Residential Energy Consumption by Income Class

The study highlights the differences about residential energy consumption patterns by income class in Brazil and the need for more effective clean cooking policies for low-income families.

Elaborated by:

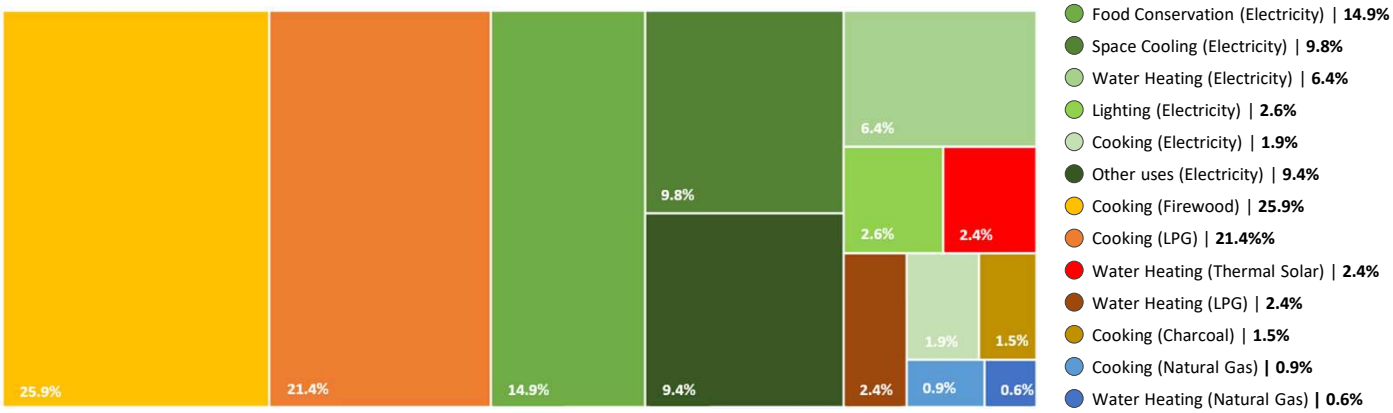
The Atlas of Energy Efficiency 2023 produced by the Energy Research Office had a special chapter dedicated to the residential sector. Among others, this chapter's objective is to propose a methodology for international comparison of energy consumption patterns and inequality in access to energy services estimation. The main objective behind this study is to support the development and public policies evaluation, related to the energy poverty eradication, to promote the Energy Efficiency, and the achievement of the Sustainable Development Goals (SDGs). In addition, this study aims to expand the discussion highlighted by the Residential Electricity Consumption by Incomings Class Fact Sheet to the other energy sources consumed in the residential sector.

This Fact Sheet is an excerpt from the Atlas of Energy Efficiency 2023 and debates the Brazilian residential sector energy consumption patterns through a disaggregated analysis by energy sources, services and income classes in order to identify evidences about energy poverty and energy efficiency potential. For that, data from EPE's Residential Sector Model between 2000 and 2019 about energy demand in the sector were used.

The Brazilian residential sector consumes electricity, firewood, liquefied petroleum gas (LPG), natural gas, solar thermal energy and charcoal. Considering the mix of energy sources **(Graph 1)**, electricity is the most consumed energy source, with approximately 45% of the residential sector's energy demand to promote the different services, represented in green on the graph. This may be because of the high-level electricity access in Brazil. In 2019, 99.8 per cent of Brazilian households had access to electricity. Among the families without access to electricity, 73% are in rural areas (91% in the North and Northeast) and 27% in urban areas (52% in the Northeast).

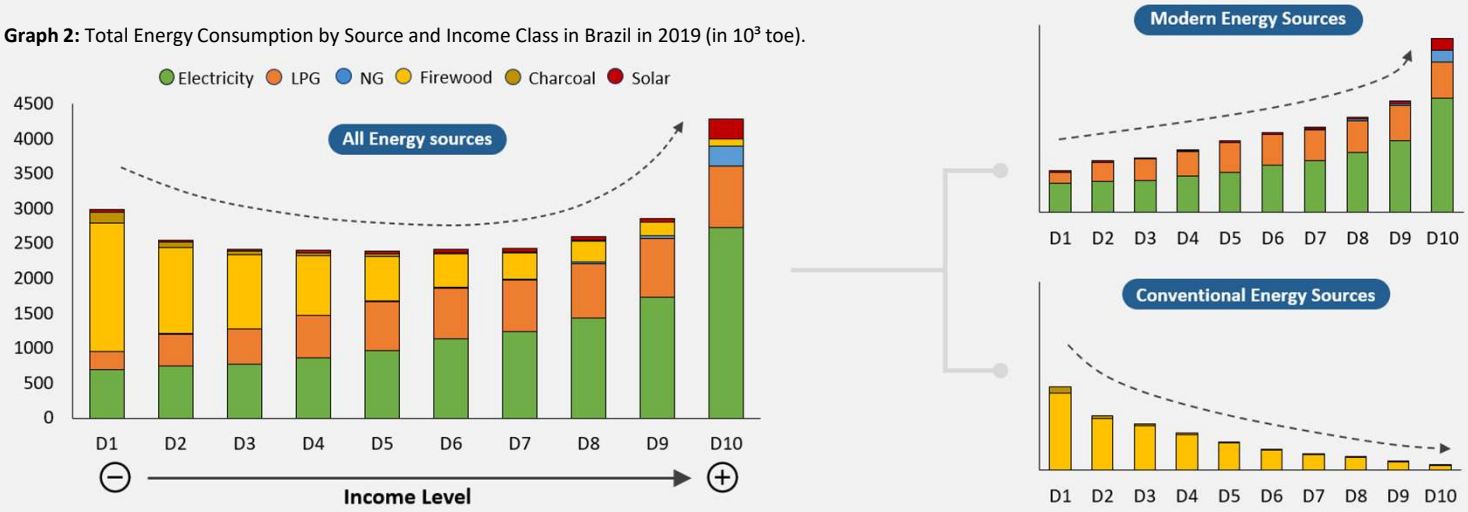
In terms of energy services (Graph 1), the Brazilian residential sector demands energy to food preservation, space cooling, water heating, lighting, food cooking and other uses (domestic appliances). Among these services, food cooking means 52 per cent of the residential sector's Brazil and is mostly fulfilled by firewood and LPG (in yellow and orange colors, respectively).

Graph 1: Energy consumption distribution by Energy Services and sources in the Brazilian Residential Sector in 2019.



By the analysis of the energy consumption by income class **(Graph 2)**, there is a significant electricity use concentration for higher income classes and biomass (firewood and charcoal) for lower income classes. As a result, the lowest income classes tend to have higher energy efficiency potential due to the conventional energy sources use (firewood and charcoal), and a greater pent-up demand for energy services provided by modern energy sources (electricity, solar thermal, LPG and natural gas). In this way, to elaborate suitable and applicable solutions to Brazilian reality in contribution to the public policies conception, this study splits energy sources into two groups - modern and conventional.

Graph 2: Total Energy Consumption by Source and Income Class in Brazil in 2019 (in 10^3 toe).

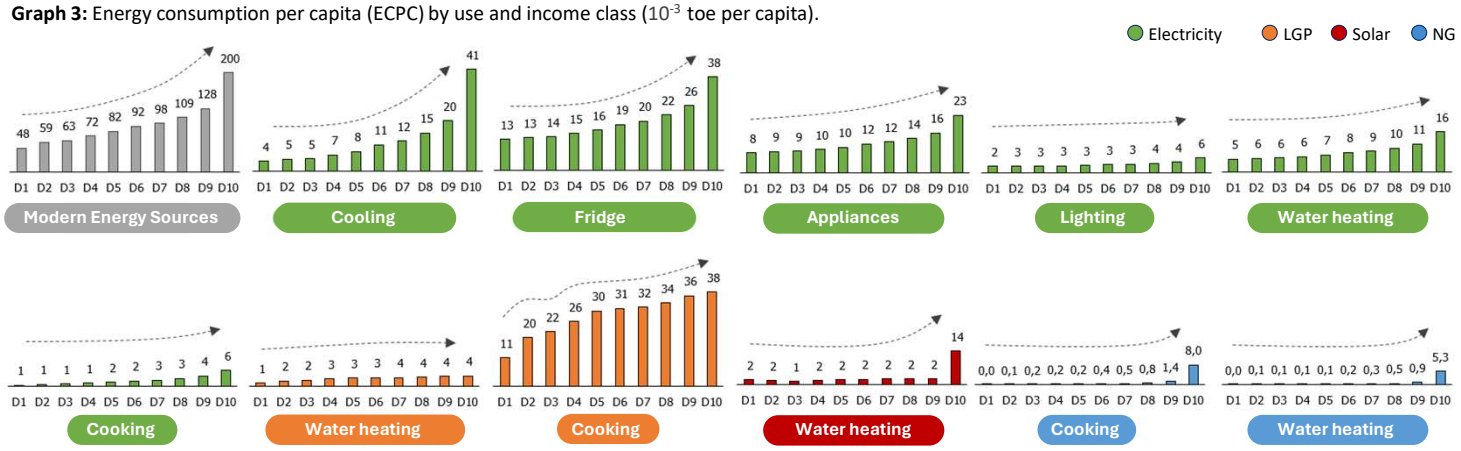


Note: Classes D1 to D10 have the same amount of people (10% of the population or 20.9 million people).
D1 represents the lowest income class and D10 the highest.

Analysis of Energy Services Access Inequality provided by Modern Energy Sources in Brazil

By the analysis of modern energy sources and services in Brazil, the **(Graph 3)** shows that the Energy Consumption Per Capita (ECPC) tends to increase as household income rises. However, the income-elasticity depends on the energy source and service. LPG for cooking has the highest elasticity because it is widespread among all the income classes when compared to other moder sources. The only exceptions are the lower income classes, where there is a high use of firewood and coal, while the higher income class has a significant cooking portion covered by using natural gas and electricity.

Graph 3: Energy consumption per capita (ECPC) by use and income class (10^{-3} toe per capita).

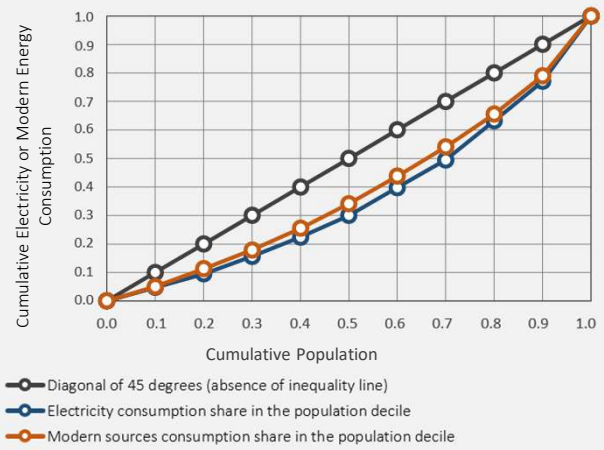


Electricity Gini Rate and Modern Energy Gini Rate for Brazil

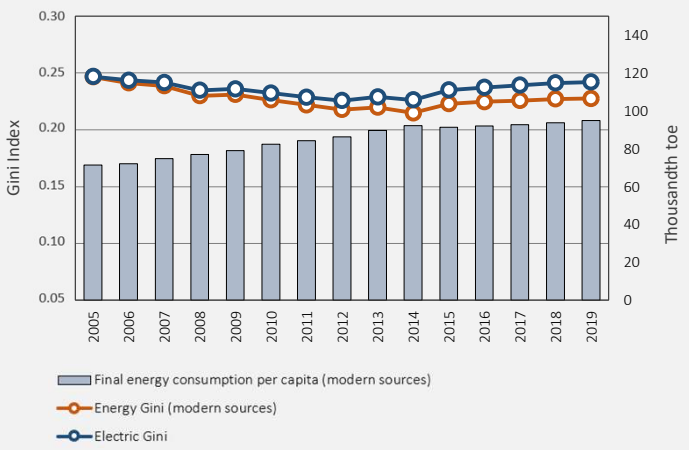
The Electricity and Modern Energy Gini Rates for the residential sector are additional indicators to measure the annual inequality in electricity consumption evolution by income class (or deciles). This report brings data from 2005 to 2019. Analogous to the traditional Gini Rate, they are numerically equivalent to the area between the Lorenz curve and the Line of Absence of Inequality[1]. As larger is the area between these two curves, higher are the values of these indices, which means higher inequality to electricity access distribution and modern energy sources.

As the Gini Rate, the equivalent index for Electricity and Modern Energy can range between 0 and 1. When they are equal to zero, mens that there is no inequality; that would also mean that all people would have the same consumption. On the other hand, if they are equal to one, means that concentration is maximum, and one single person would be responsible for consuming all the country's demand for electricity or modern energy sources. From 2005 to 2014, both indicators decreased, which indicates a reduction in inequality. However, in 2015, the Gini Rates changed its trajectory and began to show a growing demand concentration in the higher income classes. In 2019, consumption of modern energy sources proved to be less concentrated than electricity consumption in the Brazilian residential sector.

Graph 4: Lorenz Curve - Eletricity and modern sources (2019)



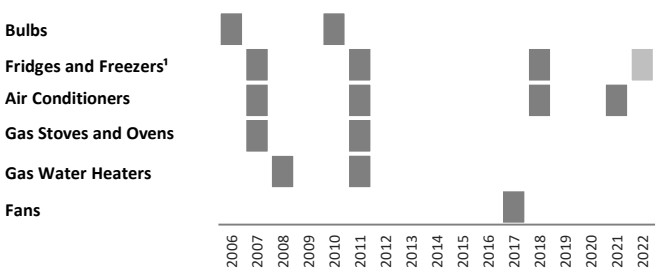
Graph 5: Gini Rates and Energy Consumption Per Capita (2005-2019)



Energy Efficiency Policies to Reduce Inequality of Modern Energy Sources Use in Brazil

The Brazilian residential sector has several energy efficiency policies, such as the Minimum Energy Performance Indexes (MEPS), the Brazilian Labelling Programme (PBE) and endorsement labels. The MEPS criteria are currently applied to the equipment listed in Figure 1. In terms of energy efficiency policies focused on reducing Inequality in the Use of Modern Energy Sources in Brazil, it is worth highlighting the Energy Efficiency Programme (PEE).

Figure 1: Minimum Energy Performance Index



The Energy Efficiency Programme (PEE) requires electricity distributors to allocate a amount of their net revenue to energy efficiency projects every year, including the replacement of obsolete and inefficient electrical appliances with new, more energy-efficient alternatives in low-income households. According to ANEEL, PEE invested more than R$1.9 billion (55%) in 274 energy efficiency projects dedicated to low-income families between 2009 and 2022.

Among the 8,256 low-income families benefiting from the PEE between 2018 and 2022 (ANEEL, 2023), it is estimated that the equipment replacement saved 6.9 per cent in the monthly electricity consumption of these households, which could translate into significant benefits, such as lower electricity bills and possible access to additional energy services that could contribute to an increase in average household consumption (rebound effect).

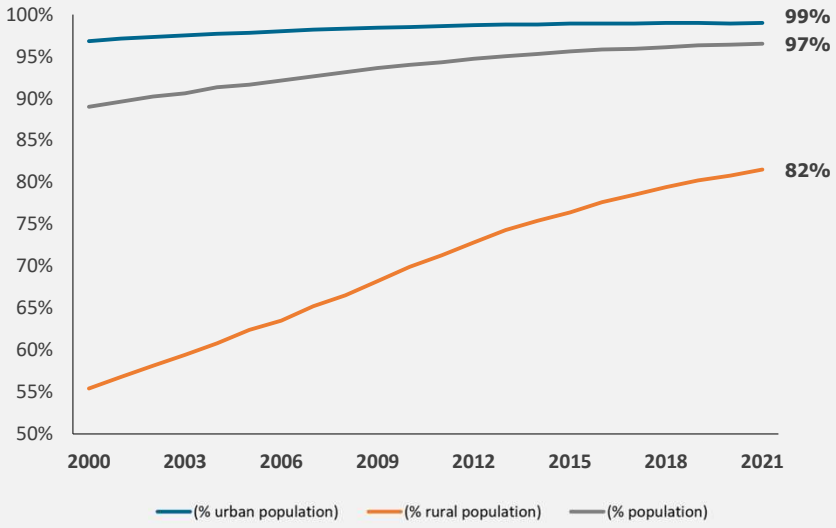
Note: [1]The Inequality Absence Line represents the perfect lack of inequality in the electricity consumption or modern energy sources distribution.

Policies to boost the clean cooking in Brazil

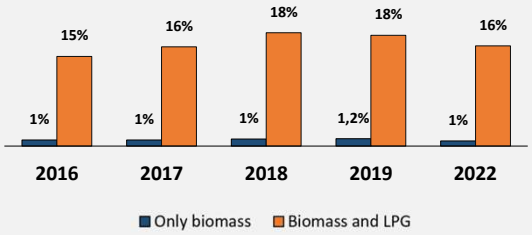
According to the United Nations, the biomass use for cooking can cause a large amount of environmental and health problems, being associated with almost 4 million premature deaths every year in the world. Universal access to clean cooking is, therefore, part of the Sustainable Development Goals (SDGs) of the 2030 Agenda. As well as other countries, Brazil is making efforts to improve the population's access to clean cooking fuels and technologies. According to the World Bank, this rate raised to 97% in 2021, with 81.5% in rural areas and 99% in urban areas **(Graph 6)**. However, it is important to note that access to clean cooking technologies does not necessarily means that cooking will only be done by clean fuels usage. In 2022, according to IBGE (2023), 0.9% of households reported cooking only with biomass, compared to 16.3% who reported cooking with biomass and other modern fuels, mainly LPG **(Graph 7)**.

That means that families may have access to LPG stoves, but still use collected firewood in nature very often, to save money from the family budget. The biomass consumption for cooking in Brazil is centered in the lower income classes, according to IBGE (2023), reinforcing its association with the economic vulnerability issue. In 2019, the poorest 50% (D1 to D5) were 80% of residential consumers using biomass for cooking in the country **(Graph 8)**. Currently, the Gas Assistance Program is in running as an addition to the Bolsa Família program with the aim of promoting clean cooking and relieve social vulnerabilities resulting from this energy use.

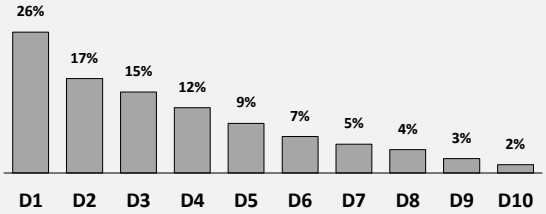
Graph 6: Population percentage with access to clean cooking sources and technologies in Brazil.



Graph 7: Population percentage who declare to consume biomass for cooking in Brazil



Graph 8: Distribution by income class of the population that declares consuming biomass for cooking in Brazil in 2019



What does these data allow us to conclude...?

- Electricity is the most consumed energy source in the Brazilian residential sector. In 2019, 99.8% of the population had access to electricity in the country, thanks to the efforts of universalization programs such as Luz para Todos (Light for All).
- Cooking is the service with the highest energy demand in the residential sector and is mostly fulfilled by firewood and LPG.
- In Brazil, there is a significant disparity in the energy consumption pattern between different income classes, with the highest electricity consumption concentration in the higher classes and biomass consumption (firewood and charcoal) in the lower classes.
- In the case of modern energy sources, energy consumption per capita (ECPC) tends to increase with household income, but the income-elasticity ranges for each energy source and service.
- The Gini Indices for electricity consumption and modern sources show that inequality in the consumption distribution of these sources by income class decreased between 2005 and 2014 but became mostly centered in the higher income classes from 2015 onwards.
- The lower income classes seems to have pent-up demand for energy services provided by modern sources (electricity, LPG, natural gas, and solar thermal) and substantial potential for efficiency due to the remaining firewood and charcoal use for cooking.
- Brazil has implemented several energy efficiency policies, including minimum energy performance indexes, labeling programs and endorsement labels, as well as programs with specific solutions aimed to low-income households, such as the Energy Efficiency Program (PEE).
- The issue of clean cooking is still relevant, especially in cases of low-income families located in rural areas. The Gas Assistance program, an addition to the Bolsa Familia program, was implemented to relieve the cost of LPG on the family budget for cooking.

This document is an outcome of an evaluation of the Survey of Ownership and Usage Habits of Electrical Equipment in the Residential Class (PPH), published by PROCEL/Eletrobras in 2019, the Continuous Annual Household Sample Surveys (PNADCA/IBGE) and the Household Budget Surveys (POF/IBGE) in blend with EPE's studies on Energy Demand in the Residential Sector. For more information about the methodology of the Residential Sector Energy Demand Model (MSR), you can access the **Technical Note** published by EPE on its website in 2021.

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Note: icons used throughout this edition were obtained from the www.flaticon.com platform.

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