

International comparison of residential energy consumption

The study shows that residential energy consumption per capita tends to be proportional to the country's development level, highlighting a suppressed energy demand in developing countries.

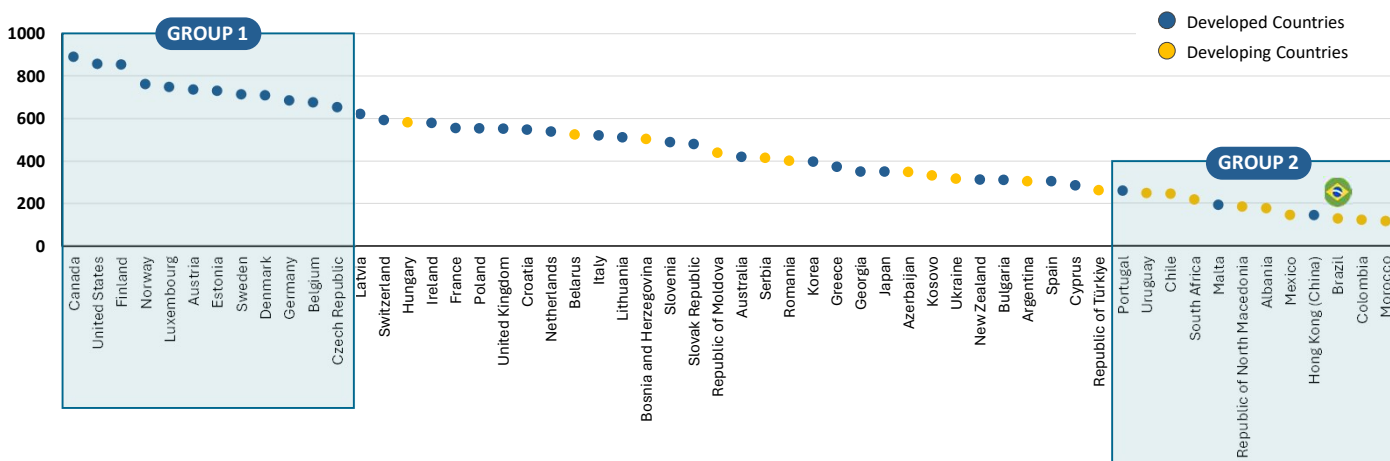


The Atlas of Energy Efficiency 2023 produced by the Energy Research Office had a special chapter dedicated to the residential sector. Among others, this chapter's objective is to propose a methodology for international comparison of energy consumption patterns and inequality in access to energy services 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 extract from the Atlas of Energy Efficiency 2023 and aims to discuss the Brazilian residential sector energy consumption patterns through an international comparison from different perspectives in order to identify evidences of energy poverty and energy efficiency potential. To this end, Energy Demand data in the Residential Sector between 2000 and 2019 were used, as well as data from Energy Efficiency and End-Use Indicators Database of the International Energy Agency (IEA)¹.

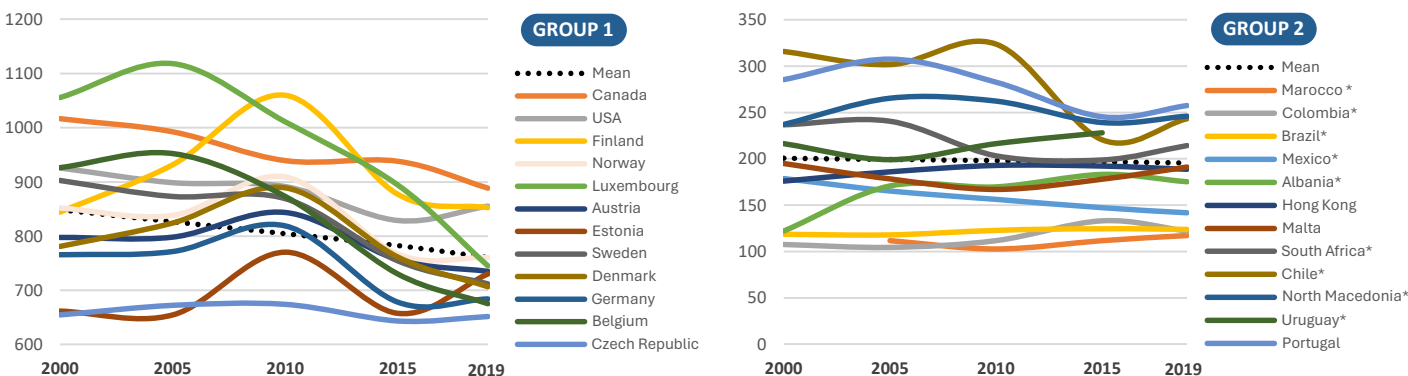
International comparisons of residential energy consumption can be a powerful tool to identify good practices and energy efficiency benchmarks, as well as possible evidences about energy poverty. In the residential sector, the population effect is one of the main drivers of energy consumption in the residential sector. **Energy Consumption Per Capita (ECPC)** can be an appropriate indicator for a comparison between different countries sizes population. The **Graph 1** rates countries according to the average ECPC of the residential sector. According to this analysis, Canada and USA have the highest residential ECPCs, while Brazil, Colombia and Morocco are at the bottom of the list with the lowest residential ECPCs. The comparison shows a significant difference between the countries: **Canada (889 x 10⁻³ toe per capita) has a residential ECPC equivalent to seven times the residential ECPC of Brazil (126 x 10⁻³ toe per capita).**

Graph 1: Energy Consumption Per Capita in the Residential Sector (10⁻³ toe per capita) in 2019.



Graph 1 shows a possible correlation between energy consumption per capita in residential sector and the country development level, since there is a large concentration of developed countries with higher residential ECPCs (Group 1) while developing countries have lower residential ECPCs (Group 2). **Graph 2** analyses the trend in residential ECPC in these two groups of countries between 2000 and 2019.

Graph 2: Evolution of Energy Consumption Per Capita (ECPC) in the Residential Sector (10⁻³ toe per capita).



Graph 2 analyses the 12 highest countries ECPC in the residential sector (Group 1), it is worth that this group has tended to reduce its consumption. This fact happens probably because of their energy efficiency gains. In other hand, the lowest ECPC 12 countries in residential sector (Group 2) shows mostly flat trends in Graph 2. **This may indicate that households do not change their consumption patterns or maybe the efficiency gains have been reduced by an energy consumption increasing, because of a pent-up demand for energy services (boomerang effect).**

Note: Developing countries are labelled with (*) next to their names
¹ IEA (2023), Energy End-uses and Efficiency Indicators. Available at <https://www.iea.org/data-and-statistics/data-product/energy-efficiency-indicators>

Main energy services demanded in the residential sector



Lighting
Electricity
Kerosene



Space Heating
Electricity, Natural Gas,
Process Heating, Firewood,
Coal Secondaries, Charcoal



Space Cooling
Electricity



Cooking
Electricity, LPG, Natural
Gas, Firewood, Charcoal



Water Heating
Electricity, Natural Gas, Process
Heating, Firewood, Coal
Secondaries, Charcoal



Other Uses
Electricity



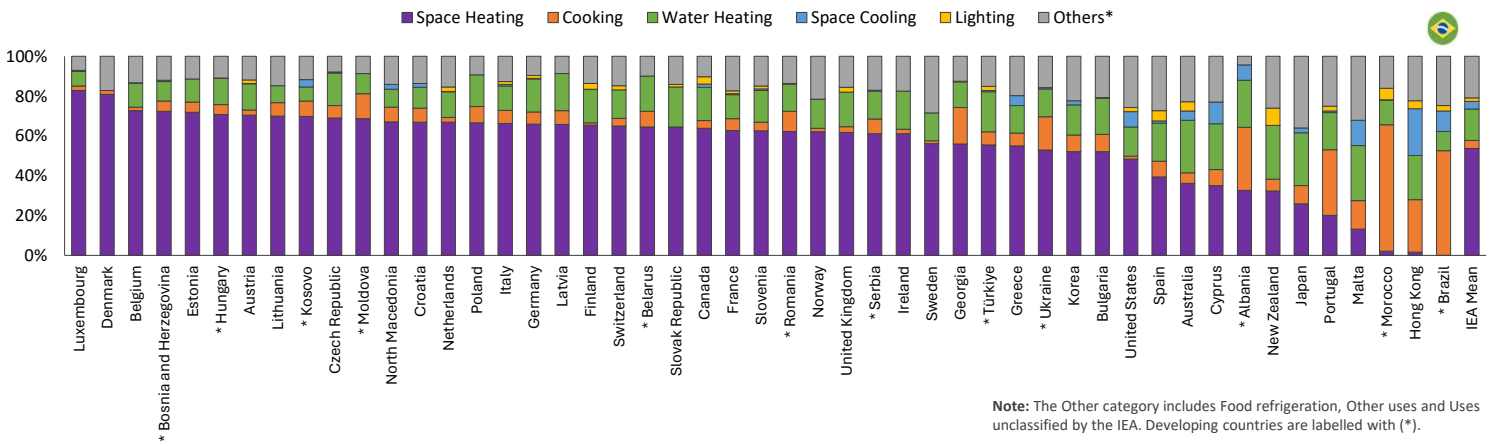
Households demand energy services, but what about energy sources?

The choice of energy sources will depend on secondary factors such as availability, technology, efficiency, costs, cultural habits, political and environmental issues.

International comparison of energy services consumption patterns

Most of the countries with available data from IEA have space heating as their main energy service (**Graph 3**). This can be explained by the fact that most of them are in temperate or subtropical climate zones. Morocco, Hong Kong and Brazil were the countries with the smaller or almost no-demand for this type of use, given that these are also some of the few countries in the sample located in regions with a mostly tropical or subtropical climate.

Graph 3: Energy Consumption Distribution by Energy Services in the Residential Sector in 2019.

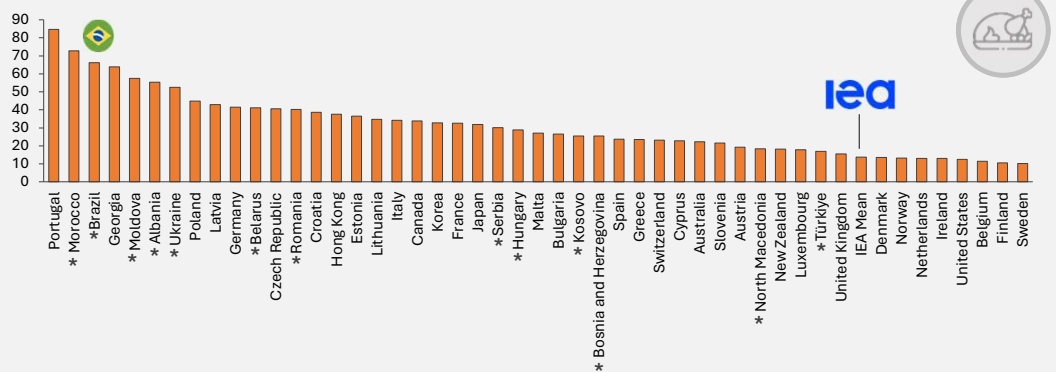


Note: The Other category includes Food refrigeration, Other uses and Uses unclassified by the IEA. Developing countries are labelled with (*).

A good way to compare the energy efficiency level, is to analyze the Energy Consumption Per Capita (ECPC) by energy service. Below, the countries are ranked according to their ECPC for cooking, water heating, space cooling and lighting. These energy services were selected because they are the ones that have been verified as significant in the energy demand of the Brazilian residential sector and have disaggregated information from the IEA.

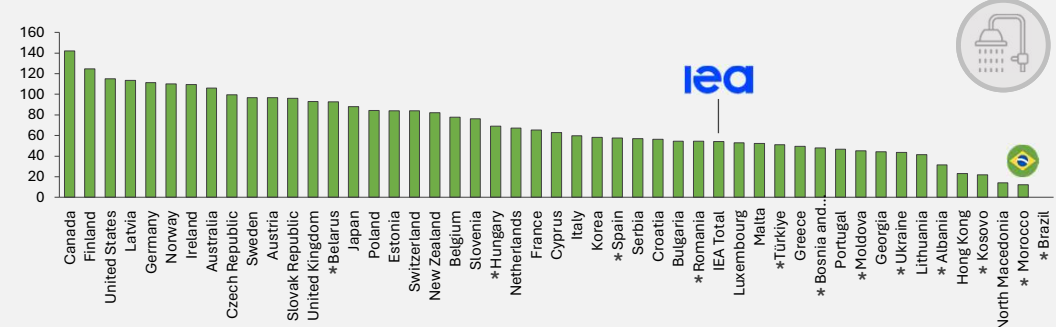
Food cooking is the only final energy use that Brazil has a significantly higher ECPC than the IEA average, being only lower than Portugal and Morocco (**Graph 4**). Among the 10 countries with the highest ECPC for cooking, 5 are developing countries. This high ECPC for cooking, especially in developing countries, may be related to the firewood remaining use in improvised cookers with low energy efficiency.

Graph 4: Energy Consumption Per Capita (ECPC) for Cooking in the Residential Sector in different countries in 2019 (10^{-3} toe per capita).



Brazil and Morocco are the lowest ECPC countries for water heating (**Graph 5**). This can be explained by structural, cultural and climatic aspects.

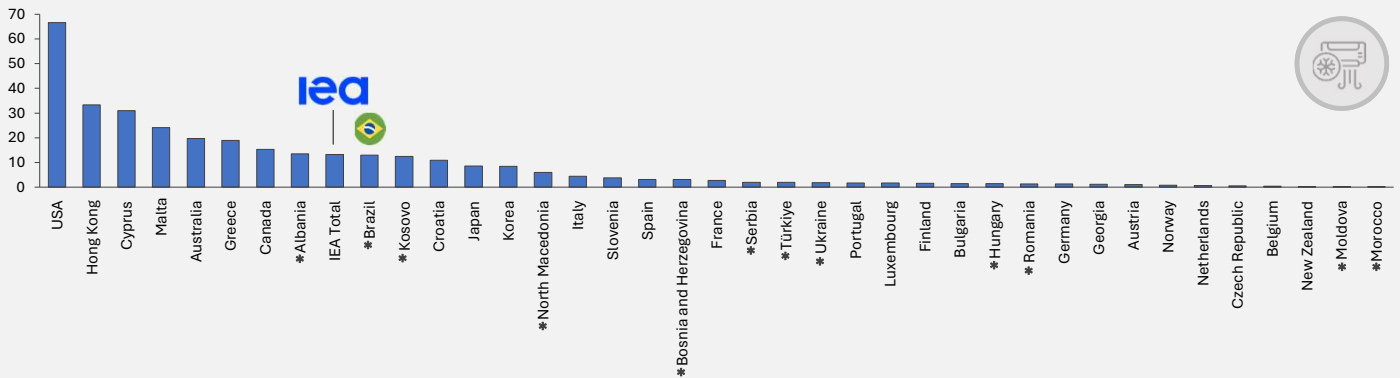
Graph 5: Energy Consumption Per Capita (ECPC) for Water Heating in the Residential Sector for different countries in 2019 (10^{-3} toe per capita).



Note: Developing countries are identified with (*) in their names

Brazil has a ECPC for space cooling equivalent to the IEA sample average and lower than the average for Canada and Albania, both countries with average temperatures lower than Brazil (Graph 6). This can be a sign of a pent-up demand for this energy service in Brazil and, therefore, an indication of energy poverty. However, more accurate studies should be carried out to assess the real potential demand for space cooling based on regional climate data. Although, space cooling is one of the most energy-intensive services in the residential sector. It is not necessarily a popular energy service in all countries due to several reasons - performance restrictions, climatic, structural or cultural aspects. For example, many countries don't rely on energy consumption for thermal comfort because they don't face high temperatures. This explains why does many countries in the IEA sample have a low ECPC for space cooling.

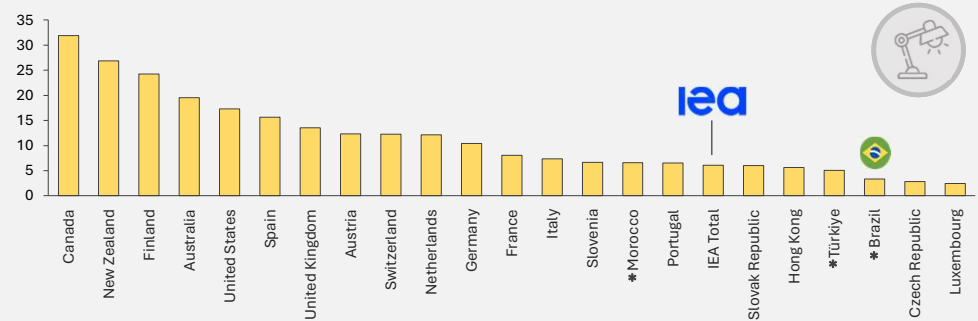
Graph 6: Per Capita Energy Consumption (ECPC) for Space Cooling in the Residential Sector in different countries in 2019 (10⁻³ toe per capita).



Developed countries tend to have higher ECPC for lighting than developing countries (Graph 7).

In the case of Brazil, the ECPC for space conditioning and lighting are lower than the average for the IEA sample, which may indicate both a pent-up demand for these services and gains in equipment efficiency.

Graph 7: Energy Consumption Per Capita (ECPC) for Lighting in the Residential Sector of different countries in 2019 (10⁻³ toe per capita).



Note: Developing countries are identified with (*) in their names

What does these data allow us to conclude?

- Developing countries like Brazil tend to have lower Energy Consumption Per Capita (ECPC), indicating a correlation between this indicator and the level of development.
- Historically, developed countries tend to reduce their ECPC, reflecting in energy efficiency gains, while developing countries keep a static trend due to increasing consumption to meet a pent-up demand, offsetting efficiency gains (boomerang effect).
- To understand energy consumption in the residential sector, it is essential to analyze the structural effects relating to the energy sources mix and services demanded by households.
- Space heating is predominant in temperate climate regions, while in Brazil, due to its mostly tropical climate, the demand for this end-use is minimal.
- Brazil stands out for its high ECPC for cooking, explained by the significant use of firewood, and low ECPC for water heating, due to technological, cultural and climatic factors.
- Energy demand for space cooling can change based not only on climatic factors, but also because of cultural and socio-economic features. As a result, Brazil has a lower ECPC than countries with milder climates.
- ECPCs for space cooling and lighting in Brazil are below the IEA sample average. This can indicate a possible pent-up demand (energy poverty) for these services and the effectiveness of Brazil's energy efficiency policies for light bulbs, fans and air conditioners. However, a precisely analysis would be necessary to better in-depth studies.
- Analyzing the inequality in energy consumption by incoming classes is paramount for guiding sustainable development and inclusion policies, especially in developing countries like Brazil.



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