

Analyzing energy deprivation for cooking in Argentina and Brazil

Analizando la privación de energía a la hora de cocinar en Argentina y Brasil

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Abstract

Lack of access to clean cooking is one dimension of energy poverty that has called the attention of many international organizations and policymakers, due to the relevance of cooking, as an energy service, in the satisfaction of essential needs. The present paper has two central objectives: it intends to characterize the population with energy deprivation for cooking and detect if their characteristics are coincident in Brazil and Argentina, and it analyses whether the selection of traditional fuels for cooking is related to the presence of other socioeconomic deprivations. To fulfill these objectives, an analysis of descriptive statistics is performed, and logistic models are estimated during the period 2004-2014.

From the descriptive analysis, it is found that the socioeconomic characteristics of the population that presents energy deprivation in cooking are markedly different from those that are not deprived in this dimension. In turn, there is a strong dependence between the multidimensional deprivations and energy poverty in cooking.

Keywords: urban energy poverty, energy for cooking, logistic models, Brazil, Argentina.

Resumen

La falta de acceso a una cocina limpia constituye una dimensión de la pobreza energética que ha llamado la atención de muchas organizaciones internacionales y formuladores de políticas, debido a la relevancia de la cocina, como servicio energético, en la satisfacción de necesidades esenciales. Con este trabajo, se persiguen dos objetivos centrales: se pretende caracterizar a la población con carencia energética para cocinar y detectar si sus características son coincidentes en Brasil y Argentina; además, se analiza si la selección de combustibles tradicionales para cocinar se encuentra relacionada con la presencia de otras privaciones socioeconómicas. Para cumplir con dichos objetivos, se realiza un análisis de estadística descriptiva y se estiman modelos logísticos durante el período 2004-2014.

A partir del análisis descriptivo, se considera que las características socioeconómicas de la población que presenta carencia energética en la cocina se muestran marcadamente diferentes a aquella que no sufre carencia en esta dimensión. A su vez, existe una fuerte dependencia entre las privaciones multidimensionales y la pobreza energética en la cocina.

Palabras clave: pobreza energética urbana, energía para cocinar, modelos logísticos, Brasil, Argentina.

1 Introduction

Worldwide, there is an increasing concern about reducing energy poverty, especially since the promotion of the Sustainable Development Goals in 2015 by the United Nations. One of these goals emphasizes the need to reduce energy poverty and mitigate negative impacts on the environment.

The use of solid fuels (firewood, charcoal, and other traditional biomass)¹ for cooking is an indicator of energy poverty (Ekouevi & Tuntivate 2012). According to the International Energy Agency worldwide, 36 % of the population did not have access to clean cooking in 2017 and, in the case of Latin America, this percentage is 11 % (IEA 2019). This type of deprivation is a distressing and predominant phenomenon in developing countries, since it generates particles and gases that can have not only a considerable impact on global warming, but also on health. At the same time, these negative impacts on health tend to disproportionately affect women and children, as they spend more time in the household (IEA 2017).

In agreement with the energy balances, the consumption of firewood for cooking increased in 2018, concerning 2017 and 2016, in absolute terms in both Argentina and Brazil. However, the consumption of traditional fuels in the residential sector demonstrates a decreasing trend from 2004 to 2018 in both countries. The residential consumption of firewood, coal, kerosene, or burning of waste for cooking represents less than 1 % for 2018 in the case of Argentina, and 25 % in the case of Brazil.

This study has two central objectives: on the one hand, it intends to characterize the households that used solid fuels for cooking and detect if their characteristics are coincident in Brazil and Argentina; on the other hand, this study analyses whether the selection of traditional fuels for cooking food (firewood, coal, kerosene, or burning of waste) is related to the presence of other socioeconomic deprivations. To fulfill these objectives, the period between 2004 and 2014 is used to assess the trends of energy deprivation in cooking (one dimension of energy poverty) in both economies.

Few studies focus on energy poverty in urban households in Latin American countries from the perspective of the choice of cooking fuel. Argentina and Brazil were selected, because they are relatively large economies in South America (CEPAL 2019a) and concentrate a great part of their population in urban areas (Lattes 2001). In turn, according to Quiroga and Juncos Castillo (2020), both economies present significant levels of inequality and population in monetary and multidimensional poverty. Although some deprivations are dissimilar (mainly due to climatic differences), the characteristics and trends of poverty in Brazil and Argentina coincide (CEPAL 2019b). For example, the relative variation of household

1 Biomass or bioenergy use can be divided into two categories: traditional or modern. The first one refers to the combustion of biomass in such forms as wood, animal waste, and traditional charcoal. The second one includes liquid biofuels from bagasse and other plants, bio-refineries, biogas produced through anaerobic digestion of residues, wood pellet heating systems, and other technologies (IRENA 2021). In this paper, we focus on traditional biomass.

income in both economies during the period 2003-2014 was significant, with a reduction in monetary poverty and multidimensional poverty, with an important achievement in educational terms. Additionally, both countries present a severe difference between the first percentiles of the income distribution (CEPAL 2019b). Furthermore, both primary energy matrices are based predominantly on non-renewable energy sources, but at the same time there are a series of sensible differences between them (Núñez 2019, Del Valle Guerrero 2020). Particularly, Brazil has a greater penetration of renewable energies and diversification of energy sources compared to Argentina. For instance, in 2018 oil (32 %) and sugar cane products (18 %) are the predominant energy sources in Brazil, and together they account for 50 % of the matrix. On the other hand, oil and natural gas together represent 84 % of the Argentine energy matrix of 2018. As well, Argentina is a good reference for Brazil and South American countries in the use of cleaner energy sources for cooking (IEA 2020).²

These similarities and differences motivated the analysis of energy for cooking trends between urban areas in Argentina and Brazil. Some studies evaluate the choice of cooking fuels at the local or national level (Cardoso and González 2019, Caruana and Méndez 2019, Bravo *et al.* 2008, Heltberg 2004), but do not examine the use of energy for cooking in different South American countries. This paper contributes to the knowledge about the population that presents energy deprivation in cooking for both countries and the comparison between them, since it allows its socioeconomic characterization and its comparison with the non-private group.

The paper is structured as follows: first, a discussion about the concept of «energy poverty» is presented, including the choice of cooking fuel and the evolution of the energy sources used in the household's sector in Argentina and Brazil; in the followed section, a descriptive analysis of energy-deprived households in Argentina and Brazil is performed. Then, in the fourth section, logistics models are estimated with the objective to analyze the relationship between multidimensional deprivation and one dimension of energy poverty. Finally, in the last section, a discussion and conclusions are provided.

2 What is energy poverty?

In the literature, there are several studies about energy poverty (Boemi & Papadopoulos 2019, Castaño-Rosa *et al.* 2019, Day *et al.* 2016, González-Eguino 2015) and different definitions of the phenomenon. Consequently, as there is no consensus, it is important to clarify the perspective from which energy poverty will be studied in this paper.

2 <https://www.iea.org/reports/sdg7-data-and-projections/access-to-clean-cooking>.

At the beginning of the literature, the concept of «energy poverty» was associated with fuel poverty. This notion represents a situation in which a household cannot afford the necessary fuel, to maintain the heat or temperature that provides thermal comfort to its members (Lewis 1982, in García Ochoa 2014). However, over the years, the focus turned from fuel poverty to energy poverty. At this point, the simplest definitions of energy poverty emphasized the lack of energy access, particularly to modern and clean energy; for instance, electricity, natural gas, liquefied petroleum gas (LPG), and biogas (OECD/IEA 2017, p. 21). Consequently, energy poverty was associated with the use of traditional fuels, such as garbage, manure, organic waste, coal, wood, and kerosene.

Likewise, there are broader definitions of energy poverty, as the one proposed by the European Energy Poverty Observatory. This institution states that energy-poor households are those that experience inadequate levels of energy services, due to a combination of high energy expenditure, low income, inefficient buildings, and appliances and specific energy needs of the household.³ However, the most complex definitions are those that incorporate elements such as subjectivity and the temporal space dimension of satisfaction (PNUD 2018). Day *et al.* (2016) proposed a complex definition based on the Capabilities approach. For these authors, energy poverty is an inability to realize essential capabilities as a direct or indirect result of insufficient access to affordable, reliable, and safe energy services, and taking into account available reasonable alternative means of realizing these capabilities. This definition highlights that energy is necessary to develop various capacities, including but not limited to health problems. In addition, the central role of energy services is recognized, but none particularly is mentioned; thus, the definition is broad enough to adapt to different situations.

In general, the broad definitions emphasize the concept of energy services rather than energy as a good. This is because people do not demand energy, but rather energy services, such as heating, cooking, lighting, refrigeration, etc., because that energy is not an end in itself, but it is a means to meet fundamental needs (Fell 2017, Day *et al.* 2016, Bouille 2004). In this sense, the degree of coverage, quality, and cost of energy services are ultimately the determinants of human well-being. Therefore, energy poverty cannot be discussed without considering the link between energy services and energy. Energy services are those functions performed using energy which are means to obtain or facilitate desired end services or states (Fell 2017). In this context, the importance of technology in the satisfaction of energy services is highlighted. If households can access more efficient equipment, they can reduce energy consumption and, consequently, require a lower percentage of their income to meet their needs (Ochoa García 2014). For this reason, energy efficiency measures should be considered comple-

3 <https://www.energy-poverty.eu/about/what-energy-poverty>.

mentary to social security policies for reducing energy poverty (ENEA 2019).

As mentioned earlier, energy poverty cannot be defined only as the lack of access to energy since attributes such as the quantity and quality of energy matter. Thus, as shown in Figure 1, energy poverty can be defined as the lack of satisfaction of essential energy services for human life (cooking, heating, lighting, domestic hot water, and others), induced by a lack of access, quantity, and quality not only of energy, but also of equipment, which is caused by various factors, such as socioeconomic (insufficient level of income, or education), geographical (grid disconnection), building (type of construction, insulation in windows, etc.), and cultural (preferences for certain energy sources),⁴ which ultimately affects the level of well-being of household members. The advantage of mentioning well-being is that this definition is flexible to different conceptions. As an example, it would be compatible with Sen's capabilities approach, understanding well-being as the ability (positive freedom) to be or to do (capability to functioning) and to choose the way of life.

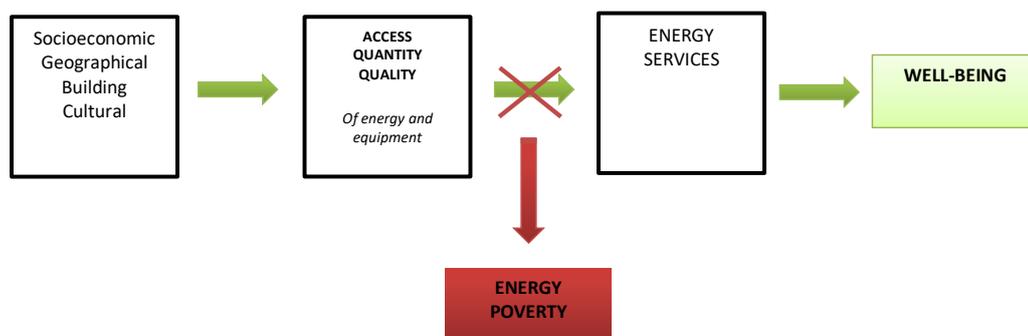


Figure 1
Concepts and relations with Energy Poverty
Source: own elaboration.

Within this broad definition of energy poverty, energy deprivation for cooking can be considered a dimension of the phenomenon, which is multidimensional. Additionally, the relationship of this deprivation with other socioeconomic deprivations can be analyzed with statistical data, to find empirical evidence that the definition of energy poverty in theoretical terms, as a multidimensional phenomenon, is valid.

2.1. The choice of cooking fuel: background

To measure energy poverty, it is desirable to have information on all household energy services. However, this research will focus exclusively on cooking due to two reasons. The first one is that cooking is one of the main energy services in the residential sector; in fact, it is the second most important energy use and it rep-

4 This list is not restricted but indicative since other factors may be included.

resented 29% of energy consumption in 2010 (Lucon *et al.* 2014, p. 681). In the case of Argentina, cooking is also the second most important energy use in households, as it represents approximately 17 % of energy consumption (Secretaría de Energía 2020). Even though Brazil has developed useful energy balances, it does not include data on energy use by sector (MME & EPE 2018, p. 201). The other reason is related to data availability. As it will be explained in section 3, there is no available data on end-user services in developing countries, since the main official household surveys do not include questions related to other energy services.

Access to clean cooking is a central issue and different organizations are working on promoting this issue.⁵ At the same time, there are databases about clean cooking, such as the report of Regulatory Indicators for Sustainable Energy (RISE 2020), and the database of Access to clean cooking of the International Energy Agency (IEA 2019). According to the latter, worldwide in 2017, 36 % of the population did not have access to clean cooking. For the Latin America region, this percentage is 11 %, for Argentina less than 1 % and for Brazil 4 % (IEA 2019). In addition, 2,359 million people rely on biomass for cooking in the world, 56 million in Latin America, less than 1 million in Argentina and 9 million in Brazil (IAE 2019).

It is important to note that modern and non-polluting fuels are electricity, LPG, and biogas systems, or the efficient use of biomass. On the contrary, traditional fuels are garbage, manure, organic waste, coal, wood, and kerosene (PNUD 2018). Using traditional biomass or other traditional fuels represents a complex problem because it has significant climate, public health, economic and social impacts. Cooking with traditional energy sources (such as wood, dung, and charcoal) causes indoor air pollution and contributes to climate change in developing countries, because it generates relatively more Greenhouse Gases emissions than other fuels. In addition to the global environmental impact, indoor air pollution at household level is one of the largest contributors to disease and early mortality (RISE 2020). Women, children, and the elderly are the most exposed, resulting in respiratory infections, chronic obstructive pulmonary diseases, eye problems, and lung cancer (IEA 2017). The transition from traditional biomass to clean fuels will empower women and girls, because they will gain time and reduce drudgery, by avoiding the collection of firewood (Lewis *et al.* 2017, in Rosenthal *et al.* 2018).

It is also relevant to discuss how the process of transition towards clean energy for cooking in households is. Generally, the energy ladder model is assumed (Masera 2000). This approach implies a simple progression from traditional to modern fuels as household income increases; that is, as families gain socioeconomic status, they abandon technologies that are inefficient, less costly, and more polluting (Masera 2000). Under this approach, there are

5 The Clean Cooking Alliance, The Clean Cooking Implementation Science Network, The Climate, and Clean Air Coalition and the Sustainable Energy for All.

three phases: the first one is characterized by universal reliance on traditional biomass; in the second, households use transition fuels such as kerosene, coal, and charcoal in response to higher incomes, urbanization, and traditional biomass scarcity; finally, in the third phase, households switch to LPG, natural gas, or electricity for cooking (Heltberg 2004).

However, the energy ladder model is not appropriate partly, because energy and energy consumers cannot be treated as independent technical, institutional, and economic systems, mostly in underdeveloped countries. It is important to link the practice of cooking with the material world, skills, competencies, and meaning ascribed by people who perform the task (Herington *et al.* 2017). The transitions from traditional to modern energy sources are haphazard, incremental, and typically involve multiple stoves. Because of this, some authors use the term «fuel stacking», and it implies that people will often use several cooking technologies or operate modern stoves only on special occasions (Herington *et al.* 2017).

Regarding estimations of the fuel choice for cooking, there are several research studies in the literature. Rahut *et al.* (2019) studied the variables that influence the choice of cooking fuel in households of rural Pakistan. The authors found that households with higher income and assets and with an educated head tend to use clean and modern fuel, such as natural gas. Paudel *et al.* (2018) found that households with residence in urban areas, availability of electricity, higher wealth, high education, married status, and separate cooking places are likely to use LPG in Afghanistan. Özcan *et al.* (2013) analyzed economic and socio-demographic factors which affect energy choices in households in Turkey. The authors found that the monthly income of households and ages of members have a significant effect on energy choices. Gupta & Köhlin (2006) investigated the demand for firewood, coal, kerosene, and LPG in households in Kolkata, India. They found that household expenditure is significant in explaining the urban fuel choice (except for dung), the size of the household is more significant for electricity, LPG demand is sensitive to kerosene price, kerosene demand is sensitive to coal price, and coal and firewood have negative cross-price elasticities indicating complementarity.

Rosenthal *et al.* (2018) studied households in a group of 40 low and middle-income countries and they detected that the programs using LPG stoves and fuel will yield greater reductions in both DALYs and Global Warming Commitment than those using improved biomass stoves. Masera *et al.* (2000) analyzed the energy ladder model for a village and four states of Mexico. The author found that in rural areas the fuel switching process is a multiple fuel cooking or fuel stacking process of both firewood and LPG. Heltberg (2004) studied the determinants of household fuel use and fuel switching

in Brazil, Ghana, Guatemala, India, Nepal, Nicaragua, South Africa, and Vietnam. His results show that electrification, per capita expenditures, education, and tap water are associated with a statistically significant reduction in the probability of using only solid fuels. One year later, Heltberg (2005) analyzed patterns of fuel use, fuel spending, and fuel switching in Guatemala, finding that income or expenditures induce fuel switching in urban areas, whereas fuel stacking is more common in rural areas. In addition, the fuel choice is influenced by education, electrification, ethnicity, prices, and region of residence (Heltberg 2005).

The choice of cooking fuel is a relevant aspect to understand one of the dimensions of energy poverty and trends of different energy uses. It should be noted that it is not the objective of this paper to evaluate energy poverty from the consumption perspective but to analyze the characteristics of households without access to clean energy sources for cooking in Argentina and Brazil.

2.2. Data and trends in household cooking fuel use

Before analyzing the energy sources used for cooking in Argentina and Brazil, it is important to have an overview of the energy consumption matrix of the residential sector in both countries. As can be seen in Figure 2, the household sector of both countries uses the same energy sources, but in different proportions. In the case of Argentina, natural gas is the principal energy source, followed by electricity and LPG. In Brazil, the lead position is for electricity, followed by LPG and firewood. In both economies, electricity consumption increases during the period analyzed. In addition, the relative share of firewood over the total consumption of the residential sector decreased slightly in Brazil over the last five years.

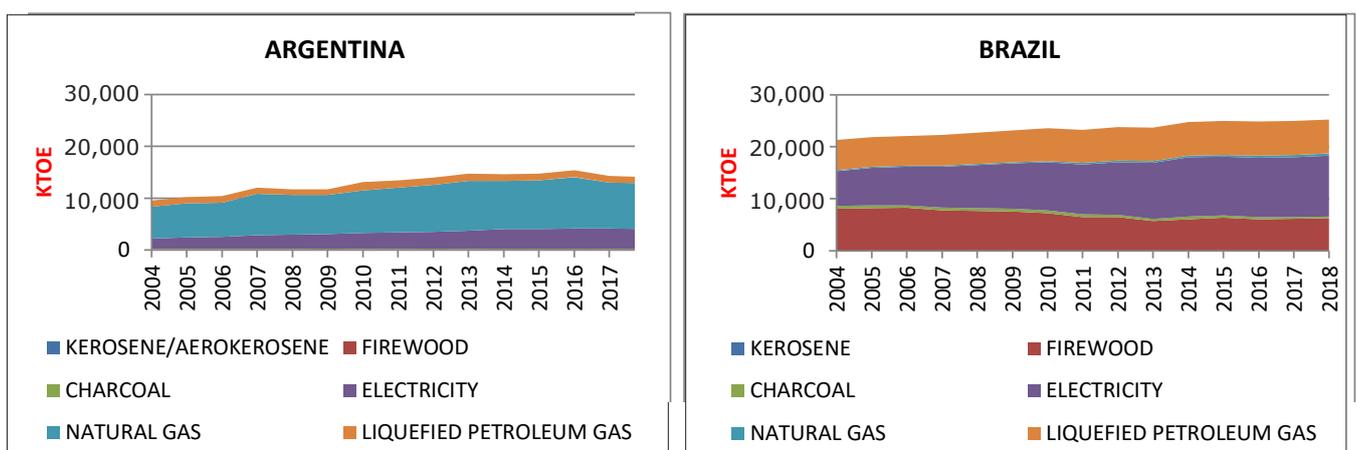


Figure 2
Residential energy consumption by energy source in the period, 2004-2018
Source: own elaboration based on the National Energy Balances from the Secretary of Energy and the Energy Research Company (EPE, as per its initials in Portuguese).

As mentioned previously, there are three phases that a household goes through as income increases and three types of fuel: traditional, transition, and modern. As can be seen in Table 1, in 2004, Argentina had 97 % of energy consumption from modern fuel, whereas Brazil had only 60 %. This situation improved in 2008, as Argentina increased modern fuel consumption up to 98 % and kept this participation also in 2014 and 2018. An improvement can be seen over the years for the case of Brazil. In 2008, the consumption of modern fuels rose to 64 %, then it increased up to 73 % in 2014 and up to 74 % in 2018. In conclusion, households in Brazil present severe energy deprivations in the selection of fuels to satisfy their energy services. However, it has shown a deeper improvement in the period under study.

Type of fuel	2004		2009		2014		2018	
	Argentina	Brazil	Argentina	Brazil	Argentina	Brazil	Argentina	Brazil
Traditional (TS)*	3 %	40 %	2 %	35 %	2 %	27 %	2 %	26 %
Traditional ¹	1 %	38 %	1 %	33 %	1 %	25 %	1 %	25 %
Transition ²	2 %	2 %	1 %	3 %	1 %	2 %	1 %	1 %
Modern (MS) ³	97 %	60 %	98 %	65 %	98 %	73 %	98 %	74 %

¹ Firewood; ² Kerosene, Aero-kerosene and Charcoal; ³ LPG, Natural Gas and Electricity.

* Although traditional, transitional, and modern fuels are distinguished in the literature, in this paper, both the traditional and transitional categories will be considered traditional.

Table 1

Energy sources by type of fuel according to the development phase

Source: own elaboration based on the National Energy Balances from the Secretary of Energy and the Energy Research Company (EPE, as per its initials in Portuguese).

3 Empirical approach

3.1. Household with energy deprivation for cooking: characterization

Although most urban households in Argentina and Brazil use modern energy sources, some households still depend on firewood and charcoal for cooking. In this paper, the demographics, and dwelling characteristics in urban households in Argentina and Brazil are examined in two subgroups: households using traditional energy sources for cooking (TS) (kerosene, firewood, coal, burning garbage,⁶ etc.), and on those which use modern energy sources (MS) (natural gas, LPG, electricity). Depending on this division, the population subsets have distinctive characteristics.

For the case of Brazil, the data of cooking fuel households was extracted from National Household Sample Survey (PNAD, for its

6 In Brazil, the survey asked the family what fuel was most used for cooking, and the answer could be: gas cylinder, natural gas, electricity, firewood, and charcoal and others. Then, in Brazil, the traditional sources are only referred to firewood and charcoal.

acronym in Portuguese). The PNAD is a survey applied annually by the Brazilian Institute of Geography and Statistics since 1981 and aims to investigate the socioeconomic condition of the household.⁷

To evaluate the situation in Argentina, the Permanent Household Survey (EPH, for its acronym in Spanish) was used. The EPH has been carried out in Argentina since 1973 by the National Institute of Statistics and Censuses (INDEC, for its acronym in Spanish) with a quarterly frequency. It is carried out in households (INDEC 2018).

The analysis periods are 2004, 2009 and 2014, because, in the first place, the objective is to estimate the evolution of energy deprivation, as one dimension of energy poverty, for cooking. Secondly, it is evident that some indicators selected for the characterization of the population should show some rigidity in the short term. Third, the Brazilian government established in 2003 a regulatory framework in the LPG sector that gave priority to the consumer's well-being (ANP 2019). Therefore, an analysis in 2004 would capture this regulatory change. Meanwhile, in 2004, the Social Gas Cylinder Plan⁸ for Buenos Aires city was implemented. By the end of 2008, the National Program on Household Consumption of Bottled Liquefied Petroleum Gas was created (GNESD 2014, p. 16). In this sense, analyzing the 2009 period may reflect the effects of the program in lower use of solid fuels. Also, 2009 and 2014 periods are important to analyze due to the declination of GDP in Brazil and Argentina (CEPAL 2009, CEPAL 2014), which had negative impacts on income and employment. Additionally, in both countries there are difficulties to address the issue after 2015: in Brazil, the methodology of the survey changed, affecting the answer about the use of fuels for cooking, while in Argentina the microdata for 2015 and 2016 are not available and are not comparable since the sample selection changed. Thus, this study only focused on the period from 2004 to 2014.

The central hypothesis of this research is that the two subsets of populations not only differ in the fuel used for cooking, but also in the presence of multidimensional deprivations. To analyze this aspect, a series of socioeconomic characteristics are examined. The definition of each of them can be found in Table 2.

As can be seen in Table 3, over the years, households using traditional energy sources (TS) have reduced their presence at the national level in both countries. In 2004, around 2.25 % of households were in energy deprivation for cooking in Argentina, and around 1.87% in Brazil. However, by the end of the period, this proportion is reduced by almost two percentage points in Argentina, and less than one percentage point in the case of Brazil.

When analyzing the proportion of individuals living in households at risk of monetary poverty in each population subset, there is a substantial difference between them in both countries. Thus, in Argentina, approximately 80 % of the households that used tradi-

7 For more information, please refer to <https://www.ibge.gov.br/estatisticas/sociais/trabalho/9127-pesquisa-nacional-por-amostra-de-domicilios.html>.

8 With the aim of subsidizing the price of 10 kg LPG gas cylinders for low-income households with no access to clean energy sources.

Variables	Description
Female-headed households	Dummy that takes the value of 1 if the household head is female, 0 otherwise (base category)
Risk of monetary poverty	Dummy that takes the value of 1 if the disposable income of the person or household is less than 60 % of the median national income, 0 otherwise (base category)
Home educational climate	Maximum level of education achieved by the household head
Low	Completed primary education
Middle	Completed secondary education
High	Assisted or completed higher education (base category)
Sanitary sewage	
General network	Sewer collection network, septic tank connected to sewage or rainwater collection system (base category)
Septic tank not connected or others	Septic tank not connected to collection network and other traditional forms: rudimentary pit, ditch, channeled directly into a river, lake or sea and others (dummy that takes the value of 1, 0 otherwise)
Build quality	
Poor materials	Dummy that takes the value of 1 if the household has rigged wood, rustic material as adobe, reused wood, leaves of palm and other materials are predominant in the walls (Brazil) or dirt or loose bricks in the floor (Argentina)
Non-poor materials	Brick is the predominant material in the walls (Brazil) or mosaic, tile, wood, ceramic, carpet, cement, fixed brick in the floor (Argentina) (base category)
Water network	
General distribution network	Households have access to a general distribution network to be provided with water (base category)
Well, nascent, other	Households have access to a well or spring to be provided with water (dummy that takes that value of 1, 0 otherwise)
Age of the household head	Age of the household head
Household size	Number of household members
Monoparental household	Dummy that takes the value of 1 if the head household does not have a spouse, 0 otherwise (base category)

Clarification: Table 3 shows the situations in which deprivation is verified, that is, when the dichotomous variables listed here take a value of 1.

Table 2

Definition of variables included in the descriptive analysis and in the logit model

Source: own elaboration

tional sources for cooking are also exposed to monetary poverty, while only 30 % of the households that did not use solid fuels showed monetary poverty. The coincidence of both deprivations decreases towards the end of the analyzed period. In Brazil, the population exposed to monetary poverty risk reached 61 % in 2004 but decreased over time.

Regarding the gender issue, in Argentina, this energy deprivation is more frequent in households with a female head of household. The opposite situation is verified in Brazil.

In turn, in Argentina, the average age of the household head is lower in energy-deprived households, while in Brazil, the average age of the household head is higher in energy-deprived households.

Variables	2004				2009				2014			
	Argentina		Brazil		Argentina		Brazil		Argentina		Brazil	
	n = 376,475		n = 39,688,728		n = 48,785		n = 46,088,555		n = 361,354		n = 53,951,586	
	TS	MS	TS	MS	TS	MS	TS	MS	TS	MS	TS	MS
<i>Proportion</i>	2.0 %	98.0 %	1.9 %	98.1 %	1.0 %	99.0 %	1.1 %	98.9 %	0.4 %	99.6 %	0.5 %	99.5 %
Gender for household head												
Female	51.7 %	47.6 %	75.2 %	71.0 %	51.5 %	47.0 %	67.9 %	63.7 %	53.7 %	47.8 %	59.8 %	58.7 %
Male	48.3 %	52.4 %	24.8 %	29.0 %	48.5 %	53 %	32.1 %	36.3 %	46.3 %	52.2 %	40.2 %	41.3 %
Monetary poverty risk	82.0 %	28.9 %	60.7 %	26.8 %	80.2 %	28.0 %	55.9 %	25.1 %	51.4 %	26.5 %	46.9 %	24.9 %
Home educational climate												
Low	15.0 %	2.6 %	94.9 %	63.3 %	15.2 %	2.4 %	94.1 %	56.2 %	9.9 %	1.7 %	90.0 %	51.8 %
Middle	57.9 %	29.7 %	4.5 %	24.0 %	56.7 %	26.0 %	4.3 %	28.6 %	40.3 %	22.6 %	7.4 %	29.7 %
High	27.1 %	67.8 %	0.6 %	12.6 %	28.1 %	71.7 %	1.6 %	15.3 %	49.8 %	75.7 %	2.6 %	18.5 %
No Sewer	64.0 %	12.6 %	64.1 %	30.5 %	57.7 %	10.8 %	68.1 %	29.8 %	29.8 %	8.4 %	69.3 %	26.4 %
Poor build quality	25.5 %	1.2 %	22.4 %	6.9 %	30.9 %	1.0 %	20.3 %	5.4 %	15.3 %	0.6 %	20.6 %	4.3 %
No access to water	64.9 %	8.6 %	6.5 %	5.0 %	58.6 %	6.2 %	8.9 %	5.4 %	29.3 %	3.8 %	13.0 %	5.1 %
Average age of the household head	46	50.3	51	47	46	50	54	48	47	52	57	49
Household size average	7	4	4	3	6	4	4	3	5	4	3	3
Monoparental household	31.1 %	27.8 %	29.7 %	32.9 %	40.9 %	29.3 %	33.4 %	34.8 %	46.0 %	31.2 %	39.6 %	37.5 %

Table 3

Characterization of two subgroups (TS and MS) of the population in Brazil and Argentina – 2004, 2009, and 2014

Source: own elaboration based on EPH and PNAD.

In both countries, the average number of members is higher in homes that use traditional fuels for cooking.

When analyzing housing deprivations, interesting differences are seen between the two subgroups studied. Households in energy-deprived conditions have a greater presence of other types of deprivation in the housing dimension, such as lack of bathrooms, water, sewers and the presence of dirt floor or loose brick. In Brazil, the waste collection system in energy deprived households is not fully supplied; nonetheless, more than 90 % of non-energy-deprived households have access to a proper infrastructure of waste systems. At the same time, the sewage system is extremely different between the subgroups. On the contrary, the roofing material and water access are homogeneous.

Finally, the educational climate of the household⁹ is markedly different between the two population subsets. In Argentina, households with energy deprivation for cooking have (mostly) a medium educational climate while in Brazil a low educational climate prevails. In both countries, a high educational climate is the most recurrent in households that use modern sources for cooking.

The comparison of statistics would seem to indicate that energy deprivation for cooking occurs in households with the presence of other types of multidimensional deprivation, consistent with the definition of energy poverty adopted in this paper. It is worth remembering that energy deprivation in cooking is a dimension of energy poverty. Thus, it is worth analyzing which are the socioeconomic factors that affect energy deprivation for cooking in both economies and what is their incidence. To answer this question, it was decided to estimate logistic regression models to assess whether the presence of other types of deprivation in relevant areas of social life explains the likelihood of a household being energy deprived for cooking.

3.2. Logistic regression models

Logistic regression models are used when the problems or situations under study are characterized by categorical variables that do not satisfy the continuity assumption (Williams 2006). The problem addressed in this paper is under this condition, since being energy deprived for cooking or not is a dichotomous issue: deprivation involves using traditional fuels to cook food.

The objective of the logistic models is to estimate the probability of an event after the explanatory variables selected and the values they take (Liao 1994). Then, these models allow estimating the relationship between social and economic factors and the probability of using traditional sources for cooking in Argentina and Brazil. This type of model assumes that the logarithm of the odds ratio is linearly related to the return variables. The model can be defined as a linear function of the explanatory variables incorporated, which forms a vector of k -dimensions (Gujarati & Porter 2009) and takes the following form:

$$\text{logit}(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \dots + \beta_k X_{k,i}$$

Where the parameters that accompany the explanatory variables are estimated through maximum likelihood and represent the probability that the event will occur.

One of the objectives is to analyze whether the deprivations verified in households are explanatory or independent factors of the selection of the material for cooking. To fulfill this objective, it is appropriate to estimate logistic regression models.

9 The definition of this variable can be found in Table 2. The educational climate of the household refers to the level of schooling achieved by the head and its level is constructed based on the years of education.

In this context, the dependent variable is «type of fuel used for cooking», that takes value 1 when a household declares using predominant firewood, charcoal, or kerosene, or 0 otherwise. The coefficients of the model indicate, for example, whether the probability of belonging to an energy-deprived cooking household is positively or negatively related to the fact of having a woman as household head, of belonging to a low-income family, or of having a low educational climate at home.

The explanatory variables were selected based on the previous descriptive analysis of socio-demographic and economic characteristics of Brazilian and Argentinian households, and the literature review outlined in section 2.1. It is also important to highlight that the objective of the paper is to perform a comparative analysis between Brazil and Argentina, so the selection of variables was limited by the availability of comparable survey data from both countries.

It is recognized that the set of factors and deprivations that can influence the choice of cooking fuels is broader than the one selected. Affordability is a key issue in the energy deprivation in urban households (Belaïd 2017); however, the PNAD and EPH do not provide data on fuel prices for cooking and affordability can only be associated with income variables. Even though energy prices and subsidies are relevant when analyzing energy consumption choices, it is complicated to include a price variable in this study, because there would be an inconsistency, as the price would be a macroeconomic variable in a microdata base. Affordability has been recognized as an important factor of the use of energy for cooking in separate studies for Argentina (Bravo *et al.* 2008), and Brazil (Coelho & Goldemberg 2013, Pereira *et al.* 2016, Coelho *et al.* 2018, Gioda 2019), but has not been analyzed for both countries. In Argentina, energy subsidies have played an important role in expanding energy access in the period under analysis. However, there is a discussion about the distortions that this policy has generated. For example, the subsidy for electricity consumption in 2013 was relatively proportional with a pro-rich trend (Puig & Salinardi 2015) and in the period 2003-2014 the distribution of electricity and natural gas subsidies was biased towards upper and middle income (Hancevic *et al.* 2016).

The results of the estimated logistic models for each temporary sub-period for Argentina and Brazil can be seen in Table 4. Estimates show homogeneity in the statistical significance of the variables throughout the analyzed time periods. Social and economic deprivations seem to be explanatory factors of the choice of cooking fuels in both economies.

In the case of Argentina, belonging to families with household heads more advanced in age reduces the likelihood of families using traditional sources. This may suggest that young people facing economic difficulties use traditional fuels while old people use modern

energy sources (Muller & Yan 2018). These findings are in line with results from other countries (Gupta & Köhlin 2006, Farsi *et al.* 2007, Özcan *et al.* 2013). Nonetheless, in the case of Brazil, this effect is the opposite. Such results in Brazil may support the notion that the older household head has more difficulties with participation in formal labor.

In both countries, a single-parent household increases the probability of belonging to a household with energy deprivation for cooking in 2004, coinciding with Conde-Ruiz *et al.* (2020). However, in 2009 and 2014, a negative relationship in Brazil was found. This could be explained by the social policies applied in the last two decades, with a focus on vulnerable populations.

The probability of households using traditional fuels for cooking seems to increase with housing deprivation (no sewer, no access to water, poor build quality...). The reason is that the dwelling characteristics are frequently considered as proxies of a household's

Variables	2004		2009		2014	
	Argentina	Brazil	Argentina	Brazil	Argentina	Brazil
Observations	376,475	39,688,728	488,785	46,088,555	361,354	53,951,586
Female-headed household	-0.113* (0.024)	-0.393* (0.004)	-0.185 (0.036)	-0.210* (0.003)	0.231*** (0.055)	-0.027* (0.004)
Monetary poverty risk	1.138* (0.033)	1.208* (0.002)	1.103* (0.049)	1.160* (0.003)	0.599* (0.065)	0.770* (0.004)
Home educational climate – low	1.537* (0.044)	2.460* (0.014)	1.632* (0.063)	1.790* (0.011)	1.404** (0.106)	1.600* (0.012)
Home educational climate – middle	0.483* (0.028)	0.871* (0.015)	0.808* (0.043)	0.005 (0.013)	0.408** (0.063)	0.280* (0.014)
No Sewer	0.893** (0.029)	0.915* (0.003)	0.662* (0.043)	1.200* (0.003)	0.631* (0.070)	1.470* (0.000)
Poor build quality	1.431* (0.034)	0.918* (0.004)	1.612** (0.0468)	0.970* (0.003)	1.982** (0.091)	1.130* (0.005)
No access to water	1.434* (0.030)	-0.288* (0.000)	1.498* (0.0447)	0.000 (0.005)	1.278* (0.076)	0.200* (0.006)
Age of the household head	-0.001*** (0.006)	0.007* (0.006)	-0.001** (0.000)	0.027* (0.008)	-0.000 (0.001)	0.028* (0.00)
Household size	0.140* (0.004)	0.204* (0.006)	0.0910 (0.006)	0.130* (0.000)	0.021 (0.013)	0.097* (0.01)
Monoparental household	0.178** (0.027)	0.095* (0.004)	0.604** (0.037)	-0.270* (0.004)	0.478* (0.057)	-0.250* (0.000)
Constant	-6.323* (0.059)	-8.250* (0.010)	-6.760* (0.085)	-8.810* (0.012)	-6.065* (0.123)	-9.430* (0.010)

*, **, *** Statistically significant variables at 1 %, 5 %, 10 % respectively. Standard deviations in parentheses

Table 4

Results of Logistic regression for Argentina and Brazil – 2004, 2009, 2014

Dependent variable: type of fuel used for cooking

Source: own elaboration based on EPH and PNAD, with STATA 14.

wealth and living conditions (Muller & Yan 2018). Moreover, the risk of monetary poverty has a positive and significant association with using traditional fuels for cooking in both countries. A household at risk of monetary poverty must allocate a higher percentage of the domestic budget to the purchase of LPG. In this sense, the lower-income households would substitute clean energy sources for cooking for firewood, because it is cheaper than LPG.

The variables associated with educational climate are significant for solid-fuel dependence in all periods analyzed for both countries. According to Salvia *et al.* (2018), households with higher educational levels tend to choose cleaner energy sources and, on the other hand, a greater educational background is positively related to higher income and hence, affordability and the opportunity cost of time.

The estimates indicate that female-headed households in Brazil have a lower probability of using traditional energy sources for cooking, which may be attributed to the higher opportunity costs of time for collecting firewood and charcoal. However, this effect is not found in Argentina. Thus, the existence of a gender effect in energy deprivation for cooking cannot be affirmed, although the need to delve into this aspect to draw a conclusion in this regard is acknowledged.

A household of larger size is more likely to depend on solid fuels in Brazil, which is consistent with the background (Özcan *et al.* 2013, Paudel *et al.* 2018, Choumert-Nkolo *et al.* 2019). The possible reason is that larger household size is often associated with low-income families (Wajnman 2007). This effect is not verified for Argentina.

Then, the results indicated that income is a relevant, but not the only, incident factor of the use of solid fuels in Argentina and Brazil. Opportunity costs are an important determinant in the household choice, which may be seen in the incidence of educational levels and the role of women as heads of households. Also, structural

Variable	Argentina	Brazil
Single parent household	Positive	Negative (2009, 2014)
Housing deprivation	Positive	Positive
Risk of monetary poverty	Positive	Positive
Educational climate of household	Positive	Positive
Female-headed household	Not significant	Negative
Households size	Not significant	Positive

Table 5
Summary of logistic model results – effects on the probabilities of belonging to household with energy deprivation in cooking
Source: own elaboration.

poverty, represented by dwelling characteristics, is significant to explain the use of traditional sources of energy for cooking. A summary of these results can be seen in Table 5.

In sum, the estimation of these simple models allows us to make a first approximation towards the explanatory factors (and their incidence) in a dimension of energy poverty, more precisely in the energy deprivation for cooking.

4 Conclusions and discussion

The aim of this paper was to assess one of the dimensions of urban energy poverty in Argentina and Brazil. An energy poor household is characterized by the lack of satisfaction of essential energy services for human life, induced by a lack of access, quantity, and quality not only of energy but also of equipment that ultimately affect the level of well-being of the household members. In this context, the cooking energy service becomes relevant, as it is one of the most important energy services in the residential sector.

Therefore, a descriptive and econometric analysis of the use of energy for cooking was performed. In this paper, only one dimension of energy poverty was evaluated, recognizing the limitation but identifying that the cooking energy service is one of the most relevant in the residential sector. Accordingly, it is defined that a household is energy deprived for cooking if it uses traditional energy sources for this purpose.

From the descriptive analysis, in both countries, energy-deprived households in cooking are characterized by less education of household heads, greater, and multiple housing deprivations and high exposure to monetary poverty. In Argentina, this type of household has a younger head and most frequently female (the contrary to Brazil).

Through the application of logistic models, it was found that education, monetary risk, and housing deprivation have a significant impact on energy deprivation for cooking in both countries. The main differences between the countries are that, in the case of Argentina, the gender of the household head and the household size are not significant variables in the analysis, whereas, in Brazil, they are. Moreover, the age of the household head is significant in both cases, but it has opposite impacts; more age increases the probability of energy deprivation in Brazil, while it decreases the likelihood of energy deprivation in Argentina.

It is clear from the analysis that there is a strong dependence between the existence of multidimensional deprivations and the choice of energy sources for cooking. From these results, the reflec-

tion regarding the approach to this problem arises: can the phenomenon of energy poverty be relieved by socioeconomic transversal action plans?

It is worth mentioning that this paper is a first approach on the subject and that it is necessary to strengthen the results presented, as well as the explanatory factors incorporated in the logistic models, as these are limited and other factors (cultural, ideological, family organization, and LPG prices, among others) may influence the choice of cooking fuel. However, the selection prioritizes the objective of comparability between countries and time periods. Consequently, this analysis should be further deepened in future research.

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6 Acronyms

CEPAL: Economic Commission for Latin America and the Caribbean (for its acronym in Spanish)

DALY: Disability Adjusted Life Years

EPE: Energy research company (for its acronym in Portuguese)

EPH: Permanent Household Survey (for its acronym in Spanish)

GDP: Gross domestic product

GHG: Greenhouse Gases

IEA: International Energy Agency

INDEC: National Institute of Statistics and Censuses (for its acronym in Spanish)

KTOE: kilotonnes of oil equivalent

LPG: Liquefied petroleum gas

MME: Ministry of Mines and Energy

MS: modern energy sources for cooking

OECD: Organisation for Economic Co-operation and Development

PNAD: National Household Sample Survey (for its acronym in Portuguese)

PNUD: United Nations Development Programme (for its acronym in Spanish)

RISE: Regulatory Indicators for Sustainable Energy

TS: traditional energy sources for cooking