PEDER-MT 2050

STRATEGIC PLAN FOR THE DEVELOPMENT OF RENEWABLE ENERGY IN MATO GROSSO

UN environment programme · PAGE · Governo de Mato Grosso · UFMT · NIEPE Núcleo Interdisciplinar de Estudos em Planejamento Energético

TECHNICAL TEAM

GOVERNMENT OF THE STATE OF MATO GROSSO

Mauro Mendes Ferreira
Governor of the State of Mato Grosso

Cesar Alberto Miranda Lima dos Santos Costa
State Secretary for Economic Development

Celso Paulo Banazeski
Deputy Secretary of Industry, Commerce and Entrepreneurship

PARTNERSHIP FOR ACTION ON GREEN ECONOMY (PAGE)

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)

Denise Hamú de La Penha
UNEP Representative in Brazil

Regina Cavini
Senior Programme Officer

Elisa Dettoni
Project Manager

Camila Cavallari
Programme Analyst

Katrina Junghwa Kim
United Nations Volunteer (UNV)

LOCAL COORDINATION

Eduardo C. Chiletto
National Project Coordinator

Marcela Gaiva
Project Assistant

FEDERAL UNIVERSITY OF MATO GROSSO (UFMT)

Evandro Aparecido Soares da Silva
University Rector

UNISELVA FOUNDATION

Cristiano Maciel
General Director

ECONOMY COLLEGE

Dirceu Grasel
Director

INTERDISCIPLINARY CENTRE OF STUDIES IN ENERGY PLANNING (NIEPE)

Aluísio Brígido Borba Filho
Coordinator

Ivo Leandro Dorileo
Deputy Coordinator and Head Researcher

Leonardo Gomes de Vasconcelos
Researcher

Getúlio Gonçalves de Queiroz
Researcher

Margarete Tomásia de Aquino Nunes
Researcher

Marina Timo de Sá
Intern

Priscila Costa Nascimento
Intern

Graphic design
Inara Vieira

Photos
https://unsplash.com/

N674b NIEPE
Avaliação dos potenciais técnico e econômico de geração e uso de energias renováveis em Mato Grosso.
NIEPE.– Cuiabá, 2019.
106 p.: Il.; color.
1. Recursos energéticos – Mato Grosso.
2. Fontes Renováveis – Mato Grosso.
3. Potencial energético – Mato Grosso.
4. Planejamento Energético Regional.

CDU – 620.91(817.2)

PEDER-MT 2050

STRATEGIC PLAN FOR THE

DEVELOPMENT OF RENEWABLE ENERGY IN MATO GROSSO

AUGUST
2019

TABLE OF CONTENTS

FIGURES

TABLES

BOXES

LISTA DE SÍMBOLOS E ABREVIATURAS

AGR — Average Growth Rate

AV — Added Value

ALM — Asset Liability Matching

Aneel — National Electric Energy Agency

AGER — State Agency of Public Services Regulation

BFS — Brazilian Forest Service

CEDEM — State Council of Bussiness Development

DER — Distributed Energy Resource

DG — Distributed Generation

DSM — Demand side management

EDP — 10-Year Energy Plan

EE — Energy Efficiency

EPE — Energy Research Company

FCA — Fuel Consumption Account

FIEMT — Federation of industries in the State of Mato Grosso

FINISA — Financing for Infrastructure and Sanitation

FPri — Private Forests

FPF — Florestas Públicas Federais

GDP — Gross Domestic Product

GHG — Greenhouse Gases

GWh — Giga Watt hour

GWp — Giga Watt peak

ICMS — Tax on the Circulation of Goods and Services

IEA — International Energy Agency

IEI — International Energy Initiative

IPCC — Intergovernmental Panel on Climate Change

IRP — Integrated Resources Planning

IRR — Internal Return Rate

kWh — Kilo watt hour

kWp — Kilo Watt peak

LCOE — Levelized Cost of Electricity

LPG — Liquefied petroleum gas

MT — Mato Grosso

NBESD — National Bank for Economic and Social Development

NCFP — National Council of Finance Policy

NIS — National Interconnected System

NPV — Net Present Value

NZEB — Net Zero Energy Buildings

O&M — Operation and Maintenance

ONS — National Electrical System Operator

PEDER-MT — Strategic Plan for the Development of Renewable Energy in Mato Grosso

PESI — Sustainable Energy Industry Program

PIR — Integrated Resource Planning

PIS — Social integration program

PNR/P — Production of New Renewables per Total Production

PPA — Permanent conservation Areas

PRODEIC — Industrial and Commercial Development Program

PROINFA — Incentive Program for Alternative Energy Sources

PV — Photovoltaic

RD — Demand Response

R&D — Research and Development

REIDI — Special Incentive Regime for Infrastructure Development

RES — Renewable Energy Source

SCNI — Social Contribution on Net Income

SENAI — National Service of Industrial Learning

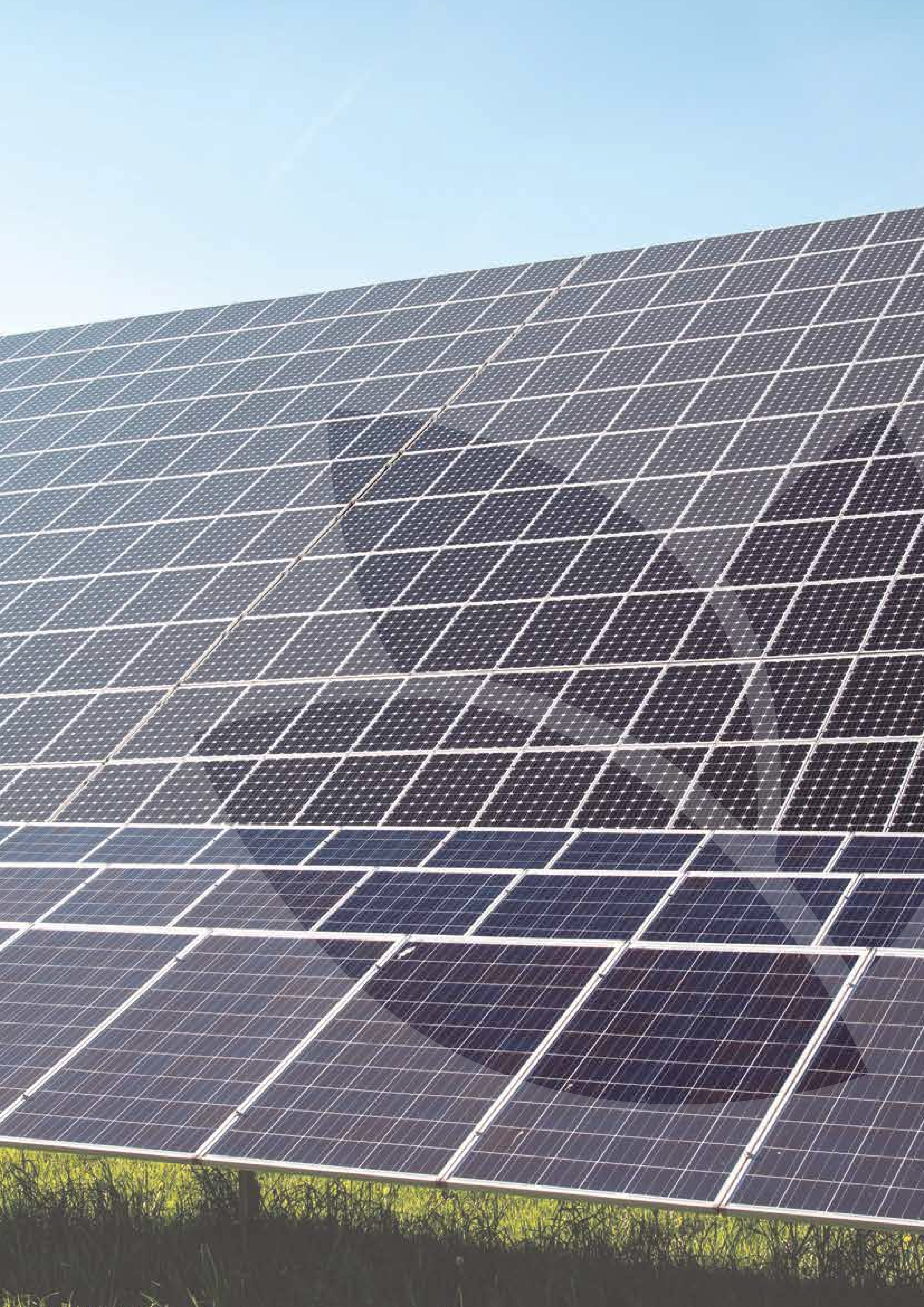
SICME — State Secretariat of Industry, Commerce, Mines and Energy

SHP — Small Hydropower Plant

SI — Isolated System

SSM — Supply side management

tOE — Equivalent Ton of Oil



1 GOALS

The Strategic Plan for the Development of Renewable Energy in Mato Grosso - PEDER-MT is a guiding document for the energy sector and society, for indicative purposes, on the prospects for expanding renewable energy sources, specifically the solar photovoltaic and biomass-based on forestry residues by 2050.

Through an integrated vision of the state energy supply and demand, the analyses contained in this Plan provide support for energy planning, identify and evaluate strategies for expanding the supply of these renewable sources.

PEDER-MT was prepared based on the Report “Evaluation of the Technical and Economic Potentials of Generation and Use of Renewable Energy in Mato Grosso” that presented relevant information and useful prospective scenarios for carrying out this Plan.

The document guides the government and the private sector towards decision-making and actions to take advantage of the energy potential, considering an efficient supply of electricity with reduced impact on the environment. The report also considers the state cross-cutting plans that interact with the energy sector and support policies and strategies related to it and guided by national energy area rules.

2 KEY POINTS

- To keep and improve current rules and incentives for production of from energy renewable sources, which have contributed to the difference in the energy matrix of Mato Grosso and the reduction of dependence on electricity in the State.
- Mato Grosso has incorporated renewable energy into the gross final consumption of electricity as observed in 2017, when it reached 94.0% of participation.
- With the increase in electricity consumption due to the current rate of the economy growth, it is necessary to implement measures to stimulate the modernization of the energy industry, with investments in innovative equipment for renewable energy produciton using the potential of the state.
- The role of the Government is essential along with the private initiative to create a more favorable business and regulatory environment by promoting rising photovoltaic micro-generation in sectors of the economy.
- In terms of distributed generation (DG), designs must be encouraged from renewable sources such as solar photovoltaic and biomass-based. Its pillars must be concern with the environment, opportunities for the electricity sector and the socio-economic benefits of the agreed measures, such as jobs creation, specialization of labor, energy inclusion, among others, more efficient costumer service in public services and general well-being of the local population.
- Focus on distributed generation as a great motivator for the abatement of greenhouse gases emissions, observing both national and international policies for climate change, guiding the effective allocation of renewable resources and effectively increasing its participation in energy planning.
- By favoring DG, Mato Grosso now has a higher indicator of confidence in electricity supply and independent of the traditional hydrothermal system, favoring Interconnected Electrical System. In this way, generation deficits and the construction of long transmission and distribution lines in the state are avoided, allowing for efficiency gains, postponing investments in new large enterprises and reducing conflicts with indigenous areas and environmental agencies.

- The most viable scenario in the short and medium term for biomass-based on wood waste is the taking advantage of the potential in isolated systems (IS). Thus, diligent Government interventions are needed to ensure the success of public policies that aim to promote these renewable sources and overcome barriers and difficulties in relation to the "complexity of forest and energy issues, especially in relation to the management of Southern Amazon Forest and the replacement of the Diesel generation in IS (EPE, 2018).

- For electricity from biomass, production in isolated systems can rise from 5 GWh to 539 GWh in the long term if tapped the full potential of residues of effective forest management in Mato Grosso.

- Figures show that the State has shown strong development in photovoltaic plants, in the order of 1926.0% between 2015 and 2018. With an expressive potential to all sectors of the economy, this estimated value points to an important role of photovoltaic generation in the State electric demand in the coming decades, being projected installed capacity of 5.6 GWpeak in 2050. With the assumptions adopted in the report "Evaluation of the Technical and Economic Potentials of Generation and Use of Renewable Energy in Mato Grosso", and supported by new and favorable public policy, we can produce 1.01 GW average, just about 42.0% of the electricity demand that year.

- In order to acomplish this potential is essential to integrated planning of energy resources that, in unison with the environmental planning, water resources management and regional development, guarantee the adapting development of renewable considering the intra-regional differences of Mato Grosso. In this scenario, there is a need for a comprehensive and integrated approach to social, economic, political and technological environment, so that the energy sector is sustainable, seating themselves in the context of infrastructure, considering their specific characteristics and their relationships with the development and, mainly, with the environment.

3 BRIEF SECTOR DIAGNOSIS

3.1 ENERGY PRODUCTION AND CONSUMPTION

The State of Mato Grosso produces only renewable primary energy and presents an increase in total energy production in the period from 2007 to 2017 of 194.0%, with an Average Growth Rate (AGR) of 6.0% per year. With an increasing consumption at a rate of 5.0% per year, the relationship between production and consumption keeps an average within 75.0% as shown in **Table 1**.

Table 1 Production and final energy consumption in Mato Grosso in the period from 2007 to 2017. Unit: 10^3 tOE.

FLOW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	AGR (%)
Production	2,304	2,795	2,728	2,799	2,677	3,224	3,408	3,544	3,671	3,701	4,476	6
Final energy consumption	3,119	3,474	3,467	3,830	4,054	4,428	4,922	5,031	4,977	4,859	5,094	5
PRODUCTION/ CONSUMPTION (%)	**74**	**80**	**79**	**73**	**66**	**73**	**69**	**70**	**74**	**76**	**88**	**2**

3.2 PRIMARY ENERGY PRODUCTION

Among the primary energy produced, the main products are sugarcane, with 37.8%, followed by hydraulic energy, who tripled production in 11 years, with 35.5% of the total energy produced. Biodiesel is the energy that presents the highest growth rate (47.0% per year), accompanied by other primaries as biogas, photovoltaic, rice husks and wood waste. The wood is an energy that decreased its participation in half the time, but it gradually grew back, with an oscillation with a negative rate of 0.5% per year, according to the **Table 2**.

Table 2 Primary energy production in Mato Grosso in the period 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
Wood	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
Other sources (*)(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**

(*) Forestry residues, biogas and photovoltaic energy.

(1) Energy production from biogas began from 2015..

3.3 SECONDARY ENERGY PRODUCTION

Electricity is the main secondary energy produced, displaying high growth rate along the historical series, 10.0% p.y., followed by the production of ethanol, which represented, in 2017, 27.0% of the production of secondary energy in the State (**Table 3**). Other secondary sources together, like rice husk briquettes, sawdust, chaff charcoal, overcome the charcoal production, increasing at rate of 9.0% p.y.

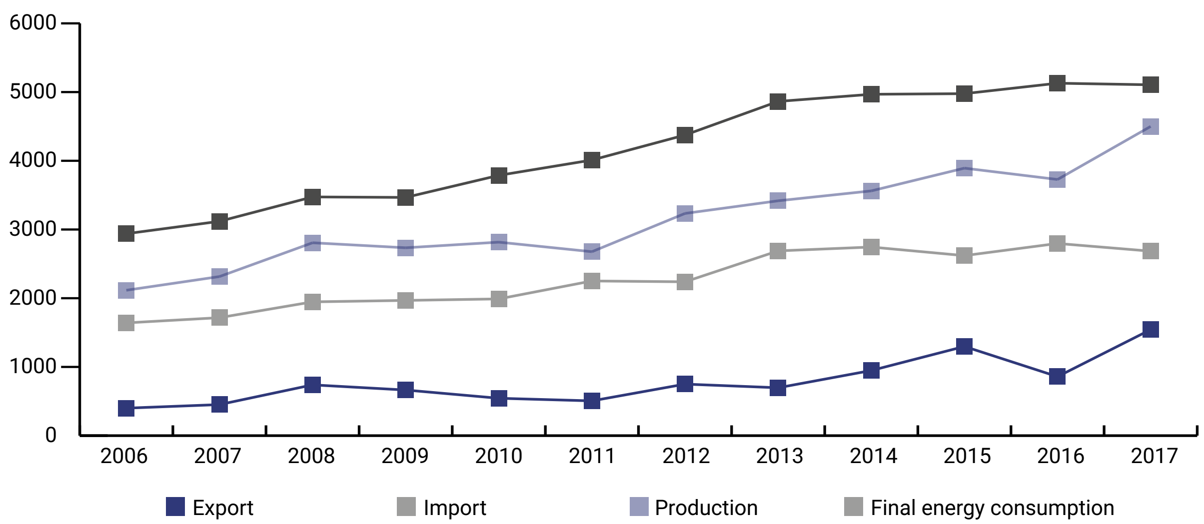
Table 3 Secondary energy production in Mato Grosso in the period from 2007 to 2017. Unit: 10^3 tOE.

SOURCES	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	AGR (%)
Electricity	608	735	762	666	729	1,007	1,096	1,235	1,382	1,077	1,706	10
Charcoal	26	35	43	50	33	36	20	12	26	21	24	-1
Hydrous ethanol	253	314	285	294	262	254	278	337	407	341	427	5
Anhydrous ethanol	199	204	145	146	176	254	288	271	282	280	297	4
Other sources (*)	11	11	6	16	20	10	11	17	28	30	29	9
TOTAL	**1,097**	**1,300**	**1,241**	**1,173**	**1,220**	**1,560**	**1,692**	**1,872**	**2,125**	**1,749**	**2,482**	**8**

3.4 FINAL CONSUMPTION AND ENERGY EXPORT AND IMPORT

Figure 1 shows the evolution of final energy consumption, reaching, in 2017, a 13.5% level greater than the energy production in the State. Importation, due mostly to petroleum products, keeps an increasing rate, having increased in the period under examination 64.0%, and the state exportation, almost exclusively of electricity, between 2006 and 2017 has quadrupled.

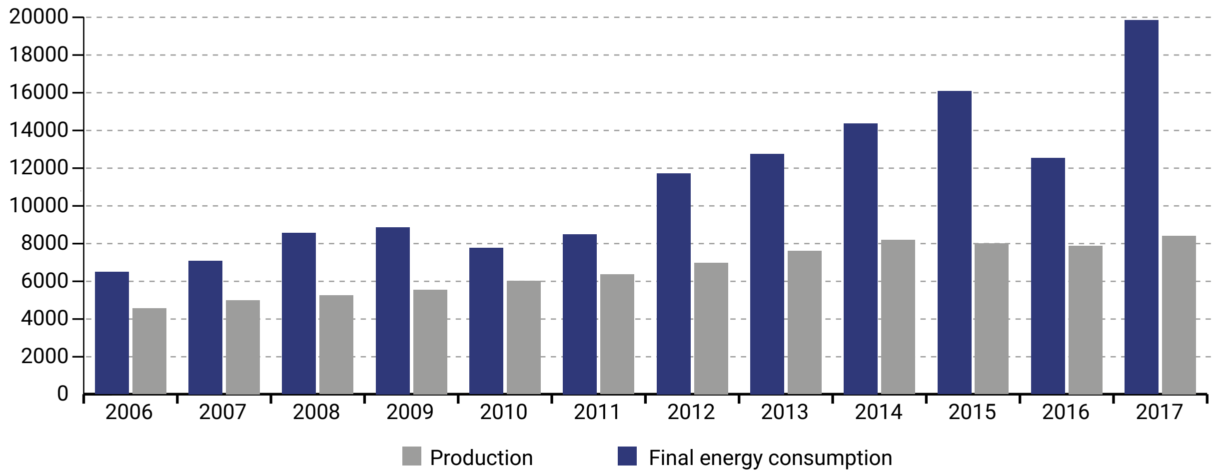
Figure 1 Energy Production x Consumption x Import x Export in Mato Grosso in the period from 2006 to 2017. Unit: 10^3 tOE.



3.4.1 Electricity

In terms of production and consumption of electricity, **Figure 2** shows that the electricity consumption grows at an average annual rate of 5.3% p.y. while the production shot up in the period at a rate of 9.8% p.y. with investments mainly in hydroelectric power plants and large number of small hydropower plants, reaching a production near 20,000 GWh in 2017.

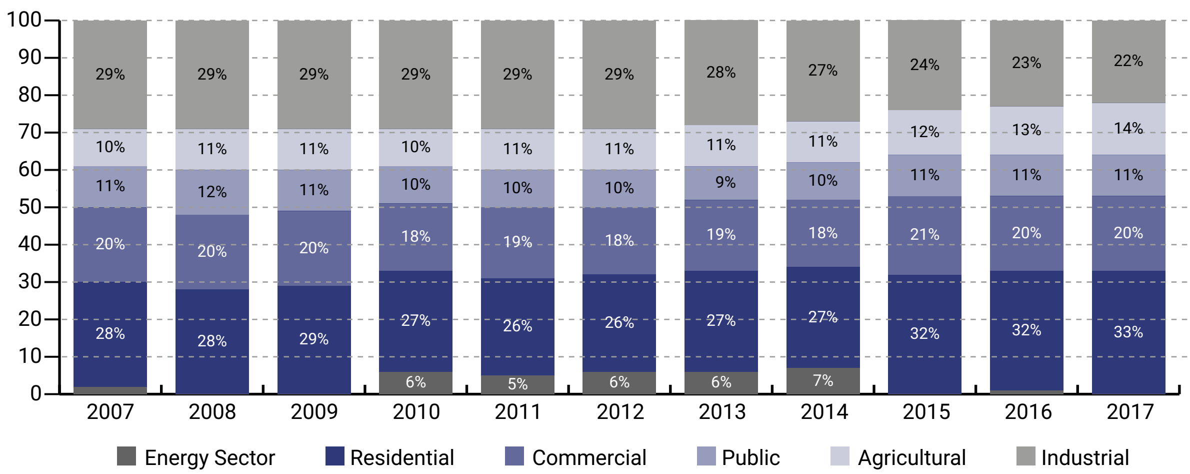
Figure 2 Production x Final energy consumption in Mato Grosso in the period from 2006 to 2017. Unit: GWh.



3.4.2 Electricity Consumption by Sector

The sectoral consumption (Figure 3) points to an industrial sector's supremacy in the consumption of electricity in the State, but, descending in the last 5 years of the series, being overcome by the residential sector. The highlight is the agricultural sector that shows in the last 4 years of the series an average annual growth rate of 2.03% p.y., followed by the residential sector, of 1.7% p.y. The commercial sector maintains an average consumption of about 19.0%, the third largest.

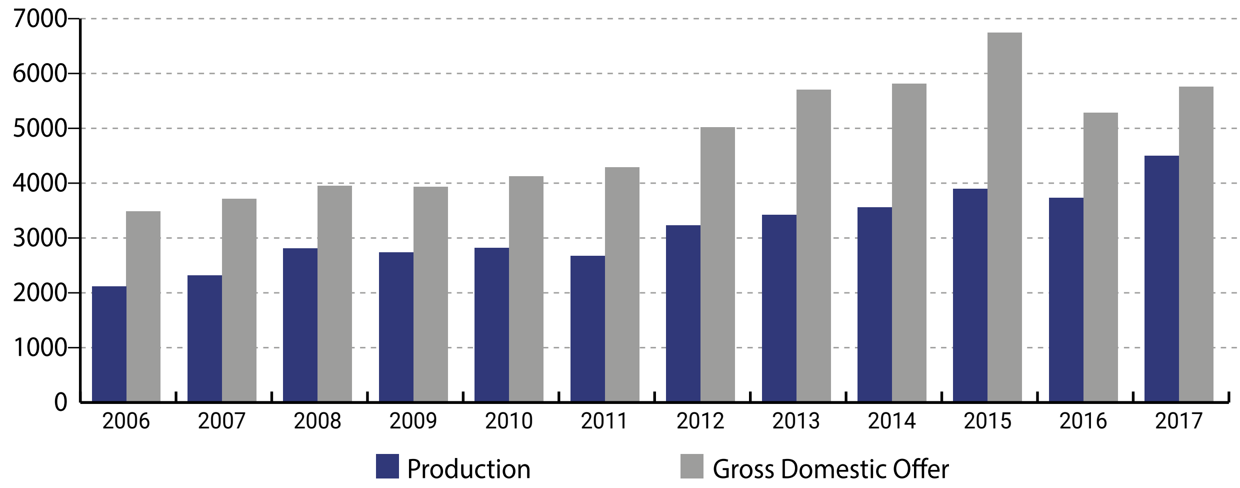
Figure 3 Sectoral participation of electricity consumption in Mato Grosso in the period from 2007 to 2017.



3.5 DOMESTIC ENERGY SUPPLY

Gross Domestic Supply of energy in the State increased in the period analyzed 165.0% due to increased production of primary energy (sugarcane products and hydraulic energy, mostly) and to electricity, at an accelerated rate of 6.5% p.y. (**Figure 4**).

Figure 4 Production x Gross Domestic Supply in Mato Grosso in the period from 2006 to 2017. Unit: 10^3 tOE.



By analyzing the **Table 4** Gross Domestic Supply of energy in Mato Grosso is mostly not renewable, with the presence of petroleum products and natural gas, making up 51.0% of the total, but the renewable sources supply are also growing at a rate of 4.3% p.y.

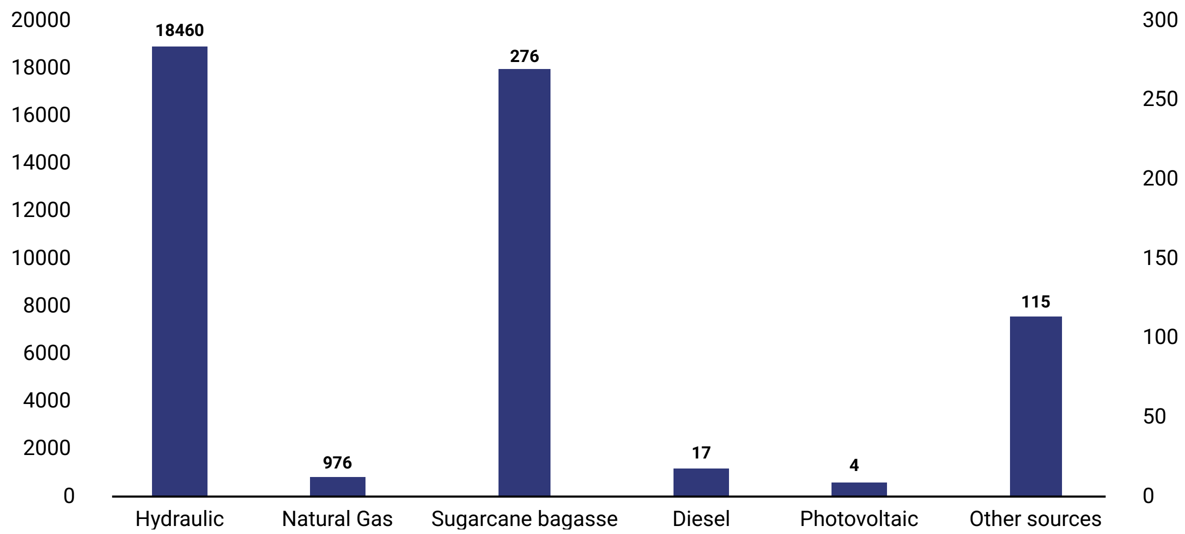
Table 4 Gross Domestic Supply of energy in the period from 2006 to 2017 in Mato Grosso. Unit: 10^3 tOE.

SOURCES/ YEAR	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
NON-RENEWABLE	**1774**	**1810**	**1950**	**1963**	**2011**	**2269**	**2769**	**3265**	**3419**	**4410**	**2980**	**2923**
Natural gas	184	186	5	2	2	2	333	475	573	792	29	183
Petroleum products	1590	1624	1945	1960	2009	2267	2436	2790	2846	3618	2950	2740
RENEWABLE	**1714**	**1877**	**1998**	**1969**	**2114**	**2019**	**2248**	**2443**	**2390**	**2332**	**2303**	**2831**
Hydraulic energy	426	479	657	703	627	698	831	884	938	902	1042	1588
Electricity	-89	-90	-208	-204	-1	-15	-253	-278	-356	-590	-309	-886
Wood	294	279	277	283	418	352	317	307	243	271	256	263
Charcoal	-8	-8	-8	-14	-17	-11	-12	-7	-4	-19	-12	-15
Sugarcane products	1012	1078	1212	1129	962	883	1250	1303	1340	1547	1143	1316
Other sources	80	139	68	73	125	114	115	233	230	221	184	565

3.6 ELECTRICITY-PRODUCING SOURCES – RENEWABLE

With a strong predominance of hydraulic source - 93.0% of all production (**Figure 5**) 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 electricity 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 the suspension of supply of the input.

Figure 5 Share of sources in electricity production in Mato Grosso, by 2017. Hydraulic (left axis values). Unit: GWh.



The sugarcane bagasse has been tapped for electricity generation in three sugarcane-alcohol plants, as in Table 5, being the Itamarati, Alto Taquari, Caramuru Sorriso and the Barrálcool classified as Independent Power Plants and the Coprodia, Self-Producing of Energy[1]. 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 5 Installed capacity of electricity production in sugar-alcohol plants in Mato Grosso, by 2018.

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, 2018).

The utilization of biogas produced from animals (pigs) and agricultural wastes presents an installed capacity in 2018 of 4.263,5 kW, as **Table 6**.

Table 6 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 = agricultural waste.

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

Forestry residues

The introduction of sources from forestry residues began in the year 2010, reaching today a total installed power of 66,975 kW (**Table 7**).

Table 7 Installed capacity of thermoelectric biomass power plant 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.

Figure 6 compares the evolution of electricity production due to all renewable sources combined (photovoltaic, biogas and forestry residues), except hydraulics, in Mato Grosso. The share 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 564.0%. Combined with the production of sugarcane bagasse, other primary sources of electricity production have emerged over the past four years: thermoelectric based on biomass of forestry residues and biogas from animal wastes and agricultural.

Figure 6 Electricity production from solar and biomass-based sources in Mato Grosso from 2010 to 2017. Unit: GWh.

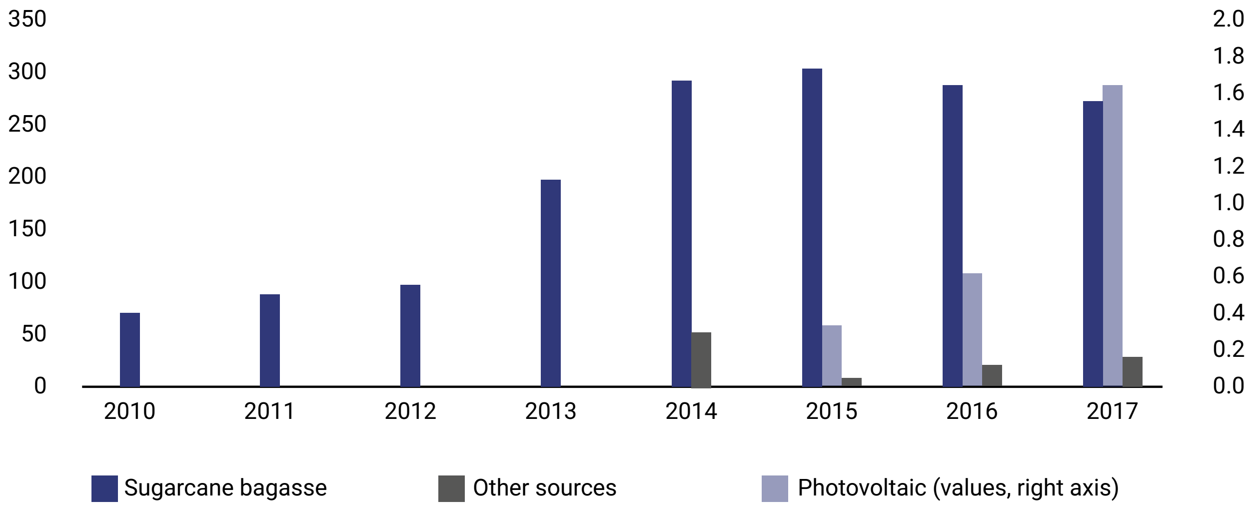


Table 8 indicates the production of electricity by photovoltaic solar source for the sectors of Mato Grosso's economy in the period from 2015 to 2018. These sectors have produced 5,645,161.1 kWh by the year 2018, an increase of 1,926.0% over the year of 2015, with the residential, commercial and agricultural sectors.

Table 8 Electricity production from solar and biomass of wood waste sources by economy's sector. Unit: KWh.

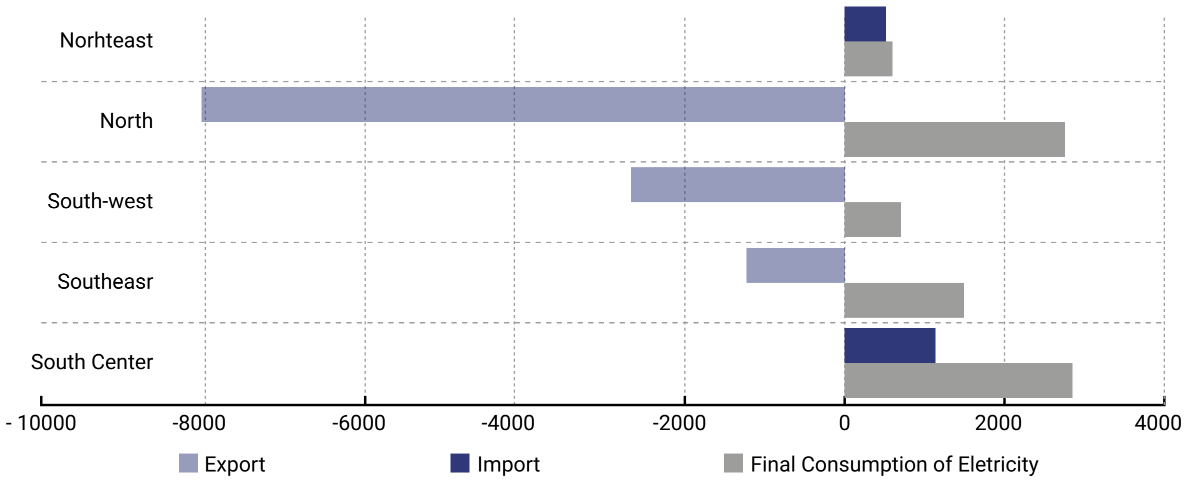
SECTOR/YEAR	2015	2016	2017	2018
Agricultural	255,312.0	262,233.8	423,990.9	1,308,380.4
Industrial	1,446.8	79,464.4	127,369.5	379,915.6
Public power	-	8,113.3	13,389.7	195,115.1
Commercial	28,277.2	142,526.5	564,092.0	2,062,830.2
Residential	8,839.5	154,529.0	423,990.9	1,698,919.8
TOTAL	**293,875.5**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

4 TECHNICAL-ANALYTICAL CONSIDERATIONS AND INDICATORS TO THE DEVELOPMENT OF RENEWABLE SOURCES IN MATO GROSSO

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 connected to a power grid, to support the meeting of the basic social demands of mesoregions of Mato Grosso. Analyzing the Figure 7, 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 energy produced.

The others mesoregions of the State produce electricity and they trade with each other, according to the intra-regional demand or they, also, export to the national interconnected System – NIS, as is the case of the South Central region that generates excess electricity when the Cuiabá natural gas-fired plant operates.

Figure 7 Energy imports and exports between the mesoregions of Mato Grosso, by 2017. Unit: GWh.



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

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

In more developed regions North, Southeast and South Central the complementation of electric power by Renewable energy sources-centralised and/or decentralised RES should be performed using individual and collective systems as well as strengthening existing networks.

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

- Electricity generated by renewable sources (%) = RES or new renewable production/ total production of electricity (PNR/P);
- Total production capacity of renewable (GWh);
- Specific consumption of electricity per inhabitant (GWh year/hab);
- Electric intensity economic sector (GWh/Added value);
- Total production capacity of fossil sources (GWh);
- Electricity consumption due to the fossil sources (GWh);
- CO_2 emissions *per capita* (due to all the energy sources and fossil sources); and
- Number of measures/ incentive policies/ existing subsidies accumulated over the years.

The share of new renewable sources is still very shy in the production of electricity in the State as shown in **Table 9** representing, in 2017, only 0.6% of the total, renewable sources face serious problems of infrastructure for its broadcast, 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 region of the State, the evolution of the indicator PNR/P can direct incentives to renewable sources.

Table 9 Electricity production by renewable sources in State of Mato Grosso's mesoregions, by 2017.

MESOREGION	TOTAL PRODUCTION (P) GWh	TOTAL PRODUCTION (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 of sources renewable. It must disaggregate the level of ability required according to the existing capabilities in the different regions of the State, 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, resistances 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:

- 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);
- Establishment of a model of regional and social integration; and
- Adjustment of the industrial society to the limits of the resources.

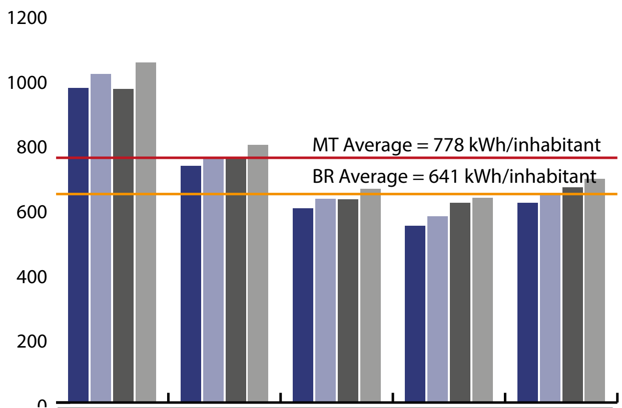
In addition, allows finding the continued great achievement, over time, in the short and in the long term, with balanced analysis of socioeconomic factors. This model is indicative and decentralized, and coexists with the various forms of power generation (with different cost and risk), including the objectives of the Government and society regarding the composition of the energy matrix 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 relevant independent variables 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.

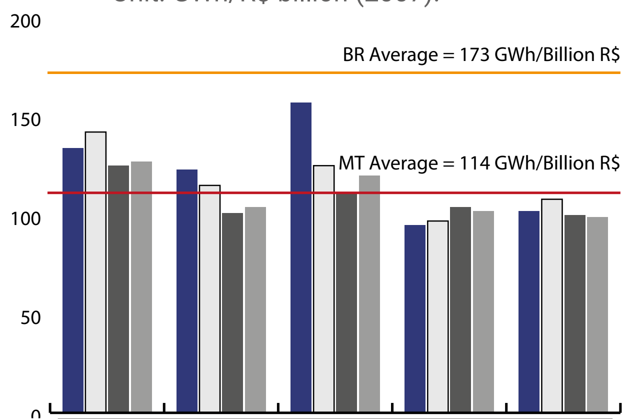
Figure 8 shows a comparison of the evolution of the specific residential consumption of electricity for the five mesoregions of the State of Mato Grosso in the period of 2014 to 2017. From the perspective of planning, there are significant differences in the evolutions and that the consumption of electricity 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, 1,050 kWh/inhabitant in 2017, is 1.7 times higher than that of the Northeast mesoregion, due to the development conditions of the region, far above the average specific consumption of Mato Grosso. The North mesoregion, with practically the same population as the South Center mesoregion, presents a specific consumption in the order of 691 kWh/inhabitants in 2017, 35.0% lower than that of the South Center mesoregion. In this case, not only the habits of the population or the technological efficiency of the processes explains this low specific consumption, but a socioeconomic condition insufficient of the majority of the families. 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 8 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	SOUTH-WEST	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 9 Evolution of the mesoregions electric intensity of Mato Grosso in the period from 2014 to 2017.
Unit: GWh/R$ billion (2007).



	SOUTH CENTER	SOUTHEAST	SOUTH-WEST	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, that is not disaggregated in energy end uses, but important, which supports the development of policies, seeks to correlate the consumption of electricity with the gross domestic Product – 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 sector of the economy (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 variance in energy consumption due to 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).

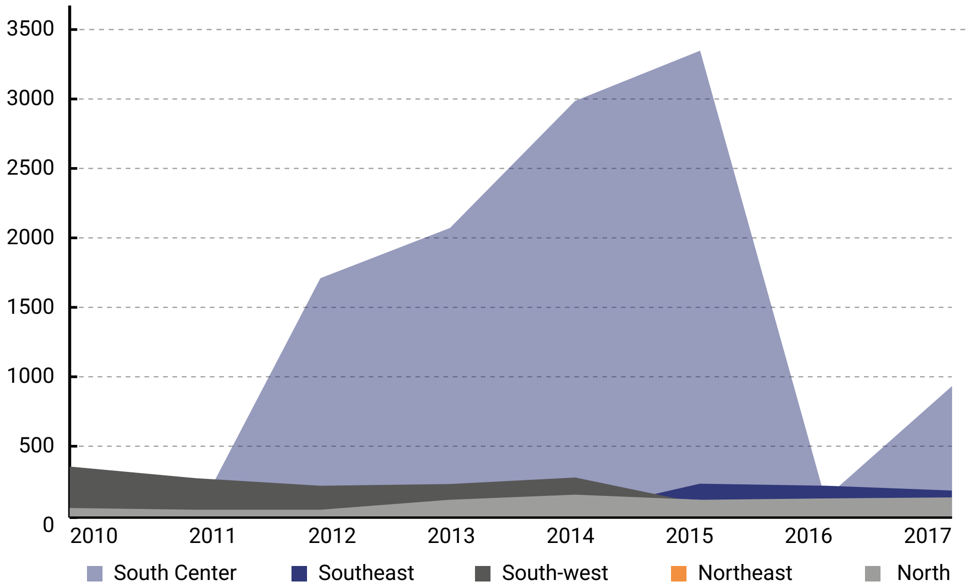
Generally, **Figure 9** shows the evolution of the electric intensity, with only the energy content, of Mato Grosso mesoregions in the period from 2014 to 2017. There are two main drivers in the evolution of this indicator among the Mato Grosso mesoregions: i) social issues, including human development and economic and the quality of life; and (ii) environmental issues, which are obviously linked to the biomes in which populations are present. Thus, it can be seen 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 Northeast mesoregion has an average 11.0% higher than the Mato Grosso average, motivated by the positive rate of the AV 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 an effective energy policy is to measure this indicator annually for all mesoregions of the State and/or sectors of the economy, and to use, with a 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 variations of the share of the economic product 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 Thermo power plant, in the South Center mesoregion of the State, when the energy supplied by the Bolivian import is offered. **Figure 10** 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 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 water balance of the reservoirs. 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 10 Electricity production by fossil sources in the mesoregions of Mato Grosso from 2010 to 2017. Unit: GWh.



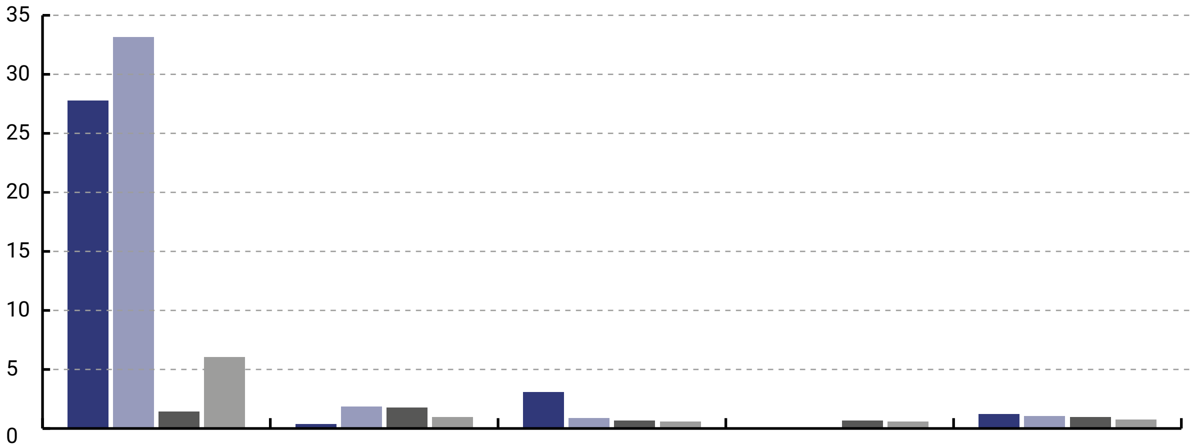
Electric intensity and the "energy content effect"

The consumption of electricity via fossil fuels, which is conditioned to the prices of oil and oil products and the modal 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 participation of the energy 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 measure of the displacement of the share of the fossil energy in the total of the sources, 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 11 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 oscillation of the natural gas production. In other regions, the amplitudes vary more depending on the economy, relative prices of goods. North and Northeast mesoregions stand out.

Figure 11 Energy content effect of 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 behavior of the scale effect in the South Center mesoregion depends closely on the thermoelectricity generation of natural gas, **Table 10**, 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.

Table 10 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**

Regarding the substitution effect, in **Table 10**, it is observed that fossil fuels remain present throughout the period, composing the energy matrix, with an "apparent" substitution; in the year 2017 the intensity is lower in four regions, and with great amplitude in the South Center region.

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.

Figure 12 shows the CO_2 emissions related to the consumption of electricity in the NIS in Mato Grosso in the 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% p.y., followed by the industrial sector, which now issues 22.0% of the total.

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

Figure 12 CO_2 emissions related to the consumption of electricity in the NIS in Mato Grosso in the sectors of the economy from 2007 to 2017. Unit: tCO_2 / MWh.

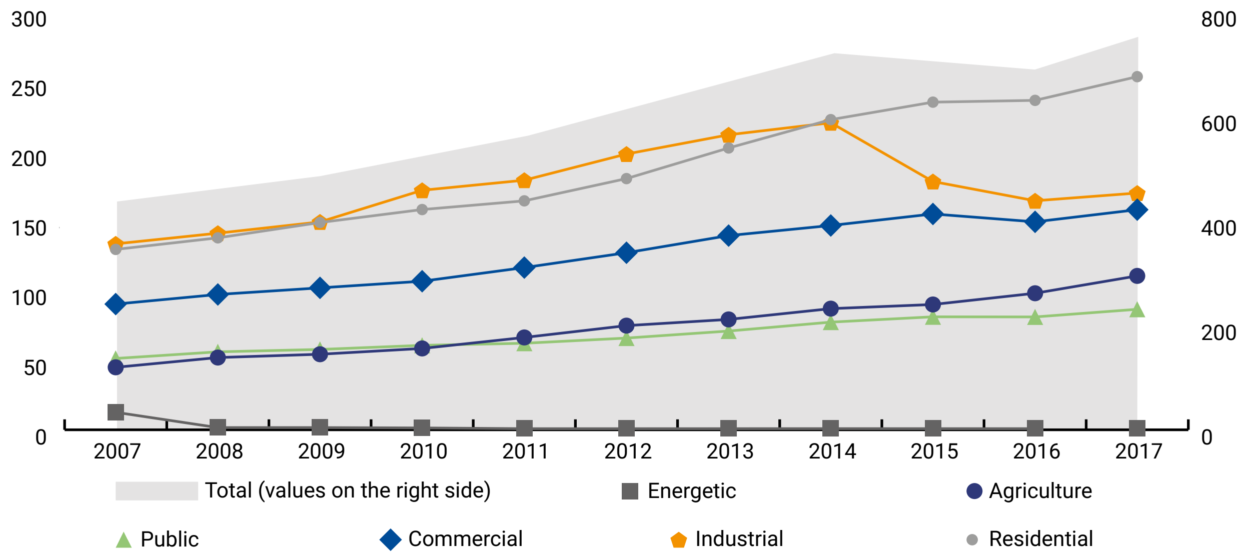


Figure 12 shows the evolution of CO_2 emissions between 2007 and 2017, indicating that the residential sector of Mato Grosso is responsible for most of the emissions, with an evolution of 6.2% p.y., followed by the industrial sector that represents 22.0% of the total of almost 780 thousand tCO_2/MWh. 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 12**, 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 share of the emissions. A policy directed towards a massive insertion of renewable sources can balance this situation, since it is not possible to dispense large thermo power plants in the NIS.

The number of measures/policies of incentives/subsidies that have accumulated over the years's indicator expresses public and private efforts in the search for greater stimulus to the use of renewable energy resources. Another feature is to show competition and economic efficiency in this important sector and to allow an energy transition - based on fossil fuels to renewables - as sustainable as possible, ensuring first the public benefit.

In this way, the indicator demonstrates the incorporation and advancement of programs and the maintenance of the role of public policies regarding collective benefits. 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.

5 FUTURE PROSPECTS AND POTENTIAL USE

The implementation of a model of Integrated Resources Planning - IRP by river basins in Mato Grosso can ensure the expansion of the generation, transmission and distribution of renewable 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.

Energy policies in Brazil have been formulated on a centralized basis by the federal Government, 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 on 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, which should take into account the intra-regional disparities and the sensitivity of the three biomes that make up the territory of Mato Grosso:

- Empower 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 (supply and demand sides) 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 existing reality of the basin: the physical environment, the

socioeconomic aspects and the examination of the demands 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 energy 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 energy 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 are necessary:

- 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 monitoring of the full life-cycle 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 based on biomass of forestry residues can be feasible, in each region of the state, by sector of the economy, establishing realistic short-term goals and coordinated implementation strategies in regional level, by public and private efforts.

According to BNDES (2005) 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 strong hydraulic vocation of Mato Grosso to produce electricity leads, by now, at least, to a context in which new renewable sources are not competitive, with low market share. Still under the BNDES analysis (2005), the justification for the development of renewable energy 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, gaps, and provide deficiencies of the general population and social unfeasibility for inclusion in a low-carbon program. However, it is important to notice that the state of Mato Grosso supplies great 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[2], regional interventions must dictate guidelines, 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.

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

Under these conditions, there are some important macro strategic objectives to be pursued by the State that can support and promote renewable energy sources in the different regions, as shown in **Box 1**.

Box 1 Summary of the macro strategic objectives 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).

5.1 PHOTOVOLTAIC SOLAR ENERGY - MARKET POTENTIAL

Insertion scenarios of RES

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 in that year. We consider the parameter of 8.6% for the 2050 horizon in a “Moderate Scenario for DG” of electricity comsumption growth in that year, according to estimates of the Energy Supply and Demand of Mato Grosso and Mesoregions, 2036 Analysis - work carried out by NIEPE-UFMT for the State Government.

2. The “Mato Grosso Scenario” is the second scenario, also proposed in the energy matrix of Mato Grosso and Mesoregions, 2036 and corresponds to an accelerated growth of GDP of Mato Grosso and the electricity consumption above the national average. Under these conditions, the two variables achieve an 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, a gradual decline in prices of photovoltaic systems, photovoltaic generation, and cost parity with prices of tariffs paid by consumers before taxes3. 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.

Box 2 shows the main assumptions adopted for determining the market potential of photovoltaic solar energy in Mato Grosso.

Box 2 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%

3 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.

The IEI-Brazil scenarios are adopted, 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 11.**

Table 11 Estimation of the market potential 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 end of the period, what would correspond to 78.5% of the total electricity demand of Mato Grosso System that same year.

5.2 Photovoltaic Solar Energy - Market Potential Attainable

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, agricultural (average scale), and industrial (large scale)[4].

The methodology adopted that follows the assumptions described in the Technical Note DEA 13/15 (EPE, 2016) for the photovoltaic sector, considered for small scale DG "that institutional conditions of the energy sectors will promote the necessary environment for

4 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 logics of the industrial sector as a guarantee of the supply and energy security, increased reliability, increased energy efficiency and economic development."

that to happen the renewal of infrastructure. In addition, contribute to the paradigm change of the distribution agents and also be disseminated the market of energy services, stimulating that investment dispersed” (EPE, 2016)

Scenarios adopted

For the attainable market the “Moderate Scenario” was adopted, described in the section of the Market Potential calculation with the projections of the final consumption of electricity in the sectors of the economy of Mato Grosso by 2050 associated with the assumptions of the Scenario “New Policies” 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 residential, commercial, industrial and public sectors, according to a trajectory in which they are evidenced, in greater scale, development policies for decentralized photovoltaic generation. Buildings are expected to be adapted to receive photovoltaic plates and also incentives for greater adoption by users.

With the lack detailed works of market estimates by consumption range for the commercial, public, industrial and agricultural sectors, the top down approach is suitable for the purposes of this evaluation from the projection of electrical demand by sector and the estimated attendance percentage of 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 social and economic benefits. Public buildings must also follow the example of the care with the environment and reducing costs by integrating 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 life of the enterprise. Considering these factors and the moment when distributed photovoltaic generation reaches the tariff parity for each sector, we assumed that the following percentages of electricity demand service will be supplied via DG photovoltaic in the case of the EPE’s “New Policies” trajectory: 7%, 14% and 18%, for the commercial, industrial and public sectors, respectively. The agricultural sector of Mato Grosso was included, assuming the percentage of 10%.

For the residential sector, we evaluate the potential according to a more disaggregated approach. We consider the electricity demand in the year 2050, the projections of the number 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)[5] and the mathematical Bass Model:

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

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.

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

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 1** presents the projection of the number 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 sectors of the economy and receive credits from the local distributor, and the calculation of the NPV (Net Present Value), obtaining results for the residential, commercial, industrial, public and agricultural sectors. Adjustments of electric energy tariffs were considered above inflation.

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

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 2**).

The Internal Rate of Return (IRR) was also calculated for investments in all sectors, obtaining a rate of 51% (**Annex 2**). 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 maintenance of the value 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 3** 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 information of the local market, we have adopted the costs a little bit below the reference.

For the estimates, tariff impacts were not applied 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, it was not simulated the impacts of consumer credits neither variations of tariff flags according to regulation of the Regulatory Agency.

Assumptions adopted

Residential sector

Box 3 Assumptions adopted for the residential sector.

Adopting consumer class	>200kWh≥ 500 kWh/month
PV system capacity	3.0 – 5.0 kWp
Service life of the system	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 4 Assumptions adopted for the commercial sector.

Maximum PV system capacity	10.0 – 20.0 kWp
Service demand in 2050	14.0%
Service life of the system	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 5 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%
Service life of the system	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 6 Assumptions adopted for the public sector.

Maximum PV system capacity	10.0 – 20.0 kWp
Service demand in 2050	18.0%
Service life of the system	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 7 Assumptions adopted for the agriculture sector.

Maximum PV system capacity	10.0 – 30.0 kWp
Service demand in 2050	10.0%
Service life of the system	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 12**.

Table 12 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.

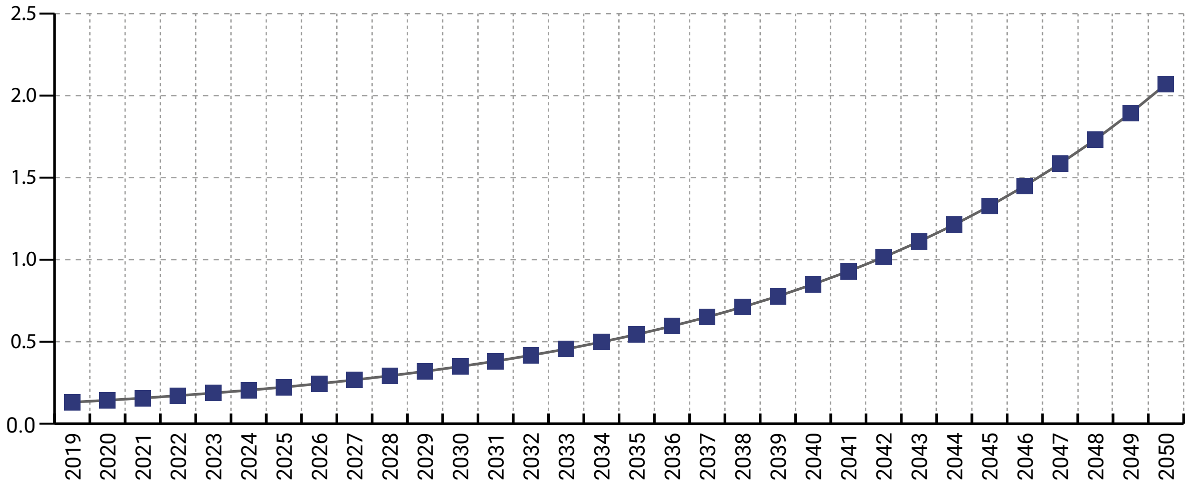


Figure 14 Evolution scenario of photovoltaic installed capacity in Mato Grosso's industrial sector on the horizon 2050. Unit: GWpeak.

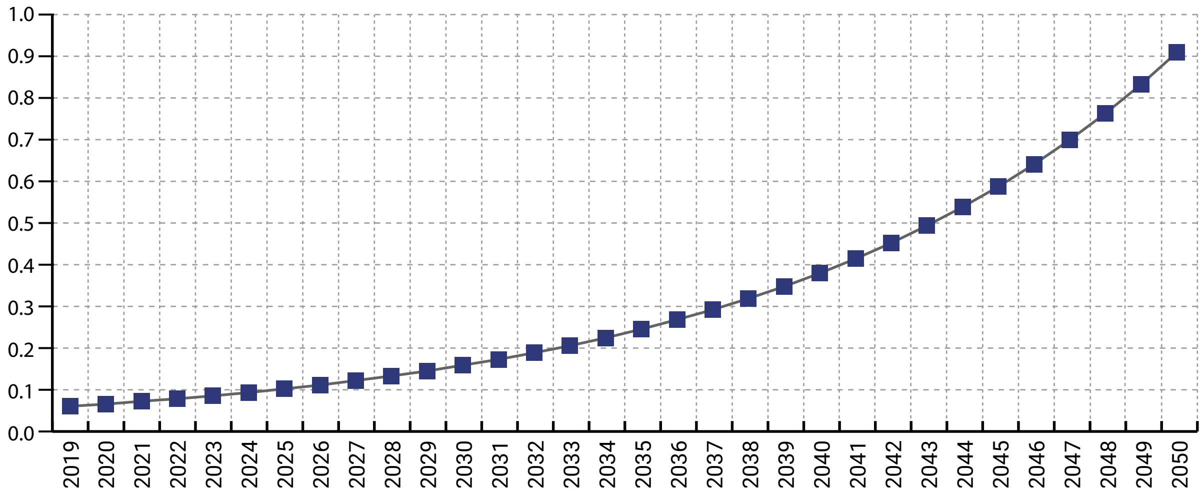


Figure 15 Evolution scenario of photovoltaic installed capacity in Mato Grosso's public sector on the horizon 2050. Unit: GWpeak.

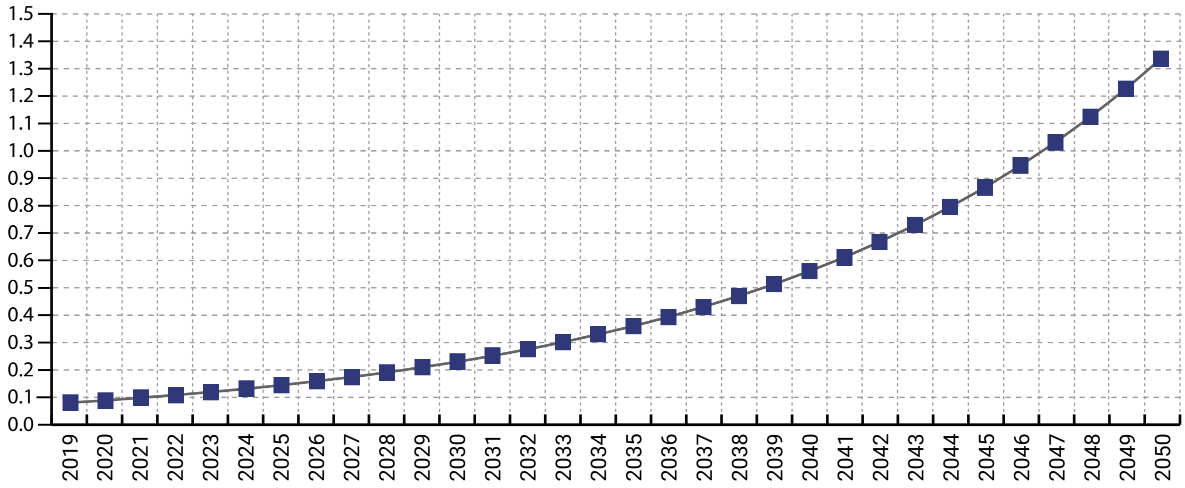


Figure 16 Evolution scenario of photovoltaic installed capacity in Mato Grosso's agricultural sector on the horizon 2050. Unit: GWpeak.

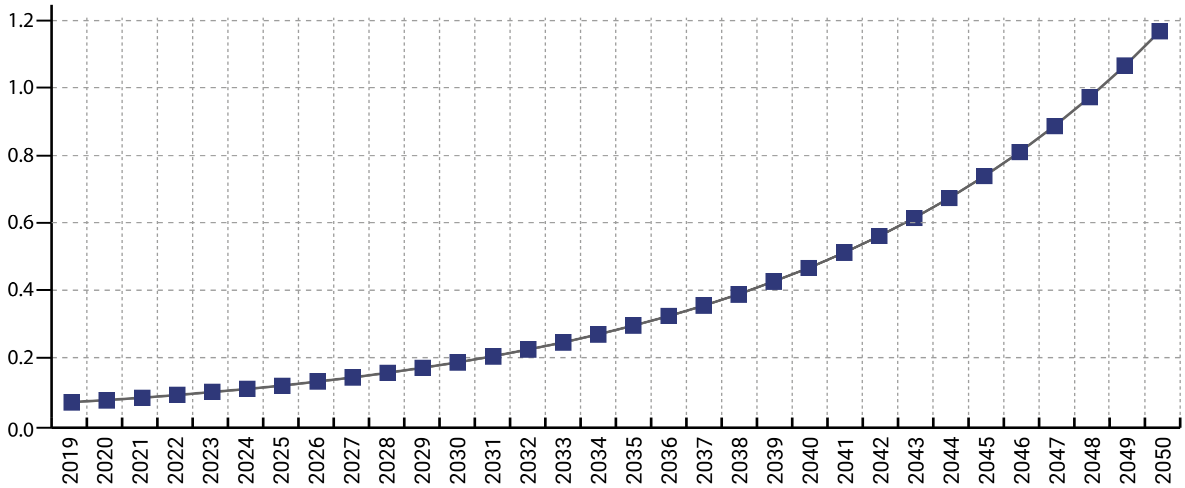
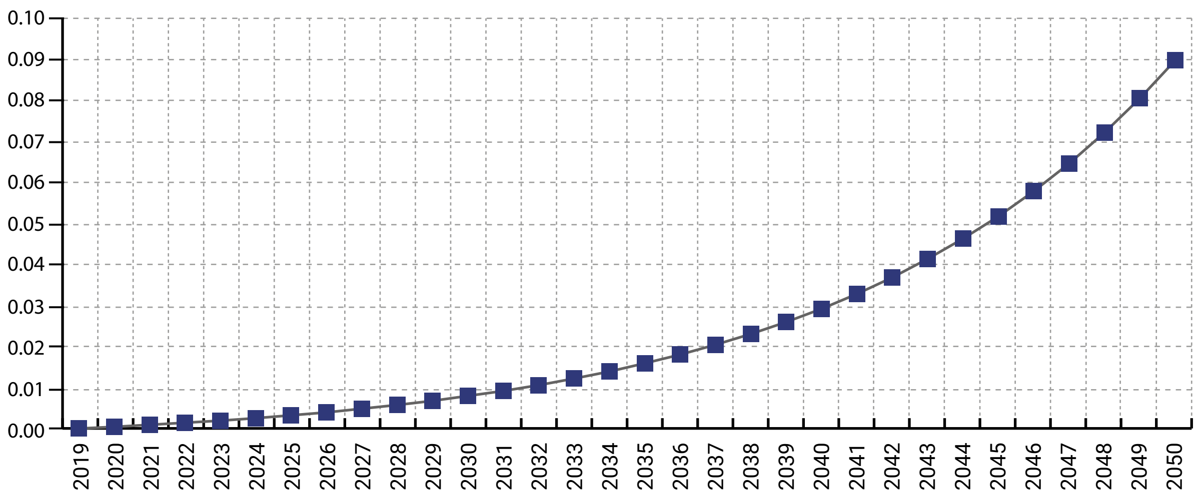


Figure 17 Evolution scenario of photovoltaic installed capacity in Mato Grosso's residential sector on the horizon 2050. Unit: GWpeak.



5.3 POTENTIAL OF FORESTRY RESIDUES

In this particular case of study of the potential of wood waste[6] 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, the technical, financial and environmental factors. For the determination of the potential study of (EPE, 2018) and are two specific goals: potential for (1) Isolated Systems (IS)[7] and (2) for the National Interconnected System (NIS). For the first are estimated the total technical potential electricity generation with woody biomass and residual electricity generation potential of this biomass that would replace Diesel generation of basis of ISs. For NIS is estimated the potential electricity 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 4** presents the NIS current configuration.

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 accomplishment of the estimated potential.

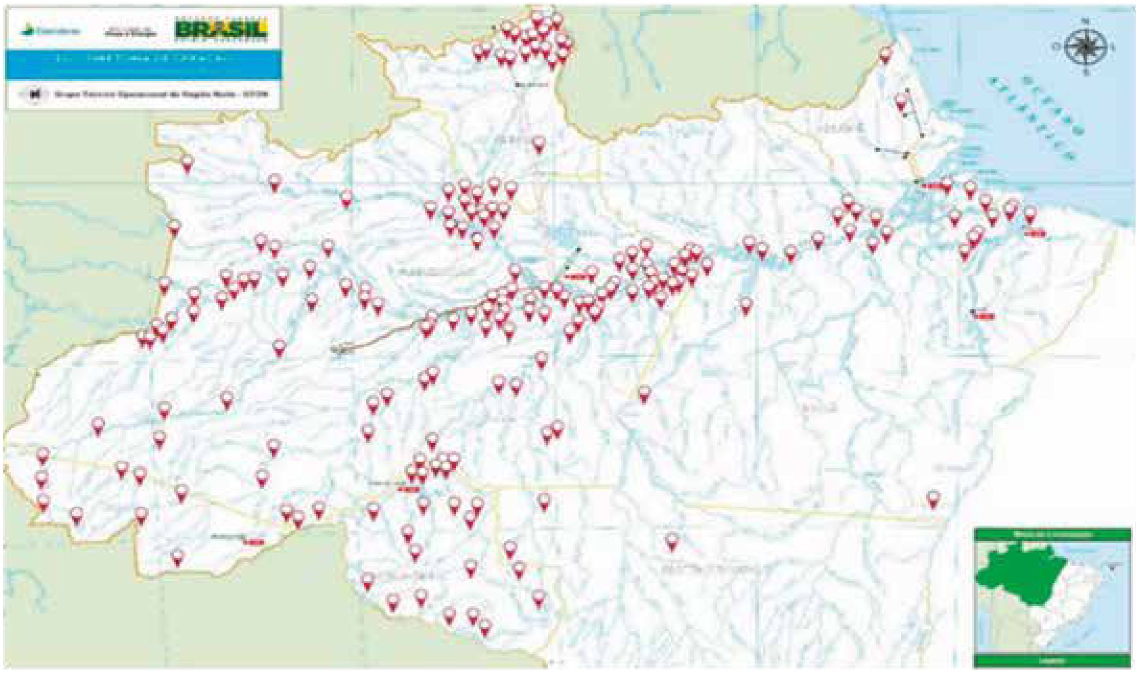
6 The generic term "wood waste" is used to the forestry residues, to the urban source (remains of works and pruning) and industrial (furniture, paper and cellulose and wood) coinciding with the term "woody biomass". Many energy drinks are derived directly or indirectly from wood and, to this set of processing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

7 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).

5.3.1. Potential for Isolated Systems

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, page of the EPE, 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 13 shows the total production and estimated Diesel oil consumption in the IS of Mato Grosso, in the north of the State.

Table 13 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, 2018b).

The Base Capacity of Mato Grosso IS considered (North of the State in the Legal Amazon) is of a Maximum Active Power of 3,265 kW and load factor of 57.0% (ANEEL, 2018).

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[8], 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[9]. 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.

Initially, areas in particular forests that could be exploited through sustainable management were identified[10] (**Table 14**).

Table 14 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, 2018)** with basis on SFB (2018), with basis on Rural Environmental Registry (CAR) and Brazilian Forest Service (SFB), 2018.

8 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.

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

10 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 sustainability of the ecosystem 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.

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, as well as the potential logging and waste generation are presented in **Table 15**.

Table 15 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 16 shows the potential of waste production in FPri in Mato Grosso.

Table 16 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.

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 17**.

Table 17 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 18** presents the total areas suitable for exploration via sustainable management, effective management areas and potential waste loggers.

Table 18 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 exploitation of the whole area of effective management and the energy conversion of all the 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 18**, 110 times the current Diesel generation capacity, and would represent approximately 2.4% of the current installed capacity of Mato Grosso system.

5.3.2 Potential for the Interconnected System

Wood based biomass potential in forestry plantations

With reference to the EPE (2018) study to estimate the energy potential of the processing residues, 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, position of the sample 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. 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, 2018).

This potential is estimated based on the reference thermo power plant, described in the EPE document (2018) “Thermo power plant for Residual Reference Biomass”[11].

The residual biomass potential of the wood industry in logs in Mato Grosso is described in **Table 19**. In the NIS area, the generation potential is 26,000 MWh which represents 0.13% of Mato Grosso’s electricity production in 2017.

Table 19 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).

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 20 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 (m³)	COST OF DIESEL OIL (R$) ANNUAL
1	7,008	1,942	2,521,000

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

11 The reference thermo 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 thermo power 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 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; 12
- 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.

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

6 ACTION GUIDELINES AND PROPOSALS

This section identifies actions and proposals aimed at contributing to the implementation of renewable energy in the State of Mato Grosso. Goals are outlined that will materialize future public policies for the realization of the use of energy potential and guarantee support for the national policy of energy expansion and security strategy and sustainable economic development.

These actions and proposals were identified based on the assessment of the complex and regulated structure of the Brazilian energy sector and must be interpreted in harmony with the legal instruments that govern the national system; in addition to the analysis of related documents issued by the state government in recent years.

This plan is indicative of the prospects for expanding renewable sources, specifically solar photovoltaic and biomass-based wood waste, and the basic actions and goals presented support it and represent its main guidelines.

A general proposal, which meets the objective of expanding renewable sources in the State, precedes specific proposals. These are analyzed interdependently to achieve the overall plan's goal and the description of the methods used to execute the proposal. The impacts and expected results are associated with the implementation of future horizontal actions (goals) estimated in function of the applied changes, encouragement of the private initiative, economy's growth, promotion of energy sources and political motivation.

6.1 BASIC ACTIONS AND TARGETS

Action 1 Keep updated on an annual basis the State Energy Balance of Mato Grosso and its regions, as well as the State's energy supply and demand, with potential energy studies.

Established by State law, the State Energy Balance is required planning instrument of the State sector. It is the essential document, associated with the energy supply and demand, for realization of regional energy planning, and leading to modeling the future energy supply and demand.

Action 2 Reactivate the State Energy Council in the field of Government Department that deals with the energy theme.

The State Energy Council is the most important forum for the debate and collegiate decision making of the energy sector in the State, whose representations are made by members of the government, organized society, research institutions and professional bodies.

Action 3 Set goals for the exploitation of the State's energy potential.

Establish goals for the exploitation of the State's energy potential in line with the documents produced from the State Energy Balance of Mato Grosso and Mesoregions, of Mato Grosso Energy Supply and Demand, among others. To carry out cooperation agreements between the State Government - Economic Development State Department and the Ministry of Mines and Energy - Energy Research Company and research institutes, aiming at common studies on the use of the State's energy potential and of regulatory legislation for the sustainable exploitation of the potential by regional mission.

Action 4 Strengthen the existing incentive measures and promotion of renewable energy in the State in close grip with national policies (Box 8). Establish a single/ agency sector in Specific secretary to take care of the theme energy and to drive the programs directly related to this subject.

Box 8 Existing and ongoing National and State 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	<u>Incentive Program for Alternative Energy Sources.</u> 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	<u>MT Industrial and Commercial Development Program</u> 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.

continues

continuation

POLICIES	YEAR	EMPHASIS
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.
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.

Action 5 Enable the creation of a Centre of Excellence in renewable energy in photovoltaic generation and biomass-based from forestry residues within the scope of the Technological Pole of Mato Grosso.

The Centre of Excellence, with participation of research institutions in the energy area, should promote the development and use of renewable sources in the State in close and integrated articulation between government, companies, industries and universities. In this context, the structure should allow the research and development of works in this area, with the aim of disseminating knowledge, information, innovative products, more efficient and economically viable, supporting the transition to a low carbon economy.

Action 6 Encourage and/or establish through mandatory measures, the adoption of sustainable construction standards using renewable energy, especially solar, in the public and private spheres.

To develop a green economy and renewable energy value chain, in addition to the incentives to increase the economic attractiveness of the projects, the Government should promote measures to extend the use of the significant potential of renewable sources, such as photovoltaic, in all regions. As an example, must practice in public buildings, following the current standards.

Action 7 Promote industrial cogeneration with biomass-based from forestry residues.

Disseminate the technical knowledge of cogeneration designs. Articulate lines of financing with lower interest rates for their development. It is possible to propose a reduction in the ICMS tax rate on equipment and technologies that prove to be more sustainable than traditional options.

Action 8 Mandatorily determine the gradual replacement of energy sources for electricity production with a high GHG emission factor by renewable sources, especially in the North and Northeast regions of the State.

Participate with ANEEL in the preparation of documents for public public procurement of distributed generation to enable a mandatory percentage or minimum installment in the State of renewable sources of photovoltaic solar or wood-based biomass. Updates to the Energy Balance and Suplly and Demand Studies are essential for fulfillment of this action.

Establish tax incentives, credit, tax and other government benefits for the sources that meet the same demand, but present smaller emission factors with effective results in GHG reduction.

This action can be carried out by the Superintendence of Industry, Commerce, Mines and Energy of the Economic Development Secretariat, with the support of the bodies that prepare the State Energy Balance.

Action 9 Establish a Foment Program for energy use from waste wood.

Create, with the timber industry and the Federation of industries in the State of Mato Grosso – FIEMT, a program designed to expand and enhance the use of forestry residues from forest management in public and private areas energy purposes. The goal is to develop the value chain in the industry, promoting strategic partnerships, consolidating the existing actions and including incentives for attracting new investments. Strengthen skills for the efficient management of the waste in each municipality, with regulation of waste management, with specific guidelines for its production and storage and/or reduction, and, in addition to power generation, its reuse, reuse, recycling, treatment and appropriate disposal.

Technical support from associations of reforestation wood producers, such as AREFLORESTA - Association of Reforesters of Mato Grosso, CIPEM - Center for Wood Producing and Exporting Industries of the State of Mato Grosso, Faculty of Forest Engineering at UFMT and SEMA - State Secretariat of Environment to FIEMT and the energy sector to leverage the energy use of wood waste, in a systematic and coordinated way, under the responsibility of SEDEC - State Secretariat for Economic Development.

Enable the application of portion of P&D features of the power utilities, in mandatory procedure, for deployment and increase in biomass-based energy systems. This action aims the creation and absorption of technology aimed at improving the efficiency and environmental quality, rationalization of the use of energy and environmental resources, and stimulating scientific and technological research. Establish working group with the local dealership, AGER and ANEEL, universities and research centers for the formulation of specific rules in order to make feasible the existing potential. The Center of Excellence must exercise the central coordination of the work.

Action 10 Make the implementation of renewable energy sources and energy efficiency a requirement in tenders for purchase of energy, acquisition of equipment and products in the public institutions of the State.

When considering the implementation of a low-carbon economy, renewable energy is priority. The public sector must use criteria in bids that prioritize equipments with green seal or energy efficiency standards and/or certificates for energy facilities and purchase of renewable energy. A working group in the bidding may exercise the task of specifying such products and services. The Center of Excellence must exercise the central coordination of the work.

Action 11 Estimated use of energy from a photovoltaic solar source of 2.5 GWp, in the period 2019-2050. It is considered virtually the same rate of current photovoltaic installed capacity growth that has been registered in the State of 79.0% p.y. to achieve, in 2050, the production of 3,990 GWh, or 20.0% of total global electricity consumption that year (Appendix 1**). The composition of this goal by sector of the economy is presented in** Table 21**.**

Table 21 Metas estimadas de capacidade de potência fotovoltaica nos setores da economia de Mato Grosso no horizonte de 2050.

SECTOR	CAPACITY TO BE ACHIEVED (MWpeak)
Residential	50
Commercial	950
Industrial	500
Public	550
Agricultural	450
TOTAL	2500

Action 12 Establish goals for the use of the technical potential considered for the production of electricity from biomass of forestry residues, according to Table 22**.**

Table 22 Estimated targets of photovoltaic power capacity in sectors of the economy of Mato Grosso on the horizon of 2050.

REGION	PRODUCTION TO BE ACHIEVED (MWh)
Isolated System	538,962
Interconnected System	26,000

6.2 COMPREHENSIVE PROPOSALS

Ensure the production of renewable energy in the State of Mato Grosso valuing the potential of each region and promoting the increase in the supply of photovoltaic solar energy and biomass-based from wood, in line with national standards, with the aim of guarantee:

- the sustainability of the State and National Electric Systems;
- lower prices of electricity for domestic, commercial, industrial and rural consumers;
- continuing to invest in renewable energy;
- the development of an energy system harmonious with the environment and the economy based on knowledge and innovation;
- promoting sustainable growth through a more efficient, greener and more competitive economy;
- inclusive growth, based on an economy with high employment rates, while offering social and territorial cohesion;
- Mato Grosso’s contribution to the reduction of greenhouse gas emissions by replacing fossil fuels in final energy consumption;
- the compliance with the State Agreement signed on December 06, 2015, during COP 21 in Paris.

Mato Grosso's energy policy must focus on promoting and developing new investments in renewable capacity, without burdening consumers, rewarded only at market prices – without Feed-in tariffs – with special focus on photovoltaics.

6.3 SPECIFIC PROPOSALS

The specific proposals to make feasible the actions of photovoltaic renewable energy potential development and based on biomass of forestry residues in Mato Grosso have direct action of the State and articulation with the federal, municipal and private spheres, as it shows the **Box 9.**

Box 9 Specific proposals. Actions under the State Government with joints with Municipal and Federal Governments and the private sector.

THEME	PROPOSAL	NECESSARY TOOLS	EXPECTED IMPACTS AND RESULTS	GOAL
Licensing	Establish simplified and standardized licensing practices, in particular to issues related to financing of projects.	Working Group involving producer agents, funding bodies and public power.	Streamlining the deployment of production units and the supply of raw materials. Mitigation of risk to energy supply.	2020
Technological Development	Invest in research aimed at reliability, increasing the efficiency and competitiveness of renewable sources.	Linking public and private resources for research and development. Articulation next to the universities and their centers for research and these, opportunely, next to the Technological Pole of Mato Grosso.	Increased supply of electricity from renewable solar photovoltaic sources and based on forest biomass.	2020
Specific Funding for Production Lines	Facilitate access to financing lines for the production sectors involved.	Specific funding lines through state and federal funding institutions.	Growth of energy supply in the state market.	2019
Tax Analysis (1)	Enable tax incentives for acquisition of assets for the implementation or renovation of production enterprises.	Establishment Confaz - ICMS Agreements. Incorporate into PRODEIC the photovoltaic projects to be implemented in the industrial and commercial sectors with power equivalent to at least half the installed load.	Increased attractiveness in strategic sectors, without loss of revenues whereas the entire production chain.	2020
Tax Analysis (2)	Enable absorption of ICMS credits throughout the production chain.	Establishment of technical groups, with the participation of the private sector, to formulate proposals which will be discussed at the three levels of Government.	Increasing the competitiveness of renewable energy.	2020
Participation of the State (Solar and biomass of forestry residues)	Establish the mandatory installation of solar thermal heaters, photovoltaic cells and photovoltaic micro generators in places of common use of all housing projects financed with public resources.	Regulation. Expand consumer information about thermal and photovoltaic systems. Trade incentives of photovoltaic plates and other materials.	Make the State one of the references on the use of solar energy and biomass from forestry residues. Increase the share of renewable sources in the State's Energy Supply and Demand..	2021

continues

continuation

THEME	PROPOSAL	NECESSARY TOOLS	EXPECTED IMPACTS AND RESULTS	GOAL
Incentive the Municipalities to install photovoltaic systems and biomass	Encourage the introduction of such systems in the sectors of the economy, using the existing financing incentives. Build new business models according to the characteristics of the municipality. Encourage cooperatives.	Establishment of Multidisciplinary Working Group with representatives of municipalities, utilities, the energy sector and the river basin committees. Participation of the federal sphere.	Development of energy potential of the State. Reduction of intra-regional energy dependence. Increase the supply by renewable energy and competitiveness of distributed generation. Strengthening the participation of the society with the cooperatives.	2020
Energy security of the State of Mato Grosso	Make effective the expansion of production capacity of electric power generation utilities in the State by photovoltaic and biomass-based sources.	Improvement of the legal framework and existing standards. Lawsuits (ad futurum or ongoing).	Increase the energy security of the State of Mato Grosso, benefiting all the National Interconnected System.	2021
Integrated resource planning and use of infrastructure	Establish Integrated Resource Planning for river basins of the State of Mato Grosso. Promote integrated management of infrastructure expansion considering water energy resources. Adopt a model that addresses government and society objectives regarding the composition of the energy supply and demand and the regional distribution of the population. They emphasize non-traditional energy alternatives and allow, through a regulated organic constitution, the real participation of stakeholders, owners and non-owners of resources, bodies involved in the resource plan, and criteria for selecting alternatives (energy, water resources and those that make it possible to conduct the energy and water sectors in time and space) with decisions made in “free will”. Within the scope of the institution of this model, it is established the significance graduation that the society wishes to limit the environmental effects of the production and use of energy and water resources. To revise the plan periodically.	Institution of Integrated Planning Group. The elaboration of integrated river basin resource planning requires a technical team capable of meeting the scope and size of the required services, based on the Basin Water Resources Plans. This Group will coordinate the actions of the other Groups established in municipalities or in government agencies. Establish a Multidisciplinary Working Group with representatives of municipalities, energy concessionaires, energy sector bodies and Hydrographic Basin Committees, universities and research centers in energy and water resources. Subsequent participation of the federal sphere.	Model indicative and decentralized, coexists with the various forms of energy generation (with different costs and risks). Streamlining energy security works. Cost reduction. Reduction of environmental impacts. Effective participation of stakeholders with benefits in the political, economic, social, cultural and environmental dimensions, with specific gains, respectively, freedom, income and employment, education and health and conservation of the physical and biotic environment.	2022

continues

continuation

THEME	PROPOSAL	NECESSARY TOOLS	EXPECTED IMPACTS AND RESULTS	GOAL
Strengthening the State's role in the processes of electro-energetic planning (1)	Enable the execution, by the State, of integrated resource planning, of an indicative nature, and promotion of distributed generation. The model must provide: 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 regional integration and social model; 3) adjustment of society to the limits of State resources.	Cadastral information system about the developments of interest to the State. Annual update of the State and regions energy balance. Operating agreement with the EPE for monitoring and construction of integrated planning of water and energy resources in Mato Grosso according to their regional vocations and sustainable development of its energy potential.	Development energy projects of interest to the State. Development of backward regions. Regional integration. Rational use of the State's energy resources potential.	2022
Strengthening the State's role in the processes of electro-energy planning (2)	Consolidate and strengthen the monitoring of the implementation of generation expansion and improvement of transmission and distribution system.	Technical working group between Economic Development secretariat-coordination of energy companies in the sector, dealers of generation, transmission and distribution, institution responsible for State energy balance, EPE and ONS.	Increased reliability and mitigation of the vulnerabilities of the state electric system, monitoring the energy/ electric sector strategies, as well as identification of interinstitutional conflicts in relation to the implementation of the projects in the territory of Mato Grosso.	2021
Photovoltaic systems in rural areas in indigenous districts, settlements and villages	Establish viabilization obligatoriness of districts attendance, settlements quilombolas, indigenous villages, with renewable sources available on site (photovoltaic and/or biomass).	Working Group with the government, energy concessionaire, representatives of the organizations and groups. Regulation of ANEEL.	Adequate use of the State's energy potential. Increase the supply of renewable energy. Reduce investments in distribution lines and networks.	2020

continues

continuation

THEME	PROPOSAL	NECESSARY TOOLS	EXPECTED IMPACTS AND RESULTS	GOAL
Public institutional management **(1)**	Encourage the research and development of equipment and materials in the production of photovoltaic energy; support the establishment of partnerships with companies in the field for the development and practical application of the research developed on the production of photovoltaic and biomass-based renewable energy; and in the production of equipment. Support groups/research centers in the field of renewable energy. To encourage the qualification, in the graduation and postgraduate of collaborators, technicians and professors in the area of photovoltaic energy and other renewable energy, considering the necessity of the commitment and responsibility of the Institution in the solutions and sustainable development of the State.	Agreements with medium and higher education institutions in the technological area. Public-private partnerships for the provision of training and capacity-building services.	Development of skills and abilities in renewable energy in the government sector. Preparation of technicians in the energy area to perform functions in the area of government, contributing to the improvement of plans and planning instruments. Pedagogical innovation in courses on renewable energy conversion for be a transformative agent in the reality of society. Access to new technologies, together with research and teaching institutions and companies.	2020
Public institutional management **(2)**	Publish annually the PEDER-MT and reports with its adjustments and adaptations.	Publication by the State Government of the Strategic Renewable Energy Development Plan – PEDER 2050 and annual status reports and evaluation of the implementation of the proposals. In addition to the adaptation and/or complementary measures to be adopted in the short, medium and long term, considering the monitoring and evaluation study through the indicators, and the integration with the municipalities, in a regionalized way.	Strategic Plan for the Development of Renewable Energy and Renewable Energy Policies made public, as well as reassessed and revised over time in order to consolidate themselves as a reference in the sector for energy planning. Better performance of the planning at the regional level. Participation of municipalities and associations of municipalities. Interaction with regional and municipal development plans. The application of regional indicators allows for better measurement of local reality and reflects the social and economic dynamics with greater accuracy.	2021

continues

continuation

THEME	PROPOSAL	NECESSARY TOOLS	EXPECTED IMPACTS AND RESULTS	GOAL
Public institutional management **(3)**	Conduct meetings and training/awareness workshops for local governments, organized society and associations and consortia of municipalities.	Implementation by the competent government body of meetings and awareness/ training workshops about the aspects and opportunities related to renewable energy, with the target audience the associations of municipalities, authorities and local governments.	Stakeholders trained and sensitized about the use of renewable energy resources in their region. Identification of knowledge gaps on the renewable sources. Understanding and settlement of doubts as to the benefits related to improving the quality of life, job creation, economic growth, environmental conservation and reduction of environmental conflicts.	2021
Public institutional management **(4)**	Develop a partnership with the National Planner, the Energy Research Company (EPE) a Ministry of Mines and Energy's agency for continuous improvement of the Plan.	The Secretary of State shall develop partnership, in addition to the local institutions – universities and research centers that produce the energy balance, energy distribution, with the EPE for enhancement of the continuous monitoring of the plan in relation to the annual increment of energy sources, the construction of transmission and distribution and the new national energy policies.	Detailed control and monitoring of electrical works distributed in Mato Grosso territory. Strengthening and the search for synergies between the State plan and national plans. Improvement and updating of the proposals, actions and goals of the State plan.	2021
Public institutional management **(5)**	Conduct synergistic studies between PEDER-MT and regional development plans and sectoral plans. See Appendix 2.	The thematic groups must submit periodically synergistic studies between these plans aiming at compatibility of actions between the sectors. Development of studies in partnership with the respective Secretaries of State responsible for the plans and/or programs, assessing, reviewing and adapting the plan, if necessary, to their actions.	Systematization of an Information Inventory on energy infrastructure, and social, economic and environmental objectives, considering adaptations to regional and / or sector conditions and the reduction of conflicts, by region. Increased knowledge of sectorial problems by region of the State.	2020

continues

continuation

THEME	PROPOSAL	NECESSARY TOOLS	EXPECTED IMPACTS AND RESULTS	GOAL
Private institutional management (including training)	Encourage companies in the energy sector (industrial and commercial) to improve knowledge and expertise on renewable energy; and understand the business as their market feasibility, costs of materials, preparation courses and improvement, customers and target audience in MT and its different regions. Develop technical expertise about designs and installation, operation and maintenance of photovoltaic energy systems based on biomass (termeletricidade), as well as the sale of the product. Supply and exchange knowledge and partnerships with educational institutions from research and improving the exchange of experiences and use of skilled labor to market growth.	Agreements or contracts with medium and higher education institutions in the technological area for training, qualification, lato sensu or strictu sensu postgraduate courses (professional masters or specific area).	Achieving savings in material, input and financial resources in the proposition, budgeting, specification, project development, installation, commissioning and operationalization phases of power plants. Social and environmental value added to the product, the customer collective and private individual. Supply of skilled labor in the labor market and the generation of highly qualified jobs. New strategies and teaching tools for possible applications of electric power generation projects that use renewable resources in professional technical education with the skills that come up in the labor market.	2020

7 MONITORING AND ASSESSMENT OF THE PLAN

Monitoring and evaluation of the implementation of the Strategic Plan for the Development of Renewable Energies in Mato Grosso - PEDER 2050 are carried out with the analysis of the established annual indicators (**Section 4**), tool thats allowing control over the development of the Plan over time. This procedure guarantees a short and medium-term view of the plan, allowing the correction of its trajectory, in addition to favoring the management of the effects and mitigations of changes that occurred during the period.

The data needed to update the monitoring and assessment tool of PEDER-MT must be collected annually, always at the same time, so that they can compare the evolution of each action. They can be obtained with the implementation of the State energy balance and meso-regions annually. This update is the responsibility of the energy Coordination of the State Secretariat for Economic Development, in cooperation with other State Departments and Government agencies, and must be guided and approved by the State Council for Energy, once in operation.

8 FINAL CONSIDERATIONS

Electricity generation by renewable sources in Mato Grosso, in particular photovoltaic solar and based on forestry residues, should be encouraged in the context of the implementation of measures/public policies linked to local development drives, goals of job creation, other socioeconomic and environmental conservation benefits.

The proposals contained in this Plan are linked to the Technical Report on “Evaluation of the technical and economic potentials of generation and use of renewable energy in Mato Grosso”, the document that set the formulation of actions and proposals. For its implementation, it must be understood that meeting the future energy demand in the State of Mato Grosso, through its renewable energy resources, does not prevent the conservation of the environment, nor is it done without it. The energy supply is characterized both by the diversification of its sources and by the capacity to produce electricity with a reduction in environmental impacts.

In these circumstances, however, the challenges are significant, considering the three sensitive bioregions and intra-regional development disparities, requiring the plan adopt the best strategies and the emphasis on the risks and opportunities, in addition, to guide the agents toward the difficulties encountered to perform projects, undertaking, investing and increasing the upward curve of production of renewable energy.

The Plan is just one of the stages for the establishment and development of new renewable sources in Mato Grosso. It highlights the main proposals based on the scenario of the renewable energy market and how it can evolve from the perspective of the main entity – the government. The Plan also presents how measures can direct the expansion of these sources in the long term in line with the cross-cutting development plans conducted by the state government and sectoral plans.

To implement the Plan, it is necessary to define the functional structure of government, linked to the competent Secretariat, dedicated to the coordination of activities. The development of the plan requires the implantation and interaction of multisectoral thematic groups, maintaining a centralized government agency organized to coordinate studies, analyze, monitor and evaluate the proposals comprised in the plan. Plan path, responsibilities and timelines shall be monitored by the State Energy Council once in operation.

The results are the guarantee of sustainable public policies for a renewable matrix, rational use of resources, safety and reliability of the electrical system, frequent and permanent monitoring of electrical structuring works, supply of electricity cheaper to the consumer, generation of employment and income, and support for the development of the Green Economy Program in the State of Mato Grosso.


E-70

BIBLIOGRAPHIC REFERENCES

ANEEL. Special Bidding Committee. **National Electric Energy Agency**, 2016. Available in: <http://www2.aneel.gov.br/aplicacoes/editais_geracao/documentos/Comunicado_Relevante_2_NT_EPE_sistemas_h%C3%ADbridos_leilao-02-2016.pdf>. Accessed in: October 2018.

ANEEL. National Electric Energy Agency. **Isolated Systems**, 2018. Available at: <http://www.aneel.gov.br/busca?p_p_id=101&p_p_lifecycle=0&p_p_state=maximized&p_p_mode=view&_101_struts_action=%2Fasset_publisher%2Fview_content&_101_returnToFullPageURL=http%3A%2F%2Fwww.aneel.gov. % 2Feed% 3Fp_auth% 3DwfjL43yl% 26p_p_id% 3D3% 26p_p_lifecycle>. Accessed on: September 2018.

ANEEL. BIG - Generation Information Bank. **ANEEL**, 2018. Available at: <http://www2.aneel.gov.br/aplicacoes/ResumoEstadual/GeracaoTipoFase.asp>. Accessed on: December, 2018.

ANEEL. Distributed generation. **ANEEL**, 2018. Available at: <http://www2.aneel.gov.br/scg/gd/gd_estadual_detalhe.asp?uf=MT>. Accessed on: December 2018.

ARCARDIS TETRAPLAN. **Study on the potential of energy generation from waste from sanitation (garbage, sewage), aiming to increase the use of biogas as an alternative source of renewable energy**. United Nations Development Program - UNDP and Ministry of Environment - MMA. São Paulo - Brazil, p. 56. 2010.

BARBOSE, G. et al. **Tracking the Sun VI: An historical summary of the installed price of photovoltaics in the United States from 1998 to 2012**. Berkeley Lab's: Lawrence Berkeley National Laboratory. California, USA, p. 70. 2013.

BRAZIL. **Solar energy in Brazil: situation and perspectives**. Chamber of Deputies, Legislative Consulting. Brasília, Federal District, p. 46. 2017.

BRAZIL, G. **GREENPEACE BRASIL ANNUAL REPORT**. GREENPEACE BRAZIL. Acknowledgments 16. 2013.

COSTA, Ricardo Cunha da; PRATES, Cláudia Pimentel Trindade. The role of renewable energy sources in the development of the energy sector and barriers to market penetration. **BNDES Sectorial**, Rio de Janeiro, n. 21, p. 5-30, mar. 2005.

CPFL. R & D project “Panorama and comparative analysis of the electric energy tariff in Brazil with tariffs practiced in selected countries, considering the influence of the current institutional model”. **Report V - Formation of costs and prices of electricity generation and transmission**, São Paulo, SP, Brazil, p. 130, 2015. Available at: <https://www.cpfl.com.br/energias- sustainable/innovation/projects/Documents/PB3002 / training-of-costs-and-prices-of-generation-and-transmission. pdf>. Accessed on: September 2018.

DORILEO, I. L. **Integrated planning of energy and water resources in river basins: methodological proposal and application to the Cuiabá-MT River basin**. Thesis (PhD in Energy Systems Planning), Post-graduation Program in Mechanical Engineering, State University of Campinas - UNICAMP. Campinas, São Paulo, p. 548. 2009.

DYKSTRA, D. R.; BINKLEY, C. S. **The global forest sector: an analytical perspective**. International Institute for Applied Systems Analysis. Luxemburg, Austria, p. 24. 1987.

ELYSIA SOLAR ENERGY. Types of Solar Inverter: Everything you need to know about the equipment that is the heart of the photovoltaic system. **Elysian Solar Energy**, 2018. Available in: <https://www.elysia.com.br/blog/tipos-de-inversor-solar/>. Accessed on: 07 Dec. 2018.

EPE. **Technical Note EPE: Analysis of the insertion of solar generation in the Brazilian electrical supply and demand**. Ministry of Mines and Energy - MME. Rio de Janeiro - Brazil, p. 64. 2012.

EPE. **Technical Note: Analysis of the insertion of solar generation in the Brazilian electrical supply and demand**. Energy Research Company, Ministry of Mines and Energy. Rio de Janeiro, Brazil, p. 58. 2012.

EPE. **Studies of energy demand. Technical Note DEA 13/15**. Research Company Energétia, Ministry of Mines and Energy. Rio de Janeiro, RJ, Brazil. 2016.

EPE. **Technical qualification: overview of the process and results. Auction Workshop A-6, 2018**. Energy Research Company - Ministry of Mines and Energy. Brasília, Federal District. 2018.

EPE. **Technical note EPE 17/18: Energy potential of forestry residues from sustainable management and residues from the industrialization of wood**. Energy Research Company, Ministry of Mines and Energy. Rio de Janeiro, RJ, Brazil.2018.

FERNANDES, M. C. **Techno-economic analysis of biomass gasification for rural electrification**. Dissertation (Master’s Degree in Mechanical Engineering), Post-graduation Program in Mechanical Engineering, State University of São Paulo - UNICAMP. Campinas, São Paulo, Brazil. 2000.

FGV. **Notebook opinion FGV energia. Financing of alternative renewable energies in Brazil**. Getúlio Vargas Foundation. São Paulo Brazil. 2017.

FINEP-BRAZIL. Inova-energy. **FINEP**, 2018. Available at: <http://www.finep.gov.br/apoio-e-financiamento-externa/programas-e-linhas/programas-inova/inova-energia>. Accessed on: November 2018.

GREANPEACE BRASIL. **Energy [Re] Evolution - For a Brazil with 100% clean and renewable energy.** GREANPEACE BRASIL. [Sl]. 2016.

HIGA, A. R.; KAGEYAMA, P. Y.; FERREIRA, M. Variation of the basic wood density of Pinus elliottii var elliottii and Pinus taeda. **IPEF (Current Scientia Forestalis)**, n. 7, p. 79-91, 1973.

IBGE. **Brazil's regional division in immediate geographic regions and intermediate geographic regions:** 2017. Rio de Janeiro: [sn], 2017. 80 p.

IEE - USP. **Photovoltaic microgeneration in Brazil: economic viability**. Institute of Energy and Environment of the University of São Paulo, Laboratory of Photovoltaic Systems. São Paulo Brazil. 2015.

IEI - BRAZIL. **Impacts of the insertion of photovoltaic distributed generation and of energy efficiency in the Brazilian electric sector: methodology, scenarios and results**. International Energy Initiative Brazil. Campinas, São Paulo, Brazil, p. 73. 2018.

IEI - BRAZIL. **Greater dissemination of distributed energy resources (RED): suggestions for mitigating tariff impacts and guidelines for a new energy policy**. International Energy Initiative Brazil. Campinas, SP, Brazil, p. 31. 2018.

IEI - BRAZIL. **The advancement of distributed generation, energy efficiency and other distributed resources: possible solutions and experiences in Brazil and in other countries**. International Energy Initiative - Brazil. Campinas, São Paulo, Brazil, p. 25. 2018.

INPE. **Atlas Brazilian in energy solar.** National Institute of Space Research. Are Joseph two Fields, Sao Paulo, Brazil. 2017.

IPCC. **Guidelines for National Greenhouse Gas Inventories. Volume 2 - Energy. Chapter 2 - Stationary Combustion**. Intergovernmental Panel on Climate Change. [Sl], p. 47. 2006.

IPT. **Catalog of Brazilian hardwoods for civil construction**. Institute of Technological Research. São Paulo, Brazil, p. 104. 2013.

JANNUZZI, G. D.M. **Public policies for energy efficiency and renewable energy in the new market context**. 1ª. ed. Campinas - São Paulo: Autores Associados, 2000. 128 p.

JANNUZZI, G.M.; SWISHER, J. N. P. **Integrated planning of energy resources. Environment, energy conservation and renewable sources**. 1ª. ed. Campinas, São Paulo: Autores Associados, 1997. 246 p.

KOHLBACH. Custom biomass energy solutions. **Kohlbach**, 2018. Available at: <www.Kohlbach.at>. Accessed on: November 2018.

LAURI, P. et al. Woody biomass energy potential in 2050. **Energy Policy**, v. 66, p. 19-31, 2014.

LEHMANN, H.; PETER, S. **Asessment of roof & façade potentials for solar use in Europe**. ISUSI, Institute for Sustainable Solutions and Innovations. Römerweg 2, 52070 Aachen, Germany, p. 3. 2003.

LIMA, C. M.; CAMURÇA, L. C. V. The obstacles to the development of renewable energies in Brazil. **JUS**, 2017. Available at: <https://jus.com.br/artigos/58916/os-entraves-para-o-desenvolvimento-das-energias-renovaveis-no-brasil>. Accessed on: 07 Dec. 2018.

MARTINS, V. A. **Analysis of the potential of public policies in the viability of distributed generation in Brazil**. Dissertation (Master in Energy Planning), Graduate Program in Energy Planning of the Federal University of Rio de Janeiro - COPPE. Rio de Janeiro, Brazil, p. 93. 2015.

MCTIC. Corporate Issuance. **Ministry of Science, Technology and Innovation**, 2018. Available at: <https://www.mctic.gov.br/mctic/opencms/ciencia/SEPED/clima/textogeral/emissao_corporativos.html>. Accessed in: October 2018.

MELLO, E. C. J. D. **Strategic planning for the implementation of photovoltaic energy in deprived areas of Maranhão: ecological proposal of socio-economic energy solution**. Dissertation (Master's Degree in Mechanical Engineering), Graduate Program in Mechanical Engineering, State University of Campinas. São Luiz - MA, Brazil, p. 123. 2003.

MITIDIERI, M. F. **Analysis of the potential of distributed generation of photovoltaic solar energy in the banking, basic education and gas stations sectors**. UFRJ-COPPE. Rio de Janeiro, Brazil, p. 89. 2017.

NARUTO, D. T. **Advantages and disadvantages of distributed generation and case study of a photovoltaic solar system connected to the electric grid**. Undergraduate Project (Electrical Engineering Course), UFRJ / Escola Politécnica.Rio de Janeiro - Brazil, p. 97. 2017.

NOGUEIRA, L. P. P. **Current state and future prospects for the wind industry in Brazil**. Dissertation (Master in Energy Planning), Graduate Program in Energy Planning - COPPE. Rio de Janeiro, p. 137. 2011.

OMNIPELLETS. Certification and Quality. **Omnipellets**, 2018. Available at: <http://www.omnipellets.com/certification>. Accessed on: 07 Dec. 2018.

ONS. **Annual plan of operation of the isolated systems for 2018 (PEN SISOL 2018)**. National Operator of the Electrical System. Rio de Janeiro, RJ, Brazil, p. 53. 2017.

RIBEIRO, F. D. A.; ZANI, J. Variation of basic wood density in species / provenances of Eucalyptus spp. **IPEF (Atual Scientia Forestalis)**, n. 46, 1993.

ROGERS, E. **The diffusion of innovations**. 5th. ed. New York, USA: The Free Press, 2003.

ROMEIRO, D. L.; FERRAZ, C. The protagonism of the new renewable energies and the challenge of remunerating the greater flexibility required to the electrical systems. **Brazilian Journal of Energy**, Itajubá, Minas Gerais, Brazil, v. 22, n. 2, p.68-82, 2016.

SEDEC. **Energy balance of the state of Mato Grosso and mesoregions 2015 - Base year 2014**. Secretary of State Economic Development. Cuiabá, MT, Brazil. 2015.

SINGLETON, C. Can Conquer the Next Phase of Renewables Integration. **Greentechmedia**, 2017. Available at: <https://www.greentechmedia.com/articles/read/can-california-conquer-the-next-phase-of-renewables-integration#gs.xWXrRgg>. Accessed on: 30 Oct. 2018.

SOCCOL, F. J. et al. Challenges for the Implementation of Distributed Energy Generation in Brazil-An Integrative Review of Literature. **Brazilian Journal of Production Engineering**, v. 2, n. 3, p. 31-43, 2016.

STAROSTA, J. Maximum instantaneous demand or “peak load”. **Portal The electric sector**, 2016. Available in: <https://www.osetoreletrico.com.br/demanda-instantanea-maxima-ou-pico-da-carga/>. Accessed on: 07 Dec. 2018.

APPENDICES

APPENDIX 1 **FINAL CONSUMPTION OF ELECTRICITY IN THE SECTORS OF THE ECONOMY OF THE STATE OF MATO GROSSO IN THE PERIOD FROM 2007 TO 2017 AND PROJECTION OF THE DEMAND FOR THE PERIOD FROM 2018 TO 2050.**

Flow	Final energy consumption	Energy	Residential	Commercial	Public	Agricultural	Industrial
2007	4,983	137	1,397	973	552	484	1,440
2008	5,237	19	1,486	1,048	603	559	1,522
2009	5,538	19	1605	1,099	622	585	1,609
2010	6,031	204	1,705	1,150	654	630	1,688
2011	6,384	193	1,772	1,256	670	715	1,778
2012	6,966	214	1,945	1,371	710	806	1,920
2013	7,638	234	2,182	1,504	764	854	2,100
2014	8,290	304	2,401	1,614	834	938	2,199
2015	7,985	10	2,537	1,671	875	970	1,922
2016	7,874	10	2,550	1,610	874	1,057	1,773
2017	8,406	10	2,734	1,704	933	1,191	1,833
2018	8,987	93	2,828	1,832	957	1,159	2,149
2019	9,221	186	2,910	1,839	973	1,197	2,142
2020	9,857	143	3,124	1,979	1,045	1,347	2,241
2021	10,045	93	3,230	2,057	1,067	1348	2,299
2022	10,267	186	3,304	2,056	1,082	1,382	2,288
2023	10,934	143	3,529	2,204	1,157	1,545	2,391
2024	11,104	93	3,632	2,283	1,178	1,536	2,450
2025	11,312	185	3,699	2,273	1,190	1,566	2,435
2026	12,010	142	3,934	2,429	1,269	1,743	2,541
2027	12,162	92	4,033	2,508	1,289	1,725	2,600
2028	12,357	185	4,094	2,490	1,299	1,751	2,582
2029	13,087	142	4,340	2,653	1,382	1,940	2,691
2030	13,221	92	4,435	2,733	1,399	1,913	2,751
2031	13,402	185	4,489	2,708	1,407	1,936	2,728
2032	14,163	142	4,745	2,878	1,494	2,138	2,841
2033	14,279	92	4,837	2,958	1,510	2,102	2,901
2034	14,447	184	4,883	2,925	1,515	2,120	2,875
2035	15,239	142	5,150	3,103	1,606	2,336	2,991
2036	15,338	92	5,239	3,183	1,621	2,290	3,051
2037	15,492	184	5,278	3,142	1,624	2,305	3,021
2038	16,316	141	5,556	3,328	1,718	2,533	3,141
2039	16,396	92	5,641	3,409	1,731	2,479	3,202
2040	16,537	184	5,673	3,359	1,732	2,490	3,168

continues

continuation

Flow	Final energy consumption	Energy	Residential	Commercial	Public	Agricultural	Industrial
2041	17,392	141	5,961	3,553	1,830	2,731	3,291
2042	17,455	92	6,042	3,634	1,842	2,667	3,352
2043	17,582	183	6,067	3,576	1,841	2,674	3,314
2044	18,469	141	6,367	3,777	1,943	2,928	3,441
2045	18,513	91	6,444	3,859	1,953	2,856	3,503
2046	18,627	183	6,462	3,793	1,949	2,859	3,461
2047	19,545	141	6,772	4,002	2,055	3,126	3,591
2048	19,572	91	6,846	4,084	2,063	3,044	3,653
2049	19,672	183	6,857	4,010	2,057	3,044	3,608
2050	20,622	140	7,177	4,227	2,167	3,324	3,741

Unit: GWh.

1. The projection of the demand for electricity has been carried out according to studies of the energy matrix of Mato Grosso prepared by the interdisciplinary studies in energy planning at the Federal University of Mato Grosso. The methodology used is that of structural Decomposition using the gross domestic Product of Mato Grosso and Scenario of growth of the economy of the World Bank, marked by the development of Brazil's GDP and the plots of energy consumption by sector of the economy; and also, using the 10-Year Energy Plan 2026 premises of the EPE/MME. In this way, the model is: CE = [CE/VA x VA] x [VA/GDP x GDP] x [CEsector/CEtotal x CE total].

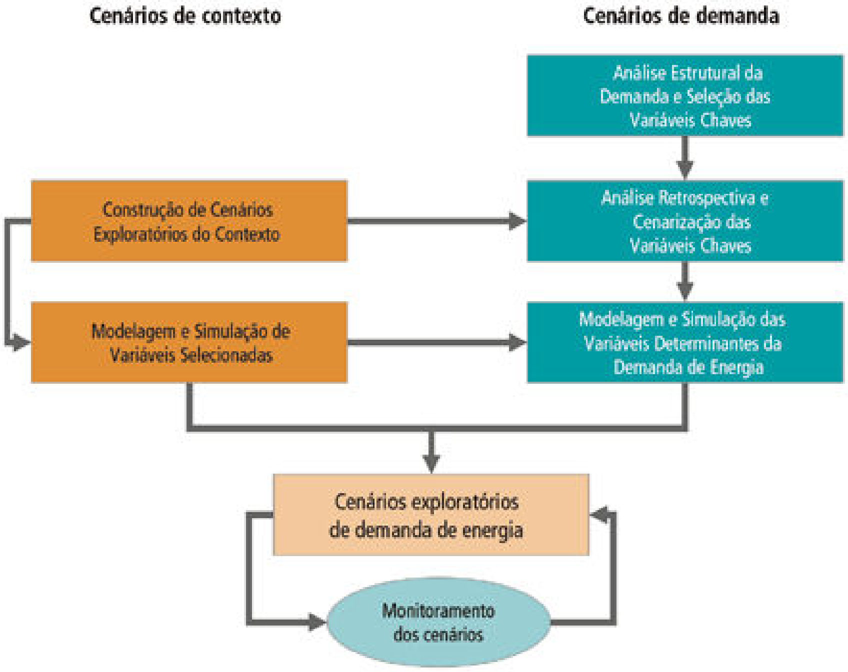
Where: CE = Final energy consumption
VA = Industry added value
GDP = Gross domestic product

Diagram of the process of preparation of exploratory scenarios of energy demand.

46

Plano Nacional de Energia 2030

Figura 1.1 – Esquema do processo de elaboração de cenários exploratórios de demanda de energia



A macro etapa dos **cenários de contexto** compreende as seguintes fases:

- análise retrospectiva da evolução recente do ambiente objeto dos cenários (mundial e nacional);
- pesquisa qualitativa de coleta de percepções e expectativas sobre o futuro do objeto de cenários;
- identificação dos condicionantes de futuro do contexto (tendências e incertezas);
- seleção das incertezas críticas - variáveis centrais de futuro altamente incerto;
- formulação de hipóteses plausíveis de desempenho das incertezas críticas;
- geração dos cenários exploratórios;
- quantificação das variáveis sociais e econômicas relevantes;

A macro etapa dos **cenários de demanda** compreende as seguintes fases:

- análise estrutural de mapeamento das variáveis centrais que determinam a demanda de energia sob condições sócio-econômicas, tecnológicas e políticas;
- hierarquização e seleção das variáveis de maior poder de determinação direta da demanda (rede de causalidade);
- análise retrospectiva do desempenho da demanda como um todo e das variáveis-chave;
- formulação de hipóteses plausíveis de desempenho das variáveis-chave nas condições dos cenários do contexto;
- geração e desenvolvimento dos cenários exploratórios de demanda de energia;
- quantificação da demanda de energia.

Source: EPE, 2010.

Proceeded to the verification of the consistency of the macroeconomic scenario formulated. The scenario is considered consistent macroeconomically based on verification of compatibility of the main variables with the qualitative characterization of the scenarios. Later, the results were verified against references available and evaluated in discussion with experts. So, we're going to have a macroeconomic scenario of "moderate" growth. It should be noted that the State of Mato Grosso's historical growth rates greater than those of Brazil.

Assumptions of EDP 2026 scenarios for Brazil:

- It was considered that the obstacle to growth comes from two fronts: the first, cyclical, is on the economic crisis starting in 2014 and the ability to rollback this scenario, with growth to pre-crisis levels; the second, structural measures, refers to the logistics and infrastructure bottlenecks, in addition to the low-skill labor and lack of industrial policies in the direction of developing higher value-added activities and greater competitiveness International, in order to generate high rates of vigorous and sustained growth.

- In this study, it is considered that the growth will be more strongly at the end of the first five-year period (2017-2022). The weak demand will remain in the early years, due to the greater persistence of unemployment, credit constraints and low confidence of consumers and investors. This will lead to a weak growth of domestic market-dependent sectors, such as services and construction industry sectors and some processing, such as cement, paper, and producers of consumer goods industries durable (vehicles, home appliances) and capital goods (machinery and production equipment).

- In the second five-year period, due to the resumption of internal demand and the excess of idle capacity, projected industry growth, especially of the manufacturing industries and construction. Primary industries-exporters, such as farming and some sectors of the extractive industry (iron ore and oil) and processing (such as cellulose), will benefit by natural brazilian competitiveness and submit more vigorous growth along the horizon. Thus, the growth will be pulled more strongly by primary industries-exporters, while the more intensive industry in capital goods (processing, construction) and services will present a more modest growth. "Until 2036 macroeconomic prospects will be better and will mark a more accelerated development of the economy. To Mato Grosso is considered an average growth rate of 4.1% per year until the horizon of 2050.

2. The table below shows the projections of GDP and of the regional GDP of the State of Mato Grosso to the scene admitted to the projections of energy demand and applied in VA sector.

Billions (10^9) R$

YEARS	BRAZIL	SOUTH CENTER	NORTHEAST	NORTH	SOUTHWEST	SOUTHEAST	MT
2009	2,239.14	14.75	3.26	16.20	9.30	4.02	**47.54**
2010	2,402.60	16.04	3.21	15.27	9.47	4.63	**48.61**
2011	2,510.71	16.49	4.01	19.59	10.78	4.83	**55.70**
2012	2,631.23	18.14	4.44	22.09	11.28	4.93	**60.88**
2013	2,749.63	18.71	4.83	23.26	12.10	5.28	**64.19**
2014	2,870.62	20.58	5.32	24.72	12.66	5.22	**68.50**
2015	2,985.39	19.78	5.35	23.82	12.38	5.33	**66.67**
2016	3,104.74	21.64	5.39	25.69	13.72	5.84	**72.28**
2017	3,227.15	22.37	5.89	27.83	14.40	5.89	**76.38**
2018	3,354.25	23.45	6.36	29.48	14.95	6.15	**80.38**
2019	3,486.21	24.47	6.73	31.09	15.63	6.38	**84.31**
2020	3,623.18	25.54	7.12	32.77	16.34	6.62	**88.39**
2021	3,765.36	26.64	7.52	34.51	17.08	6.86	**92.62**
2022	3,907.96	27.75	7.93	36.25	17.82	7.11	**96.86**
2023	4,057.44	28.92	8.35	38.08	18.60	7.36	**101.31**
2024	4,214.20	30.13	8.79	40.00	19.42	7.63	**105.97**
2025	4,378.65	31.41	9.26	42.01	20.27	7.92	**110.87**
2026	4,551.20	32.76	9.75	44.12	21.17	8.21	**116.00**
2027	4,728.02	34.13	10.25	46.28	22.09	8.52	**121.27**
2028	4,913.42	35.57	10.78	48.55	23.05	8.84	**126.78**
2029	5,107.85	37.08	11.33	50.92	24.07	9.17	**132.57**
2030	5,311.78	38.67	11.91	53.42	25.13	9.52	**138.64**
2031	5,525.66	40.33	12.51	56.03	26.24	9.89	**145.00**
2032	5,743.24	42.03	13.13	58.69	27.37	10.26	**151.48**
2033	5,968.77	43.78	13.77	61.45	28.54	10.65	**158.19**
2034	6,202.51	45.60	14.43	64.31	29.76	11.05	**165.15**
2035	6,444.71	47.48	15.12	67.27	31.02	11.47	**172.35**
2036	6,695.64	49.43	15.83	70.34	32.32	11.90	**179.82**
2037	6,943.35	51.36	16.53	73.37	33.61	12.33	**187.19**
2038	7,199.06	53.35	17.25	76.49	34.94	12.77	**194.80**
2039	7,462.99	55.40	18.00	79.72	36.31	13.22	**202.66**
2040	7,735.35	57.52	18.77	83.05	37.73	13.69	**210.76**
2041	8,016.39	59.70	19.57	86.49	39.19	14.17	**219.12**
2042	8,295.12	61.87	20.36	89.90	40.64	14.65	**227.42**
2043	8,581.87	64.10	21.17	93.40	42.13	15.14	**235.95**
2044	8,876.84	66.39	22.01	97.01	43.67	15.65	**244.73**
2045	9,180.23	68.75	22.87	100.72	45.24	16.17	**253.76**
2046	9,492.24	71.18	23.75	104.53	46.87	16.71	**263.04**
2047	9,813.04	73.68	24.66	108.46	48.53	17.26	**272.59**
2048	10,142.97	76.24	25.60	112.49	50.25	17.83	**282.41**
2049	10,482.28	78.88	26.56	116.64	52.01	18.41	**292.51**
2050	10,831.19	81.59	27.55	120.91	53.83	19.01	**302.89**

APPENDIX 2 DEVELOPMENT AND INTEGRATION PROPOSALS WITH CONVERGENT/ CROSS PLANS.

The State of Mato Grosso, in order to establish Fiscal Incentive Programs, instituted through Law 7.958 of September 25, 2003 the Industrial and Commercial Development Program - PRODEIC (Program with modules of a minimum duration of 10 years and evaluated the every two years by a Deliberative Council, lynched, at its creation, to the State Secretariat of Industry, Commerce, Mines and Energy - SICME and to the State Council for Business Development - CEDEM) whose purpose is to leverage the development of defined economic activities as strategic for the priority production of goods and services in the State, considering the social and environmental aspects, in order to improve the Human Development Index and the social well-being of the population. Article 1 of this Law defines the Mato Grosso Development Plan, guided by the guidelines of the State Development Policy, with the objective of contributing to the expansion, modernization and diversification of economic activities, stimulating the realization of investments, the technological renovation of structures productive and the increase of the state competitiveness with emphasis on the generation of employment and income and the reduction of social and regional inequalities.

The State of Mato Grosso faces as bottlenecks for the development of its economy the following premises: the difficulty of availability of financial resources; and savings to stimulate private investment. The State has abundant natural resources and large production of agricultural raw materials (economy based on the primary sector), and in order to promote the development of the economy, there is a need to stimulate industrialization with a focus on agroindustrialization. However, the State does not have enough financial resources to promote this development, due to the high indebtedness, lack of value added and verticalization, and the low consumer population.

As an alternative to these bottlenecks faced by the State, the only way to boost the economy in attracting private investments and expanding the investments of entrepreneurs already installed in the State, is through fiscal policy that uses as fiscal incentives instruments through specific programs/projects and of the ICMS Regulation. These instruments allow us to leverage resources from future non-existent revenues, without compromising fiscal responsibility. In this way, it is possible to increase the collection through the movement of the several productive chains existing and those that will be constituted in the State, given the conditions for the private investors to carry out their economic activities.

The proposal is to incorporate into PRODEIC investments for photovoltaic projects to be implemented in industrial and commercial sectors with a power equal to at least half of the installed load that is eligible in the program.

The table below contextualizes the various programs/projects that enable and/or enabled the granting of tax incentives in the State of Mato Grosso and their status.

PROGRAMS/ PROJECTS	CREATION	GOAL	INCENTIVE CONDITIONS	MANDATORY FOR INCENTIVE	STATUS
Industrial Development Program - PRODEI	Law no 5.323/88	Promote the deployment and expansion of activities to promote the Industrial Development of Mato Grosso.	Special term for payment of the ICMS for a period of 10 years; limited to 70% of the amount due.	Collection of 5% to FUNDEIC, 6% to FUNDED and 3% as administration fee.	Inactive
PRODEIC		To contribute to the expansion, modernization and diversification of economic activities, stimulating the realization of investments, technological renewal of productive structures, increasing state competitiveness, conservation of natural resources and preservation of the environment, with emphasis on employment and income generation; and reducing social and regional inequalities.	Up to 100% of ICMS due.	Up to 7% collection to FUNDEIC.	Active
Incentive Program for the Textile and Clothing Industries of MT - PROALMAT	Law no 7.183/99; Decree no 1.154 of 02/10/00	Streamline the process of industrialization of cotton produced by the Mato Grosso, in technological and environmental standards of quality and preservation, as well as stimulate public and private investment by offering tax incentives to industrialists regularly registered and accredited.	Tax credit of up to 85% of ICMS due.	The gathering FUNDEIC of 5% on the incentive granted.	Active
Program for the Development of the Ox Productive Chain - PROCOURO	Law no 7.216/99; Decree no 1.290 of 04/14/00	Development of the ox productive chain.	Tax credit of up to 85% of ICMS due.	The gathering FUNDEIC of 5% on the incentive granted.	Inactive (December 2005)
Agribusiness Development Program of Wood-PROMADEIRA	Law no 7.200/99; Decree no 1.239 of 03/20/00	Agribusiness development of wood in the State.	Tax credit of up to 85% of ICMS due.	Collection of 7% on the incentive granted to FUNDEIC.	Inactive (December 2005)

continues

continuation

PROGRAMS/ PROJECTS	CREATION	GOAL	INCENTIVE CONDITIONS	MANDATORY FOR INCENTIVE	STATUS
Incentive Program for the Processing, Roasting and Grinding Industries of the State of Mato Grosso - PROCAFÉ/MT	Law no 7.309/00; Decree no 2.437 of 03/29/01	Boost the industrialization process of the coffee produced in Mato Grosso, in technological and environmental standards of quality and preservation, as well as stimulate public and private investment, offering tax incentives to industries regularly registered and accredited.	ax credit of up to 85% of the ICMS due.	The gathering FUNDEIC of 5% on the incentive granted.	Active
Mining Development Program - PROMINERAÇÃO	Law no 7.606/01; Decree no 4.15 of 04/04/02	Increased mining production chain, encouraging the adding value, the modernisation and industrialization of mineral activities, promoting the competitive insertion in the sector.	Tax credit up to 70% of ICMS due.	The gathering FUNDEIC of 5% on the incentive granted.	Active
Programme to encourage Rice industries of Mato Grosso	Law no 7.607/01; Decree no 4.366 of 05/21/02	Streamline the process of industrialization of the rice produced in Mato Grosso, in technological and environmental standards of quality and conservation, as well as stimulate public and private investment, offering tax incentives to industries regularly registered and accredited.	Tax credit up to 85% of ICMS due.	The gathering FUNDEIC of 5% on the incentive granted.	Active
Dairy Industry Development Program - PROLEITE	Law no 7.608/01; Decree no 4.629 of 07/11/02.	Promote and stimulate milk production within the highest standards of social, environmental and economic sustainability, in accordance with the increasing demands of society in General and of national and international consumers, offering benefit and tax incentives to those industries and, also, the industries of machinery, equipment, installations, packaging and supplies aimed at the agribusiness dairy, located in Mato Grosso.	Tax credit up to 85% of ICMS due.	The gathering FUNDEIC of 5% on the incentive granted.	Active

All these programs (denominated Sectorial Programs) migrated to PRODEIC (being included as projects), according to Resolution no. 012/2005 of CEDEM.

ANNEXES

ANNEX 1 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 2 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 3 ADOPTED RESULTS OF LEVEL COST FOR THE CITY OF CUIABÁ - TEXT TAKEN AND ADAPTED FROM (IEE-USP, 2015).

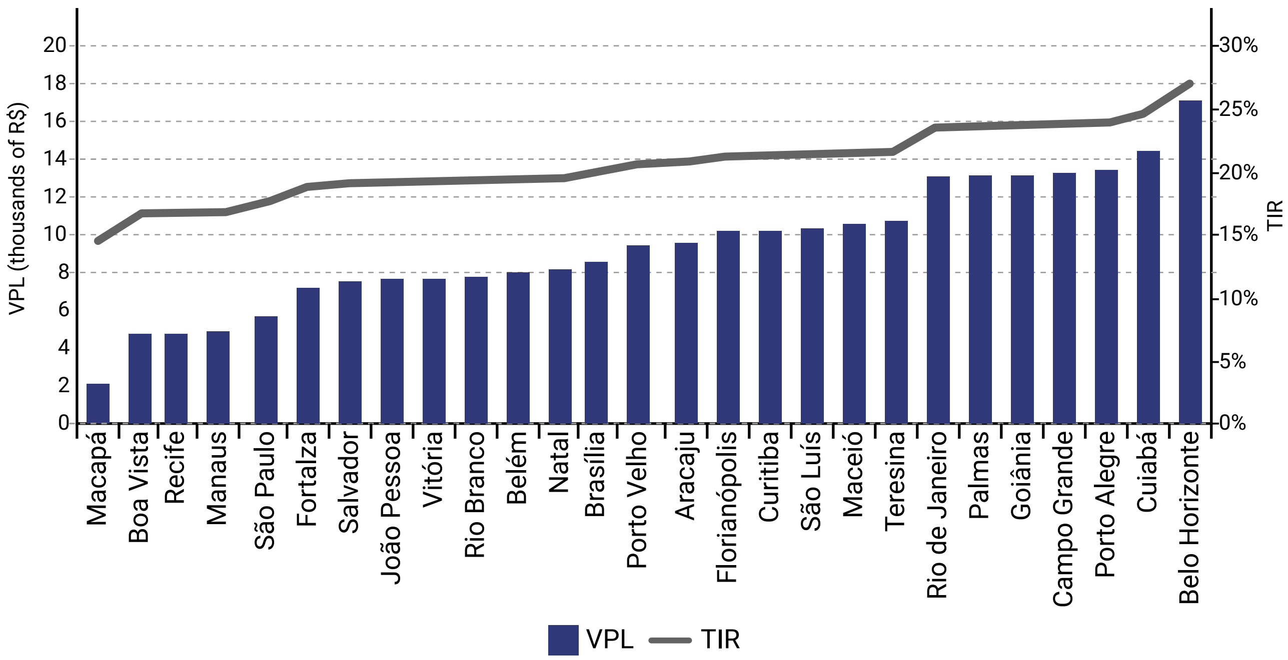
Standard Scenario

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

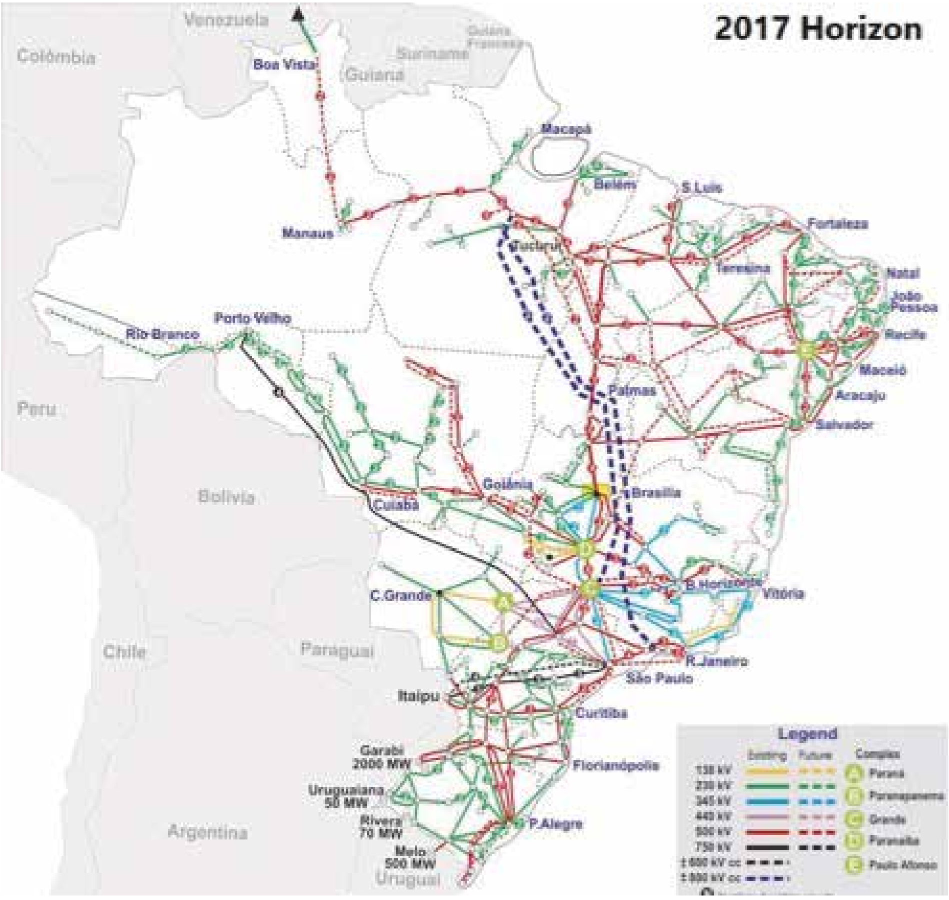
For the calculation of the energy cost, it is more appropriate to use the real discount rate, ie the discounted nominal rate of inflation. Since the use of the nominal discount rate of 12.25% would lead to a distortion in the comparison of the level of energy cost with the current conventional electricity 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 4 NATIONAL INTERCONNECTED SYSTEM (NIS).



Source: ONS (2017).

ANNEX 5 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%.

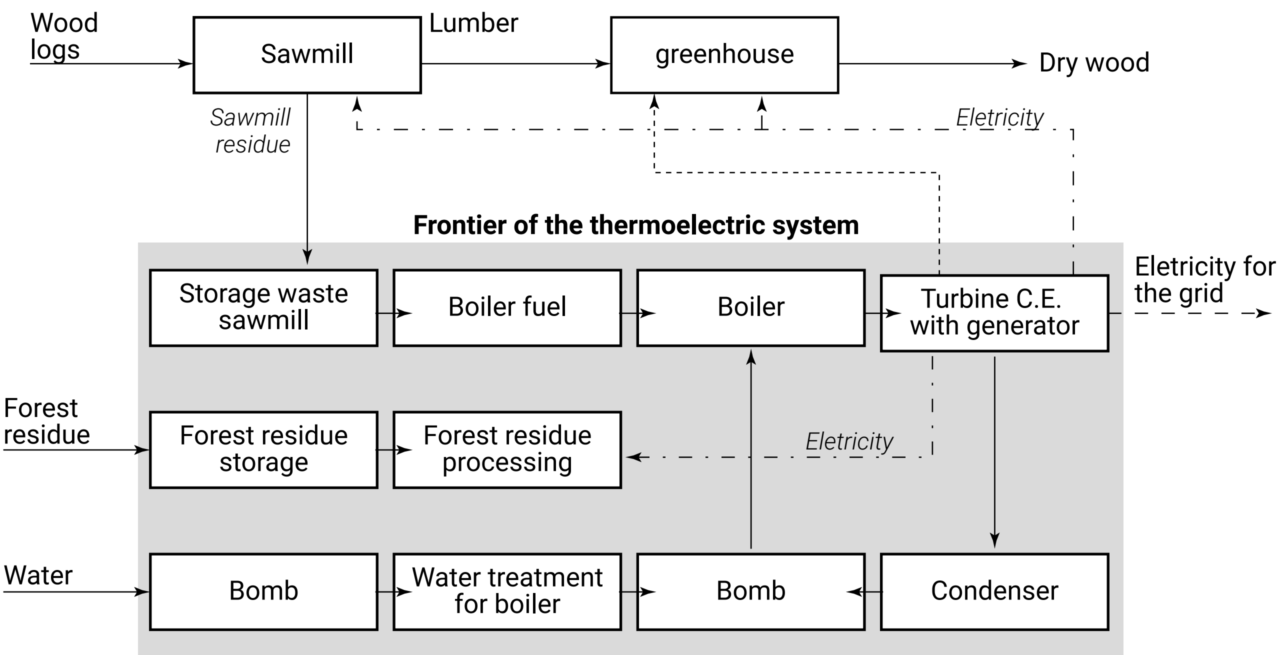
The thermal energy of the steam extracted from the turbine is used in kilns to dry the wood, which adds value to the product. It is considered that 100% of the lumber is sent to the greenhouse. In this condition, the specific vapor consumption at 8.7 bar of pressure is 0.9 t/m³ of steam processed, or 0,6[1] MWh of thermal/m³ log (INEE, 2003). The greenhouse condensate at 90°C returns to the tank that feeds the boiler.

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).