The relationship between energy accessibility and income inequality in Latin America and Caribbean countries

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Content

Introduction

Introduction

- Access to electricity is previous to the energy transition
- 17 million people in Latin America and the Caribbean (LAC) currently do not have access to power, and 75 million do not have access to clean fuels and cooking technologies (United Nations, 2022).
- LAC: a region marked by pronounced income disparities and significant variations in energy access. Often understudied. Most of the most unequal countries and cities in the world are located in LAC.
- Explore the relationship between **access to modern energy services** and **income inequality** within Latin America and the Caribbean (LAC).

Introduction

- The objective is to offer insights into which strategies are most effective in reducing income inequality through improved energy access and provide recommendations for taking advantage of the energy revolution to address socio-economic disparities.

- Access to electricity is essential for improving living conditions and human development.
- Uneven access to energy can lead to energy poverty, which deepens inequalities since access to energy directly influences income inequality by helping people build assets, and indirectly by improving health, education, gender equality, and agriculture (Aiyar & Ebeke, 2020; Bouzarovski & Petrova, 2015; IEA, 2017; Sovacool et al., 2017).

Introduction

- The 2030 Agenda for Sustainable Development emphasizes two key goals: reducing income inequality (**SDG 10**) and ensuring access to reliable and clean energy (**SDG 7**).
- There is a solid connection between SDG 7 (Affordable and Clean Energy) and several SDGs, including SDG 1 (No Poverty) and SDG 10 (Reduced Inequality).

- A nation that lacks access to modern energy may find it difficult or impossible to address other issues such as air pollution, low life expectancy, and scarce access to essential healthcare services (SDG 3), providing quality education (SDG 4), adapting to and mitigating climate change (SDG 11), food production and security (SDG 2), economic growth and employment (SDG 8), sustainable industrialization (SDG 9), and many others.

Introduction

- Econometric approach with Granger causality analysis from **2000 to 2019**, for **Bolivia**, **Brazil**, **Colombia**, **Costa Rica**, **El Salvador**, and **Honduras**, known for their disparities in energy access and income distribution policy approaches (Barnes et al., 2018).

- Social, economic, and energy-related variables

Introduction

- Results suggest that enhancing access to electricity can reduce income inequality within the LAC region, with country-specific impacts.
- The case of **Costa Rica** is highlighted for its unique bidirectional causality between electricity access and income inequality, fostering a virtuous cycle where development becomes endogenous, while **Honduras** presents bidirectional causality between electricity access and the HDI index.
- Implications extend beyond the LAC region, offering relevant insights to other middle-income nations facing similar challenges.

SDG 7

Affordable and clean energy

Legend

Click on a country to see its performance.

- SDG achieved
- Challenges remain
- Significant challenges remain
- Major challenges remain
- Information unavailable

Description

Ensure access to affordable, reliable, sustainable and modern energy for all.

SDG 10

Reduced inequalities

Legend

Click on a country to see its performance.

- SDG achieved
- Challenges remain
- Significant challenges remain
- Major challenges remain
- Information unavailable

Description

Reduce inequality within and among countries.

Literature overview

Literature

- *"About 1.2 billion people still lack access to electricity"* (UNDP, 2018a, p. 2)
- "… 2.3 billion people worldwide - nearly one third of the global population still cook their meals over open fires or on basic stoves, breathing in harmful smoke released from burning coal, charcoal, firewood, agricultural wastes, and animal dung. (…) These practices can still be found in 128 countries today. (…)

A lack of clean cooking contributes to 3.7 million premature deaths annually, with women and children most at risk. Poor indoor air quality is a leading cause of **premature death** worldwide. (…) Lost time and productivity results in a huge economic cost due to hours spent collecting firewood and other fuel sources." (https://www.iea.org/reports/a-vision-for-clean-cooking-access-for-all/executive-summary)

- In the LAC region clean cooking adoption has been notably slow. Receiving a stove for free does not mean changing the way of cooking and using it.

Literature

- The **price of energy** can significantly influence energy access, particularly for individuals and communities with limited financial resources, impacting its **affordability**, availability, energy transition, and efficiency. Other factors, such as **infrastructure development**, technological advancements, and **policy frameworks**, are also crucial in ensuring **equitable and sustainable energy access** (IEA, 2017; UNDP, 2018a).

- In emerging countries, inadequate infrastructure and energy deprivation are linked to energy poverty, with nations struggling with a **lack of energy networks** necessary for economic growth (Charlier et al., 2021).

Literature

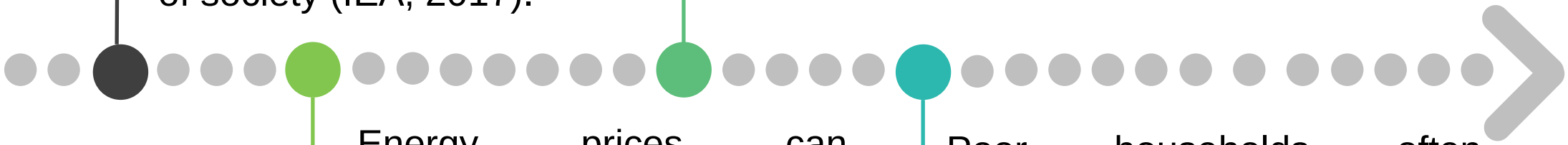
- Households with lower incomes tend to spend a more significant proportion of their disposable income on energy services or choose not to join grid networks. **Income and equipment/appliance prices** can directly contribute to **energy poverty** through accessibility and affordability.

- **Homes with poor energy efficiency and outdated home furnishings require people to pay more for the same energy services, which negatively impacts their quality of living and increases inequality (Oum 2019).**

- **Energy poverty may affect other types of poverty, as the lack of access to energy can entail being denied not only necessities like cooking and house heating, but also other components essential for both individual and societal growth, such as access to information, health care, education, and political involvement (González-Eguino 2015).**

Access to energy services is essential for promoting human development and the social inclusion of the most vulnerable and underprivileged members of society (IEA, 2017).

Societies with high-income inequality experience slower economic growth and are less successful in eradicating poverty (DESA, 2020).



Energy prices can exacerbate energy poverty, preventing individuals and communities from meeting their basic energy needs (IEA, 2017).

Poor households often consume more energy and emit more CO_2 than they would otherwise because they cannot afford essential expenditures in energy efficiencies (Madlener, 2020; Reames, 2016)

Literature

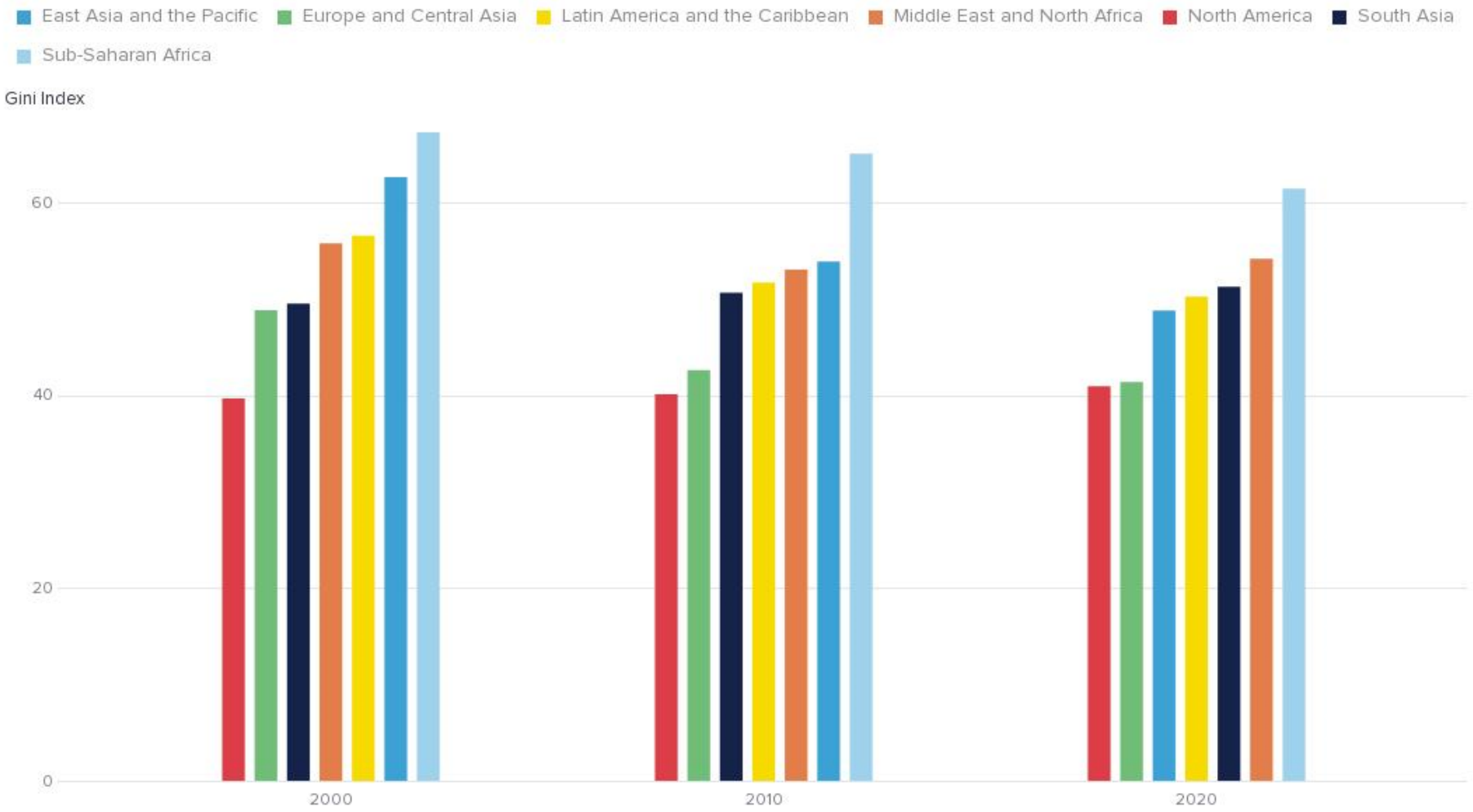
People with higher educational levels and longer life expectancies live in regions with higher electrification rates.

Improvements in school completion rates enable residents to obtain well-paying jobs, increasing purchasing power and raising living standards.

Furthermore, access to electricity increases the quality of medical care and lowers maternal and infant mortality, increasing life expectancy (Njiru & Letema, 2018).

Therefore, improving access to energy and modern energy services is crucial to raising the quality of living and reducing energy poverty, besides income, gender, and other inequalities (Acheampong et al., 2021)

17 million people in LAC currently do not have access to power, and 75 million do not have access to clean fuels and cooking technologies (United Nations, 2022)



Gini index of previous decades by region. Source: WIID, 2022.

Latin America and the Caribbean=50.2

Research Questions

RQ1. Does access to electricity have an impact on income inequality?

RQ2. Does access to clean cooking fuels have an impact on income inequality?

RQ3. Does access to electricity impact the access to clean cooking fuels?

Methodology

Table 1 - Descriptive Statistics per Country (2000-2019)

Country	Variable	Obs	Mean	Std.dev.	Min	Max
Bolivia						
	Gini	18	50.51	6.25	41.63	61.47
	GDPC	20	2.45	1.34	-0.10	5.07
	Electric	20	82.84	9.84	64.00	95.08
	Clean cook	20	74.95	7.71	62.90	85.70
	Urbanpop	20	6731091	913430.70	5309144	8217386
	HDI	20	0.66	0.03	0.62	0.72
Brazil						
	Gini	18	53.85	2.56	49.90	58.32
	GDPC	20	1.37	2.73	-4.38	6.48
	Electric	20	98.32	1.56	94.39	99.80
	Clean cook	20	93.26	2.26	89	95.80
	Urbanpop	20	164148046.5	12721066.98	142795391	183878366
	HDI	20	0.72	0.03	0.67	0.76
Colombia						
	Gini	19	53.51	2.24	49.72	57.91
	GDP	20	2.49	1.85	0.01	5.85
	Electric	20	97.00	1.38	94.91	99.76
	Clean cook	20	85.64	4.52	78.10	92.50
	Urbanpop	20	34638020.45	3463280	29002337	40703994
	HDI	20	0.73	0.03	0.67	0.77
Costa Rica						
	Gini	20	48.82	1.20	46.74	51.65
	GDPC	20	2.54	1.82	-2.37	6.73
	Electric	20	99.10	0.64	96.94	99.71
	Clean cook	20	92.33	2.06	89	95.60
	Urbanpop	20	3248050	543918	2349793	4071490
	HDI	20	0.76	0.03	0.71	0.81
El Salvador						
	Gini	20	44.63	4.47	38.01	51.72
	GDPC	20	1.69	1.35	-2.46	4.41
	Electric	20	91.70	3.99	84.52	97.36
	Clean cook	20	75.45	10.39	57.90	90.75
	Urbanpop	20	4004265	344067.10	3510261	4568607
	HDI	20	0.65	0.02	0.61	0.68
Honduras						
	Gini	19	53.18	3.62	48.10	59.46
	GDPC	20	1.87	1.91	-4.50	4.40
	Electric	20	78.44	10.18	63.14	91.60
	Clean cook	20	41.01	5.32	30.70	48.10
	Urbanpop	20	4337142	852305	3026014	5749232
	HDI	20	0.59	0.02	0.55	0.63

- Bolivia, Brazil, Colombia, Costa Rica, El Salvador, and Honduras
- Total population of the LAC region surpassed 659 million people in 2022, and the countries selected represent almost half of this figure, around **47%** (The World Bank, 2022).
- Countries' selection was dictated by data availability.

- The chosen timeframe begins in 2000, for data availability reasons.
- The cut-off year of 2019 was deliberately chosen to prevent the distorting effects of the COVID-19 pandemic on income inequality trends

- percentage of people with access to electricity
- percentage of people with access to clean fuels and technology for cooking
- GDP growth
- urban population size
- HDI (composite index including life expectancy, education, per capita income, and overall quality of life)
- collected from the World Bank, following the work of Acheampong et al. (2021) and Nguyen & Nasir (2021), and UN Development Programme.

Methodology

- Vector Autoregressive (VAR)-based Granger causality Wald tests
- Identify causal effects between variables
- Whether past values of one variable provide information that helps predict future values of another variable
- While correlation analysis focuses on the magnitude but not on the direction of the relationship, Granger causality focuses on the predictive power of one variable for another.
- Essential, since policy interventions should target causal factors if the goal is to address income inequality.
- Only variables that are integrated of the same order can be tested for Granger causality. So, check for variables stationarity, via Fisher unit root tests with augmented Dickey-Fuller and the Phillips-Perron test methods (missing values for some countries rendered the KPSS (Kwiatkowski-Phillips-Schmidt-Shin) tests unfeasible).

Results and Discussion

Table 3 - Correlation analysis by country.

Bolivia	Gini	Eletric	Clean cook	Urbanpop	GDPC	HDI
Gini	1.0000					
Eletric	-0.9647	1.0000				
Clean cook	-0.9551	0.9525	1.0000			
Urbanpop	-0.9480	0.9352	0.9952	1.0000		
GDPC	-0.3756	0.4967	0.4540	0.3989	1.0000	
HDI	-0.9341	0.9803	0.9175	0.9891	0.3201	1.0000
Brazil	Gini	Eletric	Clean cook	Urbanpop	GDPC	HDI
Gini	1.0000					
Eletric	-0.8554	1.0000				
Clean cook	-0.8255	0.9877	1.0000			
Urbanpop	-0.7395	0.9561	0.9846	1.0000		
GDPC	0.3030	-0.3657	-0.3876	-0.4060	1.0000	
HDI	-0.7595	0.9630	0.9879	0.9924	-0.4012	1.0000
Colombia	Gini	Eletric	Clean cook	Urbanpop	GDPC	HDI
Gini	1.0000					
Eletric	-0.6505	1.0000				
Clean cook	-0.7867	0.7316	1.0000			
Urbanpop	-0.7793	0.7333	0.9990	1.0000		
GDPC	0.3598	-0.3247	-0.0897	-0.1039	1.0000	
HDI	-0.7819	0.7314	0.9939	0.9901	-0.0725	1.0000

Costa Rica	Gini	Eletric	Clean cook	Urbanpop	GDPC	HDI
Gini	1.0000					
Eletric	-0.0129	1.0000				
Clean cook	-0.3027	0.8024	1.0000			
Urbanpop	-0.3086	0.8138	0.9987	1.0000		
GDPC	-0.2023	0.0569	-0.0738	-0.0599	1.0000	
HDI	-0.2999	0.8290	0.9914	0.9959	-0.0450	1.0000
El Salvador	Gini	Eletric	Clean cook	Urbanpop	GDPC	HDI
Gini	1.0000					
Eletric	-0.9590	1.0000				
Clean cook	-0.9773	0.9877	1.0000			
Urbanpop	-0.9647	0.9811	0.9899	1.0000		
GDPC	-0.3643	0.2753	0.2889	0.2728	1.0000	
HDI	-0.9491	0.9452	0.9651	0.9225	0.3459	1.0000
Honduras	Gini	Eletric	Clean cook	Urbanpop	GDPC	HDI
Gini	1.0000					
Eletric	-0.9058	1.0000				
Clean cook	-0.8624	0.9808	1.0000			
Urbanpop	-0.8993	0.9737	0.9821	1.0000		
GDPC	0.3596	-0.0923	-0.0257	-0.0338	1.0000	
HDI	-0.8760	0.9698	0.9884	0.9859	-0.0545	1.0000

These figures indicate a substantial negative correlation between energy access and income inequality, which is even stronger in the poorest countries, and illustrate that it is impossible to have a one-size-fits-all strategy in the LAC region.

- Correlation of both energy-based variables with the Gini index higher in the lower-income countries (> 0.95 in Bolivia and El Salvador, >0.86 in Honduras)
- Correlation lower in the upper-middle-income countries Brazil and Colombia (>0.65) and much lower in Costa Rica (0.01 for access to electricity and 0.3 for access to clean cooking fuels).
- An increase in urban population can help reduce income inequality, which is more pronounced in lower-income countries (with a high percentage of rural population).
- Negative correlation between HDI and income inequality across all countries, higher in Bolivia, El Salvador and Honduras (low-middle income countries) and lower in Brazil, Colombia and Costa Rica (upper-middle income countries).

Table 4 - VAR-based Granger causality Wald test results by country.

Bolivia					
Null hypothesis	χ2	Prob > χ2	Null hypothesis	χ2	Prob > χ2
Gini does not cause Electric	3.3508	0.187	Electric does not cause Gini	7.8615	0.020
Brazil					
Null hypothesis	χ2	Prob > χ2	Null hypothesis	χ2	Prob > χ2
Gini does not cause Clean cook	6.1953	0.045	Clean cook does not cause Gini	3.2248	0.199
HDI does not cause Clean cook	8.9485	0.011	Clean cook does not cause HDI	7.1619	0.028
Colombia					
Null hypothesis	χ2	Prob > χ2	Null hypothesis	χ2	Prob > χ2
Gini does not cause Clean cook	3.1371	0.208	Clean cook does not cause Gini	0.17529	0.916
HDI does not cause Clean cook	1.6741	0.433	Clean cook does not cause HDI	0.93392	0.627
Costa Rica					
Null hypothesis	χ2	Prob > χ2	Null hypothesis	χ2	Prob > χ2
Gini does not cause Electric	7.0089	0.030	Electric does not cause Gini	10.429	0.005
Gini does not cause Clean cook	5.1392	0.077	Clean cook does not cause Gini	0.3071	0.858
Electric does not cause Clean cook	5.5864	0.061	Clean cook does not cause Electric	0.13846	0.933
El Salvador					
Null hypothesis	χ2	Prob > χ2	Null hypothesis	χ2	Prob > χ2
Electric does not cause Clean cook	44.098	0.000	Clean cook does not cause Electric	0.53938	0.764
HDI does not cause Clean cook	6.6962	0.035	Clean cook does not cause HDI	6.4695	0.039
HDI does not cause Eletric	0.75291	0.686	Eletric does not cause HDI	8.5882	0.014
Honduras					
Null hypothesis	χ2	Prob > χ2	Null hypothesis	χ2	Prob > χ2
Gini does not cause Electric	19.386	0.000	Electric does not cause Gini	2.932	0.231
Gini does not cause Clean cook	21.506	0.000	Clean cook does not cause Gini	0.21262	0.899
HDI does not cause Clean cook	6.4711	0.039	Clean cook does not cause HDI	3.558	0.169
HDI does not cause Eletric	9.6194	0.008	Eletric does not cause HDI	6.3451	0.042
Electric does not cause Clean cook	16.36	0.000	Clean cook does not cause Electric	11.689	0.003

Note: The null hypothesis states that a certain variable does not Granger cause another variable within the VAR system. The null hypothesis is rejected when the p-value obtained from the Wald test (Prob > χ2) is less than the significance level of 0.1.

Granger Causality Testing

- By country
- It is not possible to evaluate the same hypothesis in all countries due to the variables' differences in stationarity levels
- Reinforces that the impact of energy access on income inequality can be different from one country to another

Research Questions

RQ1. Does access to electricity have an impact on income inequality?

RQ2. Does access to clean cooking fuels have an impact on income inequality?

RQ3. Does access to electricity impact the access to clean cooking fuels?

Bolivia and Costa Rica are the only countries in which access to electricity Granger causes income inequality in the sense of reducing the Gini index (RQ1). In Costa Rica, Granger causality is bidirectional, suggesting a virtuous circle between these variables (for example, access to electricity might affect income inequality through improved education and job opportunities, while income inequality could influence access to electricity through affordability issues).

Table 5 – Summary of causality relations.

(2) / (1)	Electricity access	Access to Clean cooking facilities	Gini Index	HDI
Electricity access		Costa Rica, El Salvador, Honduras	Bolivia, Costa Rica	El Salvador, Honduras
Access to Clean cooking facilities	Honduras			Brazil, El Salvador
Gini Index	Costa Rica, Honduras	Brazil, Costa Rica, Honduras		
HDI	Honduras	Brazil, El Salvador, Honduras		

in Costa Rica, El Salvador and Honduras electricity access Granger causes the access to clean cooking fuels. (**RQ3**)
Costa Rica and El Salvador: policies should aim at expanding the availability of the electricity infrastructure, which may indirectly enhance access to clean cooking fuels.
Honduras: results suggest an integrated approach to energy and infrastructure policies, because the causality is bidirectional.

In low-income countries such as El Salvador and Honduras electricity access causes human development.

In Bolivia access to electricity Granger causes “Palma” inequality (RQ1).

(1) \ (2)	“Palma” inequality (10% richest / 50% poorest)
Electricity access	Bolivia
Access to Clean cooking facilities	Honduras

Bolivia: there is co-integration and long-run causality from EA to “Palma”

Honduras: there is co-integration and long-run bidirectional causality between ACCF and “Palma”

“Palma” ratio = % of total income in the hands of the 10% richest / % of total income in the hands of the 50% poorest. The higher the ratio, the stronger the inequality.

In Honduras access to clean cooking facilities Granger causes “Palma” inequality (RQ2).

Colombia is the only country in the sample with no causality between the 2 energy-related variables and inequality in its 3 measures.
For Bolivia, Honduras, and El Salvador (the lower-income countries in the sample) 2 causalities were obtained.

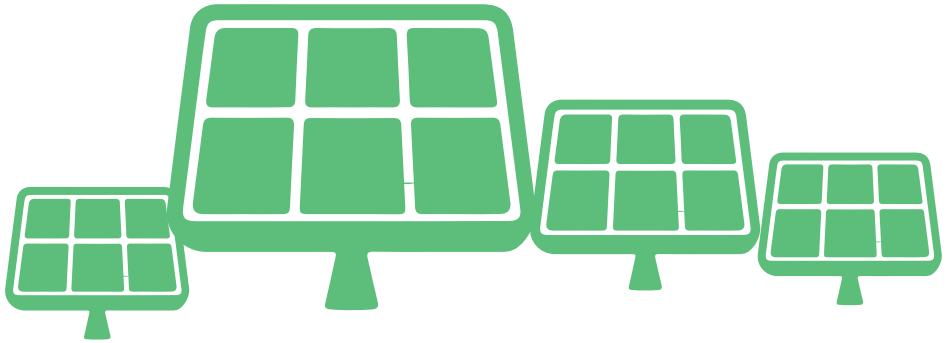
Conclusion

As we navigate through an energy transition, understanding how access to energy and income inequality relate becomes crucial

Achieving SDG 7 can support other SDGs, including 10 (reducing inequalities)

The LAC region was chosen because these households spend a significant amount of their budget on electricity (from 5% to 20%), there is high income inequality and significant variations in access to energy

Findings demonstrated that energy access can contribute to reducing income inequality



The impact of energy accessibility on income inequality is country-specific and seems to be dependent on the inequality and the energy accessibility measures chosen

Need for tailored strategies and policies to improve access to electricity and address income disparities in the LAC region – adapted to each context

Need for an integrated approach

Limitations and Further Research

Lack of access to consistent income inequality data from 2000 to 2019, which prevented the inclusion of a wider range of countries, and more indicators for income inequality

Investigate the impact of energy accessibility on other types of inequality, such as wealth, gender, health, education, employment and job opportunities, social, and environmental disparities

Thank You

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