues, the value of the US dollar was of significant importance, because the cost for transport was set at US$10.00 per ton for each 100 km for river transport and US$30.00 per ton for each 100 km for road transport, according to the local transport association (O LIBERAL 2005).

$$QTT_{Transp.} = Dolar(R\$)xQTD_{res.}x(LandDist.x\tfrac{30}{100} + WaterDist.x\tfrac{10}{100}) \quad (3)$$

Where:

$QTT_{Transp.}$ = Total transport costs

For this calculation, the value of the dollar was R$2.30.

Table 3 shows the amount of residue per hour, transport costs, and costs of transport per ton-hour, where this last variable would be the best one of choice for an analysis of economic viability.

Table 3. Quantity of residuals and costs

TRANSPORT ROUTE	RESÍDUE NEEDED (ton/h)	TOTAL TRANSPORT COSTS (R$)	COST PER TON (R$/ton)
BAIXO AMAZONAS			
SANTARÉM – ALENQUER	6,7693	94,97	14,03
GOIANÉSIA - ROTA BREU BRANCO	11,779	463,25	39,33
NOVO REPARTIMENTO - ROTA BREU BRANCO	10,036	477,82	47,61
TUCURUÍ – ROTA BREU BRANCO	17,725	134,53	7,59
DOM ELISEU - ROTA BREU BRANCO	7,2613	1603,28	220,80
PARAGOMINAS - ROTA BREU BRANCO	8,5798	2125,29	247,71
ROTA BREU BRANCO - ROTA PORTO DE MOZ	55,38	9030,85	163,07
ROTA PORTO DE MOZ – ALENQUER	1,8139	609,01	335,74
ROTA PORTO DE MOZ – ALMERIM	4,7988	1252,44	260,99
ROTA PORTO DE MOZ – GURUPÁ	3,2923	872,12	264,90
ROTA PORTO DE MOZ – CURUÁ	1,7355	600,64	346,09
ROTA PORTO DE MOZ – FARO	1,3033	505,60	387,96
ROTA PORTO DE MOZ – JURUTÍ	3,7413	1361,93	364,03
ROTA PORTO DE MOZ - MONTE ALEGRE	11,608	3584,99	308,83
ROTA PORTO DE MOZ – ÓBIDOS	10,524	3731,65	354,60
ROTA PORTO DE MOZ – ORIXIMINÁ	12,321	4434,23	359,89
ROTA PORTO DE MOZ – PRAINHA	2,08	590,71	283,99
ROTA PORTO DE MOZ - TERRA SANTA	3,0128	1140,39	378,52
SUDESTE			
ÁGUA AZUL DO NORTE – BANNACH	0,455	56,51	124,20
CONCEIÇÃO DO ARAGUAIA – KARAPANÃ	0,377	92,09	244,26
JACUNDÁ - SANTANA DO ARAGUAIA	6,6053	2771,03	419,52

REDENÇÃO - SANTA MARIA DAS BARREIRAS	0,7475	91,81	122,82
REDENÇÃO - BARREIRA DO CAMPO	0,6208	89,09	143,52
REDENÇÃO – BANNACH	0,105	7,82	74,52
SÃO FÉLIX DO XINGU - VILA MANDI	0,5818	22,08	37,95
SUDOESTE			
RURÓPOLIS – AVEIRO	0,689	65,13	94,53
RURÓPOLIS - NOVO PROGRESSO	1,3584	428,35	315,33
ITAITUBA - JACAREACANGA	0,74	195,56	264,27
ITAITUBA - CASTELO DOS SONHOS	4,5988	1723,01	374,67
ITAITUBA – NOVO PROGRESSO	1,32	350,66	266,34
TRAIRÃO – NOVO PROGRESSO	2,4075	518,29	215,28
MARAJÓ			
BREVES – ANAJÁS	1,755	81,13	46,23
BREVES - BAGRE	0,9525	9,42	9,89
BREVES - CACHOEIRA DO ARARÍ	1,7875	119,64	66,93
BREVES – CHAVES	0,425	26,20	61,64
BREVES - SANTA CRUZ DO ARARÍ	0,9425	77,17	81,88
AFUÁ – CHAVES	0,3063	3,94	12,88
PORTEL – CURRALINHO	2,0085	97,93	48,76
PORTEL – MELGAÇO	1,01	5,33	5,29
PORTEL - OEIRAS DO PARÁ	2,171	79,39	36,57
PORTEL - SÃO SEBASTIÃO DA BOA VISTA	2,24	94,80	42,32
CASTANHAL – ROTA BELÉM	0,178	8,96	50,37
BENEVIDES – ROTA BELÉM	3,5981	76,96	21,39
MARITUBA – ROTA BELÉM	1,9145	26,42	13,80
ANANINDEUA – ROTA BELÉM	5,25	57,96	11,04
ROTA BELÉM – COTIJUBA	0,975	10,67	10,94
ROTA BELÉM – MUANÁ	2,9575	103,08	34,85
ROTA BELÉM - PONTA DE PEDRAS	2,9075	62,55	21,51
ROTA BELÉM - SALVATERRA	6,0515	144,11	23,81
ROTA BELÉM – SOURE	7,3678	182,23	24,73

To supply wood residues to the Southeast (Figura 10) and Southwest (Figure 11) it is not necessary to concentrate residues in one municipality for distribution to communities not linked to the state power grid. On the other hand, this would be necessary to supply the regions of the Lower Amazon River and Marajó Island, that will require residues from the Southeast (via Breu Branco – figure 8 – and Porto de Moz – figure 9), and from the Belém metropolitan region (via Belém– figure 12), respectively. The cost of residue transport was proportionately distributed among the consuming municipalities (figure 13).

5.1Maps:

Baixo Amazonas:

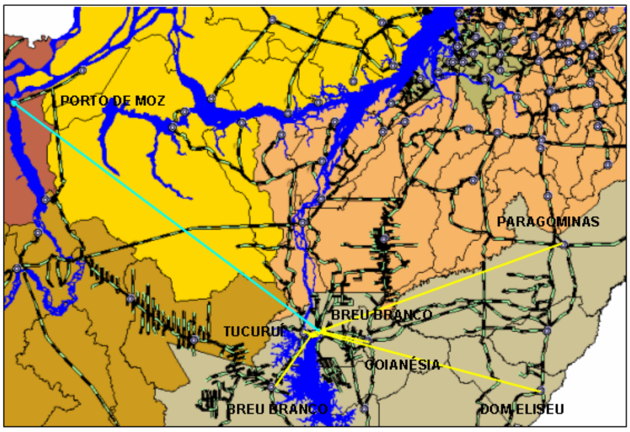

Figure 8 Breu Branco Route to Porto de Moz

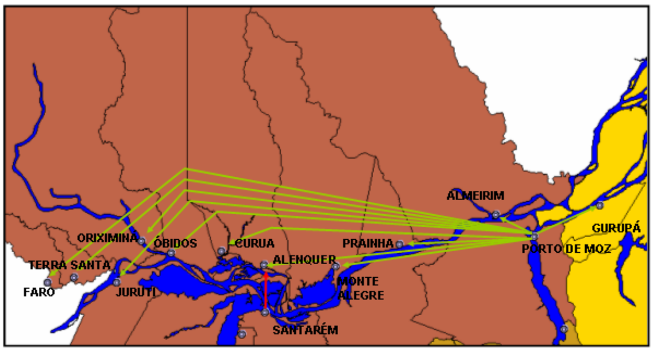

Figure 9 Porto de Moz to BaixoAmazonas isolated communities

Southeast:

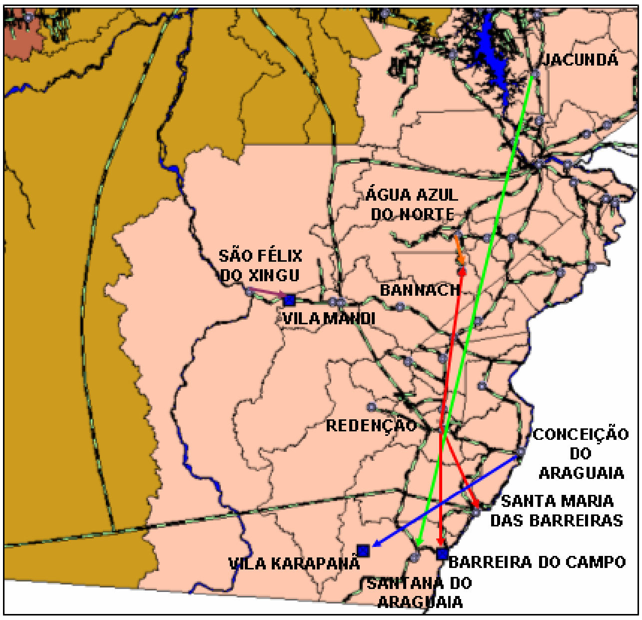

Figure 10 Route to Southeast´s isolated communities

Southwest:

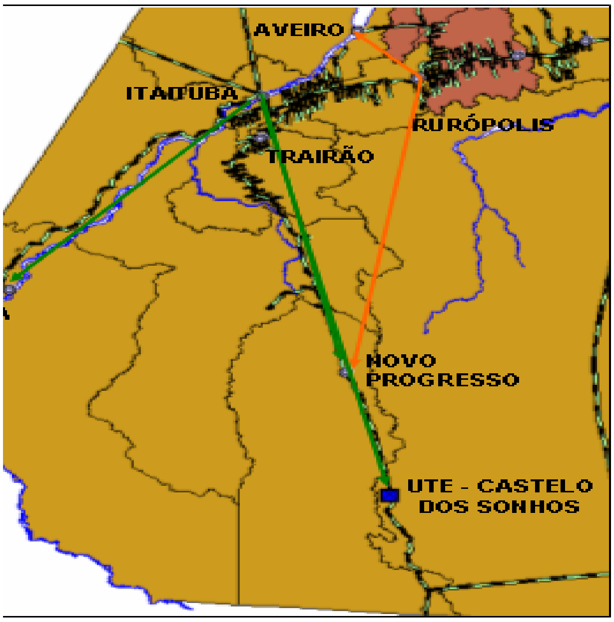

Figure 11 Route to Southwest´s isolated communities

Marajó:

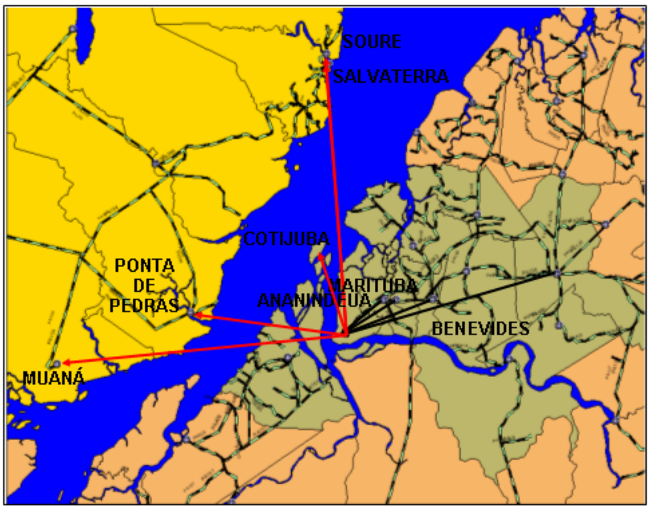

Figura 12 Belém to Marajó´s isolated communities

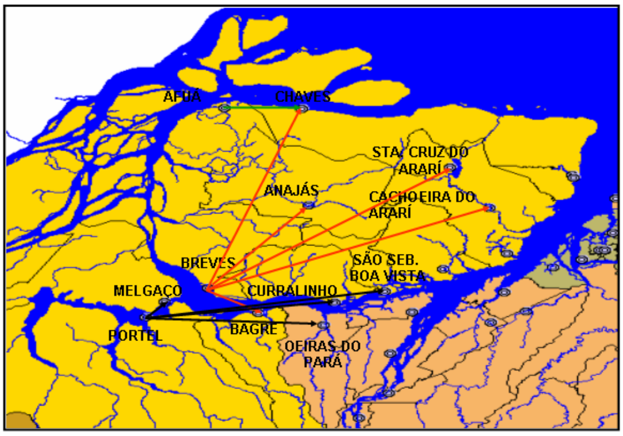

Figura 13 To Marajó´s isolated communities

7. CONCLUSIONS

Marajó Island in the Amazon River delta has the best possibility of using residues produced within the region since it would require little additional residue from other regions. Marajó has the potential to generate about 16,177 kW of electricity, and the municipalities in this region have a demand of about 24,073 kW. Another factor is that almost all transport in Marajó is by river, lowering the cost of residue transport. Since Marajó currently has the largest number of municipalities that are not linked to the state power grid and with poor prospects for future linkage, according to Rede Celpa, these findings are especially interesting.

Most of the potential for electrical generation from wood residues is in municipalities already linked to the state power grid. In some cases a surplus of residues can be distributed to isolated communities or used locally to produce electricity in order to reduce costs.

The implantation of thermoelectric generators powered by biomass (wood residues) can become economically feasible due to subsidies from programs such as “Carbon Credits” or from special financing from Brazilian governmental sources.

Since vapor powered plants have lower maintenance and operating costs in comparison with diesel powered units, such biomass powered plants can be successful in parts of Pará state where the continual supply of wood residues is assured and especially in places not connected with the power grid.

The rational use of this potential also solves the problem of how to dispose of wood residues from the lumber industry, as well as decreasing the consumption of diesel oil and the emission of CO_2 in the state.

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