CEC Dauphine | PSL

N°2024 – 03 • AUGUST 2024

WORKING PAPER

Energy Poverty has a justice dimension: comparing Bolivia, Côte d'Ivoire, and France

Anna CRETI [1, 2*], Alpha LY [1*, 2*, 3*, 4*], Maria-Eugenia SANIN [2*, 5*, 6*]*

Energy poverty is a multidimensional issue, as demonstrated by a comparison between two low-income countries, Bolivia (BOL) and Côte d'Ivoire (CIV), and a high-income European country, France (FRA). These three countries represent different stages of access and energy poverty. BOL and CIV have very low access to clean cooking, while BOL has achieved universal access to electricity, like FRA. However, both BOL and CIV face significant energy affordability issues, leading to widespread energy poverty. CIV lags behind BOL and FRA in electricity access but still contends with energy poverty. This study examines the socio-economic determinants of access to energy infrastructure, energy services, and energy poverty. It finds that as the share of households with energy access and services increases the likelihood of an energy poverty trap also rises. The energy-poverty gap, which is the total cash transfer needed to address energy poverty, is higher in BOL and FRA compared to CIV due to higher average energy expenditures and a larger number of energy-poor households. Using clustering techniques, the study identifies the socio-demographic profiles of the most vulnerable households. Targeting these groups is shown to be more effective in bridging the energy poverty gap. The findings highlight the importance of considering affordability in efforts to ensure universal energy access, to prevent further exclusion and promote energy justice.

JEL CODES: Q41; I38; Q58; D63

1* Paris Dauphine-PSL University
2* Climate Economics Chair (CEC)
3* EIEA Chair (UM6P)
4* Energy and Prosperity Chair
5* Paris- Saclay University
6* Evry University (EPEE)

KEYWORDS

Energy poverty | Affordability | Climate justice | Distribution | Bolivia | Ivory Coast | France

Executive summary

This paper investigates the critical issue of energy poverty and its implications for economic development and climate justice across three distinct countries: Côte d'Ivoire (CIV), Bolivia (BOL), and France (FRA). By comparing these countries, which represent different stages on the energy access ladder, the study explores the link between energy access, affordability, and the risk of falling into an energy poverty trap.

Energy is a fundamental driver of economic growth and an essential component of sustainable development. However, inadequate infrastructure, unequal access, and affordability challenges hinder progress, especially in developing countries. In many low-income countries, households' resort to expensive and polluting energy alternatives, exacerbating poverty and increasing vulnerability to climate change.

Our analysis reveals significant disparities in energy access and affordability across the three countries. While Côte d'Ivoire struggles with low electricity access and minimal clean cooking coverage, Bolivia is close to achieving universal electricity access but still struggles with widespread energy poverty. France, despite having universal access, faces substantial energy affordability issues, particularly among low-income households.

The study employs various methodologies to assess the extent and determinants of energy poverty. A key finding is the existence of an energy poverty trap, where households that gain access to energy services may become vulnerable to energy poverty due to affordability issues. This phenomenon is particularly evident in Bolivia and France, highlighting the inadequacy of generalized subsidies in addressing energy poverty.

Governments should replace broad subsidies with targeted financial assistance, such as social tariffs and direct cash transfers, to protect vulnerable households from energy poverty. Developing countries like Côte d'Ivoire and Bolivia should focus on enhancing energy infrastructure through public-private partnerships, while developed countries like France should implement energy efficiency programs to reduce household energy burdens. Improved data collection and monitoring are essential for understanding energy poverty dynamics and informing effective policies. Finally, policymakers should design tailored interventions that address the unique needs of different socio-demographic groups, identified through clustering techniques

1 Introduction

Human development indicators depend on the capability of households to access infrastructure, particularly energy (see Acheampong et al., 2021 for a recent review). Energy is an integral part of economic growth due to its critical role as an input in producing goods and services (public and private) when combined with capital and labor. Energy is also central to climate transition as it is one of the main factors behind global warming, due to its greenhouse gas emissions. Thus, the challenge of achieving universal access to modern energy services in urban areas highlights the strong linkages between two Sustainable Development Goals (SDGs), namely SDG7 (Affordable and Clean Energy) and SDG11 (Sustainable Cities and Communities).

Ensuring growth in developing countries is hindered by insufficient energy infrastructure, inadequate production capacity, poor reliability, and unequal access between rural and urban areas. Many households lack access to affordable, clean, reliable, and safe modern energy services and often resort to expensive, polluting substitutes with harmful environmental and health impacts. Significant regional differences exist in energy access. Most sub-Saharan countries, except for a few large oil producers, lack substantial domestic fossil fuel reserves and depend on imports for over 65% of their energy needs. In Latin America, while progress has been made in access to energy, prices remain high, and widespread subsidies further entrench poverty, negatively affecting education and health. This also increases long-term vulnerability to climate change.

In a first attempt to account for the different barriers that stand in the way of access to reliable and affordable energy, Bhatia and Angelou (2015) from the World Bank have elaborated the Multi-tier framework (MTF). This latter defines different stages of access to energy services incorporating the affordability dimension, as well as the reliability and capacity of the connection that allows the usage of different appliances. Since then, the framework has been applied to assess energy access and its progress in Myanmar, Rwanda, Ethiopia, and Cambodia. The limited panel of cases is due to the need for detailed data to conduct such an assessment, generally missing in low-income countries.

Another strand of literature has focused on measuring access to reliable and affordable energy services by studying energy poverty. This latter is defined as insufficient access to services like clean cooking, household lighting, and temperature comfort (Belaïd, 2018). Affordability can be also factored in Belaïd (2022b), due to high prices and low-income issues. The literature on energy poverty is abundant and has provided different indicators that complement each other.

It is worth noting that definitions of energy poverty are evolving (Pachauri and Spreng, 2011). Recently, new dimensions that drive the concept of energy-poverty closer to the MTF have been accounted for: ownership of appliances that help households avoid temperature discomfort, or clean cooking and other energy services that improve welfare (Grottera et al., 2018). Nevertheless, almost all studies on energy poverty are conducted in the developed world, with few exceptions that focus in upper-middle-income countries (Belaïd, 2022a), most likely due to data availability. The sole and recent exception is Poblete-Cazenave and Pachauri (2021) that include Ghana in their simulation of future energy needs. Sy and Mokaddem (2022) explains the inadequacy of applying fuel or energy poverty concepts coined in developed countries to developing ones.

This paper encompasses the debate on energy access and poverty in a novel approach. On one hand, we consider whether there is a path toward increasing welfare benefits as long as more people have access to electricity and clean cooking, as predicted by the MTF. On the other, we characterize the obstacles that hinder these benefits, once access is reached. To do so, we compare two lower-middle income countries on two continents, Côte d'Ivoire (CIV) and Bolivia (BOL), together with a developed country, France (FRA). Overall, we assess the determinants of the dynamics toward full electricity access that may turn into an energy poverty trap, when households struggle to pay for energy services once access to infrastructure is obtained, and how policy interventions can alleviate that trap if direct subsidies are implemented. This allows us to measure what we call the energy poverty gap and compare it across BOL, FRA and CIV. Overall, our comprehensive analysis contributes to a deeper understanding of energy justice, particularly about access and poverty (Heffron, 2022).

The three countries represent different rungs on the energy access ladder, making their analysis valuable for numerous reasons. Côte d'Ivoire and Bolivia are classified as low-income countries, where the energy and development transition is still ongoing. They are also comparable in terms of the dynamics of GDP growth, GNI per capita, the headcount of poor as a percentage of population, and energy use (see Table 1). Instead, they are very different in other dimensions relevant to energy consumption. Ivorian population doubles the Bolivian population on a surface that is less than one-third of the Bolivian one, with a difference in population density which is almost 8 to 1. This scattered pattern is also explained by urbanization, which increases almost twice as fast in Côte d'Ivoire than in Bolivia. France represents the ideal situation of universal electricity and clean cooking access but still presents some issues in terms of the affordability of such services.

BOL is close to FRA reaching almost universal electricity access and ahead of CIV (where access is 56.3%). In terms of clean cooking, both low-income countries have a very low coverage of around 18%, while France has a very high one (86%). The budget share of energy expenditure increases as access to electricity generalizes and subsidies are eliminated.

In the Table 1, we compute one synthetic indicator of energy poverty, the Low Income High Cost index (Hills, 2012b) which considers a household as energy poor when its energy bill is above the national median level, and its residual income after the energy expenditure falls below a certain level, the relative poverty line. According to that index, energy poverty is an important problem in BOL (6.7% of inhabitants), suggesting generalized subsidies are insufficient to help the poorest pay their bills. FRA also presents an important issue of energy poverty (6.3%) while CIV is at the very beginning (2.4%). Income is the key determinant of being energy-poor in each of these countries. Household characteristics such as size, age, education level, and the sector in which the head works have varying impacts across different countries. Interestingly, in the two low-income countries, households with higher levels of education tend to experience energy poverty. These findings indicate a concerning trend: as households improve their standards of living and gain access to energy services, they also become susceptible to energy poverty. This phenomenon suggests the existence of an energy poverty trap, where households become accustomed to accessing energy services they cannot afford. While households in CIV have not yet fallen into this trap, the poorest households in Bolivia and even in FRA are already experiencing energy poverty.

We encounter several methodological challenges to comprehensively compare energy poverty across the three countries. Firstly, sourcing databases with consistent characteristics and structures is crucial to obtaining a meaningful overview of energy usage in these diverse nations. Secondly, we require appropriate metrics to gauge energy poverty among populations with access to energy, spanning both developing and developed economies. Lastly, to determine the existence of an energy-poverty trap, we must supplement energy-poverty measurement with suitable econometric techniques, enabling us to pinpoint the most effective policy solutions.

We standardize the data sourced from National Household Surveys and investigate energy poverty using various definitions that we deem suitable. Initially, we employ a single indicator to assess access to infrastructure (electricity or clean cooking), followed by a multidimensional approach that examines access to energy services through appliance ownership. Additionally, we compute diverse energy poverty indicators based on recent advancements in the literature. We extend beyond existing research by employing logit/probit and go-logit models to explore the primary determinants of energy poverty across all three countries simultaneously. This approach allows us to disentangle the key determinants of access to the infrastructure (electricity and clean cooking, respectively) and energy services (TV, fridge, computer, cooker, washing machine, air conditioner, etc), together with affordability (by considering alternative definitions of energy poverty).

Following this, we calculate what we term the "energy-poverty gap," which quantifies the total expenditure required from the government to assist households in escaping energy poverty in each country. As previously indicated, the cost is significantly higher in FRA and also considerable in BOL. We then assess the extent to which broad measures proposed as potential solutions, such as enhancing RISE indicators or implementing energy efficiency initiatives following SDG 7, could contribute to reducing the cash transfer needed to bridge this gap.

Lastly, we utilize the aforementioned findings to pinpoint the most vulnerable groups based on their socio-demographic characteristics. To achieve this, we employ clustering techniques to categorize the population into groups that should be the focus of tailored policies aimed at alleviating energy poverty.

The paper is organized as follows. In Section 2 we describe the databases used and the methodology while in Section 3 we show our main findings and in Section 4 we discuss the policy implications. Finally, Section 5 concludes.

Table 1: Comparison of Development Indicators

	Côte d'Ivoire	Bolivia	France
Population, total	27,053,629	11,832,936	67,499,343
Surface area (sq. km)	322,460	1,098,580	549,087
Population density (people per sq. km of land area)	85	11	123
Urban population growth (annual %) - 2021	3.44%	1.86%	0.50%
GNI per capita, Atlas method (current US$) - 2021	2,450	3,360	43,880
GDP (current US$) - 2021	69,764,827,467	40,408,208,524	2,937,472,757,953
GDP growth (annual %) - 2021	7.02%	6.11%	7.00%
Poverty headcount ratio at national poverty lines (% of population)	39.5% (2018)	39% (2020)	13.8% (2019)
Income share held by lowest 20%	7 (2018)	4.7 (2020)	8 (2018)
Life expectancy at birth, total (years) - 2020	58	72	82
Energy use (kg of oil equivalent per capita) - 2014	613	778	3,692
Electric power consumption (kWh per capita) - 2014	275	743	6,940
Access to electricity⊛ (% of households)	56.3%	91.5%	87.3%
Access to clean cooking⊛ (% of households)	17.8%	18.2%	86.0%
Energy poverty - LIHC (%)	2.4%	6.7%	6.3%

Source: World Development Indicators (July, 2022) & National Surveys. ⊛In France, it is worth noting that only households with a positive expenditure are considered in the categories of access to electricity and to clean cooking.

2 Data Description and Methodology

To understand the key determinants for inappropriate access to energy services as well as differences between countries, in this section, we first present the household survey data used as well as the key methodological choices we have made.

2.1 Data

To understand the sociodemographic determinants of energy access and energy poverty, we use the latest household budget survey for CIV (2015) and FRA (2017). For ease of comparability, we use the closer year for BOL (2015). These household surveys contain data about access to infrastructure like electricity and gas distribution, ownership of appliances that provide energy services and expenditure, as well as other indicators of the household's situation like income, education of its head, or size.

Tables 2 and 3 display the data summary statistics. Few variables are defined differently for France due to longer life expectancy and living conditions (see the details in the Tables' legends), in particular, the classification into Young, Middle-aged and Elder. Similarly, while for BOL and CIV the house materials may not be permanent, in FRA we consider another criterion, i.e. whether the dwelling is less than 10 years old or not, as energy efficiency improvements have mostly

Table 2: Summary statistics: non-categorical variables

	Mean	SD	Min	Max	N
Sample BOL					
Household size	3.66	1.91	1	14	9,566
Number of dependents	1.11	1.28	0	9	9,566
Employed per Working-age	0.69	0.36	0	1	9,563
Income per CU	68,585.48	93,083.80	0	2,014,281	9,566
Sample CIV					
Household size	3.67	2.54	1	34	6,707
Number of dependents	1.39	1.61	0	14	6,707
Employed per Working-age	0.47	0.36	0	1	6,707
Income per CU	734,482.03	616,843.75	22,857	10,713,860	6,707
Sample FRA					
Household size	2.15	1.33	1	10	15,456
Number of dependents	0.80	1.19	0	9	15,456
Employed per Working-age	0.75	0.33	0	1	15,441
Income per CU	17,548.68	15,625.64	-4,098	285,815	15,456

Notes: Income per consumption unit (CU) are measured in local currencies and, for CIV, total expenditure per consumption unit is used.

taken place in recent years.

We use four alternative definitions of energy poverty. We consider the definition of Boardman (2013) both in relative terms (people spending more than 2 times the median expenditure for the country or 2M) and absolute terms (people that spend more than 10% of their income in energy, which was the 2M measure in Broadman's study). We also adopt the Low Income-High Cost (LIHC) definition of energy poverty first proposed by Hills (2012b). A household is then energy-poor if its energy expenditures are higher than the country's median expenditure and, at the same time, the remaining income after energy expenditure is lower than the official poverty line (defined as 60% of the country's median income).[1] Hills (2012b) explains that this measure should be calculated after housing costs. We manage to take into account these costs and call this measurement low-income-high-house-cost (LIHHC) as Belaïd and Flambard (2023). The share of households falling into each of the categories is presented in Table 3. It is worth noting that, while the 10% measure as well as the 2M measure only considers households with excessively high energy expenditures, the other two definitions do care about to which extent a household has little income left once it has paid energy costs. In this sense, only LIHC and LIHHC households can be considered energy poor.[2]

[1]We follow Romero et al. (2018) in subtracting the median energy from the median household income to be consistent with the first term of the equation and to overcome the criticism that Robinson et al. (2018) makes to Hills (2012b) regarding the consideration of the median energy cost instead of the 60% of the median.

[2]For a detailed discussion on energy poverty definitions in the literature and its appropriateness see Appendix A.2.

Table 3: Summary statistics: categorical variables

	iso			
	BOL	**CIV**	**FRA**	**Total**
	%	%	%	%
Access to energy services				
No access	46.7	89.9	1.2	33.6
Access to 50%	38.1	8.0	8.2	17.2
Access to 75%	14.2	1.8	60.8	34.3
Access to all the services	1.1	0.3	29.9	14.9
House (1=Permanent or New, 0=Other)				
Non-permanent or Old	11.7	21.6	8.0	12.0
Permanent or New	88.3	78.4	92.0	88.0
Occupation status (1=Owner, 0=Other)				
Other status	39.6	68.8	31.6	41.9
Owner	60.4	31.2	68.4	58.1
Sex of household head (0=Female, 1=Male)				
Female	25.2	23.3	32.0	28.1
Male	74.8	76.7	68.0	71.9
Head's age (Young, Middle-aged, Elder)				
Young	18.9	25.6	32.4	26.9
Middle-aged	45.2	50.6	52.6	49.9
Elder	36.0	23.8	15.0	23.2
Education (0=None, 1=Prim, 2=Secon, 3=Univ)				
None	5.4	47.1	12.9	18.5
Primary	28.3	17.7	35.0	28.6
Secondary	43.3	27.6	16.9	28.6
University	23.0	7.6	35.2	24.4
Sector (0=Farmers, Craftsmen or Workers, 1=Other)				
Farmers, Craftsmen or Workers	13.4	25.6	16.6	17.6
Other sectors	86.6	74.4	83.4	82.4
Poverty status (0=Not poor, 1=Poor)				
Not poor	71.4	71.9	85.1	77.7
Poor	28.6	28.1	14.9	22.3
LIHC				
Not poor	93.3	97.8	94.5	94.8
Poor	6.7	2.2	5.5	5.2
LIHHC				
Not poor	93.0	95.9	93.5	93.8
Poor	7.0	4.1	6.5	6.2
Budget share (>10%)				
Not poor	93.9	86.0	64.1	77.7
Poor	6.1	14.0	35.9	22.3
2M				
Not poor	83.4	89.0	64.6	75.4
Poor	16.6	11.0	35.4	24.6
Area (0=Rural, 1=Urban)				
Rural	17.5	31.3	25.1	24.1
Urban	82.5	68.7	74.9	75.9
Total	100.0	100.0	100.0	100.0

Notes: For the housing quality, Permanent Vs Non-Permanent refers to BOL and CIV whereas for FRA, we distinguish New (constructed after 2006) vs Old as we have the information on the year of the construction. Regarding age: in FRA we consider Young (0-30), Middle-aged (30-65) and Elder (+65) whereas in BOL and CIV we consider Young (0-30), Middle-aged (30-50) and Elder (+50).

In Appendix A.1 we present, for each country, a more detailed summary statistics cross-referencing the variables for urban versus rural locations, which indeed has a strong impact on energy access and consumption patterns.

In what follows we analyze this data to understand the roots of energy poverty in each country.

Table 4: Dependent variable: Access to electricity grid — Access to clean cooking

	Access to electricity grid						Access to clean cooking					
	Logit			Probit			Logit			Probit		
	BOL	CIV	FRA	BOL	CIV	FRA	BOL	CIV	FRA	BOL	CIV	FRA
Area (0=Rural, 1=Urban)	0.095***	0.200***	0.000	0.082***	0.205***	0.000	0.341***	0.052***	0.000	0.297***	0.048***	0.000
	(0.007)	(0.006)	(.)	(0.006)	(0.007)	(.)	(0.023)	(0.006)	(.)	(0.018)	(0.006)	(.)
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	0.013***	0.038***	0.001	0.013***	0.038***	0.001	0.058***	0.029***	0.000	0.058***	0.030***	0.000
	(0.003)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.005)	(0.002)	(0.003)	(0.005)	(0.002)	(0.003)
Sector (0=Farmers, Craftsmen or Workers, 1=Other)	0.022***	0.089***	-0.009	0.021***	0.092***	-0.008	0.074***	0.058***	-0.007	0.070***	0.053***	-0.006
	(0.005)	(0.007)	(0.008)	(0.005)	(0.008)	(0.008)	(0.019)	(0.007)	(0.008)	(0.018)	(0.007)	(0.008)
Head's age (Young, Middle-aged, Elder)	0.001	0.018***	0.007	0.002	0.019***	0.006	0.058***	0.000	0.011	0.058***	0.000	0.009
	(0.003)	(0.005)	(0.007)	(0.003)	(0.005)	(0.007)	(0.006)	(0.004)	(0.007)	(0.006)	(0.004)	(0.007)
Number of rooms	0.009***	-0.002		0.008***	-0.002		0.048***	0.002		0.048***	0.002	
	(0.003)	(0.002)		(0.002)	(0.002)		(0.004)	(0.001)		(0.004)	(0.002)	
Employed per Working-age pop.	0.002	0.024**	0.028**	0.001	0.026**	0.030**	-0.019*	0.022***	0.025**	-0.018	0.023***	0.028**
	(0.005)	(0.011)	(0.012)	(0.005)	(0.011)	(0.012)	(0.011)	(0.007)	(0.012)	(0.011)	(0.007)	(0.012)
Sex of household head (0=Female, 1=Male)	-0.014**	-0.027***	0.004	-0.013**	-0.026***	0.004	0.006	-0.015***	0.001	0.005	-0.011**	0.002
	(0.006)	(0.009)	(0.007)	(0.005)	(0.009)	(0.007)	(0.009)	(0.005)	(0.007)	(0.008)	(0.005)	(0.007)
Occupation status (1=Owner, 0=Other)	-0.000	-0.074***	0.074***	-0.000	-0.076***	0.074***	0.072***	-0.020***	0.082***	0.070***	-0.017***	0.081***
	(0.006)	(0.007)	(0.007)	(0.005)	(0.008)	(0.007)	(0.008)	(0.006)	(0.007)	(0.008)	(0.006)	(0.007)
House (0=Non-Permanent or Old, 1=Permanent or New)	0.058***	0.198***	0.017*	0.058***	0.202***	0.019*	0.076***	0.049***	0.023**	0.062***	0.047***	0.025**
	(0.005)	(0.006)	(0.009)	(0.004)	(0.006)	(0.010)	(0.021)	(0.006)	(0.010)	(0.019)	(0.006)	(0.010)
Household size	0.000	0.010***	0.001	0.001	0.010***	0.001	-0.011***	0.004***	0.004	-0.011***	0.004***	0.005
	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)	(0.003)
log(Income per CU)	0.007***	0.052***	0.009*	0.007***	0.053***	0.010	0.007*	0.065***	0.012**	0.007*	0.057***	0.013**
	(0.001)	(0.006)	(0.006)	(0.001)	(0.006)	(0.006)	(0.004)	(0.005)	(0.006)	(0.004)	(0.005)	(0.006)
Observations	10168	12797	11494	10168	12797	11494	10168	12797	11494	10168	12797	11494
Constant	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wald chi2	1151.1	3618.9	337.1	1126.2	4434.3	334.1	1384.9	2098.6	378.3	1453.2	2347.2	377.3
Prob > chi2	2.72e-232	0	5.03e-62	5.83e-227	0	2.16e-61	2.22e-282	0	1.29e-70	4.87e-297	0	2.02e-70

Notes: Standard errors in parentheses. Coefficients represent the average marginal effects. Number of observations vary between estimations simply for convergence reasons in the probit estimation.

2.2 Empirical strategy

We use both standard econometric techniques and clustering techniques to study the determinants of energy access and energy poverty in the three countries.

As a first step, we study access to the infrastructure itself, that is access to the electricity grid as well as to electricity or gas for cooking. We estimate the probability of having access as a function of the household location (rural or urban) and other socioeconomic relevant characteristics (Belaïd, 2022b; Kettani and Sanin, 2024) by applying standard logit and probit estimations. The dependent variable is access to electricity or access to clean cooking, respectively.

We then study access to infrastructure altogether in a gologit estimation. We consider access as an ordinal variable with 3 categories: no access (0), access to either electricity or clean cooking (1) and access to both (2). A detailed explanation of the econometric method can be found in Williams (2006) and it simply consists of estimating the probability of having access to each category (0, 1 or 2).

Households' surplus from energy consumption depends on the difference between the utility derived from the use of energy services and the price paid. They are about being able to profit from quality energy services at an affordable price and not just on infrastructure access. In our data we identify energy services available in each country: for CIV is TV, Fan, Refrigerator, Freezer, Air conditioner, Computer, Cooker and Iron; for BOL, to the previous we add internet access, and; for FRA we further add cloth washing and dryer machine. We apply the same gologit methodology to study the determinants for access to energy services among the households that have basic access to the infrastructure. To this end, the dependent variable takes the value 3 if a household has access to all services, 2 if it only has access to 75%, 1 if it only has access to 50%, and 0 if none.

We then move into the analysis of the determinants for households to be energy poor according to alternative energy poverty definitions detailed in Section 2.1 using a simple logit and probit estimation. Here we only consider households that have access to the infrastructure (electricity or gas grids).

We complement the previous estimation with a two-step clustering method to better characterize which type of household is more likely to be energy-poor. First, we use Multiple Correspondence Analysis (MCA) to represent the categorical variables in our database.We use a bi-dimensional space where the proximity of the points in the space indicates the degree of association between the corresponding categories. Then, in a second step, we perform a Hierarchical Ascendant Clustering (HAC) to study the existence of natural groups and their underlying structure within the energy-poor categories and present the results using a dendrogram. We choose the number of clusters by applying the *Elbow approach*. [3] Given the desired level of heterogeneity between clusters (and homogeneity within), this technique allows us to draw 2 different profiles for energy-poor households that we will describe in the following section.

Finally, after studying the determinants of energy poverty as well as the different energy-poor groups in each country we perform a series of calculations to nourish the energy-poverty mitigation policy debate in Section 4. In particular, we calculate the energy poverty gap to understand the cost in terms of cash transfers that an energy poverty mitigation policy would imply in each of the three countries. We compare such costs across countries when coupled with alternative energy efficiency measures, which have been recently presented not only as a way to smooth energy demand growth but also as to alleviate energy poverty. We finally compare the impact that alternative energy efficiency measures would have on these countries and suggest ways forward.

3 Results

We present the main results in terms of vulnerability characterization in the three countries studied. Our objective is to single out household groups that could be distinctively treated in policy mitigation design.

3.1 Determinants of access to infrastructure

As shown in Table 1, FRA and BOL have similar rates of electrification (87.3% and 91.5%, respectively), while BOL is closer to CIV in terms of access to clean cooking (18.2% and 17.8%, respectively).[4] Let us now study if, in terms of socioeconomic determinants of access, this is also the case. Table 4 shows the result of logit and probit estimations where the dependent variable is access to electricity and to clean cooking, respectively.

For FRA, since there is universal access and thus low data variability, only few variables are significant. Income and dwelling energy efficiency for permanent houses are significant. All other variables do not display common patterns across the three countries. FRA and CIV share the importance of employment.

In BOL and CIV being in an urban area increases the probability of having energy access but this effect is stronger for access to electricity in CIV and for access to clean cooking in BOL. This latter is quite scattered in BOL while access to electricity is widespread. In CIV a large share of the population lacks access independently of being rural or urban.

[3]This method relies on computing the Within-Cluster-Sum of Squared Errors (WSS) for various numbers of clusters (k) and determining the value of k at which the decrease in WSS begins to diminish.

[4]It is important to remind the reader that we have chosen to consider households with access only households that report positive expenditure in the electricity line as well as in the clean cooking line. This explains the fact that France does not reports a 100% access rate to electricity

Other demand determinants are always significant with positive sign like education and employment outside agriculture. Interestingly, female-headed households tend to have more access, probably due to the need to have efficient energy services if the woman leaves the home to work and sustain the whole family. Other variables are less clear, in line with the literature (see Kettani and Sanin, 2024). Surprisingly, dwelling ownership harms access in CIV. This may be because wealthier people in CIV live in rented houses.

Table 5: Dependent variable: Access to energy services (1=50%, 2=75% and 3=100% of the services)

	BOL	CIV	FRA
Access to 50% of energy services			
Area (0=Rural, 1=Urban)	0.377***	0.380**	0.000
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	0.860***	0.780***	-0.081
Sector (0=Farmers, Craftsmen or Workers, 1=Other)	0.222**	0.792***	-0.018
Head's age (Young, Middle-aged, Elder)	0.255***	0.293***	0.425***
Number of rooms	0.471***	0.159**	
Employed per Working-age pop.	-0.147**	0.183	0.988***
Sex of household head (0=Female, 1=Male)	-0.004	-0.152	-0.939***
Occupation status (1=Owner, 0=Other)	0.160***	-0.442***	1.659***
House (0=Non-Permanent or Old, 1=Permanent or New)	1.078***	0.805***	-0.013
Household size	0.100***	0.290***	0.834***
log(Income per CU)	0.389***	1.842***	0.299***
Access to 75% of energy services			
Area (0=Rural, 1=Urban)	0.740***	0.395	0.000
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	1.187***	0.967***	-0.120***
Sector (0=Farmers, Craftsmen or Workers, 1=Other)	0.158	1.344**	0.098
Head's age (Young, Middle-aged, Elder)	0.255***	0.348**	0.514***
Number of rooms	0.555***	0.151**	
Employed per Working-age pop.	0.108	-0.477	0.803***
Sex of household head (0=Female, 1=Male)	0.046	-0.676***	-0.432***
Occupation status (1=Owner, 0=Other)	0.032	0.518*	1.273***
House (0=Non-Permanent or Old, 1=Permanent or New)	1.414***	-0.051	0.351***
Household size	0.039	0.318***	0.602***
log(Income per CU)	0.517***	2.600***	0.411***
Access to 100% of energy services			
Area (0=Rural, 1=Urban)	0.644	12.363***	0.000
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	1.360***	0.857***	-0.101**
Sector (0=Farmers, Craftsmen or Workers, 1=Other)	1.055	13.131***	0.245**
Head's age (Young, Middle-aged, Elder)	-0.058	0.781	0.305***
Number of rooms	0.650***	0.264	
Employed per Working-age pop.	-0.368	0.332	-0.246
Sex of household head (0=Female, 1=Male)	0.090	-0.550	0.169*
Occupation status (1=Owner, 0=Other)	-0.166	0.997	1.482***
House (0=Non-Permanent or Old, 1=Permanent or New)	-0.265	13.375***	-0.054
Household size	-0.027	0.106	0.168***
log(Income per CU)	0.491***	1.771***	0.396***
Observations	9558	6508	11494
Constant	√	√	√
Region FE	√	√	√
Wald chi2	3102.9	4330.0	1826.8
Prob > chi2	0.000	0.000	0.000

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Next, let us analyze the determinants of access to energy services among the population who has access to at least one of the infrastructures just described. In Table 5 we observe that access to 50% of services is determined, aside from income, by the family size and the heads' age for the three countries. Moreover, in BOL and CIV the most important driver aside from income is education. In FRA this variable has no impact, as well as working outside of agriculture. In

FRA, access to clean cooking as compared to other countries is well established, which explains that these two variables are not significant. The amount of adults working has a different impact in BOL than in FRA. While in FRA access to at least 50% is positively determined by being employed in BOL households with housewives are more likely to have access than households where all members of the family are working.

When considering access to an increasing number of energy services (75% and 100%, respectively), education gains importance as access to cumulative services increases in the two low-income countries while it decreases the probability of having full access in FRA. This may be explained by the fact that many wealthy households decide not to have a TV in France, a peculiarity among European countries. Moreover, proxies of a higher permanent income like working outside of agriculture and education increase their importance while other socioeconomic variables become less relevant for the case of CIV, where most households do not have access to at least one of the services. These results suggest that once access to basic services are granted, households become part of a group that is more homogeneous among countries.

3.2 Affordability and Energy poverty

In the previous section, we have looked into access to energy services and the fact that more complete access helps households live a better life. That being said, even if households have access to energy services they might be unable to afford the energy consumption deriving from such services. An affordability problem could arise, particularly if the households spend a high portion of their income on energy or if they are obliged to choose what service to prioritize to reduce consumption because of income constraints. The first case is what is generally captured by the definition in Boardman (2013), when households spend an important portion of their income on energy.

The second, more complex case contemplates households that not only spend a high portion of their income in energy but that such expenditure leaves them with a residual income under the poverty line (LIHC or LIHHC, respectively). Table 6 shows results for this more complete definition and its socioeconomic determinants. In Appendix A.3 we analyze these determinants into the more general definition of Boardman (1991).

We observe that for BOL and CIV energy energy-poor households live in urban areas, in a home with permanent materials (two characteristics that determined the fact of having infrastructure access), and generally small households belonging to the first income deciles in CU. Poor households in urban areas gain access to the infrastructure and might have great difficulty in paying energy bills, spending a disproportionate amount of their income.

Since BOL is ahead from CIV in terms of electricity access and usage, a few other variables are significant for BOL that are not for CIV. Such variables are, moreover, for most cases aligned with the results for FRA. Households headed by elderly people, owned by the residents, and well endowed by energy services are more likely to be energy-poor in both BOL and FRA. Two variables have contrasting signs between these two countries: education and employment status. Educated households are more likely to be energy-poor in BOL since they need energy services with a generally lower income while, in FRA where services are already available, these are instead less likely to be so. Something similar happens with employment, but interestingly, when considering LIHHC, results between BOL and FRA concerning employment align: unemployed and retired are more likely to have an income that falls under the poverty line after accounting for energy and housing expenditures. Instead, the rest of results are stable across LIHC and LIHHC definitions.

Finally, we observe that, as expected, the probability of being energy-poor decreases with income. However, other determinants are more difficult to assess. Access to services of course increases the probability of being energy-poor.

Education has a positive impact in BOL and a negative one in FRA when considering LIHHC. This may be be-

Table 6: Energy poverty dependent variable: LIHC — LIHHC

	LIHC						LIHHC					
	Logit			Probit			Logit			Probit		
	BOL	CIV	FRA	BOL	CIV	FRA	BOL	CIV	FRA	BOL	CIV	FRA
Area (0=Rural, 1=Urban)	0.023**	0.028***	0.000	0.021**	0.027***	0.000	0.025***	0.048***	0.000	0.023***	0.045***	0.000
	(0.009)	(0.006)	(.)	(0.008)	(0.006)	(.)	(0.009)	(0.008)	(.)	(0.009)	(0.007)	(.)
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	0.010***	-0.004	0.001	0.009***	-0.004	0.001	0.011***	0.003	-0.019***	0.010***	0.004	-0.018***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Sector (0=Farmers, Craftsmen or Workers, 1=Other)	0.010	0.013*	0.004	0.009	0.011*	0.003	0.004	0.023***	-0.018***	0.002	0.021***	-0.019***
	(0.009)	(0.007)	(0.006)	(0.009)	(0.006)	(0.006)	(0.009)	(0.008)	(0.006)	(0.009)	(0.007)	(0.006)
Head's age (Young, Middle-aged, Elder)	0.028***	0.002	0.016***	0.028***	0.002	0.017***	0.030***	0.014***	0.017***	0.030***	0.014***	0.018***
	(0.004)	(0.003)	(0.006)	(0.004)	(0.003)	(0.006)	(0.004)	(0.004)	(0.006)	(0.004)	(0.004)	(0.005)
Number of rooms	0.007**	0.001		0.006**	0.001		0.009***	0.004***		0.009***	0.005***	
	(0.003)	(0.002)		(0.003)	(0.002)		(0.003)	(0.001)		(0.003)	(0.001)	
Employed per Working-age pop.	-0.022***	-0.001	0.021**	-0.023***	-0.001	0.018**	-0.024***	0.009	-0.022**	-0.026***	0.011	-0.025**
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.009)	(0.007)	(0.007)	(0.010)	(0.007)	(0.007)	(0.010)
Sex of household head (0=Female, 1=Male)	-0.009*	-0.008	0.002	-0.010*	-0.008	0.001	-0.008	-0.003	-0.015***	-0.008	-0.002	-0.013**
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)
Occupation status (1=Owner, 0=Other)	0.016***	-0.008	0.065***	0.015***	-0.007	0.066***	-0.010*	-0.021***	0.062***	-0.015***	-0.018***	0.064***
	(0.005)	(0.007)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.005)	(0.007)	(0.006)
House (0=Non-Permanent or Old, 1=Permanent or New)	0.052***	0.016**	0.001	0.052***	0.016***	-0.000	0.052***	0.022***	-0.003	0.051***	0.020***	-0.003
	(0.010)	(0.006)	(0.007)	(0.009)	(0.006)	(0.007)	(0.010)	(0.007)	(0.009)	(0.010)	(0.007)	(0.009)
Household size	-0.020***	-0.012***	0.020***	-0.020***	-0.012***	0.020***	-0.022***	-0.022***	-0.022***	-0.022***	-0.021***	-0.023***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
Energy services (1=50%, 2=75% and 3=100% of the services)	0.016***	0.000	0.028***	0.016***	0.000	0.028***	0.019***	0.009	0.010*	0.018***	0.007	0.011*
	(0.004)	(.)	(0.005)	(0.004)	(.)	(0.005)	(0.004)	(0.006)	(0.006)	(0.004)	(0.006)	(0.006)
Quintiles of income per CU=2	-0.187***	-0.049***	-0.431***	-0.186***	-0.052***	-0.418***	-0.172***	-0.061***	-0.010	-0.169***	-0.065***	-0.011
	(0.014)	(0.011)	(0.014)	(0.014)	(0.010)	(0.014)	(0.014)	(0.016)	(0.010)	(0.014)	(0.014)	(0.010)
Quintiles of income per CU=3	-0.190***	-0.072***	-0.469***	-0.188***	-0.075***	-0.460***	-0.195***	-0.096***	-0.034***	-0.190***	-0.099***	-0.035***
	(0.015)	(0.010)	(0.013)	(0.014)	(0.010)	(0.013)	(0.015)	(0.015)	(0.011)	(0.014)	(0.013)	(0.011)
Quintiles of income per CU=4	-0.288***	-0.089***	-0.469***	-0.283***	-0.091***	-0.460***	-0.263***	-0.112***	-0.063***	-0.256***	-0.114***	-0.063***
	(0.014)	(0.010)	(0.013)	(0.013)	(0.010)	(0.013)	(0.014)	(0.014)	(0.011)	(0.013)	(0.013)	(0.011)
Quintiles of income per CU=5	-0.288***	0.000	0.000	-0.284***	0.000	0.000	-0.277***	-0.129***	-0.068***	-0.269***	-0.130***	-0.068***
	(0.014)	(.)	(.)	(0.013)	(.)	(.)	(0.014)	(0.014)	(0.011)	(0.013)	(0.013)	(0.011)
Observations	9563	5030	8895	9563	5030	8895	9563	6621	11509	9563	6621	11509
Constant	√	√	√	√	√	√	√	√	√	√	√	√
Region FE	√	√	√	√	√	√	√	√	√	√	√	√
Wald chi2	646.2	257.8	784.8	683.2	212.2	887.5	770.1	342.0	470.9	746.2	267.6	456.8
Prob > chi2	9.46e-122	1.39e-41	3.71e-154	1.56e-129	1.44e-32	5.20e-176	7.13e-148	2.03e-57	3.48e-87	7.91e-143	1.74e-42	3.18e-84

Notes: Standard errors in parentheses. Coefficients represent the average marginal effects. Number of observations vary between estimations simply for convergence reasons in the probit estimation.

cause Bolivian households consider access to energy as a necessity and spend more. Educated households in FRA have significantly more income than uneducated households and avoid the energy poverty trap.

All in all results suggest that, once a certain level of access has been attained, the energy poverty trap materializes. Households are ready to spend more money on energy (a sort of dependency on a new standard of living) which drives them to energy poverty.

In Table A10 in the Appendix we present results for the two alternative definitions of energy poverty (inspired by Broadman's work) that remain in line with the results just discussed.

4 Escaping the energy poverty trap: policy measures

In this section, we discuss policy measures that could help countries to drive the population out of energy poverty. In Table 7 we look into how many euros per year would be necessary to bridge the gap between the energy poor's residual income, net of energy payment, and the poverty line's income. We observe that the average transfer is much almost 4 times higher in FRA than in BOL which in turn is more than 10 times higher than in CIV. Once energy-poor households live in richer countries, increasingly higher efforts are needed to escape the energy-poverty trap.

We now discuss to which extent different regulatory measures could help reduce the cash transfer needed to help people out of energy poverty by improving energy conservation and affordability.

We consider three alternative policy measures (see Tables 8 and 9): (i) the SDG 7.3 target, meaning 3.2% improvement in energy efficiency; (ii) an improvement in efficiency equivalent to leap-frogging to reach the South-Korean benchmark value in the Regulatory Indicator for Sustainable Energy[5] (RISE), and (iii) satisfying the Minimum Energy Efficiency Performance Standard (MEEPS) subcategory.

Let us first analyze the energy efficiency considered by SDG 7.3. Not surprisingly, the effort needed in terms of cash

[5]This means an improvement of 18% efficiency for FRA, a 30% for CIV and a 61% for BOL

Table 7: Annual average cash transfer required to get households out of energy poverty (LIHC) by country (Weighted)

	Mean	SD	Min	Max	N
Panel BOL					
Cash transfer (euros/year)	1,470.30	913.72	1	6,193	721,170
Panel CIV					
Cash transfer (euros/year)	242.08	171.71	0	758	542,984
Panel FRA					
Cash transfer (euros/year)	4,429.02	2,984.27	1	13,565	6,489,048

transfer does not reduce much since the improvement in efficiency is very small. In all cases, the percentage of households coming out of energy poverty with this tiny improvement in efficiency is very small. The reduction of the transfer amount to 1.6% for FRA, 1.1% for BOL and 0.2% for CIV, respectively.

We then look into the potential impact on the gap to be filled due to an improvement in the RISE indicator. Due to the large improvement in efficiency to reach South Korea, Bolivia should imrpove the situation of 50% of its energy-poor population, while the percentage is almost 30% for CIV and 18% for FRA. Cash transfers needed after this policy are thus therefore significantly smaller in particular for BOL and CIV.

Something similar happens with MEEPS, with a caveat, the amount of households coming out of energy poverty is much lower, particularly for CIV (12%) and FRA (10%). This result illustrates the need for a higher cash transfer than in the case of RISE. In Appendix A.4 we show the overall distribution of the required cash transfer per household.

Table 8: Annual total cash transfer required to get all the households out of energy poverty (LIHC) by country (Weighted)

	Total transfer (in euros)
Panel A: Bolivia	
Cash transfer without any target	1,060,000,000
Cash transfer with SDG 7.3 target	1,050,000,000
Cash transfer with RISE target	789,000,000
Cash transfer with MEEPS target	789,000,000
Panel B: Côte d'Ivoire	
Cash transfer without any target	131,444,000
Cash transfer with SDG 7.3 target	131,170,000
Cash transfer with RISE target	93,194,000
Cash transfer with MEEPS target	115,735,000
Panel C: France	
Cash transfer without any target	28,800,000,000
Cash transfer with SDG 7.3 target	28,200,000,000
Cash transfer with RISE target	24,200,000,000
Cash transfer with MEEPS target	25,900,000,000

Notes: Notes: Simulations based on SDG 7.3 which requires an average annual improvement rate of 3.2 percent every year from 2018 through 2030 to meet the goal Energy efficiency, RISE (Regulatory Indicators for Sustainable Energy) and MEEPS (Minimun Energy Efficiency Performance Standards subcategory).

We now turn to the challenge of identifying the most vulnerable groups. The econometric analysis has helped us

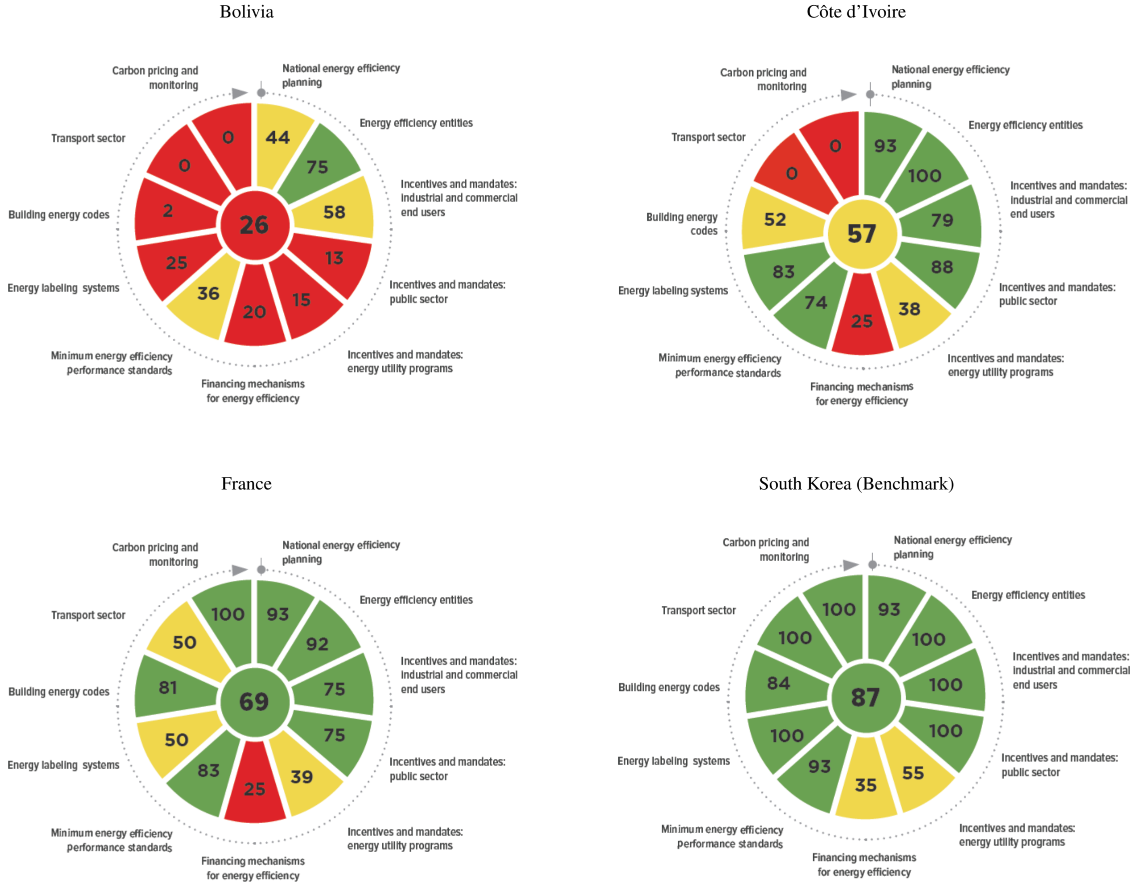

Figure 1: Energy efficiency, RISE – Regulatory Indicators for Sustainable Energy (The World Bank)

understand the key determinants of energy poverty. Now, using clustering techniques we can look into the intersection between all those determinants to characterize the groups that are most likely to be energy-poor in each of the countries (See Tables 10, 11 and 12). We observe that the majority of energy-poor households share a few characteristics (cluster 1 for each country) that could be used to alleviate energy poverty. For example, in the case of FRA, targeting subsidies to middle-aged renting couples would be a good strategy. Similarly, for CIV, couples living in urban areas in a dwelling made of permanent materials and working outside of farming would resolve the energy poor status of 87% households.

Table 9: Energy efficiency policies and energy poverty reduction (Weighted)

	Country			
	BOL %	**CIV** %	**FRA** %	**Total** %
SDG 7.3 - Energy efficiency				
Out of energy poverty = No	98.9	99.8	98.4	98.6
Out of energy poverty = Yes	1.1	0.2	1.6	1.4
RISE – South Korea as Benchmark				
Out of energy poverty = No	50.3	70.9	81.9	78.2
Out of energy poverty = Yes	49.7	29.1	18.1	21.8
MEEPS – South Korea as Benchmark				
Out of energy poverty = No	50.3	88.0	89.3	86.0
Out of energy poverty = Yes	49.7	12.0	10.7	14.0
Total	100.0	100.0	100.0	100.0

Notes: Simulations based on SDG 7.3 which requires an average annual improvement rate of 3.2 percent every year from 2018 through 2030 to meet the goal Energy efficiency, RISE (Regulatory Indicators for Sustainable Energy) and MEEPS (Minimun Energy Efficiency Performance Standards subcategory).

Table 10: Clusters characterization in Bolivia

	Mean	SD	Min	Max
Cluster 1 (76.67%)				
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	1.71	0.87	0	3
Head's age (Young, Middle-aged, Elder)	2.32	0.73	1	3
Sex of household head (0=Female, 1=Male)	0.61	0.49	0	1
Occupation status (1=Owner, 0=Other)	0.66	0.48	0	1
House (0=Non-Permanent or Old, 1=Permanent or New)	0.93	0.26	0	1
Household size	2.61	1.25	1	5
Area (0=Rural, 1=Urban)	0.87	0.34	0	1
Number of rooms	1.68	1.03	0	6
Cluster 2 (23.33%)				
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	1.81	0.65	0	3
Head's age (Young, Middle-aged, Elder)	2.05	0.55	1	3
Sex of household head (0=Female, 1=Male)	0.79	0.41	0	1
Occupation status (1=Owner, 0=Other)	0.58	0.50	0	1
House (0=Non-Permanent or Old, 1=Permanent or New)	0.85	0.36	0	1
Household size	5.49	1.52	3	10
Area (0=Rural, 1=Urban)	0.80	0.40	0	1
Number of rooms	1.41	0.93	0	4

Table 11: Clusters characterization in Côte d'Ivoire

	Mean	SD	Min	Max
Cluster 1 (87.16%)				
Sector (0=Farmers, Craftsmen or Workers, 1=Other)	0.89	0.31	0	1
House (0=Non-Permanent or Old, 1=Permanent or New)	0.79	0.41	0	1
Household size	2.02	1.08	1	5
Area (0=Rural, 1=Urban)	0.81	0.40	0	1
Cluster 2 (12.84%)				
Sector (0=Farmers, Craftsmen or Workers, 1=Other)	0.68	0.48	0	1
House (0=Non-Permanent or Old, 1=Permanent or New)	0.95	0.23	0	1
Household size	5.84	1.30	5	10
Area (0=Rural, 1=Urban)	0.79	0.42	0	1

In Table 13 we observe that the average cash transfer needed per country is very different. In CIV the annual cash transfer is small, meaning that the fiscal effort to help energy-poor countries is not very big. Instead, the effort is much higher in BOL and almost 4 times higher in FRA. This latter would not only transfer a much higher amount but also has a much higher share of the population that is energy poor.

5 Conclusions

This paper compares the usage of energy services in two low-income countries with that in a developed country, taking into account socio-demographic differences, development levels, and energy consumption patterns. It explores the determinants of household access to energy services, the affordability barriers for an increasing number of services, and the policies that could bridge the energy-poverty gap. Despite the specific differences among the three countries analyzed, the study finds that as infrastructure access increases, a significant portion of the population experiences energy poverty. Consequently, more financial resources are needed to address this energy-poverty gap. The findings indicate a potential energy-poverty trap for developing countries as they progress and expand energy access. Addressing energy poverty is

Table 12: Clusters characterization in France

	Mean	SD	Min	Max
Cluster 1 (91.76%)				
Head's age (Young, Middle-aged, Elder)	2.08	0.48	1	3
Occupation status (1=Owner, 0=Other)	0.47	0.50	0	1
Household size	2.83	1.33	1	5
Cluster 2 (8.24%)				
Head's age (Young, Middle-aged, Elder)	2.00	0.00	2	2
Occupation status (1=Owner, 0=Other)	0.39	0.49	0	1
Household size	6.57	0.91	6	10

Table 13: Annual average cash transfer required to get households out of energy poverty (LIHC) by country and in the largest cluster or cluster 1 (Weighted)

	Mean	SD	Min	Max	N
Panel BOL					
Cash transfer (euros/year)	1,222.33	983.04	5.82	6,193	552,921
Panel CIV					
Cash transfer (euros/year)	192.10	139.36	8.35	657	473,265
Panel FRA					
Cash transfer (euros/year)	4,770.26	2,862.36	5.61	11,749	5,954,350

a crucial social policy objective, which has garnered attention from NGOs as well. For instance, the Abbé Pierre Foundation's Roofs First program in France aims to increase the availability of social housing with high energy performance. Additionally, both private and public stakeholders implement energy audit programs to provide vulnerable households with energy-saving advice. Despite these efforts, concerns about energy poverty persist, as electricity constitutes a significant portion of household budgets in both developed and developing countries. This issue underscores the broader context of energy justice, highlighting the need for equitable access to affordable energy services.

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A Appendix

A.1 Summary statistics

Herein we provide a detailed summary statistic for all the variables included in this study.

A.1.1 Summary statistics for access to electricity and clean cooking technologies

Variables are discriminated by area (rural or urban) since the literature shows this is a key driver to having access to distribution of electricity or distribution of butane (or natural gas) for cooking, which are the two technologies that are inside our variable "combust".

Table A1: Summary statistics for Bolivia

	Count			Row percentages			Column percentages		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Access to electricity (0=NO, 1=YES)									
NO	825	37	862	95.7%	4.3%	100.0%	25.0%	0.5%	8.5%
YES	2,470	6,839	9,309	26.5%	73.5%	100.0%	75.0%	99.5%	91.5%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Access to combustion (0=NO, 1=YES)									
NO	3,265	5,051	8,316	39.3%	60.7%	100.0%	99.1%	73.5%	81.8%
YES	31	1,824	1,855	1.7%	98.3%	100.0%	0.9%	26.5%	18.2%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent or Old, 1=Permanent or New)									
Non-permanent or Old	1,718	408	2,126	80.8%	19.2%	100.0%	52.1%	5.9%	20.9%
Permanent or New	1,577	6,468	8,045	19.6%	80.4%	100.0%	47.9%	94.1%	79.1%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Overcrowded dwelling (0=NO, 1=YES)									
NO	2,287	5,345	7,633	30.0%	70.0%	100.0%	69.4%	77.7%	75.0%
YES	1,008	1,530	2,538	39.7%	60.3%	100.0%	30.6%	22.3%	25.0%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Occupation status (1=Owner, 0=Other)									
Other status	534	3,043	3,577	14.9%	85.1%	100.0%	16.2%	44.3%	35.2%
Owner	2,761	3,832	6,594	41.9%	58.1%	100.0%	83.8%	55.7%	64.8%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Sex of household head (0=Female, 1=Male)									
Female	614	1,801	2,415	25.4%	74.6%	100.0%	18.6%	26.2%	23.7%
Male	2,681	5,075	7,756	34.6%	65.4%	100.0%	81.4%	73.8%	76.3%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Head's age (Young, Middle-aged, Elder)									
Young	453	1,333	1,786	25.4%	74.6%	100.0%	13.8%	19.4%	17.6%
Middle-aged	1,265	3,155	4,420	28.6%	71.4%	100.0%	38.4%	45.9%	43.5%
Elder	1,577	2,388	3,965	39.8%	60.2%	100.0%	47.9%	34.7%	39.0%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	443	290	733	60.5%	39.5%	100.0%	13.4%	4.2%	7.2%
Primary	1,712	1,583	3,295	51.9%	48.1%	100.0%	51.9%	23.0%	32.4%
Secondary	939	3,146	4,085	23.0%	77.0%	100.0%	28.5%	45.8%	40.2%
University	202	1,857	2,058	9.8%	90.2%	100.0%	6.1%	27.0%	20.2%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Sector (0=Farmers, Craftsmen or Workers, 1=Other)									
Farmers, Craftsmen or Workers	2,118	307	2,425	87.4%	12.6%	100.0%	64.3%	4.5%	23.8%
Other sectors	1,177	6,569	7,746	15.2%	84.8%	100.0%	35.7%	95.5%	76.2%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	1,687	5,119	6,806	24.8%	75.2%	100.0%	51.2%	74.5%	66.9%
Poor	1,608	1,757	3,365	47.8%	52.2%	100.0%	48.8%	25.5%	33.1%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Median of income per CU									
Under Median	2,368	3,002	5,370	44.1%	55.9%	100.0%	71.8%	43.7%	52.8%
Over Median	928	3,873	4,801	19.3%	80.7%	100.0%	28.2%	56.3%	47.2%
Total	3,295	6,876	10,171	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
N	2,236	7,935	10,171						

In Table A1 we observe that, for the case of Bolivia, rural areas account for 95.7% of the people that have no access to electricity, 80.8% of people that have a house with non-permanent materials, 87.4% of household's head work in the agricultural sector and 60.5% have no education. Most of the people with income under the median and under the poverty line are also in rural areas.

It is worth noting that even if almost all of the households without access to electricity are in rural areas, there are only few households left since 91.5% of the population has access to electricity. Instead, only 18% of population has access to clean cooking using electricity or gas.

Table A2: Summary statistics for Côte d'Ivoire

	Count			Row percentages			Column percentages		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Access to electricity (0=NO, 1=YES)									
NO	4,585	1,052	5,638	81.3%	18.7%	100.0%	68.3%	17.0%	43.7%
YES	2,124	5,137	7,261	29.3%	70.7%	100.0%	31.7%	83.0%	56.3%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Access to combustion (0=NO, 1=YES)									
NO	6,430	4,177	10,606	60.6%	39.4%	100.0%	95.8%	67.5%	82.2%
YES	280	2,013	2,293	12.2%	87.8%	100.0%	4.2%	32.5%	17.8%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent or Old, 1=Permanent or New)									
Non-permanent or Old	4,082	1,474	5,556	73.5%	26.5%	100.0%	60.8%	23.8%	43.1%
Permanent or New	2,628	4,715	7,343	35.8%	64.2%	100.0%	39.2%	76.2%	56.9%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Overcrowded dwelling (0=NO, 1=YES)									
NO	6,004	5,538	11,542	52.0%	48.0%	100.0%	89.5%	89.5%	89.5%
YES	706	652	1,357	52.0%	48.0%	100.0%	10.5%	10.5%	10.5%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Occupation status (1=Owner, 0=Other)									
Other status	2,560	4,730	7,290	35.1%	64.9%	100.0%	38.2%	76.4%	56.5%
Owner	4,150	1,460	5,609	74.0%	26.0%	100.0%	61.8%	23.6%	43.5%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Sex of household head (0=Female, 1=Male)									
Female	1,129	1,392	2,521	44.8%	55.2%	100.0%	16.8%	22.5%	19.5%
Male	5,581	4,798	10,378	53.8%	46.2%	100.0%	83.2%	77.5%	80.5%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Head's age (Young, Middle-aged, Elder)									
Young	2,019	1,808	3,827	52.8%	47.2%	100.0%	30.1%	29.2%	29.7%
Middle-aged	3,084	3,142	6,226	49.5%	50.5%	100.0%	46.0%	50.8%	48.3%
Elder	1,607	1,239	2,846	56.5%	43.5%	100.0%	23.9%	20.0%	22.1%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	4,254	2,779	7,033	60.5%	39.5%	100.0%	63.6%	45.5%	55.0%
Primary	1,261	989	2,250	56.1%	43.9%	100.0%	18.9%	16.2%	17.6%
Secondary	1,095	1,768	2,864	38.2%	61.8%	100.0%	16.4%	28.9%	22.4%
University	78	572	650	12.1%	87.9%	100.0%	1.2%	9.4%	5.1%
Total	6,689	6,108	12,797	52.3%	47.7%	100.0%	100.0%	100.0%	100.0%
Sector (0=Farmers, Craftsmen or Workers, 1=Other)									
Farmers, Craftsmen or Workers	3,995	971	4,966	80.4%	19.6%	100.0%	59.5%	15.7%	38.5%
Other sectors	2,715	5,218	7,933	34.2%	65.8%	100.0%	40.5%	84.3%	61.5%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	4,056	4,716	8,772	46.2%	53.8%	100.0%	60.4%	76.2%	68.0%
Poor	2,654	1,473	4,127	64.3%	35.7%	100.0%	39.6%	23.8%	32.0%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
Median of income per CU									
Under Median	3,958	1,885	5,843	67.7%	32.3%	100.0%	59.0%	30.5%	45.3%
Over Median	2,751	4,304	7,056	39.0%	61.0%	100.0%	41.0%	69.5%	54.7%
Total	6,710	6,189	12,899	52.0%	48.0%	100.0%	100.0%	100.0%	100.0%
N	7,115	5,784	12,899						

In Table A2 we observe summary statistics for Cote d'Ivoire. In this country 44% of households still lack access to electricity and 82% lack access to clean fuels for cooking like gas or electricity. For the case of Côte d'Ivoire, rural areas account for 82% of the people that have no access to electricity, 60% of households without access to clean cooking technologies, 73% of people that have a house with non-permanent materials. Similarly to Bolivia, rural households account for 80% of household's head work in the agricultural sector and 60% have no education. Ownership status of the house and poverty status of the family seem less influenced by the area.

Bolivia is ahead of Côte d'Ivoire in terms of permanent income proxies like education, house materials and ownership, for example. The gap is very consistent ranging from 15 to 20% difference in all of these variables. This indeed explains important gaps in terms of energy usage but not all of them. Particularly, even if geographic and demographic condition in Côte d'Ivoire facilitate the deployment of the power network (less surface, more population density and urbanization) only 56.3% of households use electricity as compared to 91.5% for Bolivia. This huge gap is nonexistent, on the other hand, in terms of clean cooking where both countries are around a 18% usage.

Finally, in Table A3 we observe the fact that access to infrastructure is more balanced in France than in other countries thanks to a more homogeneous population where the key factor is indeed having an income lower than the mean.

To study access to energy services, in Table A4,A5 and A6 we look into households in terms of their availability of electricity, clean cooking, fridge and entertainment for each of the three countries.

Table A3: Summary statistics for France as a function of the area

	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
	Count			Row percentages			Column percentages		
Access to electricity (0=NO, 1=YES)									
NO	0	1,966	1,966	0.0%	100.0%	100.0%	0.0%	12.7%	12.7%
YES	2	13,488	13,490	0.0%	100.0%	100.0%	100.0%	87.3%	87.3%
Total	2	15,454	15,456	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Access to combustion (0=NO, 1=YES)									
NO	0	2,169	2,169	0.0%	100.0%	100.0%	0.0%	14.0%	14.0%
YES	2	13,285	13,287	0.0%	100.0%	100.0%	100.0%	86.0%	86.0%
Total	2	15,454	15,456	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent or Old, 1=Permanent or New)									
Non-permanent or Old	0	1,650	1,650	0.0%	100.0%	100.0%	0.0%	10.7%	10.7%
Permanent or New	2	13,804	13,806	0.0%	100.0%	100.0%	100.0%	89.3%	89.3%
Total	2	15,454	15,456	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Occupation status (1=Owner, 0=Other)									
Other status	0	6,952	6,952	0.0%	100.0%	100.0%	0.0%	45.0%	45.0%
Owner	2	8,501	8,504	0.0%	100.0%	100.0%	100.0%	55.0%	55.0%
Total	2	15,454	15,456	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Sex of household head (0=Female, 1=Male)									
Female	0	6,245	6,245	0.0%	100.0%	100.0%	0.0%	40.4%	40.4%
Male	2	9,209	9,211	0.0%	100.0%	100.0%	100.0%	59.6%	59.6%
Total	2	15,454	15,456	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Head's age (Young, Middle-aged, Elder)									
Young	2	1,992	1,994	0.1%	99.9%	100.0%	100.0%	12.9%	12.9%
Middle-aged	0	10,179	10,179	0.0%	100.0%	100.0%	0.0%	65.9%	65.9%
Elder	0	3,283	3,283	0.0%	100.0%	100.0%	0.0%	21.2%	21.2%
Total	2	15,454	15,456	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Sector (0=Farmers, Craftsmen or Workers, 1=Other)									
Farmers, Craftsmen or Workers	0	3,501	3,501	0.0%	100.0%	100.0%	0.0%	22.7%	22.7%
Other sectors	2	11,953	11,955	0.0%	100.0%	100.0%	100.0%	77.3%	77.3%
Total	2	15,454	15,456	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	0	13,164	13,164	0.0%	100.0%	100.0%	0.0%	85.2%	85.2%
Poor	2	2,290	2,292	0.1%	99.9%	100.0%	100.0%	14.8%	14.8%
Total	2	15,454	15,456	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Median of income per CU									
Under Median	2	5,008	5,010	0.0%	100.0%	100.0%	100.0%	32.4%	32.4%
Over Median	0	10,446	10,446	0.0%	100.0%	100.0%	0.0%	67.6%	67.6%
Total	2	15,454	15,456	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
N	3,874	11,582	15,456						

Note: We cannot include Education in FRA when discriminating by area. Also, we should remember that access is defined as all households with a non-zero bill.

A.1.2 Summary statistics for energy affordability

The last aspect we wish to study herein is energy affordability since a dimension of poverty is the incapacity for households to use energy services due to the impossibility of paying the bill.

In the first line of graphs in Figure A1, we observe that considering only households with access to energy, important affordability issues arise. For some of the poorest households with access, both in Bolivia and in Côte d'Ivoire, energy represents more than 10% of their spending. This means that, if we apply the fuel poverty definition first defined by Boardman (1991) for the UK, they can be considered energy poor. For the case of France, poor households are almost at 10% of the income spent in energy. The 10% limit is not crossed but is very close for the first three quintiles. In the second line we observe that energy poverty is particularly important in cities that are in a developing stage like Abidjan and Pando. Instead, the problem is weaker in centers where income per capita has been at a good level for the last couple

Table A4: Summary statistics for households with access in Bolivia

	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
	Count			Row percentages			Column percentages		
Access to energy services									
No access	1,864	2,893	4,758	39.2%	60.8%	100.0%	73.4%	41.2%	49.7%
Access to 50%	600	2,839	3,439	17.5%	82.5%	100.0%	23.7%	40.4%	36.0%
Access to 75%	70	1,205	1,275	5.5%	94.5%	100.0%	2.8%	17.1%	13.3%
Access to all the services	4	90	94	3.9%	96.1%	100.0%	0.1%	1.3%	1.0%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent or Old, 1=Permanent or New)									
Non-permanent or Old	1,073	396	1,469	73.1%	26.9%	100.0%	42.3%	5.6%	15.4%
Permanent or New	1,466	6,632	8,097	18.1%	81.9%	100.0%	57.7%	94.4%	84.6%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Occupation status (1=Owner, 0=Other)									
Other status	460	3,107	3,568	12.9%	87.1%	100.0%	18.1%	44.2%	37.3%
Owner	2,079	3,920	5,998	34.7%	65.3%	100.0%	81.9%	55.8%	62.7%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Sex of household head (0=Female, 1=Male)									
Female	503	1,842	2,345	21.5%	78.5%	100.0%	19.8%	26.2%	24.5%
Male	2,036	5,186	7,221	28.2%	71.8%	100.0%	80.2%	73.8%	75.5%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Head's age (0=[0-45] or [0-65], 1=+45 or +65)									
$[0-45]$ or $[0-65]$	1,074	3,867	4,942	21.7%	78.3%	100.0%	42.3%	55.0%	51.7%
+45 or +65	1,465	3,160	4,624	31.7%	68.3%	100.0%	57.7%	45.0%	48.3%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	292	292	584	50.0%	50.0%	100.0%	11.5%	4.2%	6.1%
Primary	1,267	1,607	2,874	44.1%	55.9%	100.0%	49.9%	22.9%	30.0%
Secondary	793	3,223	4,016	19.7%	80.3%	100.0%	31.2%	45.9%	42.0%
University	187	1,905	2,093	9.0%	91.0%	100.0%	7.4%	27.1%	21.9%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Sector (0=Farmers, Craftsmen or Workers, 1=Other)									
Farmers, Craftsmen or Workers	1,517	311	1,828	83.0%	17.0%	100.0%	59.8%	4.4%	19.1%
Other sectors	1,022	6,716	7,738	13.2%	86.8%	100.0%	40.2%	95.6%	80.9%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	1,421	5,239	6,660	21.3%	78.7%	100.0%	56.0%	74.6%	69.6%
Poor	1,118	1,788	2,906	38.5%	61.5%	100.0%	44.0%	25.4%	30.4%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Energy poverty (LIHC)									
Not poor	2,403	6,523	8,927	26.9%	73.1%	100.0%	94.7%	92.8%	93.3%
Poor	135	504	639	21.2%	78.8%	100.0%	5.3%	7.2%	6.7%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Energy poverty (over 10%)									
Not poor	2,321	6,624	8,946	26.0%	74.0%	100.0%	91.4%	94.3%	93.5%
Poor	217	403	620	35.0%	65.0%	100.0%	8.6%	5.7%	6.5%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
Median of income per CU									
Under Median	1,795	3,187	4,982	36.0%	64.0%	100.0%	70.7%	45.4%	52.1%
Over Median	744	3,840	4,584	16.2%	83.8%	100.0%	29.3%	54.6%	47.9%
Total	2,539	7,027	9,566	26.5%	73.5%	100.0%	100.0%	100.0%	100.0%
N	1,674	7,892	9,566						

Table A5: Summary statistics for households with access in Côte d'Ivoire

	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
	Count			Row percentages			Column percentages		
Access to energy services									
No access	1,977	4,006	5,983	33.0%	67.0%	100.0%	97.2%	85.7%	89.2%
Access to 50%	52	528	580	9.0%	91.0%	100.0%	2.6%	11.3%	8.6%
Access to 75%	5	114	118	3.9%	96.1%	100.0%	0.2%	2.4%	1.8%
Access to all the services	0	26	26	0.0%	100.0%	100.0%	0.0%	0.5%	0.4%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent or Old, 1=Permanent or New)									
Non-permanent or Old	754	715	1,469	51.3%	48.7%	100.0%	37.1%	15.3%	21.9%
Permanent or New	1,280	3,958	5,238	24.4%	75.6%	100.0%	62.9%	84.7%	78.1%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Occupation status (1=Owner, 0=Other)									
Other status	1,045	3,815	4,860	21.5%	78.5%	100.0%	51.4%	81.6%	72.5%
Owner	989	858	1,847	53.5%	46.5%	100.0%	48.6%	18.4%	27.5%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Sex of household head (0=Female, 1=Male)									
Female	444	1,090	1,535	28.9%	71.1%	100.0%	21.8%	23.3%	22.9%
Male	1,590	3,582	5,172	30.7%	69.3%	100.0%	78.2%	76.7%	77.1%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Head's age (0=[0-45] or [0-65], 1=+45 or +65)									
$[0-45]$ or $[0-65]$	1,345	3,366	4,711	28.5%	71.5%	100.0%	66.1%	72.0%	70.2%
+45 or +65	690	1,307	1,996	34.6%	65.4%	100.0%	33.9%	28.0%	29.8%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	1,026	1,917	2,944	34.9%	65.1%	100.0%	50.8%	41.7%	44.5%
Primary	473	726	1,199	39.5%	60.5%	100.0%	23.4%	15.8%	18.1%
Secondary	485	1,447	1,932	25.1%	74.9%	100.0%	24.0%	31.5%	29.2%
University	35	510	546	6.5%	93.5%	100.0%	1.8%	11.1%	8.2%
Total	2,020	4,601	6,621	30.5%	69.5%	100.0%	100.0%	100.0%	100.0%
Sector (0=Farmers, Craftsmen or Workers, 1=Other)									
Farmers, Craftsmen or Workers	1,040	465	1,505	69.1%	30.9%	100.0%	51.1%	9.9%	22.4%
Other sectors	994	4,208	5,202	19.1%	80.9%	100.0%	48.9%	90.1%	77.6%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	1,331	3,712	5,043	26.4%	73.6%	100.0%	65.4%	79.4%	75.2%
Poor	703	961	1,664	42.3%	57.7%	100.0%	34.6%	20.6%	24.8%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Energy poverty (LIHC)									
Not poor	2,008	4,540	6,548	30.7%	69.3%	100.0%	98.7%	97.2%	97.6%
Poor	26	133	159	16.4%	83.6%	100.0%	1.3%	2.8%	2.4%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Energy poverty (over 10%)									
Not poor	1,885	3,864	5,749	32.8%	67.2%	100.0%	92.7%	82.7%	85.7%
Poor	149	809	958	15.6%	84.4%	100.0%	7.3%	17.3%	14.3%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
Median of income per CU									
Under Median	1,338	1,733	3,071	43.6%	56.4%	100.0%	65.7%	37.1%	45.8%
Over Median	697	2,940	3,636	19.2%	80.8%	100.0%	34.3%	62.9%	54.2%
Total	2,034	4,673	6,707	30.3%	69.7%	100.0%	100.0%	100.0%	100.0%
N	2,102	4,605	6,707						

Table A6: Summary statistics for households with access in France

	Under Median	Over Median	Total	Under Median	Over Median	Total	Under Median	Over Median	Total
	Count			Row percentages			Column percentages		
Access to energy services									
No access	216	151	367	58.9%	41.1%	100.0%	4.3%	1.4%	2.4%
Access to 50%	1,041	1,002	2,043	51.0%	49.0%	100.0%	20.8%	9.6%	13.2%
Access to 75%	3,572	8,529	12,101	29.5%	70.5%	100.0%	71.3%	81.6%	78.3%
Access to all the services	180	765	944	19.0%	81.0%	100.0%	3.6%	7.3%	6.1%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent or Old, 1=Permanent or New)									
Non-permanent or Old	852	799	1,650	51.6%	48.4%	100.0%	17.0%	7.6%	10.7%
Permanent or New	4,158	9,648	13,806	30.1%	69.9%	100.0%	83.0%	92.4%	89.3%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Occupation status (1=Owner, 0=Other)									
Other status	3,390	3,563	6,952	48.8%	51.2%	100.0%	67.7%	34.1%	45.0%
Owner	1,620	6,883	8,504	19.1%	80.9%	100.0%	32.3%	65.9%	55.0%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Sex of household head (0=Female, 1=Male)									
Female	2,430	3,815	6,245	38.9%	61.1%	100.0%	48.5%	36.5%	40.4%
Male	2,579	6,631	9,211	28.0%	72.0%	100.0%	51.5%	63.5%	59.6%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Head's age (0=[0-45] or [0-65], 1=+45 or +65)									
$[0-45]$ or $[0-65]$	3,997	8,176	12,173	32.8%	67.2%	100.0%	79.8%	78.3%	78.8%
+45 or +65	1,013	2,270	3,283	30.9%	69.1%	100.0%	20.2%	21.7%	21.2%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	925	634	1,559	59.3%	40.7%	100.0%	24.7%	8.2%	13.5%
Primary	1,525	2,382	3,907	39.0%	61.0%	100.0%	40.7%	30.6%	33.9%
Secondary	660	1,225	1,885	35.0%	65.0%	100.0%	17.6%	15.8%	16.4%
University	641	3,531	4,172	15.4%	84.6%	100.0%	17.1%	45.4%	36.2%
Total	3,751	7,773	11,524	32.5%	67.5%	100.0%	100.0%	100.0%	100.0%
Sector (0=Farmers, Craftsmen or Workers, 1=Other)									
Farmers, Craftsmen or Workers	1,832	1,669	3,501	52.3%	47.7%	100.0%	36.6%	16.0%	22.7%
Other sectors	3,178	8,777	11,955	26.6%	73.4%	100.0%	63.4%	84.0%	77.3%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	2,717	10,446	13,164	20.6%	79.4%	100.0%	54.2%	100.0%	85.2%
Poor	2,292	0	2,292	100.0%	0.0%	100.0%	45.8%	0.0%	14.8%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Energy poverty (LIHC)									
Not poor	4,033	10,443	14,477	27.9%	72.1%	100.0%	80.5%	100.0%	93.7%
Poor	976	3	979	99.7%	0.3%	100.0%	19.5%	0.0%	6.3%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Energy poverty (over 10%)									
Not poor	4,035	9,318	13,353	30.2%	69.8%	100.0%	80.6%	89.2%	86.4%
Poor	974	1,129	2,103	46.3%	53.7%	100.0%	19.4%	10.8%	13.6%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Area (0=Rural, 1=Urban)									
Rural	2	0	2	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%
Urban	5,008	10,446	15,454	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
Total	5,010	10,446	15,456	32.4%	67.6%	100.0%	100.0%	100.0%	100.0%
N	7,728	7,728	15,456						

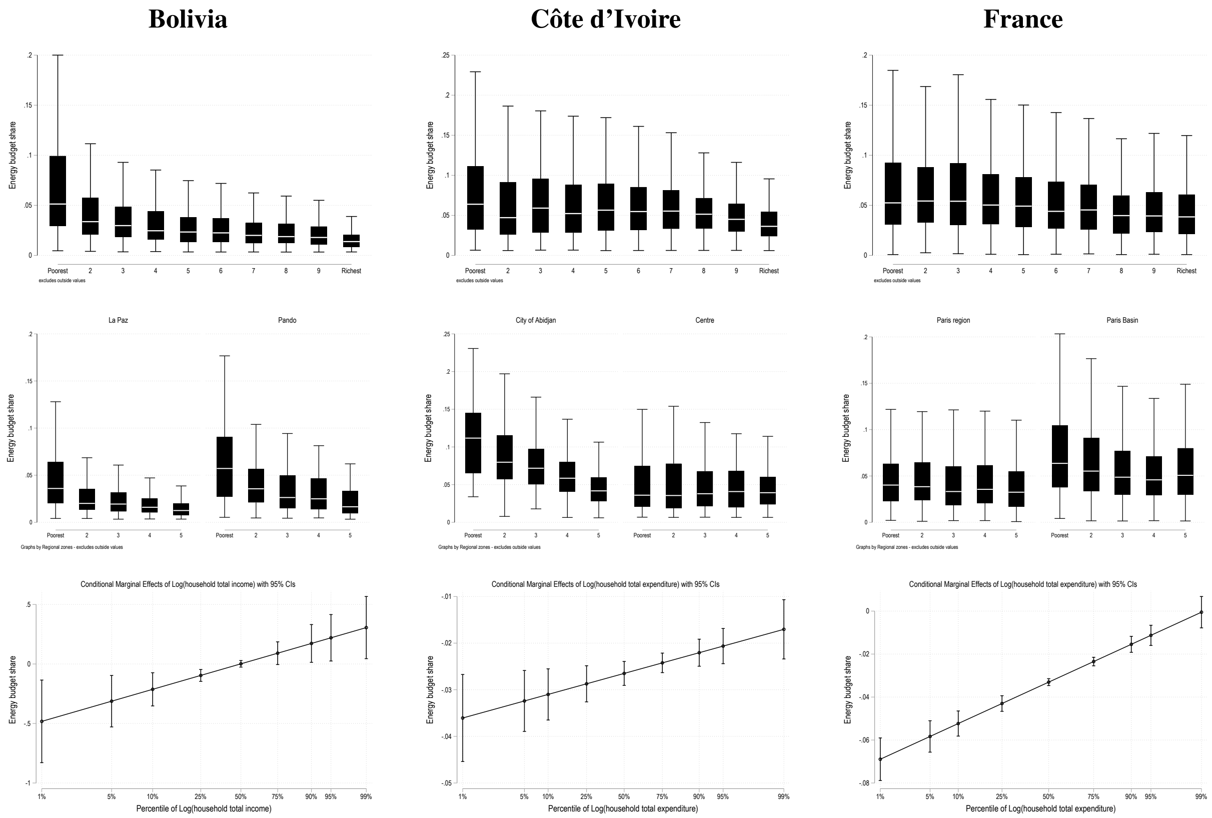

Figure A1: Energy Budget Shares per Quantiles

of years. Finally, the third line shows the important positive correlation that is present for the three countries between energy expenditure and income.

A.2 A discussion on the Operative definitions of Energy Poverty

The definition of energy poverty is a subject of open debate. According to González-Eguino (2015), energy poverty is having a level of consumption that is insufficient to meet basic needs and is analyzed in the literature on two dimensions: (i) absence of physical opportunity to connect/acquire energy, and/or (ii) inability to consume modern energy for various reasons.

Sy and Mokaddem (2022), in their extensive review of this literature, classify the definitions of energy poverty in three broad categories: the "single indicator" approach, the "dashboard indicators" approach and the "composite indicators or multidimensional" approach. The first way of defining energy poverty is based on whether the household consumes more or less than the threshold that defines the energy-poor category. That threshold can be defined in economic terms (relative to income) or technical terms (KWh consumed, e.g.). Dashboard indicators, instead, focus at the same time on economic, environmental, social, technical and even institutional sustainability of energy access. The Latin America Energy Organisation, United Nations Economic Commission for Latin America and the Caribbean, and GTZ carried out the first investigation into dashboard indicators in developing countries (OLADE, 1997). This constitutes a great example because the indicators include electricity access rate, consumption of useful residential energy, and indoor air pollution in the residential sector. Finally, multidimensional measurement is mostly applied to developing countries where the lack of harmonized data makes it useful to intersect several dimensions at a time. Among the different multidimensional measurements, the most commonly used is the Multidimensional Enegy Poverty Index (MEPI) developed by Nussbaumener

Table A7: Summary statistics for Bolivia

	Count: Under Median	Count: Over Median	Count: Total	Row percentages: Under Median	Row percentages: Over Median	Row percentages: Total	Column percentages: Under Median	Column percentages: Over Median	Column percentages: Total
Access to electricity (0=NO, 1=YES)									
NO	697	165	862	80.9%	19.1%	100.0%	13.0%	3.4%	8.5%
YES	4,673	4,636	9,309	50.2%	49.8%	100.0%	87.0%	96.6%	91.5%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
Access to combustion (0=NO, 1=YES)									
NO	4,755	3,561	8,316	57.2%	42.8%	100.0%	88.6%	74.2%	81.8%
YES	615	1,240	1,855	33.1%	66.9%	100.0%	11.4%	25.8%	18.2%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent or Old, 1=Permanent or New)									
Non-permanent or Old	1,652	473	2,126	77.7%	22.3%	100.0%	30.8%	9.9%	20.9%
Permanent or New	3,718	4,328	8,045	46.2%	53.8%	100.0%	69.2%	90.1%	79.1%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
Overcrowded dwelling (0=NO, 1=YES)									
NO	3,450	4,183	7,633	45.2%	54.8%	100.0%	64.2%	87.1%	75.0%
YES	1,920	618	2,538	75.6%	24.4%	100.0%	35.8%	12.9%	25.0%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
Occupation status (1=Owner, 0=Other)									
Other status	1,866	1,711	3,577	52.2%	47.8%	100.0%	34.8%	35.6%	35.2%
Owner	3,504	3,090	6,594	53.1%	46.9%	100.0%	65.2%	64.4%	64.8%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
Sex of household head (0=Female, 1=Male)									
Female	1,256	1,159	2,415	52.0%	48.0%	100.0%	23.4%	24.1%	23.7%
Male	4,114	3,643	7,756	53.0%	47.0%	100.0%	76.6%	75.9%	76.3%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
Head's age (Young, Middle-aged, Elder)									
Young	1,087	699	1,786	60.8%	39.2%	100.0%	20.2%	14.6%	17.6%
Middle-aged	2,554	1,866	4,420	57.8%	42.2%	100.0%	47.6%	38.9%	43.5%
Elder	1,729	2,236	3,965	43.6%	56.4%	100.0%	32.2%	46.6%	39.0%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	543	190	733	74.1%	25.9%	100.0%	10.1%	4.0%	7.2%
Primary	1,989	1,306	3,295	60.4%	39.6%	100.0%	37.0%	27.2%	32.4%
Secondary	2,239	1,846	4,085	54.8%	45.2%	100.0%	41.7%	38.5%	40.2%
University	599	1,459	2,058	29.1%	70.9%	100.0%	11.2%	30.4%	20.2%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
Sector (0=Farmers, Craftsmen or Workers, 1=Other)									
Farmers, Craftsmen or Workers	1,782	643	2,425	73.5%	26.5%	100.0%	33.2%	13.4%	23.8%
Other sectors	3,588	4,158	7,746	46.3%	53.7%	100.0%	66.8%	86.6%	76.2%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	2,178	4,628	6,806	32.0%	68.0%	100.0%	40.6%	96.4%	66.9%
Poor	3,191	173	3,365	94.8%	5.2%	100.0%	59.4%	3.6%	33.1%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
Area (0=Rural, 1=Urban)									
Rural	2,368	928	3,295	71.8%	28.2%	100.0%	44.1%	19.3%	32.4%
Urban	3,002	3,873	6,876	43.7%	56.3%	100.0%	55.9%	80.7%	67.6%
Total	5,370	4,801	10,171	52.8%	47.2%	100.0%	100.0%	100.0%	100.0%
N	5,086	5,085	10,171						

Table A8: Summary statistics for Côte d'Ivoire

	Count			Row percentages			Column percentages		
	Under Median	Over Median	Total	Under Median	Over Median	Total	Under Median	Over Median	Total
Access to electricity (0=NO, 1=YES)									
NO	3,416	2,221	5,638	60.6%	39.4%	100.0%	58.5%	31.5%	43.7%
YES	2,427	4,834	7,261	33.4%	66.6%	100.0%	41.5%	68.5%	56.3%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
Access to combustion (0=NO, 1=YES)									
NO	5,481	5,125	10,606	51.7%	48.3%	100.0%	93.8%	72.6%	82.2%
YES	362	1,930	2,293	15.8%	84.2%	100.0%	6.2%	27.4%	17.8%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
House (0=Non-Permanent or Old, 1=Permanent or New)									
Non-permanent or Old	3,214	2,342	5,556	57.8%	42.2%	100.0%	55.0%	33.2%	43.1%
Permanent or New	2,629	4,714	7,343	35.8%	64.2%	100.0%	45.0%	66.8%	56.9%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
Overcrowded dwelling (0=NO, 1=YES)									
NO	4,957	6,585	11,542	42.9%	57.1%	100.0%	84.8%	93.3%	89.5%
YES	886	471	1,357	65.3%	34.7%	100.0%	15.2%	6.7%	10.5%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
Occupation status (1=Owner, 0=Other)									
Other status	2,722	4,568	7,290	37.3%	62.7%	100.0%	46.6%	64.7%	56.5%
Owner	3,122	2,487	5,609	55.7%	44.3%	100.0%	53.4%	35.3%	43.5%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
Sex of household head (0=Female, 1=Male)									
Female	1,133	1,387	2,521	45.0%	55.0%	100.0%	19.4%	19.7%	19.5%
Male	4,710	5,668	10,378	45.4%	54.6%	100.0%	80.6%	80.3%	80.5%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
Head's age (Young, Middle-aged, Elder)									
Young	1,708	2,119	3,827	44.6%	55.4%	100.0%	29.2%	30.0%	29.7%
Middle-aged	2,699	3,528	6,226	43.3%	56.7%	100.0%	46.2%	50.0%	48.3%
Elder	1,437	1,409	2,846	50.5%	49.5%	100.0%	24.6%	20.0%	22.1%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
Education (0=None, 1=Prim, 2=Secon, 3=Univ)									
None	3,824	3,209	7,033	54.4%	45.6%	100.0%	65.8%	45.9%	55.0%
Primary	980	1,270	2,250	43.6%	56.4%	100.0%	16.9%	18.2%	17.6%
Secondary	953	1,910	2,864	33.3%	66.7%	100.0%	16.4%	27.3%	22.4%
University	52	598	650	8.0%	92.0%	100.0%	0.9%	8.6%	5.1%
Total	5,810	6,987	12,797	45.4%	54.6%	100.0%	100.0%	100.0%	100.0%
Sector (0=Farmers, Craftsmen or Workers, 1=Other)									
Farmers, Craftsmen or Workers	2,907	2,059	4,966	58.5%	41.5%	100.0%	49.8%	29.2%	38.5%
Other sectors	2,936	4,997	7,933	37.0%	63.0%	100.0%	50.2%	70.8%	61.5%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
Poverty status (0=Not poor, 1=Poor)									
Not poor	1,874	6,898	8,772	21.4%	78.6%	100.0%	32.1%	97.8%	68.0%
Poor	3,969	158	4,127	96.2%	3.8%	100.0%	67.9%	2.2%	32.0%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
Area (0=Rural, 1=Urban)									
Rural	3,958	2,751	6,710	59.0%	41.0%	100.0%	67.7%	39.0%	52.0%
Urban	1,885	4,304	6,189	30.5%	69.5%	100.0%	32.3%	61.0%	48.0%
Total	5,843	7,056	12,899	45.3%	54.7%	100.0%	100.0%	100.0%	100.0%
N	6,450	6,449	12,899						

et al. (2012) which focuses on the deprivation of access to modern energy services such as cooking, lighting, cooling, entertainment and education, and communications.

The "single indicator" approach has been dominant to define energy poverty due to its simplicity of implementation. Historically, it was first measured as "fuel poverty" by Boardman (1991) using a 1988 consumer expenditure survey in the UK, considered energy poor all households with an energy budget share that was above twice the median (2M). In Boardman (1991) this 2M threshold coincided with a budget share of 10%, which has since then been extensively used in the literature.

Since then, numerous refinements of the concept have been applied.

Households with very high income may be counted as "energy poor" according to the 10% and 2M definitions. For this reason Hills (2012a) suggests considering energy-poor households that, after energy expenditure, are left with an income that is under the poverty line. Hills (2012a) also suggests using the Low-Income High Costs (LIHC) indicator of energy poverty. Households are then considered energy-poor if energy expenditures are above the median and, income left after energy expenditure is below the poverty line. He also recommends using household income after housing costs are normalized by consumption units using the OECD normalization.[6] Hills (2012a) has been extensively used with alternative interpretations. In 2011, France created the National Fuel Poverty Observatory (ONPE) that, since 2016, has used the 10% indicator for deciles 1 to 3, the LIHC for the dwelling size, and a declared qualitative indicator of discomfort. No similar initiative can be found in Bolivia and Cote d'Ivoire.

The operative definition mostly used in academic literature is Romero et al. (2018)'s that considers the poverty line as 60% of median income net of average energy costs. Among alternative definitions we can find Moore (2012) that suggests a budget standard approach, and where energy poor have an energy expenditure higher than income net of housing and minimum living costs. More recently, Belaïd (2018) considers energy expenditures by m^2 and Belaïd (2022a) the Low-Income Low-Energy Efficiency (LILEE) indicator, first introduced in the UK. Finally, the MIS indicator or "minimum income standard" is a measurement that considers energy poor the household that, after paying for energy, is left with an income that is less than the minimum required to live.

Table A9 summarizes the numerous operative definitions of energy poverty that have been applied throughout the years in the Global North.

Table A9: Fuel poverty metrics and determinants

Study	Energy poverty metrics	Determinants
Boardman (1991)	Ratio $= \frac{\text{Required Fuel expenditures}}{\text{Income}} > 10\%$ which corresponds to twice the median (2M) in the sample	Not studied

[6] Glossary: Equivalised disposable income

Hills (2012a)	Low Income High Costs (LIHC) if 1. ”required fuel costs that were above the median level” 2. ”were they to spend that amount, they would be left with a residual income below the official poverty line” Residual income is considered after housing costs.	Not studied
Moore (2012)	Budget standard approach, Minimum Income Standard (MIS) fuel poor if fuel costs > Net household income – housing costs – minimum living costs	Not studied
Romero et al. (2018)	• 10% indicator • Moore (2012)’s indicator: fuel costs > household income - housing costs - minimum living costs • Operational adaptation of Hills (2012a)’s LIHC with : household income - household expenditure on energy < 60% [median household income - mean expenditure on energy]	Binary Logit Regression results: the most vulnerable to energy poverty are low-income households, with children, household heads with job instability
Belaïd (2018)	Hills (2012a)’s LIHC with energy expenditures in €/m^2	Multiple Correspondence Analysis (MCA) and Ascending Hierarchical Classification (AHC) to identify 4 fuel poor profiles. ”(i) foreign family, employed, in shared building group, (ii) single person, retired, in small size flat group, (iii) family in individual house with gas and individual central heating system group and (iv) owner of high size rural house group”. Also use logit regression to identify critical factors impacting the odds of being fuel poor.

Belaïd (2022b)	same as Belaïd (2018)	Clustering and regression methods similar to Belaïd (2018). Fuel poor household types in Jordan and Egypt are: (i) older households with higher incomes relative to the rest of the fuel-poor households, homeowners living in rural areas (ii) married homemakers, living in apartments (iii) lower incomes relative to other fuel poors, homeowners living in appartments
Belaïd and Flambard (2023)	Extension of LIHC: defines three categories of fuel poor to disentangle the effects of housing and fuel consumption: 1. low income, high housing costs and high fuel costs 2. low income, high housing costs and low fuel costs 3. low income low housing costs and high fuel costs	Trivariate probit regression to investigate critical factors of fuel poverty in Egypt: fuel poor households have large families, live in detached houses and have a low educated household's head.
Belaïd (2022a)	Low-Income Low Energy Efficiency (LILEE) 1. "have an FPEER[7] equal or lower than D" 2. "were they to spend that amount, they would be left with a residual income below the national standard poverty line." Income threshold set at 60% national median equivalized residual income after all housing-related expenditures per consumption unit and energy bill	Not studied

[7] Fuel Poverty Energy Efficiency Rating

Legendre and Ricci (2015)	• 10% indicator • After fuel cost: Income - housing costs - fuel costs $<$ 60% median. Focus on *vulnerable* households that are not below the poverty line before fuel costs. • Hills (2012a)'s LIHC	C log-log and mixed effect logit model to investigate wich factors influence the odds of being fuel vulnerable using the French 2006 National Housing Survey: the probability of being vulnerable is higher for retired households, living alone, renting their home, with poor roof insulation, using an individual boiler for heating and cooking with gas.
	Expenditure-based indicators	
EU Energy Poverty Observatory (EPOV)[8]	• M/2: Low absolute energy expenditure. Energy expenditures below half the national median. • 2M: Share of energy expenditure over income above twice the national median	Not studied
French National observatory on Energy Poverty (ONPE)[9]	• 10% indicator restricted to the poorest 30% (TEE indicator)[10] • Hills (2012a)'s LIHC • LIHC adaptation with energy expenses in relation to the size of the dwelling (m^2). • Qualitative declarative metrics of discomfort and cold	No studied

Source: Bousquet and Sanin (2024)

A.3 Results with alternative definitions of energy poverty

In Table A10 the most striking difference with respect to the Table on LIHC is that numerous variables become significant for FRA. This is the case because both indicators mostly concentrate on excessively high consumption without considering an income restriction aside from it. Numerous households in FRA are indeed over-consuming energy due to the very energy-intensive standard of living in developed countries.

[8] https://energy-poverty.ec.europa.eu/system/files/2021-09/epov_methodology_guidebook_1.pdf
[9] https://www.ecologie.gouv.fr/sites/default/files/thema_essentiel_25_precarite_energetique_2021_mars2023.pdf
[10] Taux d'Effort Energétique in French

Table A10: Dependent variable: Energy Poverty (EE10% Tot inc/exp) — Energy poverty (2M indicator)

	Energy Poverty (EE10% Tot inc/exp)						Energy poverty (2M indicator)					
	Logit			Probit			Logit			Probit		
	BOL	CIV	FRA	BOL	CIV	FRA	BOL	CIV	FRA	BOL	CIV	FRA
Area (0=Rural, 1=Urban)	0.008	0.122***	0.000	0.007	0.123***	0.000	-0.025**	-0.005	0.000	-0.025**	-0.007	0.000
	(0.007)	(0.011)	(.)	(0.007)	(0.011)	(.)	(0.013)	(0.009)	(.)	(0.013)	(0.009)	(.)
Education (0=None, 1=Prim, 2=Secon, 3=Univ)	0.002	-0.010**	-0.034***	0.001	-0.010**	-0.033***	-0.020***	-0.007	-0.037***	-0.021***	-0.006	-0.036***
	(0.003)	(0.005)	(0.004)	(0.003)	(0.005)	(0.003)	(0.006)	(0.005)	(0.003)	(0.006)	(0.005)	(0.003)
Sector (0=Farmers, Craftsmen or Workers, 1=Other)	-0.005	0.084***	-0.028***	-0.008	0.082***	-0.028***	-0.118***	0.018*	-0.021***	-0.120***	0.022**	-0.022***
	(0.008)	(0.013)	(0.008)	(0.008)	(0.012)	(0.008)	(0.013)	(0.010)	(0.007)	(0.013)	(0.010)	(0.007)
Head's age (Young, Middle-aged, Elder)	0.023***	0.012*	0.079***	0.024***	0.012*	0.081***	0.057***	0.001	0.021***	0.062***	-0.000	0.023***
	(0.004)	(0.006)	(0.007)	(0.004)	(0.006)	(0.007)	(0.007)	(0.006)	(0.005)	(0.007)	(0.006)	(0.005)
Number of rooms	0.013***	0.002		0.013***	0.002		0.014**	-0.000		0.012**	0.000	
	(0.003)	(0.003)		(0.003)	(0.003)		(0.005)	(0.004)		(0.005)	(0.004)	
Employed per Working-age pop.	-0.017***	-0.008	-0.055***	-0.015**	-0.006	-0.051***	-0.051***	-0.013	-0.072***	-0.053***	-0.004	-0.076***
	(0.007)	(0.013)	(0.012)	(0.007)	(0.013)	(0.012)	(0.011)	(0.012)	(0.009)	(0.012)	(0.014)	(0.009)
Sex of household head (0=Female, 1=Male)	0.001	-0.018*	-0.013*	-0.001	-0.019**	-0.012*	0.002	0.005	-0.035***	-0.002	0.004	-0.033***
	(0.005)	(0.009)	(0.007)	(0.005)	(0.009)	(0.007)	(0.010)	(0.009)	(0.006)	(0.010)	(0.009)	(0.006)
Occupation status (1=Owner, 0=Other)	0.015***	0.003	0.138***	0.014***	0.003	0.137***	0.023**	-0.032***	0.042***	0.024**	-0.032***	0.043***
	(0.005)	(0.011)	(0.008)	(0.005)	(0.010)	(0.008)	(0.010)	(0.010)	(0.006)	(0.010)	(0.010)	(0.006)
House (0=Non-Permanent or Old, 1=Permanent or New)	0.026***	0.055***	-0.018*	0.025***	0.052***	-0.021**	-0.024*	-0.022**	-0.027***	-0.022	-0.022**	-0.025***
	(0.007)	(0.011)	(0.011)	(0.007)	(0.011)	(0.011)	(0.013)	(0.009)	(0.008)	(0.013)	(0.009)	(0.008)
Household size	-0.023***	-0.018***	-0.046***	-0.022***	-0.019***	-0.045***	-0.106***	-0.075***	-0.092***	-0.101***	-0.069***	-0.088***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
Energy services (1=50%, 2=75% and 3=100% of the services)	0.018***	0.006	0.006	0.018***	0.004	0.006	-0.023***	-0.033	-0.039***	-0.024***	-0.044	-0.040***
	(0.004)	(0.013)	(0.007)	(0.004)	(0.012)	(0.007)	(0.008)	(0.037)	(0.006)	(0.008)	(0.043)	(0.006)
Quintiles of income per CU=2	-0.246***	-0.121***	-0.067***	-0.238***	-0.121***	-0.072***	-0.338***	-0.298***	-0.114***	-0.347***	-0.313***	-0.122***
	(0.014)	(0.018)	(0.012)	(0.013)	(0.017)	(0.012)	(0.011)	(0.012)	(0.011)	(0.011)	(0.012)	(0.012)
Quintiles of income per CU=3	-0.290***	-0.177***	-0.102***	-0.279***	-0.176***	-0.108***	-0.423***	-0.448***	-0.143***	-0.426***	-0.457***	-0.152***
	(0.014)	(0.017)	(0.013)	(0.013)	(0.017)	(0.013)	(0.012)	(0.010)	(0.012)	(0.012)	(0.010)	(0.012)
Quintiles of income per CU=4	-0.313***	-0.235***	-0.123***	-0.302***	-0.234***	-0.128***	0.000	0.000	-0.181***	0.000	0.000	-0.190***
	(0.014)	(0.017)	(0.013)	(0.013)	(0.016)	(0.013)	(.)	(.)	(0.012)	(.)	(.)	(0.012)
Quintiles of income per CU=5	-0.320***	-0.295***	-0.128***	-0.310***	-0.294***	-0.136***	0.000	0.000	-0.221***	0.000	0.000	-0.226***
	(0.014)	(0.017)	(0.014)	(0.013)	(0.016)	(0.014)	(.)	(.)	(0.012)	(.)	(.)	(0.012)
Observations	9563	6621	11509	9563	6621	11509	5745	3974	11509	5745	3974	11509
Constant	√	√	√	√	√	√	√	√	√	√	√	√
Region FE	√	√	√	√	√	√	√	√	√	√	√	√
Wald chi2	984.9	668.7	1195.8	973.8	669.8	1180.9	1368.8	534.3	1683.5	1542.6	558.0	1681.7
Prob ¿ chi2	2.14e-193	4.98e-125	5.92e-241	4.86e-191	3.02e-125	9.20e-238	4.46e-277	2.54e-98	0	2.54e-314	2.79e-103	0

Notes: Standard errors in parentheses. Coefficients represent the average marginal effects. Number of observations vary between estimations simply for convergence reasons in the probit estimation.

A.4 Distribution of cash transfer to get households out of energy poverty

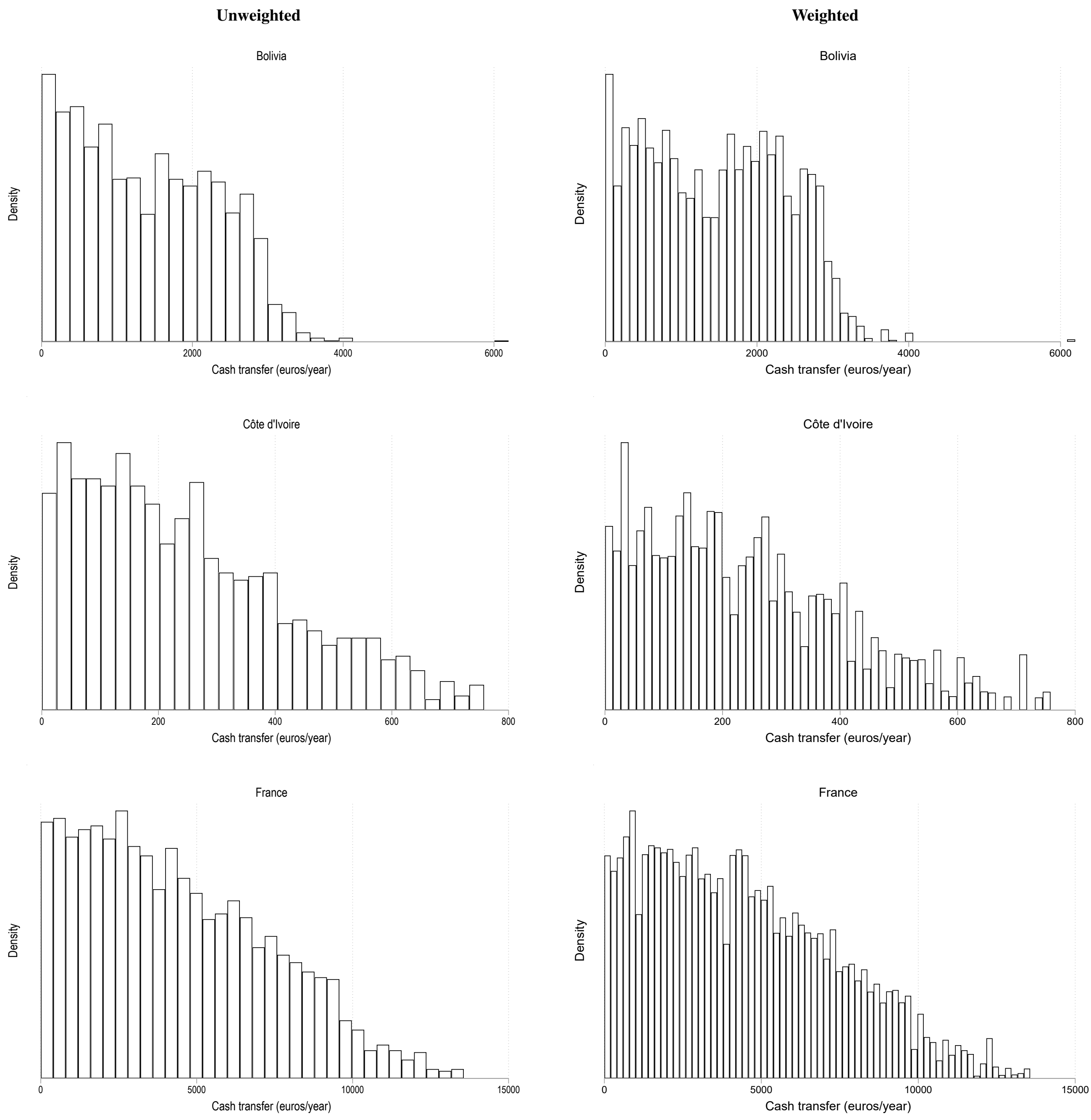

Figure A2: Distributions of cash transfer (in euros/year) required to get households out of energy poverty (LIHC) by country

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Working Paper Publication Directors :

Marc Baudry, Philippe Delacote, Olivier Massol

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