Biomass Residues as Electricity Generation Source in Low HDI Regions of Brazil

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***Abstract* -- Currently, there are 1.3 billion people with no access to electricity worldwide. Almost 1 million of those are in the Brazilian Amazon region. Yet, electricity access to allow basic needs is not enough to ensure a sustainable development. Hence, it is important to understand linkages among poverty alleviation, energy access, and carbon footprint of future energy consumption patterns. The paper focuses on municipalities with the lowest HDI so as to increase energy access for households and for productive use since they are fundamental factors for income generation in poor regions. The study's objective was to analyze the use of biomass residues as electricity generation source for productive purposes among poor households in isolated areas of Brazil. The study's main contribution is to enable local sustainable development in low HDI regions of Brazil by using local biomass residues as primary energy source. This study is an outcome of the BREA and ECOPA projects.**

***Index Terms* -- Biomass, Environmental management, Renewable energy sources, Sustainable development, Waste management.**

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I. Nomenclature

CCC	Account of Fuel Consumption
DC	Developing Countries
HDI	Human Development Index
kWe	Kilowatt Electric
kWh	Kilowatt hour
LPG	Liquefied Petroleum Gas
LPT	Luz Para Todos (Lightning for All Program)
MSW	Municipal Solid Waste
MWe	Megawatt Electric
MWh	Megawatt hour
N	North
NE	Northeast
PV	Photovoltaic

II. Introduction

THERE are presently 1.3 billion people with no access to electricity worldwide and 2.7 billion people using traditional biomass for heating and cooking [1]. The definition of energy access usually includes both electricity access and access to modern fuels for cooking and heating to replace traditional biomass. However, only electricity access to allow basic needs is not enough for poverty alleviation and economic development. Besides residential use, the concept of energy for productive use (or energy services) is being considered an important and fundamental factor among others [1]. Increased access to energy allows economic growth and poverty alleviation [2]. This definition envisages clearly two steps: a first connection that solves the basic problems of lighting and the use of radio and TV; and a more ambitious step of using electricity for productive uses [3]. In this context, the Brazilian experience can be significant for other DCs since it addresses not only the electricity access for basic needs but also for the economic development of the region.

In Brazil, the LPT program on energy access allowed the country to reach more than 99% of the urban population with electricity access. It also showed that 50 kWh per month was sufficient to solve immediate problems of the families leaving in urban slums, such as lighting during evenings and powering radios and TVs. However, as soon as the consumers covered the basic needs, they start increasing the consumption by installing refrigerators and other electrical appliances [4].

This increment on energy consumption is actually the fundamental problem that the LPT program is facing in isolated areas, where PV systems correspond to the preferred option of electrification. A PV array for the production of 5 to 10 kWh per month is easy to install but as soon as consumption increases, either by residential consumption or productive process, the PV installation will not be enough by itself. Therefore, electricity supply using biomass residues is understood as a good option to implement and/or complement energy access in isolated areas of DCs whether PV systems are already installed or not.

Another important aspect is the fact that the lack of modern and affordable forms of energy affects agricultural and economic productivity, opportunities for income generation, and more generally the ability to improve living conditions. Moreover, low agricultural and economic productivity as well as diminished livelihood opportunities in turn result in malnourishment, low earnings, and no or little surplus cash. This contributes to the poor remaining poor, and consequently they cannot afford to pay for cleaner or improved forms of energy such as fuels and equipment. In this sense the problem of poverty in isolated areas remains closely intertwined with a lack of cleaner and affordable energy services.

Aiming at increasing electricity access in a sustainable way in these isolated areas, it is necessary to develop electricity access systems based in local energy sources like small hydro and biomass such as rural residues. Such systems would allow higher installed power, contributing to the development of economic activities.

III. Increasing Energy Access with Biomass Residues

Rural poverty and urban poverty differ on many levels, with distinctive issues that characterize quality of life. Yet, there are similarities since poverty usually entails deprivation, vulnerability and powerlessness. However, these issues are sometimes inflicted on certain individuals or groups more than others. For example, women and children are more likely to experience poverty more intensely than men and minorities tend to suffer more greatly than other groups [5].

There are more than 5,500 municipalities in Brazil, from which 2,512 have less than 10 thousand inhabitants. Remarkably, the municipalities with the lowest HDI and energy access rates are located in North and Northeast regions, where there are abundant and available biomass residues that could be used for energy generation. Hence, there is a significant opportunity not only for small-scale power generation but also jobs creation and income generation in these municipalities. In this context, 32 municipalities were selected. They are localities with very low HDI and their ranging between 0.418 and 0.499 [6]. They represent in which people who lack access to cleaner and affordable energy are often trapped in a re-enforcing cycle of deprivation, lower incomes and the means to improve their living conditions.

A. Very low HDI municipalities in Brazil

The number of people living in urban areas is smaller than the rural population within the selected municipalities. In average, they present 33% of population in urban areas and 67% in rural areas [7]. In average of monthly income per capita, 8,501 people or about 1% of the population within selected municipalities are living under the threshold of extreme poverty, which means that people is living with US$ 2 per day or less. However, only four out of 32 municipalities crossed the threshold of US$ 4 per day. They correspond to about 12% of the population within the selected municipalities. Although these populations are high above the extreme poverty line when compared with other selected municipalities, they cannot satisfy basic needs beyond food and has a limited capacity to pay. Clearly, these figures are a generalized illustration of local inequalities and do not translate fully the complexity of poverty but they ratify that selected municipalities are areas with the lowest living conditions or the poorest among the poor municipalities in Brazil.

Access to energy is considered an essential precondition for human development. This nexus is very clear on the macro scale such as the correlation between the HDI and primary energy consumption per capita [8]. A positive impact of energy access is the electricity supply, which can offer development options at the household level. Access to electricity is in practice indispensable for certain basic activities and cannot easily be replaced by other forms of energy. Therefore, electricity is an additional asset which offers end-users the option of new activities – such as productive activities – that were previously not possible. As well, it can foster productive activities already in place.

B. Local energy needs

Assuming the energy ladder from Coelho & Goldemberg (2013) and the rate of access to electricity in selected municipalities of Colombia and Brazil, it is possible to estimate the potential future demand to attend two distinctive phases [9]:

- First Phase: basic energy needs (i.e., lighting, cooking, and heating), which would demand about 50 up to 100 kWh per person per year. This demand can be supplied with PV systems and firewood.
- Second Phase: productive uses (i.e., water pumping, irrigation, agricultural processes, heating, and cooking), which would demand about 500 up to 1,000 kWh per person per year. In this case, Solar Home Systems, engines fed with Straight Vegetable Oil, small-scale biomass-gasifier, and LPG for cooking can supply the demand.

In this context, the potential increment on local electricity demand for covering basic needs is evaluated for each selected municipality, considering both the low electricity demand estimate for covering basic needs of 50 kWh per capita and the high electricity demand estimate for covering basic needs of 100 kWh per capita.

The same rationale is used to estimate the potential increment on local electricity demand for new productive activities for each selected municipality, considering the low electricity demand estimate for covering new productive activities of 500 kWh per capita and the high electricity demand estimate for covering new productive activities of 1,000 kWh per capita.

Table I summarizes the potential increment on the current local energy demand for covering the basic needs and for supplying new productive activities in the selected municipalities.

TABLE I
POTENTIAL INCREMENT ON LOCAL ELECTRICITY DEMAND IN MWH FOR COVERING FIRST AND SECOND PHASES IN THE SELECTED MUNICIPALITIES

Municipalities	First Phase		Second Phase	
	P50	P100	P500	P1000
JORDÃO	191	383	3289	6577
ATALAIA DO NORTE	297	593	7577	15153
ITAMARATI	124	247	4019	8038
SANTA ISABEL DO RIO NEGRO	431	862	9073	18146
IPIXUNA	373	747	11127	22254
SANTO ANTÔNIO DO IÇÁ	132	265	12241	24481
PAUINI	273	546	9083	18166
MARAÃ	87	174	8764	17528
UIRAMUTÃ	304	608	4188	8375
AMAJARI	242	483	4664	9327
MELGAÇO	446	892	12404	24808
CHAVES	393	787	10503	21005
BAGRE	425	851	11932	23864
CACHOEIRA DO PIRIÁ	454	909	13242	26484
PORTEL	736	1472	26086	52172
ANAJÁS	335	669	12380	24759
AFUÁ	522	1043	17521	35042
IPIXUNA DO PARÁ	581	1161	25655	51309
FERNANDO FALCÃO	54	108	4621	9241
MARAJÁ DO SENA	171	342	4026	8051
JENIPAPO DOS VIEIRAS	44	89	7720	15440
SATUBINHA	44	88	5995	11990
SÃO FRANCISCO DE ASSIS DO PIAUÍ	95	190	2784	5567
CAXINGÓ	32	65	2520	5039
BETÂNIA DO PIAUÍ	63	125	3008	6015
COCAL	135	269	13018	26036
COCAL DOS ALVES	21	43	2786	5572
ASSUNÇÃO DO PIAUÍ	12	24	3752	7503
MANARI	19	37	9042	18083
INHAPI	67	134	8949	17898
OLIVENÇA	3	6	5524	11047
ITAPICURU	117	233	16131	32261

C. *Assessment of Biomass Residues*

To improve the access to electricity especially in isolated areas, renewable energy technologies have been gaining ground in the last decade. Biomass residues correspond to a renewable, low carbon fuel that is already widely available throughout the isolated areas of the country and not adequately disposed. Its production and use also brings additional environmental and social benefits. Correctly managed, biomass (and biomass residues) is a sustainable fuel that can deliver a significant reduction in net carbon emissions when compared with fossil fuels. The most common source in the selected municipalities is agricultural residues, which can be divided into crop residues (e.g., husks, straw, peel, etc.) and animal residues (e.g., manure). Fig. 1 presents the share of agriculture residues in selected municipalities and Fig. 2 shows the share of animal residues.

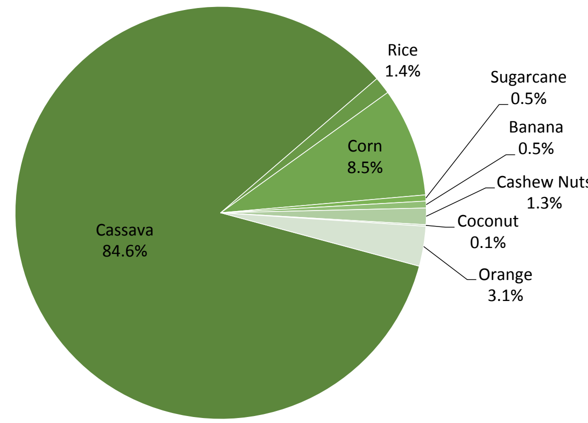

Fig. 1. Share of agriculture residues for selected municipalities

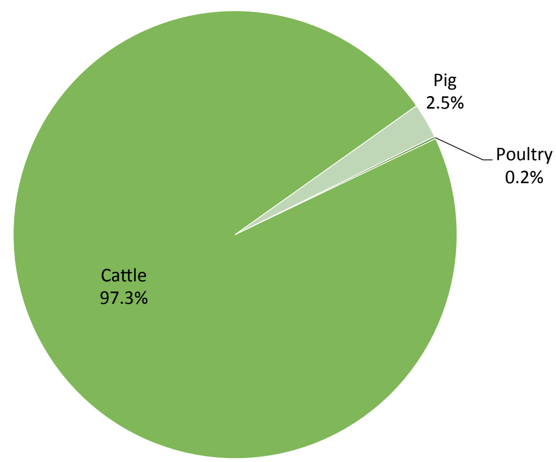

Fig. 2. Share of animal residues for selected municipalities

In this study, the amounts of residues available for energy production correspond to a theoretical potential [10-12]. This potential is calculated assuming that all waste is processed inside the municipal boundaries. For example, when conducting the estimative for cassava, the analyses assumed that 100% of root yield is used for flour production, entailing wastewater as output. This assumption should not be far from reality because cassava root "*in natura*" is toxic and should be processed for human and animal consumption. Urban Solid and Liquid (sewage) waste (the amount being collected) are also important bioenergy sources alongside wood residues and they were considered in estimative of the theoretical potential.

D. *Small scale biomass-conversion technologies*

In this section, a brief overview of the available technologies for biomass energy conversion is presented. Our study considered mainly those technologies adapted to produce energy below 1 MWe due to the scarce of energy demand and low biomass residues concentration[1] in the target areas. Furthermore, this study exclusively considers technologies with heat and electricity as final energy products, as already discussed. With these basic restrictions, the beast available technologies are showed in Table II.

TABLE II
BEST AVAILABLE TECHNOLOGIES FOR THE SELECTED MUNICIPALITIES

Technology Category	Biomass Conversion	Primary Energy Produced	Conversion and Recovery	Final Energy Products
Direct combustion	Boilers /Steam cycles	Heat, steam	Steam turbine Steam engine	Heat and Electricity
Gasification (atmospheric)	Downdraft, Fixed bed / engines	Syngas (Low Btu gas)	Spark engine	Heat and/or Electricity
	Fluidized bed / engines	Syngas (Low Btu gas)	Spark engine	Heat and Electricity
Anaerobic digestion	Biodigesters /biogas engines	Biogas (Medium Btu gas)	Spark ignition Combustion turbines	Heat and Electricity

Notes: 1. Steam cycles are commercially available in Brazil from 200 kWe; 2. Downdraft gasifier systems are indicated for up to 200 kWe; 3. Fluidized bed gasifiers are indicated for a wider range and are indicated also for urban residues; 4. Anaerobic digesters are indicated for organic residues

IV. EVALUATION OF THE THEORETICAL BIOENERGY POTENTIAL TO ATTEND THE LOCAL ENERGY DEMAND

The power demand was evaluated considering three different scenarios. Two scenarios use the rates of 50-100 kWh/person.year to supply the basic needs, as discussed previously. Scenario 1 considers the electricity supply during only 8 hours per day. Scenario 2 considers the electricity supply covering 12 hours per day and the Scenario 3 uses the rate of 500 kWh/person.year aiming at assuring energy for productive activities in the municipalities. This last scenario considers that electricity supply lasts for 24 hours per day.

The theoretical potentials were evaluated for each one of the residues and it was then reviewed for each type of technology, taking into account that it would be important to use in the same plant all the residues available for each technology so as to aim at benefiting from the project scale[2].

The main results of the assessment of theoretical potential of biomass residues electricity production in the selected lowest HDI municipalities in the North and Northeast regions of Brazil is presented in the Appendix. The check mark indicates that the theoretical potential meets the local demand.

Based on the results presented, it is important to make the following considerations, as ahead: biodigestion, combustion, and gasification.

A. Theoretical energy potential for organic residues through biodigestion

For this technology the following residues were taken into account

- Organic matter from MSW – considering that there would be a (mechanical or manual) separation of the MSW collected[3] and the organic portion would be fed into the biodigester to produce biogas that would feed an engine to produce electricity
- Liquid effluents – considering that the liquid effluents would have adequate treatment[4] and the biogas produced would feed an engine to produce electricity
- Agricultural and animal residues – considering that all residues (available and potentially available) to feed the biodigester.

The residues show that in some municipalities there may be a significant energy production from biogas, such as Cachoeira do Piria (banana residues), Chaves and Jenipapo dos Vieiras (cattle), Cocal and Cocal dos Alves (cashew nuts), Itapicuru (orange[5]).

B. Combustion and gasification

Solid residues from agricultural and wood residues were evaluated taking into account two options: combustion or gasification system.

The definition of the best technology (combustion or gasification) for each municipality depends upon a next analytical step, in which a field assessment addressed the location of the residues since the desk review could not find relevant information on this topic. Considering the dispersion of biomass residues and the amount available in each location, the more adequate technology was selected, as follow:

- For agricultural and wood residues availability able to produce up to 200 kWe, the technology recommended is a small-scale biomass gasification plant [13].
- For agricultural and wood residues availability able to produce values higher than 200 kWe, the technology recommended is steam cycles [13].

Therefore, the theoretical potential was evaluated for both technologies, taking into account the corresponding energy conversion factor based on existing systems already installed in Brazil and abroad.

Some municipalities have presented a high theoretical potential. For example, Ipixuna, Ipixuna do Pará, Melgaço, and Portel. These high values are due to the fact of residues from sawmills and existing forests.

In the cases of Melgaço and Portel these values are higher because of the wood residues potential based not only on

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[1] Only in a few municipalities there are perspectives of plants above 1 MW, as discussed ahead in this report.

[2] Gasification and combustion systems were analyzed and the potentials were estimated but the choice for each one depends on a further field assessment to realize what is the real availability of residues.

[3] Initially two scenarios were considered: the current situation where only partial collection of MSW is treated; the optimistic scenario where all the MSW would be collected and treated. In a second phase it was considered the first scenario as a conservative approach.

[4] Similarly to MSW, two scenarios were considered to sewage. The current situation, in which occurs partial collection of sewage that is treated. The optimistic scenario considers that all sewage would be collected and treated. In a second phase it was considered the first scenario as a conservative approach.

[5] The municipality of Itapicuru is already one of the biggest producers of orange production in the Bahia State. Due to its high production, there is a plan of installing an industry for orange processing (http://paginarural.com.br/noticias_detalhes).

residual potential of sawmills but also on the National Concession of Public Forests and the Central Area of Sawnwood[6].

The wood residues generated in the Sustainable Forest Management Plan could generate energy in small steam cycles (with a 12% yield [14]), producing approximately 253,000 MWh/year for the two municipalities. This would correspond to an installed power of 28 MW, without considering sawmill residues. It is important to mention that the municipalities of Amajari in Roraima State and Ipixuna do Pará in Pará State are located near the Central Area of Sawnwood, which is an area that can enhance the access to sawmill residues.

V. Concluding remarks

Clearly, the current electrification models for isolated areas do not provide any appropriate solutions to enhance electricity for productive uses. This is because there are no measures in place in any of the municipalities that enables it.

In this context, the main advantages of biomass residues energy conversion are related to emissions avoided from diesel engines the adequate use of residues and the increase in the energy access for production uses. However, there are still several barriers against the use of biomass residues in these municipalities.

The main barrier is the lack of funding not only for the implementation of the project but also for the adequate local capacity building to allow local people to work on it (operation and maintenance). Also, there is no adequate legislation to oblige the local utilities mainly in the Amazon region to change from diesel oil engines to biomass residues based systems (only for small hydro and biodiesel, which in most villages are not suitable).

Another major limitation in the country is the lack of adequate commercialized technology for energy conversion mainly for small volumes, typical of cities with populations of less than 50,000 inhabitants, technically considered small.

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Energy use of municipal waste is not present a scale to support a strategy of expanding electricity supply in the country or biofuel in the long run. In these places, where biogas generation may be implemented from the digestion of animal and urban waste, they are small scale-power systems (4 -100 kW) in adapted vehicle-engines. These adjustments result in a lower system cost, but also lower reliability and durability.

The related political barriers against biogas energy conversion are associated with lack of political incentives and the lack of prioritization for issues relating to sanitation in the country.

The lack of market incentive legislation and legal obligation to purchase electricity generated from renewable sources makes the utilities choose other options of energy supply. In this context, for decentralized energy systems from biogas, it is important to define public policies that integrate the sanitary waste treatment and energy utilization of biogas.
When it comes to wood residues, is estimated at 30 million tonnes annually that can be used for energy production. The main source is the timber industry, which contributes to 91% of waste generated. The Sustainable Forest Management Plan activities generate an amount of waste from removed trees during the execution of the necessary infrastructure. Nowadays, companies mainly use this waste as raw material for the steel industry (charcoal production),

In this context, the Federal Public Forest Concessions may be a possibility of changing the current situation, with the registration of approximately 313 million hectares, which concentrates (92.1%) in the Amazon region, where coincidentally is found the municipalities with the lowest HDI in the country that depend exclusively on CCC for the generation of electricity in the isolate areas of the country.

In short, a new model, in which local institutions and communities are better placed to share their knowledge, will be useful for the purpose of designing, implementing and operating effective off-grid solutions that can support not only the achievement of universal electricity access in isolate areas with low HDI but also help to identify synergies among electricity access and development initiatives. The role of the government at central and local levels will be decisive but needs to be complemented with contributions from other agents, especially the role of community based organizations in operationalizing the new rules.

[6] In fact, there is a large wooden residual potential from the sustainable management of forests in the Brazilian Amazon: 1 m^3 of wood removed for logging in Amazon generates up to 5 m^3 of wood (if considered only the National Concession of Public Forests). Big companies of the timber industry in the Amazon take advantage of this potential for sustainable charcoal production. Then, the surplus can be used to increase access to energy in communities with low HDI in the region. The municipalities of Portel and Melaço, located in the Pará State, that have HDI lower than 0.5, are situated in the Caxiuanã National Forest, which is a National Concession of Public Forests. Since the Federal Government in 2015 offered the concession of 322,000 hectares for a management plan, in which 184,000 hectares was approved for sustainable forest management that represents a potential to produce an average of 566,000 tonnes of wood residues per year.

VI. Appendix

Municipality	Power demand (kW)			Treatement Technology/Instaled power (kWe)									
	8h/day	12h/day	24h/day	Biodigestion			Combustion			or	Gasification		
				Instaled power 8h/day (kWe)	Instaled power 12h/day (kWe)	Instaled power 24h/day (kWe)	Instaled power 8h/day (kWe)	Instaled power 12h/day (kWe)	Instaled power 24h/day (kWe)		Instaled power 8h/day (kWe)	Instaled power 12h/day (kWe)	Instaled power 24h/day (kWe)
AFUÁ	627	1 253	2 089	✓ 747	✗ 498	✗ 249	✓ 2 986	✓ 1 990	✗ 995		✓ 4 976	✓ 3 317	✗ 1 659
AMAJARI	179	357	595	✓ 637	✓ 425	✗ 212	✓ 5 249	✓ 3 500	✓ 1 750		✓ 8 749	✓ 5 833	✓ 2 916
ANAJÁS	455	909	1 515	✗ 261	✗ 174	✗ 87	✓ 5 986	✓ 3 990	✓ 1 995		✓ 9 976	✓ 6 651	✓ 3 325
ASSUNÇÃO DO PIAUÍ	131	262	436	✓ 239	✗ 159	✗ 80	✗ -	✗ -	✗ -		✗ -	✗ -	✗ -
ATALAIA DO NORTE	294	588	980	✗ 149	✗ 99	✗ 50	✓ 853	✗ 569	✗ 284		✓ 1 421	✓ 948	✗ 474
BAGRE	457	913	1 522	✗ 153	✗ 102	✗ 51	✓ 1 347	✗ 898	✗ 449		✓ 2 245	✓ 1 496	✗ 748
BETÂNIA DO PIAUÍ	104	208	347	✓ 187	✗ 125	✗ 62	✗ 66	✗ 44	✗ 22		✓ 110	✗ 73	✗ 37
CACHOEIRA DO PIRIÁ	506	1 011	1 686	✓ 1 447	✗ 965	✗ 482	✗ 476	✗ 317	✗ 159		✓ 793	✗ 529	✗ 264
CAXINGÓ	89	179	298	✓ 175	✗ 117	✗ 58	✗ 77	✗ 52	✗ 26		✓ 129	✗ 86	✗ 43
CHAVES	377	754	1 257	✓ 1 287	✓ 858	✗ 429	✗ 116	✗ 77	✗ 39		✗ 194	✗ 129	✗ 65
COCAL	467	934	1 557	✓ 2 100	✓ 1 400	✗ 700	✗ 458	✗ 305	✗ 153		✓ 763	✗ 508	✗ 254
COCAL DOS ALVES	97	194	324	✓ 1 466	✓ 978	✓ 489	✓ 116	✗ 78	✗ 39		✓ 194	✗ 129	✗ 65
FERNANDO FALCÃO	168	335	558	✓ 414	✗ 276	✗ 138	✓ 217	✗ 145	✗ 72		✓ 362	✗ 242	✗ 121
INHAPI	317	634	1 057	✓ 598	✗ 399	✗ 199	✗ 19	✗ 13	✗ 6		✗ 32	✗ 21	✗ 11
IPIXUNA	317	634	1 057	✓ 410	✗ 273	✗ 137	✓ 16 206	✓ 10 804	✓ 5 402		✓ 27 010	✓ 18 007	✓ 9 003
IPIXUNA DO PARÁ	935	1 870	3 117	✓ 2 009	✗ 1 339	✗ 670	✓ 12 050	✓ 8 034	✓ 4 017	or	✓ 20 084	✓ 13 389	✓ 6 695
ITAMARATI	141	282	470	✓ 91	✗ 61	✗ 30	✓ 120	✗ 80	✗ 40		✓ 201	✗ 134	✗ 67
ITAPICURU	604	1 207	2 012	✓ 30 276	✓ 20 184	✓ 10 092	✗ 62	✗ 41	✗ 21		✗ 103	✗ 69	✗ 34
JENIPAPO DOS VIEIRAS	272	544	907	✓ 1 413	✓ 942	✗ 471	✗ 266	✗ 177	✗ 89		✓ 443	✗ 295	✗ 148
JORDÃO	122	245	408	✓ 155	✗ 103	✗ 52	✗ 95	✗ 63	✗ 32		✓ 158	✗ 106	✗ 53
MANARI	339	678	1 129	✓ 541	✗ 361	✗ 180	✗ 140	✗ 93	✗ 47		✗ 233	✗ 156	✗ 78
MARAÃ	314	627	1 045	✗ 155	✗ 103	✗ 52	✗ 143	✗ 95	✗ 48		✗ 238	✗ 159	✗ 79
MARAJÁ DO SENA	132	264	441	✓ 329	✗ 219	✗ 110	✓ 344	✗ 229	✗ 115		✓ 573	✓ 382	✗ 191
MELGAÇO	443	886	1 476	✗ 113	✗ 75	✗ 38	✓ 87 888	✓ 58 592	✓ 29 296		✓ 146 480	✓ 97 653	✓ 48 827
OLIVENÇA	199	397	662	✓ 542	✗ 361	✗ 181	✗ 8	✗ 5	✗ 3		✗ 2	✗ 1	✗ 1
PAUINI	328	656	1 093	✓ 469	✗ 313	✗ 156	✗ 74	✗ 49	✗ 25		✗ 123	✗ 82	✗ 41
PORTEL	961	1 921	3 202	✗ 619	✗ 413	✗ 206	✓ 161 212	✓ 107 475	✓ 53 737		✓ 268 686	✓ 179 124	✓ 89 562
SANTA ISABEL DO RIO NEGRO	359	719	1 198	✗ 205	✗ 137	✗ 68	✗ 1	✗ 1	✗ 0		✗ 1	✗ 1	✗ 0
SANTO ANTÔNIO DO IÇÁ	417	833	1 389	✗ 91	✗ 61	✗ 30	✗ 295	✗ 197	✗ 98		✓ 492	✗ 328	✗ 164
SÃO FRANCISCO DE ASSIS DO PIAUÍ	98	196	327	✓ 267	✗ 178	✗ 89	✗ 1	✗ 1	✗ 0		✗ 1	✗ 1	✗ 0
SATUBINHA	222	444	740	✓ 249	✗ 166	✗ 83	✗ 42	✗ 28	✗ 14		✗ 71	✗ 47	✗ 24
UIRAMUTÃ	156	313	521	✗ 152	✗ 102	✗ 51	✗ -	✗ -	✗ -		✗ -	✗ -	✗ -

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