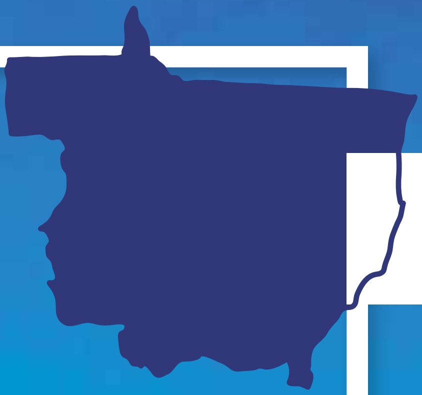

EVALUATION OF THE TECHNICAL AND ECONOMIC POTENTIALS OF GENERATION AND USE OF RENEWABLE ENERGIES IN MATO GROSSO

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EVALUATION OF THE **TECHNICAL AND ECONOMIC POTENTIALS OF GENERATION AND USE OF RENEWABLE ENERGIES** IN MATO GROSSO

AUGUST
2019

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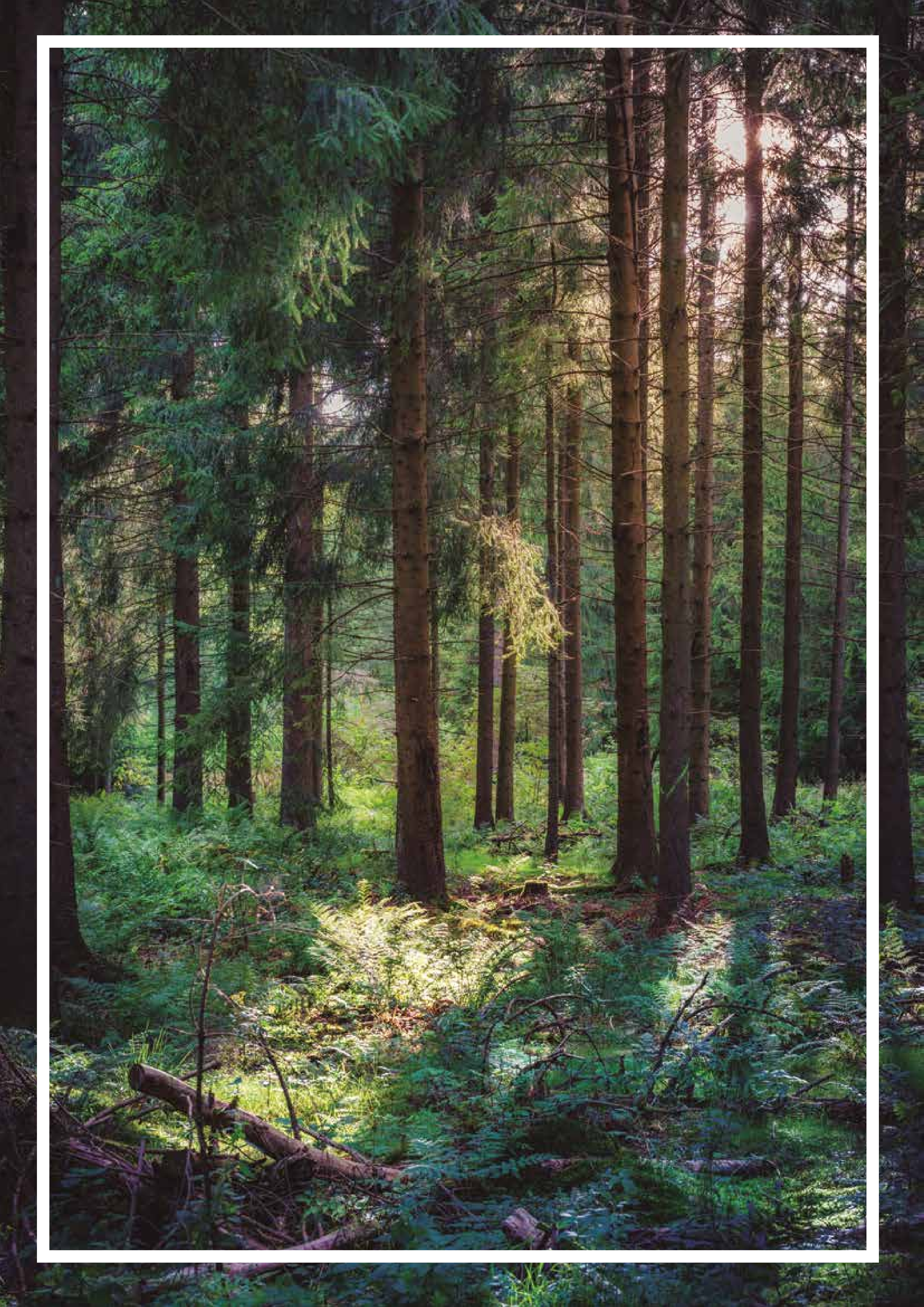

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ABBREVIATIONS

AGR — Average Growth Rate

ALM — Asset Liability Matching

ANEEL — National Electric Energy Agency

BFS — Brazilian Forest Service

CAPEX — Capital Expenditure

CEDESU — Center-West Development Superintendence

CIT — Corporate Income Tax

COP 21 — United Nations Conference on Climate Change in 2015 held in Paris, France

COSSF — Contribution to Social Security Financing

CoU — Consumer Unit (end user)

DG — Distributed Generation

Dm — Module Density

DSM — Demand side management

EARM — Stored Energy

EE — Energy Efficiency

ENERGISA — Distributor of Electric Power in Mato Grosso

EPE — Energy Research Company

FCA — Fuel Consumption Account

FCE — Free Contracting Environment

FCR — Regulated Contracting Environment

FIEMT — Federation of industries in the State of Mato Grosso

FINEP — Financier of Studies and Projects

FINISA — Financing for Infrastructure and Sanitation

FPart — Private Forests

FP — Physical Person

FPF — Federal Public Forests

GHG — Greenhouse Gases

GWh — Giga Watt hour

GWp — Giga Watt peak

IBGE — Brazilian Institute of Geography and Statistics

ICMS — Tax on the Circulation of Goods and Services

IDB — Inter-American Development Bank

IEA — International Energy Agency

IEI — International Energy Initiative

IPCC-AR4 — Intergovernmental Panel on Climate Change - Fourth Assessment Report

IRP — Integrated Resources Planning

Irr — Incident Irradiation

IRR — Internal Rate of Return

ISC — Infrastructure Services Commission

kWh — Kilo watt hour

kWp — Kilo Watt peak

LCOE — Levelized Cost of Electricity

LP — Legal Person

LPG — Liquefied petroleum gas

MME — Ministry of Mines and Energy

MT — Mato Grosso

NBESD — National Bank for Economic and Social Development

NCEP — National Council for Energy Policy

NCFP — National Council of Finance Policy

NIS — National Interconnected System

NORDESU — Northeast Development Superintendence

NZEB — Net Zero Energy Buildings

O&M — Operation and Maintenance

ONS — National Electrical System Operator

OPEX — Operational Expenditure

PESI — Sustainable Energy Industry Program

PIB — Gross Domestic Product

PIR — Integrated Resource Planning

PIS — social integration program

PME — Small and Medium Business

PPA — Permanent conservation Areas

PPP — Purchasing Power Parity

PR — Performance ratio

PRODEIC — Industrial and Commercial Development Program

PROINFA — Incentive Program for Alternative Energy Sources

PV — Photovoltaico

RD — Demand Response

RED — Distributed Energy Resource

REIDI — Special Incentive Regime for Infrastructure Development

RES — Renewable Energy Source

SCNI — Social Contribution on Net Income

SENAI — National Service of Industrial Learning

SHP — Small Hydropower Plant

SI — Isolated System

SPDSI — Support Program for the Technological Development of the Semiconductor Industry

SSM — Supply side management

SUDAM — Superintendence of the Development of the Amazon

tOE — Ton oil equivalent

TPG — Thermal Power Generation Plant

TUSD — Distribution System Usage Tariffs

TUST — Transmission System Use Tariffs

1 PREFACE

This report is part of the action concerning to the main theme “Renewable Energies” and the activities are entered in the local initiatives of Green Economy program of the United Nations to be implemented in the State of Mato Grosso. Between government commitments at COP 21, renewable energy and low-carbon emission are one of the major axes, one of the sustainable development goals, encouraging the employ of efficient technologies in the private and public companies, including with tax incentives. The region of Mato Grosso presents high energy potential, but yet little known under the technical and economic points of view, more detailed studies are needed that will be useful for the understanding, analysis and prospection of new renewable sources and which may compete and integrate the energy system of Mato Grosso and the National Interconnected System. Among the several sources, photovoltaic solar energy and biomass-based on forestry residues represent good alternatives for achieving these goals.

Located in the Center West of Brazil, the State has three biomes in its territory: forest, savanna and wetlands, where occur the sources of the three largest river basins of South America (Amazônica, Araguaia-Tocantins e Prata), which results in a high potential aquifer promote, also, its biodiversity. Since the beginning of the 2000, Mato Grosso has experienced changes in its energy profile, notably in the exploration of water resources, rising from a deficit state to a surplus in the production of electricity, but also strongly dependent on oil products in key sectors of its economy as agriculture and transportation.

A great advance in the state energy matrix occurs through the countless opportunities that exist in the Mato Grosso territory in terms of energy potential and that, if explored consciously and with good planning; you can bring greater benefits and balance to the supply and demand. Examples of the energy potential of biomass – mainly wastes from forest and agriculture activities, and the solar resource for photovoltaic and low temperature use, whose radiation is about twice the average intensity of Europe. The state’s energy demand is also characterized by increased use of renewable sources derived from biomass, cases of sugarcane bagasse, firewood and charcoal, among others. Between 2007 and 2017, the share of renewable sources increased at rates of 39.5% p.y. Regarding liquid biofuels, Mato Grosso produces ethanol from sugarcane and corn, in addition to Biodiesel, accounting for 4.5% and 23.0%, respectively, of the production national, with significant potential for expansion.

In this context, the State is one of the only ones able to be self-sufficient in energy in the country, except for the free and reciprocal transit of energy between the Brazilian states, according to the current regulated energy model, serving the nation as a whole, but ensuring the security of the local offer.

The objectives of this Report are to evaluate the potential for the generation and use of photovoltaic solar energy and biomass-based on forestry residues from wood in Mato Grosso, providing subsidies for public policies in this area, still incipient in the State, and allowing a more assertive energy planning with a view to more efficient resource allocation.

2 EXECUTIVE SUMMARY

01 The implementation of a **Green Economy Program** in the State of Mato Grosso could allow faster and more intense integration of **new renewable energies sources** in the local energy matrix. This Report shows the State **energy potential** considering sources as solar energy and biomass-based on forestry residues and discusses the possibilities of its feasibility, obstacles and barriers, as well as **technical and economic solutions and the benefits** derived from its appropriate utilization.

02 Mato Grosso is characterized for producing primary energy source only renewable, but, for the most part, hydraulic (37.0%). The matrix rest is constituted by the sugar cane products, with 40.0%, other sources (waste wood, rice husk, biodiesel, solar photovoltaics, biogas from agriculture and animal source), with 17.0% and firewood, with 6.0%. Particularly, the other sources, except biodiesel, not contribute, currently with more than 5% on state energy matrix. **Ascendant in the electricity production** the State provided a growth in electric power consumption of 5.0% per year over the past decade, notably by the residential sector. Other **secondary energy is the ethanol** that represents 27% of secondary energy total production. However, the **State remains dependent on petroleum products** such as Diesel oil, among them, leads the consumption with 79.0%.

03 According to ANEEL (2018a) data, **electric generation initiatives for solar source** make up, today, 1269 enterprises in all sectors of the economy, totaling an installed capacity of 19.9 MW between GD and centralised plants, with **tendency to significant increase**. The sources from forestry residues reach a 67.0 MW installed capacity across the North of Mato Grosso, with nine plants currently operating.

04 The report points out several critical points and obstacles to the full development of renewable solar photovoltaic and biomass-based in the State, as the **structural differences under intra-regiona**l economic and energy points of view and their unequal needs. In this context, it has been insufficient governmental and private initiatives aimed at the public interest for the **balanced development of a market for renewable energy in the State**

05

Deeper discussions about the **technical bottlenecks, limitations and barriers to the development of new renewable energy source**s as a way to assist in the understanding of the difficulties that can stop the **energy transition** in the State and that is already happening in the world. **The renewable sources price, the competition with other energy costs, interest rates for investments**, the technical limitations of distribution networks regarding the penetration of stochastic sources, regional infrastructure and municipalities poorer are factors that will only be overcome with **planning and effective public policies**. By identifying these factors as **strategic points for the transition state energy**, the work signals a priority that the State establish mechanisms, through documents updated in the energy area, compatible with the guidelines nationals, which can guide the actions to the **generation and proper use of its energy potential**.

06

Potential estimates for harnessing solar pointed to significant values in irradiation between 4,750 Wh/m². day and 5,570 Wh/m². day in the whole State. The economic potential of attainable market may reach 5.6 GWp on the horizon the year 2050 with full viability in several sectors of the economy, considered the demand growth scenarios, projections of the number of consumer households and potential number of consumers likely to adopt photovoltaic technology, tariff adjustments and the financial return by the net present value and the internal rate of return. The **potential of biomass from forestry residues was estimated for (1) the isolated systems (SI)** – which can replace Diesel generation and base and (2) to the **National interconnected system (SIN)** – electricity that can be produced by the residues of the industrialization of wood logs from planted forests, without risk of increase deforestation. For the first are estimated 539 GWh year-ten times the current Diesel generation; and in the SIN region, a generating capacity of approximately 26 GWh/year.

07

The prospects for the coming years of inserting new renewable sources represent **advancement and diversification in the energy matrix of Mato Grosso**, infrastructure gains, energy independence, and population autonomy to generate its own energy. The assessment is made under the technical point of view, economic-financial and regulatory systems, and dependent on national policies. However, it is necessary to propose a technological route for the State, enabling the ability to Mato Grosso, making its **greener energy matrix**. With potential well distributed in the territory, the **photovoltaics potential and forestry wastes constitute a geo-economic summit to be explored as a vocation**, with ability to decrease the weight of the economic reversal that falls still about these sources, measuring the social, economic, environmental benefits, and at the end of the day, more accurately assessing externalities

08

Energy expansion, with a transition that aim for the inclusion of new renewable sources, will be possible with measures benefiting the implementation of economic projects. Many initiatives of economic-financial solutions exist and should be improved and applied with greater intensity, benefiting the scale of projects involved

09

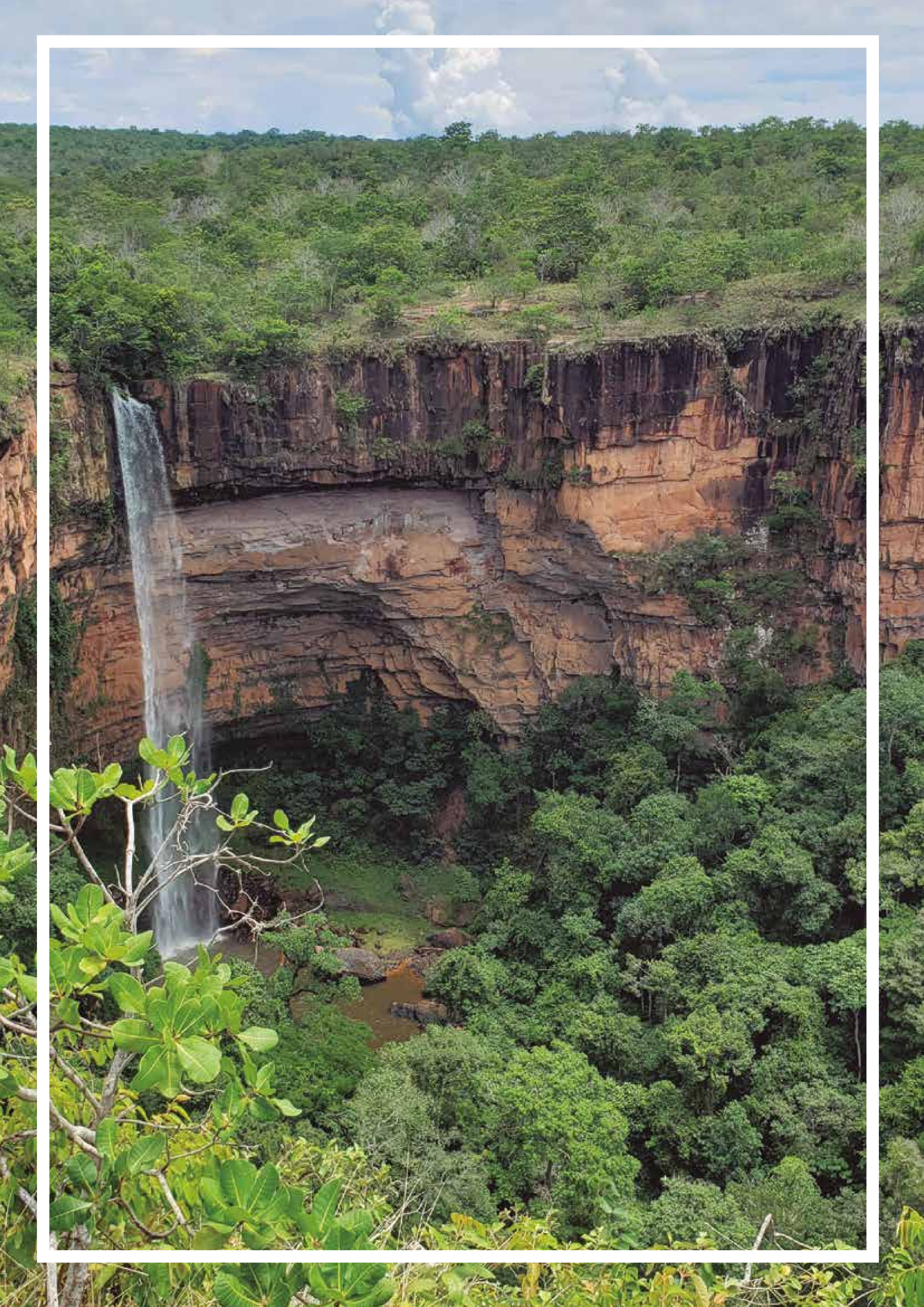
The increase of financial support lines and technological, in addition to increasing the fluidity of financial flows, increase the **penetration of new technologies**, promoting **meaningful impact on employability and comparative advantages in the global economy**. In this context, the Government has a decisive role for the **stimulus to small business** for activities in the area of energy and exploration of its potential.

10

Insertion results of renewable sources in the energy matrix bring, among other benefits, the **significant increase in the number of jobs**. In 2050 are estimated 7,886 posts linked to the implementation of projects in this sector of the Mato Grosso economy. Another benefit, in addition to the social and economic gains, is the **reduction of greenhouse gases**, avoided by the use of solar sources replacing the Diesel, with the horizon 2050, 1.5 million of tCO_2 in isolated systems of the State, whose current emissions are of 21.2 million tCO_2.

11

Through Government initiatives, business and society, we can **achieve the goals of the low carbon economy**, changing some paradigms of production and energy consumption. It is clear that there is room for implementing effective policies that increase the attractiveness of investments in this area. The efforts of this work show, plus the potential energy, a contribution to the discussion of the energy transition, with the use of renewable energy, proposing measures that will **support a robust plan for its development in Mato Grosso**.



3 GOALS

3.1 GENERAL GOALS

Evaluate the technical and economic potential of generation and use of renewable energies in Mato Grosso. To broaden the reach and knowledge about the State's energy potential in relation to solar sources and biomass-based of forestry residues, providing technical conditions to subsidize the formulation of public policies and support of a strategic plan of development of renewable energy in the state.

3.2 SPECIFIC GOALS

- Research for initiatives of solar and biomass energy generation existing in Mato Grosso;
- Devise a Strategic Plan for the development of Renewable Energy in the State of Mato Grosso;
- Launch the study results through a Workshop in the city of Cuiabá - MT, which includes: a) Public event to share the results and; b) Publication of the full study report in PDF format and a summary of the conclusions in English and Portuguese.

4 METHODOLOGY AND SCOPE

In-depth study and analysis with literature reviews, including all relevant available data and interviews with key stakeholders (including wood products factories - SME):

1. **Politics and public strategies existing in the State of Mato Grosso**

   Number of main ongoing initiatives identified for evaluation - Existing technical bottlenecks, limitations, insufficiency, observed failures - Number of existing strategies, intervention methods and relevance of the means used to reach these strategies - Number of power management plants implemented.

2. **Energy market research (offer and demand)**

   Number of kWh generated from renewable energy sources in Mato Grosso - Number of public and private institutions involved in solar power and energy biomass-based - Number of certificates, energy performance capability - Number of SME involved in the generation of solar power and biomass-based.

3. **Economic implementation of solutions**

   Systems, tools and technology according to the companies and needs for the implementation phase - Types of proposed funding tools or set consideration - Additional financial means available to support SME (technological and non-technological innovation) - Number of potential beneficiaries.

5 THE GENERATION AND USE OF RENEWABLE ENERGY IN MATO GROSSO

5.1 BRIEF SOCIOECONOMIC AND ENERGY CHARACTERIZATION OF THE STATE OF MATO GROSSO

With extensive and diverse territory, Mato Grosso presents economic, social and environmental challenges, so that no Government has so far managed to drastically reduce their regional differences that present significant contrasts: in population occupation, in transportation infrastructure, education, health and housing, with human development indexes completely distinct, varying between 0.654 (city of Porto Estrela located in the Pantanal biome) and 0.824 (city of Sorriso located in the Forest biome, with strong agriculture activity). **Figure 1** shows the administrative division of the State into mesoregions of planning established by Brazilian Institute of Geography and Statistics (IBGE, 2017).

Figure 1 Administrative division of the State of Mato Grosso in mesoregions established by IBGE.

Source: Adapted from (IBGE, 2017).

Table 1 shows how the state economy was distributed and developed among its five administrative mesoregions in the period from 2007 to 2017. There is strong economic growth of the north mesoregion in the period, at a rate of 5.0% p.y., representing, in 2017, 36.0% of the state's GDP. The southeast mesoregion doubled its GDP in this period and the south central mesoregion maintained a practically stable economic activity during the analyzed period, maintaining a participation of 29.0% in total. The northeast and southwest mesoregions, the poorest, represent, in 2017, both, 7.7% of the state GDP. This GDP composition denotes an unequally distributed economic activity in the territory of Mato Grosso between the three types of biomes, showing a tendency of stagnation in the Pantanal region (South Center meso) and a dynamic growing in the region of forest (North meso), given the advance of the population for the Amazon region and the increase of agriculture and industry.

Table 1 Regional GDP composition evolution in Mato Grosso in the period from 2007 to 2017. Unit: Millions R$ of 2007.

MESOREGION	YEAR										
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
South Center	12,502	13,924	14,753	16,039	16,490	18,135	18,714	20,581	19,780	21,643	22,375
Northeast	2,517	3,213	3,262	3,214	4,013	4,444	4,833	5,316	5,353	5,385	5,893
North	12,295	16,357	16,203	15,268	19,585	22,090	23,262	24,720	23,821	25,694	27,829
Southeast	7,349	9,214	9,295	9,467	10,777	11,276	12,100	12,663	12,380	13,722	14,396
Southwest	3,364	3,851	4,024	4,626	4,834	4,931	5,280	5,223	5,333	5,836	5,893
TOTAL	**38,028**	**46,559**	**47,538**	**48,614**	**55,699**	**60,876**	**64,189**	**68,503**	**66,668**	**72,281**	**76,385**

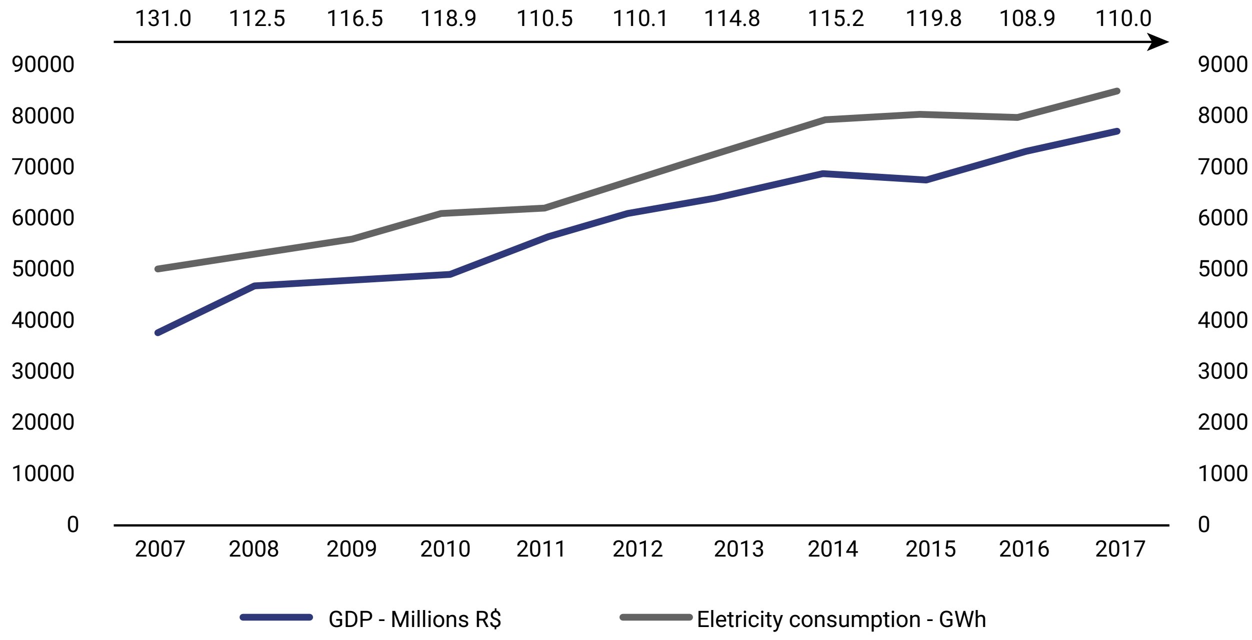
Source: (SEDEC, 2015).

Note: PPP GDP deflated the 2007 values.

The relation of economic growth versus increased demand for energy, does not necessarily imply direct relation (as more development more energy consumption), but depends on complex factors of economy, climate, energy resources etc. Figure 2 shows this relation to the State of Mato Grosso, between the GDP and electricity consumption (energy intensity), showing that the GDP grew at a rate of 5.8% p.y. in the analyzed period and the electricity consumption, 5.0% p.y. In these conditions the intensity energy fluctuated between 131 MWh/million R$ in 2007 and 110 MWh/million R$ in 2017, indicating a decrease of the order of 1.6% p.y.

There is, however, a tendency of stabilization of this energy intensity from the past two years, caused by the increase in the productive capacity efficiency of the State leading to economic expansion and growing GDP, without increasing exponentially the electricity consumption, as it points in **Figure 2**.

Figure 2 GDP evolution versus electricity consumption (value axis on the right) and Energy Intensity in the State of Mato Grosso in the period from 2007 to 2017. Units: Millions R$, GWh and GWh/Billion R$.

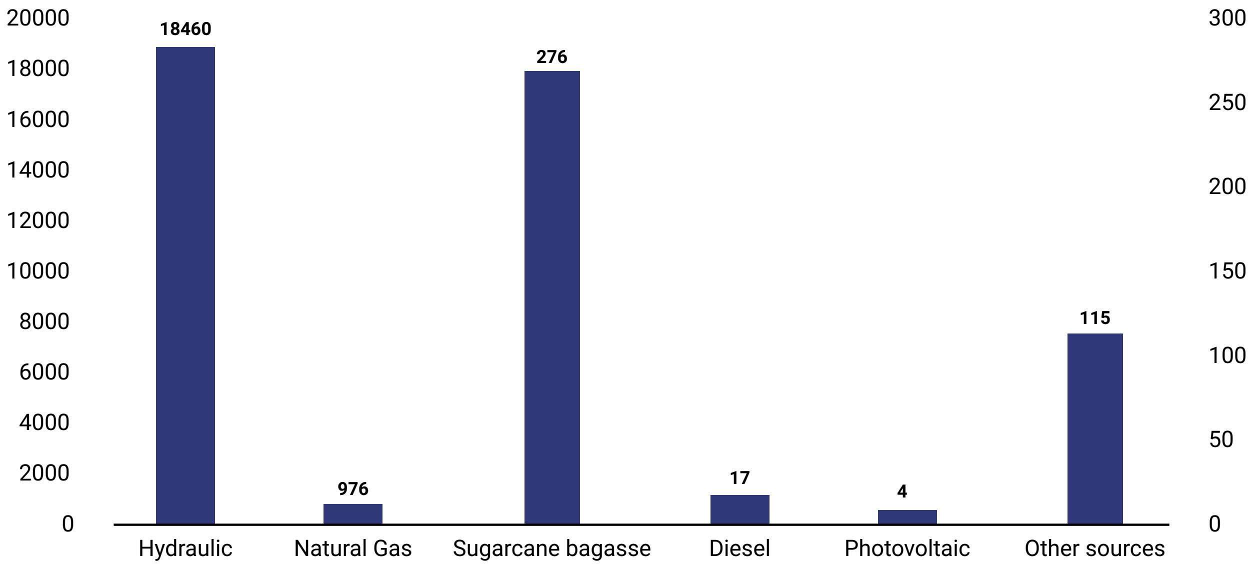


Source: (SEDEC, 2015).

Note: PPP GDP deflated the 2007 values.

With a strong predominance of hydraulic source - 93.0% of all production (**Figure 3**) the electrical generation have in other renewable sources a vague participation, such as sugarcane bagasse, wood waste, biogas and photovoltaic - these last three adding up only 0.6% currently. Among the non-renewable resources, it is noted that natural gas already represented 22.0% of electric generation in the State, in 2014, while there was supply of natural gas imported from Bolivia, and in 2017 participated with 4.9% due to import interruption.

Figure 3 Share of sources in electricity generation in Mato Grosso in the year 2017. Hydraulic and Natural Gas (left axis values). Unit: GWh.



5.2 MATO GROSSO ENERGY MATRIX CURRENT STATUS

5.2.1 Primary energy production

Mato Grosso is characterized for producing only primary energy of renewable source. The hydraulic power participation has increased over the past 11 years at a high rate of 11% p.y., as seen in **Table 2**, contributing with 36.6% of the energy matrix, behind only the sugarcane products, with 39.8%. The firewood comes from reducing its production, which, added to the production of other primary sources (wood residues, rice husks, biogas, and solar energy), accounts for 6.6%. Biodiesel production has increased strongly in the last three years of the series and presents the highest growth rate among the primary energy sources of the State.

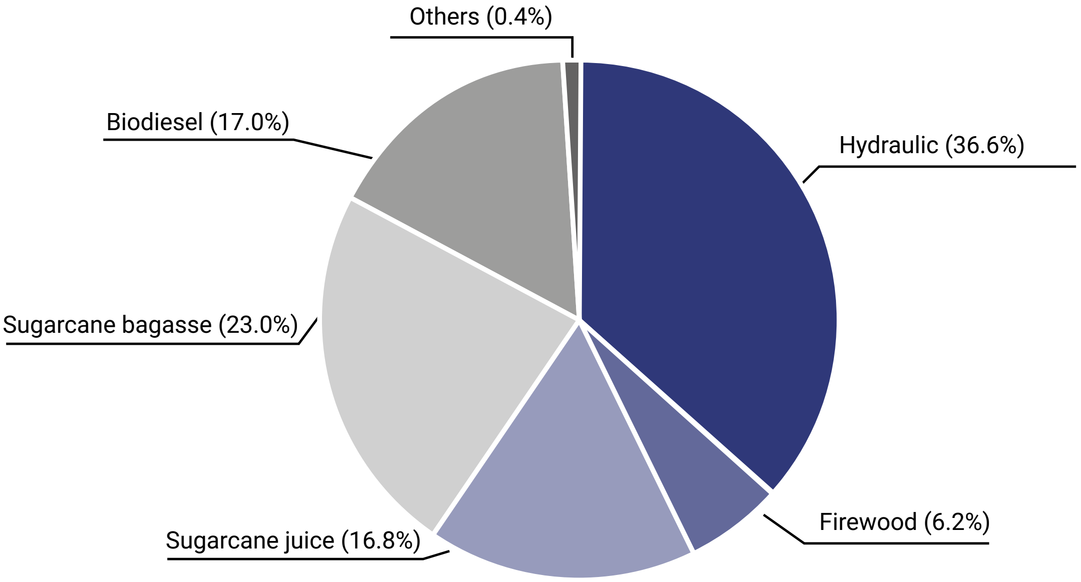
Table 2 Evolution of the sources's participation in the primary energy production of Mato Grosso, from 2007 to 2017. Unit: 10^3 tOE.

SOURCES	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	AGR (%)
Hydraulic	479	653	703	627	698	831	884	938	902	1,042	1,553	**11**
Firewood	279	277	283	418	352	317	307	243	271	256	263	**-0.5**
Sugarcane juice	652	704	646	578	529	716	751	754	760	724	714	**1**
Sugarcane bagasse	881	920	785	721	699	980	1,029	1,033	1,041	992	978	**1**
Biodiesel	10	242	311	450	396	378	331	484	670	648	724	**47**
Others (*)(1)	4			6	4	2	105	93	10	11	18	**16**
TOTAL	**2,304**	**2,795**	**2,728**	**2,799**	**2,677**	**3,224**	**3,408**	**3,544**	**3,655**	**3,673**	**4,250**	**6**

(*)(1) Forestry residues, biogas and photovoltaic energy.

Figure 4 highlights the current composition of the primary energy production in the State.

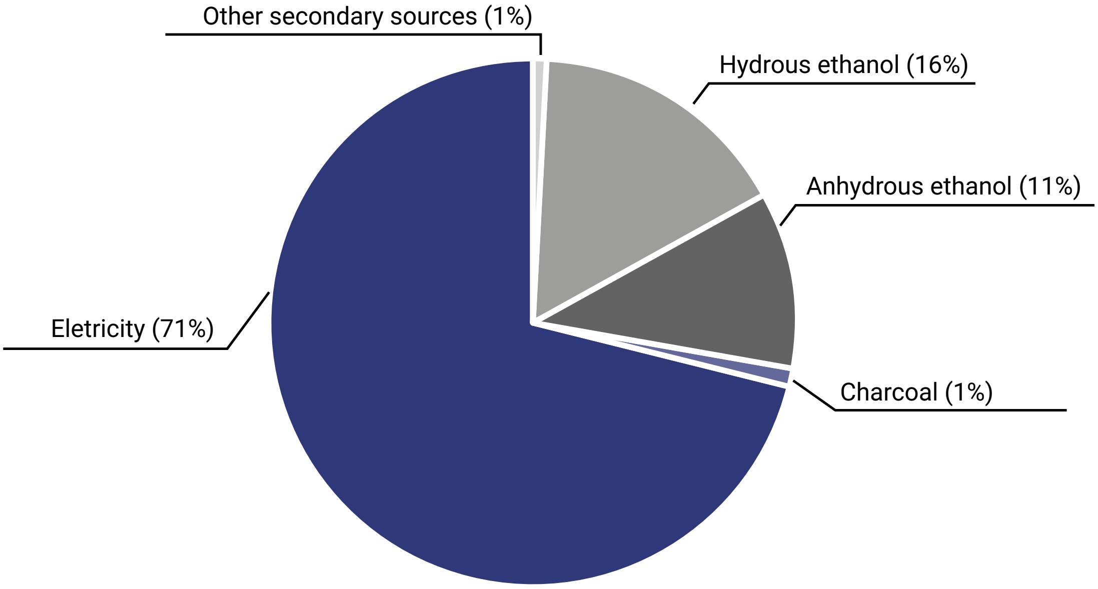
Figure 4 Figure 4. Current primary energy production composition in Mato Grosso in the year 2017.



5.2.2 Secondary energy production

Electricity is the main secondary energy produced, showing a high growth rate of 10.0% p.y., followed by ethanol production, which represented, in 2017, 27.0% of the secondary energy production in the State. Other secondary sources together, like rice husk briquettes, wood sawdust and pulverized charcoal, have been increasing production at a rate of 9.0% p.y., while charcoal production has been dropping 1.0% p.y. **Figure 5** shows the current composition of the sources participation in the State energy production secondary, stand out the electricity and sugarcane products.

Figure 5 Figure 5. Current secondary energy production composition in Mato Grosso in the year 2017.



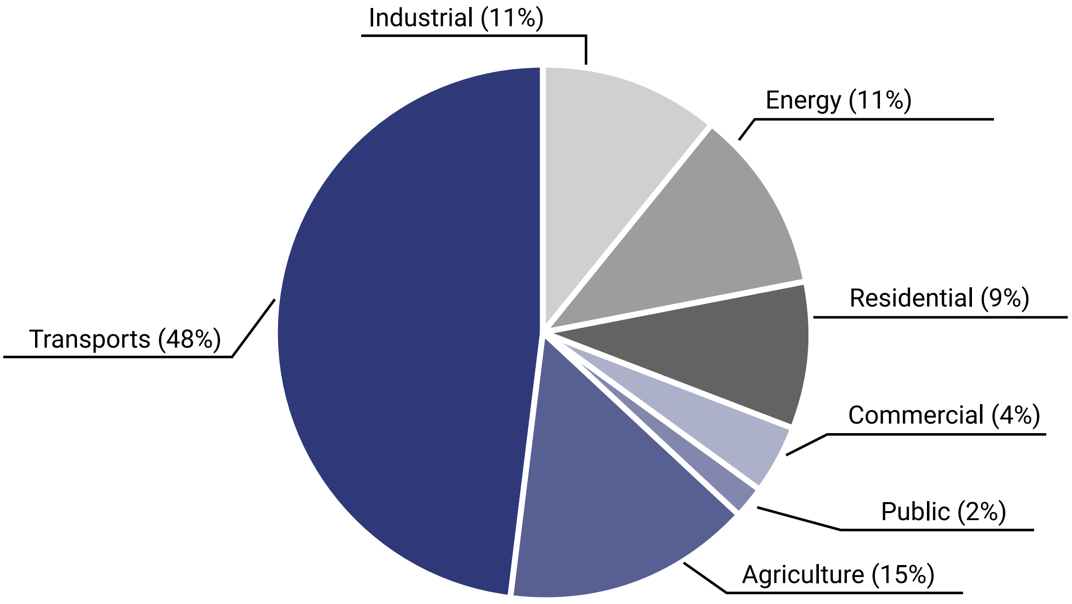
5.2.3 Energy demand

The State total energy demand has translated into increased use of renewable energy sources derived from biomass, cases of the firewood and the charcoal, among others; and including electricity, presents a growth rate of 4.0% p.y. in the period from 2007 to 2017.

5.2.4 Final energy consumption by sector

The sectorial consumption (**Figure 6**) shows that the transport sector, based heavily on the road modal, widely leads the energy demand of the State, accounting for 48.0% of total consumption in 2017. Highlight that the agriculture sector, with territorial and technological advance, emerges with second place with 15.0% of total State consumption, before occupied by industry. The commercial, public, energy and residential sectors continue to increase their share of total consumption.

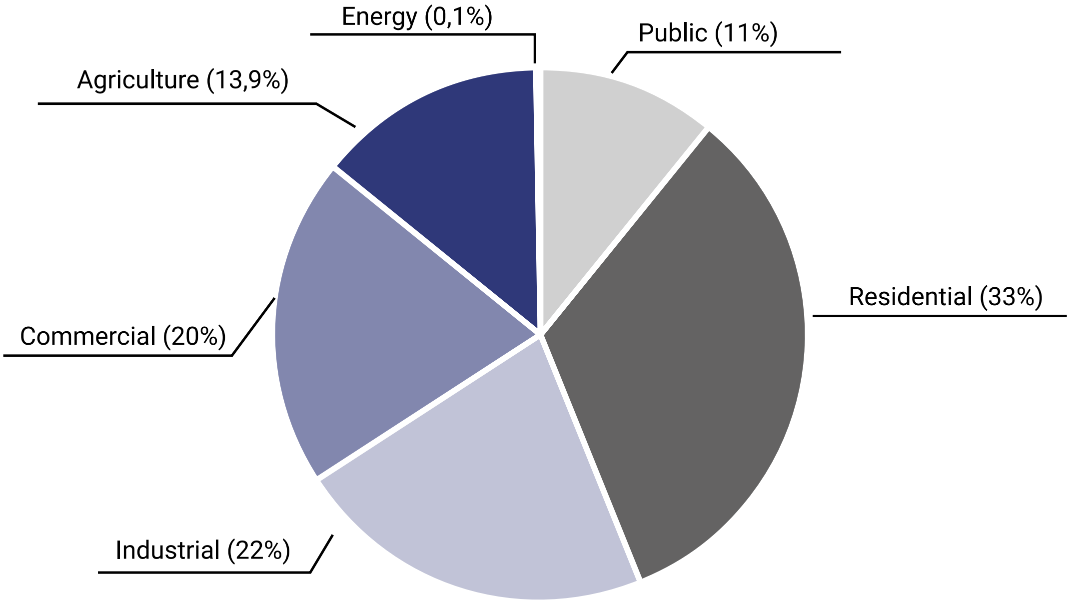
Figure 6 Sectorial share in final energy consumption in Mato Grosso in the year 2017.



5.2.5 Electricity consumption

In the year 2017, in terms of electricity consumption, the residential sector led with 2,733 GWh, followed by the industrial sector with 1,833 GWh and commercial, with 1,705 GWh. The agriculture sector consumed 1,192 GWh in this year followed by the public sector, with 933 GWh. **Figure 7** shows the composition of electricity sectorial consumption in the State in 2017.

Figure 7 Economy sectors participation in electricity consumption in the year 2017, in Mato Grosso.



5.2.6 Structure of final energy consumption by sources

5.2.6.1 Oil products

The oil products account for 55.0% of the energy consumed in the State, and the Diesel oil is the main fuel of this group, participating with 79.5% of total consumption among fossil fuels. The consumption of fuel oil has decreased over the last decade at the rate of 4.0% p.y. and gasoline consumption has increased significantly from 2010 to 2017 with a rate of 5.0% p.y., **Figure 8**. The LPG presented a soft increase in consumption throughout the series, maintaining an average participation of 5.0% in the state consumption. Aviation kerosene consumption showed a performance with average growth rate over the eleven years, 5.0% p.y.

5.2.6.2 Electricity

The electricity consumption grew along the historical series from 2007 to 2017 at a rate of 5.0% p.y., almost doubling the consumption of the year 2007. In 2017, the electricity represents 14.2% of all energy consumed in the State, **Figure 8**.

5.2.6.3 Natural gas

Natural gas is mainly destined to the transformation center for electricity generation and consumption of the transportation and industrial sectors in the south center mesoregion of the State. With irregular supply over the period, the supply of this energy has been decreasing drastically since the year of 2013 when 5 million m³ were consumed, falling to 955 thousand m³ in 2017. The average consumption between the years 2007 and 2017 is no more than 3 thousand tOE (tonnes of oil equivalent).

5.2.6.4 Biomass products

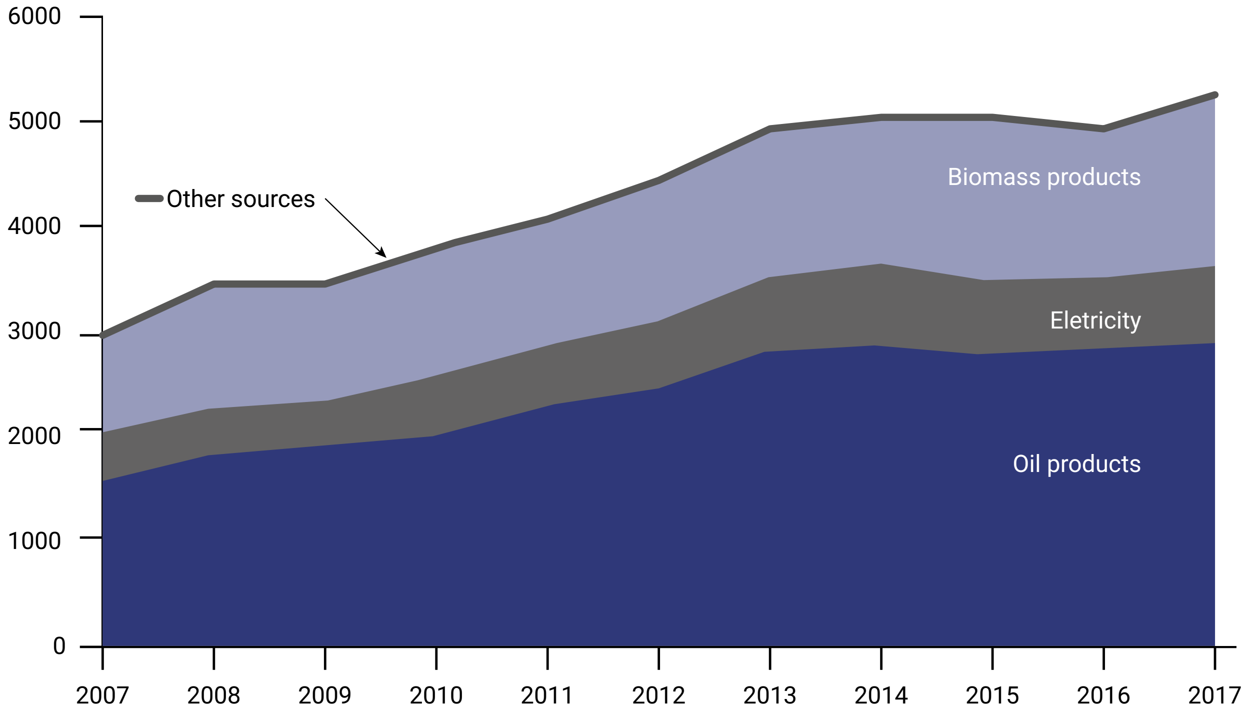
Between the products of Biomass, the firewood and charcoal represented, in 2017, 15.3% of energy consumed. The sugarcane products maintain leadership in the biomass group, constituting 74.0% of the energy consumed in the State, with emphasis on the hydrous ethanol consumption which, in historical series, grows at the average annual rate of 15.6% p.y. Sugarcane bagasse can be better utilized, presenting today an energy potential of 222 thousand tOE[1] that is not used. Biodiesel increased its consumption at a rate of 6.0% p.y., added to Diesel[2], participating with 11.0% of total biomass products consumed. The consumption of other sources such as wood waste, rice husk and pulverized charcoal, used for thermal purposes, has increasing its participation at the average rate of 1.8% p.y. between 2010 and 2017. The consumption of animal waste for biogas production from the year 2015 is highlighted. **Figure 8** shows the participation evolution of these products along the historical series.

---

[1] For sugarcane bagasse 1 tOE is equivalent to 4.7 tons of energy.

[2] Until February 2017 the addition of pure Biodiesel (B 100) to Diesel oil was 7.0%. From the month of March the addition already was 8.0% (ANP, 2018).

Figure 8 Evolution of final energy consumption by sources in Mato Grosso. Unit: 10^3 tOE.



5.3 ELECTRICITY PRODUCTION EXISTING INITIATIVES THROUGH RENEWABLE ENERGY SOURCES (RES)

5.3.1 Photovoltaic Solar

With the advent and reducing of cost of new generation technologies, and high prices of electric energy, the protagonism of photovoltaic energy has passed to compose the Mato Grosso energy matrix, even though it is still incipient, but showing signs clear of evolution. In all sectors of the economy, there are initiatives of investments in renewable sources, as shown in **Table 3**. A progressive increase is noticed in the residential sector that represents, today, 66.8% of the facilities followed by the commercial sector with 22.5%. A good part of these initiatives is the search result for cost reduction in electric power consumption, with high tariffs, as well as, in the commercial sector, a marketing through the exposure and commercialization of “green” products. Similarly, the industrial and public sectors have increased their participation in the installation of photovoltaic plants, adopting measures of sharing and strengthening the scientific and technological research with research centers and universities, promotion of awareness and education of the population about the use of renewable sources and adherence to national programs of reversal and adaptation to climate change. Together the two sectors make up 6.7% of existing plants. The agriculture sector accounts for 4.0% of the total plants in 2018.

Leader in commodities production, the agriculture sector has sought not to compromise its business on an international level, also investing in renewable sources, trying to fulfill its part in reducing GHG. Existing initiatives jumped 1600.0% between 2015 and 2018.

Table 3 DG photovoltaic plants number and centralized power plants, by economic sector in Mato Grosso, accumulated from 2015 to 2018.

SECTOR/ NUMBER OF PLANTS	2015	2016	2017	2018
Commercial	5	28	85	284
Industrial	1	9	27	76
Public power		1	3	10
Residential	7	84	278	845
Agriculture		4	16	51
Centralized Power Plants	1	1	1	3
TOTAL ANNUAL	**14**	**127**	**410**	**1269**

Source: Own elaboration using (ANEEL, 2018) data, 2018. Updated on 09/november/2018.

In the year 2018 the installed capacity is 19.9 MW, including centralized power plants. This penetration, which favors the expansion of State energy matrix, encourages distributed generation and has occurred mainly in the commercial and residential sectors, through small plants, with reduced production, representing these two sectors, 67.0% of total installed capacity, as shown **Figure 9**. **Annex 1**, presents the photovoltaic plants number, by sector, existing in Mato Grosso in the year 2018 with their respective powers installed. **Annex 2** shows the plants number by mesoregion and the respective generation modality and use of photovoltaic energy.

Figure 9 Photovoltaic installed capacity in the year 2018, in Mato Grosso. Unit: kWp.

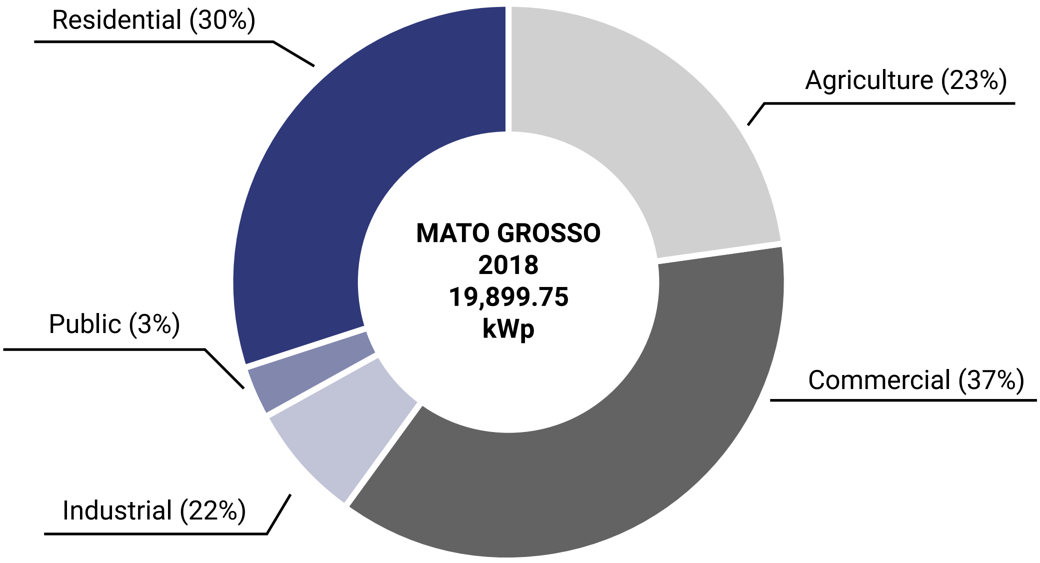


Table 4 presents the installed capacity evolution of photovoltaic generation by economy sector of Mato Grosso indicating strong growth in commercial and residential sectors, of the order of 5,443.0% and 14,602.0%, respectively, in the period from 2015 to 2018. There is also a vertiginous growth in the agriculture capacity of 4,900.0% in the last three years.

Table 4 Cumulative installed capacity of photovoltaic generation by economy sector in Mato Grosso, without the centralized power plants. Unit: kWp..

SECTOR	2015	2016	2017	2018
Commercial	99.7	502.4	1,988.5	7,271.7
Industrial	5.1	280.1	448.9	1,339.2
Public power		28.6	47.2	687.8
Residential	31.2	544.7	1,865.2	5,988.9
Agriculture		924.4	1,494.6	1,752.2
TOTAL ANNUAL	**136.0**	**2,280.2**	**5,844.4**	**17,039.8**

Source: (ANEEL, 2018b)

When analyzing the installed capacity in the year 2018 by mesoregion of the State, a very unequal distribution is observed, according to **Table 5**, in which the south center region had 35.0% of installed capacity, followed by the North region, with 34.0% and the Northeast with only 8.0%.

Table 5 Accumulated installed capacity of photovoltaic generation by mesoregion of Mato Grosso, by 2018. Unit: kWp.

SOURCE/MESOREGION	SOUTH CENTER	NORTHEAST	NORTH	SOUTHEAST	SOUTHWEST	TOTAL
Distributed Generation	5,680.1	1,339.6	6,600.4	1,510.2	1,909.5	**17,039.8**
Centralized Power Plants			2,860.0			**2,860.0**
TOTAL	**5,680.1**	**1,339.6**	**9,460.4**	**1,510.2**	**1,909.5**	**19,899.8**

Source: (ANEEL, 2018b).

In terms of electric power production, these sectors produced 5,645,161.1 kWh in the year 2018, an increase of 1,926.0% compared to the year 2015, as shown **Table 6.**

Table 6 Photovoltaic energy generated by economy sectors in Mato Grosso in the years 2015, 2016, 2017, and 2018. Unit: kWh.

SECTOR/YEAR	2015	2016	2017	2018
Agriculture	255,312.0	262,233.8	423,990.9	1,308,380.4
Industrial	1,446.8	79,464.4	127,369.5	379,915.6
Public power	-	8,113.3	13,389.7	195,115.1
Commercial	28,277.2	142,526.5	564,092.0	2,062,830.2
Residential	8,839.5	154,529.0	423,990.9	1,698,919.8
TOTAL	**293,875.5**	**646,867.0**	**1,552,833.0**	**5,645,161.1**

Source: (ANEEL, 2018b).

5.3.2 Biomass

5.3.2.1 Sugarcane bagasse

The sugarcane bagasse has been tapped for electric generation in three sugarcane-alcohol plants, as the **Table 7**, being the Itamarati, Alto Taquari, Caramuru Sorriso and the Barrálcool classified as Independent Power Producers and the Coprodia, Self-Producing of Energy[3]. The total installed power is 177.096 kW, accounting for 5,4% of the total installed electrical generating capacity of the State - 3,285 MW.

Table 7 Installed capacity of electricity production in sugar-alcohol plants in Mato Grosso.

PLANTS	INSTALLED POWER (KW)	CITY/MESOREGION	OWNER
Itamarati	37,500	Tangará da Serra/Southwest	Plant Itamarati S/A
Barrálcool	30,000	Barra do Bugres/Southwest	Plant Barrálcool S/A
Coprodia	27,200	Campo Novo do Parecis/North	Agriculture Cooperative of Sugarcane Producers of Campo Novo do Parecis LTD.
Alto Taquari	72,700	Alto Taquari	Brazilian Company of Renewable energies.
Caramuru Sorriso	9,696	Sorriso	Caramuru Foods LTD.
TOTAL	**177,096**	**-**	**-**

Source: (ANEEL, 2018b).

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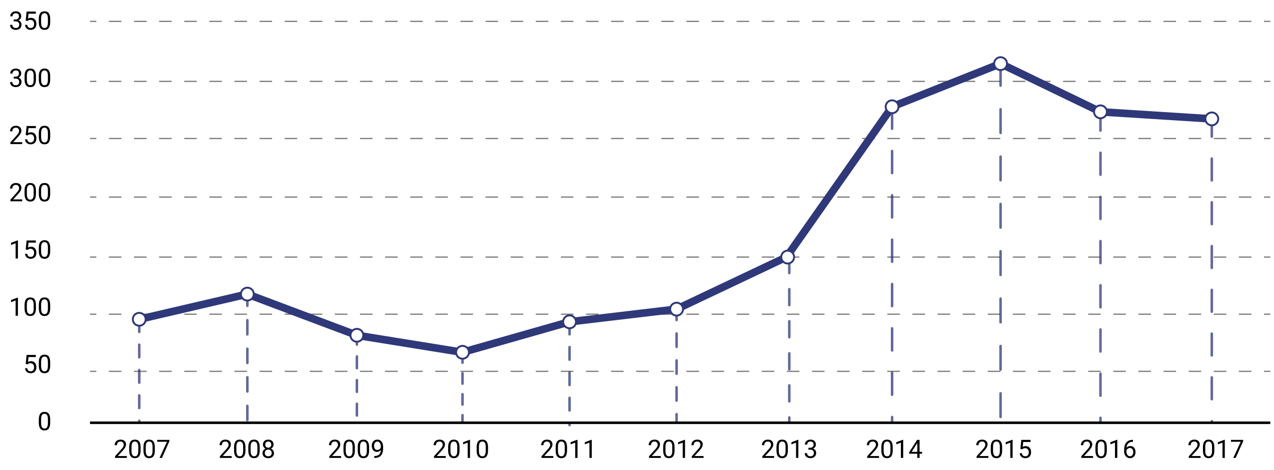
[3] Independent Power Plants – IPP traditionally are classified as SPE – Self-Producing of Energy.

The electricity generated by these plants in 2017 was of the order of 272 GWh (**Figure 10**), accounting for just 1.5% of the total electricity produced in the State. Underutilization of this input in all alcohol and sugar producing plants of the State leads to a waste of energy about 2,584 GWh/year, which would multiply by 25 the current production.

Figure 10 Electric generation evolution from sugarcane bagasse in Mato Grosso in the period from 2007 to 2017. Unit: GWh.



5.3.2.2 Biogas

Animal and agriculture waste

The biogas use produced from waste of animals (pigs) presents an installed capacity in 2018 of 4.263,5 kW, as **Table 8**.

Table 8 Installed capacity of thermoelectric biogas power plants, by 2018 in Mato Grosso.

CITY	SOURCE	INSTALLED POWER (kW)
Sorriso	Biogas - RA	780
Tapurah	Biogas - RA	1,560
Tapurah	Biogas-AGR	276
Vera	Blast Furnace Gas Biomass	276
Vera	Blast Furnace Gas Biomass	276
Sorriso - MT	Biogas-AGR	276
Sorriso - MT	Biogas - RA	67.5
Tapurah - MT	Biogas - RA	500
Santa Rita do Trivelato - MT	Biogas-AGR	252
TOTAL		**4,263.5**

Note: RA = animal waste; AGR = agriculture waste.

Forestry residues

Sources introduce from forestry residues began in the year 2010, reaching today a total installed power of 66,975 kW (**Table 9**).

Table 9 Installed capacity of thermoelectric biomass power plants from forestry residues, by 2018, in Mato Grosso.

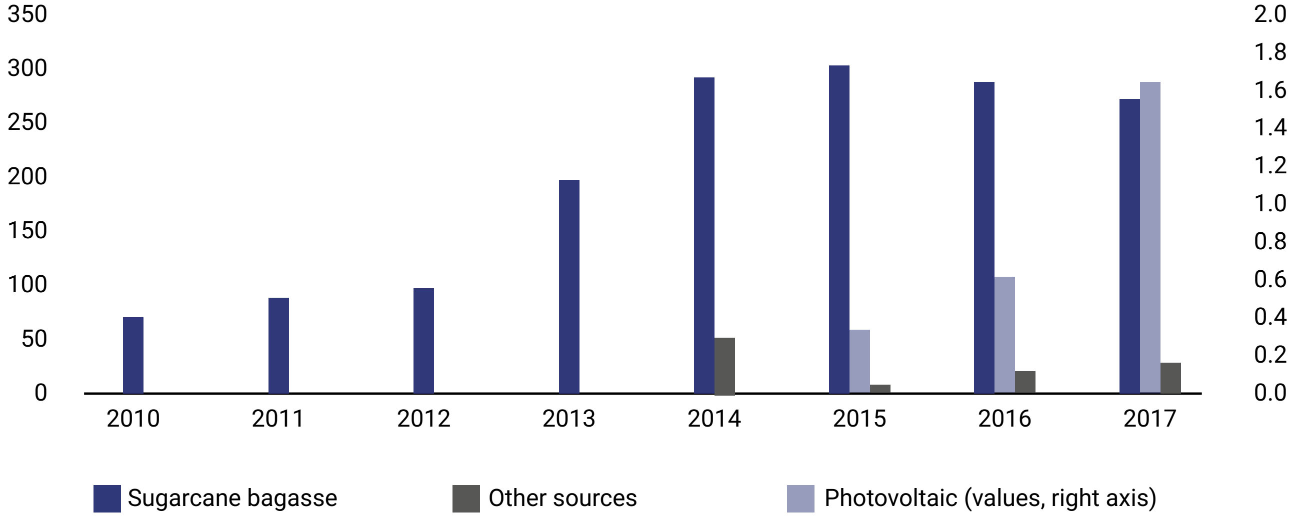
PLANT	CITY	POWER (kW)
Araguassu	Porto Alegre do Norte	1,200
Egídio	Juruena	2,000
Nortao	Aripuanã	1,275
Primavera do Leste	Primavera do Leste	8,000
Guaçu	Aripuanã	30,000
Conselvan	Aripuanã	1,500
Atos	Nova Bandeirantes	3,000
Martins	Colniza	2,000
F&S Agri Solutions	Lucas do Rio Verde	18,000
TOTAL		**66,975**

The companies in the wood industry chain presents an effective capacity of diversified production, with limitations and technical bottlenecks ranging from the age of equipment, technical competence to the structural difficulties for establishment of sawmills and beneficiation units. **Annex 3** show the relation of companies that operate in Mato Grosso in the year 2018.

Figure 11 compares the evolution of electricity production due to all renewable sources combined (photovoltaic, biogas and forestry residues), except hydraulics, in Mato Grosso. The participation of the solar source began more frequently in the year 2015.

Photovoltaic generation went from 0.294 GWh in 2015 to 1.658 GWh in 2017, an increment of 564 %. Combined with the production of sugarcane bagasse, other primary sources of electricity production have emerged over the past four years: thermoelectric biomass-based on forestry residues and biogas from animal wastes and agriculture.

Figure 11 Electricity production from solar and biomass-based sources in Mato Grosso from 2010 to 2017. Unit: GWh.



6 TECHNICAL BOTTLENECKS ANALYSIS, LIMITATIONS, BARRIERS, GENERATION DEVELOPMENT PERSPECTIVES AND USE OF ELECTRICITY FROM RENEWABLE ENERGY SOURCES (RES) IN THE MEDIUM AND LONG TERM

6.1 TECHNICAL BOTTLENECKS

Several of the technologies applicable to the electricity generation from biomass of woody wood waste do not yet have the necessary maturity of application in Brazil. The combined cycle technology "integrated gasification to a gas turbine" – combining gas turbines (Brayton cycle) along with steam turbine (Rankine cycle) – is used in cogeneration plants to increase the generation of electric power compared with the thermal power generation[4]. Biomass projects in Mato Grosso may present difficulties of commercial implementation related to the continuous supply of gasifier with raw material, the options of gasification and gas cleaning. Some elements must be filtered in order to use the gas produced in the gasification (such as tar, fly ashes, nitrogen oxides) without affecting the operation of the engine or turbine. Depending on the application, the systems for gas control and cleaning are technically feasible, but can be expensive to economically preclude projects (FERNANDES, 2000).

Direct or indirect storage issue of electricity and the energy management are also constituted in two technical bottlenecks. In many cases, the prosumer desire to meet their demand at peak times and the batteries backup system with electricity intelligent control must have capacity of at least 4 hours over the period.

Distribution networks modernization (digitization) is imperative to make them "smart" in order to incorporate and better manage so-called Distributed Energy Resources (RED) (IEI - BRASIL, 2018). RED include technologies that enable Distributed Generation (GD), the

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[4] Plants number that use this system of energy generation has increased considerably in recent years. Fuels used are sugarcane bagasse, coal – this due to its high calorific power and high availability and natural gas. Plants that use biomass as fuel have as difficulty the continuous use of biomass, due to the problem of storage and seasonality.

direct and indirect energy storage, energy conservation measures and load control (Energy Efficiency - EE and Demand Response - DR) and Electric Vehicles (EV) (IEI - BRASIL, 2018). This is an issue that affects the existing distribution networks uniqueness in the counties; many are precarious and must undergo restructuring.

In addition, with regard to the technological aspect, the main challenges are also present in the energy production process modernization and in the energy potential utilization efficiency of both the solar source and the biomass of forestry residues (woody wood). With the advent of new technologies of management forest should explore residual biomass from wood processing (lamination, beneficiation). It's a challenge the waste of raw materials removed from tropical forests transported to processing centers and consumers of wood, where is most of the beneficiaries. This causes some parts of the trees to be wasted, cutting off only the most noble part, considerably reducing the amount of wood taken to the beneficiation, and, thus generating less waste that could be used.

In wood producing municipalities, large volumes of forestry residues are deposited in the open sky, with no final destination, for lack of knowledge, absence of incentive programs and development of conscious practices for the use of waste, both for the purposes of producing thermal energy and for purposes of producing electricity.

Considering the State isolated regions, there is the technical bottleneck of innovation, configured in the risk associated with not only the pioneer of source, but also the innovative aspect and environmental effects in relation to where is the source of the woody biomass - the Amazon region (its topography, its biome). It's perceived by the electric power distributors in the North region, a preference for conventional Diesel generation, given their reliability (ANEEL, 2018b).

The theme of "water resources" has been extremely sensitive to energy planning. It is important for the thermoelectric power plants because, depending on the adopted cooling technology, there may be significant water consumption, which influences hydric availability for other uses. Consumption can be minimized in thermoelectric power plants through technologies of low cooling water consumption, waste reduction and reuse of water.

Another point to be observed is the generation of liquid effluents, which in the case of biomass plants are represented by the process water and the sanitary sewage. Process water launch and sanitary sewage without proper treatment can change the quality of soil and water and, consequently, interfere in biota as a whole, especially aquatic. In order to mitigate these impacts, the effluents must be treated and disposed of properly, respecting the limits imposed by the standards of environmental legislation release. In addition, the effluents released and the water quality of the receiving water body should be monitored.

Thus, the most attractive options should be evaluated both in environmental and socioeconomic criteria, but also technological, for adoption of projects that ensure the supply and expansion of electric energy offer, adapting to the needs and resources of each region involved.

In this regard, in the words of Lima and Camurça (2017) “the country has invested in recent years in researches in the areas of green technologies, however, because it is not a pioneer in this area, has faced certain difficulties related to the protection of property alien intellectual”. Thus, to the intangible property is not an obstacle to sustainable development, at the thought of Wachowicz (LIMA and CAMURÇA, 2017), “it is necessary to rethink their justification principles and so attribute it new legitimacy, being subject to the requirement of sustainable development”.

6.1.1 Others technical aspects regarding the RES introduction in distribution grids

RES introduction in the electric system of Mato Grosso has occurred without the necessary analysis of the issues related to the real participation of the concessionaire (only the prosumer costs for connecting to the network, for example, or generation credits), distributed generation and, fundamentally, in line with Energy Efficiency programs – another topic of dense study.

Recent works like Romeiro e Ferraz (2016) indicate that intermittent generation of RES adds to the systems high levels of variability and supply unpredictability. Conclude that with the RES insertion in the electrical system, requires greater flexibility of Generator Park towards an integration of these sources with the installed hydraulic and thermal block. Under these conditions, there must be greater availability of flexible elements (hydroelectric and thermal power plants dispatchable, with interconnection of regions and markets, demand response mechanisms and storage) with appropriate remuneration to allow more penetration of RES. Is a problem of “missing money” of quantitative character, related to the need for flexible resources, able to accommodate the greater variability of residual generation[5] (ROMEIRO and FERRAZ, 2016).

Photovoltaic generation injection growth can displace the load point, promoting operational alternative transmission methods, such as the use of flexible generation, including storage systems, increasing costs (SINGLETON, 2017).

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[5] The residual generator is the one capable of being flexible and guaranteeing the supply in sudden oscillations of the supply, or at times when the RES will not be available. Thus, the resource portfolio of supply must conform more to a list of attributes, with these characteristics (qualitative), than to the quantitative aspect.

The insertion of intermittent sources changes the operating strategy of conventional power plants that migrate from the “base” to operate in the “margin”, significantly increasing the costs. With implications in the distribution grids, the RES can produce negative effects such as: harmonics generation and variations of voltage and power quality degradation, instability, mismatches of protection schemes of maneuvers, in addition to the need for strengthening the distribution grid.

6.2 LIMITATIONS, BARRIERS AND DEVELOPMENT PROSPECTS

Mato Grosso experience has shown that private and government efforts and initiatives aimed at the public interest are insufficient when developing a balanced energy market, especially, with center point in a competition based on consideration of energy as public good and with competitive prices.

One of the biggest barriers to the public in the area of energy is the absence of the State in effective actions for the creation and promotion of incentive mechanisms and programs financing aimed at investments in renewable energy and energy efficiency. In this aspect, by not only financing lines, it is imperative to good quality in public intervention as responsible for determining the limits of actions that can to benefit all classes of consumers, without compromise the interests of the community or of the enterprises. Planning can formulate to support the application of public policies for this purpose.

Mato Grosso distinct mesoregions have divergent needs and different energetic potentials to be explored. In this regard, energy policies must be implemented in a disparate way, taking into account these differences, promoting, in addition to competitive energy systems, social objectives, environmental protection and investments with greater sustainability. Identify some shortcomings, which constitute barriers and limitations to the full development of solar and renewable energy biomass-based in the State as described below.

6.2.1 Subsidies barriers and competition with other sources

The competition, even if indirect with the hydraulic source, is a strong barrier and impact, through transaction costs – very high for RES -, on the decision to implement a photovoltaic or biomass based generation project. The exploration of the hydraulic potential, with lower costs, occurs in all regions of the State and strongly in the North region, where the biomass is increasing its production. The competition between the hydraulic, photovoltaic and biomass sources are at different levels in relation to information and data registered in the State, the investment and risk analyses, to the uses of areas of possible implementation of hydroelectric projects, and updated potentials.

The costs of solar and biomass sources, in most cases, are higher than those of conventional sources, whose current rules encourage them. According to the National Electric Energy Agency (ANEEL), there are some difficulties for power generation from biomass of forest origin related to the following aspects:

- CAPEX and Financing – higher investment cost in terms of R$/kW compared to conventional Diesel generation. With higher cost associated with the funding, the biomass generation incurs high cost of operation, although less than the Diesel generation and difficulty to prove ability to fuel supply.

- Opportunity cost of current generators – the current generators agents can take advantage of the existing Diesel generation facilities, making it difficult to replace this source for generating to biomass of forest origin.

- Implementation schedule – greater ease and speed in the implementation of Diesel generation in relation to generation from forest biomass.

PROINFA - Incentive Program for Alternative Sources of Electric Energy was created by the federal government through Law No. 10,438/2002 to increase the production of electricity by renewable wind sources, small hydropower plants and based on biomass. These generation projects must be carried out by agents that do not have corporate ties with generation, transmission or distribution concessionaires.

The difficulty to get financing on the part of government agencies, such as the National Bank for Economic and Social Development (BNDES), leads the private initiative to decide to invest for its own account in the implementation of production plants for self-consumption and sale of surplus energy to the public grid. However, the remuneration offered by the federal government program PROINFA serves as one of the factors to the discourage entrepreneurship.

A barrier to investments that can be made in the installation of generation plants is the amortization period that is usually long. Another obstacle is the tariffs that do not reflect marginal costs and energy subsidies have values set by government agencies. These constraints persist with the lack of a regulatory framework that will allow to equate the problem of high generation costs, high taxes (sic), and the forms of financing offered (SOCCOL, PEREIRA, et al., 2016).

Public acceptance – associated with the lack of knowledge and culture of unconventional sources[6] (or new renewable sources) - constitutes another difficulty for the promotion of RES. There is a strong public power limitation on the use of diffusion mechanisms and incentives to these sources. According to research conducted by Market Analysis (BRASIL, 2013); (SOCCOL, PEREIRA, et al., 2016) to assess the Brazilian consumer perceptions in relation to the distributed microgeneration "(…) 71% of respondents claim to know little or nothing about the proposal of regulated microgeneration (...), indicating a great ignorance of the population". According to Soccol et. al (2016) the characteristic of those who know (28%) follows the pattern of upper class, high schooling and older. This situation remains very clear in Mato Grosso.

6.2.2 Infrastructure and logistic barriers

Electrical networks expansion in smaller centers and its connection to power plants may present technical difficulties with electrical parameters and management. In the case of installation of photovoltaic plants distributed, there could be greater instability in the network, with a view to the issue of sources intermittency, besides generating a high degree of complexity in procedures and execution of maintenance, safety measures and system planning.

Regions with availability of biomass feedstock are often far from the energy producing plants and/or these present difficulties to connect to networks of transmission or distribution. Many regions of the State present very precarious road network, impeding or preventing an adequate transportation of machinery from plant to biomass.

6.2.3 Regarding the transport capacity restrictions of woody biomass

The woody biomass production costs consist of harvesting and transportation costs. It is known that transport costs are not spatially explicit, but are shaped using cost functions constant elasticity transport at regional level which they approach the short-term availability of woody biomass

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[6] The Brazilian electricity sector was, over time, mostly dominated by an energy monoculture, that is, the supply of electricity by hydroelectric dams. The disruption of this energy production form and the transition to new sources have been introduced through incentive programs and public policies that seek to diversify the energy matrix. In this context, due to the security and guarantee of supply through the known technology of the dams, there is a social reluctance, for most consumers, to use new sources of energy, in the case of a new modality in the technological field.

in each region (Lauri, et al., 2014)[7]. Under these conditions, the volume variation in time changes the average costs of transport, which, in the long term, become more important. Thus, for various regions of Mato Grosso, where access and movement are still obstacles, the woody biomass supply less short-term variable becomes viable with the construction of forest roads destined for the transport of waste, according to studies of (DYKSTRA and BINKLEY, 1987).

6.2.4 Barriers of technical training

Lack of technical training courses and programs of specific human resources directed to projects of photovoltaic and biomass sources, increasing the capacity to develop and accumulate "know-how" in Mato Grosso in the implementation of renewable energy projects.

The diffusion of renewable sources raises the concern about the service quality offered in the entire supply chain of equipment and installation, and requires, necessarily, qualified technicians for the execution of tasks. The qualification minimizes human errors, reduces deadlines and rework in projects, installations and commissioning and decreases costs. There is a shortage of skilled labor in Mato Grosso and the issue becomes all the more critical when it comes to installation, operation and maintenance in the State interior. The problems of adaptation, integration with the location and the costs of recruitment, selection and hiring of employees are greater the more distant are the sources.

The permanent presence of technicians trained on regions to deploy, install, operate and perform maintenance of RES offer more reliability to the consumer, reducing operation and maintenance costs.

6.2.5 Strategy limitations for the development of RES

There are no government agencies prepared to monitor and guide the regional energy planning. The performance of public committees and organs of State Government must accomplish these tasks, even if there are national MME guidelines through Energy Research Company - EPE. The characterization of resources and implementation of fonts in all regions of the State have been made, mostly by the private sector, taking into account the geographical scope of interest. The attributes of resource analysis of offer shall be conducted by the public entity when it comes to balance supply and demand of electricity. State each region offers an insight of the resource differently, considering all the attributes (technical, environmental, geographic, socioeconomic, political, infrastructure), as there are different perspectives of its application and its use. If it is not like that, there are possibilities

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[7] Transport costs include costs of access and movement of woody biomass from forests or plantations to domestic production units such as sawmills, cellulose mills and power plants. The transport costs are based on recursive regional cost-elasticity functions, which are parameterized by volumes collected in the previous period and average costs of forest transportation to power plants.

for inadequate allocation of resources, inappropriate technologies investment, high costs of externalities and generation, risk maximization, including project feasibility before authorities environmental, absence or low consumer participation.

From the point of view of regional energy planning, and the balanced and homogeneous development among State different regions, feature selection of offer should give priority to local characteristics. Existing renewables attributes and demand scenarios should consider, in addition to socioeconomic factors, usage habits, environmental preservation, social costs, full costs, energy efficiency and resource conservation.

The lack of knowledge about the adequacy of an energetic resource to meet the needs of a region or a group of consumers is the lack result of precise evaluation of the repressed demands of each region. This evaluation should be carried out, as far as possible, at the level of final uses, thus avoiding waste and costly and unnecessary costs in the implantation of plants and networks. This is especially important in isolated regions of Mato Grosso, away from the transmission and/or distribution, or with small networks or have a power shortage.

There is no concentration of efforts, so far, to implement an energy supply and demand that increases the participation, in the medium and long term, solar and biomass supply in the State. There is a need to work with related plans to offer about the demand structure; to know in detail the consumer market characteristics (technologies, consumer habits, etc.) as the electrical system characteristics in operation and its prospects for expansion (Jannuzzi & Swisher, 1997) in line with the plans of regional development. The expansion by RES, properly implemented, responds to a strategy of increasing capacity on the demand growth that considers energy efficiency, decentralized sources and more environmental benefits (Jannuzzi G. d., 2000).

Lack of development plans RES combined with water resources and environmental plans, considerably reducing conflicts and impacts. This means that it must focus on technological options of RES more attractive from an environmental point of view, economic, social benefits, compared with traditional offer options, especially those which exploit water resources in Mato Grosso. In this way, the privilege of RES on hydraulic sources in consideration of which the latter use for minimal cost of offer, while the RES is part of a wider range of options including environmental costs, social costs and “cleaner” technology. The difficulty lies in the lack of regional energy planning and regulation of incentives to drive the market towards the renewable energy technologies more efficient and less polluting.

The current model of electric power auctions in Brazil presents process improvements to meet the term demand and future market, but not sufficient to establish the importance of feasible timelines that create conditions of competition for the renewable sources. This includes a schedule compatible with the volume of services and works required for the implementation and operation of enterprises: rights, licenses, authorizations, projects, studies, drawings, plants and documents, books and tax registrations, in addition to material assets, land, logistics studies, equipment, civil buildings and other facilities, which constitute a substantial part of the collection necessary and/or appropriate to the enterprise deployment (EPE, 2018a).

One of the factors that contributes to low insertion of renewable sources, notably biomass -based on forestry residues, is related to the absence of potential data, offer of supplies and studies relating to socio-economic and environmental impacts and concerning interference with anthropic activities, and a good energy planning regionalized. In this area, there are no answers from the Government as to whether the spatial concentration of economic activity or resource use is sustainable because of local differences, resources existence, symmetries, of interactions between economies, the transport, mobility, environment treatment, exploitation and consumption of resources, politics etc. (Dorileo, 2009). For a good planning of energy resources, the database should cover groups of updated information of regional infrastructure, local development engines elements in the region, political data, and natural resources, resources from the supply sides and demand and water, which, along with the other socioeconomic and environmental information will assist in the determination of energy skills in the region.

For photovoltaic systems, there are still no business models, from concessionaires or leasing companies, in which companies renting equipment or offer financing with reduced rates for those who do not have economic conditions of afford the expensive costs of installation and project corresponding to the high initial investments. Added to this limitation is the fact that the consumer bears all the costs of connection to the electric network.

For the photovoltaic source, the current subsidy system is perverse: smaller consumers with lower incomes tend to subsidize larger consumers. Given the cost of installing solar panels, those with higher purchasing power can install the solar plate on the roof and generate their own energy. Those who do not have the purchasing capacity to buy these panels continue to buy power from the distributor and pay the subsidies included in the tariff. The current arrangement is unsustainable (BRASIL, 2017).

Sales of surplus power from photovoltaic sources (intermittent) may involve regulatory risks if there are government incentives. While there are some tools to manage surplus production (for example, inverters, storage or consumption management), this usually involves a degree of demand (commercial) risk, as this renewable energy source (solar) remains variable.

The spread of distributed generation incurs increased operating costs and the need for new investments in electrical systems, due to the complexity introduced – to the system dynamic equilibrium, pre-established levels quality maintenance (voltage and frequency) and reliability of supply, which will lead to a reduction of revenue. In order to mitigate the complexities of planning and electrical system operation, also because of the significant increase in connections to the network with distributed generation units, there is a need for the definition of public policies that favor obtaining of financing and flexibly regulations in force, in order to facilitate the distributors activities in the new scenario (BRASIL, 2017).

Remains the problem about the concessionaire role in the realization of the generator site connection with the power network. In the case of an independent consumer, the energy distributor may only be a carrier not purchaser of the energy that is injected into the network (MARTINS, 2015).

The lack of clear policies in this area can cause problems due to the increase in DG facilities. The distributors' utilization factor can be reduced, if not suggested any economic policy, with a possible increase in the average price of electric energy supply, compensating for deficits in the generators accounts, transmitters and distributors, affected by the increase in the number of micro generations.

The volatility of electricity generation from photovoltaic plants causes uncertainty in prices and adds new risks to the energy market, although it reduces cost due to low marginal costs of operation these sources (CPFL, 2015).

The lack of performance establishment standards and labeling is determinant for the non-penetration of efficient equipment and services in the market. This prevents a more assertive decision-maker of investors who make the investment in a particular technology when the international market already has a high penetration curve.

In isolated regions, where the exploitation of wood, typically the population biggest part has modest life and can't afford the real costs of energy tariff produced by alternative sources, yet. Possibly these sources would receive or might require government subsidies to reverse this situation, increasing the values transacted in the electric sector in terms of tariff charges.

6.3 INTERVENTION METHODS AND PROSPECTS FOR THE RES DEVELOPMENT

According to the IPCC-AR4, mitigation of greenhouse gas emissions is necessary, including the incorporation of sustainable development models (LIMA and CAMURÇA, 2017). In the context of planning the adoption of renewable energy sources assists, in many ways, the major emissions mitigation measures to stabilize greenhouse gas concentrations. However, we still have a long way to go to achieve the necessary conditions to maintain an energy matrix capable of truly sustaining a green economy. The public and private roles are crucial in order to ensure that the demand for these sources, effective planning system, combining renewable generation expansion plan from other sources, in investment in infrastructure suitable for connection and operation and to generate adequate financing conditions, including the participation of private sector financing agents (NOGUEIRA, 2011).

According to the national planning agency, the EPE (2016), “the question of renovation and change of urban infrastructure also indicates a higher degree of decentralization of energy systems. Increasingly integrated buildings, following concepts of ZEB (Zero Energy Buildings) or NZEB (Net Zero Energy Buildings), indicate a high degree of efficiency and great penetration of distributed generation technologies “. In this perspective, “the penetration of other mobility technologies, such as electric vehicles, also increases the degree of decentralization, by introducing storage elements in the way distributed system”, says the agency.

As a result, the modernization of electric power networks is inevitable; the largest introduction of communication technologies will also be necessary and will allow better management of resources, in a trend line to Smart grids.

6.3.1 Management and energy efficiency

The management (of quality and consumption) of energy with appropriate instrumentation is one of the tools to operate in all the scenarios of development of RES. Knowing not only the sources capabilities, but above all, the load behavior in real time enables agility in the actions, increasing the reliability and allowing operators to understand the phenomena, avoiding, if applicable, the problems recurrence.

Energy efficiency, load management and the energy are factors that enable the rapid readjustment in cases of emergency, in addition to avoid investments in generation side. The construction of these “virtual energy mini center” who are serious energy efficiency projects avoid electrical losses still on transmission and distribution, in addition to the costs for the energy produced are a lot more interesting. The correct knowledge of electrical variables and management tools are solutions that increase reliability and reduce operating costs and power consumption (STAROSTA, 2016).

6.3.2 An indicative and decentralized integrated planning

One of the ways to ensure the generation expansion, transmission and distribution of energy, articulate with the energy policies of various aspects, including energy efficiency, with the sector policies of development and environment, water resources and the system of regulation and social control through the implementation of a model of Integrated Resources Planning - IRP by river basins in Mato Grosso (DORILEO, 2009).

The federal Government has formulated energy policies in Brazil on a centralized basis, while the policies of water resources and the environment are being practiced in a decentralized way. This model has led to a series of problems and conflicts between these areas, notably in relation to large enterprises of hydropower plants. The IRP can respond to key issues of infrastructure through the search of the balance between the environment, the economic interests and the populations involved.

In a regional development scenario in which aims to integrate the State Government has implemented social programs focused to structural policies, mainly in rural areas. In energy infrastructure works, the indicative planning cannot be limited to megaprojects, but must contemplate the small enterprises, taking into account the local needs of necessary infrastructure to energy production system, giving opportunity, particularly for small and medium-sized enterprises.

Thus, with the IRP guidelines, the means to guarantee the adequate development of RES in the state of Mato Grosso incorporate measures that must take into account the intra-regional disparity and the sensitivity of the three biomes that make up the territory of Mato Grosso:

- Train government team and partner entities to identify supply and demand resources, make available local resources and assess their potential for regional development;

- Raise and characterize the energy uses (on the supply side and the demand side) and the technologies linked to them. A mobilization for data collection precedes this phase. An information system of interest to the program should be developed and used as support for the diagnostic stage. A geo-referenced information system can assist in forming a database;

- Identify the strategic needs or expectations of each region or basin. To construct the diagnosis of the basin existing reality: the physical environment, the socioeconomic aspects and the demands examination for water and energy resources and their evolution in time. It is essential to highlight only what is important to the plan, interpreting its meaning and its consequences.

- Inter-relate the information obtained and indicate the possibilities of energetic utilization available (always within the SSM – Supply Side Management and DSM – Demand Side Management, in equilibrium);

- Disseminate information on the possibility of using the energy resources of supply and demand in the region;

- Perform an analysis for possible geo energetic modeling;

- Consider the use of distributed and / or isolated generation as an optimization vector of transmission and distribution systems;

- Analyze local environmental impacts of the regional energy potential, characterizing them by hydrographic basin;

- Study the repressed demand and predict the energy and capacity needed to meet future energy needs.

To achieve measures that favor the greater diffusion and insertion on RES in Mato Grosso the intervention still includes:

- Close cooperation between production and Distribution energy companies and the Government for the development of regulation and standards that make compatible the different Technologies that use energy.

- Coordinated action of environmental partners, notably in the area of environmental licensing, energy, water resources and industry for joint technology initiatives, research and demonstration projects related to innovative technologies and their applications.

In addition to bringing together, in a permanent network, the city chambers belonging to each region or basin and the corresponding basin committee for conducting and maintaining programs at the local level, supporting and encouraging compliance with higher efficiency standards, voluntary initiatives, and full life-cycle monitoring of the incentive programs for renewable sources.

The natural effect is that this strategy allows the elaboration of an indicative planning by clusters of counties belonging to that geographic region, since the demand for goods and services by the citizen occurs at local levels, valuing the decentralized form. It also provides for the overcoming of difficulties and insurmountable barriers of small and medium counties to achieve socioeconomic development, associating with larger ones, so that the sum of efforts and resources allows the complete organization of an institution to exercise of integrated planning activities with autonomy.

With these measures, the development of solar sources and biomass-based on forestry residues can be feasible, in state each region, by economy sector, establishing realistic short-term goals and coordinated implementation strategies in regional level, by public and private efforts.

6.3.3 Means of strategic intervention

The State must assume the role of inducer in the economic and regulatory field in the regional, social and environmental areas. Mato Grosso will only overcome its economic and financial congestion, with increasing investments in economic infrastructure and public debt equation, leading to the solution of the problems of intra-regional inequality.

The productive base needs to undergo an intense restructuring, expanding competitiveness. The production structure must be established, through a government plan and strategy, a process of territorial deconcentrating, spreading progress across all regions. Following the standard of the most developed countries, the agriculture sector must smoothly decline its share in GDP.

According to BNDES analysis, renewable energy sources need, necessarily, public resources, either for research and development, or to subsidize the initial costs of production. In the initial stage of development, the aim is to identify market niches in which renewable sources have greater potential for penetration and, therefore, greater prospects of competition with conventional sources.

The hydraulic vocation of Mato Grosso to produce electricity leads, at least currently, to a context in which new renewable sources are not competitive, with low market share. Still under the BNDES analysis, the justification for the development of renewable energies is based on its strategic character, because there is still much inequality between the regions. The question arises in the sense of knowing for which types of sources should be directed the greatest efforts. Another point considered is technological innovation and public investments in RES, always observing the costs of new technologies and those of conventional technologies, as well as the learning curve on renewable sources.

The State development model and the current regional structure of energy consumption present limitations and gaps, and provide deficiencies of the general population and social unfeasibility for inclusion in a low-carbon program[8]. It is important to notice that the State of Mato Grosso offers economic and social opportunities for renewable energy sources, even though these options also face technical and economic constraints for large-scale implementation.

In line with the national rules on the electricity sector, ANEEL, ONS and EPE[9], regional interventions must dictate, within the framework of programs and policies for the promotion of renewable energy and environmental protection, introduce a new energy economy socially satisfactory and fair, economically viable and environmentally sustainable.

Box 1 summarizes the macro strategic objectives to be pursued by the State that can support and promote renewable energy sources in the different regions.

Box 1 Macro strategic objectives summary to be pursued by the State in order to support and promote renewable energy sources in the different regions..

MACRO OBJECTIVES		
Infrastructure	**Conservation and Protection of the Environment**	**Sustainable development**
• Improve and expand transport infrastructure; • Improve and consolidate the electricity infrastructure; • Stimulate the technological innovation process; • Encourage the private sector to participate in strategic investments; • Intensify professional training programs in the workforce; • Favor and promote graduation and postgraduate studies in areas of interest in the development of renewable energy in the state.	• Intensify the use of regional potential; • Effect the agro-ecological-economic state zone; • Monitor the occupation and exploitation of natural resources.	• Reduce social deficits (illiteracy, education, health, mortality, housing, basic sanitation, etc.); • Expand and adapt training / qualification and retraining opportunities for the labor market; • Encourage and support small and micro enterprises; • Maintain updated studies of the regional-urban space restructuring, always reordering the productive and social activities.

Source: Adapted from (MELLO, 2003).

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[8] The five mesoregions of Mato Grosso are unevenly developed. They present levels of economic activities (GDPs) and income per capita discrepantes, implying different energy intensities and models of consumption and below the state average. According to Faria (2014), “the regional productive structure is rapidly changing, overlapping new productive models over the old ones and seeking to remain embedded in an international competitive environment. The question that remains unanswered is whether this moving structure could engender a new socioeconomic scenario that would guarantee another development model capable of including marginalized social groups and at the same time maintain the structure and functionality of regional ecosystems. “

[9] Under review, about the system of auctions and the electric energy market, regulations of service rendering, on the electric system operation, and participation in the expansion indicative planning of the electrical system and their national decennial and long-term plans.

6.4 EXISTING AND ONGOING POLICIES AND PROGRAMS IN MATO GROSSO

There are some policies and programs adopted to stimulate the insertion of renewable sources isolated or through Distributed Generation, in an environment in which the State seeks to follow, tending to balance public and market instruments. Inserted in the national energy policy, the government has adopted measures adhering to current standards, with public instruments that can be active in this area as tax incentives, tax reductions through tax credits, public-private partnerships, etc.

The **Box 2** presents, in chronological order, legal landmarks of the policies and programs of DG applied in Mato Grosso.

Box 2 Existing and ongoing Policies and Programs in Mato Grosso.

POLICIES	YEAR	EMPHASIS
Law no. 9.247	1996	Reduction of not less than 50% in transmission and distribution systems usage tariffs.
Agreement ICMS 101	1997	Exemption of ICMS on operations with equipment and components.
PROINFA **Law no. 10.438**	2002	**Incentive Program for Alternative Energy Sources.** Increased participation of alternative renewable sources (small hydropower plants, wind power plants and biomass thermoelectric undertaking) in the production of electric energy, privileging entrepreneurs who do not have corporate ties with generation, transmission or distribution concessionaires. It differentiates the amounts paid from the sources of DG in relation to the generation of more competitive sources.
PRODEIC **Law 7.958 from 09/25/2003, Agreement no. 1.432 from 09/29/2003**	2003	**MT Industrial and Commercial Development Program** Exemption of ICMS to companies with industrial economic activity of any nature and on the industrialized products of enterprise established or establishing itself in the territory of Mato Grosso, benefiting, firstly, the companies of production of energy of biomass, renewable source at the time
Agreement no. 5.163	2004	It showed characteristics of the DG for distributors.
Auctions of Alternative Energy Sources Agreement no. 6.048, from 02/27/2007	2007	The auction of alternative sources was established to meet market growth in the regulated environment and increase the share of renewable energy sources - wind, biomass and energy from Small Hydroelectric Power Plants (PCHs) - in the Brazilian energy matrix. First auction: 003/2009 (wind power) Last auction: 003/2018 (Hydro / Wind / Thermos - Gas, coal or Biomass) First Solar Auction: 009/2013
Normative Resolution ANEEL 482	2012	It establishes the general conditions for microgeneration and minigeneration access to electric power distribution systems and the electric energy compensation system.
Agreement ICMS 16 CONFAZ	2015	Authorizes to grant exemption in the internal operations related to the circulation of electric energy, subject to billing under the Compensation System
Agreement no. 382 (MT)	2015	Accession to Confaz ICMS Agreement 16/2015, granting the exemption in the internal operations related to the circulation of electric energy, subject to billing under the Electric Energy Compensation System referred to in Normative Resolution No. 482 of 2012, of the National Agency of Electric Power - ANEEL.

continues

continuation

Law no. 13.169	2015	The rates of the Contribution for PIS/Pasep and the Contribution for Social Security Financing - CONFINS imposed on active electric energy are reduced to zero.
Law no. 13.203	2015	Discounts of at least 50% on transmission and distribution system usage fees and BNDES (differentiated rates).
Normative Resolution ANEEL no. 687/2015	2015	Review Normative Resolution ANEEL 482 and distribution procedures.
ProGD	2015	Stimulate the growth of DG in Brazil
PESI (FIEMT, SENAI-MT)	2018	**Sustainable Energy in Industry Program in Mato Grosso** It provides the natural and legal persons of the industrial segment of Mato Grosso with reliable solutions and credit lines for energy generation with lower cost, efficient consumption and sustainability. There are 5 Programs: 1) Solar Industry MT Program; 2) Biomass Energy Generation; 3) Energy Efficiency; 4) Electric Vehicle Mobility; and 5) Professional Qualification.

Box 3 details the SEIP - Sustainable Energy in Industry Program.

Box 3 SEIP Program: advantages and pillars of sustainable energy in the industry..

ADVANTAGES	
Optimize energy consumption in the industry	Adequate disposal of industrial waste
Sustainable generation of energy at lower costs and affordable credit lines.	Strengthening of associative and the Industry System.
Property type Self-financing	Property valuation
PILLARS	
Energy Efficiency	Perform diagnostics in the industries to check the opportunities for improvement, propose the necessary technical measures and the best way to acquire energy.
MT Solar Industry Program	Encourage the generation of solar energy by industry (LP and FP) with prices and differentiated lines of credit for associated industries.
Biomass Energy Generation	Use of wasted residues from industry for energy generation. Technical visit, pre-project, feasibility analysis, inspection of facilities and follow-up from the start-up phase.
Professional Qualification SENAI	Prepare labor to meet all demand generated by the sustainable energy market. Courses in the professional solar energy area.
Electric Vehicle Mobility	Disseminate the economic and environmental benefits of using electric vehicles.

The bill no. 118/2017, which contains state policy to encourage the use of solar energy throughout the State, by State Representative Oscar Bezerra, is still being processed in the Legislative Assembly of Mato Grosso (**Annex 4**).

7 POTENTIAL EVALUATION OF RENEWABLE ENERGY RESOURCES

7.1 PHOTOVOLTAIC SOLAR ENERGY

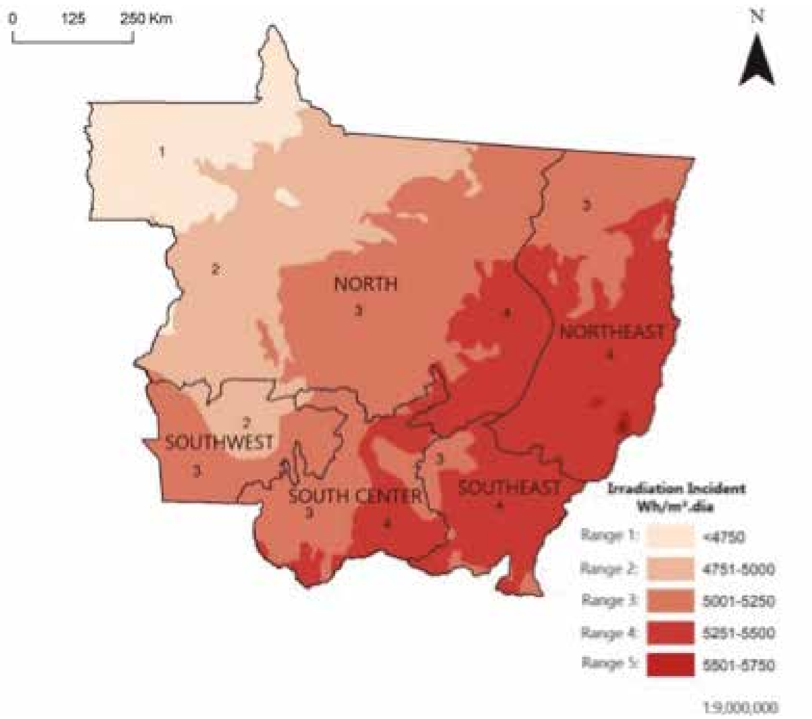
7.1.1 Technical Potential

The technical potential represents the total resource's implementation, successfully, considering all consumers, thus forming a theoretical potential. The technically feasible potential (usable) is the quantity available of the technical potential for use. The economic potential represents the successful implementation of a portion of the cost-effective resource considering all consumers - in this work is the market potential. Therefore, there is a need to distinguish, and determine, an attainable market potential that is the successful implementation of only share of the cost-effective potential taking into account a realistic fraction of consumers.

To evaluate the technical potential of photovoltaic generation in the State of Mato Grosso, it was decided to use the division of the territory according to its five mesoregions, due to the variation of five different daily incident irradiances. The estimation of values is theoretical and considers a known methodology that allows to obtain the potential at the macro level, through technical literature data, obtaining, therefore, an expanded panorama of the potential for Mato Grosso by mesoregion.

From the incident radiation Solarimmetric Atlas data (INPE , 2017) the irradiance values were obtained by intensity range for the State five mesoregions, according to **Figure 12**.

Figure 12 Figure 12. Map of Average Inclined Solar Irradiation Intensity by Mesoregion of Mato Grosso.



Source: (INPE , 2017).

Thus, the conversion of the total area into power or installed capacity is an estimative and informs the possibility to produce photovoltaic energy, theoretically, in the entire area considered[10].

$$\text{Considered Area} = \text{Total Area} \tag{1}$$

Table 10 Areas of each mesoregion by irradiation range.

IRRADIATION RANGE	AVERAGE IRRADIATION	AREA BY MESOREGION AND TOTAL MATO GROSSO (km²)					
	Wh/m2.day	South Center	North	Northeast	Southeast	Southwest	TOTAL
1	2,375		99,409.6				**99,409.6**
2	4,875.5	3,433.1	173,638.9			22,631.4	**199,703.3**
3	5,125.5	56,691.8	138,870.6	61,766.1	11,953.9	49,428.6	**318,710.9**
4	5,375.5	39,174.3	70,789.8	111,929.3	59,866.7		**281,760.0**
5	5,625.5			3,618.5			**3,618.5**
TOTAL		**99,299.2**	**482,708.9**	**177,313.9**	**71,820.6**	**72,060.0**	**903,202.3**

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[10] Lehmann and Peter (2003) studied and determined a factor (Lehmann's factor) for the use of available roof areas in urban regions, usually adopted as 0.9. Thus, if it was adopted the factor, considering the urban area, we would have, theoretically: Area considered = Total area x 0.9.

For the calculation of technical potential an efficiency average of commercial photovoltaic systems must be used. Barbose et al. (2013) have indicated an installation reference of these plants in the United States with an efficiency of about 16%, resulting in a Module Density (Dm) of approximately 160Wp/m² (BARBOSE, DARGHOUTH, et al., 2013). Thus, the installed average power will be:

$$\text{Pot} = \text{Considered Area} \times \text{Dm} \tag{2}$$

The technical potential of generation of energy per year is given by equation (3) of conversion of installed power into energy, taking into account the technical parameters obtained in studies of photovoltaic systems.

$$\text{Pot} = \text{Considered Area} \times \text{PR} \times \text{Irr} \times \text{Rpainel} \times 365 \tag{3}$$

Where: PR = system performance ratio, typically 75.0% in Brazil;
Irr = incident radiation on an inclined surface at an angle equal to the local latitude, and facing the Equator, in Wh/m²/day.
Rpainel = 16.0%

Table 11 presents the results for the estimated installed capacity.

Table 11 Technical potential estimation (theoretical) by mesoregion and their respective average incident irradiation ranges.

IRRADIATION RANGE	AVERAGE IRRADIATION	CAPACITY INSTALLED BY MESOREGION AND TOTAL MATO GROSSO (GW)					
	Wh/m2.day	South Center	North	Northeast	Southeast	Southwest	TOTAL
1	2,375		15,906				**15,906**
2	4,875.5	549	27,782			3,621	**31,953**
3	5,125.5	9,071	22,219	9,883	1,913	7,909	**50,994**
4	5,375.5	6,268	11,326	17,909	9,579		**45,082**
5	5,625.5			579			**579**
TOTAL		**15,888**	**77,233**	**28,371**	**11,492**	**11,530**	**144,514**

In this work, it was estimated the technical potential and evaluated the market potential and, finally, the economically viable potential – the market potential attainable. The introduction of these renewable sources depends on several factors, including the economic and financial impacts (prices and tariff), social, environmental, and the interests of the agents involved with the generation through RES for which scenarios should be established.

7.1.2 Economic potential (market)

RES insertion scenarios

1. **The International Energy Initiative – IEI-Brazil (2018)** generated predictions of the insertion of photovoltaic GD in Brazil using four scenarios, among them, the scenario of EPE. One scenario, nominated the "Intermediate Scenario for Distributed Generation", shows the maximum penetration of DG FV, equivalent to 30% of the installed capacity of electricity generation in 2040, which corresponds to 8.6% of electricity consumption that year. In this work, being conservative, we consider the parameter of 8.6% for the 2050 horizon in a "Moderate Scenario for DG" of growth of electricity consumption that year, according to projections of the energy supply and demand of Mato Grosso and Mesoregions, 2036 - work in progress for the State Government.

2. The **"Mato Grosso Scenario"** is also a second scenario proposed in the energy supply and demand matrix of Mato Grosso and Mesoregions, 2036 and corresponds to the faster growth of GDP of Mato Grosso and the electricity consumption above the national average. Under these conditions the two variables achieve average growth of 4.1% p.y. and 4.05% p.y., respectively, in relation to the base year of 2017. It is considered conditions of regulatory stability, of a gradual decline of prices of photovoltaic systems and photovoltaic generation cost parity with prices of tariffs paid by consumers before taxes11. On the issue of technological development are considered advances in storage systems, with strong cost-cutting trend about to become accessible to the portion of household's adopters of photovoltaic systems.

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11 The study of the (IEI - BRASIL, 2018) "TD5 – Greater dissemination of distributed energy resources (DER): suggestions to mitigate tariff impacts and guidelines for a new energy policy" recommends the gradual implementation of binomial and horosazonal tariffs for consumers served in the low voltage. Or yet, the scheduling of the implementation of these tariffs by categories of consumers, taking into account the differential impact in all groups: prosumers, consumers adopting various types and measures of energy conservation and/or demand response and consumers that do not generate part of their electricity consumption or do not seek to rationalize their consumption.

Box 4 shows the main assumptions adopted for determining the market potential of photovoltaic solar energy in Mato Grosso.

Box 4 Assumptions adopted.

PARAMETERS	MODERATE SCENARIO FOR DG	MATO GROSSO SCENARIO
Market for electricity in 2050	8.6% of the total electricity demand in 2050 scenario of moderate growth in the economy.	8.6% of demand due to the accelerated growth of the economy. EC = GDP.EC/GDP x GDP growth rate 2017 (base year) - 2050. EC = Consumption Electricity
Average annual GDP change	4.1%	5.6%
Growth Rate of Total Electricity Demand (%)and Demand Growth (GWh)	3.0% p.y. – 24,578	4.05% p.y. – 31,302
Factor of capacity of the PV plants	18%	18%

In this work, are adopted the IEI-Brazil scenarios, adhering to a "Moderate Scenario for DG" and the "Mato Grosso Scenario", obtaining estimates of market potential in an aggregated way for the distinct regions of Mato Grosso according to the **Table 12.**

Table 12 Market potential estimation of photovoltaic solar energy in Mato Grosso.

MESOREGION	ELECTRICITY CONSUMPTION IN BASE YEAR - 2017 - (GWh)	ELECTRICITY CONSUMPTION IN THE YEAR 2050 – MODERATE SCENARIO FOR DG (GWh)	ELECTRICITY CONSUMPTION IN THE YEAR 2050 - MATO GROSSO SCENARIO (GWh)	MODERATE SCENARIO FOR DG – ENERGY GENERATED (GWmedium)	MATO GROSSO SCENARIO – ENERGY GENERATED (GWmedium)	MODERATE SCENARIO FOR DG – CAPACITY INSTALLED (GWp)	MATO GROSSO SCENARIO – CAPACITY INSTALLED (GWp)
South Center	2,848	6,621	10,240	569	881	3,164	4,892
Southeast	1,494	5,086	4,919	437	423	2,430	2,350
Southwest	706	1,698	3,866	146	332	811	1,847
Northeast	600	1,360	2,964	117	255	650	1,416
North	2,758	7,644	11,481	657	987	3,652	5,485
TOTAL MT	**8,406**	**21,185**	**24,254**	**1,926**	**2,878**	**8,520**	**13,875**

In the moderate scenario for DG photovoltaic generation reaches a 11,743 GWp installed capacity in 2050, while that in scenario Mato Grosso this capacity increases 27.0%. The estimated power in the first scenario is capable of generating nearly 2.2 GW medium at the period end, what would correspond to 78.5% of the total electricity demand of Mato Grosso System that same year.

7.1.3 Attainable market potential

There is a growing introduction of isolated off-grid photovoltaic systems connected to electricity grids, forming the Distributed Electricity Generation - now representing 95% of the installations, in a dispersed market, in the sectors residential (small scale), commercial, public, agriculture (average scale), and industrial (large scale)[12].

The adopted methodology of scenarios, monitoring the premises for the photovoltaic sector described in Technical Note DEA 13/15 (EPE, 2016), considered for small scale DG "that energy sectors institutional conditions will promote the necessary environment for that to happen the renewal of infrastructure, the paradigm change of the distribution agents and be disseminated the market of energy services, stimulating that investment dispersed " (EPE, 2016).

RES insertion scenarios

For the attainable market took the "Moderate Scenario" described in the Market Potential section calculation was adopted with the final consumption projections of electricity in the economy sectors of Mato Grosso in the horizon of the year 2050 associated with the Scenario "New Policies" premises of the prospective EPE study – the National Energy Plan - PNE 2050 and DEA 13/15 (EPE, 2016) that establishes base scenarios for the penetration of photovoltaic DG in Brazil. In the chosen EPE scenario, the corresponding indicators obtained are for the sectors residential, commercial, industrial and public, according to a trajectory in which they are evidenced, in greater scale, development policies for decentralized photovoltaic generation, leading to a greater appropriateness of installing photovoltaic buildings, as well as to a greater stimulus to its adoption by the users.

With the lack detailed works of market estimates by consumption range for the sectors commercial, public, industrial and agriculture, top down approach is suitable for the purposes of this evaluation from the projection of electrical demand by sector and the estimated attendance percentage this demand through photovoltaic systems. Under these conditions, it is considered that the trend is a growing concern of commercial and industrial companies with the image associated to the best practices in relation to the environment, including renewable energy sources, as well as its benefits social and economic. Public buildings must also follow the care example with the environment and reducing costs by integrating

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[12] According to TECHNICAL NOTE DEA 13/15 - Energy Demand 2050 of EPE (2016) "The capacity scale relationship is directly linked to the investment decision logic, so the boundary conditions for the analysis must also be differentiated between small and medium scales, and large scale. Small and medium scales have more defined scenarios for the integration of urban systems, definition and establishment of "microgrids", institutional evolution and forms of remuneration, while the larger scales are more related to the industrial sector logics as a supply guarantee and energy security, increased reliability, increased energy efficiency and economic development."

emerging technologies of renewable sources in its premises in the medium and long term with more intensity.

As the technical note DEA 13/15 (EPE, 2016) for photovoltaic systems, the biggest costs involved are in initial investment, since the cost of operating a plant of this technology is low. On the other hand, fuel thermal plants, have fuel costs added to operating cost, which has a larger share of the total costs presented over the enterprise life. Considering these factors and the moment when distributed photovoltaic generation reaches the tariff parity for each sector, it is assumed that the following percentages of electricity demand service will be supplied via DG photovoltaic in the EPE's case "New Policies" trajectory: 7%, 14% and 18%, for the commercial, industrial and public sectors, respectively. In this work the agriculture sector of Mato Grosso was included, assuming the percentage of 10%.P

For the residential sector, the potential was evaluated according to a more disaggregated approach, considering the electric demand evolution in the year 2050, the number projections of consumer households and their distributions in relation to the consumption ranges (> 220 kWh and < 500 kWh and > 500 kWh) as the potential number of consumers likely to adopt photovoltaic technology. In order to estimate the number of adopting consumers, who will effectively install a photovoltaic system at the end of the 2050 horizon, the Theory of Diffusion of Innovations described in Rogers (2003)13 and the mathematical model of Bass:

$$N(t) = m * F(t) \tag{4}$$

Where: N(t) is the cumulative number of adopters at time t;
m= final consumer potential market obtained from equation 6; and
F(t) = is the cumulative distribution function obtained with equation 5.

$$F(t)= \frac{1 - e^{-(p+q)t}}{1+(q/p)\, e^{-(p+q)t}} \tag{5}$$

Where: F(t) is the cumulative distribution function;
p is the coefficient of innovation; and
q is the coefficient of imitation.

$$m = fmm * MP \tag{6}$$

Where: fmm is the maximum fraction of consumers obtained in equation 7; and
MP is the potential consumer market.

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13 See more in ROGERS, E. The Diffusion of Innovations. The Free Press, New York, USA, 5th edition, 2003.

$$fmm = e^{SPB * TPB} \tag{7}$$

Where: SPB is a sensitivity factor to payback; and
TPB is the payback time, in years.

According to Rogers's theory of diffusion (2003) and its classification of adopters, it is estimated that in the next decades the PV systems will no longer be a technology adopted only by the innovating part and the initial adopters of the population, reaching also the "majority initial" and "late majority" (ROGERS, 2003). By 2050, the adoption factor may also reflect a greater consumer investor profile, linked to greater environmental awareness of society (ANEEL, 2016). **Annex 5** presents the number projection of consumers in the residential sector by the year 2050.

The attainable market potential was also evaluated in the context of an economic-financial feasibility analysis of the energy projects that could be installed in the economy sectors and receive credits from the local distributor, and the NPV calculation (Net Present Value), obtaining results for the residential, commercial, industrial, public and agriculture sectors. Adjustments of electric energy tariffs were considered above inflation. With an average (or discount) attractiveness rate of 12.0% p.y. the simulated investments for the respective systems under evaluation in this work presented NPV>0, making them acceptable over the useful life of the installed plants (25 years) (See **Annex 6**).

The Internal Rate of Return (IRR) was also calculated for investments in all sectors, obtaining a rate of 51% (**Annex 6**). Considering this average rate of return greater than the attractiveness rate, the considered projects are viable.

Still for the market attainable, another figure of merit considered is the benchmarking of the economic feasibility of photovoltaic solar generation, comparing, year by year, the cost level of energy and the final tariff of the local electric energy distributor, or LCOE (*Levelized Cost of Electricity*), assuming as hypothesis the value maintenance of the tariff in real terms over the horizon (EPE, 2012). The LCOE lists the costs involved and the energy generated by the project over its useful life. This Figure of merit represents how much an electric power producer should derive from revenue per kWh, so that it is enough to cover operating expenses, investments, interest and adequately remunerate investors.

The (IEE - USP , 2015) calculated the LCOE for the city of Cuiabá - MT finding the level value of R$/MWh 534.26 for an electricity tariff value of 726.76 R$/MWh with taxes in a "standard scenario". **Annex 7** shows the results when adopted this level cost.

As a premise of cost reduction over the coming decades, it has been used as reference the projections of percentage reduction of costs, according to IEA (2012), about the installation costs in Brazil in 2017 of up to R$ 7.50/Wp for system 5 kWp and of R$ 6.50/Wp for system from 31 to 100 kWp (MITIDIERI, 2017). For the local market information, we have adopted the costs a little bit below the reference.

For the estimates, do not applied tariff impacts by classes of consumers, nor were made distinctions between classes and between distributed generation modalities contained in the Normative Resolution ANEEL - REN nº 482/2012: generation next to the load, remote self-consumption, enterprise with multiple consumer units (condominium) and shared generation. Also, not be simulated impacts of consumer credits neither variations of tariff flags according to regulation of the Regulatory Agency.

Assumptions adopted

Residential sector

Box 5 Assumptions adopted for the residential sector.

Adopting consumer class	>200kWh≥ 500 kWh/month
PV system capacity	3.0 – 5.0 kWp
System service life	25 years
Annual system degradation	0.5%
Average residential tariff	R$/MWh 796.76
Number of household consumers adopting in 2050 (realistic fraction)	30,451
Cost of investment	R$ 6.00/Wp
Payback (Energisa MT concession area) (ANEEL, 2018)	5.8 years
Discount rate	12.0%

Commercial sector

Box 6 Assumptions adopted for the commercial sector.

Maximum PV system capacity	10.0 – 20.0 kWp
Service demand in 2050	14.0%
System service life	25 years
Annual system degradation	0.5%
Average tariff	R$/MWh 568.00
Cost of investment	R$ 5.50/Wp
Payback (Energisa MT concession area) (ANEEL, 2018)	4.8 years
Discount rate	12.0%

Industrial sector

Box 7 Assumptions adopted for the industrial sector.

Number of household consumers adopting in 2050 (realistic fraction)	5.0%
PV system capacity	30 - 50 kWp
Service demand in 2050	7.0%
System service life	25 years
Annual system degradation	0.5%
Average tariff	R$/MWh 568.00
Cost of investment	R$ 5.50/Wp
Payback (Energisa MT concession area)	5.8 years
Discount rate	12.0%

Public sector

Box 8 Assumptions adopted for the public sector.

Maximum PV system capacity	10.0 – 20.0 kWp
Service demand in 2050	18.0%
System service life	25 years
Annual system degradation	0.5%
Average tariff	R$/MWh 568.00
Cost of investment	R$ 6.50/Wp
Payback (Energisa MT concession area) (ANEEL, 2018)	5.8 years
Discount rate	12.0%

Agriculture sector

Box 9 Assumptions adopted for the agriculture sector.

Maximum PV system capacity	10.0 – 30.0 kWp
Service demand in 2050	10.0%
System service life	25 years
Annual system degradation	0.5%
Average tariff	R$/MWh 568.00
Cost of investment	R$ 6.50/Wp
Payback (Energisa MT concession area) (ANEEL, 2018)	4.8 years
Discount rate	12.0%

Results of estimates

Considering the assumptions for the economy sectors were obtained the market potential attainable according to **Table 13**.

Table 13 Attainable market potential for photovoltaic solar energy in Mato Grosso in the 2050 forecast horizon.

SECTOR	INSTALLED CAPACITY (GWp)	ENERGY GENERATED (GWmedium)
Residential	0.09	0.02
Commercial	2.06	0.37
Industrial	0.91	0.16
Public	1.36	0.24
Agriculture	1.16	0.21
TOTAL MATO GROSSO	**5.59**	**1.01**

The estimated potential points to an important role of photovoltaic generation in service the state's electric demand in the coming decades, reaching an installed capacity of 5.6 GW peak in 2050. With the assumptions adopted, where this technology is feasible in this quantity, also in function of news and favorable public policies, it is possible to generate 1.01 GW average, which corresponds to 42.0% of the projection of total electricity demand in that year.

In terms of installed power (GWpeak), **Figures 13, 14, 15, 16** and **17** present the gradual insertion of projected capacity of the market potential attainable in the Mato Grosso electric system over the period 2019 to 2050 for each economy sector.

Figure 13 Evolution scenario of photovoltaic installed capacity in Mato Grosso's commercial sector on the horizon 2050. Unit: GWpeak.

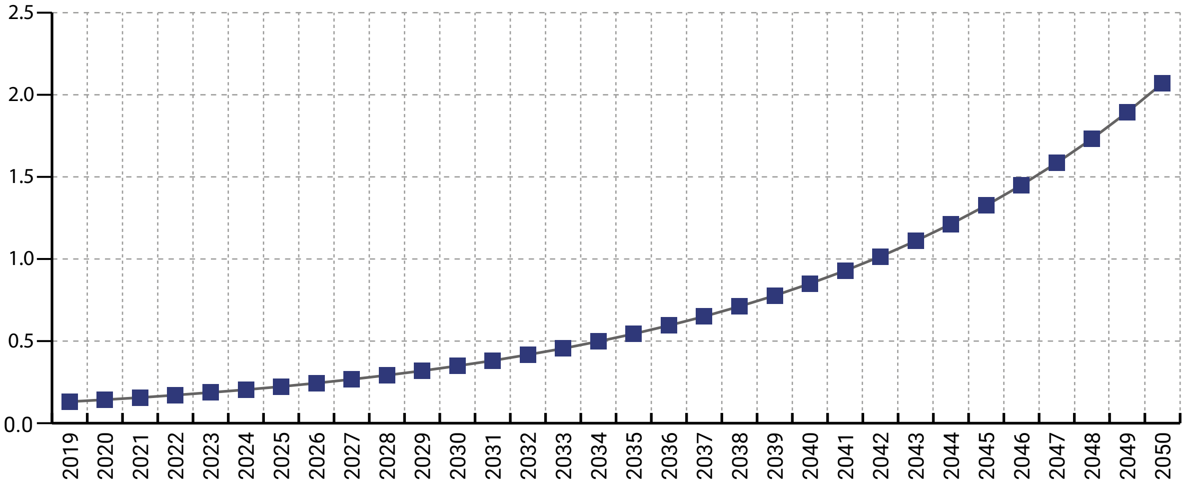


Figure 14 Evolution scenario of photovoltaic installed capacity in Mato Grosso's industrial sector on the horizon 2050. Unit: GWpeak.

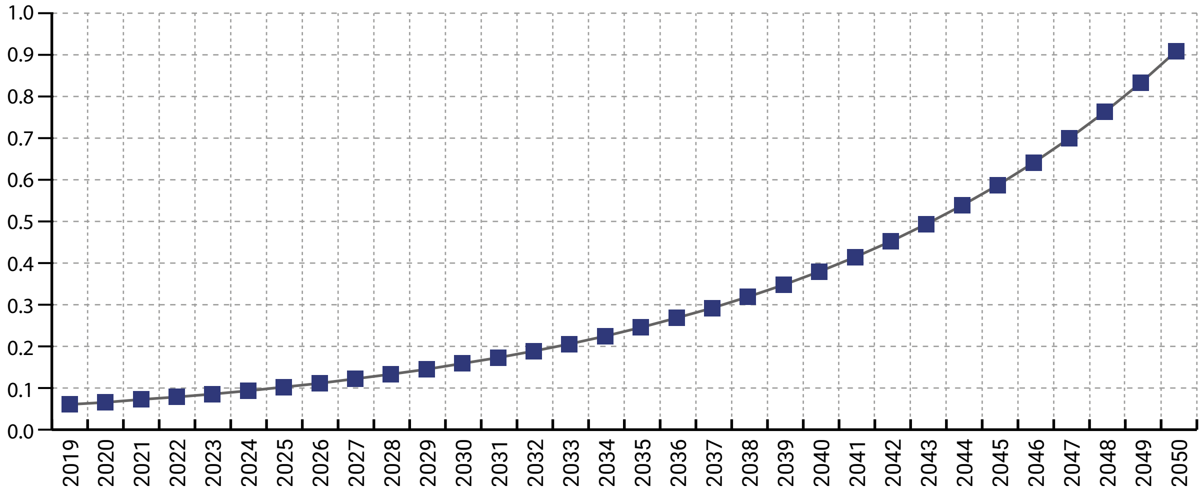


Figure 15 Evolution scenario of photovoltaic installed capacity in Mato Grosso's public sector on the horizon 2050. Unit: GWpeak.

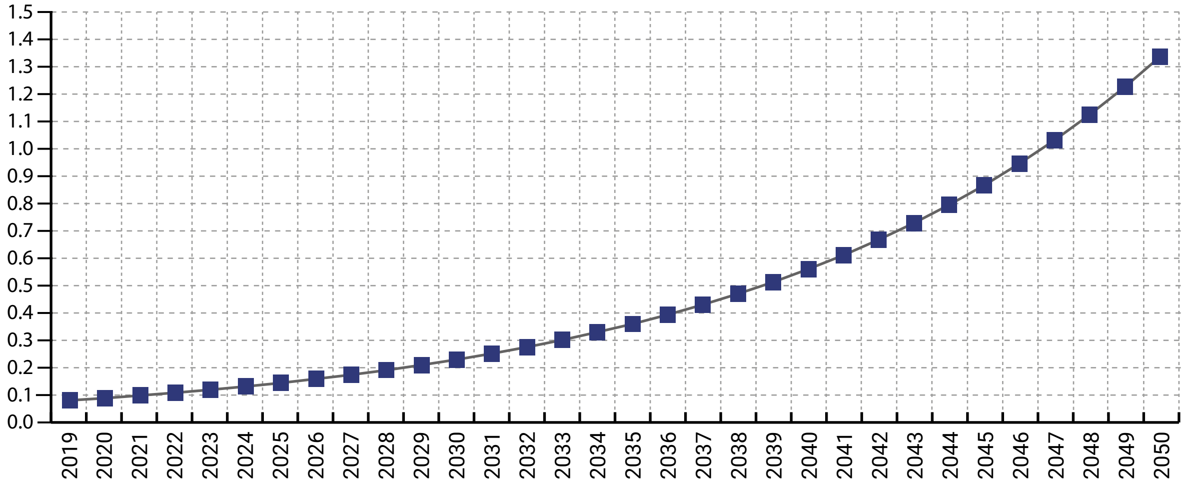


Figure 16 Evolution scenario of photovoltaic installed capacity in Mato Grosso's agricultural sector on the horizon 2050. Unit: GWpeak.

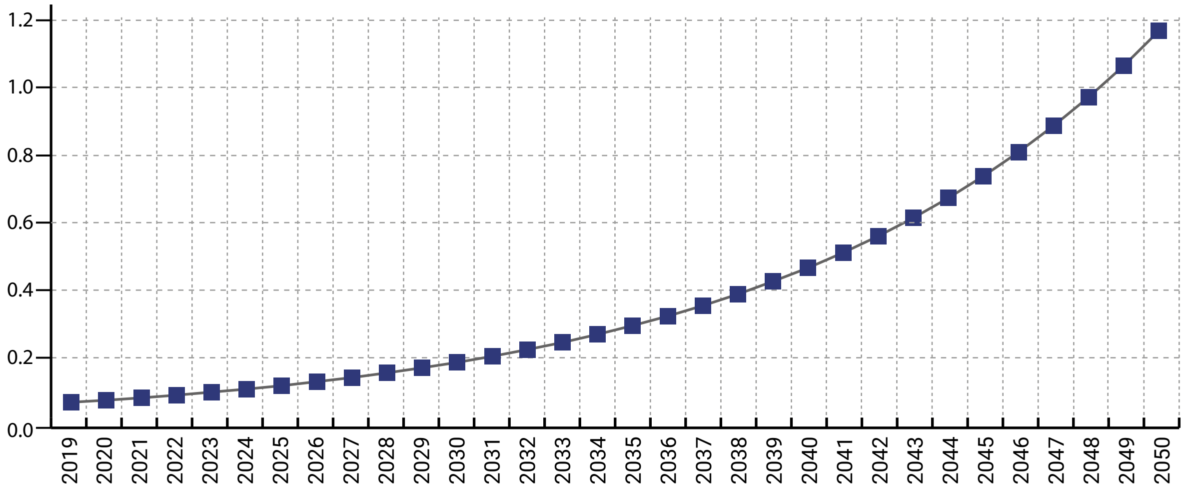
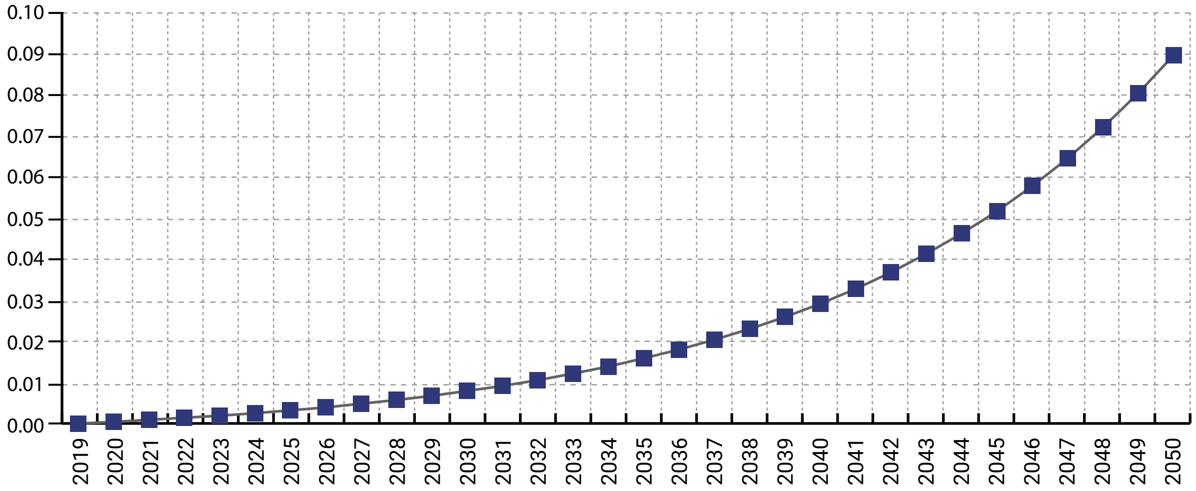


Figure 17 Evolution scenario of photovoltaic installed capacity in Mato Grosso's residential sector on the horizon 2050. Unit: GWpeak.



7.2 WOODY BIOMASS - FORESTRY RESIDUES

In this particular case of potential study of wood waste[14] to energy use of woody biomass for power generation, the technical potential can be fully implemented due to the possibility of using available resources. But the implementation of this potential, under the economic point of view, or that of cost effective, will depend on, among others, of the technical, financial and environmental factors. For the potential study determination of (EPE, 2018) and are two specific goals: potential for (1) Isolated Systems (IS)[15] and (2) for the National Interconnected System (NIS). For the first are estimated the total technical potential electric generation with woody biomass and residual electric generation potential of this biomass that would replace Diesel generation of basis of ISs. For NIS is estimated the potential electric generation with woody biomass residual industrialization of wood logs from planted forests and identified opportunities for commercialization of the electric energy generated from biomass residual Woody. Annex 8 presents the NIS configuration.

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[14] In this work, we use the generic term "wood waste" to the forestry residues, to the urban source (remains of works and pruning) and industrial (furniture, paper and cellulose and wood) coinciding with the term "woody biomass". Many energy drinks are derived directly or indirectly from wood and, to this set of processing and uses called "Wood Energy Chain". The potential in question here refers to the direct derivative for the production of electricity.

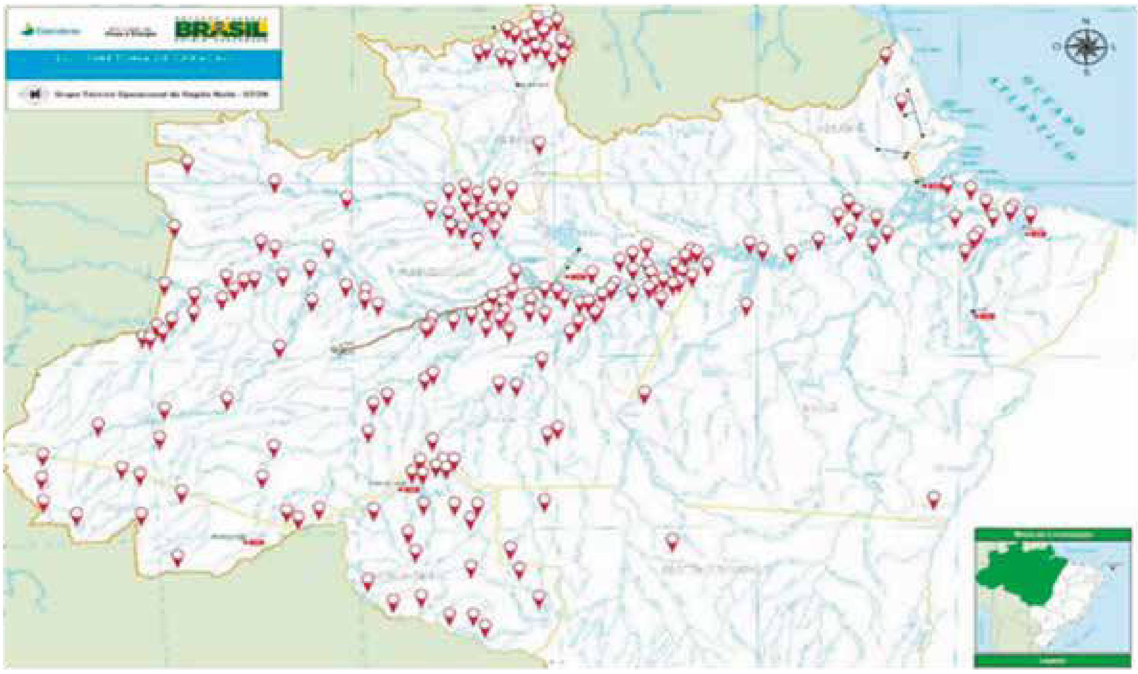
[15] The Isolated Systems (IS) are the electric utility public electricity distribution systems that, in their normal configuration, are not electrically connected to the NIS, for technical or economic reasons, as defined by Decree 7.246 / 2010. With this, each IS must have local generation to meet its loads (ANEEL, 2018). By August 2018 there was provision for the integration of a Isolated System to NIS, the Monte Dourado system, in the CELPA concession area. It is worth noting that, in 2017, the towns of Cachoeira do Arari, Salvaterra and Soure, located in Pará and Paranorte, located in Mato Grosso, were integrated into NIS, and the localities of the Marupá Community and Lago Grande Community, located in Roraima, have been integrated with other existing Isolated Systems. (Text extracted from (ONS , 2017).

EPE's study based on recovery of waste from forestry and wood processing in log in the North of Mato Grosso (beyond the North of the country) (including the State of Maranhão) In Federal Public Forests (FPF) and in Private Forests (FPri). Only the physical availability of biomass, in the forest typologies presented, was considered. Other variables, specific to each subject area of management, were not considered and may interfere with the estimated potential accomplishment.

7.2.1 Isolated systems potential

Figure 18 presents a map with the location of isolated systems in northern Brazil and in northern Mato Grosso, considered in this study area of the Isolated System of Mato Grosso.

Figure 18 Isolated systems in the northern region of Brazil and Mato Grosso (Spotlight).



Source: Print Screen adapted from the NIS Dynamic Map, EPE page, 2018.

According to ONS data (2018), the expected maximum demand for the Mato Grosso Isolated System in 2018 is 1.04 MWh/h and the Average Energy is 0.56 MWmed.

Table 14 shows the total production and estimated Diesel oil consumption in the IS of Mato Grosso, in the north of the State.

Table 14 Estimated production of electricity and Diesel oil consumption of thermal power plants in Isolated System of Mato Grosso, by 2018.

ISOLATED SYSTEM OF MATO GROSSO	ELECTRIC POWER GENERATION (MWh)	ESTIMATION OF DIESEL OIL CONSUMPTION (m^3)
North	4,938	1,427

Source: EPE, TN 17/18 (2018). (EPE, 2018b).

The base capacity of the Mato Grosso IS considered (North of the State in the Legal Amazon) is of a Maximum Active Power of 2,814 kW and load factor of 57.0% (ANEEL, 2018b).

For the calculation of production estimates of woody forest residue and logging, was adopted the average productivity of 18 cubic meters of industrializable log per hectare[16], with a cycle of 25 years. According to the SFB (Brazilian Forest Service), this value reflects the average productivity in the areas of grant or private forests. To achieve the potential of waste, it was considered that the extraction of 1 cubic meter of wood logs in forest management results in 1 cubic meter of woody residue. On industrialization, a generation of residues (sawdust, shavings etc.) of 65%.

In this way, the total production of waste factor reaches 1.65 m^3/m^3 of wood logs processed. It was adopted a basic wood density in log of 0.8t/m^3 as typical of Amazonian species[17]. Thus, in terms of mass, the factors of production of woody residue per tonne of wood logs extracted are 0.8 and 0.52, respectively in management and industrialization. Considering that the operations vary greatly according to the business plan of the activity, more conservative values were adopted.

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[16] For the entire Legal Amazon, was adopted the legal reserve percentage for forests which corresponds to 80%, according to Law 12.651, dated May 25, 2012.

[17] This value was chosen based on the density values of native species given in (IPT, 2013).

Initially, areas in particular forests that could be exploited through sustainable management were identified[18] (**Table 15**).

Table 15 Private forests areas liable to exploitation via sustainable management in Mato Grosso.

PUBLICLY REGISTERED LEGAL RESERVE (ha)	APPROVED LEGAL RESERVE AND NON-REGISTERED (ha)	LEGAL RESERVE PROPOSAL (ha)	TOTAL (ha)
2,891,461	100,422	24,441,712	**27,433,595**

Source: (EPE, 2018b) with basis on SFB, 2018 with basis on Rural Environmental Registry (CAR) and Brazilian Forest Service (SFB), 2018.

Effective management area corresponds to a portion of Permanent Conservation Areas (PPA) (80.0%). The areas of effective management and potential production of log wood, on private land (**Table 16**).

Table 16 Areas of effective management discounted the areas of permanent conservation in private forests in Mato Grosso.

PUBLICLY REGISTERED LEGAL RESERVE (ha)	APPROVED LEGAL RESERVE AND NON-REGISTERED (ha)	LEGAL RESERVE PROPOSAL (ha)	TOTAL (ha)
2,313,169	80,338	19,553,370	**21,946,876**

Source: (EPE, 2018b) with basis on SFB, 2018.

Table 17 shows the potential of waste production in FPri in Mato Grosso.

Table 17 Wood production potential and biomass waste generation in Mato Grosso's private forests.

WOOD LOGS (M^3) (m^3)	WOODY FOREST WASTE (t)	PROCESSING WASTE (t)
15,801,751	12,641,401	8,216,910

Source: (EPE, 2018b) with basis on SFB, 2018.

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[18] Sustainable Forest Management (SFM) is regulated as a regime for sustainable timber extraction in the Amazon. CONAMA Resolution N°. 406/2009, defines MFS as "forest management to obtain economic, social and environmental benefits, respecting the mechanisms of ecosystem sustainability subject to management and considering, cumulatively or alternatively, the use of multiple species. "Decree 5.975/2006, Normative Instructions MMA 04 and 05/2006 and CONAMA Resolution 406/2009.

With the use of this potential of management and processing residues in federal public forests (FPF) and private forests (FPri) 11,851,709 MWh could be obtained, as shown in **Table 18**.

Table 18 Potential of electric generation and installed capacity from woody biomass residual of forest management and wood processing in Mato Grosso, by 2017.

ELECTRICITY GENERATION (MWh)		INSTALLED CAPACITY (MW)		
Federal Public Forest	Private Forest	Federal Public Forest	Private Forest	TOTAL
556,934	11,294,775	79	1,612	**1,691**

Source: (EPE, 2018b).

Part of this potential is in areas served by the NIS and the energy produced, if connected to the system, can be marketed in accordance with regulated market rules.

With respect to the FPF eligible for concession in the State of Mato Grosso, **Table 19** presents the total areas suitable for exploration via sustainable management, effective management areas and potential waste loggers.

Table 19 Potential for timber production and generation of biomass residues in the area of Mato Grosso's Federal Public Forests managed, by 2017.

TOTAL AREA SUBJECT TO EXPLORATION VIA SUSTAINABLE MANAGEMENT (ha)	EFFECTIVE MANAGEMENT AREA (ha)	WOOD IN LOGS (m^3)	WOODY FORESTRY RESIDUES (t)	PROCESSING RESIDUE (t)	GENERATION INSTALLED CAPACITY (MWh)	POTENTIAL OF GENERATION (MW)
1,352,722	1,082,178	779,168	623,334	405,167	538,962	77

Source: EPE with basis on SFB, 2018.

Considering the whole area exploitation of effective management and the energetic conversion of the entire woody residue (forest and industrial) into electrical energy, we would have, at the Mato Grosso IS, the production of 538,962 MWh in 2018, according to **Table 19**, 110 times the current Diesel generation capacity. This represents approximately 2.4% of the Mato Grosso system current installed capacity.

7.2.2 Interconnected system potential

Wood based biomass potential in forestry plantations

With reference to the EPE (2018) study to estimate the processing residues energy potential, the waste generation factor of the logging industry based on plantations of 50% was adopted, due to the greater uniformity expected of the logs. It is assumed that forest production residues are left for incorporation into the soil or are destined for other purposes.

The predominant forest genera in this activity are *Eucalyptus* and *Pinus*. The basic density of wood varies according to several factors such as age, tree species, location, sample position etc. (RIBEIRO and ZANI, 1993) indicate values for eucalyptus around 0.51 t/m^3, with eucalyptus species with higher and lower densities at this value. (HIGA, KAGEYAMA and FERREIRA, 1973) analyzed species of Pinus and obtained an average value of 0.338 t/m^3 for the basic density of wood. In this study, will be adopted a typical basic density of Pinus, of 0.338 t/m^3, with the motivation of being conservative in the estimates (EPE, 2018b).

This potential is estimated based on the reference thermoelectric plant, described in the EPE document (2018) "Thermoelectric Plant for Residual Reference Biomass"[19] (see **Annex 10**).

The residual biomass potential of the wood industry in logs in Mato Grosso is described in **Table 20**. In the NIS area, the generation potential is 26,000 MWh that represents 0.13% of Mato Grosso's electricity production in 2017.

Table 20 Potential production of wood in logs for other purposes, potential for residues generation and electricity and installed capacity.

WOOD IN LOGS (1000 m³)	PROCESSING RESIDUES (1000 t)	PROCESSING RESIDUES (MWh)	INSTALLED CAPACITY (MW)
283	48	26,000	4

Source: (EPE, 2018b).

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[19] The reference thermoelectric power plant was modeled as an integrated project to a wood industrialization unit or to a lumber pole, carrying out cogeneration of energy, that is, simultaneous generation of thermal energy and electric energy, for subsequent uses. It is assumed that the plant operates at 80% of the time in the year, corresponding to the Capacity Factor. This model seeks to represent a small thermoelectric plant park to the residual biomass to allow estimates of the electric power supply potential. Thermoelectric power plants associated with the processing of wood produced by forest management in the Amazon region use as fuel the woody forest residue and the residue from the processing of logs. In the case of logging-based enterprises with planted forests, only the beneficiation residue is considered.

Economic viability

In this evaluation, we consider the installed capacity of Diesel operating at the Mato Grosso Isolated System service base, as previously reported, of 1 MW (Maximum Demand 1 MWh/h) and capacity factor of 80%.

Table 21 Technical parameters for evaluating the economic feasibility of using biomass of forestry residues in the Isolated System of Mato Grosso.

INSTALLED CAPACITY TO DIESEL (MW)	ENERGY GENERATED (MWh)	DIESEL OIL CONSUMPTION PER YEAR (m^3)	COST OF DIESEL OIL (R$) ANNUAL
1	7,008	1,942	2,521,000

Source: (EPE, 2018b); (ONS , 2017).

The cost of importing this Diesel oil corresponds to approximately R$ 5.8 million per year, partially covered by the Fuel Consumption Account (FCA) and repassed on to all NIS consumers. Federal and state taxes are also taxed on fuel, corresponding respectively to R$ 605 thousand per year and R$ 1.3 million per year.

According to the EPE document (2018b) "Reference Thermoelectric Power Plant", 5.2 million tons of biomass per year are needed to replace Diesel in the generation of the base (Plant of 1 MW). The premises for assessing economic viability are as follows (EPE, 2018b):

- Gross remuneration of forest biomass: R$ 180 million/year; 20
- Investment in woodchip thermal plants (based on the plants registered data in the auctions of energy): US$ 2,000/kW; and
- Annual operating and maintenance cost (O&M): 5% of the investment value.

Considering the technical and financial parameters of the Thermoelectric Reference Plant and the plant useful life, the relative share of the investment and O&M in the generated energy is of R$ 200.00/MWh (EPE, 2018b). The annualized value for base generation in the Isolated Systems of Mato Grosso is of R$ 1,401,600.00.

This generation represents a good opportunity for electric generation in the Isolated Systems, replacing the generation to Diesel as the useful life of this park is exhausted, with expectation of reduction of generation costs, taking into account the investment feasibility, the operation and maintenance of thermoelectric plants to biomass of forestry residues.

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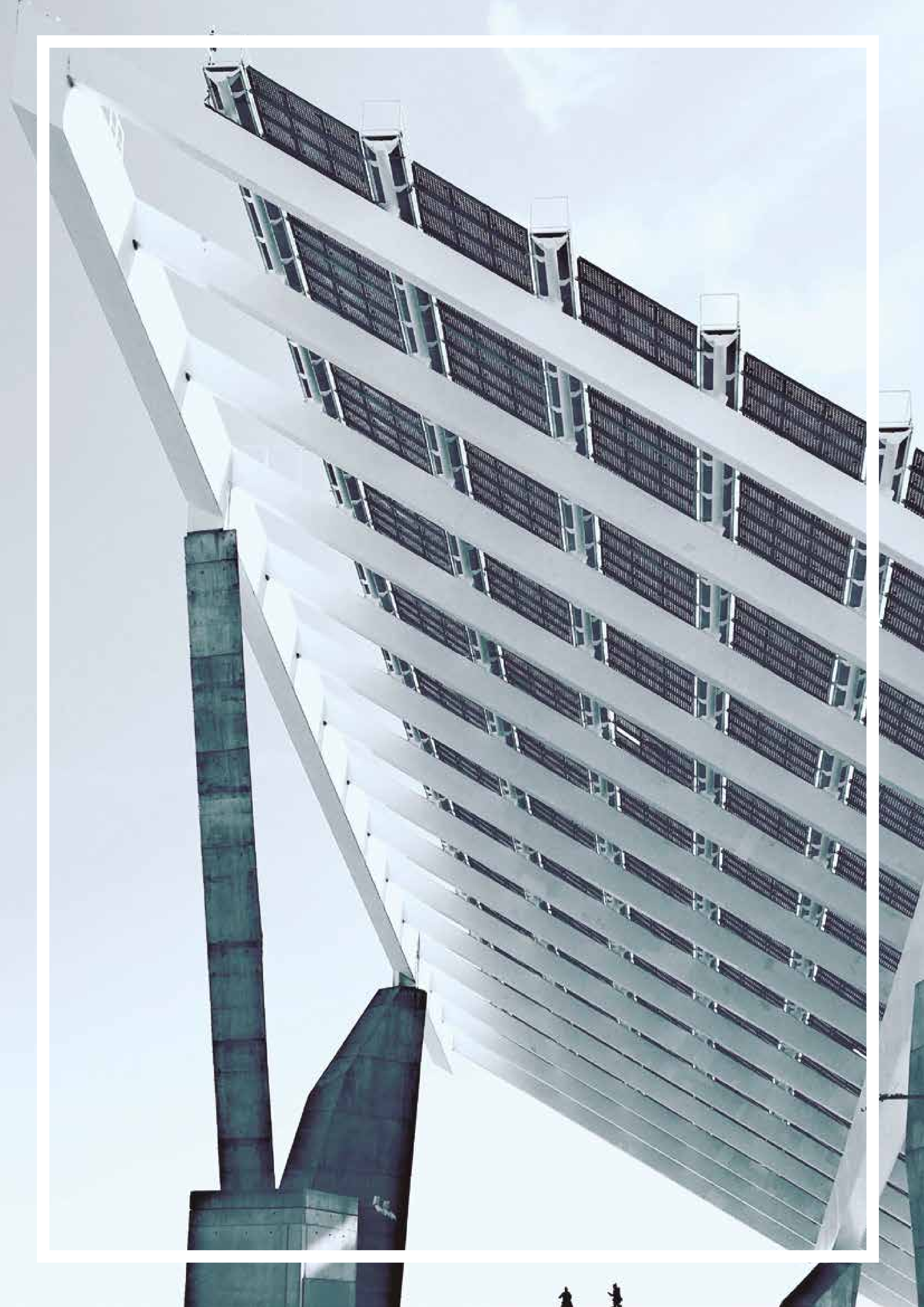
20 The reference is the average price of extractives firewood in the region (R$ 34.00/t of biomass).



8 PERSPECTIVES FOR NEXT YEARS

With the increase in the use of existing potentials, it´s important to consider a greater tendency to participate in renewables through specific auctions for RES with competitive public calls, quantities to be acquired and pre-specified ceiling prices for distributed generation should be considered as already practice in Europe (IEI - Brasil, 2018b). In the perspective of mass introduction of RES in the Brazilian electrical system, the ONS operation planning body should review the behavior of the variables Marginal Cost of Operation (CMO). In addition to the risk of subsystem deficit, stored energy (EARM) and total cost of operation, taking into account the seasonal pattern of the sources and the subsystem characteristic where they are installed. This will be the guarantee of supply through the reservoirs level, interchange between the subsystems, formation of prices and successful auctions, benefiting consumers and all the NIS.

Thermoelectric power plants based on medium and large-scale forestry residues can achieve a slightly higher price on the sale of energy in Distributed Generation Auctions. Distributors, who must interconnect to the basic transmission network, can contract distributed generation energy up to 10% of their load, according to Decree 5,163 / 2004, which does not establish restrictions on the plant installed capacity.

A great future market perspective is for the production of electricity to the residual biomass resulting from the production through forest plantations that occurs almost in its entirety in the area of the National Interconnected System (NIS). The remuneration of this energy follows other market opportunities in the Energy Auctions whose demands to be met predominate large enterprises, without capacity restrictions. In this way, the full potential can be commercialized (EPE, 2018b).

Aneel’s Normative Resolution 482/2012 allows another opportunity for enterprises that are also consumers, but have the capacity to generate surplus electricity, through the formation of cooperatives or condominiums of consumers, according to this Resolution. Under these conditions, the excess energy could be transferred to other units through the distribution grid by a compensation mechanism.

Cogeneration can be a model to be exploited in ventures using the potential of industrial wood residues, trading surplus energy with competitive advantages over dedicated biomass ventures (power forests) that generate only electricity and have higher generation costs.

A biomass thermoelectric plant normally operates steadily, with little variation of load throughout the day, unlike Diesel generation, which has greater flexibility. Therefore, generation using biomass is also a candidate for base generation in the Isolated Systems of Mato Grosso.

The strong growth of the intermittent generation in the electric system has been a energy planning concern in the country, recognized by the Ministry of Mines and Energy, which sees in the dissemination of the distributed sources “a high disruptive potential capable of profoundly transforming the electrical systems that today are predominantly operated with resources of greater size and centrally managed “(EPE, 2018). In this context, the expansion plans should go further, taking into account distributors’ plans, including more comprehensive regulatory analyzes by ANEEL (IEI - Brasil, 2018b).

From the regulatory point of view, the medium- and long-term prospect of increasing use of RES in the electricity matrix will still represent a risk, especially for producers receiving government subsidies. Depending on the location in Mato Grosso, some technologies require incentives to be profitable (eg, biomass). Another risk to consider is related to the network connection, which may also remain uncertain.

For a greater RES expansion, one of the problems to be solved refers to the NIS topology and the locational aspect of the generating sources. The (IEI - Brasil, 2018) analyzes that TUST does not adequately signal where it will be more economical to expand generation or consumption. In the same study, the (IEI - Brasil, 2018) considers that the TUSD does not vary for connections in network different parts and regions of the concession areas, for which the costs of its networks, compensation of invested capital and incident charges must certainly be different[21]. It is desirable, therefore, in the medium term, as normative tradition has done, that, through the mediating action of the regulatory agency, the correction mechanism is implemented, aligning the large, medium generators, the distributors and the consumer, in a market competition with existing regulatory rules.

The tariff issue should bring solutions of systemic benefits. The conclusions of the IEI – BRASIL (2018a) recommend “the gradual implementation of binomial and seasonal rates for consumers served in the low voltage network. Or, the implementation scheduling of these tariffs by categories of consumers, taking into account the differential impact in all groups: prosumers, consumers adopting various types and measures of energy conservation and / or demand response and consumers that do not generate part of their electricity consumption or do not seek to rationalize their consumption. In proposing, however, the

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[21] The public consultation to Technical Note N° 5/2017/AEREG/SE (MME, 2017suggestions from interested parties were accepted until August 17, 2017. Among them is a proposal that substantially affects the breadth and speed of diffusion of distributed electricity generation and energy efficiency measures in the country, and also refers to (TUTS) and distribution tariffs (TUDS) tariffs and captive consumer tariffs, proposing locational signals to TUDS.

innovative modality for the B1 tariff called the “progressive decoupled tariff modality”, the work of the IEI – BRASIL (2018a) shows in a case study for the concessionaire CPFL Santa Cruz that the relative increase in tariff B1 in 2040 would be null, making the adoption of this proposal a simpler and cheaper form than the adoption of a binomial tariff for this tariff class. This brings a satisfactory effect to mitigate the tariff increase and preserving the distribution services remuneration. It also concludes that “Prosumers collaborate with the cheapness of technology, since the consolidation of a distributed photovoltaic market in the country brings reduction of service costs, possible to occur with the use of technology by a significant mass of consumers. With this, the cost of photovoltaic systems becomes cheaper for future prosumers.”

Recent international studies show that from the point of view of investment strategies, RES and Energy Efficiency projects can be an interesting combination for investors, such as pension funds, using Asset Liability Matching (ALM) techniques. The ALM attempts to synchronize future sales flows and asset revenue to match the expected future outflows. This makes the FERs and EE highly suitable due to the predictability of their capital expenditures (CAPEX), operating expenses (OPEX) and production values over the project life. For example, given the predictability of a PV system’s monthly revenues, an investor such as a pension fund can match predicted monthly (PV system) cash inflows against expected monthly cash outflows (payments to retirees) to reduce the risks of cash-flow (BRIANO, 2014).

Brazil needs to define and encourage direct electricity storage systems in photovoltaic systems, considering the fast expansion of these sources, the annual or multiannual regularization capacity of the reservoirs of its hydroelectric plants and the high costs of complementary thermoelectric plants.

According to the work IEI – BRASIL (2018c) “the strong cost reduction trend of the various technologies involved in the FERs, signals the greater disruptive potential of these technologies and, consequently, their competitiveness with the technologies and the business models based on them.” According to the same study, this is already perceived in Brazil by the actions of incentives and programs, but “more ambitious support is still needed in the country to foster innovation and to internalize the larger scale production of RES technologies, or their components, to be part of its global production chain “.

Regarding the cost of photovoltaic technology, the learning curve in this area is high, because the technology is recent, and often the innovations generate larger than expected reduction (IEI - Brasil, 2018a). The variation of acquisition and installation prices has been gradually falling and, according to the EPE (**Table 22**), the average price for the three sectors reaches, in 2050, 33.0% of the price of 2015.

Table 22. Cost reduction of photovoltaic systems perspectives. Unit: (R$/Wpeak).

	2015	2020	2030	2040	2050
Residential	7.0	4.4	3.2	2.7	2.3
Commercial	6.5	4.2	3.0	2.5	2.1
Industrial	6.0	3.4	2.7	2.3	2.0
TOTAL	**19.5**	**12.0**	**8.9**	**7.5**	**6.4**

Source: (Empresa de Pesquisa Energética - EPE, 2012).

The State of Mato Grosso offers several market opportunities and niches in its electric matrix for photovoltaic generation and biomass of forestry residues. These sources could give security to the supply of electricity that regions, especially those of domestic supply dependent on other distant regions, will demand in the future. Many of these sources will not operate on the electricity system basis, but with seasonality, due to their operating characteristics, thus constituting a complementary generation that can serve the market of these regions, including helping to reduce the annual risks of water deficit in the reservoirs of large hydropower plants. However, it is necessary to propose our own technological route and to enable the ability to make our energy matrix greener. The State has created interesting alternatives for the promotion of SHP as an obvious technical and geo-economic solution, and its potential will still be explored. With potential well distributed in the territory, those of photovoltaic energy and those of forestry residues are another geo-economics apex to be explored as a state vocation, capable of reducing the weight of the economic inversion that still falls on these sources, measuring the social, economic, environmental impacts, and, in the end, more accurately assessing externalities.

Also, the use of wood biomass potential can only be considered if its origin is verified in areas with forest management responsible for audited certification (GREENPEACE, 2016), providing an indicative planning. Mato Grosso is expected to mirror, in the medium term, the states of Paraná, Santa Catarina and Minas Gerais, where the residual biomass source of sawmill stands out. In the state of Paraná, the potential of electric generation is equal to the potential market for the contracting of distributed generation. In the state of Santa Catarina, residual sawmill biomass has the potential to generate about half of this market and in Minas Gerais about one quarter (EPE, 2018b).

One possibility of rapid expansion of distributed generation in Mato Grosso is to a large extent on the roofs. There is a projection in this study of more than 30 thousand households in the year 2050 to adopt the system to produce their own electricity. In this scenario, there is a need for public policies aimed to democratize solar energy in the State. In addition, isolated communities without electricity can be benefitted from off-grid systems with the aid of battery systems for storage.

9 ECONOMIC IMPLEMENTATION OF SOLUTIONS

According to Arcardis Tetraplan (2010), “the diversity observed in financing modalities is an advantage for entrepreneurs in the sector, who find a growing market with a dynamic of their own, involving national, international and private sources and multilateral organizations.” However, as the Ministry itself admits most of the sources “tends to privilege large ventures, mainly by the costs and projects involved scales.” In this context, multilateral organizations such as the IDB, for example, highlight support for projects with some public sector involvement, where long-term strategies are involved (ARCARDIS TETRAPLAN, 2010).

There are several sources of funding for renewable energies, which include photovoltaic solar energy and the use of biomass of forestry residues to generate electricity. These include:

i) Financing lines with extended terms and grace periods and / or below market rates;

ii) Direct incentive programs for renewable energies;

iii) Fiscal incentives;

iv) Partial financing, as in the market case for carbon credits;

v) Technical cooperation;

vi) Direct sponsorship of projects;

vii) Corporate participation to leverage and structuring of projects. In these cases, are covered by independent producers and autoproducers aimed or not receiving credit for electric utility location (demand side).

9.1 TOOLS PROPOSED TYPES

Supply-side financing mechanisms

1) **Special Regime of Incentives for the Infrastructure Development - SRIDI (Law nº 11,488 of June/2007).** Contribution Suspension to the Social Integration Program and the Formation of Civil Servants’ Equity (SIP/PASEP) and Contribution for the Financing of Social Security (COFINS) in the acquisition of goods, services and leases incorporated in new infrastructures, destined for to property, plant and equipment. The benefit is valid for five years, counting from the project owner qualification.

2) **Support Program for the Technological Development of the Semiconductor Industry - SPDSI (Law No. 11,488 of June 2007).** SIP/CSE reduction and COFINS tax rates levied on the domestic sale or importation of machinery, apparatus, instruments and equipment, for incorporation in the fixed assets of the legal entity acquiring in the domestic market or of the importer, and of the intervention contribution in the economic domain of remittances destined abroad for the payment of contracts related to the exploitation of patents or the use of trademarks and those for the provision of technology and the provision of technical assistance.

3) **FINEP and BNDES.** The Financing of Studies and Projects (FINEP) and the National Bank for Economic and Social Development (BNDES) are two of the main public institutions supporting industrial projects by offering lines of credit at subsidized interest rates or non-refundable lines.

4) **Incentive Debentures (Law No. 12,431 of 2011)**. Income tax exemption of individual income related to the issuance of debentures by a special purpose company, certificates of real estate receivables and quotas of investment fund in credit rights related to the raising of funds with a view to implementing projects of investment in the area of infrastructure, or intensive economic production in research, development and innovation, considered as priorities in the form regulated by the Executive Branch. Among the projects mentioned are those destined to the generation of electric power by solar source.

5) **Investment Funds of the Ministry of Science, Technology and Innovation.** The CT-Energ Sectoral Fund provides support for technological development through funding lines for energy projects.

6) **Investment Funds of Caixa Econômica Federal.** The Bank provides resources through FINISA - Financing for Infrastructure and Sanitation, a product launched in 2012 to facilitate and expand credit granting for environmental sanitation, transportation and logistics and energy works, and use resources from the Employee's Severance Guarantee Fund - FGTS.

7) **Reduction of Income Tax.** Priority projects such as energy, implemented in the areas of operation of the Northeast Development Superintendence (NORDESU), the Amazon Development Superintendence (SUDAM) and the Center-West Development Superintendence (CEDESU) of income.

8) **BNDES Energy Efficiency.** Can be beneficiaries of this program any customers (companies, government agencies, foundations, associations and cooperatives) that require funding for buildings, with a focus on air conditioning, lighting, envelope and distributed generation. Include also cogeneration to new or existing units (retrofit), production processes, with a focus on cogeneration, using process gas as energy source and other prioritized interventions by BNDES, as well as electrical networks smart.

9) **BNDES Funtec.** Supports technological development and innovation in the areas of renewable energy, the environment and health.

10) **BNDES Climate Fund.** It supports the implementation of projects, the acquisition of machinery and equipment and the technological development related to the reduction of greenhouse gas emissions and adaptation to climate change and its effects..

11) **Discounts on the Tariff for the Use of Transmission Systems -TUST and on the Tariff for the Use of Distribution Systems -TUDS (Law N° 9,427 of 1996).** 80% discount for enterprises whose power injected into the transmission or distribution systems is less than or equal to 30,000 kW and that started operating until December 31, 2017; the discount will be 50% from the 11th year of operation of the solar plant and for projects that began operating as of January 1, 2018.

12) **Direct Sale to Consumers (Law nº 9,427, of 1996).** Permission for solar energy generators, and other alternative sources, with an injected power of less than 50,000 kW to commercialize electricity, without intermediation of distributors, with special consumers, with a load between 500 kW and 3,000 kW. In the acquisition of energy, special consumers benefit from a discount on TUDS, which encourages the substitution, as an energy supplier, of the distributor for the alternative source generator.

Demand-side financing mechanisms

1) **Agreement o. 101 of 1997 of the National Council of Finance Policy (CONFAZ):** exempt from the Tax on Circulation of Goods and Services (TCGS) operations involving various equipment for the generation of electric energy by photovoltaic cells and by wind farms; does not cover all the equipment used by solar generation, such as inverters and meters.

2) **Electric Energy Compensation System for Micro Generation and Distributed Mini Generation,** instituted by Normative Resolution No. 482, of April 17, 2012, of Aneel.

3) **"*Luz para Todos*" Program (LPT)**: installs solar panels in communities that do not have access to electric power, including in the Isolated System.

9.2 ADDITIONAL FINANCIAL MEANS AVAILABLE TO SUPPORT SME (TECHNOLOGICAL AND NON-TECHNOLOGICAL INNOVATION)

1) ***Inova Energy***. It offers differentiated conditions, and even grants, to finance innovation initiatives. Those interested can obtain resources to provide technological solutions related to photovoltaic or solar thermal generation, among other generation sources. It includes the development of technologies for the production of purified silicon solar, silicon wafers, photovoltaic cells of silicon, the development of technologies for the production of photovoltaic cells of thin films and the development of technologies and solutions for the production of inverters and equipment applied to photovoltaic systems. According to the (FINEP-BRASIL, 2018), the amount of resources made available for the entire program totaled R$ 3 billion for the years 2013 to 2016.

2) **Solar Fund.** Launched in 2013 by Institution Ideal and Grüner Strom Label (Germany's Green Electricity Seal), it offers financial support in the amount of R $ 1,000.00 to R $ 5,000.00 per project of photovoltaic micro-generation connected to the grid. According to EPE (2014), the total budget of the Fund was approximately R $ 65,000.00 in the first phase of the project.

3) **Caixa Producard**. Any JP client that needs financing of micro power generation systems - solar and wind.

4) **Caixa Construcard**. Any FP client that needs financing of solar water heating systems and micro power generation system - solar and wind.

5) **Sicredi Solar Energy**. Any PJ client associated with Sicredi who needs financing to generate electricity through solar energy.

6) **Itaú Unibanco IDB Line**. Line of credit for the financing of sustainability projects. The focus is investments in renewable energy, energy efficiency and "clean" production methods.

7) **Santander DCC Sustainable**. Any JP client that needs financing for Machinery and Equipment that promotes Energy Efficiency, Rational Use of Water, Sustainable Construction and Accessibility, Waste Treatment and Corporate Governance.

8) **Pesearch and Development (P&D)**. The objective of the P&D Program is to adequately allocate human and financial resources in projects that demonstrate the originality, applicability, relevance and economic viability of products and services in the processes and end uses of energy. It seeks to promote a culture of innovation, stimulating research and development in the Brazilian electric sector, creating new equipment and improving the provision of services that contribute to the security of

> electric power supply, modality of tariffs, environmental impact reduction of the sector and country technological dependence (ANEEL, 2018). Every P&D project should be framed within a particular theme and sub-theme. Strategic themes or sub-themes are those whose development is of national interest and of great relevance to the electric sector, involving high complexity in scientific and / or technological terms and low attractiveness for investment as an isolated or individual business strategy. In addition, they require joint and coordinated efforts of various companies and executing agencies and a large amount of financial resources. Projects in the area of renewable sources are contemplated as heliothermic generation, storage, technical and commercial arrangements for storage systems, mini generation with renewable in public institutions and others. The strategic sub-themes will be defined through Calls for Strategic P&D Projects proposed by ANEEL.

Since 2016, BNDES has been practicing a new policy in the energy sector in Brazil, increasing the participation of the TJLP loans for projects of power generation from the solar source, while at the same time establishing a reduction of its participation in projects of hydroelectric dams. In addition, the bank determines the end of support for any coal and oil thermal projects and transmission lines. In addition, international funds are available in Brazil, which aim to finance projects aligned to sustainable development, including RES projects. The BID, through its Action Plan on Climate Change, disbursed $ 390 million in Brazil in 2014 and CAF in the amount of $ 470 million (FGV, 2017).

10 SYSTEMS, TOOLS AND TECHNOLOGIES FOR THE IMPLEMENTATION PHASE

In order to achieve the goals of a green economy, Government efforts of companies voluntarily (early actions) and of society should be stepped up and become more distributed by Mato Grosso territory, with strong stimuli specific to the activities in the area of energy and exploration of its potential, especially for smaller companies.

Companies must formulate action strategies to be implemented its energy business, focusing on value chain associated with the photovoltaic solar energy segment and/or based on biomass. In this value chain the main assets (systems, tools and technologies) are the equipment and services.

Among the photovoltaic chain components, the photovoltaic modules (or cells) have the highest participation in terms of cost. Other elements, such as fittings, frames, electrical and mechanical components (sockets, inverters, transformers, circuit breakers, electrical connectors, washers, rivets, PIN, spring, shaft, bearing, transformer, circuit breaker, disconnector, station electric cables, weather etc.) represent approximately 40.0% of the total cost of equipment deployment.

The services include the supply of manpower in all activities, by supporting institutions, financial institutions (agent's financiers), consulting and engineering companies. You can include in this jail, insurers, business advice, tools and equipment distributors, project developers, system integrators, equipment vendors, publishing and publishing companies Affairs of the segment, and energy producers and distributors.

The Box 10 informs the technologies available to photovoltaic plants its characteristics and advantages.

Box 10 Photovoltaic Board technologies available in the market.

Crystalline Silicon Panels	Monocrystalline (m-Si)	- Single crystal pure silicon; - Efficiency between 14%-21%; - It occupies less space, more expensive, waste in production.
	Polycrystalline (p-Si)	- Multiple crystals; - Cheaper production than the previous one; - Lower efficiency; - Lower cost.
Thin film panels	Amorphous Silicon (a-Si)	- Consume less raw material and energy in production; - Low cost; - Less efficient.
	Copper, Indian and gallium disselenide (CIGS)	
	Cadmium Telurete (CdTe)	
Organic or Polymeric Cell Panels	- Technology in research and development phase; - Organic Semiconductor.	
Multilayer panels with concentrators	- Recent Technology (George Washington University – USA); - Concentrators (lenses) and multilayer; - Efficiency 44.5% (current plates in the world: 25% maximum; In Brazil: 17.3%); - Uses materials found in laser and infrared photodetectors;	

O **Box 11** presents the specifications of inverters available on the market and their possible applications in the economy sectors.

Box 11 Solar Inverter technologies available in the market.

TYPE	FEATURES	APPLICATION IN THE SECTOR
Solar inverter grid-tie or on-grid	- Connected to the network - No batteries - Automatic network disconnect in case of fall - Most used	- Residential and commercial
Solar inverter off-grid	- Disconnected from the network - Uses batteries - Isolated systems	- Agriculture farming (poles, transmission systems, rural residential)
Hybrids Inverter	- Connected to the network or disconnected in power outage - Uses battery bank	- Residential and commercial
String Inverter	- Series (line) modules	- Residential and commercial
Micro Inverter	- For only one plate or pair of plates - Fixed behind the plate; - Independent operation of panels (different inclinations of roofs)	- Residential
Central Inverter	- Large size and capacity; - Module Series	- Commercial, industrial (Solar plants, buildings, industries)

Source: (ELYSIA ENERGIA SOLAR , 2018).

In respect of thermoelectric plants to biomass, thermochemical conversion can be performed by direct combustion and using steam turbines or biomass gasification with gas turbines or combined cycle. These technologies are available in the country, as well as the institutions of support and engineering companies are prepared for the installation of plants, providing the chain services. **Box 12** presents combustion systems for different types of fuels.

Box 12 Forestry waste combustion technologies.

FUEL	COMBUSTION TECHNOLOGY
Wood chips and bark	Furnace with grate (Hydraulics) of movement contrary to the flow of fuel and compression cone for water cooling.
Wood chips and saw dust	Furnace with grate opposite motion fuel flow and speed control.
Wood chips and bark	Furnace with grate of bracket (Hydraulics) and compression cone for water cooling.
EN pellets, quality A1, A2 and B (industrial pellets), as well dry wood chips.	Furnace with grate and speed control, without compression cone for water cooling.
Recycled wood	Stationary combustion, mobile, with no grid fluidized bed system.

Source: (KOHLBACH , 2018).

Box 13 presents the classes description: A1, A2 and B of the pellets.

Box 13 Pellets classes.

A1	Top Quality Class - Ash content = 0.7% - Calorific power = 16.5 MJ/Kg.
A2	Pelet also good quality - Ash content = 1.2% - Calorific power = 16.5 MJ/Kg.
B	- Maximum ash content = 2.0% - Calorific power = 16.5 MJ/Kg B classes Pellet can be produced with a wider variety of raw material, including pine bark. This is intended mainly for large installations, industrial facilities.

Source: (OMNIPELLETS, 2018).

11 BENEFITS PRODUCED BY NEW RENEWABLE SOURCES

In virtually all regions and in the various economy sectors of Mato Grosso, the decentralized generation with the introduction of RES brings benefits to society and the electrical system, by increasing the supply of electricity. One of the biggest benefits to the consumer that invests in self-production is the tariff independence of the local electric power distribution concessionaire, besides the availability of electricity and the contribution to the environment. The compensation system (net metering[22]) for the possibility of injecting power in the distribution grid extends the benefits to the consumer.

In production in plants (with non-intermittent generation) near the load, independent of long transmission lines, the benefits will be accounted for in relation to system stability, reduction of overloads, reduction of failures and energy compensation reactive (NARUTO, 2017), in addition to the lower environmental impact and local development.

In the isolated systems of Mato Grosso, assisted by Diesel sources, the analysis of the benefits arising from the generation based on the biomass of forestry residues depends on the state policy of maintaining the collection of ICMS on Diesel oil at the current aliquot. Moreover, a policy of remuneration of the biomass itself in the timber market making it attractive for energy purposes.

The EPE (2016) Through Technical Note nº NT-091/2016-r0 estimated that hybrid systems with Diesel generators and photovoltaic solar energy, with the option of storing energy by means of batteries, in Amazonian isolated systems can provide:

- Economic benefit in the value of energy, in R$/MWh, despite the increase of the initial investment. In the cases analyzed by ANEEL, a reduction in the level of energy cost of the order from 5% to 8% was observed;
- Lower vulnerability in relation to eventual increases in the price of Diesel oil;
- Economy in the consumption of fossil fuels (up to 26% in the cases analyzed), providing reduction of greenhouse gas emissions; and

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[22] In the model adopted in Brazil, the injected energy compensates the energy consumed, which has a tariff established by ANEEL for each concessionaire. The electricity bill covers, in a simplified form, two installments: (i) energy and (ii) “wire”, which remunerates the networks responsible for energy transport; by the energy compensation system, energy compensation occurs not only in the energy itself, but also in the portion that remunerates the use of the transmission and distribution grids.

- Generation of knowledge in renewable systems in the Amazon region, providing technological, commercial and development of local labor 23.

Electricity generation RES can promote along the implementation of projects social and economic benefits in the generation of direct jobs and jobs throughout the supply chain:

- Design, construction and installation
- Manufacturing
- Operation and Maintenance (O&M)
- Fuel supply

For the utility of electric power, distribution and other energy producers' benefits can be obtained, still:

- Under the financial aspect: prevention of contractual fines associated with surplus energy supply contracts; Avoided capital costs associated with energy reserves in peak load situations;
- From the technical point of view: development of demand control platform to absorb the growth of solar intermitency; Platform to improve network reliability and resiliency;
- Under the strategic aspect: economic rewards with the possibility of issuing "green certificates" and reducing carbon emissions. Feasibility of partnerships with residents and community companies for collective work in the realization of programs of delivery and consumption of electricity cleaner, safer and more efficient; And
- Employments and benefits for small and medium-sized enterprises.

The Economic potential scenario (attainable market) has the capacity to increase the supply of new employments. **Table 23** presents the estimation of stations jobs[24] that can be created with a strategy of supplying energy services through renewable sources and distributed generation, in a scenario of 25 (twenty-five) years (2019-Start and 2044-end) of useful life PV system according to the model described in **Annex 9**. For the estimation of the biomass systems was considered the model of "thermal power plant for reference Residual biomass" of EPE (**Annex 10**).

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[23] The Agency stresses that "the choice of the alternatives studied should also take into account the availability of skilled labor and, given the complexity of access to localities; it becomes necessary to pay more attention to the reliability of supply of these systems". See more in NT-091/2016-r0 (ANEEL, 2016).

[24] Input-output analysis is the most appropriate methodology for more rigorous estimates of the impacts of different energy scenarios on job creation. However, this macroeconomic modeling extrapolates the purposes of this work, being the model developed perfectly suitable for the proposed objectives.

Table 23 Number of direct employments generated by the economy sector and GWh produced by renewable sources – photovoltaic and biomass of forestry residues.

SECTOR	GWh	DIRECT EMPLOYMENT GENERATED	INDIRECT EMPLOYMENT GENERATED
Residential PV	26	49	44
Commercial PV	593	1,450	1,305
Industrial PV	262	786	707
Public PV	391	1,141	1,027
Agriculture PV	333	955	860
Total Mato Grosso PV	1,605	4,381	3,943
Biomass	539	8,922 (Plant implantation)	1,308 (O&M)
TOTAL	**3,749**	**17,684**	**7,886**

Source: Author elaboration applying the informed models.

In this estimation are the opportunities in the commercial and industrial sectors that can leverage new businesses, especially small and medium-sized enterprises, and still find in the self-production of renewable energy, besides the offering of external work, Strategies to increase their activities and generate more jobs. The public sector also appears with enormous potential for impacting the renewable energy market.

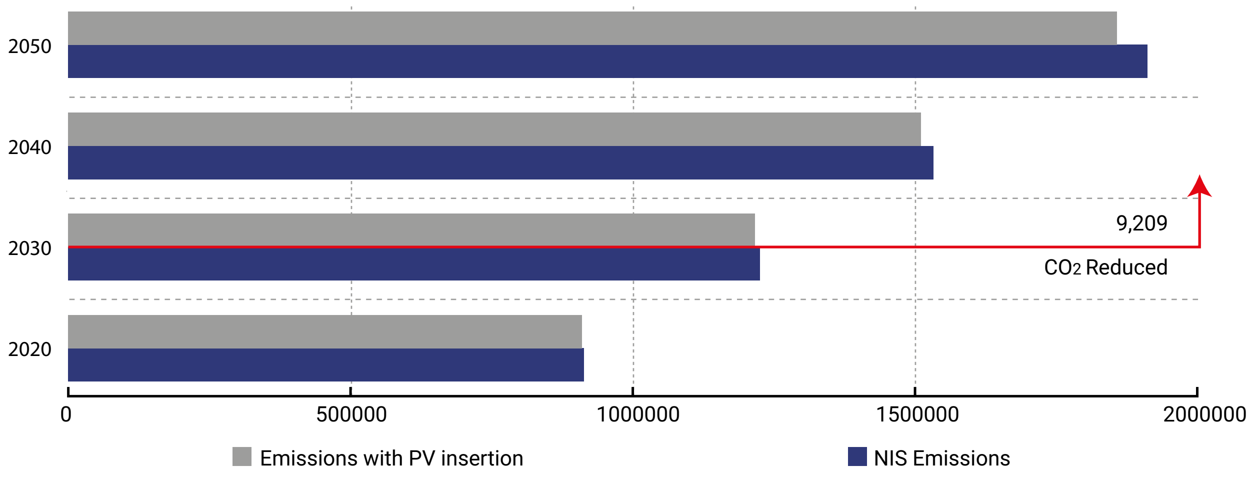
The population supplied today by the isolated system of Mato Grosso is the order of 90,000 people and, on the 2050 horizon, it is estimated that a population of 450,000 people can benefit through the deployment of renewable sources biomass-based on forestry residues and by photovoltaic systems in the north and northeast Mesoregions. The northern region, which already contributes to most of the state's GDP-36.4%-can play an even more important role in the growth of the economy of Mato Grosso, with greater internal or external competitiveness, in the production of commodities, in an accounting irreversible improvement of quality of life, quality and real progress, indicator as is the consumption of electricity by a person.

The low economic expansion of the northeast region – only 7.8% of the state's GDP – is due to the lack of energy structure, internal logistics, inadequate territorial occupation policy, etc. The increase in the supply of electricity through renewable sources in this poorly developed area can promote the availability of technologies to the processes of agriculture, services and industry, and increase the labor, improving substantially the socio-productive structure.

CO_2 reduction

Another estimated benefit is the reduction of CO_2, avoided by the containment of conventional sources, both in the interconnected system and in the isolated system, especially of Diesel oil mills in the regions considered in this work (parts of the north and northeast). **Figure 19** shows the emissions avoided over the period of implementation of the achievable market potential in Mato Grosso, until the year 2050.

Figure 19 CO_2 emissions from NIS with and without the introduction of photovoltaic energy. Unit: Ton.



Source: Elaborated through the model of (MCTIC, 2018).

To estimate benefits related to CO_2 discount in isolated systems with Diesel generation in the north and northeast Mesoregions, we consider that this fuel will still remain in the energy matrix in the horizon of 2050, with substitution effect not very significant, due to the diversity of available sources, the useful life of the installed generator Park, the development model of the most isolated regions, and the long-term projections of the Mato Grosso energy matrix itself. **Figures 20** and **21** show the emissions avoided in the 2050 horizon, with harnessing the achievable market potential.

With the gradual introduction of photovoltaic source, it is observed that they will be avoided up to 2046, 386 million tons of CO_2 in the north isolated system and 65 million in the Northeast SI, with the implementation of these plants, and considering their useful life.

Figure 20 CO_2 emissions reduction by photovoltaic production in relation to Diesel emissions in the northern region of Mato Grosso. Unit: ton.

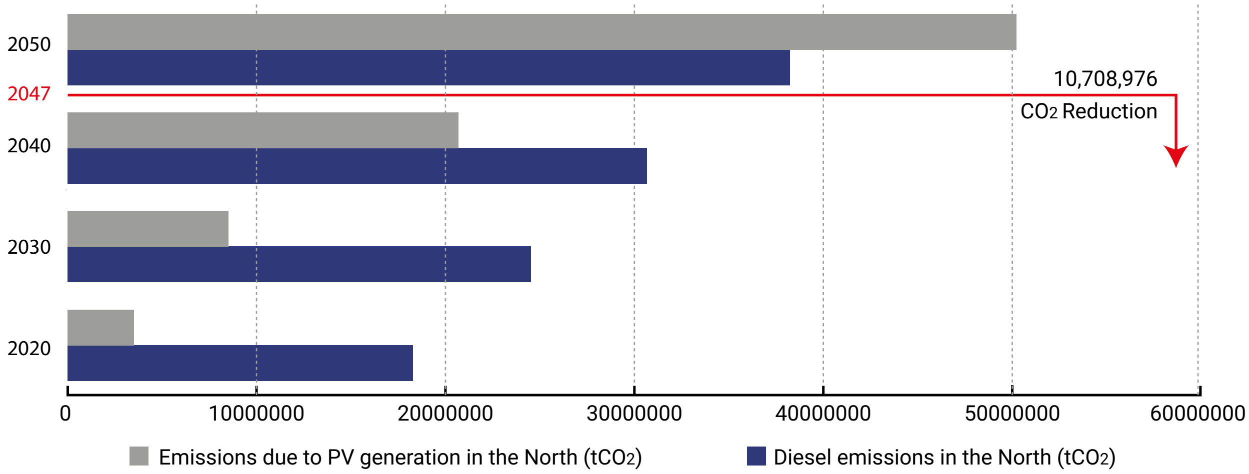
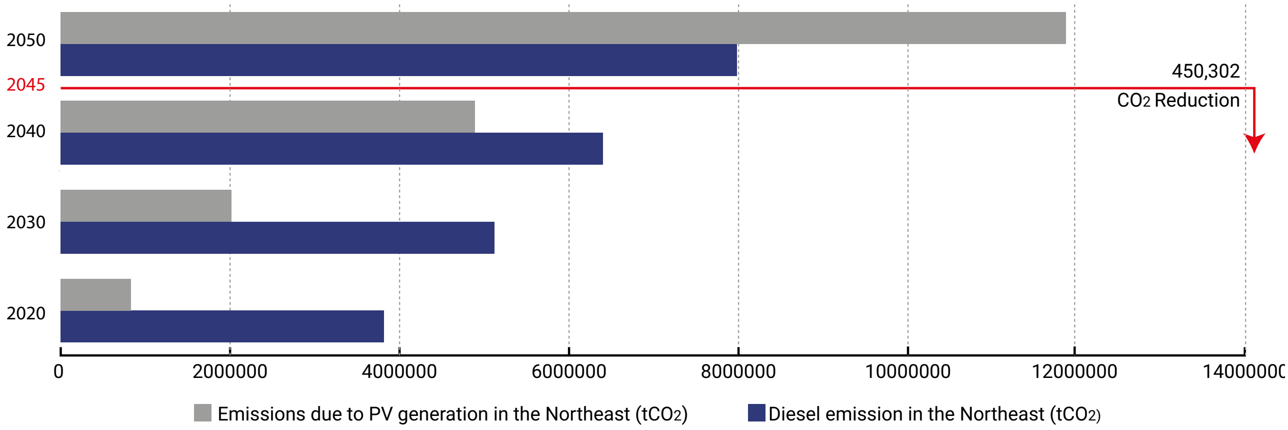


Figure 21 CO_2 emissions reduction by photovoltaic production in relation to Diesel emissions in the northeast mesoregion of Mato Grosso. Unit: ton.



12 CONTRIBUTIONS FOR RENEWABLE ENERGY POLICIES IN MATO GROSSO

The brazilian reality, and consequently of Mato Grosso, is low insertion of new renewable sources in its matrix by the absence of more robust public policies for the national industry development of distributed generation, to reduce or tax exemption and reduction of interest rates, lack of micro-generation promotion mechanisms, financing facilities, creation of a more favorable regulatory and business environment, etc.

The required balance between the public and the market instruments to effective renewable energy policies should allow for clear guidelines to support and increase the attractiveness and inclusion of these sources in Mato Grosso, defining the best strategies, considering more efficient technical and commercial models of distributed generation. This procedure benefits the consumers and overcomes the main barriers that prevent its disseminationmarket uptake in line with the environment.

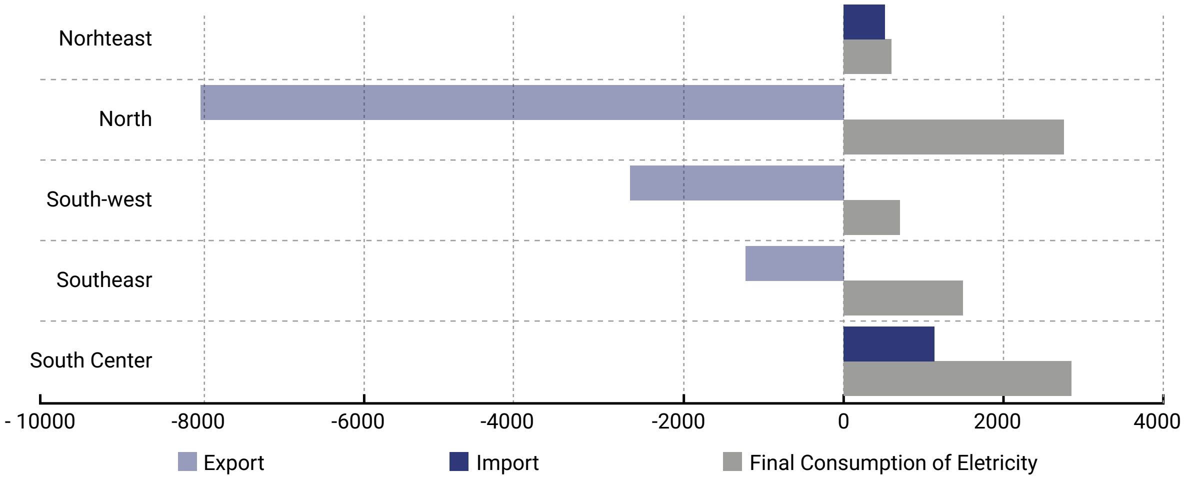
The implementation of measures/public policy depends, usually of local development goals, goals of job creation, social, environmental, etc. Combine goals and objectives for different regions inside the State matches, many times, assign disproportionate advantages and disadvantages; the task is to reconcile as much as possible, the choice of instruments of promotion to achieve homogeneous incentives at the regional level.

PROPOSED MEASUR

One of the main commitments of the Government to get the full development and well-being of the population is the installation of energy systems of production and use in poor communities, isolated, not served by mains, to support the meeting the basic social demands of mesoregions of Mato Grosso. Analyzing the **Figure 22** we note that the Northeast region imports from other regions practically all the electricity it consumes - a deficit resulting from its low production of only 1.4% of the State total.

The other State mesoregions produce electricity and they trade with each other, according to the intra-regional demands or export to NIS too, as is the case of the South Center that generates excess electricity when the Cuiabá natural gas-fired plant operates.

Figure 22 Energy imports and exports between the mesoregions of Mato Grosso, by 2017. Unit: GWh.



Under the conditions of supply and balance of the current context of energy production by photovoltaic and biomass sources, public policy should direct efforts, in large part, to the viability of micro-energy facility local production and use, promoting the supply of electricity to small producers, the cores of colonization and isolated populations.

The complementarity of decentralized renewable sources to conventional systems should be prioritized in the poorest State regions to the Northeast and the Southwest which have isolated communities and away from the largest centers through measures to increase of energy supply for the region, and lower costs by replacing fossil sources, and associated with social and economic development programs.

In the more developed regions as North, Southeast and South Center, the complementation of electric power by decentralized and/or centralized RES should be performed using individual and collective systems as well as strengthening existing networks.

Some indicators assist in this process and enable you to subsidize the formulation of public policy instruments.

1) Electricity generated by renewable sources (%) = Production by RES/total production of electricity;;

2) Total production capacity of renewable (GWh);

3) Specific consumption of electricity per inhabitant (GWh year/hab);

4) Electric intensity economic sector (GWh/Added value);

5) Total production capacity of fossil sources (GWh);

6) Electricity consumption due to the fossil sources (GWh);

7) CO_2 emissions per capita (due to all the energy sources and fossil sources); and

8) Number of measures/ incentive policies/ existing subsidies accumulated over the years.

The participation of new renewable sources is still very shy in the production of electricity in the State as shown in **Table 24** representing, in 2017, just 0.6% of the total, renewable sources face serious problems of infrastructure for its market uptake, in addition to the barriers already discussed. The North mesoregion leads investments in these sources with 98.0% of State production, with large contribution of forestry residues and biogas, and has the highest ratio of renewable production and total production of electricity. Note that, due to the characteristics of each State region, the evolution of the indicator PNR/P can direct incentives to renewable sources.

Table 24 Electricity production by renewable sources in State of Mato Grosso's mesoregions by 2017.

MESOREGION	TOTAL PRODUCTION (P) GWh	PRODUCTION OF NEW RENEWABLES (PNR) GWh	INDICATOR PNR/P %
South Center	1,945.2	1.2	0.06
Southeast	2,972.6	0.2	0.01
Southwest	3,008.9	0.5	0.02
Northeast	283.10	0.4	0.14
North	11,858.0	116.8	0.98
MATO GROSSO	**20,067.7**	**119.1**	**0.59**

Under these conditions, the installed capacity of RES to the Mato Grosso state must be planned according to a portfolio of generation (resource adequacy) determining the degree of flexibility required by electrical system considering the penetration rate of sources renewable. Must disaggregate the level of ability required according to the existing capabilities in the State different regions, considering their attributes (technical, environmental, geographic, socioeconomic, political, infrastructure). In this way, the programmes proposed would have correct targeting of the sources its potential, would have provided second the right incentives, overcoming more feasible barriers, resistors and bottlenecks, and would respond to the specificities of each region and its local model of development.

This planning is the main part of the public policies to be implemented and should be based on the integration of energy resources. This model provides a triad of benefits:

1) Development of backward regions (e.g: application of resources and promotion of renewable initiatives with benefits of reducing poverty; provides energy services to people without access, in geographically dispersed areas);

2) Establishment of a model of regional and social integration; and

3) Adjustment of the industrial society to the resources limits.

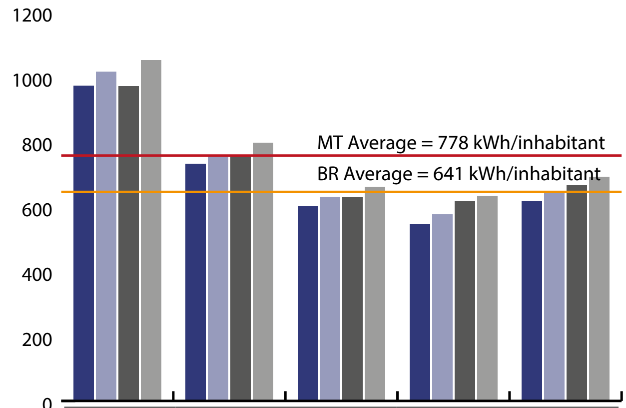
In addition, allows you to find the continued great achievement, over time, in the short and in the long run, with balanced analysis of socioeconomic factors. This model is indicative and decentralized, and coexists with the various forms of power generation (with different cost and risk), including the Government objectives and society regarding the energy matrix composition and regional distribution of the population.

SPECIFIC CONSUMPTION INDICATORS AND ELECTRIC INTENSITY

The specific consumption is an indicator that can assist in the formulation of energy policies, being a technical coefficient of relationship between energy consumption and independent variables relevant as the behavior and habits, efficiency in use, and allows better understanding and prediction of energy demand. Thus, it is possible to obtain a quantitative description, based on measures or physical quantities, which can derive to final uses (lighting, heating, cooling, driving force, etc.), which allows to know in detail the characteristics of the market consumer (technologies, consumer habits etc.) and, therefore, assess the need for new resources to particular region.

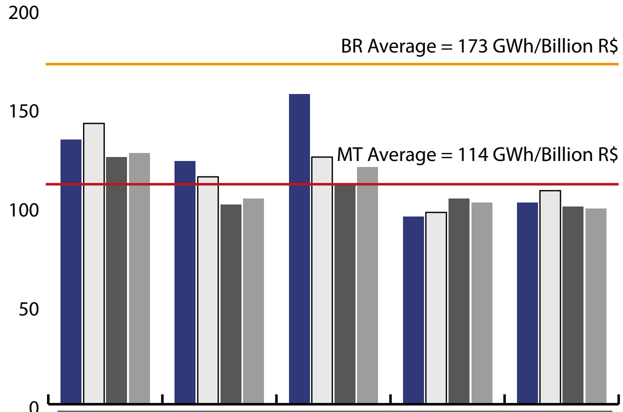
Figure 23 shows an evolution comparison of the specific residential consumption of electricity for the five mesoregions of the State of Mato Grosso in the period 2014 to 2017. From the perspective of planning, there are significant differences in the evolutions and that the consumption of electricity intraregional level is still far from reaching the average *per capita* consumption level of Mato Grosso, although this is still higher than that of Brazil. The specific consumption of residential electricity in the South Center mesoregion, 1050 kWh/inhabitant in 2017, is 1.7 times higher than that of the Northeast mesoregion, due to the region development conditions, far above the average specific consumption of Mato Grosso. The North mesoregion, with practically the same population as the South Center meso, presents a order specific consumption of 691 kWh/inhabitants in 2017, 35.0% lower than that of the South Center meso. In this case, not only the population habits or the technological efficiency of the processes explain this low specific consumption, but a socioeconomic condition of the families majority. With a growing tendency, the average amplitudes in the four years of the Southwest and Northeast mesoregions did not exceed 629 kWh/inhabitants and 592 kWh/inhabitants, respectively, 80.0% and 76.0% of the average specific state consumption.

Figure 23 Evolution of the residential electricity specific consumption in the mesoregions of Mato Grosso in the period from 2014 to 2017. Unit: kWh/inhabitant



	SOUTH CENTER	SOUTHEAST	SOUTHWEST	NORTHEAST	NORTH
■ 2014	971	730	599	546	616
■ 2015	1014	755	629	575	643
■ 2016	969	755	627	616	664
■ 2017	1050	795	660	632	691

Figure 24 Evolution of the mesoregions electric intensity of Mato Grosso in the period from 2014 to 2017.
Unit: GWh/R$ billion (2007).



	SOUTH CENTER	SOUTHEAST	SOUTHWEST	NORTHEAST	NORTH
■ 2014	134	123	157	95	102
■ 2015	142	115	125	97	108
■ 2016	125	101	111	104	100
■ 2017	127	104	120	102	99

Another analysis, disaggregated not in energy end uses, but important, which supports the development of policies, seeks to correlate the electricity consumption with GDP – the electric intensity. This indicator, monetarized, when decomposed, tries to reduce passive reflections of phenomena that are intended to summarize, and explains that, as is the economic growth, the variation of the electric energy consumption (energy content effect) and own participation of every economy sector (activity effect) in economic product change, and these changes influence the evolution of energy consumption. The variation in sectoral energy consumption may still reflect a "structure effect" which signals the change in energy consumption based on the observed change in the participation of the sector considered in the formation of GDP. In the case of the economic sector, the Added Value (AV).

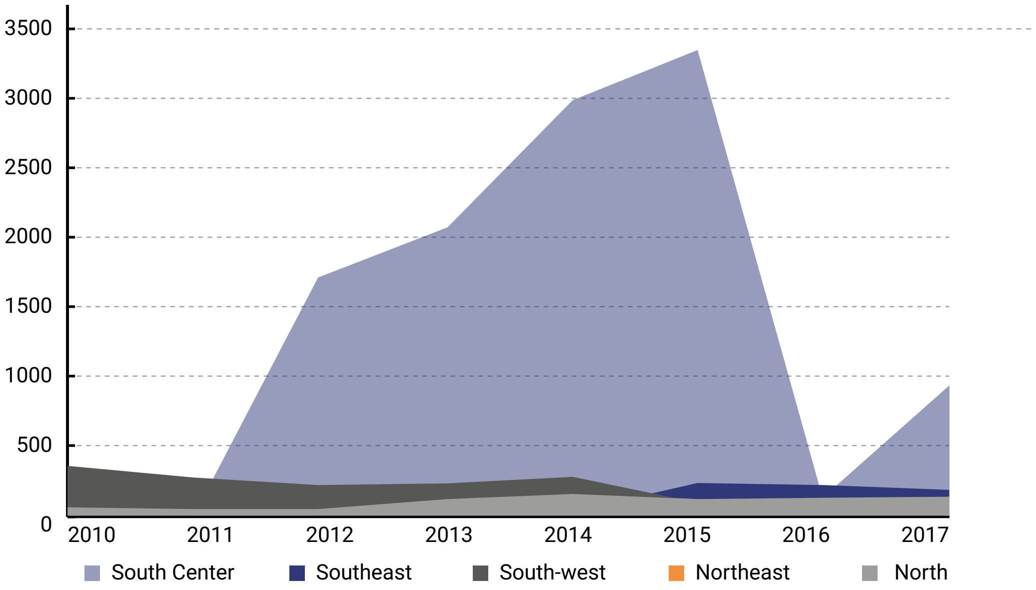
Generally, **Figure 24** shows the electric intensity evolution, with only the energy content, of the Mato Grosso mesoregions in the period from 2014 to 2017. There are two main drivers in the evolution of this indicator among the Mato Grosso mesoregions: i) social issues, including human and human development and economic and the quality of life; and (ii) environmental issues, which are obviously linked to the biomes in which populations are present. Thus, we can see a certain stability in the indicator for each mesoregion in the analyzed period, clearly showing that the South Center meso presents the highest variation, 15.0% higher than the Mato Grosso average, with a more energy-intensive socioeconomic profile. The meso Northeast has an average 11.0% higher than the Mato Grosso average, motivated by the AV positive rate and reduction of the energy content. The Southeast and Northeast regions have similar electric intensities in the last two years, in the order of 102 GWh/billion R$ with different profiles: the first one with a higher energy content and almost triple the Northeast AV, and this, with greater variation in this effect in the period.

An instrument for effective energy policy is measuring this indicator annually for all State mesoregions and/or economy sectors, and use, with greater accuracy of analysis, structural decomposition. The “effect of energy content” Efi/AVi, which indicates energy efficiency improvements (conservation of the technical processes used); the “effect of structure” AVi/GDP, indicating the consumption changes due to economic product participation variations of the given sector i (AVi) in the total economy (GDP); and the “effect of activity” GDP, which indicates the variation of energy consumption relative to the observed change in the level of global economic activity.

FOSSIL FUEL ELECTRICITY PRODUCTION CAPACITY INDICATOR

The production of electricity by fossil fuels in Mato Grosso is carried out mainly through natural gas at the Cuiabá Thermoelectric Power Plant, in the South Center State mesoregion, when the energy supplied by the Bolivian import is offered. **Figure 25** shows the evolution of production in the last eight years by mesoregion, indicating a strong oscillation throughout the historical series, when, in 2015, natural gas accounted for 87.0% of production. Connected to NIS, most of the Mato Grosso system participates in the hydrothermal supply dynamics and is subject to the methods of accounting for the produced/required electric energy and the effects of the necessary balance of this relation and the reservoirs water balance. In the isolated systems (parts of North and Northeast mesoregions) the production by fossil fuels has been accomplished through the burning of Diesel oil.

Figure 25 Electricity production by fossil sources in the mesoregions of Mato Grosso from 2010 to 2017. Unit: GWh.



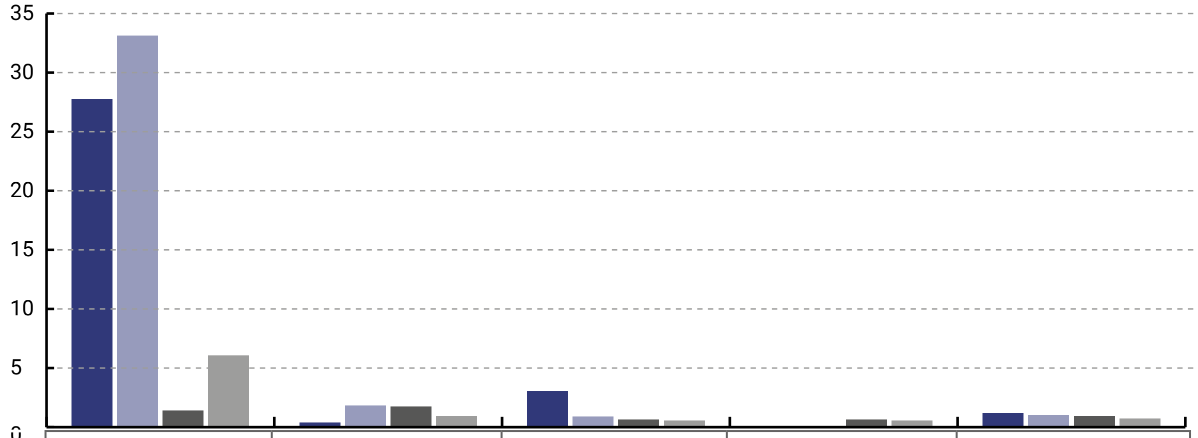
ELECTRIC INTENSITY AND THE “ENERGY CONTENT EFFECT”

The consumption of electricity via fossil fuels, which is conditioned to the prices of oil and oil products and the mode of road transport, gain two important components of analysis on the “energy content effect” previously seen - the “conservation effect” or “effect of scale” and “ substitution effect”. In the first one, it is necessary to observe, during the period, the energetic participation in the consumption of electricity of fossil origin in relation to the total consumption of electricity produced by all the sources (CEcfi/VAi) and (CEtfi/VAi). The difference between the “content effect” measured for the fossil fuel CEcfi/VAi and the “conservation effect” is the participation displacement measure of the fossil energy in the sources total, called the “substitution effect”.

Where: CEcfi is the consumption of electricity from fossil sources in sector i;
AVi is the aggregate value of sector i;
CEtfi s the consumption of electricity due to all sources in sector i.

Figure 26 shows the variation in the energy content of fossil fuel share in the Mato Grosso mesoregions, indicating drastic changes in the South Center mesoregion due to the natural gas production oscillation. In other regions, the amplitudes vary more depending on the economy, relative prices of goods, and where the North and Northeast mesoregions stand out.

Figure 26 Energy content effect on fossil sources in mesoregions of Mato Grosso. Period from 2014 to 2017. Unit: GWh/billion R$ (2007).



	SOUTH CENTER	SOUTHEAST	SOUTHWEST	NORTHEAST	NORTH
2014	27.77	0.37	3.06	-	1.20
2015	33.13	1.83	0.88	-	1.04
2016	1.40	1.76	0.66	0.66	0.94
2017	6.05	0.96	0.58	0.57	

THE ELECTRIC INTENSITY AND THE “SCALE EFFECT”

The scale effect behavior in the South Center mesoregion depends closely on the thermoelectric generation of natural gas, **Table 25**, which, however, has a substitute for this fuel, not compromising the energy consumption, when the “gas” input is reduced or zeroed, unlike other regions that have isolated communities subject to the supply of Diesel oil without substitute energy. This occurred clearly in the Northeast mesoregion in the years 2016 and 2017.

In relation to the effect of substitution in **Table 25**, says that fossil fuels remain present throughout the period, composing the energy matrix, with a replacement “apparent” in the year 2017 the intensity is less in four regions, and with great amplitude in the South Center region.

Table 25 Scale effect - share of fossil sources in the consumption of electricity by mesoregion of Mato Grosso in the period from 2014 to 2017..

MESOREGION/YEAR		2014	2015	2016	2017
South Center	GWh	572	655	30	135
	%	21	23	1	5
Southeast	GWh	5	23	24	14
	%	0	2	2	1
Southwest	GWh	16	5	4	3
	%	2	1	1	0
Northeast	GWh	0	0	4	3
	%	0	0	1	1
North	GWh	30	25	24	20
	%	1	1	1	1
TOTAL MATO GROSSO	**GWh**	**622**	**708**	**86**	**176**
	%	**24**	**27**	**5**	**7**

CO_2 EMISSIONS

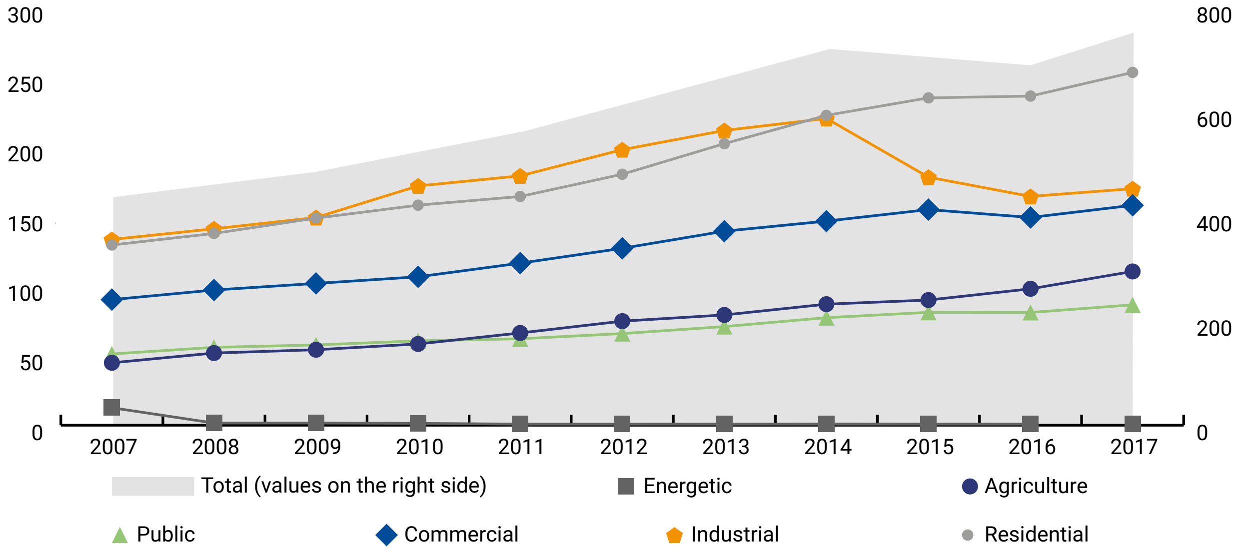
The IPCC Report released in October 2018 expresses the urgent need to limit global warming to 1.5 ° C in order to avoid severe environmental and socioeconomic impacts (IPCC, 2006). The monitoring of net greenhouse gas emissions is an important part of this process and the goals to be achieved realistically by the countries in the Paris 2015 Agreement should incorporate the energy sector with increased insertion of renewable sources.

Brazil undertook, under the Paris Agreement, to reduce emissions by 37% in relation to the levels from 2005 until 2025, and until 43% for 2030. The replacement of fossil fuels by renewables is one of the most important contributions to emissions mitigation.

Per capita emissions are indicators that must first be monitored as a decarbonisation factor of the economy, after as a factor to generate more jobs, possibility of replacement of sources by advanced technologies and increase of energy security; besides allowing monitoring of public policies related to climate change. For comparison purposes, the indicators relate to emissions from all sources and fossil sources.

Figure 27 shows CO_2 emissions on the energy consumption in the NIS in Mato Grosso in sectors of the economy in the period 2007 to 2017. The evolution of emissions indicates that the residential sector is responsible for most of the total (33.0%), growing at a rate of 6.0%, followed by the industrial sector, representing 22.0% of total of nearly 780,000 tCO_2/MWh.

Figure 27 CO_2 emissions related to the consumption of electricity in the NIS in Mato Grosso in the economy sectors from 2007 to 2017. Unit: $tonCO_2$/MWh.



In this way, the indicator is used to estimate and plan the scale of substitution of fossil sources according to the international commitments of mitigation of GHG emissions, the adaptations to the effects of the climate changes and the fulfillment of goals together with the rest of the country. Mato Grosso already has a larger share of primary energy from hydropower in its electric matrix, with significant comparative advantages (emissions from the energy sector, according to **Figure 27**, has not exceeded 2,200 tCO_2/MWh per year on average - 0.3% of the total); but sources such as natural gas will continue to contribute to most emissions. A policy directed towards a massive insertion of renewable sources can balance this situation, since it is not possible to dispense large thermoelectric plants in the NIS.

NUMBER OF MEASURES/INCENTIVES POLICIES/EXISTING ALLOWANCES ACCUMULATED OVER THE YEARS

It is the indicator that expresses the public and private efforts in the search for greater stimulus to the use of renewable energy resources, competition and economic efficiency in this important sector and to allow an energy transition - based on fossil fuels for renewables - as sustainable as possible, ensuring first of all the public benefit.

In this way, the indicator demonstrates the incorporation and advancement of programs and the role maintenance of public policies regarding collective benefits and, when possible and available, their results for the population, indicating areas of public interest, income from investments , the beneficiaries, the options by sources, the levels of subsidies by sources and by sector of the benefited economy; and also makes it possible to induce the development and dissemination of renewable energy in the various layers of society.

Other public interventions are necessary for the viability and adoption of new renewable sources of energy and adequate use of potentials.

On the supply side

1. Creation of funds to finance projects with biomass. The funds would be used to build new small and medium-sized plants and purchase machinery.
2. Priority funds, according to demand, for SMEs that produce forestry residues with difficulties to obtain financing due to lack of guarantee should be prioritized in specific programs for projects of independent production of electricity.
3. Promotion of a mandatory mechanism for the use of forestry residues as “greening” policy part of the energy matrix and the regional economy and as a reaction to the high carbon intensity in the Mato Grosso energy consumption mirrored in the demand for oil products products. It is hoped, therefore, to reduce electricity costs in distant regions, due to the significant decrease of imported Diesel oil.
4. Encouraging the creation of small cooperatives of small producers of the wood chain, with the support of municipal governments, to join small and medium-low-cost projects with known and dominated technologies, establishing standard plants for the state different regions, especially in those with low charge density.
5. Establishment of partnership programs, with governmental promotion of research and development, among universities, the agriculture-forestry sector, energy companies, component producers, municipal governments, etc.), bringing together knowledge and skills that can identify the appropriate technologies and the its economic potential aiming at scale gains in the insertion of renewable sources.

6. There is a need for incentive programs that improve the sector performance in terms of technological innovation, that is, public policies that translate into investment in technology to reduce the cost of production, with the drop-in price per kWh, to make compared to the economies of competing sources scale, thus allowing a greater price competitiveness in the auctions of alternative energies.
7. Promotion of programs with teaching and training entities such as SENAI for the training of human resources and the development of technologies and national industries essential to the operational continuity of the systems to be implemented.
8. To consolidate the creation of the Mato Grosso Technological Pole, with one of its objectives being support for innovation in the area of renewable energies focused on local potential and the environment.
9. State Energy Council Reactivation within the scope of the Government Secretariat to play the role of emanating public policy proposals, receive evaluations and criticisms, and define the medium - and long-term goals and guidelines. The Council should be the forum for energy discussions with the participation of government bodies and private entities, with an indispensable seat of the State Agency for the Regulation of Delegated Public Services - AGER and state-related energy.

On the demand side

1. To expand the energy base with new renewable sources, energy auctions must be structured so that there are no privileges between sources and offer prices that are commensurate with the costs of each technology. Projects that guarantee greater process efficiency in the generation of electric energy, using renewable energy, could be a way to reduce the cost per unit produced and thus guarantee the supply of electricity.
2. The net-metering model established by ANEEL Resolution n° 482/2012 is the main policy to encourage the generation of distributed generation in the country. At the moment of insertion of the distributed generation in the energy matrix, the need to maintain the compensation incentive is also recognized for the share of the tariff corresponding to the costs of using the networks; in this situation the adoption of a more efficient system in which the compensation for the energy injected into the network occurred only in the portion of the tariff corresponding to the energy consumed, passing the consumers with micro or mini generation to bear the portion of the tariff corresponding to the use of the wire, would make investment in photovoltaic energy less attractive. With the gradual evolution of these sources, new policies on the remuneration of networks used by micro and mini generators and cross subsidies produced on consumers who did not invest in RES in the same concession area are required.

3. There is a need to review the federal taxes levied on electricity tariffs, PIS/Pasep and COFINS. There was a significant advance with the publication of Law N° 13,169, of 2015, which determined its collection on the net consumption of consumer units, but the exemption granted does not cover the recent changes promoted in ANEEL regulations through Resolution N° 687 of 24 of 2015, which allowed for compensation for condominiums (multi-consumer enterprises) and consortia or cooperatives (shared generation). The project of law Conversion n° 29, of 2016, included a device that promoted such adjustment, so as to exempt from the collection of taxes the portion of energy consumed equivalent to that injected into the network by condominiums or by consortia. However, this device was vetoed by the President of the Republic, and the veto has not yet been appreciated by the National Congress. It is recommended that such a veto be rejected by Congress.

4. Official banks should create credit lines with more favorable financing conditions for the purchase of photovoltaic systems. An important contribution to the diffusion of renewable sources is in the law that is negotiated in the National Congress that facilitates the acquisition of photovoltaic solar generation equipment - the project of law Senate (PLS) nº 371, of 2015, authorizing the use of (FGTS) for the acquisition and installation of equipment for the generation of electric energy from renewable sources in homes.

13 CONCLUSIONS

Regarding implementation of a green economy program in the state of Mato Grosso, and truly transitioning to a low-carbon economy, renewable sources play a fundamental role in the energy needs of society. In this work, we conducted a study evaluating the technical and economic potential of the new renewable solar photovoltaic sources and based on the biomass of forestry residues for the state of Mato Grosso, seeking to subsidize programs and public policies in this related to measures for regional development.

Following a national trend, Mato Grosso, with a large attainable market potential, is increasing its supply of these sources, notably the photovoltaic, but still faces difficulties related to the costs of systems, financing and rates of Interest and competitive prices with other sources, in addition to several technical bottlenecks in the distribution grids of their counties. The technical and economic potentials (market and market achievable) found and the economic-financial simulations of projects carried out reaffirm the viability of the potential of photovoltaic sources and biomass of forestry residues.

The identification of market potential and attainable market potential for photovoltaic solar energy offers a vision of the possibility of implementing projects in the short, medium and long term. As well as for energy based on the biomass of forestry residues, determining the existing potential considering the isolated systems and the potential of the interconnected system area. The achievable market potential is quite significant, in a moderate scenario of distributed generation market entry in the state. Adherent to the base scenario designed by (EPE, 2016) For the forecast of the dissemination of photovoltaic sources in Brazil (new policies), were considered electricity markets in the 2050 horizon for all economy sectors, emphasizing that the potential is very dependent on the business models adopted by the entrepreneur.

The most viable scenario in the short and medium term for biomass is the potential use in the isolated systems. But, this needs urgently diligent government interventions to ensure the success of public policies designed to remove barriers and difficulties in relation to the "complexity of forest and energy issues, especially in relation to the management of native forests in the Amazon region and the substitution of Diesel generation in the IS" (EPE, 2018). In the NIS, the potential obtained refers to the electric generation with residual woody from industrialization of wood in log from planted forests.

The results obtained show that the Mato Grosso has presented strong evolution in photovoltaic plants, from the order of 9,000.0% between 2015 and 2018. With an expressive potential for all economy sectors, this estimated potential points to an important point of the photovoltaic generation in the next decades, reaching an installed capacity of 5.6 GWp in 2050. With the adopted premises, where this technology is feasible in this quantity, also in function of new and favorable public policies, can be generated 1.01 GW medium, which would correspond to 42.0% of the projected total electricity demand in that year. For the biomass, the electricity production in the Isolated Systems can jump from 5 GWh to 539 GWh in the long term if all the potential of waste of the area of effective forest management in the IS of Mato Grosso was carried out.

In order to accomplish this potential, an integrated planning of energy resources is indispensable, which, in unison with environmental planning, water resources and regional development, ensures the adapting of the development of renewable sources, considering the intraregional differences of Mato Grosso. In these circumstances, what has been dealt with in this work makes it clear that there is plenty of room for effective policies to increase the attractiveness of investments in this area – this is especially true for forest-based biomass-, and provide the necessary support for the integration of variable renewable energies into the electrical system.

There are evidences that the solar and biomass generation sources are viable in several economy sectors with tariff parity of conventional electricity, financial return or reward of plants to their owners and continuous changes in regulatory conditions. But there is much to do, as presented in this work, so that these sources become the first option as supply resources in the State different regions, with implementation of public policies and measures associated with local development objectives, employment, social and environmental goals.

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ANNEXES

ANNEX 1 PHOTOVOLTAIC PLANTS INSTALLED IN MATO GROSSO FROM 2015 TO 2018 BY SECTOR OF THE ECONOMY. MESOREGION AND THEIR RESPECTIVE CAPACITY INSTALLED.

PHOTOVOLTAIC PLANTS IN MATO GROSSO										
SECTOR	INSTALLED QUANTITY				Total Plants	INSTALLED CAPACITY (kW)				Installed Capacity Total
	2015	2016	2017	2018		2015	2016	2017	2018	
Commercial	**5**	**23**	**57**	**199**	**284**	**100**	**403**	**1,486**	**5,283**	**7,272**
South Center	3	14	19	69	105	52.2	297.9	682.3	1,723.9	2,756.3
Northeast	1	1	9	15	26	1.5	7.3	194.9	489.3	692.9
North		5	17	77	99		84.4	399.3	2,028.0	2,511.7
Southeast	1	2	3	17	23	46.0	8.1	22.3	407.9	484.4
Southwest		1	9	21	31		5.0	187.3	634.0	826.3
Industrial	**1**	**8**	**18**	**49**	**76**	**5**	**275**	**169**	**890**	**1,339**
South Center		6	9	9	24		259.9	65.9	78.6	404.4
Northeast	1		2	5	8	5.1		20.8	30.9	56.7
North		2	1	14	17		15.1	40.0	388.9	444.0
Southeast			4	13	17			26.3	249.9	276.2
Southwest			2	8	10			16.0	141.9	157.9
Public	**0**	**1**	**2**	**7**	**10**	**0**	**29**	**19**	**641**	**688**
South Center			1	2	3			15.6	335.0	350.6
Northeast				1	1				70.2	70.2
North		1	1	2	4		28.6	3.0	140.2	171.8
Southeast										
Southwest				2	2				95.2	95.2
Residential	**7**	**77**	**194**	**567**	**845**	**31**	**514**	**1,320**	**4,124**	**5,989**
South Center	5	36	83	167	291	20.1	272.9	582.09	1,149.5	2,024.6
Northeast	1	6	24	48	79	1.5	20.5	117.48	285.1	424.7
North		25	57	205	287		151.3	431.87	1,712.7	2,295.8
Southeast		4	15	83	102		37.5	103.80	497.3	638.6
Southwest	1	6	15	64	86	9.6	31.4	85.15	479.1	605.3
Agriculture	**1**	**4**	**12**	**37**	**51**	**900**	**24**	**570**	**3,118**	**1,752**
South Center		2	2	3	7		2.7	7.5	134.0	144.2
Northeast			1	3	4			3.0	92.0	95.0
North	1	1	7	23	29	900	17.0	480.1	2,640.0	1,177.1
Southeast		1	1	3	5		4.6	7.5	98.80	111.0
Southwest			1	5	6			72.0	152.7	224.7
TOTAL	**14**	**113**	**283**	**859**	**1,269**	**1,037**	**1,244**	**3,564**	**14,055**	**19,899.8**

ANNEX 2 NUMBER OF PHOTOVOLTAIC PLANTS INSTALLED IN MATO GROSSO FROM 2015 TO 2018 BY MESOREGION AND WITH THEIR RESPECTIVE MODALITY OF GENERATION AND USE. PLANTS HOMOLOGATED BY ANEEL*.

	MESOREGIONS											
	SOUTH CENTER		NORTHEAST		NORTH		SOUTHEAST		SOUTHWEST		TOTAL	
	Total Plants	Installed power (kW)	Total Plants	Installed power (kW)	Total Plants	Installed power (kW)	Total Plants	Installed power (kW)	Total Plants	Installed power (kW)	Total Plants	Installed power (kW)
Distributed generation												
Self-consumption Remote	41	810.6	21	357.3	32	649.3	11	143.4	19	430.6	**124**	**2,391.3**
Shared Generation	1	3.0			2	87.8					**3**	**90.8**
Generation in the CoU	388	4,866.5	97	982.2	402	5,863.3	136	1,366.8	116	1,478.9	**1,139**	**14,557.6**
Centralized Power Plants					**3**	**2,860.0**					**3**	**2,860.0**
GRAND TOTAL	**430**	**5,680**	**118**	**1,340**	**439**	**9,460**	**147**	**1,510**	**135**	**1,909**	**1,269**	**19,899.8**

* The plants installed in Mato Grosso do not have certification. They are homologated by ANEEL - National Electricity Agency. according to the rules cited below. Note: CoU: Consumer Unit (end user).

The procedures. standards for the installation of photovoltaic systems in Energisa MT. in accordance with the Normative Resolutions of the National Electric Energy Agency - ANEEL are as follows:

- NDU 001
- NDU 013
- NDU 019
- NDU 020

Source: Energisa MT. 2018. Website: <https://www.energisa.com.br/>. Consulted in October/2018.

1. Requirements for equipment certifications:

Certifications assists manufacturers and importers of Solar Panels (Photovoltaic Panels) and equipment that are part of the system (Load Controller. Inverter and Batteries) in the certification and granting of registration before INMETRO according to Ordinance N° 004. of January 4. 2011.

- **Standards for testing photovoltaic modules:**

  a) IEC 61215 - Crystalline Silicon Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval (Photovoltaic modules of crystalline silicon)

  b) IEC 61646 - Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval (thin film photovoltaic modules)

- **Standards for tests on Load Controllers:**

  There are no standards. only established references that the load and discharge controllers when submitting must support.

- **Standards for testing inverters for autonomous photovoltaic systems:**

  There are no standards. only established benchmarks that the investors when submitting must bear.

- **Inverter testing standards for grid-connected photovoltaic systems:**

  ABNT NBR 16149: 2013. ABNT NBR 16150: 2013 and ABNT NBR IEC 62116: 2012 must be used.

- **Standards for battery testing:**

  The standards and sequence of procedures for battery testing are as follows:

  a) NBR 14200 - Ventilated stationary lead-acid accumulator for photovoltaic system - Tests

  (b) NBR 14201 - Stationary Nickel-Cadmium Alkaline Accumulator - Specification

  (c) NBR 14202 - Stationary nickel-cadmium alkaline accumulator - Testing

  d) IEC 61427 - Secondary cells and batteries for photovoltaic energy systems (PVES) - General requirements and methods of test

2. Certification requirements for installation of PV systems:

  - Safety certificate for works with low and medium voltage basic electrical energy - NR10
  - Safety certificate for basic height work - NR35

These are a mandatory requirement of the Ministry of Labor for 100% of the work performed by PV installers.

Source: <https://www.trabalho.gov.br>. Consulted in October / 2018.

ANNEX 3 COMPANIES THAT OPERATE IN MATO GROSSO. BY 2018. IN THE LUMBER MILLS SECTOR.

MESOREGIONS	FORESTRY PRODUCTION PLANTED FORESTS									FORESTRY PRODUCTION NATIVE FORESTS							
	SMALL							ME-DIUM	TOTAL	SMALL							TOTAL
	0	1-4	5-9	10-19	20-49	50-99	0-99	100-249		0	1-4	5-9	10-19	20-49	50-99	0-99	
South Center	8	18	10	5	1	1	43	0	43	0	3	0	0	0	0	3	3
Southeast	2	21	8	3	1	0	35	0	35	0	1	0	1	0	0	2	2
Southwest	2	11	4	2	4	1	24	1	25	0	4	0	1	0	0	5	5
Northeast	0	2	2	0	1	0	5	0	5	1	0	1	0	0	1	3	3
North	8	37	6	7	4	1	63	0	63	20	89	30	6	4	0	149	149
TOTAL	20	89	30	17	11	3	170	1	171	21	97	31	8	4	1	162	162

MESOREGIONS	WOOD SCROLLING									MANUFACTURE OF LAMINATED WOOD AND SHEETS OF PLYWOOD. PARTICLE BOARD AND AGGLOMERATED								
	SMALL							ME-DIUM	TOTAL	SMALL							ME-DIUM	TOTAL
	0	1-4	5-9	10-19	20-49	50-99	0-99	100-249		0	1-4	5-9	10-19	20-49	50-99	0-99		
South Center	1	3	2	0	1	2	9	0	9	0	1	0	1	0	0	2	1	3
Southeast	1	0	1	1	1	0	4	0	4	0	1	0	2	0	0	3	0	3
Southwest	2	3	2	0	2	0	9	0	9	0	0	1	0	0	0	1	0	1
Northeast	0	7	1	2	0	0	10	0	10	0	1	0	0	0	0	1	0	1
North	47	234	141	174	77	10	683	3	686	2	14	6	10	13	2	47	1	48
TOTAL	51	247	147	177	81	12	715	3	718	2	17	7	13	13	2	54	2	56

MESOREGIONS	MANUFACTURE OF WOODEN STRUCTURES AND CARPENTRY FOR BUILDING							MANUFACTURE OF COOPERAGE AND ARTIFACTS OF WOOD PACKAGING					MANUFACTURE OF WOODEN ARTIFACTS. STRAW. CORK. BASKETWARE AND BRAIDED MATERIAL NES. EXCEPT FURNITURE							MANUFACTURE OF BRUSHES. BRUSHES AND BROOMS	
	SMALL						TOTAL	SMALL				TOTAL	SMALL						TOTAL	SMALL	TOTAL
	0	1-4	5-9	10-19	20-49	0- 49		0	1-4	5-9	0-9		0	1-4	5-9	10-19	20-49	0-49		0-4	
South Center	2	6	3	2	1	14	**14**	0	0	3	3	**3**	**1**	**7**	**3**	**0**	**0**	**11**	**11**	2	**2**
Southeast	1	1	3	0	0	5	**5**	0	0	0	0	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**2**	1	**1**
Southwest	2	2	1	0	0	5	**5**	0	1	0	1	**1**	**1**	**2**	**0**	**0**	**0**	**3**	**3**	0	**0**
Northeast	0	1	0	0	0	1	**1**	0	0	0	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	**0**
North	6	26	9	14	6	61	**61**	1	2	1	4	**4**	**2**	**22**	**9**	**6**	**1**	**40**	**40**	1	**1**
TOTAL	**11**	**36**	**16**	**16**	**7**	**86**	**86**	**1**	**3**	**4**	**8**	**8**	**4**	**33**	**12**	**6**	**1**	**56**	**56**	**4**	**4**

MESOREGIONS	SUPPORT ACTIVITIES FOR FORESTRY PRODUCTION									TOTAL								
	SMALL							ME-DIUM	TOTAL	SMALL							ME-DIUM	TOTAL
	0	1-4	5-9	10-19	20-49	50-99	0-99	100-249		0	1-4	5-9	10-19	20-49	50-99	0-99	100-249	
South Center	1	8	2	0	1	0	12	0	**12**	13	48	20	8	4	3	99	1	**100**
Southeast	0	0	0	0	1	0	1	0	**1**	4	27	12	7	3	0	53	0	**53**
Southwest	0	2	1	1	1	0	5	0	**5**	7	25	9	4	7	1	53	1	**54**
Northeast	0	1	0	0	0	0	1	0	**1**	1	12	4	2	1	1	21	0	**21**
North	7	33	12	7	5	1	65	1	**66**	93	458	205	224	110	14	1,113	5	**1,118**
TOTAL	**8**	**44**	**15**	**8**	**8**	**1**	**84**	**1**	**85**	**118**	**570**	**250**	**245**	**125**	**19**	**1,339**	**7**	**1,346**

ANNEX 4 BILL 118/2017.

THE LEGISLATIVE ASSEMBLY OF THE STATE OF MATO GROSSO. in view of the provisions of Article 42 of the State Constitution. approve and the Governor of the State enacts the following law:

Article 1 – It is instituted the State Policy for Encouraging the Use of Solar Energy. formulated and implemented as a way of encouraging the generation of photovoltaic energy and rationalizing the consumption of electric energy and other energy sources in the State of Mato Grosso.

Article 2 – The following are the objectives of the Policy established by this Law: I - to stimulate. as a way of reducing the consumption of the different energy sources. investments and the implantation of ecologically correct solar energy systems. including technological development. in private ventures public. residential. community. commercial and industrial; II - to promote the generation of photovoltaic energy; III - create alternative employment and income.

Art. 3 – In the implementation of the State Policy to Encourage the Use of Solar Energy established by this Law. the Executive Branch may:

I. Support the implementation and development of projects that contemplate as a subsidiary source of energy. the use of solar energy equipment;

II. Create lines of financing for the acquisition of equipment for the generation of energy with the financial institutions of the State;

III. Stimulate activities using solar energy source;

IV. To develop other actions aimed at rationalizing the consumption of electric energy and other sources of energy in the State of Rio Grande do Sul.

Article 4 - The policy instruments instituted by this Law are incentives for technological research. technical assistance and product promotion. as well as financing lines for the acquisition of equipment for power generation.

I. Create mechanisms to facilitate the promotion of the use and commercialization of products inherent in the solar energy system;

II. Articulate the policies of incentive to the technology with the programs of generation of employment and income. seeking integrated development;

III. Create campaigns to promote products and the use of solar energy by supporting and stimulating their placing on the market;

IV. Identify areas with supply difficulties or lack of electrical energy that can be supplied with energy generated through solar panels;

V. To develop other actions aimed at rationalizing the consumption of electric energy and other sources of energy in the State of Rio Grande do Sul. Article 4 - The policy instruments instituted by this Law are incentives for technological research. technical assistance and product promotion. as well as financing lines for the acquisition of equipment for power generation.

Article 5 – The State Policy to Encourage the Use of Solar Energy will be managed observing;

I. Planning and coordination of incentive policies. prioritizing areas with difficulties or lack of electricity supply;

II. The definition of technical and economic feasibility of projects;

III. The technical support to the projects. with the support of the elaboration. the development. the execution and the operationalization of the enterprises;

V. The search for partnerships with entities. public or private. to maximize the production and the incentive to use the products;

V. The feasibility of public spaces. in partnership with the counties and the private initiative. destined to the exhibition and the disclosure of the benefits of the Politics regulated by this Law. with the purpose of stimulating its use.

Article 6 – The Executive Power is authorized to regulate this Law in what is necessary for its faithful fulfillment.

Article 7 – This Law shall be regulated within sixty days of its publication.

Article 8 – This Law shall enter into force on the date of its publication.

ANNEX 5 FORECAST OF RESIDENTIAL SECTOR CONSUMERS IN THE HORIZON OF 2050.

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
970,200	994,455	1,019,316	1,044,799	1,070,919	1,097,692	1,125,135	1,153,263	1,182,094	1,211,647	1,241,938

2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
1,272,986	1,304,811	1,337,431	1,370,867	1,405,139	1,440,267	1,476,274	1,513,181	1,551,010	1,589,786	1,629,530

2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
1,670,269	1,712,025	1,754,826	1,798,697	1,843,664	1,889,756	1,936,999	1,985,424	2,035,060	2,085,937	2,138,085

Selection of residential customers by range:

CUSTOMERS BY RANGE - 2015 TO 2018 – UNTIL 500 kWh			
2015	**2016**	**2017**	**2018**
783,151	837,617	846,471	872,203

CUSTOMERS BY RANGE - 2015 TO 2018 – SUPERIOR THAN 500 kWh			
2015	2016	2017	2018
88,809	64,489	75,168	97,997

Bass model:

NUMBER OF HOUSEHOLDS OR ELIGIBLE CONSUMERS IN THE POTENTIAL MARKET: Na = 2,138.085	
F(t) =	0,0025
Fmm =	5.697
m = Na*Fmm	12,180,670
N(t) = m*F(t)	30,451.68

ANNEX 6 NPV AND IRR.

Residential sector

FOR SYSTEMS UNTIL 3.0 kW		
Cost = R$ 6.00/Wp	Residential tariff = 796.76 R$/MWh	Investment = R$ 18.000.00
IRR = 51%	NPV = R$ 38,484.35	

YEAR	USEFUL LIFE	DEPRECIATION COST	COSTS O&M
2017	0	-18,000.00	-18,000.00
2018	1	16,920.00	10,321.20
2019	2	15,904.80	9,701.93
2020	3	14,950.51	9,119.81
2021	4	14,053.48	8,572.62
2022	5	13,210.27	8,058.27
2023	6	12,417.66	7,574.77
2024	7	11,672.60	7,120.28
2025	8	10,972.24	6,693.07
2026	9	10,313.91	6,291.48
2027	10	9,695.07	5,913.99
2028	11	9,113.37	5,559.15
2029	12	8,566.57	5,225.61
2030	13	8,052.57	4,912.07
2031	14	7,569.42	4,617.34
2032	15	7,115.25	4,340.30
2033	16	6,688.34	4,079.89
2034	17	6,287.04	3,835.09
2035	18	5,909.81	3,604.99
2036	19	5,555.23	3,388.69
2037	20	5,221.91	3,185.37
2038	21	4,908.60	2,994.24
2039	22	4,614.08	2,814.59
2040	23	4,337.24	2,645.71
2041	24	4,077.00	2,486.97

Industrial sector

FOR SYSTEMS UNTIL 50 kW		
Cost = R$ 5.50/Wp	Residential tariff = 568.00 R$/MWh	Investment = = R$ 165,000.00
IRR = 51%	NPV = R$ 352,773.25	

YEAR	USEFUL LIFE	DEPRECIATION COST	COSTS O&M
2017	0	165,000.00	165,000.00
2018	1	155,100.00	94,611.00
2019	2	145,794.00	88,934.34
2020	3	137,046.36	83,598.28
2021	4	128,823.58	78,582.38
2022	5	121,094.16	73,867.44
2023	6	113,828.51	69,435.39
2024	7	106,998.80	65,269.27
2025	8	100,578.87	61,353.11
2026	9	94,544.14	57,671.93
2027	10	88,871.49	54,211.61
2028	11	83,539.20	50,958.91
2029	12	78,526.85	47,901.38
2030	13	73,815.24	45,027.30
2031	14	69,386.33	42,325.66
2032	15	65,223.15	39,786.12
2033	16	61,309.76	37,398.95
2034	17	57,631.17	35,155.02
2035	18	54,173.30	33,045.71
2036	19	50,922.90	31,062.97
2037	20	47,867.53	29,199.19
2038	21	44,995.48	27,447.24
2039	22	42,295.75	25,800.41
2040	23	39,758.00	24,252.38
2041	24	37,372.52	22,797.24

Commercial sector

FOR SYSTEMS UNTIL 20 kW		
Cost = R$ 7.50/Wp	Residential tariff = 568.00 R$/MWh	Investiment = R$ 150,000.00
IRR = 51%	NPV = R$ 320,702.96	

YEAR	USEFUL LIFE	DEPRECIATION COST	COSTS O&M
2017	0	-150,000.00	-150,000.00
2018	1	141,000.00	86,010.00
2019	2	132,540.00	80,849.40
2020	3	124,587.60	75,998.44
2021	4	117,112.34	71,438.53
2022	5	110,085.60	67,152.22
2023	6	103,480.47	63,123.08
2024	7	97,271.64	59,335.70
2025	8	91,435.34	55,775.56
2026	9	85,949.22	52,429.02
2027	10	80,792.27	49,283.28
2028	11	75,944.73	46,326.29
2029	12	71,388.05	43,546.71
2030	13	67,104.76	40,933.91
2031	14	63,078.48	38,477.87
2032	15	59,293.77	36,169.20
2033	16	55,736.14	33,999.05
2034	17	52,391.98	31,959.10
2035	18	49,248.46	30,041.56
2036	19	46,293.55	28,239.06
2037	20	43,515.94	26,544.72
2038	21	40,904.98	24,952.04
2039	22	38,450.68	23,454.92
2040	23	36,143.64	22,047.62
2041	24	33,975.02	20,724.76

Public sector

FOR SYSTEMS UNTIL 20 kW		
Cost = R$ 6.50/Wp	Residential tariff = 568.00 R$/MWh	Investiment = R$ 130,000.00
IRR = 51%	NPV = R$ 277,942.56	

YEAR	USEFUL LIFE	DEPRECIATION COST	COSTS O&M
2017	0	-130,000.00	-130,000.00
2018	1	122,200.00	74,542.00
2019	2	114,868.00	70,069.48
2020	3	107,975.92	65,865.31
2021	4	101,497.36	61,913.39
2022	5	95,407.52	58,198.59
2023	6	89,683.07	54,706.67
2024	7	84,302.09	51,424.27
2025	8	79,243.96	48,338.82
2026	9	74,489.32	45,438.49
2027	10	70,019.96	42,712.18
2028	11	65,818.77	40,149.45
2029	12	61,869.64	37,740.48
2030	13	58,157.46	35,476.05
2031	14	54,668.01	33,347.49
2032	15	51,387.93	31,346.64
2033	16	48,304.66	29,465.84
2034	17	45,406.38	27,697.89
2035	18	42,682.00	26,036.02
2036	19	40,121.08	24,473.86
2037	20	37,713.81	23,005.42
2038	21	35,450.98	21,625.10
2039	22	33,323.92	20,327.59
2040	23	31,324.49	19,107.94
2041	24	29,445.02	17,961.46

Agriculture sector

FOR SYSTEMS UNTIL 10 KW		
Cost = R$ 6.50/Wp	Residential tariff = 568.00 R$/MWh	Investiment = R$ 65,000.00
IRR = 51%	NPV = R$ 138,971.28	

YEAR	USEFUL LIFE	DEPRECIATION COST	COSTS O&M
2017	0	-65,000.00	-65,000.00
2018	1	61,100.00	37,271.00
2019	2	57,434.00	35,034.74
2020	3	53,987.96	32,932.66
2021	4	50,748.68	30,956.70
2022	5	47,703.76	29,099.29
2023	6	44,841.54	27,353.34
2024	7	42,151.04	25,712.14
2025	8	39,621.98	24,169.41
2026	9	37,244.66	22,719.24
2027	10	35,009.98	21,356.09
2028	11	32,909.38	20,074.72
2029	12	30,934.82	18,870.24
2030	13	29,078.73	17,738.03
2031	14	27,334.01	16,673.74
2032	15	25,693.97	15,673.32
2033	16	24,152.33	14,732.92
2034	17	22,703.19	13,848.95
2035	18	21,341.00	13,018.01
2036	19	20,060.54	12,236.93
2037	20	18,856.91	11,502.71
2038	21	17,725.49	10,812.55
2039	22	16,661.96	10,163.80
2040	23	15,662.24	9,553.97
2041	24	14,722.51	8,980.73

ANNEX 7 ADOPTED RESULTS OF LEVEL COST FOR THE CITY OF CUIABÁ - TEXT TAKEN AND ADAPTED FROM (IEE-USP. 2015).

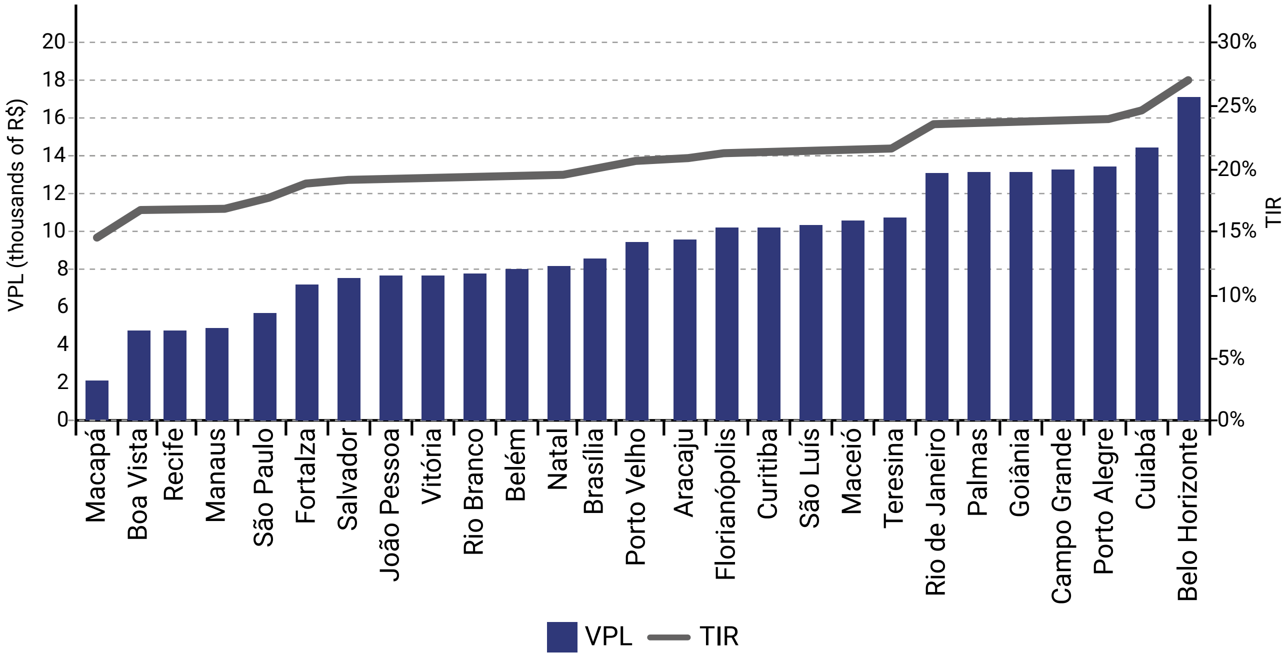
Standard Scenario

In the analysis for the standard scenario. the assumptions presented in the Table below are considered.

CLASS	RESIDENTIAL
PR	75%
O&M	1.00% p.y.
N (Years)	25
Productivity Reduction (% p.y.)	0.5
Adjustment tariff electric energy (% p.y.)	9.6%
Inflation	5.59%
Self-consumption	54.3%
Discount rate	12.25%
Price PV (R$/Wpeak)	7.19
BRL/EUR	3.25

It should be noted that for the conditions of the standard scenario there is financial viability in all capitals. especially in Belo Horizonte. where the internal rate of return exceeds 25%. Macapá and Boa Vista presented less favorable results. but even so the IRR is higher than 14.5% and the VLP positive. The distributors. CEA and CERR did not participate in the RTE of February 2015. causing a tariff gap for these distributors and. therefore. reducing the return on investment in micro-generation in these capitals.

Figure. NPV and IRR. standard scenario



Source: Elaborated for IEE-USP (2015).

Cost of energy

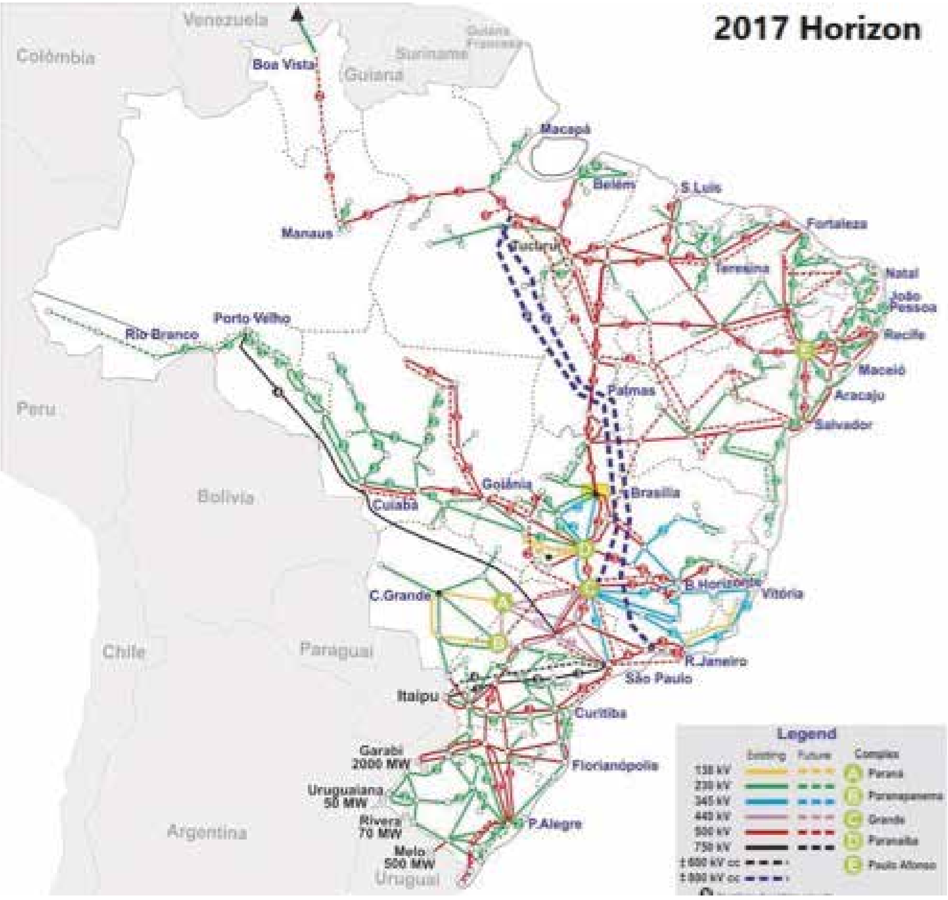
For the calculation of the energy cost. it is more appropriate to use the real discount rate. ie the discounted nominal rate of inflation. Since the use of the nominal discount rate of 12.25% would lead to a distortion in the comparison of the level of energy cost with the current conventional electricity tariff. For this. the assumptions adopted for the calculation of the energy cost level are (other conditions similar to the standard scenario):

- Discount rate: 6.3%. this is. the rate of 12.25% discounted from 5.6% (inflation).
- Tariff readjustment: 0% real. that is. readjustment equal to inflation (5.6%).

The rate adjustment impacts on cash outflows. due to the taxes paid by the energy injected into the grid. In the adopted model these costs are incorporated to the cost of photovoltaic energy generated (LCOE). The tariff data for taxes and for the cost of energy in the standard scenario for Cuiabá are presented below.

CITY	TAX RATE (R$/MWh)	LCOE PHOTOVOLTAIC (R$/MWh)
Cuiabá	726.76	584.54

ANNEX 8 NATIONAL INTERCONNECTED SYSTEM (NIS).



Source: ONS (2017).

ANNEX 9 CALCULATION MODEL FOR JOB CREATION - TEXT TAKEN AND ADAPTED FROM (IEI - BRASIL. 2018).

$$EG = \frac{FL * 8760 * FC * VU}{1000} \qquad (1)$$

Where: EG: Jobs generated in the year of execution (Work stations/MW installed)
FL: linearized employment generation factor (Table 12 values);
8760: number of hours in the year;
FC: Technology Capacity Factor (EE = 1. FV = 0.15. GN = 0.8);
VU: Technology Useful Life (EE = 10. FV = 20. GN = 15); and
1000: MWh power conversion for GWh. FL unit.

The values for job creation can be classified as raw or liquid. The gross value comprises the number of jobs generated by the economic activity itself (in this case. the renewable energy industry and the energy efficiency industry) and along its supply chain. The net value includes the positive and negative effects of the generation of jobs in the sector. It is considered. therefore. the total number of jobs generated minus the total number of jobs lost due to the development of the renewable energy sector (Sooriyaarachchi et al.. 2015). In this study. it is considered the net value for the generation of jobs. In order to estimate the net generation of jobs in the mathematical model. the specific indicators. per unit of energy produced or saved. are used by Wei et al. (2010) and presented in the Table below.

JOBS PRODUCED GWH BY SOURCE AND GWh SAVED BY EE MEASURES.

DIRECTS			INDIRECT		
Distributed Generation	Photovoltaic Plants	Natural Gas	Distributed Generation	Photovoltaic Plants	Natural Gas
0.38	0.87	0.11	0.342	0.783	0.099

In order to calculate the direct employment generation factor. the studies count the total number of workers hired to install a generation technology and divide this number by the total energy that this technology will produce throughout its useful life.

In this way. jobs are generated per year per unit of energy (jobs/GWh). only to make it possible to compare different technologies regardless of their various characteristics as a factor of capacity and useful life. For example. 1 MW of Solar PV generates less energy than 1 MW of thermoelectric. So. to compare which energy is cheaper. you have to calculate R$/MWh. Therefore. to compare what generates more jobs. it is necessary to calculate jobs/MWh. However. when deciding to invest in a particular technology. the construction of a certain installed generation capacity occurs. For example. 1 MWp of PV solar generation will be built in 2020. At the time that 1 MWp was built. did it take to create how many jobs? If the PV solar direct employment generation factor is 0.87 jobs/GWh. in one year this system will generate 1.3 GWh. Therefore. this year this action generated 1.1 jobs. However. you need to calculate how many GWh this 1 MWp will produce over its lifetime (20 years) at this location. Soon. in this year of installation. 22 direct jobs will be created. To execute an energy efficiency action that will save 1 GWh per year. where the useful life of this action is ten years. it will generate in the year of its execution the amount of jobs of the annualized factor ten times.

The direct jobs generated for the installation are: 33 for EE; 23 for GD PV and 15 for GN. Therefore. considering the net generation of jobs. for the distributed generation photovoltaic. it is considered in the installation year 8 stations/MWp. Indirect jobs are calculated by GWh of energy. 0.333 jobs/GWh for EE and 0.774 jobs/GWh for GD PV. It is also considered the tax collection resulting from net jobs generated. The rates of 9% of INSS and 7.5% of IR and R $ 1.903.98 are used as the base value for IR. In these calculations. an average salary of R $ 2.500.00 per month is assumed.Fontes consultadas pelos autores do Texto do IEI - Brasil:

Sources consulted by IEI - Brasil authors:

Sooriyaarachchi. Thilanka M.. et al. 2015. “Job Creation Potentials and Skill Requirements In. PV. CSP. Wind. Waterto-Energy and Energy Efficiency Value Chains.” Renewable and Sustainable Energy Reviews 52: 653–68. doi:10.1016/j.rser.2015.07.143.

Wei. M. et al. 2010. Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?. Energy Policy. 2010. vol. 38. issue 2. 919-931. Disponível em https://www.sciencedirect.com/science/article/pii/S0301421509007915. Acessed in October/2018.

ANNEX 10 REFERENCE THERMOELECTRIC POWER PLANT - TEXT TAKEN AND ADAPTED FROM (EPE. 2018).

The reference thermoelectric power plant was modeled as an integrated project to a timber industrialization unit or to a lumber pole. carrying out cogeneration of energy. that is. simultaneous generation of thermal energy and electric energy. for subsequent uses. It is assumed that the plant operates at 80% of the time in the year. corresponding to the Capacity Factor. This model seeks to represent a small thermoelectric plant park to the residual biomass to allow estimates of the electric power supply potential.

Thermoelectric developments associated with the processing of wood produced by forest management in the Amazon region use as fuel the woody forest residue and the residue from the processing of logs.

In the case of logging-based enterprises with planted forests. only the beneficiation residue is considered.

The steam generated in the boiler is directed to a condensation and extraction turbine coupled to an electric generator. A part of the steam is extracted for use in the greenhouse. The remainder runs through the entire turbine. and is sucked by the vacuum condenser.

The thermoelectric efficiency. the ratio between the electric energy generated and the chemical energy released by the fuel. is a function of the pressure and temperature of the steam at the entrance. the extraction and the exit of the turbine. and the amount of steam extracted. These parameters are specific to each project. which includes sawmills. wood drying. the local electricity market and the thermoelectric plant itself. In INEE (2003). this yield is about 12%. and the surplus of marketable electricity is sized for the scope of that study. Consequently. only 37% of all waste generated is used as fuel. considering only the sawmill residue.

In this document. it is intended to consume all residual biomass available. including that produced in the forest management in the field. In this way. a greater amount of steam will be destined only to the electric generation. in relation to the quantity extracted for heating. Thus. the thermoelectric efficiency should be higher. of 15%.

The thermal energy of the steam extracted from the turbine is used in kilns to dry the wood. which adds value to the product. It is considered that 100% of the lumber is sent to the greenhouse. In this condition. the specific vapor consumption at 8.7 bar of pressure is 0.9 t/m³ of steam processed. or 0.6[1] MWh of thermal/m³ log (INEE. 2003). The greenhouse condensate at 90°C returns to the tank that feeds the boiler.

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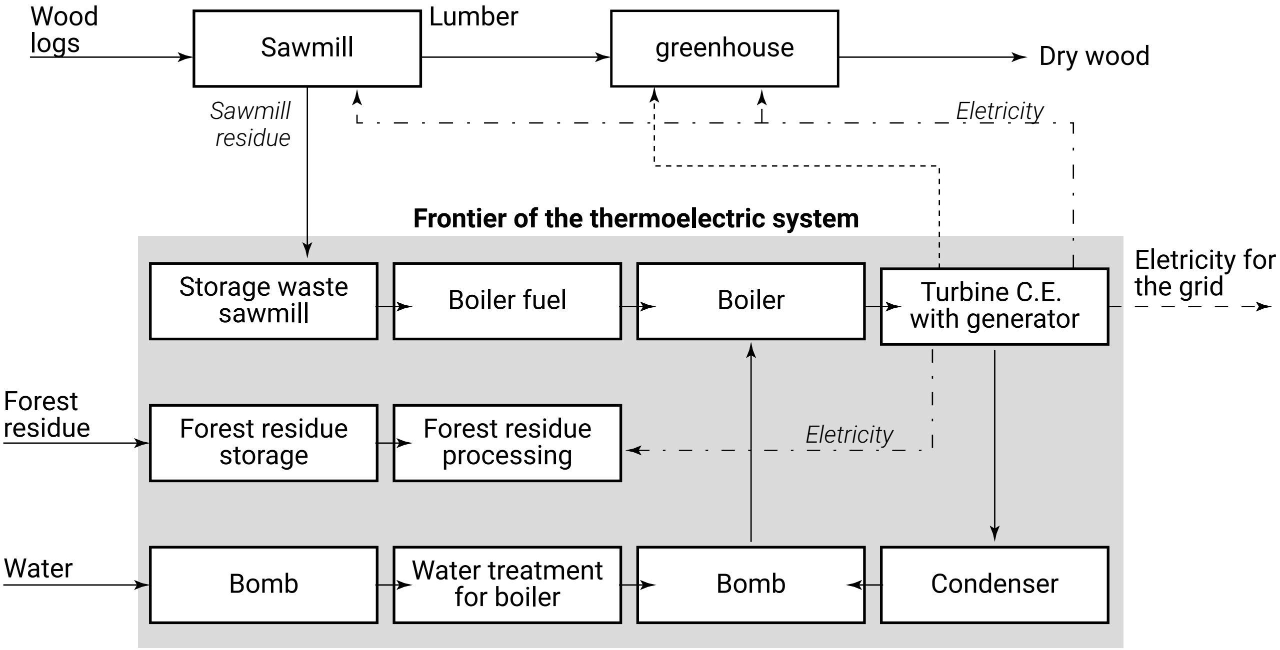
[1] It was assumed that the steam is drawn into the stove in the condition of overheating at 8.7 bar and 200° C. In addition. the energy contained in the condensate was discounted.

Part of the electricity generated is consumed by the timber unit or pole. with a specific consumption of 72.4 kWh / m3 of processed log (INEE. 2003).

Under the conditions of the reference thermoelectric plant. total electricity generation is 520 kWh/m3 of processed log (542 kWh/t fuel) and the exportable energy is 447 kWh/m³ of log (466 kWh/t fuel). The overall efficiency of cogeneration is 35%.

The figure below shows the flowchart of the integrated reference thermoelectric plant for the processing and drying of the wood.



It is important to properly allocate fuel consumption among the energy services performed. The energy base allocation method was chosen. taking the thermal energy supplied to the turbine as reference. Thus. the greenhouse accounts for 17% of fuel consumption. electric self-consumption by 12% and energy sold by 71%. The technical parameters of the model are given in the Table below.

PARAMETERS	VALUE	UNIT
PROCESSING OF WOOD AND WASTE FROM MANAGEMENT		
Basic density of log	0.8	t/m³
Factor of waste generation in processing	50%	
Processing Residue	0.4	T residue sawmills/m³ log
Factor of waste generation in forest management	100%	
Waste management	0.8	T residue management/m³ log
SPECIFIC INTERNAL ENERGY CONSUMPTION		
Electricity	0.072	MWh-e/m³ log
Steam	0.89	T steam ext/m³ log
	0.61	MWh-t steam ext/m³ log

continues

continuation

PARAMETERS	VALUE	UNIT
COGENERATION		
Capacity Factor	80%	
Total waste	1.2	T res total/m³ log
Residue recovery factor	80%	
Specific waste availability (Fuel)	0.96	T comb (=res disp)/m³ log
Potential electric generation per meter	0.93	T steam ext/t comb
Potential electric generation per ton of fuel	0.63	MWh-t steam ext/t comb
Specific fuel consumption	3.61	MWh-t bio/t bio
Global cogeneration yield	0.520	MWh-e elet total/m³ log
Thermoelectric yield	0.542	MWh-e elet total/t comb
Specific fuel consumption	1.85	T comb/MWh-e elet total
Global cogeneration yield	33%	
Thermoelectric yield	15%	
ELECTRICITY SURPLUS		
Generation surplus electricity by m³ log	0.447	MWh-e elet exc/m³ log
Generation surplus per t of fuel	0.466	MWh-e elet exc/t comb
ALLOCATION OF FUEL BASED ON HIGH VAPOR ENERGY		
Greenhouse	17%	
Electrical self-consumption	12%	
Commercialization	71%	

Generation of direct jobs by the Reference Thermoelectric Plant (EPE. 2018)

Both in the construction and in the operation of the thermoelectric plant. a demand for a labor with varying level of qualification is created. as shown in the Table of Demand for Manpower. The labor demanded in the deployment phase is temporary. But with a firm demand for projects in each region you can expect a solid job market for these professionals and for companies. Direct fixed jobs total 17 per plant.

Demand for direct job in the implementation and operation and maintenance of the thermoelectric power plant (INEE. 2003).