Universal access to electricity in Brazil: evaluation of SIGFIs and MIGDIs

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Summary

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Foreword

In order to face the challenges of universalizing access to electricity in Brazil, the Aneel (Brazilian Electricity Regulatory Agency) regulated, in 2004, the use of stand-alone renewable energy power systems as an additional alternative to the expansion of the electricity grid. This was done by means of Normative Resolution nr 83/2004, a fundamental initiative and milestone because it provided a solution to guarantee the sustainability of these systems.

In 2009, the International Energy Initiative (IEI Brasil) published a report analyzing the progress of the implementation of the Resolution after 5 years of its creation. At the time, the results showed that Aneel, the agency responsible for inspecting these systems, did not have the minimum information required by its own regulations.

Thirteen years after the publication of the first report, the IEI Brasil conductec a new analysis of the implementation of these systems. We hope to contribute constructively to the implementation of the legal, regulatory and governance frameworks that will guarantee the public benefits of universal access to electricity in Brazil.

The authors would like to thank Aneel and the consumers for the information provided.

Purpose of this study

The purpose of this study is to carry out an updated assessment of the status of SIGFI (Individual stand-alone power systems) and MIGDI (mini-grids) powered by renewable energy sources and installed by electricity distribution utilities within their plans for universal access to electricity. Besides, improvements will be proposed and suggestions from the main stakeholders will be presented (including customers interviewed).

Introduction

The Brazilian Program for Universalization of Access and Use of Electrical Energy – Light for All (LPT), provided access to electricity to more than 16 million people (around 3.4 million households) since its creation in 2003 (BRASIL, 2018, p.4). However, more challenging places (remote and/or difficult to access, for instance) have not yet received electricity, either through stand-alone power systems or by expansion of the grid.

The expansion of the conventional electricity grid was the main solution adopted by the LPT, but individual stand-alone power systems or mini-grid systems powered by renewable energy were also installed where the electricity distribution utilities did not consider the grid expansion viable (for example, logistical difficulties, long distances from consumer centers and high installation costs). According to the current Government plan (BRASIL, 2022), most of the remaining homes will be connected by stand-alone renewable energy power systems (mainly by photovoltaic systems).

According to the regulations of Aneel, these systems are called SIGFI (Individual Electricity Generation System with Intermittent Sources) and MIGDI (Stand-alone Electricity Generation and Distribution Microsystem). Distribution power utilities are obliged to universalize access to electricity within their concession areas through their universalization plans. They are approved and their implementation are overviewed by Aneel. The utilities have been accelerating the implementation of their plans through LPT.

The LPT program benefits families in rural areas, prioritizing low-income families enrolled in the federal government's Single Registry ("Cadastro Único", in Portuguese) of social programs: rural settlements, indigenous communities, quilombos[1], as well as communities located in extractive reserves and other groups that have specific social and cultural characteristics. The LPT Program had been extended to December 2022, but has recently been further extended to December 31, 2026[2].

Complementarily, in February 2020 a specific program was created for the population of remote areas of the Legal Amazon, named Brazilian National Program for Universalization of Access and Use of Electrical Energy in the Legal Amazon – More Light for the Amazon (MLA). The MLA was created to bring electricity from renewable energy sources to families living in these areas,

[1] CPISP (2022) defines "quilombo" as "the denomination for communities of black slaves who resisted the slavery regime that prevailed in Brazil for over 300 years and was abolished in 1888".
[2] Decree 11,111 of June 29, 2022.

where there are about one million Brazilians without access to the public service of electricity according to IEMA (2020). The Program was to be completed by December 31, 2022 but was extended until December 31, 2030.

However, it is not enough to simply connect these people to electriity. Inspection and monitoring and evaluation (M&E) of these stand-alone power systems are essential to ensure sustained access to electricity.

While the national regulation and governance of the LPT, and recently of the MLA, have generally been well designed to ensure the sustainability of these stand-alone power systems, since the mid-2000s there has been no robust and periodic impact and process assessments. At least publicly disclosed.

This raises the question of whether the public benefit of electricity access is in fact being guaranteed, since the supply of electricity from these systems over time is uncertain or even unknown by the regulatory agency and by society.

Therefore, the purpose of this study is to carry out a new assessment of the status of SIGFI (Individual stand-alone power systems) and MIGDI (mini-grids) powered by renewable sources and installed by electricity distribution utilities following their plans for universal access to electricity. The first survey was conducted in 2009 - five years after the first regulation of the SIGFI (JANNUZZI et al., 2009).

In addition, the study aimed to bring the perspectives of electricity distribution utilities and users of these systems.

Firstly, the relevant concepts and themes addressed in this work will be presented with an updated overview of the corresponding regulatory context. Secondly, the methodology and the results from installed systems data analysis. After that the perspectives from users and distribution companies will also be presented. Lastly, final considerations and recommendations of the study.

Methodology

The methodology used in the study is comprised of four stages as presented in Figure 1.

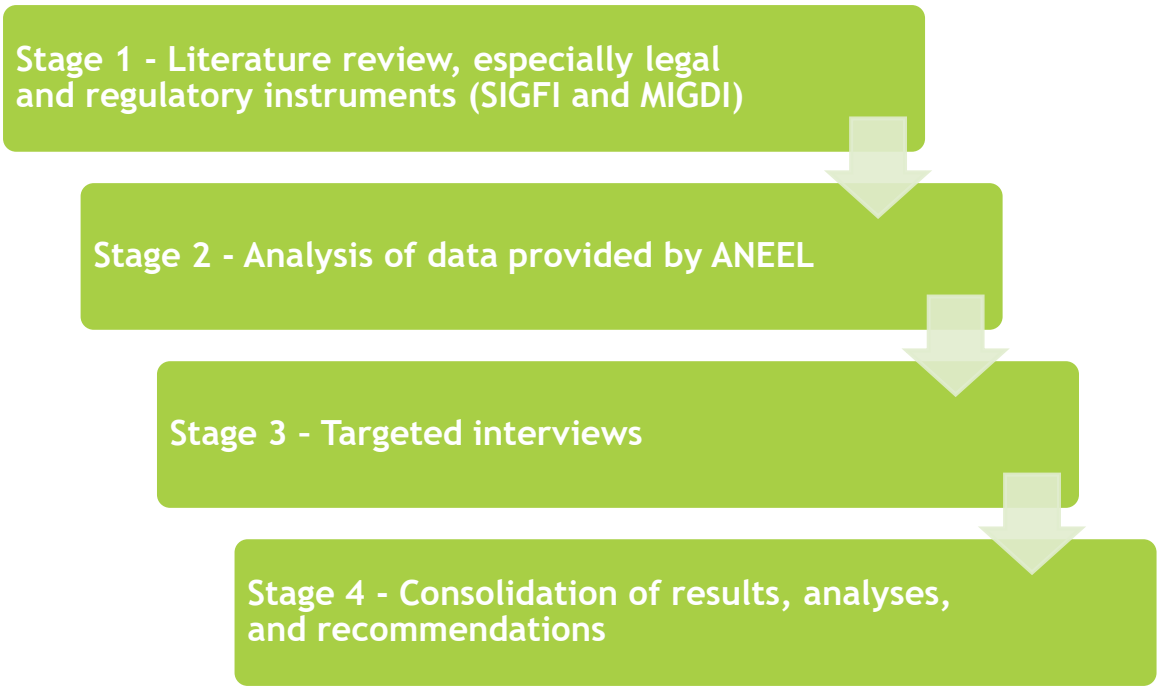

Figure 1: Study stages

Source: Own elaboration.

The stages are detailed as follows:

- **Stage 1 - Literature review, especially the legal and regulatory instruments**: the definition of the scope of the study strongly depends on the corresponding regulation. To this end, the regulations of stand-alone electric power generation systems (SIGFI and MIGDI) and of the Programs for the universalization of electricity access were reviewed.
- **Stage 2 - Analysis of data provided by ANEEL**: this stage comprises quantitative and qualitative analyses of the data available on Aneel's website, in the database entitled "Isolated and Intermittent Systems". Using dynamic tables, it is possible to correlate information and obtain results that show the status of facilities, technical data of installed systems and of the distribution

concessionaires involved, registration information and incident reports.

- **Stage 3 – Targeted interviews**: the interviews conducted throughout the project aim to understand and identify the positive and negative aspects of installing and using these systems, considering the perspectives of the distribution concessionaire and consumers.
- **Stage 4 - Consolidation of results, analyses, and recommendations**: final stage that consolidates the results, conducts a final analysis and makes recommendations for future studies.

What do we understand as energy access?

Much has been said about universal access to energy. Whether in universal programs such as the Brazilian Light for All, or in global efforts such as the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs). The latter sets the global goal of universal access to electricity and other forms of energy by 2030 (SDG 7).

However, the concept of access to energy, as we understand it, has either been misplaced, misunderstood, or poorly implemented. In other words, it has been understood or treated in a limited way. This impacts the design of the necessary actions and the material, human, and financial conditions required for these actions to guarantee access. Although this analysis is out of the scope of this study, it is worth stating our understanding of access to energy.

Access to energy is having access to energy services that are adequate, reliable, high-quality, safe, environmentally benign and affordable to support human and economic development.

Energy poverty is defined as the lack of sufficient user choice in accessing the energy services with the aforementioned characteristics. Although there is no consensual and precise definition of energy poverty in literature, we consider that this definition by Reddy et al. (2000) is the one that best captures its multidimensionality (PIAI; GOMES; JANNUZZI, 2020). A multidimensionality that is contained in the understanding that energy poverty is one of the dimensions of poverty, i.e., it is the energy dimension of poverty[3].

The definition of energy access may at first seem clear, but sometimes its actual understanding may go unnoticed.

First, the definition shows that access to energy goes beyond physical access to electricity or fuel. It is more than having the wires that come from posts, the gas cylinders or pipes or the firewood at your doorstep. What people and society need is not the electricity or fuel itself, but the services that use these forms of energy in our daily lives and for the material reproduction of life - for example, lighting, cooling, communication, and transport. These are examples of the energy services we need.

Second, these energy services can be obtained in different ways or, better said, through different technologies. For example, lighting can be achieved

[3] Reddy et al. (2000) explore these interconnections between energy and poverty and energy and social issues; interconnections that condition each other - one influencing the other and vice versa. They show that energy services “are a necessary condition for sustainable development” (p.43). However, they are not sufficient, being only “a dimension or a determinant of poverty and development, but vital” (p.44).

using candles, lamps and lightbulbs, and cooking by using electric, gas or wood stoves.

Each “way” (technology) used for lighting or cooking can offer different quality, cost, availability, safety or impact on the environment. For example, the quality of lighting with an electric lamp is better when compared to a kerosene lamp or candle, gas stoves pollute less than a traditional wood stove. The associated costs for lighting and cooking are also different depending on the technology and energy source used. Even between technologies that use the same energy source, such as the lightbulb (incandescent, halogen, fluorescent and LED), costs, energy efficiency, lifespan, color rendering index, local availability, and environmental and electrical grid impact are different.

Therefore, technology and energy source are factors that determine the different characteristics and impacts of lighting and cooking, for example, but the same is true for any energy use, whether domestic or productive. Some examples and testimonies are presented in Ribeiro et al. (2021), but there are vast records accumulated over decades in the national and international literature available.

Therefore, the full, unrestricted concept of access to energy is related to the energy service and to the characteristics it needs to have to meet the needs of people and society for a sustainable world.

Stand-alone electricity generation systems for universal access to electricity in Brazil

For the purpose of universalizing access to electricity in Brazil, the use of stand-alone electricity generation systems with intermittent renewable energy sources, whether individual or collective, has been allowed[4] as an alternative to extending the electricity grid since 2004.

So, it was necessary to regulate the supply procedures and conditions of such systems, such as, for example, the minimum monthly availability of electricity supply, the quality and continuity of this supply, deadlines for addressing orders and incidents, readings, and billing. This regulation was issued by ANEEL by means of Normative Resolution nr. 83 of September 20, 2004.

This was an important milestone because it provided a solution to one of the major problems in the use of stand-alone power systems for electrification, namely the responsibility for their maintenance. This became the responsibility of the electricity distribution concessionaire, responsible for providing the public service in its concession area.

Many initiatives carried out internationally and in Brazil have shown that without the guarantee of maintenance throughout the system's lifespan, it ceased to operate in most cases despite the good intentions of the implementers.

The regulation of stand-alone electricity generation systems has changed over time, as will be presented in the next section. According to the current rules of the Brazilian electricity regulatory agency - ANEEL, service with stand-alone power systems must be provided by means of:

- Individual Electricity Generation System with Intermittent Sources - SIGFI: system for generating electricity exclusively through intermittent renewable energy sources used to supply a consumer unit; and
- Stand-alone Electricity Generation and Distribution Microsystem - MIGDI: isolated electric power generation system with an intermittent renewable energy source, used to serve more than one consumer unit and associated with an electric power distribution microgrid.

[4] These are sources that, for the purpose of conversion into electrical energy by the generation system, cannot be stored in their original form.

Service to Consumer Units (CU) can be rendered for individual residential use or collective use[5]. Their design needs to ensure a minimum monthly availability of electricity; enough to meet the CU's basic lighting, communication, and cooling needs. The characteristics and size of SIGFI and MIGDI in the most recent regulation are presented in Table 1. For example, the SIGFI 45 has a guaranteed monthly availability of 45 kWh.

Table 1: Characteristics of systems according to classification

Guaranteed monthly availability (kWh/month/CU)	Reference consumption (Wh/day/CU)	Minimum power (W/CU)
45	1,500	700
60	2,000	1,000
80	2,650	1,250
120	4,000	1,500
180	6,000	1,800

Source: ANEEL Normative Resolution Nr. 1000/21.

In addition to the figures in **Erro! Fonte de referência não encontrada.**, MIGDI-type systems must have a total installed generation power under or equal to 100 kW, unless a higher power is approved by the concession authority or by ANEEL.

SIGFI and MIGDI systems need to be dimensioned to have an autonomy of at least 36 hours for solar source and 48 hours for other renewable sources (wind farm, mini and micro hydroelectric plant and hybrid systems6). The LPT Program allows the use of fossil sources.

The supply of electric energy through MIGDI or SIGFI systems must use alternating current (AC), observing the prevailing voltage levels in the municipality where the consumer unit is located. If electricity is supplied by SIGFI, the distribution company can implement a mixed supply system with part of the load in direct current (DC) based on the characteristics of the load to be serviced and after the consumer agrees.

[5] Are considered as consumer unit of collective use: schools, churches, healthcare centers and other units of community use.
[6] Combination of two or more primary energy sources: solar, wind, biomass, hydro and/or diesel.

Legal and regulatory context in Brazil

This section presents the main legal and regulatory instruments related to the SIGFI and MIGDI electricity generation systems and the programs for universalization of access to electricity (Light for All Program – LPT and More Light for the Amazon Program - MLA). These are service options and programs that contribute to the fulfillment of universalization plans [7] by power distribution utilities.

Each distribution company has its own plan with goals and deadlines for achieving universalization in its area of operation, whether in urban or rural areas, which is reviewed and approved by ANEEL and is to be inspected by the regulatory agency. Therefore, there are two legal segments, as shown in Figure 2.

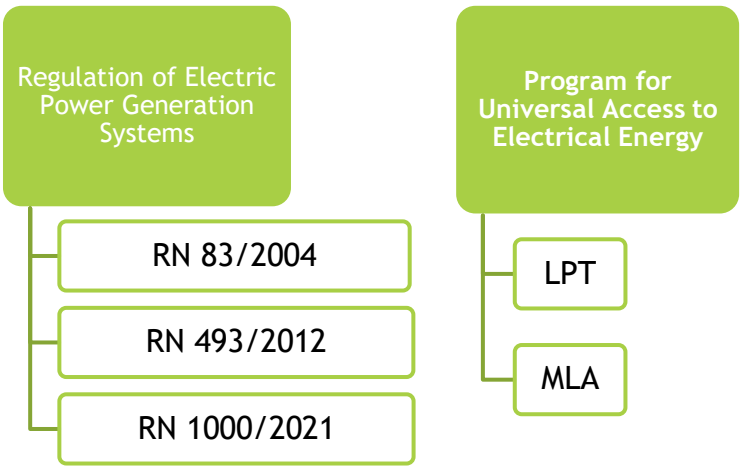

Figure 2: Regulatory structure

Source: This study.

[7] ANEEL's Normative Resolution nr. 223 of April 29, 2003 established the general conditions for preparing electricity universalization plans. This Resolution was recently revoked by Resolution nr. 950 of November 23, 2021, valid as of January 1, 2022.

Regulation of off-grid power generation systems: SIGFI and MIGDI

In 2004, ANEEL's first normative resolution was created, which established the procedures and conditions for supplying the use of Individual Electricity Generation Systems with Intermittent Sources (SIGFI). Therefore, Normative Resolution nr. 83/2004 (REN 83/2004) emerged to regulate the use of these systems for the universalization of public electricity service.

Over the years, this ANEEL regulation has been changed. Currently, these systems are regulated by ANEEL Normative Resolution nr. 1000, of December 7, 2021. Each of the resolutions will be presented in the sections that follow and a comparison between them is presented in Table 2 at the end of this section.

Some of the main changes are highlighted below:

- Inclusion of MIGDI as of 2012 (ANEEL Normative Resolution nr. 493/12, currently incorporated into ANEEL Normative Resolution nr. 1000/21);
- Possibility of part of the load being supplied with direct current (ANEEL Normative Resolution nr. 493/12, incorporated into ANEEL Normative Resolution nr. 1000/21);
- Changes in the minimum monthly availability (kWh/month) of electricity supply, from 45 kWh/CU[8] (ANEEL Normative Resolution nr. 1000/21). From 2004 to December 6, 2021, the minimum guaranteed monthly availability was 13 kWh/CU;
- Simplification of failure frequency information by system component to be reported;
- Inclusion of information on the quantity and duration of interruptions per triggering event, including the duration of interruptions (minimum, average, and maximum) and the minimum, average and maximum period for regularization of voltage levels (ANEEL Normative Resolution nr. 493/12, incorporated into ANEEL Normative Resolution nr. 1000/21);
- Inclusion of information on the means used to communicate the interruption (face-to-face assistance, letter sent by post, call center) (ANEEL Normative Resolution nr. 493/12, incorporated into ANEEL Normative Resolution nr. 1000/21).

After the creation of REN nr. 83/2004, in 2009, the Ministry of Mines and Energy (MME) published the Manual of Special Projects of the Light for All

[8] Consumer Unit.

Program (Ordinance nr 60/2009) that established the technical and financial criteria and the procedures and priorities for service provision to isolated communities.

Such a Manual became necessary because situations were identified, within the scope of the LPT Program, in which the service was conditioned to the execution of projects with special characteristics, such as in locations that were far from the existing energy distribution grid. Therefore, its concept was focused on the construction of small stretches of decentralized, and also unconventional, distribution networks (underwater crossings, forests crossings and others), called special projects, also known as mini-grids[9]. Like REN nr. 83/2004, this Manual of Special Projects also aimed to facilitate the process of universal access to electricity in the country.

After eight years of validity, REN 83/ANEEL was revised in 2012, giving rise to Normative Resolution nr. 493/2012 which, among other changes, included the procedures and supply conditions for stand-alone "mini-grids", also called Stand-alone Electricity Generation and Distribution Microsystem (MIGDI).

Almost ten years later, in 2021, Normative Resolution nr. 493/2012 was incorporated into Normative Resolution nr. 1,000/2021, which is a comprehensive resolution that consolidated the content of 61 norms previously published by ANEEL into one single resolution, revoking them. The aforementioned REN deals with the model and conditions for supplying electricity to isolated communities, in this case, SIGFI and MIGDI.

ANEEL Normative Resolution nr. 83/2004

Published on September 20, 2004 as the first regulation on Individual Electricity Generation System with Intermittent Sources - SIGFI [10], the Resolution established the conditions for the supply of electricity as well as its procedures.

Within the general conditions of service, the SIGFI needed to fit into one of the five categories in REN[11], which at the time were SIGFI 13, 30, 45, 60 and 80 with a minimum autonomy of 48 hours. These numbers refer to the

[9] It is a small section of the electricity distribution grid that cannot be linked to the concessionaire's current systems because of technical, economic and environmental reasons.
[10] Electricity generation system implemented by an electricity distribution concessionaire or licensee, using exclusively intermittent energy sources, to supply a single consumer unit, basically consisting of a generation system, an accumulation system and a conditioning system (REN Nr. 83, 2004).
[11] All details and mandatory characteristics of SIGFI can be verified in ANEEL's REN nr. 83/2004.

guaranteed monthly availability of each system, in kWh. For example, the SIGFI 13 has a guaranteed monthly availability of 13 kWh.

The concessionaire could use SIGFI with guaranteed monthly availability greater than 80 kWh/month, provided that a minimum autonomy of 48 hours was guaranteed.

As an example, the monthly availability of a SIGFI 13 allows the use of light bulbs and small household appliances, such as an AM/FM radio, a fan and a small TV set, for 1 to 4 hours a day depending on usage. However, it is not possible to use refrigerators on SIGFI 13 and 30. There are models of one-door refrigerators that consume a little more than 20 kWh per month, but would significantly compromise other end uses (JANNUZZI et al., 2009).

The Resolution also contained the condition that the SIGFI components must meet the requirements of the norms issued by the competent official bodies, by the Brazilian Labeling Program (PBE) of the National Institute of Metrology, Standardization and Industrial Quality (Inmetro) or by another organization accredited by the National Council of Metrology, Standardization and Industrial Quality (Conmetro).

Every six months, the information about installed SIGFI should be sent by the electricity distribution utilities to ANEEL so that it can monitor the quality of supply[12].

The resolution also deals with supply quality and continuity indicators (record of the interruption triggering event; the date and time of the interruption and resumption), complaints received in the period and the list of the frequency of failures by system component.

ANEEL Normative Resolution nr. 493/2012

REN nr. 493/2012 was published on June 5, 2012 to replace REN nr. 83/2004. In addition to SIGFI, it included the option of MIGDI in the procedures and conditions of electricity supply, both of which are considered options for universal access to electricity.

The REN maintained the same classification of the guaranteed monthly availability of SIGFI and MIGDI services, with the exception of the availability of 20 kWh/month/CU. Therefore, the systems could be classified as 13, 20, 30, 45, 60 and 80 kWh, all with a minimum autonomy of 48 hours. As in REN nr. 83/2004, the concessionaire could use SIGFI with a guaranteed monthly

[12] Submission deadlines were by July 31 and January 31 of each year, always referring to data from the first and second semesters respectively.

availability greater than 80 kWh/month, provided that a minimum autonomy of 48 hours was guaranteed.

Regarding monitoring by Aneel of the SIGFI and MIGDI installed by the electricity distribution utilities, as in REN nr. 83/2004, reports should be sent to ANEEL every six months for quality-of-supply monitoring.

The Resolution also maintained the provision in REN nr. 83/2004 that establishes that components of the MIGDI or SIGFI should meet the requirements in the norms issued by the competent official bodies, by the PBE or by another organization accredited by Conmetro.

ANEEL Normative Resolution nr. 1.000/2021

REN nr. 1,000, of December 7, 2021 consolidates the content of 61 norms previously published by ANEEL, which were revoked, among which REN nr. 493/2012. The Resolution "establishes the Rules for Provision of the Public Electricity Distribution Service, in which the rights and duties of the consumer and other users of the service are set forth" (Article 1).

With regard to stand-alone generation systems (SIGFI and MIGDI), practically all the content provided for in this Resolution had already been contemplated in REN nr. 493/2012.

The exceptions, detailed below, are specifically in Chapter IV, "Service by isolated systems", where section I deals with "General criteria for isolated service", p.191. This information had not been mentioned in REN 493/ 2012, precisely articles 515 and 516 of REN nr. 1,000/2021.

In this case, Art. 515 (p. 191) states that electricity distribution utilities must conduct a technical evaluation of the service by means of isolated systems (SIGFI or MIGDI) when the consumer unit is located in remote areas characterized by high consumer dispersion and lack of economy of scale or when there are technical or environmental restrictions that prevent service via the conventional grid.

Also, Art. 516 (p.191), concerning the construction work to be performed to provide service by means of SIGFI or MIGDI, establishes that the following criteria must be observed:

> *I - the cost of the development shall consider the criteria of minimum technical design possible* and minimum global cost, observing the quality standards of service provision and prudent investment;
>
> *II - the development must provide minimum power capable of meeting the basic needs of households, including lighting, communication and cooling;*
>
> *III - the project must include a planning horizon of 5 years;*

IV - in addition to the installation cost, the projected costs of operation and maintenance within the established planning horizon must be part of the analysis of the solution to be adopted; and

V - the projects must observe environmental restrictions, their sustainability and the activity of training consumers and other users.

There is also the single paragraph that establishes that the electricity distribution utilities must verify the possibility of serving other consumers and other users in the process of designing the service project in order to optimize the construction to be carried out.

With regard to the general conditions of service, unlike the classifications of the previous RENs (83/2004 and 493/2012), the classification of guaranteed monthly availability for SIGFI and MIGDI became 45, 60, 80, 120 and 180 kWh /month/CU. Therefore, it is no longer possible to install SIGFI/MIGDI 13, 20 and 30.

Regarding the autonomy of SIGFI and MIGDI, the current REN 1,000/21 modified the minimum autonomy of these systems when the source is solar - now 36 hours -, maintaining the same 48 hours for the other sources, considering total absence of the primary source.

Regarding the quality of the services offered and the DIC (Duration of Interruption per Consumer Unit) reference standards, there has been no change in the recording of interruptions that occurred in the CUs with the same monthly and annual reference standards remaining (REN 1000/2021 when compared to REN 493/2012). The only relevant observation refers to the fact that REN 83/2004 requested that the triggering event be recorded detailing the cause and damaged equipment, while in later resolutions (REN 493/2012 and REN 1000/2021) this was no longer required.

For all the above, Table 2 shows details and relevant changes (highlighted in red) of the ANEEL Normative Resolutions for the years 2004, 2012 and 2021.

Table 2: Comparison of supply procedures and conditions for SIGFI and/or MIGDI between ANEEL Normative Resolutions (REN)

REN nr. 83/2004	REN nr. 493/2012	REN nr. 1.000/2021
Status: revoked by REN nr. 493/2012	**Status: revoked by REN nr. 1.000/2021**	**Status: in force**
Covers SIGFI only	Covers SIGFI and MIDGI	Covers SIGFI and MIDGI
Electricity supply AC only	**Section II, Art 4: § 1** If electricity is supplied by SIGFI, the distribution company can implement a mixed supply system with part of the load in direct current (DC) based on the characteristics of the load to be serviced and after the consumer agrees. **Section II, Art. 4: § 2nd** In the situation provided for in the previous paragraph, the distribution company must clarify the differences between alternating current and direct current sources, including the use and future acquisition of equipment and the possibility of changes in the supply pattern due to the connection of the consumer with a conventional grid, when applicable.	Covers the same as REN nr. 493/2012, AC and DC supply.
In the general conditions of service: includes only SIGFI	In the general conditions of service: includes SIGFI and MIGDI	In the general conditions of service: includes SIGFI and MIGDI
Monthly availability (kWh): 13, 30, 45, 60 and 80	Monthly availability (kWh): 13, 20, 30, 45, 60 and 80	Monthly availability (kWh/CU): 45, 60, 80, 120 and 180
Minimum power available (W/CU): 250, 500, 700, 1000, 1250	Minimum power available (W/CU): 250, 250, 500, 700, 1000, 1250	Minimum power available (W/CU): 700, 1000, 1250, 1500, 1800

REN nr. 83/2004	REN nr. 493/2012	REN nr. 1.000/2021
Status: revoked by REN nr. 493/2012	**Status: revoked by REN nr. 1.000/2021**	**Status: in force**
Reference daily consumption (Wh/day) 435, 1000, 1500, 2000, 2650	Reference daily consumption (Wh/day) 435, 670, 1000, 1500, 2000, 2650	Reference daily consumption (Wh/day) 1500, 2000, 2650, 4000, 6000
Minimum autonomy (days): 48 hours	Minimum autonomy (days): 48 hours	Minimum autonomy (days): 36 (solar[13]), 48h (other sources)
The SIGFI components must meet the requirements of the norms issued by the competent official bodies, by the Brazilian Labeling Program of the National Institute of Metrology, Standardization and Industrial Quality (INMETRO) or by another organization accredited by the National Council of Metrology, Standardization and Industrial Quality (CONMETRO).	The MIGDI or SIGFI components must meet the requirements of the norms issued by the competent official bodies, by the Brazilian Labeling Program of the National Institute of Metrology, Standardization and Industrial Quality - INMETRO or by another organization accredited by the National Council of Metrology, Standardization and Industrial Quality - CONMETRO.	The MIGDI or SIGFI components must meet the requirements of the norms issued by the competent official bodies, by the Brazilian Labeling Program or by another organization accredited by the National Council of Metrology, Standardization and Industrial Quality - CONMETRO.
Does not include MIGDI.	MIGDI: total installed power generation up to 100 kW.	MIGDI: total installed power generation up to 100 kW, greater only when authorized by the concession authority or by ANEEL.
DIC (Duration of Interruption per Consumer Unit) - for each interruption in the CU, the concessionaire shall register: - the triggering event (cause and component damaged)[14]	DIC (Duration of Interruption per Consumer Unit) - for each interruption in the CU, the concessionaire shall register: - the triggering event - the date, time (hour and minutes) when interruption began and when service was reestablished	DIC (Duration of Interruption per Consumer Unit) - for each interruption in the CU, the concessionaire shall register: - the triggering event - the date, time (hour and minutes) when interruption began and when service was reestablished

[13] For systems with a solar source, the autonomy can be evaluated considering the lowest daily solar radiation in the historical series of the last 3 years of the location where the system will be installed.

[14] In later resolutions (REN 493/2012 and REN 1000/2021) “the cause and damaged component” were not considered, as shown in the subsequent columns.

REN nr. 83/2004	REN nr. 493/2012	REN nr. 1.000/2021
Status: revoked by REN nr. 493/2012	**Status: revoked by REN nr. 1.000/2021**	**Status: in force**
- the date, time (hour and minutes) when interruption began and when service was reestablished. Reference standard: 216 hours per month (monthly DIC) 648 hours a year (annual DIC) For the purpose of recording the information and counting the duration of each interruption, the date shall be considered of receipt, by the concessionaire, of the formal complaint from the consumer or its legal representative, provided that its origin is verified.	- means by which the interruption was communicated. Reference standard: 216 hours per month (monthly DIC) 648 hours per year (annual DIC) For the purpose of recording information and counting the duration of each interruption, the interval between the date of receipt of the consumer's complaint and the resumption of supply shall be considered, whether or not daily supply hours are reduced.	- means by which the interruption was communicated. Reference standard: 216 hours per month (monthly DIC) 648 hours per year (annual DIC) For the purpose of recording information and counting the duration of each interruption, the interval between the date of receipt of the consumer's complaint and the resumption of supply shall be considered, regardless of daily supply hours.
Submission of **SIGFI** semi-annual report**, as of** 2005, containing the minimum information: - number of units installed by service class and primary source; - number of complaints received in the period, by service class and primary source; - list of failure frequency, per system component[15].	Submission of **SIGFI and MIGDI** semi-annual report, containing: - number of consumer units by service class and primary source; - number of complaints received in the period, by service class and primary source; - quantity and duration of interruptions grouped by triggering event; - minimum, average and maximum duration of interruptions;	Submission of SIGFI and MIGDI semi-annual report, containing: - number of consumer units by service class and primary source; - number of complaints received in the period, by service class and primary source; - quantity and duration of interruptions grouped by triggering event;

[15] In subsequent resolutions (REN 493/2012 and REN 1000/2021) the “list of failure frequency per system component” was not included in the semi-annual reports, as shown in the subsequent columns.

REN nr. 83/2004	REN nr. 493/2012	REN nr. 1.000/2021
Status: revoked by REN nr. 493/2012	**Status: revoked by REN nr. 1.000/2021**	**Status: in force**
	- minimum, average and maximum period for regularization of voltage levels.	- minimum, average and maximum duration of interruptions; - minimum, average and maximum period for regularization of voltage levels.
Report submission period: by 7/31 of each year and 1/31 of each subsequent year	Report submission period: by January 31, with data from the second half of the previous year, and by July 31, with data from the first half of the current year. The information used in semi-annual reports must be available in digital media for a **Minimum** period of 5 (five) years, for the purpose of inspection by ANEEL and consumer reference.	Report submission period: by January 31, with data from the second half of the previous year, and by July 31, with data from the first half of the current year.
	The **distribution company must meet the load increase request free of charge** if this increase can be achieved using systems with monthly availability of **up to 80 kWh/CU and if at least one year has passed since the date of initial power up or since the last load increase** (Art. 30, p. 9).	The distribution company **must meet the load increase request free of charge** in MIGDI and SIGFI systems if this increase can be achieved using systems with **monthly availability lower than or equal to 80 kWh/CU** and if **at least one year has passed since the date of initial power up or since the last load increase** (Art. 30, p. 9).
The distribution company is obliged to install measurement equipment in all consumer units supplied by SIGFI, connected from the date of publication of this Resolution, whose electricity guaranteed monthly availability is above 30 kWh (Art. 4, p.4).	The installation of measurement equipment is optional in the consumer units connected in the terms of this Resolution [SIGFI and MIGDI] (Art. 12, p. 4).	The distribution company can install measurement equipment in the consumer unit connected by MIGDI or SIGFI (Art. 529).

Fonte: Created by the authors of this study based on ANEEL's Normative Resolutions (nr. 83, 493 and 1000)..

Programs for Universal Access to Electricity

The objective of universalizing access to the public electricity service was established on April 26, 2002 (Law nr. 10,438[16]). In 2002, the estimate was that about 10 million people (or 2 million families) did not have access to electricity in the country, 80% of which were located in rural areas. Since then, electricity access in urban areas has been formally finalized, but families in rural areas are still to get access to this service.

Aiming at achieving this law's objective, the Light for All program was launched in 2003. In 2020, a program focused on the Legal Amazon (More Light for the Amazon) was launched. These programs are to remain in force until 2026 and 2030 respectively.

These programs provide financial resources for electricity distribution utilities to accelerate their universalization plans. These programs also require the installation of an internal electrical system in consumer units with up to three light sockets, three efficient light bulbs, and two outlets at no cost to the beneficiary.

Along with the specific rules for each program, there are operational manuals that specify the operational structure, service priorities and technical and financial procedures and criteria.

Table 3 shows comparative and summarized information on the Light for All and More Light for the Amazon programs.

Table 3: Summary of the Light for All (LPT) and More Light for the Amazon (MLA) programs

LPT	MLA
Started in 2003	Started in 2020
Instituted by Decree nr. 4,873 (November 11, 2003)	Instituted by Decree nr. 10,221 (February 5, 2020)
Serving rural areas nationwide	Serving only the Legal Amazon region
New consumers	New consumers and existing consumers who use non-renewable energy (replacement of diesel and gasoline electric generators)
UC service for individual or collective use: SIGFI and MIGDI	UC service for individual or collective use: SIGFI and MIGDI
Renewable and non-renewable sources	Only renewable sources
Duration: until the end of 2026	Duration: until the end of 2030

Source: This study.

[16] Law later amended by Law nr. 10,762, of November 11, 2003.

Light for All Program

The Light for All Program (LPT), also known as the Brazilian National Program for the Universalization of Access and Use of Electric Energy, was established by Decree nr. 4,873, of November 11, 2003. Its objective was to universalize access to electricity for the Brazilian rural population by the end of 2008 (ELETROBRÁS, 2008).

The service alternatives were extension of the conventional electricity grid or decentralized generation systems (individual or mini-grids) using renewable and non-renewable sources. In the case of decentralized generation, the LPT Operational Manuals contained some criteria of their own about these systems without infringing ANEEL's current resolution at that time, as will be shown later.

The Program was successively extended, one of the reasons being the underestimation of the number of people without electricity - new connection requests were made as the program progressed. This showed how much the country still ignored a portion of its population.

In 2017, according to the Ministry of Mines and Energy (MME), the number of people served by the LPT was 16 million[17] and an estimated million people are still to be served in the Amazon region, a figure considered as conservative by the organization that made the estimate[18].

The increase in the volume of requests and the challenges of executing the program resulted in the publication of several decrees extending or adjusting the LPT. Table 4 presents a summary of the history of its legislation.

In addition to the decrees mentioned in Table 4, the LPT Operational Manual was revised over time, having different versions as will be presented in the following section (Table 5).

Figure 3 shows a timeline with the information shown in Table 4 and how it relates to the target date for delivering access to electricity in the LPT Program.

[17] Available at: https://www.gov.br/mme/pt-br/destaques/programa-de-eletrificacao-rural/sobre-o-programa. Accessed on 04/29/2022.
[18] Available at: https://energiaeambiente.org.br/produto/exclusao-eletrica-na-amazonia-legal-quem-ainda-esta-sem-acesso-a-energia-eletrica. Accessed on 04/29/2022.

Table 4: History of the legislation of the Brazilian National Program for the Universalization of Access and Use of Electric Energy - Light for All Program (LPT)

Legislation	Date	Description	Status
Decree nr. 4,873	November 11, 2003	Establishes the LPT Program from 2003 to 2008	Revoked (November 5, 2019, Decree nr. 10,087)
Decree nr. 6,442	April 25, 2008	New wording to art. 1 of Decree nr. 4,873.	Revoked (February 5, 2020, Decree nr. 10,223)
Decree nr. 7,324	October 5, 2010	New wording to art. 1 of Decree nr. 4,873.	Revoked (February 5, 2020, Decree nr. 10,223)
Decree nr. 7,520	July 8, 2011	Establishes the LPT Program from 2011 to 2014.	In force
Decree nr. 7,656	December 23, 2011	Decree nr. 7,520 remains in force with the addition of Art. 1-A.	Revoked (April 27, 2018, Decree nr. 9,357)
Decree nr. 8,387	December 30, 2014	Amends Decree nr. 7,520.	Revoked (April 27, 2018, Decree nr. 9,357)
Decree nr. 8,493	July 15, 2015	Decree nr. 7,520 remains in force with the addition of Art. 1-B. [19]	Revoked (April 13, 2022, Decree nr. 11,045)
Decree nr. 9,357	April 27, 2018	Amends Decree nr. 7,520.	In force
Decree nr. 11,111	June 29, 2022	Amends Decree nr. 7,520.	In force

Source: Created by the authors of this study based on the decrees mentioned above.

Table 5: LPT Operational manuals, decrees, ordinances, and current status

Operational Manual	Decree	Description	Manual Appendix	Status as to the deadline and the LPT manual
LPT 2003	nr. 4,873	Original	Ordinance nr. 38 (Mar 9, 2004)	The Ordinance approves the LPT manual. The Decree sets the duration of the LPT until 2008
LPT 2003	nr. 4,873	Review 1	Ordinance nr. 447 (Dec 31, 2004)	The Ordinance approves Review 1 of the LPT Manual (2003)
LPT 2003	nr. 4,873	Review 2	Ordinance nr. 416 (Aug 31, 2005)	The Ordinance approves Review 2 of the LPT Manual (2003)
LPT 2003	nr. 4,873	Review 3	Ordinance nr. 115 (May 22, 2006)	The Ordinance approves Review 3 of the LPT Manual (2003)
LPT 2003	nr. 4,873	Review 4	Ordinance nr. 287 (Nov 17, 2006)	The Ordinance approves Review 4 of the LPT Manual (2003)
LPT 2003	nr. 4,873	Review 5	Ordinance nr. 288 (Out 17, 2007)	The Ordinance approves Review 5 of the LPT Manual (2003)
Manual of Special Projects nr 60/2009	nr 6,442	Original	Ordinance nr. 60 (Feb 12, 2009)	The Ordinance approves the Manual of Special Projects The Decree extends the LPT until 2010
LPT 2003	nr 6,442	Review 6	Ordinance nr. 85 (Feb 20, 2009)	The Ordinance approves Review 6 of the LPT Manual (2003). The

[19] Establishes that service to remote regions of isolated systems must be contracted by the LPT Program, applying the rules adopted for contracts signed within the scope of the National Interconnected System (SIN).

Operational Manual	Decree	Description	Manual Appendix	Status as to the deadline and the LPT manual
				Decree extends the LPT until 2010
LPT 2011	nr 7,324	-	-	Extends LPT until 12/31/2011 The Decree does not change the duration of the LPT
LPT 2011-2014	nr 7,520	Original	Ordinance nr. 628 (Nov 3, 2011)	The Ordinance approves the LPT Manual (2011-2014). The Decree extends the LPT until 2014
LPT 2011-2014	nr 7,520	Review 1	Ordinance nr. 110 (Mar 26, 2013)	The Ordinance approves Review 1 of the LPT Manual (2011-2014)
Manual for Service to Remote Regions of Isolated Systems (RRSI)[20]	nr 8,387	Original	Ordinance nr. 521 (Nov 13, 2015)	The Ordinance approves the LPT manual for RRSI. The Decree extends the LPT until 2018
LPT 2015-2018	nr 8,387	Original	Ordinance nr. 522 (Nov 13, 2015)	The Ordinance approves the new manual. The Decree extends the LPT until 2018
LPT 2015-2018	nr 8,493	Review 1	Ordinance nr. 209 (May 29, 2017)	The Ordinance approves Review 1 of the LPT Manual (2015-2018) The Decree does not change the duration of the LPT
Technical specifications to comply with the RRSI Manual	nr 8,493	Reviewed (July 2017)	-	Establishing standards and methodologies that aim at streamlining the procedures of techinical-budgetary analysis of the Construction Programs, using Decree nr. 8,493 as reference.
Manual for service to RRSI	nr 8,387	Review 1	Ordinance No. 321 (Aug 14, 2017)	The Ordinance approves Review 1 of the RRSI Manual
LPT 2018-2022 (In force)	nr 9,357	Original	Ordinance nr. 371 (Aug 28, 2018)	The Ordinance approves the new manual. The Decree extends the LPT until 2022

Source: Created by the authors of this study based on LPT operational manuals.

Figure 3: Timeline of the target dates for delivering electricity access in the LPT program

Source: This study.

[20] This Manual is part of the LPT Program Operational Manual.

Still referring to the manuals mentioned in Table 5, specifically in the section that deals with individual and network decentralized generation systems, Table 6 shows the details and changes that occurred (highlighted in red) in the operational manuals from the first version to the current one (in force), detailing the technological option and the technical criteria for service adopted in each period of validity.

Unlike ANEEL's normative resolutions, the LPT has allowed for the use of fossil sources in decentralized generation systems with isolated (mini-grids) or individual grids since 2004. The only exception was the period between February 2009 and October 2011 (period of validity of Review 6 of the Manual) when it allowed only the use of renewable sources for individual generation systems.

Review 6 of the LPT Manual (2003–2010) of February 2019 brought some changes to the technical criteria compared to previous versions. One of the changes was that one should "consider technologies that best take advantage of local and regional energy potentials from the economic and energy availability point of view". The type and power of fluorescent lamps were also added: 9 W or 11 W compact type, using the term "efficient". This change remained in the manuals from 2011 to 2014.

The 2015-2018 LPT Manual amended the technical criteria section: in addition to using 9 W or 11 W compact fluorescent lamps, it allowed the use of "other types of lamps, provided that they have technology with equivalent or superior efficiency" alluding to LED lamps.

With the creation of the More Light for the Amazon Program in February 2020, the new service contracts for the Remote Regions of Isolated Systems[21] were no longer with the LPT[22]. They were with the LPT from August 2011 to February 2020.

[21] Most of the Brazilian population is connected to the National Interconnected System (SIN) and another part to the Isolated Systems. These are "electrical systems in the public electricity distribution service that, in their normal configuration, are not electrically connected to the National Interconnected System - SIN, for technical or economic reasons" (Decree 7246/2010, Art. 2nd). Remote Regions are "small groups of consumers located in an Isolated System, away from municipal headquarters, and characterized by the absence of economies of scale or density" (Decree 7246/2010, Art. 2).

[22] Art. 5 of Decree nr. 10,221, of February 5, 2020.

Table 6: LPT operational manuals: technological options and criteria adopted in the period

Operational Manual	Technological option	Criteria
2003 (Original and Review 1) Mar 9 to Aug 30, 2005	Mini-grids and individual: Hydroelectricity Solar photovoltaic Wind energy Biomass Diesel generator Hybrid systems	- For home service, include the complete internal installation (wiring, conduits, protection circuit breakers, outlet, fluorescent lamps and other installation materials), with 1 (one) light socket per room up to 3 (three) light sockets and 2 (two) outlets; - For service to collective units, such as schools and healthcare centers, include complete internal installation with fluorescent lamps and outlets. The cost related to this installation may be included in the budget of the Construction Program to be presented to Eletrobrás; - The projects shal observe the environmental restrictions and training activities for users; - In specific circumstances to be defined by the MME, service may be provided by PRODEEM.
2003 (Review 2) Ago 31, 2005 to May 21, 2006	Mini-grids and individual: Hydroelectricity Solar photovoltaic Wind energy Biomass Diesel generator Hybrid systems	- For home service, include the complete internal installation (wiring, conduits, protection circuit breakers, outlet, fluorescent lamps and other installation materials), with 1 (one) light socket per room up to 3 (three) light sockets and 2 (two) outlets; - For service to collective units, such as schools and healthcare centers, include complete internal installation with fluorescent lamps and outlets. The cost related to this installation may be included in the budget of the Construction Program to be presented to Eletrobrás; - The projects shal observe the environmental restrictions and training activities for users and their sustainability; - In specific circumstances to be defined by the MME, service may be provided by PRODEEM.
2003 (Reviews 3, 4 and 5) May 22, 2006 to Feb 19, 2009	Mini-grids and individuals: Hydroelectricity Solar photovoltaic Wind energy Biomass Diesel generator Hybrid systems	II - the installations after the point of delivery shall be in accordance with existing safety standards; III - for home service, the internal installation kit (conductors, protection circuit breaker, outlet, lamps and other installation materials) shall be considered, with one light socket per room up to three light sockets and two outlets; IV - for service to collective units, such as schools and healthcare centers, include complete internal installation with fluorescent lamps and outlets.

Operational Manual	Technological option	Criteria
		V - the projects shal observe the environmental restrictions and training activities for users and their sustainability; VI - in specific circumstances to be defined by the MME, service may be provided by PRODEEM.
2003 (Review 6) Feb 20, 2009 to Nov 2, 2011	Mini-grids: Hydroelectricity Solar photovoltaic Wind energy Biomass Diesel Hybrid systems Individual systems: Hydroelectricity Solar photovoltaic Wind energy Biomass Hybrid systems	I - consider technologies that best take advantage of local and regional energy potentials from an economic and energy availability point of view; II - the installations shall be in accordance with existing safety standards; III - for home service, the internal installation kit (conductors, protection circuit breaker, outlets, 9W and 11W fluorescent compact (efficient) lamps and other installation materials) shall be considered, with one light socket per room up to three light sockets and two outlets; IV - for service to collective units, such as schools, healthcare centers and community production centers, include complete internal installation with efficient fluorescent lamps and outlets. V - observe the environmental restrictions and training activities for users and its sustainability; VI - in specific circumstances to be defined by the MME, service may be provided by PRODEEM.
2011-2014 (Original and Review 1) Nov 3, 2011 to Nov 12, 2015	Mini-grids and individual: Micro and mini hydroelectric plants (includes hydrokinetic) SHPs Small diesel or biomass thermal power plants Photovoltaic solar energy Wind energy	I - consider technologies that best take advantage of local and regional energy potential from an economic and energy availability point of view; II - the installations shall be in accordance with existing safety standards; III - for home service, the internal installation kit (conductors, protection circuit breaker, outlets, 9W and 11W fluorescent compact (efficient) lamps and other installation materials) shall be considered, with one light socket per room up to three light sockets and two outlets; IV - for service to collective units, such as schools, healthcare centers and community production centers, include the same internal installation kit mentioned in paragraph III, but in enough quantity for all rooms of the building; V - observe the environmental restrictions and training activities for users and their sustainability;

Operational Manual	Technological option	Criteria
	Hybrid systems	
2015-2018 (Original and Review 1) Nov 13, 2015 to Aug 27, 2018	Individual systems: Micro and mini hydroelectric plants Fuel or Natural Gas thermoelectric plants Photovoltaic solar energy Wind energy Hybrid systems (may use diesel)	- The Executing Agent shall carry out the internal installation in all the homes served, with an installation kit consisting of: 01 (one) light socket per room, up to 03 (three) sockets, 02 (two) outlets and other materials required, including 9W or 11W compact fluorescent lamps (or other type of lamp with equivalent or higher efficiency technology). - for service to collective units, such as schools, healthcare centers and community production centers, the executing agent shall match the type of connection with the load to be served and shall also include the complete internal installation kit, containing compact fluorescent lamps (or other type of lamp with equivalent or higher efficiency technology), outlets and other necessary materials.
2018-2022 (Original) Aug 28, 2018 In force	Individual systems: Micro and mini hydroelectric plants Fuel or Natural Gas thermoelectric plants Solar photovoltaic plant Wind energy Hybrid systems (may use diesel)	- The Executing Agent shall carry out the internal installation in all the homes served, with an installation kit consisting of: 01 (one) light socket per room, up to 03 (three) sockets, 02 (two) outlets and other materials required, including 9W or 11W compact fluorescent lamps (or other type of lamp with equivalent or higher efficiency technology). - for service to collective units, such as schools, healthcare centers and community production centers, the executing agent shall match the type of connection with the load to be served and shall also include the complete internal installation kit, containing compact fluorescent lamps (or other type of lamp with equivalent or higher efficiency technology), outlets and other necessary materials.

Source: Created by the authors of this study based on LPT operational manuals mentioned above. Note: LPT 2003 Manuals (original and reviewed) state that projects with individual systems shall comply with specific ANEEL regulations, including REN nr. 83/2004.

The technological options and technical criteria used for remote regions followed the recommendations found in the "Manual for Electricity Provision to Remote Regions of Isolated Systems" of the LPT Program, no longer being in the LPT Operational Manual since the LPT 2015-2018 Manual (original).

The "Manual for Electricity Provision to Remote Regions of Isolated Systems" established that residential service should be provided by SIGFI 45 or MIGDI 45. For collective or productive uses, the systems should have a minimum monthly guarantee of 45 kWh. Table 7 presents some of its technical service criteria.

Table 7: Complementary documents to the LPT operational manuals: technological option, technical criteria and guaranteed monthly energy availability

Manual	Technological Option	Technical Criteria
Manual for Electricity Provision to Remote Regions of Isolated Systems (RRSI) (2015 and Review 1, 2017)	Micro and mini hydroelectric plants Fuel or Natural Gas thermoelectric plants Solar photovoltaic plant Wind energy Hybrid systems (may use diesel)	I - The Executing Agent shall carry out the internal installation in all the homes served, with an installation kit consisting of: 01 (one) light socket per room, up to 03 (three) points, 02 (two) outlets and other materials required, including 9W or 11W compact fluorescent lamps (or other type of lamp with equivalent or higher efficiency technology). II - for service to collective units, such as schools, healthcare centers and community production centers, the executing agent shall match the type of connection with the load to be served and shall also include the complete internal installation kit, containing compact fluorescent lamps (or other type of lamp with equivalent or higher efficiency technology), outlets and other necessary materials.
Technical specifications for service to RRSI (2017)	Micro and mini hydroelectric plants Fuel or Natural Gas thermoelectric plants Solar photovoltaic plant Wind energy Hybrid systems (may use diesel)	Follows the Manual for Electricity Provision to Remote Regions of Isolated Systems (RRSI)
Manual for Electricity Provision to RRSI and Technical specifications for service to RRSI		Each individual CU (service via SIGFI or MIGDI): 45 kWh/CU, meeting basic lighting, communication and cooling needs. Each CU for collective use or production process (service via SIGFI or MIGDI): at least 45 kWh/CU.

Source: Created by the authors of this study based on the manuals (and documents) mentioned above.

More Light for the Amazon Program

On February 5, 2020 (Decree 10,221), the Brazilian National Program for Universalization of Access and Use of Electrical Energy in the Legal Amazon - More Light for the Amazon (MLA) was created with the objective of providing services to the Brazilian population residing in remote regions of the Legal Amazon in Brazil. MLA's period of validity is until December 31, 2022.

The MLA Program is one of the Federal Government Programs aimed at the population located in Remote Regions of the Legal Amazon. Its objective is to ensure that electrification efforts in these regions result in increased production, providing an increase in income and social inclusion of the population.[23].

The MLA service profile is for families in remote regions[24] of the Legal Amazon that have not yet had access to electricity or consumer units with a non-renewable source of electricity. This service must be carried out using only renewable sources for electricity generation.

The MLA has the following service priorities:

- low-income families enrolled in the Single Registry ("Cadastro Único", in Portuguese) for Social Programs of the Federal Government;
- beneficiary families of federal, state or municipal government programs whose purpose is social and economic development;
- rural settlements, indigenous communities, quilombola[25] territories and other communities located in extractive reserves or directly impacted by electric energy generation or transmission projects for which the concessionaire is not responsible;
- schools, healthcare center and community water wells; and
- families residing in conservation units.

A fundamental point of the Decree creating the MLA is that it establishes that the "Ministry of Mines and Energy will coordinate with other Ministries and with other bodies and entities that it deems convenient on the implementation of socio-economic development actions for which the public energy service needs to be available" (Article 1, § 4). If this is actually seen to completion, it will maximize the benefits of electricity availability.

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[23] See footnote **Erro! Indicador não definido.**.
[24] small groups of consumers located in an Isolated System, away from municipal headquarters, and characterized by the absence of economies of scale or density.
[25] See footnote 1.

The Decree also establishes as mandatory for concessionaires, licensees and authorized public service providers of electric energy distribution operating in the Legal Amazon to adhere to the MLA Program.

ANEEL regulated the provisions of Decree nr. 10,221/20 (Normative Resolution nr. 940) and approved the initial MLA goals of distribution utilities (Resolution nr. 2,891) on June 29, 2021.

On November 23 of the same year, ANEEL published the rules for monitoring and inspecting plans for universalization of electricity distribution services, which came into force on January 1, 2022 (Normative Resolution nr. 950). This resolution revoked REN nr. 940/21 by incorporating its provisions and is briefly presented in the following section ("Monitoring and Inspection of Universalization Plans"). Table 8 is a summary with the history of the MLA Program legislation.

The consumer unit is allowed to obtain a load increase free of charge as long as it does not exceed the monthly availability of 80 kWh/CU. This increase can occur if, at least, one year has passed since the date of initial power up or since the last load increase. Otherwise, the service will be conditioned to the payment of the consumer's financial participation, which shall be calculated in accordance with ANEEL's regulation.

Table 8: History of the MLA Program Legislation

Legislation	Date	Description	Status
Decree nr. 10,221	February 05, 2020	Establishes the Brazilian National Program for Universalization of Access and Use of Electrical Energy in the Legal Amazon - More Light for the Amazon.	Effective from February 5, 2020
REN 940	June 29, 2021	Regulates the provisions of Decree nr. 10.221/20	Revoked (Jan 1, 2022, REN 950)
REH 2.891	June 29, 2021	Approves the initial goals of the More Light for the Amazon Program, established in Decree nr. 10.221/20	In force
REN 950	November 23, 2021	Establishes rules for the monitoring and inspection of plans for the universalization of electricity distribution services and other measures.	Effective January 1, 2022
Decree nr. 11,111	June 29, 2022	Amends Decree nr. 10.221/20.	In force

Source: Created by the authors of this study based on the legislation mentioned above.

The technical and financial criteria, procedures and priorities of the MLA are detailed in the Operational Manual of the More Light for the Amazon Program, published on June 16, 2020 (Ordinance nr. 244). It is worth mentioning that its section 7 ("availability of energy and power") states that services to

consumer units can occur through SIGFI and MIGDI-type systems with minimum guaranteed monthly availability that can meet basic lighting, communication and cooling needs.

Also, the MLA Manual informs that only renewable energy sources (wind, solar, hydro and biomass) are considered as options for electric energy generation. They can be used separately or in hybrid systems.

ANEEL published the initial goals[26] of distribution utilities in 2021, as shown in Table 9. A little over 210,000 connections are initially planned.

Table 9: Initial Goals[27] of the MLA Program

State	Power distribution utilities	Goal
AC	Energisa Acre	17,000
AM	Amazonas Energia	33,000
AP	Companhia de Eletricidade do Amapá	2,524
MA	Equatorial Maranhão	1,825
MT	Energisa Mato Grosso	410
PA	Equatorial Pará	154,833
RO	Energisa Rondônia – antiga CERON	1,300
RR	Roraima Energia	7,743
TO	Energisa Tocantins	586
	Total	**210,221**

Source: This study.

Monitoring and Inspection of Universalization Plans

On January 1, 2022, ANEEL Normative Resolution nr. 950, of November 23, 2021, came into force. It establishes rules for the monitoring and inspection of plans for the universalization of electricity distribution services.

The goal was to consolidate all normative rules related to the "Universalization Plans", revoking 13 resolutions published from 2003 to 2021. A brief overview of the Resolution is presented as follow, but reading it in full is recommend.

[26] The goals defined by ANEEL are initial goals already identified for the MLA Program, that is, they encompass the goals of the deeds of undertaking and other demands identified by the distribution utilities that have not yet been contracted by the MME. Available at: https://www2.aneel.gov.br/cedoc/aren2021940_1.pdf Accessed on: June 13, 2022.

[27] The initial goals for the MLA Program are merely indicative, and aim to consolidate and signal to the MME and society the demands known by the distribution utilities, considering that the Construction Programs must be submitted for analysis by the MME and Eletrobras. Available at: https://www2.aneel.gov.br/cedoc/aren2021940_1.pdf Accessed on: June 13, 2022.

The section on Universalization (Section III) of REN nr. 950/21 deals with Law nr. 10,438[28], of April 26, 2002, and with the consumer's right to free access to the electricity distribution service and its criteria.

Specific sections of REN nr. 950/21 deal with service under the LPT Program and the MLA Program (Sections IV and V, respectively). One of its provisions is that compliance with the LPT and MLA shall follow the target dates and conditions defined by the MME.

In cases where universalization plan construction work uses the resources of the distribution company (section VI), REN nr. 950/21 establishes that the provider must perform the service by expanding the conventional grid or by using isolated systems, following all the current legislation. The interested party who would initially be served by SIGFI or MIGDI can opt for conventional service, provided that there are no technical or environmental limitations that may restrict this type of service and that the party "contributes in advance with resources or with the direct execution of the construction work, as provided for in the Rules for Provision of Public Electricity Distribution Service".

Regarding monitoring of the execution of the Universalization Plan (Section VIII), distribution utilities must send quarterly monitoring reports by the last day of the month following the reference quarter. These reports must be used to verify compliance with the established goals.

[28] Law that provides for the universalization of the public electric energy service in Brazil.

Analysis of Data Provided by Aneel

This stage comprises the analysis of the data provided by ANEEL in order to have an overview of the installation of SIGFI and MIGDI. The analysis was performed as follows, as shown in Figure 4.

Figure 4: Stages of Data Analysis

Source: This study.

ANEEL's database can be accessed through the spreadsheet made available by the agency on its website (ANEEL, 2022). The version used in this study was accessed on 06/03/2022.

It is important to reiterate that the distribution companies that are installing the systems must send the minimum data corresponding to the installations every six months, in report format, to ANEEL, as stated in the specific normative resolutions. With these reports, ANEEL's database is updated, making it possible to conduct studies and analyses such as the ones presented here.

By accessing the ANEEL website, it is possible to download the spreadsheet with the data to be analyzed or carry out the desired analyses in the site interactively. The spreadsheet, or database, is divided into two parts: registration information and incident information. Each segment has the following information, as shown in Table 10.

Table 10: Information in the database

Registration Information	Incident information
Distribution utilities	Distribution utilities
Period (year-semester) of the report	Period (year-semester)
Consumer Unit Code (CU)	Type of incident (outage, voltage level problem, general complaint or other)
System type (SIGFI, Integral MIGDI or Reduced MIGDI)	Origin (not applicable, well founded, unfounded)
Class Type and Subclass (according to Module 10 of PRODIST)	Incident start date/time
Voltage Group (according to Module 10 of PRODIST)	Incident end date/time
Tariff Group (according to Module 10 of PRODIST)	Triggering event (material or equipment failure, theft, corrosion or other)
Municipality code (according to the IBGE code)	Means of communication of the incident (by telephone, e-mail, in person or other)
Type of Assistance	Interruption duration/Regularization period/Resolution period (in hours)
Guaranteed monthly availability (13, 20, 30, 45, 60, 80 or other – in kWh)	Field for other comments
Measurement	
Power up start date	
Primary Source Type	
Address of the location where the system was installed	
Latitude coordinate	
Longitude coordinate	
Field for other comments	

Source: This study.

However, since several distribution utilities send their data to ANEEL in a different way, asymmetries and errors may occur when filling in this information. Seeking to facilitate and standardize this study, the following assumptions were used to handle data in the spreadsheet:

- For Registration analyses:
    - The analyses consider the year-semester period 2021-02, that is, the report for the second half of 2021, which is the most recent version at the time of this study. The registration information is stock-like (i.e. each semi-annual report presented provides a snapshot of all installed systems). The base is not exhaustive, as there are distribution utilities with stand-alone power systems installed that have not yet sent reports or have not been included

in them. Thus, the information made available is limited only to the distribution utilities that have sent the information.

- For Incident Analyses:
    - Unlike registration information, incident information is not stock-like, but cumulative. Therefore, the report for the year-semester 2021-02 period, for example, only contains information on the incidents recorded during that semester (and not the history). For this reason, these analyses are performed for all periods available in the database.
    - In the incident duration field, negative and null values were identified. So, the analyses of incidents disregard these values.

Considering the assumptions above, the analyses pertaining to registration and incident information are presented below.

Registration Analysis

The number of SIGFI and MIGDI installed between November 30, 2006 and January 18, 2022 is 23,219 according to the last update of ANEEL's database (year-semester 2021.02).

Most of the installations took place in 2009 and 2010, representing about 61% of all systems installed in the period (*see* Table 11 and Figure 5). So, most systems are more than eleven years old.

However, these numbers are different from the data obtained by Jannuzzi et al. (2009), in which there was a total of 16,926 SIGFI systems installed in the country until 2009, while the table below shows a total of 8,959. Two possible reasons for this discrepancy are the incomplete database and the removal of installed systems with the arrival of the distribution grid, for example.

Table 11: Number of installations connected annually

Year	Number of systems installed	%
2006	1	0.00%
2007	1	0.00%
2008	9	0.04%
2009	8948	38.54%
2010	5054	21.77%
2011	207	0.89%
2012	213	0.92%
2013	175	0.75%
2014	159	0.68%
2015	92	0.40%

Year	Number of systems installed	%
2016	92	0.40%
2017	615	2.65%
2018	1702	7.33%
2019	2220	9.56%
2020	186	0.80%
2021	2643	11.38%
2022	902	3.88%
Grand total	**23219**	100.00%

Source: Created by the authors of this study based on ANEEL (2022).

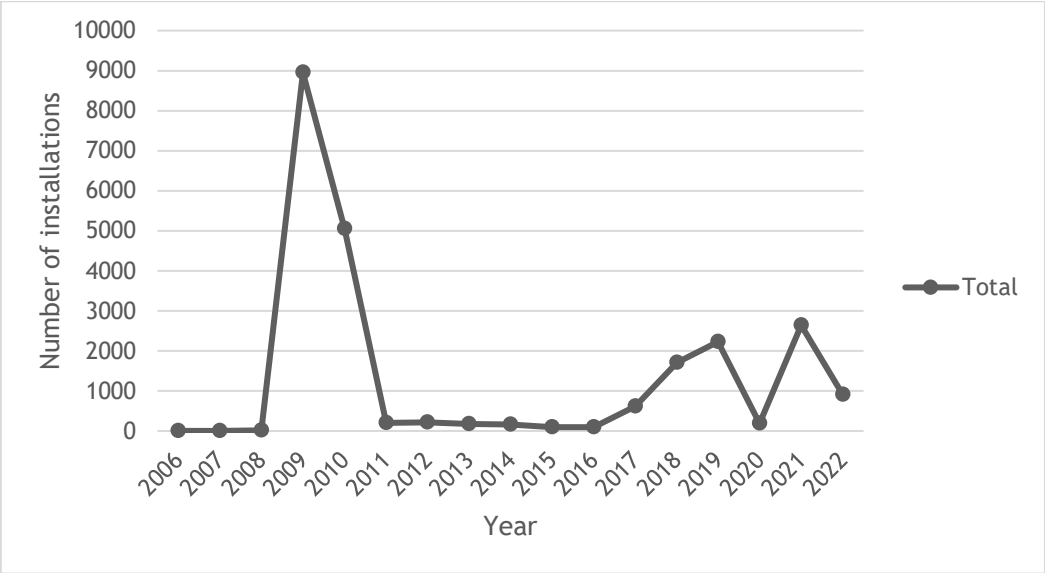

Figure 5: Number of connected installations for each year.

Source: Created by the authors of this study based on ANEEL (2022).

SIGFI are the most installed types of systems (98%) and photovoltaic (PV) solar energy is the only technology used, as shown in **Erro! Fonte de referência não encontrada.**Table 12.

Table 12: Type and source of the systems

Year	SIGFI	MIGDI	Grand total	Energy technology
2006	1		1	
2007	1		1	
2008	9		9	**FV**
2009	8948		8948	
2010	5054		5054	

Year	SIGFI	MIGDI	Grand total	Energy technology
2011	207		207	
2012	213		213	
2013	175		175	
2014	159		159	
2015	92		92	
2016	89	3	92	
2017	613	2	615	
2018	1621	81	1702	
2019	1874	346	2220	
2020	184	2	186	
2021	2630	13	2643	
2022	901	1	902	
Grand total	**22771**	**448**	**23219**	

Source: Created by the authors of this study based on ANEEL (2022).

According to the 2021-02 year-semester report, only six distribution utilities sent their reports to ANEEL (Table 13): Coelba, Equatorial Pará, Equatorial Maranhão, Enel Ceará, Enel Goiás, and Enel Rio de Janeiro. Of these, Coelba (with 67.86% of the installed systems) and Equatorial Pará (27.58% of the installed systems) represent around 96% of the total reported installations. Also, in Table 13, you can find the number of systems installed by each distribution utility per year.

We can also see that until 2015, the only distribution utility to install systems was COELBA. But, according to research developed by Jannuzzi et al. (2009) in 2009, there were two distribution utilities installing SIGFI systems, namely COELBA and CEMIG. However, the latter is not included in the current database of ANEEL reports.

Table 13: Systems installed by electricity distribution utility

Year	COELBA	ENEL CE	ENEL GO	ENEL RJ	EQUATORIAL MA	EQUATORIAL PA	Total Geral
2006	1						1
2007	1						1
2008	9						9
2009	8948						8948
2010	5054						5054
2011	207						207
2012	213						213
2013	175						175
2014	159						159
2015	92						92

Year	COELBA	ENEL CE	ENEL GO	ENEL RJ	EQUATORIAL MA	EQUATORIAL PA	Total Geral
2016	71	18			3		92
2017	80	37			2	496	615
2018	87				81	1534	1702
2019	491		99		346	1284	2220
2020	34		100	37	2	13	186
2021	133				332	2178	2643
2022	1				2	899	902
Total	**15756**	**55**	**199**	**37**	**768**	**6404**	**23219**
%	67.86%	0.24%	0.86%	0.16%	3.31%	27.58%	100.00%

Source: Created by the authors of this study based on ANEEL (2022).

In another analysis, we find that almost all (more than 97%) of the systems installed are to serve consumers in the Residential (RE1), Low Income Residential (RE2), Rural Residential (RU3) and Rural farming (RU1) classes. S*ee* Table 14. Most of the installations (57.9%) are for residential consumers (RE1).

Table 14: Percentage distribution of installed systems by consumer class

	Consumer class	Number of systems	%
RE1	Residential	13444	57.90%
RE2	Low-income residential	4158	17.91%
RU3	Rural residential	3919	16.88%
RU1	Rural farming	1080	4.65%
PP3	Municipal government	283	1.22%
REBP	Low-income residential benefit of continued provision of social assistance - BPC	94	0.40%
CO5	Places of worship	93	0.40%
REQU	Quilombola low-income residential	55	0.24%
CO1	Commercial	45	0.19%
CO4	Philanthropic organizations and associations	27	0.12%
CO9	Other services and other activities	16	0.07%
REBR	Indigenous low-income residential	2	0.01%
RU5	Agribusiness	1	0.00%
RU8	Aquaculture	1	0.00%
IN	Industrial	1	0.00%
	Total Geral	**23219**	**100.00%**

Source: Created by the authors of this study based on ANEEL (2022).

From 2006 to 2022, the most installed type of SIGFI has been type 13 (guaranteed monthly availability of 13 kWh), corresponding to approximately 67% of installed SIGFI (Table 15). From 2017 onwards, however, installation of

type 45 SIGFI (guaranteed monthly availability of 45 kWh) began to increasingly and significantly grow. From 2017 to 2021, this is mostly due to the LPT Program Operational Manuals, that recommended the installation of SIGFI type 45 and higher. Together, SIGFI types 13 and 45 correspond to approximately 97% of the systems installed in the period.

Table 15: Systems installed by guaranteed monthly electricity availability, per year

Year	13	30	45	80	90	180	Total
2006	1						1
2007	1						1
2008	9						9
2009	8808	140					8948
2010	4992	62					5054
2011	205	2					207
2012	212	1					213
2013	175						175
2014	158	1					159
2015	92						92
2016	71		3	18			92
2017	79	1	482	37	7	9	615
2018	85	2	1569		41	5	1702
2019	488	3	1617	99	5	8	2220
2020	33	1	4	137	8	3	186
2021	130	3	2417		1	92	2643
2022	1		901				902
Total	**15540**	**216**	**6993**	**291**	**62**	**117**	**23219**
Total %	**66.93%**	**0.93%**	**30.12%**	**1.25%**	**0.27%**	**0.50%**	**100.00%**

Source: Created by the authors of this study based on ANEEL (2022).

The fact that the number of SIGFI 45 type system installed grew from year 2017 on is quite positive, as SIGFI 13 and 30 are very limited in terms of energy availability, as detailed in previous sections of this project. It is worth mentioning that SIGFI 20 (guaranteed monthly availability of 20 kWh) were not installed in the period.

All MIGDI systems were installed at 45 kWh/month (Table 166). Still in Table 16, we see that all SIGFI 13 and 30 were installed by Coelba, which has not reported the installation of any system with higher availability. Only Equatorial PA and Equatorial MA have installed SIGFI 45. The remainder, which totals 470 systems, is divided into 291 SIGFI 80, distributed among Enel CE, Enel GO and Enel RJ, and 179 systems above 80 kWh/month, by Equatorial PA. The

percentage distribution of systems by guaranteed monthly availability by distribution utility is shown in Table 17.

Table 16: Distribution of systems by monthly electricity availability and by distribution utility

Distribution utilities and type of installed system	Monthly electricity availability (kWh/month)						
	13	30	45	80	90	180	Total Geral
COELBA	**15540**	**216**					**15756**
SIGFI	15540	216					15756
ENEL CE				**55**			**55**
SIGFI				55			55
ENEL GO				**199**			**199**
SIGFI				199			199
ENEL RJ				**37**			**37**
SIGFI				37			37
EQUATORIAL MA			**768**				**768**
MIGDI			320				320
SIGFI			448				448
EQUATORIAL PA			**6225**		**62**	**117**	**6404**
SIGFI			6225		62	117	6404
Total	**15540**	**216**	**6993**	**291**	**62**	**117**	**23219**

Source: Created by the authors of this study based on ANEEL (2022).

Table 17: Percentage distribution of systems by monthly electricity availability and by distribution utility

Distribution utilities and type of installed system	Monthly electricity availability (kWh/month)						
	13	30	45	80	90	180	Total
COELBA	**66.93%**	**0.93%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**67.86%**
SIGFI	66.93%	0.93%	0.00%	0.00%	0.00%	0.00%	67.86%
ENEL CE	**0.00%**	**0.00%**	**0.00%**	**0.24%**	**0.00%**	**0.00%**	**0.24%**
SIGFI	0.00%	0.00%	0.00%	0.24%	0.00%	0.00%	0.24%
ENEL GO	**0.00%**	**0.00%**	**0.00%**	**0.86%**	**0.00%**	**0.00%**	**0.86%**
SIGFI	0.00%	0.00%	0.00%	0.86%	0.00%	0.00%	0.86%
ENEL RJ	**0.00%**	**0.00%**	**0.00%**	**0.16%**	**0.00%**	**0.00%**	**0.16%**
SIGFI	0.00%	0.00%	0.00%	0.16%	0.00%	0.00%	0.16%
EQUATORIAL MA	**0.00%**	**0.00%**	**3.31%**	**0.00%**	**0.00%**	**0.00%**	**3.31%**
MIGDI	0.00%	0.00%	1.93%	0.00%	0.00%	0.00%	1.93%
SIGFI	0.00%	0.00%	1.38%	0.00%	0.00%	0.00%	1.38%
EQUATORIAL PA	**0.00%**	**0.00%**	**26.81%**	**0.00%**	**0.27%**	**0.50%**	**27.58%**
SIGFI	0.00%	0.00%	26.81%	0.00%	0.27%	0.50%	27.58%
Total	**66.93%**	**0.93%**	**30.12%**	**1.25%**	**0.27%**	**0.50%**	**100.00%**

Source: Created by the authors of this study based on ANEEL (2022).

About 51.8% of the total consumer units reported in the second half of 2021 are classified as residential class and 9.4% are in the low-income residential class; both with SIGFI 13 (Table 18). About 15.7% and 8.3% are SIGFI 45 installed in rural residential and low-income residential consumers, respectively. Therefore, SIGFI 13 and 45 systems in the residential, low-income residential and rural residential classes represent 92.7% of all installed systems (highlighted in blue in the table). The absolute numbers are shown in Table 19.

Table 18: Percentage distribution of installed systems by consumer class and by monthly availability

Consumer Class		Guaranteed Monthly electricity availability (kWh/month) in %							
		Total	13	30	45	80	90	180	Total
RE1	Residential	13444	51.8%	0.6%	5.2%	0.2%	0.0%	0.1%	57,9%
RE2	Low-income residential	4158	9.4%	0.1%	8.3%	0.0%	0.0%	0.1%	17,9%
RU3	Rural residential	3919	0.0%	0.0%	15.7%	1.0%	0.0%	0.2%	16,9%
RU1	Rural farming	1080	4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	4,7%
PP3	Municipal government	283	0.6%	0.2%	0.1%	0.0%	0.2%	0.1%	1,2%
REBP	Low-income residential benefit of continued provision of social assistance - BPC	94	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0,4%
CO5	Places of worship	93	0.1%	0.0%	0.2%	0.0%	0.0%	0.0%	0,4%
REQU	Quilombola low-income residential	55	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0,2%
CO1	Commercial	45	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0,2%
CO4	Philanthropic organizations and associations	27	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0,1%
CO9	Other services and other activities	16	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0,1%
REBR	Indigenous low-income residential	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0,0%
RU5	Agribusiness	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0,0%
RU8	Aquaculture	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0,0%
IN	Industrial	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0,0%
	Total	**23219**	**66,9%**	**0.9%**	**30.1%**	**1.3%**	**0.3%**	**0.5%**	**100.0%**

Source: Created by the authors of this study based on ANEEL (2022).

Table 19: Distribution in absolute numbers of installed systems by consumer class and by monthly availability

Consumer Class		Guaranteed Monthly electricity availability (kWh/month)						
		13	30	45	80	90	180	Total Geral
RE1	Residential	12017	135	1216	53	1	22	13444
RE2	Low-income residential	2173	14	1938	4	7	22	4158
RU3	Rural residential			3638	225	1	55	3919
RU1	Rural farming	1070		1	9			1080
PP3	Municipal government	149	51	14		53	16	283

Consumer Class		Guaranteed Monthly electricity availability (kWh/month)						
		13	30	45	80	90	180	Total Geral
REBP	Low-income residential benefit of continued provision of social assistance - BPC			93			1	94
CO5	Places of worship	32	4	56			1	93
REQU	Quilombola low-income residential	49		6				55
CO1	Commercial	33	10	2				45
CO4	Philanthropic organizations and associations			27				27
CO9	Other services and other activities	13	2	1				16
REBR	Indigenous low-income residential	2						2
RU5	Agribusiness			1				1
RU8	Aquaculture	1						1
IN	Industrial	1						1
	Total	**15540**	**216**	**6993**	**291**	**62**	**117**	**23219**

Source: Created by the authors of this study based on ANEEL (2022).

Last but not least, 31.3% (7264) of all installed systems, as reported in the 2021-02 report (23219), have electricity consumption measurement systems[29]; 88.2% of which in Equatorial PA and 10.6% in Equatorial MA (Table 20). However, in the three previous semester reports by Equatorial PA all reported systems did not have measurement systems. Thus, it is likely that the 2021-02 report was mistakenly filled. If so, the total number of systems without measurement system raises to 96.3%.

Table 20: Measuring system by electricity distribution utility

Measurement	NO	YES	Total
COELBA	15756		15756
ENEL CE		55	55
ENEL GO	199		199
ENEL RJ		37	37
EQUATORIAL MA		768	768
EQUATORIAL PA		6404	6404
Total	**15955**	**7264**	**23219**
%	68.72%	31.28%	100%

Source: Created by the authors of this study based on ANEEL (2022).

[29] System composed of a main meter, other equipment necessary to carry out the measurement for billing and, not always, a back-up meter, transformers for instruments (voltage and current transformers), communication channels and data collection systems (REN nr. 1000 , 2021).

Installation of measurement system was mandatory from 2004 to May 2012 for SIGFI above 30 kWh of guaranteed monthly electricity availability [30]. Installation became optional for every system size from June 2012[31].

Analysis of Incidents

Incidents were recorded from January 2020 to December 2021. In total, there have been 7781 recorded incidents (Table 21).

This number, however, drops to 4016 when records are disregarded whose service duration times are negative or null values (assumptions of the study), i.e., in 3765 records (Table 22). So, almost half of all records (48%) may contain typos or other types of error in submitted reports.

Table 21: Total number of incident records from January 2020 to December 2021

Type of incident	Number of incidents	%
Interruption	3925	50.44%
Other	3813	49.00%
Voltage level problem	1	0.01%
General complaint	42	0.54%
Total	**7781**	**100.00%**

Source: Created by the authors of this study based on ANEEL (2022).

Table 22: Total number of incident records from January 2020 to December 2021, excluding records with negative or null service duration

Type of incident	Number of incidents	%
Interruption	3922	97.66%
Other	51	1.27%
Voltage level problem	1	0.02%
General complaint	42	1.05%
Total	**4016**	**100.00%**

Source: Created by the authors of this study based on ANEEL (2022).

[30] ANEEL Normative Resolution nr. 83/2004. "The concessionaire is obliged to install measuring equipment in all consumer units supplied by SIGFI with guaranteed monthly availability greater than 30 kWh that are served as of the publication of this Resolution" (Art. 4, p.4).
[31] ANEEL Normative Resolution nr. 493/2012. "The installation of measuring equipment is permitted in the consumer units served under the terms of this Resolution" (Art. 12, p. 4). This Resolution was revoked by ANEEL Normative Resolution N°1000/21, but the optional measurement remained.

When searching only for the records of these cases with negative or null duration, the spreadsheet points out two cases for ENEL RJ that are not identified in the total values. When checking the Incident data, these two records are classified as "Not Applicable" and belong to the report of the second semester of 2020. The incident, however, was recorded in January 2021, signaling an error in data delivery, an issue that needs to be understood and resolved.

Virtually all cases with negative or null duration (3762 or 99.87%) occurred at Enel GO (Table 23) classified as "Other" type. When durations are divided into negative and null, the latter represent 97% of the 3767 cases, all at Enel GO. This type of event is recurrent in Enel GO's semi-annual reports, as can be seen in Table 24. This is another issue that needs to be understood and resolved.

Table 23: Total number of incident records only with negative or null service duration from January 2020 to December 2021 by electricity distribution utility

Type of incident	Number of incidents	%	Null only	Negative only
INTERRUPÇÃO	**3**	**0.08%**	**0**	**3**
COELBA	3	0.08%	0	3
OTHER	**3764**	**99.92%**	**3654**	**108**
ENEL GO	3762	99.87%	3654	108
ENEL RJ	2	0.05		
Total	**3767**	**100.00%**	**97.1%**	**2.9%**

Source: Created by the authors of this study based on ANEEL (2022).

Table 24: Total number of incident records only with negative or null service duration from January 2020 to December 2021 by electricity distribution utility and semi-annual report

Type of incident	2020-01	2020-02	2021-01	2021-02
INTERRUPÇÃO	**1**	**2**	**0**	**0**
COELBA	1	2	0	0
OTHER	**434**	**753**	**840**	**1737**
ENEL GO	434	751	840	1737
ENEL RJ		2		
Total	**435**	**755**	**840**	**1737**

Source: Created by the authors of this study based on ANEEL (2022).

Henceforth, the analyses consider this study's assumptions (no negative and null values for incident records). When looking at the distribution of records by origin (well founded, unfounded or not applicable), it appears that most were considered well founded (69.85%) and the remaining total was unfounded

(30.10%). *See* Table 25. The vast majority refers to interruption, whether well founded or unfounded. Two records were classified as not applicable, but there was no description, as mentioned before.

Table 25: Distribution of the total number of incident records by origin

Type of incident	UNFOUNDED	NOT APPLICABLE	WELL FOUNDED	Total	%
Interruption	1135		2787	3922	*97.66%*
Other	45	2	4	51	*1.27%*
Voltage level problem	1			1	*0.02%*
General complaint	28		14	42	*1.05%*
Total	**1209**	**2**	**2805**	**4016**	*100.00%*
%	**30.10%**	**0.05%**	**69.85%**	**100.00%**	

Source: Created by the authors of this study based on ANEEL (2022).

When we look at incident data by distribution company, in absolute numbers, Coelba (47.41%), Equatorial PA (29.11%), and Equatorial MA (20.12%) are the companies with the largest number of incidents recorded, as seen in Table 26.

Table 26: Distribution of the total number of incident records by electricity distribution utility

Type of incident	COELBA	ENEL CE	ENEL GO	ENEL RJ	EQUATORIAL MA	EQUATORIAL PA	Total
Interruption	1904	45	28		805	1140	3922
Other		40	5	3	3		51
Voltage level problem						1	1
General complaint		10	4			28	42
Total	**1904**	**95**	**37**	**3**	**808**	**1169**	**4016**
%	47.41%	2.37%	0.92%	0.07%	20.12%	29.11%	100.00%

Source: Created by the authors of this study based on ANEEL (2022).

A relevant indicator is the number of incidents by installed system, for each distribution company, as seen in Table 27. As the installed systems' values are very discrepant, an average would not convey information in a coherent way. Therefore, the indicator is calculated by the simple ratio between the total number of incidents and of installations, separately, and a global indicator that is calculated later by weighted mean.

As seen in Table 27, ENEL CE has a high incident factor per installed system (1.73), which indicates that each installation generated at least one complaint/incident. The same occurs with Equatorial MA (1.05). COELBA has a

low relative value (0.12), but it is important to highlight that COELBA has the largest number of installed systems and has acquired more experience over the years. Furthermore, the global indicator shows that there is an incident for every five systems installed (on average).

Table 27: Number of incidents by Installed Systems

Company	Incidents	Installed Systems	Indicator	Global Indicator
COELBA	1904	15756	0.12	0.17
ENEL CE	95	55	1.73	
ENEL GO	37	199	0.19	
ENEL RJ	3	37	0.08	
Equatorial MA	808	768	1.05	
Equatorial PA	1169	6404	0.18	
Total	**4016**	**23219**		

Source: Created by the authors of this study based on ANEEL (2022).

Of a total of 2805 well-founded records, the majority (69.40% or 2787) referred to interruption of electricity supply, of which 43.63% (1752) were registered at Coelba (Table 28). Still in Table 28, as to the total of 1209 records considered unfounded, the vast majority (1135 or 28.26%) were also interruptions, 23.53% (945) of which were identified by Equatorial PA.

Table 28: Distribution of the total number of incident records by origin and distribution company

Type of incident	UNFOUNDED	%	NOT APPLICABLE	%	WELL FOUNDED	%	Total	%
INTERRUPTION	**1135**	**28.26%**		**0.00%**	**2787**	**69.40%**	**3922**	**97.66%**
COELBA	152	3.78%		0.00%	1752	43.63%	1904	47.41%
ENEL CE	16	0.40%		0.00%	29	0.72%	45	1.12%
ENEL GO	14	0.35%		0.00%	14	0.35%	28	0.70%
EQUATORIAL MA	8	0.20%		0.00%	797	19.85%	805	20.04%
EQUATORIAL PA	945	23.53%		0.00%	195	4.86%	1140	28.39%
OTHER	**45**	**1.12%**	**2**	**0.05%**	**4**	**0.10%**	**51**	**1.27%**
ENEL CE	40	1.00%		0.00%		0.00%	40	1.00%
ENEL GO	4	0.10%		0.00%	1	0.02%	5	0.12%
ENEL RJ		0.00%	2	0.05%	1	0.02%	3	0.07%
EQUATORIAL MA	1	0.02%		0.00%	2	0.05%	3	0.07%
VOLTAGE LEVEL PROBLEM	**1**	**0.02%**		**0.00%**		**0.00%**	**1**	**0.02%**
EQUATORIAL PA	1	0.02%		0.00%		0.00%	1	0.02%
GENERAL COMPLAINT	**28**	**0.70%**		**0.00%**	**14**	**0.35%**	**42**	**1.05%**
ENEL CE	10	0.25%		0.00%		0.00%	10	0.25%

Type of incident	UNFOUNDED	%	NOT APPLICABLE	%	WELL FOUNDED	%	Total	%
ENEL GO	3	0.07%		0.00%	1	0.02%	4	0.10%
EQUATORIAL PA	15	0.37%		0.00%	13	0.32%	28	0.70%
TOTAL	**1209**	**30.10%**	**2**	**0.05%**	**2805**	**69.85%**	**4016**	**100.00%**

Source: Created by the authors of this study based on ANEEL (2022).

As COELBA is the distribution company which started its installations many years ago, in 2006, it is interesting to observe that 1513 of the 1752 well-founded incidents due to interruption occurred in the older systems, those installed in 2009 and 2010 (*see* Table 29). This means that preventive maintenance actions are necessary to avoid this type of incident.

Table 29: Distribution of the total number of COELBA incident records by origin and year of connection

Type of incident	UNFOUNDED		WELL FOUNDED		Total	
	Nr.	%	Nr.	%	Nr.	%
Interruption	**152**	**7.98%**	**1752**	**92.02%**	**1904**	**100.00%**
2009	52	2.73%	892	46.85%	944	49.58%
2010	59	3.10%	621	32.62%	680	35.71%
2011	6	0.32%	27	1.42%	33	1.73%
2012	4	0.21%	18	0.95%	22	1.16%
2013	0	0.00%	23	1.21%	23	1.21%
2014	5	0.26%	26	1.37%	31	1.63%
2015	2	0.11%	18	0.95%	20	1.05%
2016	1	0.05%	13	0.68%	14	0.74%
2017	1	0.05%	8	0.42%	9	0.47%
2018	1	0.05%	16	0.84%	17	0.89%
2019	21	1.10%	83	4.36%	104	5.46%
2020	**0**	0.00%	6	0.32%	6	0.32%
2021	0	0.00%	1	0.05%	1	0.05%

Source: Created by the authors of this study based on ANEEL (2022).

From a broader perspective, the number of incidents by electricity distribution utility is shown in Table 30.

As was mentioned and as shown in Table 30, most of the incidents occurred in the older systems installed by Coelba (2009 and 2010) and in the systems of Equatorial Pará (PA) and Equatorial Maranhão (MA), in 2019 and 2021, respectively. Systems were first installed by Equatorial Maranhão in 2017. The number of interruption incidents in relatively new systems owned by these

distribution companies requires attention. The causes need to be identified to understand what can be corrected in the process, because the failure rate should be low in new systems.

Table 30: Distribution of incidents by year of connection and by distribution company

Year	COELBA	%	ENEL CE	%	ENEL GO	%	ENEL RJ	%	EQUA.MA	%	EQUA.PA	%	TOTAL	% TOTAL
2009	944	23.51%		0.00%		0.00%		0.00%		0.00%		0.00%	944	23.51%
2010	680	16.93%		0.00%		0.00%		0.00%		0.00%		0.00%	680	16.93%
2011	33	0.82%		0.00%		0.00%		0.00%		0.00%		0.00%	33	0.82%
2012	22	0.55%		0.00%		0.00%		0.00%		0.00%		0.00%	22	0.55%
2013	23	0.57%		0.00%		0.00%		0.00%		0.00%		0.00%	23	0.57%
2014	31	0.77%		0.00%		0.00%		0.00%		0.00%		0.00%	31	0.77%
2015	20	0.50%		0.00%		0.00%		0.00%		0.00%		0.00%	20	0.50%
2016	14	0.35%	32	0.80%		0.00%		0.00%		0.00%		0.00%	46	1.15%
2017	9	0.22%	63	1.57%		0.00%		0.00%		0.00%	102	2.54%	174	4.33%
2018	17	0.42%		0.00%		0.00%		0.00%	61	1.52%	325	8.09%	403	10.03%
2019	104	2.59%		0.00%	13	0.32%		0.00%	5	0.12%	696	17.33%	818	20.37%
2020	6	0.15%		0.00%	7	0.17%	1	0.02%	9	0.22%	6	0.15%	29	0.72%
2021	1	0.02%		0.00%		0.00%		0.00%	681	16.96%	28	0.70%	710	17.68%
#N/D	0	0.00%		0.00%	17	0.42%	2	0.05%	52	1.29%	1	0.02%	72	1.79%
2022	0	0.00%		0.00%		0.00%		0.00%		0.00%	11	0.27%	11	0.27%
Total	**1904**	**47.41%**	**95**	**2.37%**	**37**	**0.92%**	**3**	**0.07%**	**808**	**20.12%**	**1169**	**29.11%**	**4016**	**100.00%**

Source: Created by the authors of this study based on ANEEL (2022).
Note: in some analyses, the spreadsheets made available by ANEEL show the field #N/D.

In a more detailed analysis, it was possible to verify (Table 31) that the majority of well-founded and unfounded incidents due to “interruption” occurred in the Residential (RE1), Low-Income Residential (RE2) and Rural Residential (RU3) consumer classes - the three classes with the most systems installed in the period (as shown previously).

Table 31: Incidents by consumer class

	Consumer Class by type of incident	Number of incidents	%
	INTERRUPTION	**3922**	**97.66%**
RE1	Residential	2004	49.90%
RE2	Low-income residential	871	21.69%
RU3	Rural residential	810	20.17%
RU1	Rural farming	85	2.12%

	Consumer Class by type of incident	Number of incidents	%
#N/D	-	70	1.74%
REBP	Low-income residential benefit of continued provision of social assistance - BPC	45	1.12%
REQU	Quilombola low-income residential	19	0.47%
PP3	Municipal government	12	0.30%
CO5	Places of worship	5	0.12%
CO1	Commercial	1	0.02%
	OTHER	**51**	**1.27%**
RU3	Rural residential	24	0.60%
RE1	Residential	18	0.45%
RU1	Rural farming	5	0.12%
#N/D	-	2	0.05%
RE2	Low-income residential	2	0.05%
	VOLTAGE LEVEL PROBLEM	**1**	**0.02%**
RU3	Rural residential	1	0.02%
	GENERAL COMPLAINT	**42**	**1.05%**
RE2	Low-income residential	17	0.42%
RU3	Rural residential	16	0.40%
RE1	Residencial	7	0.17%
RU1	Rural farming	1	0.02%
REQU	Quilombola low-income residential	1	0.02%
	TOTAL	**4016**	**100.00%**

Source: Created by the authors of this study based on ANEEL (2022).

Still on the incidents, it is worth correlating this information with the monthly availability by type of installed system. Table 32 shows this correlation for all systems (SIGFI and MIGDI). Most of the incidents were recorded in SIGFI 13 (1880) and 45 (1849), respectively, which together correspond to practically 97% of the SIGFI installed in the period.

On the other hand, when we look at the proportion of incidents to the number of systems installed, SIGFI 45 correspond to 30% of the total installed, but they account for 45.32% of the interruption-type incidents recorded. SIGFI 13 represent 67% of installed systems, but account for 47% of recorded interruptions.

It is important to mention that there are records of repeated incidents in some consumer units (CU). Of this total number, 2401 CU registered incidents in the period, 1643 UC had only 1 record (68.43%) and 759 (31.61%) recorded more than one incident in the period - one single CU recorded 25 interruption-type incidents.

Table 32: Total number of incident types recorded by guaranteed monthly availability

Type of incident x Monthly availability (kWh)	13	30	45	80	#N/D	Total
Interruption	**1880**	**24**	**1892**	**56**	**70**	**3922**
MIGDI			32			32
MIGDI INTEGRAL			40			40
SIGFI	1880	24	1820	56		3780
#N/D					70	70
OTHER			**3**	**46**	**2**	**51**
MIGDI INTEGRAL			3			3
SIGFI				46		46
#N/D					2	2
VOLTAGE LEVEL PROBLEM			**1**			**1**
SIGFI			1			1
GENERAL COMPLAINT			**28**	**14**		**42**
SIGFI			28	14		42
TOTAL	**1880**	**24**	**1924**	**116**	**72**	**4016**
%	46.81%	0.60%	47.91%	2.89%	1.79%	100%

Source: Created by the authors of this study based on ANEEL (2022).

Most (54.7%) of the well-founded or unfounded incidents recorded state "Other" as cause of the interruption, which does not offer much detail. The second cause for the incidents is supply interruptions due to material or equipment failure (34.4%). These two causes account for 89.1% of the total incident records. The other causes are distributed as seen in Table 33.

Table 33: Triggering event of the well-founded and unfounded interruptions recorded

Triggering event of the Incident	Unfounded	Not Applicable	Well founded	Total	%
INTERRUPTION	**1135**		**2787**	**3922**	**97.66%**
Material or equipment failure	218		1163	1381	34.39%
Other	723		1472	2195	54.66%
House closed	2			2	0.05%
Corrosion			97	97	2.42%
Address not located	1			1	0.02%
Connection failure			7	7	0.17%
Theft			4	4	0.10%
Individual interruption due to internal malfunction	5			5	0.12%
Connection cut	3			3	0.07%
Normal	45			45	1.12%
Broken extension			1	1	0.02%
Robbery			16	16	0.40%
Preventive service not scheduled	33			33	0.82%
Overload			27	27	0.67%

Triggering event of the Incident	Unfounded	Not Applicable	Well founded	Total	%
Inadequate voltage	105			105	2.61%
OTHER	**45**	**2**	**4**	**51**	**1.27%**
Other	45	2	4	51	1.27%
VOLTAGE LEVEL PROBLEM	**1**			**1**	**1.05%**
Other	1			1	1.05%
GENERAL COMPLAINT	**28**		**14**	**42**	**0.02%**
Other	28		14	42	0.02%
TOTAL	**1209**	**2**	**2805**	**4016**	**100.00%**

Source: Created by the authors of this study based on ANEEL (2022).

Of a total of 4016 incident records in the four reports sent, only 346 are more descriptive when the general descriptions "Equipment Failure" and "Other" are disregarded as triggering event. As they are more specific, it is possible to better identify what caused the incident, as can be seen in Table 33. All these cases fall into power supply interruption.

On the other hand, the sample is too small to identify the incident numbers and the duration of the customer service more specifically. It gets even smaller when only the well-founded incidents are observed - 152 records (44%) of 346 (Table 34).

Table 34: Triggering event of incidents recorded in more detail

Triggering event of the Incident	Unfounded	Well founded	Total	%
HOUSE CLOSED	2		2	0.05%
CORROSION		97	97	2.42%
ADDRESS NOT LOCATED	1		1	0.02%
CONNECTION FAILURE		7	7	0.17%
THEFT		4	4	0.10%
INDIVIDUAL INTERRUPTION DUE TO INTERNAL MALFUNCTION	5		5	0.12%
CONNECTION CUT	3		3	0.07%
NORMAL	45		45	1.12%
BROKEN EXTENSION		1	1	0.02%
ROBBERY		16	16	0.40%
PREVENTIVE SERVICE NOT SCHEDULED	33		33	0.82%
OVERLOAD		27	27	0.67%
INADEQUATE VOLTAGE	105		105	2.61%
TOTAL	**194**	**152**	**346**	**8.62%**

Source: Created by the authors of this study based on ANEEL (2022).

Equatorial Pará was the only one that described, in more detail, the triggering event of the incidents (Table 35). Coelba offered a little more detail than the other distribution companies when considering “Corrosion” and “Theft”. All the other companies only registered the incidents as "Material or equipment failure" or "Other".

Table 35: Triggering event of the well-founded and unfounded incidents recorded by electricity distribution utility

Triggering event of the Incident	Unfounded	Not Applicable	Well founded	Total
COELBA	**152**		**1752**	**1904**
CORROSION			97	97
MATERIAL OR EQUIPMENT FAILURE			979	979
OTHER	152		670	822
ROBBERY			6	6
ENEL CE	**66**		**29**	**95**
MATERIAL OR EQUIPMENT FAILURE	16		29	45
OTHER	50			50
ENEL GO	**21**		**16**	**37**
MATERIAL OR EQUIPMENT FAILURE			4	4
OTHER	21		12	33
ENEL RJ		**2**	**1**	**3**
OTHER		2	1	3
EQUATORIAL MA	**9**		**799**	**808**
MATERIAL OR EQUIPMENT FAILURE			15	15
OTHER	9		784	793
EQUATORIAL PA	**961**		**208**	**1169**
HOUSE CLOSED	2			2
ADDRESS NOT LOCATED	1			1
CONNECTION FAILURE			7	7
MATERIAL OR EQUIPMENT FAILURE	202		136	338
THEFT			4	4
INDIVIDUAL INTERRUPTION DUE TO INTERNAL MALFUNCTION	5			5
CONNECTION CUT	3			3
NORMAL	45			45
OTHER	565		23	588
BROKEN EXTENSION			1	1
ROBBERY			10	10
PREVENTIVE SERVICE NOT SCHEDULED	33			33
OVERLOAD			27	27
INADEQUATE VOLTAGE	105			105
TOTAL	**1209**	**2**	**2805**	**4016**

Source: Created by the authors of this study based on ANEEL (2022).

Of the 152 more detailed well-founded incidents recorded, i.e., excluding "Material or equipment failure" and "Other", 103 are from Coelba (68%) and 49 from Equatorial Pará (32%) (Table 35).

The duration of the interruption or the period of time until regularization or resolution ranged from a minimum of 17 seconds (0.005 hours) to a maximum of 203 days (4875 hours) (Table 36). The average overall duration is 21 days (511 hours).

These durations vary greatly depending on the triggering event, as seen in Table 36. Incidents related to "Material or equipment failure" and "Other", which correspond to the vast majority of triggering events reported by distribution utilities, have an average duration of 37 days (881 hours) and 12 days (304 hours), respectively.

The other triggering events of recorded incidents show that corrosion and theft are the ones that take the longest to resolve. Respectively, 53 days (1275 hours) and 20 days (480 hours).

Table 36: Duration of interruptions by triggering event (well-founded and unfounded)

	Interruption duration/Regularization period/Resolution period (hours)		
Triggering event of the Incident	**Minimum duration**	**Average duration**	**Maximum duration**
Material or equipment failure	0.03	880.93	4609.73
Other	0.005	304.19	4875.22
House closed	21.91	23.27	24.63
Corrosion	3.23	1275.34	3549.64
Address not located	32.65	32.65	32.65
Connection failure	1.15	36.80	105.13
Theft	2.36	21.87	75.21
Individual interruption due to internal malfunction	22.05	35.30	78.82
Connection cut	19.93	102.54	197.30
Normal	1.12	31.06	98.67
Broken extension	2.28	2.28	2.28
Robbery	5.81	479.53	2808.81
Preventive service not scheduled	0.86	26.32	104.22
Overload	0.97	45.79	185.52
Inadequate voltage	0.88	37.36	151.20
TOTAL	**0.005**	**511.25**	**4875.22**

Source: Created by the authors of this study based on ANEEL (2022).

When considering only the well-founded cases (Table 37), the list is reduced and the average duration of "Material or equipment failure" and "Other" is longer: 43 and 16 days.

Table 37: Duration of interruptions by triggering event (well-founded only)

	Interruption duration/Regularization period/Resolution period (hours)		
Triggering event of the Incident	Minimum duration	Triggering event of the Incident	Minimum duration
Material or equipment failure	0.27	1035.10	4609.73
Other	0.033	372.85	4875.22
Corrosion	3.23	1275.34	3549.64
Connection failure	1.15	36.80	105.13
Theft	2.36	21.87	75.21
Broken extension	2.28	2.28	2.28
Robbery	5.81	479.53	2808.81
Overload	0.97	45.79	185.52
TOTAL	**0.03**	**674.74**	**4875.22**

Source: Created by the authors of this study based on ANEEL (2022).

It is worth noting that these numbers need to be better understood; many consumer units are in remote or difficult-to-reach locations, causing some service duration to stand out for having very low values. It is thus necessary to understand the criteria and procedures used by distribution utilities and some values presented for validation.

Following the analyses, we found that almost all the contact between consumers and distribution companies was via call center (99.75%) for the 4016 incidents recorded in the period, as shown in Table 38.

Table 38: Means of communication of well-founded or unfounded incidents by type of incident

	OTHER	IN PERSON	CALL CENTER	TOTAL
Interruption			3922	3922
Other	4	4	43	51
Voltage level problem			1	1
General complaint		2	40	42
TOTAL	**4**	**6**	**4006**	**4016**

Source: Created by the authors of this study based on ANEEL (2022).

Perspectives of some Actors on Installed SIGFI or MIGDI

This section presents the perspectives of actors who have been installing SIGFI and MIGDI-type systems in compliance with their universalization plans (distribution companies), since 2006, and the perspectives of those who use (consumers) these systems.

Electricity distribution utilities

Only six electricity distribution companies sent half-yearly reports according to Aneel's database, namely: Neoenergia Coelba, Enel Ceará, Enel Goiás, Enel Rio de Janeiro, Equatorial Energia Pará, and Equatorial Energia Maranhão. In addition to them, Cemig had also installed SIGFI in the period between 2007 and 2009, as found in the previous assessment (JANNUZZI et al., 2009). There are more distribution companies installing SIGFI or MIGDI, but they did not send their semi-annual reports to Aneel and are non-compliant with the regulations.

The seven distribution companies above were contacted to provide information and their perspectives. Initially, telephone contact was attempted to inform about the objective of this study and then contact was made via e-mail and a questionnaire sent. On occasions when telephone contact was not possible, e-mail was used.

It was extremely difficult to gain access to contact information of distribution companies (telephone and/or e-mail), either through their specific websites (unclear information or absence thereof) or through Aneel's website (which did provide such information).

Attempts to establish communication with the concessionaires lasted between 60 and 90 days, starting in June 2022. Only one distribution company agreed to fill out the questionnaire, but the public version was not sent as of the closing of this report (Neoenergia Coelba). Unlike the 2009 assessment (JANNUZZI et al., 2019), when 4 of 5 companies responded to the questionnaires.

The questionnaires sent contained common and specific questions for each distribution company. As an example, the model sent to Neoenergia Coelba is in Table 39.

Table 39: Questionnaire sent to Neoenergia COELBA

1.	In the semi-annual reports found in the spreadsheet made available by ANEEL on its website, most of Neoenergia Coelba's incidents are classified under "Other". What are the two main incidents in "Others"?
2.	The vast majority of incidents due to power supply interruption occur in older systems. What are the main causes? Do you record these details? Could you provide a list of these?
3.	It may be that the number of incidents is underreported due to lack of contact with the distribution company. Are there such cases? If so, do you have an estimate (e.g., 5%, 10%, 15% of total customers) of these cases? Are there specific active search procedures for contacting these consumers?
4.	Is the call center number provided free of charge? Have you identified difficulties for customers with SIGFI to reach the correct stage of the call center to be served? If yes, what were they? Have you taken measures to reduce or resolve these difficulties? Would you have any suggestions?
5.	Are there any customer service satisfaction surveys directed as consumers who received SIGFI? ( ) Yes ( ) No. Please, elaborate. If so, what are the main results?
6.	According to the reports sent to Aneel, Neoenergia Coelba installed SIGFI only. Was there any reason not to install MIGDI during this period of time? Please, elaborate.
7.	Concerning the installation of systems, what were the main hindrances, if any, to complying with REN 493/2012 with regard to the implementation of SIFGI?
8.	Is there anything to be improved in the current ANEEL regulation? ( ) Yes ( ) No. Please, elaborate.
9.	In general, what are the main difficulties that Neoenergia Coelba faces in the planning, execution and monitoring of these systems, regardless of the Normative Resolution? Please, elaborate.
10.	Is there anything to be improved in the LPT regarding these generation systems? ( ) Yes ( ) No. Please, elaborate.
11.	What about in LPT in general?
12.	Still on SIGFI: REN 83, REN 493 and REN 1000 establish that the components of MIGDI and SIGFI must meet the requirements of the standards issued by the official bodies, by INMETRO's PBE (Brazilian Labeling Program) or another organization accredited by CONMETRO. Is it difficult to meet them? Please, elaborate.
13.	Is there a plan for monitoring and maintaining SIGFI and MIGDI? ( ) Yes ( ) No. Please, elaborate. Is the maintenance ( ) predictive or ( ) corrective? Please, elaborate. What are the main guidelines of the monitoring and maintenance plan?
14.	Is Neoenergia Coelba's monitoring and maintenance carried out by its own team and/or outsourced teams? If both, please explain the differences and similarities in the activities. What reasons led to the choice of an in-house and/or outsourced team?

<table>
<tr><td>15.</td><td>Are local agents from the communities themselves hired for predictive and/or corrective maintenance? ( ) Yes ( ) No. Please, elaborate.

If there is no paid hiring of local agents from the communities, is there voluntary engagement? ( ) Yes ( ) No. Please, elaborate.

Are these people trained? ( ) Yes ( ) No. Please, elaborate.

If these people are trained, is this offered by Neoenergia Coelba's own staff or outsourced?</td></tr>
<tr><td>16.</td><td>When batteries, inverters and other SIGFI equipment need to be replaced, how are they disposed of? Is there a record about this?</td></tr>
<tr><td>17.</td><td>Concerning the timely payment of installed SIGFI, what is the status of these systems? Is there a record about this?</td></tr>
<tr><td>18.</td><td>Regarding the universalization goal, REH 2285 of August 8, 2017, appendix (p. 14 - Table 1), informs that:

TABELA 1 - METAS DO PLANO DE UNIVERSALIZAÇÃO
<table><tr><th rowspan="2">ANO</th><th colspan="2">RECURSOS PRÓPRIOS</th><th colspan="2">LUZ PARA TODOS</th><th rowspan="2">TOTAL</th></tr><tr><th>CONVENCIONAL</th><th>SISTEMAS DE GERAÇÃO</th><th>CONVENCIONAL</th><th>SISTEMAS DE GERAÇÃO</th></tr><tr><td>2017</td><td>-</td><td>-</td><td>22.392</td><td>537</td><td>22.929</td></tr><tr><td>2018</td><td>-</td><td>-</td><td>33.661</td><td>0</td><td>33.661</td></tr><tr><td>2019</td><td>23.014</td><td>594</td><td>-</td><td>-</td><td>23.608</td></tr><tr><td>2020</td><td>16.000</td><td>594</td><td>-</td><td>-</td><td>16.594</td></tr><tr><td>2021</td><td>15.014</td><td>594</td><td>-</td><td>-</td><td>15.608</td></tr><tr><td>2022</td><td>15.014</td><td>-</td><td>-</td><td>-</td><td>15.014</td></tr><tr><td>TOTAL</td><td>69.041</td><td>1.782</td><td>56.053</td><td>537</td><td>127.413</td></tr></table>
What is the current situation of universalization compared to these numbers? We understand that the execution of the plan is quite dynamic due to the very nature of this type of activity. The question is just a status update.</td></tr>
<tr><td>19.</td><td>According to reports sent by Neoenergia Coelba, from 2017 to 2021 (first semester), 825 SIGFI were installed. The goal, according to Table 1 of the previous question, was to install 537 generation systems in the LPT. Are these 537 systems included in the 714 SIGFI installed in the period above? ( ) Yes ( ) No. Please, elaborate.</td></tr>
<tr><td>20.</td><td>Has any customer satisfaction survey been carried out with consumers who received the SIGFI? ( ) Yes ( ) No. Please, elaborate.

If so, what are the main results?</td></tr>
<tr><td>21.</td><td>Has Neoenergia Coelba used or does it currently use the Energy Efficiency Program (PEE) to serve the consumers served by SIGFI? ( ) Yes ( ) No. Please, elaborate.</td></tr>
</table>

Source: This study.

Consumers with systems installed

The very nature of the places where the SIGFI and MIGDI were installed (distant and remote) as well as the difficulty of contacting their consumers made it difficult to obtain their testimonials. Difficult, but possible and necessary.

The consumer perspectives presented here were obtained through direct conversations between them and the team and through testimonials found in other studies. All consumers were served by systems under the responsibility of the distribution companies in their universalization plans.

We spoke with three representatives of residents of the northern region of the country who received hundreds of SIGFIs. As to other studies, for the purpose of this report, we only considered Tina Bimestre Selles Ribeiro's thesis (RIBEIRO, 2015), whose field research was carried out in some communities that received SIGFI in the State of São Paulo.

This is a small number of cases in a universe of more than 23 thousand systems installed, but they are enough to show distribution companies and the regulatory agency that a closer look at the issue is necessary. They show common realities among users even when they are served by different distribution companies who do not belong to the same shareholder group and are from very different states.

Testimonials registered in the State of São Paulo

Ribeiro's (2015) field research was carried out in three communities of Ilha Bela in the State of São Paulo, Brazil. One hundred households with SIGFI 30 were served by the Light for All program in 2012. The communities are located on São Sebastião Island, Búzios Island, and Vitória Island.

In the records made by Ribeiro (2015) when collecting testimonies from users, we find that they recognize both the benefits of the energy services that electricity brought and the difficulties of configuration, prior consultation, supply, availability, customer service, maintenance, information, and others.

According to Ribeiro (2015), apparently there was no prior consultation of residents in the process of installing the SIGFI and the internal installation kits. Many have complained that light sockets have not been installed in the bathrooms and that more of them are needed beyond the three-socket limit of the LPT program and, more recently, the MLA program.

There was also no adequate transfer of information to residents, despite the explanation given by the technicians and the booklet left after the installation of the SIGFI 30. It was shown that residents did not know which type

of refrigerator they could use in these systems, what other appliances they could use and also that they use these systems in a very conservative way, with a consumption that is "far below what the equipment configuration supports" (p.101). The booklets were not "valued as a document for consultation" (p.109) when the researcher returned to the sites two years after the systems had been installed.

Systems with some technical installation problems were found, such as shading, inconsistent support, and difficult user access. Regarding shading, residents of the three islands reported that "the installers asked them to complete the service after they left, pruning the trees where necessary" (p.153). However, residents cannot cut or prune trees without authorization from the State Park, given the rules of Permanent Preservation Areas.

Another point brought up by the study is that some residents need to increase the load to include refrigerators for domestic use.

Regarding maintenance, the study identified a series of problems that negatively impacted the systems, including the interruption of supply during the very year of installation. The problems were resolved at the time, but, in 2015, systems were identified that had been waiting for maintenance by the distribution company for three months.

Also, regarding maintenance, the autonomy of the systems was apparently reduced, although the study did not quantify the number of hours. At the time, according to Aneel's rules by then, the minimum autonomy was 48 hours and Ribeiro (2015) recorded that some residents had the number of batteries reduced from four to three. Testimonials that the system stopped supplying electricity when it rained were constant.

Concerning the productive use of energy, the researcher's fieldwork concluded that "in general, for the beneficiaries, the use of energy is not related to their work. Few households use lighting at night to carry out the few productive activities identified in the communities, such as handicrafts and sewing. (...) even the much-demanded ice for fishing is not commonly linked to the possibility of having a refrigerator at home" (p.108).

In the case of fishing, residents prefer to leave the fish on the boats rather than moving it through steep terrain to their households and back to sell them later. Although not mentioned in Ribeiro (2015), this is an indication that solar generation on vessels for ice production could be an option for these communities to handle the product of their work in a safer, more economical, and durable way. By way of comparison, according to the researcher, at the time, each twenty-kilo bag of ice in scales cost R$5, lasted between one and

two days, and the value of the SIGFI 30's electricity bills was around R$13 per month.

The use of refrigerators in schools has reduced the consumption of canned food in school lunches, an indicator that it could be beneficial to children's health.

The researcher also carried out technical visits in four communities in the Ilha do Cardoso State Park and in a village in Ubatuba. In addition to field visits, Ribeiro (2015) also conducted telephone interviews with administrators of locations that received SIGFI in the Pinheirinho Sustainable Development Reserve (Vale do Ribeira) and on Montão de Trigo Island in São Sebastião. In these locations, most systems installed were SIGFI 80, with some SIGFI 30.

As occurred in the three Ilha Bela communities, there were complaints about the customer service provided by the distribution company, delay in solving problems (from two to six months), lack of consultation prior to installation, the low number of outlets, lack of supply when it rained and lack of user registration by the distribution company.

According to the researcher, "the delay in customer service and the limitation of supply resulted in bad repercussion regarding the customer service and quality of photovoltaic systems. The perception was negative to the point that residents of other communities in the RDS [Sustainable Development Reserve] gave up on requesting energy, as they would receive the same type of system, with the same limitations" (p.139).

Some testimonials collected by the project

This section presents the records taken in a non-face-to-face conversation with three representatives of residents from the northern region of the country who received hundreds of SIGFI. These systems were mostly installed in 2021 and the rest between 2018 and 2020.

In the same way as in the locations in the State of São Paulo, the arrival of electricity brought benefits and difficulties (execution, supply and post-connection) for residents. Most systems installed were SIGFI 45.

The residents' association prepared a plan along with the electricity distribution company before installing the systems. Among the planning items was a priority list of the residents who would receive the systems. However, the plan was not followed, and the number of systems was found insufficient during the installation. This broken deal was often mentioned.

It was also mentioned that the outsourced company hired to implement and maintain the systems did not listen to, consult or respect the residents, nor

did it create a good relationship with the association. This caused the relationship to deteriorate over time.

It is possible to mention two correlated examples, among others, of this consultation and listening problem. The outsourced technical team had been alerted, but still, several systems were installed in floodplain areas. These areas are periodically flooded because the rivers rise a lot in the region. This can damage the system and be conducive to theft by allowing greater access to the systems, which in fact occurs.

The second example is also related to periodic floods: many families move to avoid the flood in the flood season and return to the same place during the dry season. So, some residents need to take the equipment, or part of it, with them, either as a precaution against theft and damage, or to try to have electricity in another location.

The relationship with the distribution company is considered distant, as they have difficulties in contacting, either in person (agency located at a distant location), or remotely (no coverage or low quality of the internet and telephone signal), to make payments, ask questions or request maintenance. Residents often do not understand electricity bills because homes with the same system are charged different values.

Residents claim that it takes a long time for maintenance support to reach the area, and systems can remain idle for many months in a row.

A point that drew a lot of attention is the perception that the systems are donations from the distribution companies, as if they were a favor and not a right of the beneficiaries and an obligation of the distribution companies who have to universalize the service. This is because residents are not properly informed, which often causes them to stop complaining about problems or to feel embarrassed when they do so.

Another example of lack of information is that residents do not know they have the right to request a load increase, given that many consider the supply limited for their needs.

Finally, it was mentioned that there are still places to be electrified and places that need energy for productive use.

Conclusions and Recommendations

This study revisited the status of implementation of SIGFI and MIGDI by electricity distribution concessionaires as a solution for universal access to electricity in Brazil, thirteen years after the publication of the first report by JANNUZZI et al. (2009). During this period, there were several changes in legislation and advances were made in data transparency. However, some problems persist and demand solutions.

Progress has been made in terms of transparency and access to information. Aneel started to make the data from the semi-annual reports sent by distribution companies who have SIGFI and MIGDI installed publicly available on an easy-to-view platform where users can download raw data in a spreadsheet. In addition to inspection, the availability of this data can foster better public policies and point out improvements in universal access to electricity services.

Although distribution companies have been required to submit semi-annual reports since 2005, the oldest file on the website is from the first half of 2020, with four reports on the website so far (two from 2020 and two from 2021). Also, semi-annual reports have not been sent by some companies and, as a result, the list of distribution companies with installed SIGFI or MIGDI on the Aneel website is incomplete. A full list of all distribution companies which have SIGFI or MIGDI installed is not available.

Therefore, the non-receipt of the reports, as informed by Aneel, indicates that one of the conditions of the regulation is not being complied with by the distribution companies, nor is it being enforced by the agency as a supervisory body. Aneel informed that it is taking action that will soon have concrete results. In order to increase transparency for the public and for social control, it is recommended that a periodically updated list be included on Aneel's platform of all distributors that have installed and are installing SIGFI and MIGDI, divided into those who sent and those who did not send their reports.

Still concerning information transparency, it was quite difficult to find the right contact information for issues pertaining to universal access to electricity - the contact information did not exist on the pages of the distribution companies consulted. Companies operate a public service concession and transparency is a fundamental principle. We recommend that the contact information of those responsible for SIGFI and MIGDI at the distribution companies be made public and easily accessible on the pages of the concessionaires and of Aneel, as used to happen to the contact information of people responsible for the mandatory energy efficiency and research and development programs.

The data found in the reports sent provide a clearer picture of the characteristics of the systems, their geographical distribution, their commercial and technical aspects, among others. It is also possible to identify the incidents, their types, triggering event, and their duration. The cross-checking of information allows for various analyses and checks, such as the ones presented in this report, including data inconsistency.

Even though transparency improved, the consistency and quality of the data found in these reports need to be guaranteed by the regulator through checking and timely problem solving. Some examples of inconsistencies are the large number of negative times in the incident resolution target date field and of customers who, at the same time, have and do not have measurement equipment, among other examples mentioned in this report. Aneel has been trying to improve this process.

In addition to ensuring the consistency and quality of the data received, the information provided could be more detailed for monitoring and evaluation purposes. For example, the reasons for power supply interruption are still general ("material or equipment failure") and several fall into the "other" category. So, it is difficult to understand which equipment has the most failures and what would be the other relevant reasons included in "Others" so that solutions can be thought of and monitored. Aneel informed that this issue has already been identified and addressed, and the next half-yearly reports should include this improvement.

The global indicator of the number of incidents per installed system showed that, on average, there is one incident recorded for every five installed systems (i=0.17), but some companies presenting one or more incidents for each installed system. This is a significant number considering the lifespan of PV systems and the years of installation.

Even high, it is also likely that the number of incidents (98% of them due to power supply interruption) is underreported, based on what was found in the available literature and in the interviews carried out with beneficiaries of these systems. This underreporting is a consequence of the lack of information and appropriate options offered to this segment of consumers to get in contact with and get consistent customer service from the distribution company.

Although there are limits to the role of distribution companies, it is recommended that communication solutions (internet, satellite telephony or radio) powered by SIGFI be provided for locations with low or no access to enable contact with the distribution company and offer other benefits that access to or improvement in communication can provide. Communication and access to drinking water are two recurrent needs that energy plays a role.

Another consequence of the lack of information is that consumers are not aware of their rights, so that they can exercise them, and of their duties, so that they can comply with. The interviews carried out and the literature showed, among other issues, some misconceptions: systems are misconstrued as donations from the distribution companies; these companies and their contractors are mistakenly seen as the only agents that beneficiaries can turn to; and consumers wrongly assume that they are limited only to the monthly electricity availability of the systems, when they could actually request a no-cost load increase. Interviews and literature also showed that training is inadequate.

It is necessary to distribution companies, under Aneel's command, check if the consumers registered as residential class are eligible to the social tariff, once around 75% of the consumers are currently registered in the residential tariff (58%) and rural residential (17%).

Regarding energy availability, an important regulatory improvement, made at the end of 2021 by Aneel, was the increase in the minimum monthly availability from 13 to 45 kWh, given that food refrigeration is a necessary energy service. For some families, this availability is still considered low because the most efficient refrigerators offered in the Brazilian market consume half of this, leaving the other half for other uses every month.

Indeed an improvement, it is worth noting that two out of three existing SIGFIs have monthly availability of only 13 kWh, so it is necessary to check if these consumers would be interested in increasing their electricity availability.

Another aspect related to energy supply is the conservative consumption habit of the users. We understand that this is because most installed SIGFIs are not metered nor have consumption or battery charge gauges that would offer consumers a way to monitor if their daily consumption matches what the system generates and the storage level. Thus, it would be useful and beneficial for these systems to have at least one gauge, whether numerical and/or visual (with lights of different colors), to help users control their consumption. The selection of the gauge needs to take into account the characteristics of the users (proficiency level, preferences, literacy level and others).

Another aspect related to energy supply is battery autonomy. Literature and interviews showed that there are consumers with relatively new systems who reported supply interruption in rainy weather, even before the 48-hour battery autonomy available according to the regulation in force at the time. It is not possible to know why these supply interruptions occurred, whether due to system design or the quality, type or end of battery lifespan. So, we would need to understand these interruptions better to guarantee the necessary autonomy.

We understand that consumers' lack of information reflects the way distribution companies conduct the process of electricity access in each location, and results are not satisfactory for either party. Based on the literature and on the interviews conducted, there has been no adequate appropriation of knowledge and booklets were not valued as documents for consultation by consumers. We recommend that a multidisciplinary team reassess existing procedures or establish effective technological appropriation and relationship processes that consider the different realities involved.

These and other issues raised here reveal the need to carry out an opinion and satisfaction survey with users.

Concerning batteries, their disposal process is not yet clear. This is not an existing information field in Aneel's report template, but it is a point that needs to be tracked, given the relevant environmental damage it can cause. Therefore, it would be important for the distribution companies' semi-annual reports to record the number of batteries collected and the number of batteries replaced. Additionally, we recommend that distribution companies keep under their control, for inspection purposes, the guarantee that each battery's disposal is adequate, as is done for collected equipment, such as refrigerators, according to the rules of Aneel's mandatory Energy Efficiency Program.

All these aspects reinforce what is already recognized and recurrent in the literature of the last forty years of practice in the energy sector: an important part of the successful implementation of stand-alone power systems depends on a process of consultation and social participation, implementation, and appropriate maintenance. These are points, along with customer service, that need to be improved. Inspection by Aneel is an important tool to monitor and guarantee the quality of these processes.

In addition to individual access to electricity, there are demands for productive use that can be met by the Ministry of Mines and Energy through the LPT and MLA programs in conjunction with other ministries, states and municipalities. The few experiences with Community Production Centers can be useful. The LPT program has existed for twenty-nine years now and the opportunities that could have been created to generate and increase income should not continue to be wasted.

Since 2004, Brazil has had a relevant regulation that establishes the conditions for quality power supply, the technical aspects and the commercial relations for the use of SIGFI and MIGDI. However, to enforce it, the regulatory agency and distribution companies need to be more attentive and consistent to ensure compliance and consumer satisfaction.

The existing and recognized difficulties of economic, technical, logistical, environmental, and social nature should not be placed as deterrents to the permanent benefits of electricity access.

For decades, such difficulties were used as arguments that indefinitely postponed the electrification of millions of people in Brazil. Political will and its sustaining were necessary for the State to play its role and promote universal access to electricity and the necessary conditions for it to occur. The LPT Program, as a result of this process, is unmistakable evidence that it is possible to overcome barriers to bring and guarantee essential energy services to people.

Therefore, universal access to electricity must be envisaged as universal access to energy services that are adequate, affordable, reliable, high-quality, safe and environmentally benign to support human and economic development.

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