Understanding the role of people´s preferences and perceptions in the analysis of residential energy transition: A meta-analysis

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Highlights

-Study highlights the importance of preferences in residential energy transition.
-Meta-analysis used data from 70 studies on fuelwood consumption and energy transition.
-Preferences and perceptions are undervalued compared to socio-economic variables.
-Inclusion of preferences into the studies reduces gender and income effects but schooling remains key.
-Findings stress education's role and the need for targeted sustainable energy policies.

Abstract

Fuelwood consumption in the residential sector has been widely studied worldwide, being family income and other socio-demographic variables commonly identified as its major drivers. In this review, we questioned these findings by including people´s preferences/perceptions and context-specific variables in the analysis, and their joint effect on households´ energy choices. For this purpose, we performed a meta-analysis based on an econometrical model covering 70 studies (228 observations) on fuelwood consumption and energy transition. We conclude that people´s preferences/perceptions have been undervalued in comparison to socioeconomic variables, which are more easily measured by using surveys –or they are already included in preexisting datasets-, especially when researchers are not familiar with local sociocultural and environmental contexts (traditions, status, and worldviews, among others). When people´s preferences/perceptions are included in models, the commonly detected effects of gender and family income on energy transition significantly decrease, while the effect of people´s schooling remains. This opens the discussion whether it is correct to tackle the dilemma about residential fuelwood consumption through policies that are based on variables like income, instead of more seriously trying to understand local contexts, and also it highlights the role that people´s schooling has on energy transition beyond economic aspects. If we take into account that people´s decisions about energy includes highly behavioral elements on the personal and household levels, shaped by education, we will be able to develop targeted public policies that allow for a more sustainable use of energy in the residential sector.

Keywords: energy transition, fuelwood, household energy consumption, cooking stoves, traditional fuels, logit

Introduction

Approximately 2.7 billion people worldwide rely on woodfuels and other solid biofuels, with a significant concentration in developing countries (FAO, 2022). In Latin America, these fuels are used by nearly 19% of the population, whereas usage reaches between 53% and 71% in various regions of Asia, and as high as 82% in Africa (IEA, 2022). Concurrently, FAO (2020) estimates that roughly half of global roundwood production, approximately 2.1 billion cubic meters annually, is utilized as woodfuels. Consequently, the consumption of these fuels holds immense social significance, particularly for the forestry and energy sectors, illustrating the critical link between forests and the world's most vulnerable populations.

Current data regarding wood energy sources is fragmented, making it difficult to establish a comprehensive baseline across fuelwood categories. However, it is evident that future wood energy consumption up to 2050 will be influenced by two main trends. Firstly, the traditional use of fuelwood is expected to persist in the rapidly growing regions of sub-Saharan Africa and Southern Asia. Secondly, there is a projected increase in the use of modern biomass for renewable energy generation. Forecasts suggest that global fuelwood consumption from forests could range between 2.3 billion and 2.7 billion m^3 by 2050, compared to 1.9 billion m^3 in 2020 (FAO, 2023).

Currently, approximately 4.4 million premature deaths annually are attributed to outdoor air pollution, while about 3.2 million deaths are due to indoor air pollution from traditional biomass used for heating and cooking (IEA, 2023). The majority of these deaths occur in emerging market and developing economies, where air pollution also exacts a significant economic toll. It is estimated that air pollution reduces global GDP by approximately 6%, with some emerging market and developing economies experiencing reductions of more than 10% per year (World Bank, 2022). Presently, nearly 2.3 billion people rely on traditional biomass, coal, or kerosene for cooking, predominantly in sub-Saharan African and developing Asian countries (IEA, 2023).

The use of solid biofuels has been largely studied by many researches along decades, as it is related to two very relevant topics: a) people´s health, as the combustion of these fuels in low efficiency devices produces high concentration of indoor air pollution, which results in about 3.8 million of premature deaths each year (WHO, 2022), and b) ecosystems´ health, as collecting/producing this biomass has been identified as one of the main drivers of forest degradation due to ilegal or unsustainable wood harvesting (Kissinger, Herold and De Sy, 2012, Masera et al., 2015, Spetch et al., 2021).

The consumption of solid biofuels and the related energy transition process are also associated to energy poverty, as households cannot afford cleaner or more efficient fuels to meet their energy needs (Reyes et al., 2019). Under this condition, households spend a significant share of their income in energy, and/or they are exposed to high indoor air-pollution levels, which is linked in both cases to inefficient technologies, either when it is related to rudimentary cooking stoves or when energy is used for heating poorly insulated houses (Schueftan et al., 2016).

Understanding residential energy consumption, and what drives people´s energy choices, is crucial to design programs and policies that allow addressing these social and environmental challenges. Countless studies have been performed in both rural and urban areas around the world to characterize residential energy consumption, and the sociodemographic variables that influence people´s energy choices. These studies have considered different aspects, being household income, decision maker´s schooling and gender, family size and other similar variables the most commonly used in these analyses (Kowsari and Zerriffi, 2011).

Based on some of these findings, public policies as well as private initiatives have been implemented to reduce household use of solid biofuels and its social and environmental impacts, however, consumption patterns have not significantly changed after these interventions (Guta et al., 2022).

In this context, the present research is a review of studies on household energy transition with a multidimensional focus on the residential context. It is of our particular interest to analyze the importance that people´s preferences and perceptions, and context-specific variables have on households´ energy choices, in comparison to sociodemographic variables that are usually included in these studies. We hypothesize that people´s and context more specific characteristics have been undervalued in comparison to socioeconomic variables that are easily measured by surveying. These are more difficult to identify and measure, especially when researchers do not know local people´s traditions, preferences and contexts.

For this purpose, a meta-analysis was developed based on an econometrical model covering 70 studies on woodfuel consumption and energy transition with a total of 228 observations. The meta-regression evaluates the likelihood of a positive effect on energy transition of the three most common findings in the literature regarding the influence of sociodemographic variables on the probability of shifting from the use of biofuels to other energy sources for household energy consumption. Therefore, our model uses household income, female head of household, and years of schooling as dependent variables and assesses their effect on energy transition when the independent variables are included, which are grouped into four categories: (1) demographic variables, (2) study characteristics, (3) people's preferences/perceptions, and (4) context-specific variables.

The first section of this document presents information on the theoretical context and other studies that have been conducted; the second section describes the methods that were used; the third section presents the results of the econometrical analysis; and the fourth and last section discusses the main findings in light of the current knowledge and offers some conclusions.

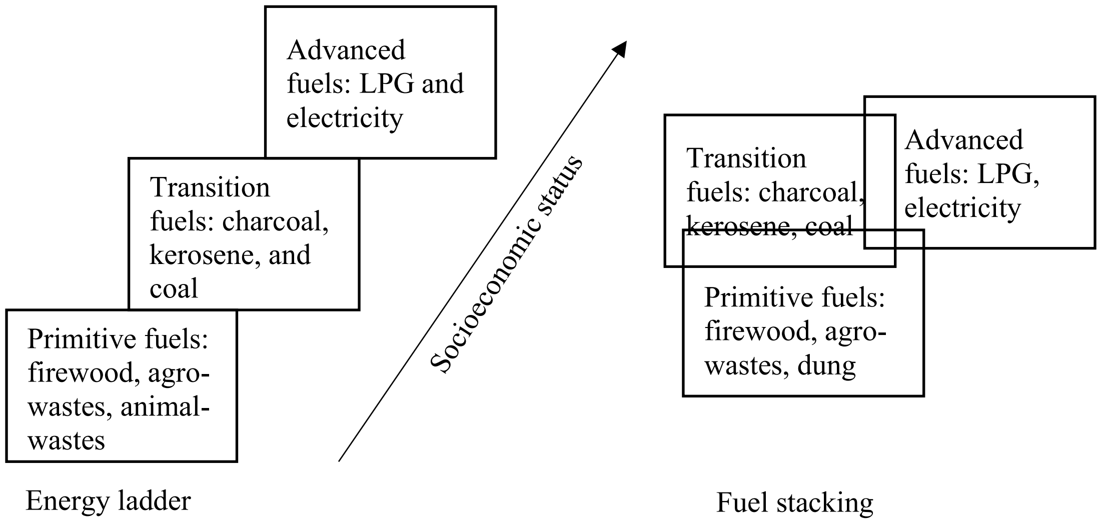
1. Background: energy transition, and people´s contexts

1.1. Theory

Energy transition relates to the economic development, which has been attempted to explain by the Theory of the Energy Ladder. This model relates energy use patterns of households to their economic status (Leach, 1992), and suggests that non-income factors have little effect on the household energy choice. Furthermore, it assumes that households totally replace one fuel by another as they climb up the ladder (Xing et al., 2017) (Figure 1).

Rather than a ladder of different preferences understood as a series of discrete leaps, another theory proposes a certain energy menu used by households to satisfy their energy needs, where energy sources can be taken in or out in a non-definitive way. This leads to a diverse energy mix where households choose to make use of a combination of different energy sources (Energy Stack Theory) (Van der Kroon et al., 2013; Masera et al., 2000).

Figure 1. Energy ladder versus fuel stacking



Source: Paunio, 2018; Xing et al., 2017

Trying to understand why and how energy transition occurs makes it necessary to identify the factors underlying residential energy demand. This has been quite a challenge, as the economic modelling of households´ behavior had to reduce the problem to the need to choose between fuel consumption versus the consumption of other goods (Poblete-Cazenave and Pachauri, 2018), or applying very sophisticated models and complex assumptions (Li and Just, 2018). The complexity arises from the fact that households do not chose freely and independently, but within their specific contexts.

In order to describe the complex decision-making process and establish a theoretical framework of household energy consumption, Van der Kroon et al. (2013; 2014) differentiate between external and internal factors that influence households´ decisions. External factors represent the context of the households and define the limits within which they make their choices. Internal factors are understood as the capabilities and opportunities of the household in accordance with its characteristics, such as family size, schooling, income, and other sociodemographic variables. But the household's set of capabilities and opportunities is also affected to a significant degree by the individual preferences of the individuals living in a household (Van Raaij and Verhallen, 1983; Cayla and Laurent, 2010; Van der Kroon et al., 2013; Zhou and Teng, 2013). Therefore, incorporating individual preferences as part of the internal factors that shape residential energy demand forces us to reconsider the true size of the effect of the other variables that are usually studied within the internal household factors.

1.2. Literature review

Literature addresses different household energy uses, such as cooking, heating or cooling. It is important to keep in mind that these final uses account for different amounts of energy consumption in different situations: across countries, rural-urban gradients, ethnicities, ecoregions, etc. This implies that, in some cases, public-policy discussions focus on the use of inefficient cooking stoves fueled with firewood, while in others, the problem is solely associated to the use of solid biofuels for heating, or it may even be a hybrid problem.
Energy transition implies the substitution of traditional fuels by more modern energy sources, which can be classified as traditional, transitional and modern energy sources (Table 1).

Table 1. Classification of energy sources

Categories	Energy sources
Traditional	Firewood, straw, harvest residues, dung, etc.
Transitional	Kerosene/oil, charcoal, coal
Modern	Electricity, LPG, natural gas, biogas

Source: based on Lokonon (2020); Malla and Timilsina (2014)

In the literature, different drivers of households´ fuel choice are described: household income, fuel prices, other sociodemographic characteristics, and what we have named people´s preferences and perceptions, and context-specific variables.
Household income is included in all econometrical studies as the main factor driving energy consumption and energy transition (Muller and Yan, 2018). Ouedraogo (2006) found that higher income results in households that prefer natural gas to kerosene in urban sectors of Burkina Faso. This transition pattern was also detected by Gupta and Köhlin (2006) in India, Lee (2013) in Uganda, Lay et al. (2013) in Kenya, among others.

However, more recent studies have shown that sometimes household income may not be significant, which mainly depends on the way this variable is measured (Chen et al., 2006; Zhang and Koji, 2012). Heltberg (2004; 2005) found evidence that contradicts the theory of the energy ladder, by showing that although in some contexts higher incomes could lead to people preferring more modern fuels, in others consumption of traditional fuels increase as household income increases, and traditional fuels are not completely replaced. Furthermore, studies have revealed that firewood is not always an inferior good, as it has been suggested (Lee, 2013; Heltberg, 2004; 2005). Unlike transitional and more modern energy sources, it seems traditional fuels have a relationship with people that has not been adequately understood.

When looking at fuel prices, there is abundant evidence showing the significant negative effects of fuel prices on fuel demand and on the probability of *choosing* such fuels (Muller and Yan, 2018). This is especially true in the case of traditional fuels such as firewood (Gupta and Köhlin, 2006; Nlom and Karimov, 2014), although the degree of the impact varies depending on the country, the year, and the energy type that is studied.

Researchers have not come to a definitive conclusion about the substitution effect that results from the price of other fuels. Mekonnen and Kohlin (2008) show that in urban sectors of Ethiopia the price of kerosene has a positive effect on the probability to shift toward solid fuels or a mix of solid and non-solid fuels. The same effect was observed in the price of firewood and the shift to a solid/non-solid mix, suggesting that solid and non-solid fuels are being replaced to a certain degree. This evidence is in accordance with the studies of Heltberg (2005) in Guatemala on the substitution process of LPG and firewood, as well as the results of the studies of Couture et al. (2012) in France, observing that the increase in firewood prices had a positive effect on the probability of choosing gasoline, gas or electricity. Other studies have even found complementarities, such as the case of LPG and firewood in Ghana (Akpalu et al., 2011) or Kenya, where Lay et al. (2013) reported a significant relationship between the price of kerosene and firewood consumption.

Regarding household´s sociodemographic factors, several studies have tried to capture this dimension through human capital. This variable does not only consider the educational level, it is also related to the composition of the household as to age, number of working persons in the household, and gender (Van der Kroon et al., 2013).

The influence of schooling has been considered central in the decision-making process of household energy choice. Mekonnen and Kohlin (2008) detected positive effects of education concerning the use of modern fuels in Ethiopia. Ozcan et al. (2013) saw the same effect in the case of transitional and modern fuels in Turkey. Some studies explain these findings from the opportunity cost of gathering traditional fuels, in terms of time and money when people´s education level increases (Muller and Yan, 2018). The pathway through which more education leads to the adoption of cleaner technologies is an area of active research, whether it is through increased wealth, having more information, improved critical decision-making, or changes to attitudes related to health and technology (Gould et al, 2020). Kar and Zeriffi (2018) suggested that objective conditions, like level of education, influence behavioral constructs such as perceptions and habits and may predict clean cooking adoption. Thus, the effect of education (or other objective condition) on increased likelihood of clean cooking adoption may be mediated by attitudes (Kar & Zeriffi, 2018).

Concerning family size, Farsi et al. (2007) found that this variable together with the head of household´s age has a positive effect on the probability of choosing cleaner fuels. In this context, a considerable effect of women being the head of the household was found when it comes to choosing cleaner fuel sources (Rahut et al, 2014). This may be an effect of their constant exposure to the pollution of conventional fuels' combustion (Dominguez et al., 2021), or because they tend to spend more income on education and health than men (Fingleton-Smith, 2018), thus when assessing energy technologies (especially for cooking), women are more prone to choose technologies that can have less hazardous effects (Mahat, 2004). Besides, as in most parts of the world, women are traditionally in charge of cooking and hence also of the gathering of firewood, so they would have a stronger interest in cleaner energy sources (Rahut et al., 2014).

Studies show other significant effects of the female head of the household in energy demand. Israel (2002) observed that energy expenses increase as the proportion of women with jobs increases. The increase in disposable income to buy new technologies is interrelated with other factors that appear when women enter the labor market. In low and middle-income countries, women generally have less control over financial resources, which leads them to have less status in decisions making (Yasmin & Grundmann, 2020), therefore the changes in energy consumption patterns within the household may be explained by the increase in women's bargaining power. Since they are traditionally in charge of collecting fuel for the family, changes in fuel sources may also be due to a higher opportunity cost when they enter the labor market (Muller and Yan, 2018).

On the other hand, context-specific variables that influence households´ energy choices can relate to public infrastructure, access to water and electricity, urban or rural location, etc., and to the fact that people´s preferences and perceptions relate to customs, environmental awareness, among others (Muller and Tan, 2018). Osiolo (2009) found that rural households are less likely to use modern fuels compared to households in urban areas mainly because of the poor infrastructure, which is added to lower incomes in comparison to urban households. People are also greatly influenced by their cultural background. Their preference for firewood, for example, has been associated to households with a stronger relation to indigenous cultures and traditional food (Israel, 2002). Taylor et al. (2011) studied the possible relationship between the increase of income of migrant families from Guatemala and the shift to gas-heated stoves. They found that although gas-heated stoves were almost universal in these households, 77% of households kept using firewood for the preparation of their traditional meals.

People´s perception about air pollution is another key aspect within the energy transition process. Studies in southern Chile show that the perception of the quality of fuels may vary depending on the socioeconomic strata, so the same public policy may fail to have transversal effects. While the medium/high socio-economic groups relate air pollution with illnesses, smoke and wood stoves, the lower socio-economic groups relate air pollution to firewood but not directly to respiratory illnesses (Alvarez and Boso, 2018).

Other context-specific variables, like public policies, are a corrective tool in the patterns of household energy consumption. Countries like Argentina have implemented subsidies for natural gas to avoid the consumption of solid biofuels. In central/southern Chile, policies to improve the insulation of dwellings, replace heating systems and promote high-quality firewood and other fuels have motivated households to shift from firewood to wood-pellets (Schueftan and González, 2013; Reyes et al., 2021).

2. Methodology: people´s preferences and contextual factors as drivers of energy transition

Assessing if sociodemographic variables are as decisive in the energy transition as it is mentioned in most of literature, after people´s preferences and context-specific variables are included in the models, is relevant for the future work on this field. Therefore, we conducted a meta-analysis evaluating the three most common findings in literature regarding the influence that sociodemographic variables have on energy transition, namely:

- **Household income has a significant and positive effect[1] on energy transition**. Therefore, higher family income increases the probability to shift from solid biofuels to more-modern energy sources.
- **The presence of a female head of household has a significant positive effect on the residential energy transition.** Female heads of households have often been found to choose cleaner energy sources.
- **Schooling of the head of household has a positive effect on energy transition**. Although this variable is usually collinear with income, studies included in this research considered one of the two or both, previously adjusted by proxies.

A meta-analysis is a systematic review of literature that allows using empirical study results on a research topic (Sánchez-Meca, 2010), applying statistical techniques. This methodology is very useful when it comes to define the state of the art of a study field, explaining the differences in the research results based on different assumptions, design standards, and measurements (Van der Kroon et al., 2013). Since the 1990s, this methodology has become more relevant in the field of environmental economy and natural resources (Nelson and Kennedy, 2009; Sebri, 2015), as it allows for an unbiased analysis. The details of this methodology are developed in the following section.

a) Search and selection protocol: characterizing the dataset

[1] With a confidence level of 95% or more. This same criterion was used for the level of education and sex of the household head.

Following the recommendations of Nelson and Kennedy (2009), we selected a searching strategy, which considered the following inclusion criteria in order to identify relevant scientific studies:

1. Papers analyzing residential energy demand (for heating, cooking and other uses), studying the probability of a household preferring one fuel type over another.
2. To determine this probability, the selected studies must use quantitative methods that allow for the mathematical interpretation of the probability of fuel replacement.

To minimize selection bias (Sánchez-Meca, 2010), the search for these studies applied formal and informal methods. In order to ensure the reliability of the process, three different people carried out the search independently and discussed the selected studies. The formal sources covered the main journals on environmental economy and natural resources and a series of keywords, while the informal methods included the review of the literature used by studies collected from the formal sources.

b) Meta-regression model

Usually, a meta-analysis uses a fixed effects model or a random effects model (Sánchez-Meca, 2010). However, as the effect we were looking for is a categorical variable, it is more appropriate to apply a logistic meta-regression (logit model) (Sebri, 2015). Three different logit regressions were run, using the following dependent variables: household income (1 if the *i* study found a significant positive effect on energy transition, 0 otherwise), female head of household (1 if the *i* study found a significant positive effect of women energy transition, 0 otherwise), and schooling (1 if the *i* study found a significant positive effect of years of schooling on energy transition, 0 otherwise); while the moderating variables were grouped into four categories: (1) demographic variables (I_h), (2) characteristics of the study, and (3) people´s preferences/perceptions, and context-specific variables.
The probability that a study will find one of the three relationships is given by:

$$Prob(Y_i = 1) = \frac{e^{\beta_i' X_i}}{1+e^{\beta_i' X_i}} \; i = 1, \dots, N \qquad \text{Equ. (5)}$$

With N being the number of studies, X is a characteristic vector for the study and the specific factors included in the methodology (Table 2), and β is the vector that holds the estimated coefficients according to the maximum likelihood estimation method. Regressions were weighted considering the number of observations of each study, and clusters were generated to include standard errors at a continental level. Logit regressions were used because the goal is to analyze the probability of each of the three variables of interest separately. This technique allows modeling the relationship between a binary dependent variable and one or more independent variables, providing a clear understanding of how each variable of interest affects the probability of the event under study. Logit regressions were preferred over probit due to their computational simplicity and efficiency in estimation, in addition, the logistic function used in the logit model has longer tails than the standard normal function of the probit, which can make the logit more robust to extreme values in the data.

Table 2. Detail of the independent variables included in the logistic meta-regression.

General characteristics of the study	**Characteristics of the household**
Year of publication	Gender of the head of household
Period studied (short term=less than 1 year), long term=several years)	Education
Type of data (rural/urban)	Household size
Data source (primary or secondary data)	Family income
Preferences and perceptions	**Context specific**
Environmental awareness, or perceptions regarding certain fuels	Price of the fuel
Indigenous ancestry	Availability of fuel
Cooking practices	Internal facilities (For example, having a connection to the gas or electricity grid in the house)

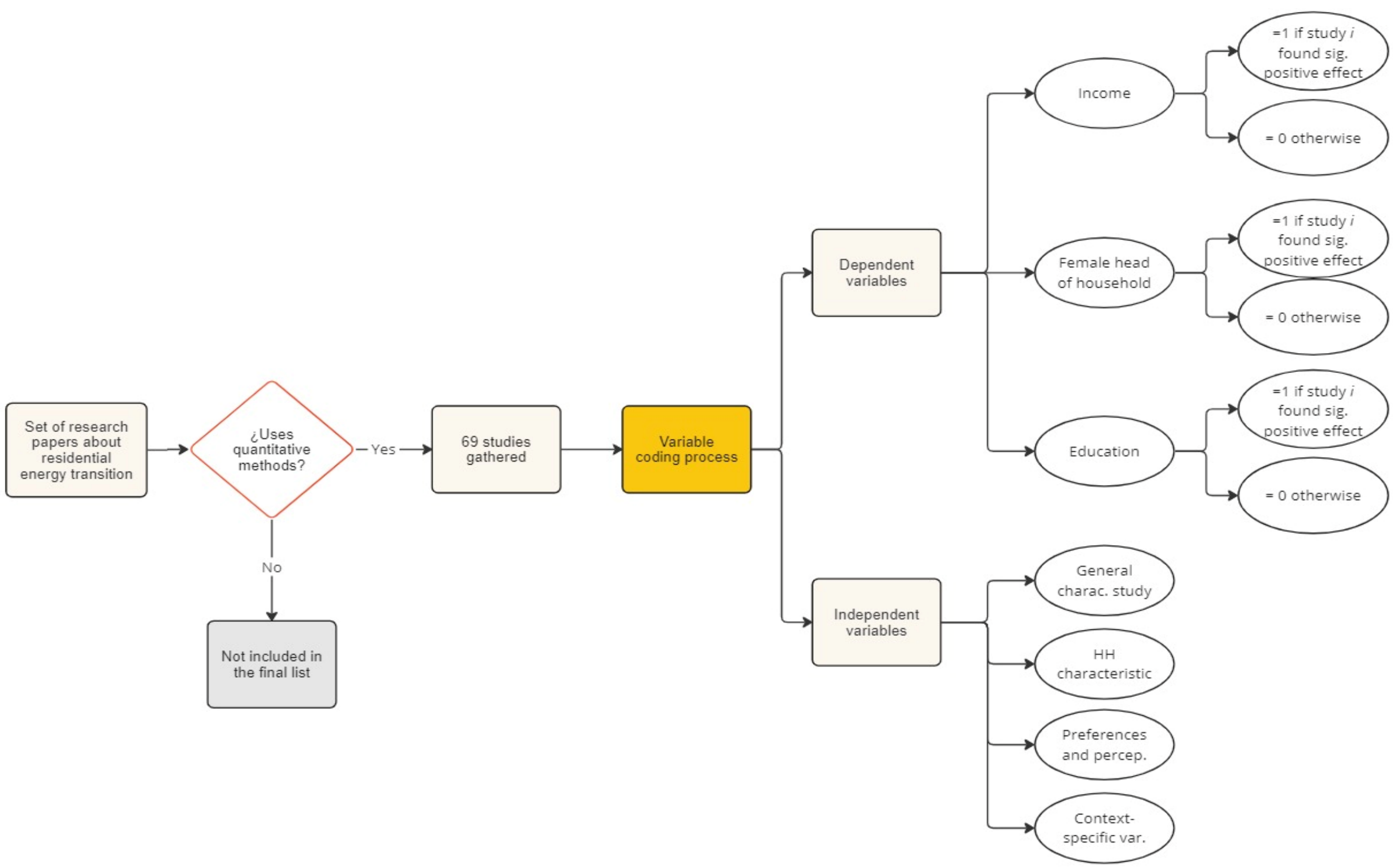
A database was elaborated based on the collected studies, accounting for the effect on energy transition (positive, negative or insignificant) for each variable. It is necessary to remember that the selected papers study the probability of a household switching from one fuel to another, therefore there is a great heterogeneity of fuels included in each study. In order to make reliable comparisons among studies, only two fuel types were considered at each stage of energy development: (1) traditional fuels: firewood or residues; (2) transitional fuels: charcoal/coal or kerosene; and (3) modern fuels: electricity or LPG. Based on this classification, in Table 3 option a) corresponds to a negative transition, associated to a deterioration of the quality of energy sources used, while options b) and c) correspond to positive transitions. These possible fuel transitions were coded as dummy variables taking the value 1 if the study *i* considered within its regressions the probability of using firewood or residues over any transitional or modern energy source, 0 otherwise, and the same with options b) and c) on Table 3.

Table 3. Possible fuel transitions

Potential transitions	Considered options
a) Choice of traditional fuels versus transitional or modern	Probability of using firewood or residues instead of any transitional (charcoal, coal or kerosene) or modern (electricity or LPG) energy source
b) Choice of transitional fuels versus traditional	Probability of using charcoal, coal or kerosene instead of traditional energy sources (firewood or residues)
c) Choice of modern fuels versus traditional	Probability of using electricity or LPG instead of transitional fuels (firewood or residues)

Our model analyses whether there is a positive or negative probability that the studies find any of the three most common findings regarding the influence of sociodemographic variables (positive effect of income, female head of household, or years of schooling on energy transition), once these studies include the independent variables mentioned in Table 2, depending on whether they have found positive, negative or non-significant results of the those variables in the residential energy transition (figure 2) (being considered as energy transition the options b) and c) of Table 3). To do so, we coded each regression in each paper, according to the type of transition it captured, and the direction and significance of its variables.

Figure 2. Methodology flowchart



For example, if one paper shows three regressions, one capturing the transition from one solid fuel to another, a second capturing the transition from solid to transition fuel, and a third regression capturing the transition from solid to advanced fuel, our database will contain three rows, one for each regression. Each variable included in those regressions will be coded with the number 1, if the regression shows a positive significant effect of that variable in the energy transition, number 2 if it shows a negative significant effect on the energy transition, or 3 if the effect is not significant. These will be the independent variables included later in our meta-regression.

We then filtered for those rows that captured only an ascending energy transition (i.e, from traditional to transitional energies, transitional to modern, or traditional to modern), which in this example would leave apart the first row (solid fuel to solid fuel). Thus, our meta-regression captures the probability that the studies find a positive effect of income, female head of household, or years of schooling on energy transition, once those studies include the independent variables that were coded according to the direction of their effect in the energy transition and significance, and which were grouped according to Table 2.

One of the main problems when conducting a meta-analysis is the publication bias (Begg and Berlin, 1988). This means that the results obtained in a certain study may affect its probability of being or not being published. In order to deal with this problem, we added a moderating variable to the search and selection protocol, which indicates if the study was published in a journal or is a working paper, thus controlling the potential systematic differences between both types of studies.

In addition, meta-regressions are subject to heterogeneity, because the reviewed studies use different methodologies, include different explanatory variables and functional forms. Furthermore, the heteroscedasticity that results from varying sample sizes and focuses can be problematic (Nelson and Kennedy, 2009), and the use of data sources from more than one primary study may result in observations which are not independent. To address this issue, one of the selection requirements was that the studies had developed a logit or multinomial model, which have the same functional form, leaving the probit model aside, as the results obtained are similar to the estimations produced by the other two methods. Our meta-regression used the logit method, weighted by the natural logarithms of the sample sizes of each study. Besides, a logit weighted with standard errors per study was developed.

3. Results

3.1. Descriptive statistics

Our dataset included 228 regressions from 70 studies. The main characteristics of these studies are described in the Table 4.

Table 4. Overview of the studies reviewed in the meta-analysis

Aspect	Description
Energy use	Cooking, heating, general (not specified)
Identification strategies	Multinomial logit, Logit, Multinomial probit
Continents:	
Africa	30
Asia	30
Europe	3
Latam	6
Year of publication	
before 2000	2
between 2000 and 2010	15
between 2010 and 2021	52

Out of 228 identified regressions, 112 capture the effect of gender on the probability of choosing different energy sources. In the case of male head of household, out of 52 regressions, 32 show no significant results (62%) (Male head of household would not be relevant to household energy choices). By contrast, in the case of female heads of households, out of 60 regressions, 34 show a significant relationship with the probability of choosing different energy sources (57%), mainly cleaner fuels (kerosene, gas and electricity). Table 5 shows the impact of gender on the probability of choosing any type of energy source (traditional, transitional or modern). No regression shows a significant positive effect on the use of traditional fuels (firewood and residues).

Table 5. Impact of gender on the probability of choosing different energy sources

Type	Energy Source	Male head of household				Female head of household			
		(+)*	(-)*	NS	Total	(+)*	(-)*	NS	Total
Traditional	Firewood	2	2	6	10	0	9	8	17
		20%	20%	60%	100%	0%	53%	47%	100%
	Residues	0	0	2	2	0	1	0	1
		0%	0%	100%	100%	0%	100%	0%	100%
Transitional	Charcoal/coal	0	4	4	8	3	1	4	8
		0%	50%	50%	100%	38%	13%	50%	100%
	Kerosene	2	0	5	7	2	2	8	12
		29%	0%	71%	100%	17%	17%	67%	100%
Modern	Electricity	0	8	7	15	7	1	3	11
		0%	53%	47%	100%	64%	9%	27%	100%
	Gas	0	2	8	10	5	3	3	11
		0%	20%	80%	100%	45%	27%	27%	100%
	Total	4	16	32	52	17	17	26	60
		8%	31%	62%	100%	28%	28%	43%	100%

First row frequencies, second row percentages

(+)*: Significantly Positive

(-)*: Significantly Negative

NS: Not Significant

Moreover, out of 228 observations 212 included the variable “family income”. As it was expected, identified studies find that income is directly related to the probability of using transitional and modern fuels (Table 6), which aligns with the energy ladder theory. In addition, the head of the household´s schooling is included in almost all available regressions in selected studies, and it is positively related to the probability of choosing more advanced fuels, which again, aligns with the most common findings in the literature (Table 7).

Table 6. Impact of family income on the probability of choosing different fuels

Type	Energy Source	Family Income			
		(+)*	(-)*	NS	Total
Traditional	Firewood	4	41	8	53
		8%	77%	15%	100%
	Residues	0	0	3	3
		0%	0%	100%	100%

Transitional	Charcoal/coal	16	7	6	29
		55%	24%	21%	100%
	Kerosene	20	10	0	30
		67%	33%	0%	100%
Modern	Electricity	32	2	10	44
		73%	5%	23%	100%
	Gas	40	3	10	53
		75%	6%	19%	100%
	Total	112	63	37	212
		53%	30%	17%	100%

First row frequencies, second row percentages

(+)*: Significantly Positive

(-)*: Significantly Negative

NS: Not Significant

Table 7. Impact of schooling on the probability of choosing different fuels

Type	Energy source	Primary Education				Secondary education				Tertiary education			
		(+)*	(-)*	NS	Total	(+)*	(-)*	NS	Total	(+)*	(-)*	NS	Total
Traditional	Firewood	1	15	6	22	0	16	6	22	0	16	7	23
		5%	68%	27%	100%	0%	71%	27%	100%	0%	72%	28%	100%
	Residues	1	9	5	15	1	10	5	16	0	10	6	16
		7%	60%	33%	100%	3%	65%	32%	100%	0%	66%	34%	100%
Transitional	Charcoal/coal	4	4	12	20	7	5	10	22	4	5	13	22
		22%	20%	59%	100%	31%	22%	47%	100%	16%	23%	60%	100%
	Kerosene	10	5	8	23	9	5	10	24	9	5	10	24
		42%	22%	36%	100%	37%	20%	43%	100%	36%	21%	43%	100%
Modern	Electricity	18	2	10	30	21	2	10	33	23	2	8	33
		57%	8%	34%	100%	63%	6%	31%	100%	71%	5%	25%	100%
	Gas	26	0	12	38	29	1	12	42	32	1	9	42
		67%	0%	33%	100%	68%	2%	29%	100%	77%	1%	22%	100%
	Total	60	35	53	148	67	39	55	161	68	39	53	160
		40%	24%	36%	100%	42%	24%	34%	100%	43%	24%	33%	100%

First row frequencies, second row percentages

(+)*: Significantly Positive

(-)*: Significantly Negative

NS: Not Significant

Concerning people´s preferences and perceptions (cooking practices, indigenous background and environmental awareness) 81 out of 228 observations included these aspects (36% of the sample) (Table 8). This smaller proportion of observations is understandable if we consider that self-preferences and perceptions variables are not commonly captured in government surveys that are generally used to carry out energy transition studies. About context-specific variables, 161 out of 228 observations included these aspects (71%).

Table 8. Impact of people´s preferences/perceptions and context-specific variables on the probability of choosing different fuels

Type	People´s preferences and perceptions				Context-specific variables			
	(+)*	(-)*	NS	Total	(+)*	(-)*	NS	Total
Trasitional and modern	25	32	24	81	57	56	48	161
	31%	**40%**	29%	100%	**35%**	**35%**	30%	100%

First row frequencies, second row percentages

(+)*: Significantly Positive

(-)*: Significantly Negative

NS: Not Significant

Note: people´s preferences/perceptions and context-specific variables correspond to diverse aspects that can have positive and negative impacts on the probability of choosing transitional and modern energy sources.

3.2. Statistical analyses

Trends observed in the literature, specifically concerning the positive significance of gender, income, and schooling in the transition to more advanced energy sources, was tested through three logistic meta-regressions. Results are presented in the following tables as marginal effects. The first three variables in Table 9 are included to reduce the possibility of correlation between the error term and the dependent variables, and therefore reduce possible bias.

Table 9. Average and weighted marginal effects by continent clusters (robust standard errors)

Variables	(1) Significance (+) of female head of HH	(2) Significance (+) of family income	(3) Significance (+) of head-HH´s schooling

Duration (short term studies, <1 year)	0.198***	-0.0266	0.0243
	(0.0695)	(0.103)	(0.284)
Method (multinomial Logit, ML)	-0.155	-0.171***	-0.134*
	(0.125)	(0.0537)	(0.0792)
Secondary information source	0.137	-0.314*	0.442***
	(0.107)	(0.187)	(0.145)
Location (rural)	-0.330**	0.00978	0.0450
	(0.135)	(0.0256)	(0.0457)
People´s preferences and perceptions	-0.146**	-0.236***	0.340
	(0.0714)	(0.0859)	(0.308)
Context-specific variables	0.0169	0.265*	0.174
	(0.154)	(0.144)	(0.178)
Female head of household		-0.0527	0.0525
		(0.0633)	(0.180)
Education effect	0.592***	-0.387***	
	(0.145)	(0.0887)	
Observations	90	196	153
Continent dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes

Standard errors in brackets. *** p<0,01, **p<0,05, *p<0,1

Regarding the first meta-regression, we seek to assess the impact of gender on energy transition (i.e from traditional to transitional, transitional to modern, or traditional to modern). This reduces the original 112 regressions capturing the effect of gender on the probability of choosing different energy sources to 90 shown in Table 9.

When peoples´ preferences and perceptions are included in models, the influence of *"female head of household"* on moving upward to transitional and more advanced energy sources is lower. Therefore, the role of the variable "*female head of household*" would be overestimated by literature in detriment to local preferences and perceptions that are usually invisible for researchers (especially when researchers are foreigners). At the same time, if only rural cases are analyzed, the influence of *"female head of the household"* on energy transition drops dramatically, which may have to do with the fact that in rural areas women tend to play a less important role in decision-making. It also interesting to note the positive effect of adding the educational level of the *"female head of the household"* in the probability that they promote energy transition. This very much follows findings of the literature and reaffirms the importance of including this variable as a proxy of higher human development, and access to information for women (Shrestha et al., 2021). Finally, we can observe a positive effect of "*female head of household*" on energy transition when analyses are based on short-term studies (<1 year). So, in studies that consider medium or long-term data, the effect of "*female head of household*" on energy transition tends to be less significant.

Moreover, including people´s preferences and perceptions in models reduces the probability that *"family income"* positively influences the transition toward transitional or more advanced energy sources (n=196). This is a relevant finding, as most studies include income or proxy variables in analyses of residential energy transition, which again indicates the possible overestimation of income when it comes to household energy decisions, in detriment to local characteristics that are less visible for researchers. Whereas, head of household´s schooling has a negative effect on the probability that *"family income"* pushes energy transition. This could seem counter-intuitive, but it is not, as a higher education of decision makers would result on reducing its impact on energy transition. Therefore, *"family income"* would be more relevant to drive energy transition at lower levels of schooling, which questions its importance in the energy transition theory and it would be relevant, mainly at lower levels of people´s education. The opposite effect has context-specific variables, like fuel prices and public infrastructure, which increase the effect of *"family income"* on promoting energy transition.

Finally, the influence of the head of household´s schooling on energy transition is analyzed in the last column of Table 9 (n=153). Unlike the other two variables (gender and family income), people´s preferences and perceptions and context-specific variables do not influence the impact of schooling on moving to transitional or more advanced energy sources. Hence, people´s schooling would be a stronger variable in models of energy transition, in terms of its independence to other, more local, aspects that are not usually considered in these studies. As literature indicates, the trend is that a higher educational level increases the probability of shifting to higher quality fuels (Mekonnen and Kohlin, 2008; Özcan et al., 2013; Muller and Yan, 2018), which would be pretty stable according to these results. Moreover, the use of secondary information sources increases the effect of people´s schooling on moving up energy transition process.

The results lead to the conclusion that once local preferences and perceptions are incorporated into the analysis, the commonly identified factors in the literature lose their impact on driving energy transition. When these variables are integrated into models, the typical effects of gender (female head of household) and family income on energy transition diminish. Research that takes into account people's preferences and perceptions generally shows a reduced influence of female head of household and family income on energy transition. Furthermore, the impact of education on energy transition is notably significant, particularly as it interrelates with gender, to promote the adoption of transitional and more modern/cleaner energy sources. Besides, higher levels of education reduce the relevance of family income on energy transition. Decision makers' education was the only factor that remained unaffected by people's preferences, perceptions, and context-specific variables, underscoring education as a critical driver of energy transition.

4. Limitations

The use of meta-analysis in economic research is not without significant limitations that must be considered. Although conducting a meta-analysis is an efficient method to synthesize results from various studies using quantitative techniques (Shelby & Vaske, 2008), combining studies can introduce potential errors and biases when interpreting relationships between variables for several reasons.

First, bias can arise from the diversity in methodologies, sampling designs, or variable measurements used in the studies, making it difficult to compare results accurately. To address this issue, we have selected only studies employing probabilistic methodologies (logit, probit, and their variations). In our regressions, we have included a control variable for the specific type of methodology used in each study. Regarding the different variable measurements, we have coded the sign of the effect (positive, negative, or non-significant results of variable X on the residential energy transition) instead of the magnitude of the effect to enable reliable comparisons among studies. To manage sampling design issues, we controlled for whether the data in each study was gathered from primary or secondary sources.

Secondly, bias can stem from mixing studies of varying methodological quality. Several researchers suggest that evaluating the quality of each study can mitigate this problem (Finckh & Tramer, 2008; Shelby & Vaske, 2008). This is in addition to a third source of bias, the selection bias, that can occur when studies are sourced only from certain outlets. To deal with this issue and ensure the reliability of the process, three researchers independently conducted the search in formal sources but also through informal methods, discussing the selected studies before the coding process.

However, some limitations of meta-analyses, such as publication bias, are more challenging to overcome. Studies with non-significant findings are often unpublished, contributing to this bias (Hedges, 1992). To mitigate this issue, establishing a clear standard for study inclusion can help reduce publication bias by not aiming to cover all studies (Shelby & Vaske, 2008), which is the approach adopted in the present study. Additionally, the methodology used in this paper restricts us from analyzing further variables that could represent a useful input in the discussion, such as the age of decision-makers. This variable was not included because it was not a common denominator in the majority of the studies considered, and the aim was to standardize as many variables as possible. It remains an open opportunity for future research in the area.

5. Discussion

In this article, we found that the influence of common factors previously detected in the literature lose influence on driving energy transition, once local people´s preferences and perceptions are introduced into the analyses. By analyzing the findings of this systematic review (n=228), the relevance of including people´s preferences and perceptions in studies about energy transition becomes significant. When these variables are included in models, the commonly detected effects of gender (*female head of the household*) and *family income* on energy transition decrease. Studies that include people´s preferences and perceptions usually reveal a lower impact of *female head of household* and *family income* on energy transition. This opens the discussion whether it is correct to tackle the energy problem with policies that are based on these aspects, and leave aside others that better characterizes the local dimension of energy transition (Steg et al., 2015; Baptista, 2018).

Additionally, the role of decision makers´ schooling on energy transition becomes very significant, as it positively interacts with gender (*female head of household*) to advance toward transitional and more modern/clearer energy sources. A higher education also reduces the weight of *family income* on energy transition, which questions the importance that this variable has been made in most of the literature about this topic (Guta et al., 2022). This is one of the key findings of this research. At the same time, decision makers´ schooling was the only variable that did not interact with people´s preferences and perceptions and context-specific variables, which reinforces the idea of education as a key driver of energy transition, beyond *family income*. Energy transition theories (the energy ladder and the fuel stacking) should include the idea of "thresholds", where different drivers would participate in pushing decision-makers to adopt new fuels along a socioeconomic gradient (income/education), which would be strongly influenced by local contexts.

Concerning this idea, it will be necessary for future studies on energy transition to focus more on the context of the studied population, as these variables greatly influence the impact of the decision maker´s acceptability of energy transition processes (Steg et al., 2015; Perlaviciute et al., 2018). The results of our logistic meta-regression make it clear that including these variables, such as judgments about local air pollution, perceptions regarding certain fuels (culturally biased), indigenous ancestry, and cooking practices, will influence the probability that gender and family income drive energy transition toward transitional or more modern energy sources (kerosene, LPG, electricity, etc.). This means that not including these variables may affect the study results and lead to overestimate the impact of some variables on energy transition. The problem, however, is not the fact that these variables are not included in most studies, it rather has to do with the poor availability of these data. Surveys typically register income and educational levels, head of the household´s gender, family size and other variables that are easier to measure by surveying. These variables have been considered relevant for energy transition by literature for decades in a self-reinforced process. It is possible that the reported relevance of these classical variables is given partly by their availability and not their degree of causality.

One of the reasons why studies on energy transition have not focused more on the context variables may be that research is mostly financed by developed countries to be implemented in poor or developing countries. Therefore, most of this work is carried out by researchers from outside the country with very low representation of local researchers and there is a perception that with the perspective of academia from developed countries the problems in very different contexts will be solved (Nunn, 2019).

The fact that the research on energy transition is carried out by researchers from outside the country where the problems are occurring reduces the possibility of including different visions and of having a richer dialogue in terms of perspectives. Furthermore, local researchers have the advantage of first-hand knowledge of the context regarding energy use, and have an additional interest in aspects that affect their own future (Amarante et al, 2021). This type of research, conducted from external points of views, may produce results that are the consequence of an incomplete or incorrect perception/interpretation of the cultural and social logics of a particular context. This is especially relevant because the incomplete information and lack of local knowledge could lead to public policy recommendations that are not appropriate and disconnected from local institutions, culture, geography and the particularities of each case (Das et al., 2013; Nunn, 2019).

The latter is relevant, as many programs and policies have been designed based on assumptions concerning the influence of gender and income on household energy choices. According to Guta et al. (2022), programs aimed to improve wood/cooking stoves and transition toward cleaner fuels in developing countries have not fully or even partially achieved the replacement of solid fuels from the households´ energy menu. As Abhishek and Zerriffi (2018) detected, these programs require specific target-group strategies to promote energy transition, which should also take into account post-intervention activities oriented to supporting families in the process of using new technologies and monitoring impacts on people wealth being.

Therefore, it is of utmost importance to focus on people´s preferences and perceptions, as on context-specific variables. If we understand that energy demand includes highly behavioral elements on the personal and household levels (Van der Kroon et al., 2013), and that it cannot be properly described without focusing on people´s contexts, preferences and perceptions, we will be able to better identify the relevant variables and develop targeted public policies which really enabling energy transition.

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Annex.

1. Details of the studies included in the metaregression

Paper	Fuels	Econometric Model	Country Studied	Fuel uses	N° of observations
Hosier y Dowd (1987)	Fuel wood, Charcoal, Kerosene, Electricity	Multinomial Logit	Zimbabwe	Cooking	2
Heltberg (2004)	Solid, Non Solid	Multinomial Logit	Grupos	Cooking	30
Ouedraogo (2006)	LPG, Firewood, Charcoal, Kerosene	Multinomial Logit	Burkina Faso	Cooking	3
Gupta y Kohlin (2006)	Fuelwood, coal, kerosene, LPG	Probit	India	Cooking	4
Rao y Reddy (2007)	Firewood, LPG, Kerosene, Electricity	Multinomial Logit	India	General	4
Farsi et al. (2007)	Firewood, Kerosene, LPG	Ordered Probit	India	Cooking	2
Mekonnen y Kohlin (2009)	Solid, Non Solid, Mix	Multinomial Logit	Ethiopia	General	4
Couture et al. (2012)	Fuelwood, electricity, kerosene, LPG	Multinomial Logit	France	General	1
Michelsen y Madlener (2012)	Gas,oil, heat pump, pellet	Multinomial Logit	Germany	Heating	4

Nnaji et al. (2012)	Charcoal, kerosene, wood	Multinomial Logit	Nigeria	Heating	2
Guta (2012)	Traditional fuels, mixed, modern fuels	Multinomial Logit	Ethiopia	Cooking	1
Gebreegziabher et al. (2012)	Wood, charcoal, kerosene, electricity	Multinomial Probit	Ethiopia	General	4
Ozcan et al. (2013)	Coal, natural gas, electricity, Liquid fuel, Dung and other, wood	Multinomial Logit	Turkey	Cooking	4
Kwakwa et al. (2013)	Electricity, kerosene, charcoal, LPG, firewood	Logit	Ghana	General	5
Suliman (2013)	LPG, biogas, kerosene, Charcoal, wood, straws, animal dung, crop residuals	Multinomial Logit	Sudan	General	1
Lay et al. (2013)	Kerosene, wood, electricity, solar, torch	Multinomial Logit	Kenia	Lighting	2
Lee (2013)	Non-solid fuels (kerosene and electricity), solid fuels (charcoal and firewood), mix	Multinomial Logit	Uganda	General	4
Rahut et al. (2014)	Kerosene, candles, electricity, others	Multinomial Logit	Bhutan	General	2
Andadari et al. (2014)	LPG, firewood, kerosene	Logit	Indonesia	Cooking, Heating and Lighting	1
Baiyegunhi & Hassan (2014)	Fuelwood, kerosene, natural gas & electricity	Multinomial Logit	Nigeria	Cooking	3
Hugues y Karimov (2014)	Firewood, Kerosene, LPG	RE Multinomial Logit	Cameroon	Cooking	2
Karimu (2015)	Modern, solid and transition fuels. LPG, fuelwood, charcoal.	Multinomial Probit	Ghana	Cooking	3
Behera et al. (2015)	Fuelwood, Dung cake, LPG and electricity, Kerosene, Biogas, others	Multinomial Probit	Bangladesh, India, Nepal	Cooking	4
Alem et al. (2016)	Biomass, non biomass and mixed	RE Multinomial Logit	Ethiopia	General	1
Moeen et al. (2016)	LPG, firewood, waste	Multinomial Logit	Pakistan	Cooking	2
Adeyemi & Adereleye (2016)	Fuelwood, kerosene, cooking gas	Multinomial Logit	Nigeria	Cooking	2
Rahut et al. (2016)	Electricity, LPG and kerosene, fuelwood, other	Multinomial Logit	Ethiopia, Malawi, Tanzania	Cooking	1
Zhang y Hassen (2017)	Firewood, LPG, coal	RE generalized	China	Cooking	2

		ordered probit (RE)			
Buba et al. (2017)	Electricity, charcoal, natural gas, kerosene, firewood	Multinomial Logit	Nigeria	Cooking and Heating	4
Yuni et al. (2017)	Kerosene, electricity & gas, coal, firewood	Multinomial Logit	Nigeria	Cooking and Lighting	3
Joshi y Bohara (2017)	Traditional, transitional, modern	Multinomial Logit	Nepal	Cooking	2
Paudel et al. (2018)	LPG, wood, straw/shrubs	Multinomial Logit	Afghanistan	Cooking	1
Curtis et al. (2018)	Not net-worked, gas, electricity	Multinomial Logit	Ireland	Cooking	2
Danlami et al. (2018)	Firewood, electricity & gas, kerosene	Multinomial Logit	Nigeria	Cooking	2
Damayanthi (2018)	Wood, transitional, LPG	Ordered Probit	Sri Lanka	Cooking	3
Muller y Yan (2018)	No switching (wood/straw-only or coal-only or mixed wood/straw-coal), partial switching (mixed wood/straw-LNG or mixed wood/straw-electricity or mixed coal-LNG or mixed coal-electricity), full switching (LNG only, or electricity only or mixed LNG-electricity)	RE Multinomial Logit	China	Cooking	3
Choumert-Nkolo et al. (2019)	(i) Traditional fuels: wood fuels and animal residue; (ii) Transition fuels: charcoal and (iii) Modern fuels: LPG, kerosene and electricity	Multinomial Logit	Tanzania	Cooking and Lighting	2
Liao, Chen, Tang & Wu (2019)	Firewood, gas, coal, electricity	Multinomial Logit	China	Cooking	3
Kuo & Azam (2019)	Clean only, mixed	RE Multinomial Logit	India	Cooking	2
Imran et al. (2019)	Residue, firewood, LPG, natural gas, electricity, renewable	Multinomial Probit	Pakistan	General	3
Mangula et al. (2019)	Firewood, charcoal, electricity, LPG	Multinomial Logit	Tanzania	Cooking	1
Rahut et al. (2019)	Gas, fuelwood, dung cake & crop residue	Multinomial Logit	Pakistan	Cooking	1
Pye et al. (2020)	LPG, any other	Logit	Cameroon	Cooking	1

Jaime et al. (2020)	Fuelwood, LPG, kerosene, electricity, coal	Multinomial Logit	Chile	Cooking and Heating	3
Lokonon (2020)	Traditional fuels, transition fuels, modern fuels	Multinomial Probit	Benin	Cooking	3
Chaudhuri y Pfaff (2003)	Wood, dung, biomass, natural gas, LPG & kerosene	Multinomial Probit	Pakistan	Cooking	2
Chen et al. (2023)	Coal, fuelwood, electricity, LPG & natural gas	Multinomial Logit	China	Cooking	1
Christiansen y Heltberg (2014)	Coal, charcoal, fuelwood, LPG, electricity & biogas	RE Multinomial Logit	China	Cooking	1
Debebe et al. (2023)	Electricity, charcoal, fuelwood, dung & crop residue	Multinomial Probit	Ethiopia	Cooking	5
Edwards y Langpap (2005)	Wood, LPG, Electricity, Coal & kerosene	RE Multinomial Logit	Guatemala	Cooking	3
Gebreegziabher et al. (2009)	Wood, charcoal, kerosene & electricity	Probit	Ethiopia	Mix	4
Gundimeda y Kohlin (2008)	Fuelwood, kerosene, electricity & LPG	Multinomial Logit	Tanzania	Mix	24
Heltberg (2005)	Electricity, LPG, Kerosene, Charcoal & Firewood	Multinomial Logit	Guatemala	Cooking	4
Hou et al. (2018)	Biomass, coal, gas & electricity	Multinomial Logit	China	Cooking	3
Israel (2002)	Firewood, kerosene & LPG	Probit	Bolivia	Cooking	1
Karimu et al. (2016)	LPG, kerosene, charcoal & firewood	Probit	Ghana	Cooking	2
Katutsi et al. (2020)	Firewood, charcoal, kerosene, gas & electricity	Multinomial Logit	Uganda	Cooking	3
Koirala y Acharya (2022)	Firewood, dungs, agriculture residues, kerosene, biogas, LPG, electricity & solar power	Multinomial Logit	Nepal	Cooking	1
Lamarre-Vincent (2011)	Firewood, kerosene & LPG	Multinomial Logit	Indonesia	Cooking	3
Ma et al. (2022)	Liquid gas, electricity, natural gas, methane, solar energy, firewood & coal	Multinomial Logit	China	Cooking	2
Mottaleb et al. (2017)	Biomass, kerosene, gas & electricity	Multinomial Probit	Bangladesh	Cooking	4
Peng et al. (2010)	Electricity, LPG, biogas, coal, kerosene, diesel,	RE Multinomial Logit	China	Mix	1

	petrol, firewood, straw & charcoal				
Rahut et al. (2017)	Electricity for lighting only and for lighting and heating	Multinomial Logit	Bhutan	Mix	2
Reddy (1995)	Firewood, charcoal, kerosene, LPG & electricity	Multinomial Logit	India	Cooking	8
Soltani et al. (2019)	LPG, electricity & kerosene	RE Multinomial Logit	Iran	Cooking & Heating	6
Wang et al. (2022)	Clean fuels (electricity, natural gas, solar and wind) and dirty fuels (fuelwood, coal, dung and crop residues)	Probit	Tibet	Mix	1
Waweru y Mose (2022)	Firewood, kerosene, charcoal, LPG, electricity & residues	Multinomial Logit	Kenya	Cooking	2
Wold Bank/Heltberg (2003)	Electricity, LPG, Kerosene, Charcoal & Firewood	Multinomial Logit	Guatemala	Cooking	5
Yan (2010)	Coal, wood/straw, LPG & natural gas	Multinomial Logit	China	Cooking	1

6. References

Abhishek, K., Zerriffi, H. (2018). From cookstove acquisition to cooking transition: Framing the behavioural aspects of cookstove interventions. Energy Research & Social Science 42, 23-33. doi.org/10.1016/j.erss.2018.02.015.

Akpalu, W., Isaac D., Peter B. A. (2011). Demand for cooking fuels in a developing country: To what extent do taste and preferences matter?. Energy Policy 39(10), 6525–6531.

Alvarez, B., Boso, A. (2018) Representaciones sociales de la contaminación del aire and las estufas de lena en diferentes niveles socioeconómicos de la ciudad de Temuco, Chile. Revista internacional de Contaminación Ambiental [online] 34(3), 527-540. doi.org/10.20937/rica.2018.34.03.14

Amarante, V., Burger, R., Chelwa, G., Cockburn, J., Kassouf, A., McKay, A., Zurbrigg, J. (2021) Underrepresentation of developing country researchers in development research, Applied Economics Letters.

Baptista, I. (2018). Space and energy transitions in sub-Saharan Africa: Understated historical connections. Energy Research & Social Science 36, 30-35. doi.org/10.1016/j.erss.2017.09.029

Begg, C. B., Berlin, J. A. (1988). Publication bias: A problem in interpreting medical data. Journal of the Royal Statistical Society, Series A (Statistics in Society) 151, 419–463.

Chen, L., Nico H., van den Berg, M. (2006). Energy Consumption in Rural China: A household Model for Three Villages in Jiangxi Province. Ecological Economics 58(2), 407-420.

CEPAL (Comisión Económica para América Latina and El Caribe). (2016). Monitoreando la eficiencia energética en América Latina. Available at: https://www.cepal.org/sites/default/files/publication/files/40505/S1600876_es.pdf

Couture, S., Garcia, S., Reynaud, A. (2012). Household energy choices and fuelwood consumption: An econometric approach using French data. Energy Economics 34(6), 1972–1981. doi:10.1016/j.eneco.2012.08.022

Das, J., Do, Q-T., Shaines, K., Srinivasan, S. (2013). U.S. and them: The Geography of Academic Research, Journal of Development Economics 105: 112-130.

Dominguez, C., Orehounig, K., & Carmeliet, J. (2021). Understanding the path towards a clean energy transition and post-electrification patterns of rural households. Energy for Sustainable Development, 61, 46–64. doi:10.1016/j.esd.2021.01.002

FAO (Food and Agriculture Organization of the United Nations). 2022. Global forest sector outlook 2050: Assessing future demand and sources of timber for a sustainable economy – Background paper for The State of the World's Forests 2022. FAO Forestry Working Paper, No. 31. Rome.

FAO Food and Agriculture Organization of the United Nations). 2023. Sustainability by numbers – Forest products at FAO. Rome. https://doi.org/10.4060/cc7561en

Farsi, M., Massimo F., Shonali, P. (2007). Fuel Choices in Urban Indian Households. Environment and Development Economics 12(6), 757-774.

Finckh, A., Tramèr, M. Primer: strengths and weaknesses of meta-analysis. Nat Rev Rheumatol 4, 146–152 (2008). https://doi.org/10.1038/ncprheum0732

Fingleton-Smith, E. (2018). The lights are on but no (men) are home. The effect of traditional gender roles on perceptions of energy in Kenya. Energy Research & Social Science, 40, 211–219. doi:10.1016/j.erss.2018.01.006

Gould, C. F., Urpelainen, J., & Hopkins SAIS, J. (2020). The role of education and attitudes in cooking fuel choice: Evidence from two states in India. Energy for Sustainable Development, 54, 36–50. doi:10.1016/j.esd.2019.09.003

Gupta, G., Köhlin, G. (2006). Preferences for domestic fuel: Analysis with socio-economic factors and rankings in Kolkata, India. Ecological Economics 57(1), 107–121. doi:10.1016/j.ecolecon.2005.03.010

Guta, D., Baumgartner, J., Jack, D., Carter, E., Shen, G., Orgill-Meyer, J., Rosenthal, J., Dickinson, K., Bailis, R., Masuda, Y., Zerriffi, H. (2022). A systematic review of household energy transition in low and middle income countries. Energy Research & Social Science 86, 102463. doi.org/10.1016/j.erss.2021.102463

Harvey CA, Guariguata MR. Raising the profile of woodfuels in the forest landscape restoration agenda. Conservation Science and Practice. 2021; 3:e342. https://doi.org/10.1111/csp2.342

Hedges , L. V. 1992 . Modeling publication selection effects in meta-analysis. Statistical Science , 7 (2) : 246 – 256 .

Heltberg, R. (2004). Fuel switching: evidence from eight developing countries. Energy Economics 26(5), 869–887. doi:10.1016/j.eneco.2004.04.018

Heltberg, R. (2005). Factors determining household fuel choice in Guatemala. Environment and Development Economics 10(3), 337-361. doi:10.1017/S1355770X04001858

IEA. (2022). Solid biofuels consumption estimation model, IEA, Paris https://www.iea.org/data-and-statistics/data-product/solid-biofuels-consumption-estimation-model, Licence: CC BY 4.0

IEA. (2023). World Energy Outlook 2023, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2023, Licence: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A)

Israel, D. (2002). Fuel Choice in Developing Countries: Evidence from Bolivia. Economic Development and Cultural Change 50(4), 865-890.

Kar, A., & Zerriffi, H. (2018). From cookstove acquisition to cooking transition: Framing the behavioural aspects of cookstove interventions. Energy Research & Social Science, 42, 23–33. doi:10.1016/j.erss.2018.02.015

Kissinger, G., Herold, M., De Sy, V. (2012). Drivers of deforestation and forest degradation: A synthesis report for REDD+ policymakers. Vancouver, Canada: Lexeme Consulting.

Kowsari, R., Zerriffi, H. (2011). Three dimensional energy profile: A conceptual framework for assessing household energy use. Energy Policy 39(12), 7505-7517. doi.org/10.1016/j.enpol.2011.06.030

Lay, J., Ondraczek, J., Stoever, J. (2013). Renewables in the energy transition: Evidence on solar home systems and lighting fuel choice in Kenya. Energy Economics 40, 350–359. doi:10.1016/j.eneco.2013.07.024

Leach, G. (1992). The energy transition. Energy Policy 20(2), 116–123. doi:10.1016/0301-4215(92)90105-b

Lee, L. Y. T. (2013). Household energy mix in Uganda. Energy Economics 39, 252–261. doi:10.1016/j.eneco.2013.05.010

Li, J., Just, R. E. (2018). Modeling household energy consumption and adoption of energy efficient technology. Energy Economics 72, 404–415. doi:10.1016/j.eneco.2018.04.019

Mahat, I. (2004). Implementation of alternative energy technologies in Nepal: towards the achievement of sustainable livelihoods. Energy for Sustainable Development, 8(2), 9–16. doi:10.1016/s0973-0826(08)60455-x

Masera, O. R., Saatkamp, B. D., Kammen, D. M. (2000). From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model. World Development 28(12), 2083–2103. doi:10.1016/s0305-750x(00)00076-0

Masera, O. R., Bailis, R., Drigo, R., Ghilardi, A., & Ruiz-Mercado, I. (2015). Environmental burden of traditional bioenergy use. Annual Review of Environment and Resources, 40, 121–150. https://doi.org/10.1146/annurev-environ-102014-021318

Mekonnen, A., Köhlin, G. (2008). Determinants of Household Fuel Choice in Major Cities in Ethiopia. Environment for Development. Discussion Paper Series. http://www.jstor.org/stable/resrep14881

Muller, C., Yan, H. (2018). Household Fuel Use in Developing Countries: Review of Theory and Evidence. Energy Economics 70, 429-439. doi.org/10.1016/j.eneco.2018.01.024

Nelson, J. P., Kennedy, P. E. (2008). The Use (and Abuse) of Meta-Analysis in Environmental and Natural Resource Economics: An Assessment. Environmental and Resource Economics 42(3), 345–377. doi:10.1007/s10640-008-9253-5

Nlom, H., Karimov, A. (2014). Modeling fuel choice among households in northern Cameroon. 10.35188/UNU-WIDER/2014/759-2.

Nunn, N. (2019), Rethinking economic development. Canadian Journal of Economics/Revue canadienne d'économique, 52: 1349-1373.

Osiolo, H. (2009). Enhancing household fuel choice and substitution in Kenya. Kenya Institute for Public Policy Research and Analysis. Nairobi, Kenya: Kenya Institute for Public Policy Research and Analysis

Ouedraogo, B. (2006). Household Energy Preferences for Cooking in Urban Ouagadougou, Burkina Faso. Energy Policy 34 (18), 3787-95.

Özcan, K., Emrah, G., Şenay Ü. (2013). Economic and demographic determinants of household energy use in Turkey. Energy Policy 60, 550–557.

Paunio, M. (2018). Kicking away the energy ladder. How environmentalism destroys hope for the poorest. The Global Warming Policy Foundation. GWPF Briefing 30.

Perlaviciute, G., Schuitema, G., Devine-Wright, P., Ram, B. (2018). At the Heart of a Sustainable Energy Transition: The Public Acceptability of Energy Projects. IEEE Power and Energy Magazine 16, 49-55. doi: 10.1109/MPE.2017.2759918.

Poblete-Cazenave, M., Pachauri, S. (2018). A Structural Model of Cooking Fuel Choices in Developing Countries. Energy Economics 75, 449-463. doi:10.1016/j.eneco.2018.09.003

Rahut, D. B., Das, S., De Groote, H., Behera, B. (2014). Determinants of household energy use in Bhutan. Energy 69, 661–672. doi:10.1016/j.energy.2014.03.062

Rahut, D., Sukanya, D., De Groote, H., Bhagirath, B. (2014). Determinants of household energy use in Bhutan. Energy 69, 661-672.

Reyes, R., Schueftan, A., Ruiz, C., González, A.D. (2019). Controlling air pollution in a context of high energy poverty levels in southern Chile: Clean air but colder houses? Energy Policy 124, 301-311. doi.org/10.1016/j.enpol.2018.10.022.

Reyes, R., Sanhueza, R., Schueftan, A., González, E. (2021). Consumo de leña y otros biocombustibles sólidos en la región de Aysén: adopción acelerada del pellet en la ciudad de Coyhaique, y predominio de la leña en el resto de la región. In: Informes técnicos BES, Bosques - Energía - Sociedad, Año 7. N° 14. Diciembre 2021. Observatorio de los Combustibles Derivados de la Madera OCDM. Instituto Forestal, Chile. p. 38.

Sánchez Meca, J. (2010). Cómo realizar una revisión sistemática and un meta-análisis. Aula abierta 38(2), 53-64.

Schueftan, A., Sommerhoff, J., Gonzalez, AD. (2016). Firewood demand and energy policy in south-central Chile. Energy for Sustainable Development, 33, 26-35. DOI: 10.1016/j.esd.2016.04.004.

Sebri, M. (2015). Use renewables to be cleaner: Meta-analysis of the renewable energy consumption–economic growth nexus. Renewable and Sustainable Energy Reviews 42, 657–665. doi:10.1016/j.rser.2014.10.042

Shelby, L. B., & Vaske, J. J. (2008). Understanding Meta-Analysis: A Review of the Methodological Literature. Leisure Sciences, 30(2), 96–110. https://doi.org/10.1080/01490400701881366

Shrestha, B., Tiwari, S.R., Bajracharya, S.B., Keitsch, M.M., Rijal, H.B. (2021). Review on the Importance of Gender Perspective in Household Energy-Saving Behavior and Energy Transition for Sustainability. Energies 14, 7571. doi.org/10.3390/en14227571

Solomon, B. D., Krishna, K. (2011). The coming sustainable energy transition: History, strategies, and outlook. Energy Policy 39(11), 7422–7431. doi:10.1016/j.enpol.2011.09.009

Spetch, M. J., Pinto, S. R. R., Albuquerque, U. P., Tabarelli, M., & Melo, F. P. L. (2015). Burning biodiversity: Fuelwood harvesting causes forest degradation in human-dominated tropical landscapes. Global Ecology and Conservation, **3**, 200–209.

Steg, L, Perlaviciute, G. van der Werff, E. (2015). Understanding the human dimensions of a sustainable energy transition. Front. Psychol. 6:805. doi: 10.3389/fpsyg.2015.00805

Taylor, M., Moran-Taylor, M., Castellanos, E., Silvel, E. (2011). Burning for Sustainability: Biomass Energy, International Migration, and the Move to Cleaner Fuels and Cookstoves in Guatemala. Annals of the Association of American Geographers 101(4), 918-928. doi.org/10.1080/00045608.2011.568881

Van der Kroon, B., Brouwer, R., van Beukering, P. J. H. (2013). The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. Renewable and Sustainable Energy Reviews 20, 504–513. doi:10.1016/j.rser.2012.11.045

Van der Kroon, B., Brouwer, R., van Beukering, P. J. H. (2014). The impact of the household decision environment on fuel choice behavior. Energy Economics 44, 236–247. doi:10.1016/j.eneco.2014.04.008

Van Raaij, W. F., Verhallen, T. M. M. (1983). A behavioral model of residential energy use. Journal of Economic Psychology 3(1), 39-63.

WHO (World Health Organization). 2022. Air pollution. https://www.who.int/health-topics/airpollution#tab=tab_1 (accessed Apr 19, 2022).

Xing, R., Hanaoka, T., Kanamori, Masui, T. (2017). Greenhouse Gas and Air Pollutant Emissions of China's Residential Sector: The Importance of Considering Energy Transition. Sustainability 9(4), 614. doi:10.3390/su9040614

Yasmin, N., & Grundmann, P. (2020). Home-cooked energy transitions: Women empowerment and biogas-based cooking technology in Pakistan. Energy Policy, 137, 111074. doi:10.1016/j.enpol.2019.111074

Zhang, J., Koji K. (2012). The determinants of household energy demand in rural Beijing: Can environmentally friendly technologies be effective? Energy Economics 34 (2), 381-388

Zhou, S., Teng, F. (2013). Estimation of urban residential electricity demand in China using household survey data. Energy Policy 61, 394–402. doi:10.1016/j.enpol.2013.06.092