

The End of Neutrality? Fuel Standards, Technology Neutrality, and Stimulating the Electric Vehicle Market

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1. Motivations underlying the research

Widespread electrification of the transportation sector is a key component of most strategies for deep decarbonization of the U.S. economy. A key element of most visions for achieving climate stabilization involves the widespread transition of the transportation sector to electricity via the adoption of electric vehicles (electric vehicles).

One policy tool for supporting electric vehicle growth that has drawn interest are the clean fuel standards, such as the Federal Renewable Fuel Standard and California's Low Carbon Fuel Standard. Traditionally, these policies offer credits to suppliers of low carbon transportation sources that suppliers can sell to producers of higher-carbon transportation fuels. Moreover, these policies have traditionally been positioned as "technology-neutral" standards that score a broad set of fuels based upon their life-cycle carbon intensity. A clean fuel standard is designed to promote clean or renewable transportation in a way that is most easily applied to blends of lower-carbon fuel used in similar (internal combustion engine) vehicles.

Adapting a clean fuel standard to promote specific and dramatically different transportation technologies, such as hydrogen or electricity, necessitates scoring vastly different technologies on the common metric of "carbon-intensity" so that credits or debits can be awarded and assessed. The assumptions necessary to do so reshape and redefine the nature and function of a clean fuel standard. To the extent that these assumptions create favorable conditions for specific decarbonization pathways, the standard loses one of its main initial benefits: technological neutrality. If, though, such policy focuses on vehicle purchases and infrastructure through a set of uncertain assumptions, it is no longer a "fuel" standard.

2. A short account of the research performed

We discuss the policy challenges presented by a goal of rapid large-scale expansion of electric vehicles. We summarize the three channels by which policies can encourage electric vehicle adoption: vehicle cost, operating (or fuel) costs, and infrastructure support.

To date, the most substantial policy support for electric vehicle adoption focuses on lowering the upfront vehicle cost through tax credits and a variety of other direct and indirect subsidies. In this paper, we explore the tradeoffs arising from the use of a clean fuel standard as an alternative policy approach to stimulating electric vehicle adoption. The primary compromise we highlight is that for a clean fuel standard to direct sufficient revenues to promote substantial electric vehicle adoption, policymakers often change fuel standards in a fundamental way as to no longer be a technologically neutral.

We describe how California's LCFS offers one such example -- awarding credits for activities other than selling low-carbon fuels (such as installing charging stations) and directing revenues from electricity sales toward vehicle rebates, rather than lowering the price of charging. We highlight the formulae used to award credits to alternative fuel vehicles and infrastructure and note how they do not reward projects based on carbon abatement potential. As one illustration, the program contains no incentives for biofuels infrastructure, such as the installation of E85 pumps. In doing so, the LCFS undermines its value as a tool to encourage decarbonization pathways based purely on their abatement potential.

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3. Main conclusions and policy implications of the work

The electrification of transportation constitutes a transition of immense scale. Although previous research estimates that a 10% decrease in the purchase price may increase electric vehicle sales by 10% - 35%, the policy resources needed to expand the share electric vehicles in line with goals to fully electrify may be enormous. Adoption can be accelerated by improving the value proposition to buyers, as has already occurred via a proliferation of models, longer driving range, and more charging stations. But governments consistently reveal a belief that substantial support for the industry remains necessary, and increasingly use clean fuel standards to aid electric vehicle adoption.

Although the minimal fiscal requirements of a clean fuel standard may seem tempting to policymakers seeking to further spur electric vehicle adoption, advantaging specific technological pathways sacrifices one of the main attractions of fuel standards, technological neutrality. This loss is meaningful in settings, like decarbonization of transportation, where there is significant uncertainty about the ultimate identity and mix of fuels and solutions that can best achieve policy goals. In such settings, the value of rewarding abatement based the amount of carbon savings achieved, rather than how a project provides it, is particularly great.

Key Fuel Poverty Indicators and Variables: A Systematic Literature Review

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1. Motivations underlying the research

Fuel poverty is associated with high energy costs and low housing quality. In addition, it results in poor physical and mental health outcomes. Fuel poverty is also known as energy poverty in the European Union and it is part of the concept energy hardship in New Zealand. However, there are no homogenous international indicators or variables of this serious condition. This inconsistency causes obstacles for researchers and policymakers trying to quantify and compare the number of households struggling with fuel poverty.

Although we do not suggest a one-size-fits-all solution to this multifaceted issue, we performed a systematic literature review to highlight and discuss the pros and cons of leading indicators and variables used to measure fuel poverty and its counterparts. Additionally, we explored and discussed the presence of major themes associated with fuel poverty in the selected publications, such as the presence of elderly members in the household and food insecurity issues.

2. A short account of the research performed

Using Google Scholar as the search engine in February 2023, we assessed at the first twenty results (sorted by relevance) of the following searches:

- Fuel poverty definition,
- Fuel poverty indicator,
- Energy poverty definition,
- Energy poverty indicator,
- Energy hardship definition, and
- Energy hardship indicator.

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Several of the same results were shown using different search criteria. Removing duplicates and results not focused on energy affordability issues resulted in eighty-four publications, including the grey literature.

We focused on eight main types of fuel poverty indicators, identifying their presence in the selected literature:

- Spending 10% of income on energy services (10%),
- The share of energy expenses over income being at least two times the mean energy expenditure (2x Mean),
- The share of energy expenses over income being at least two times the median energy expenditure (2x Median),
- The share of energy expenses over income being less than half the median energy expenditure (Median/2),
- Falling below the poverty line after energy expenditure (AFCP),
- Having above-median energy expenditure and falling below the poverty line after that expense (LIHC),
- Not being able to afford energy expenditure after paying for other established basic expenses (MIS), and
- Reporting being unable to pay their utility bills, having inadequate heating systems at home, or other subjective parameters relating to fuel poverty, often mixed with self-reported objective variables relating to housing quality (Subjective).

The key fuel poverty variables selected for analysis in the selected literature were:

- Ability to maintain home warm (subjective),
- Age of dwelling (objective),
- Age of household members (objective),
- Arrears on energy or other utility bills (subjective),
- Damp walls, floor, or foundation (objective),
- Dwelling type (objective),
- Employment status (objective),
- Fuel prices (objective),
- Income (objective),
- Leaking roof (objective),
- Rot on window frames or floor (objective),
- Size of dwelling (objective),
- Size of household (objective), and
- Tenure (objective).

The presence of the following themes was explored with the assistance of NVivo (March 2020 version), all of them selecting only valid results for the topic and allowing for synonyms: *children, elderly, food, health, and tenure*. In addition to presenting the frequency of the above indicators and variables, their strengths and weaknesses were examined, having the themes in context.

3. Main conclusions and policy implications of the work

Subjective, 10% of income, and LIHC were the most common indicators found in this systematic literature review, which shows that the policies from the United Kingdom and the European Union have a great influence in fuel poverty research worldwide. Additionally, variables associated with the households' structure and composition were the predominant, and the great majority of publications mentioned or discussed health. These latter findings show that fuel poverty is a social issue with significant health implications. The authors suggest that policymakers, researchers, and practitioners make a careful comparison of indicators and variables prior to adopting them, using a combination of objective and subjective variables to avoid overlooking underprivileged groups, especially those underconsuming energy.

Electricity Markets in Transition and Crisis: Balancing Efficiency, Equity, and Security

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1. Motivations underlying the research

Since 2021, the European electricity markets have experienced two significant shocks: a positive demand shock in 2021 after the Corona restrictions and a negative supply shock of natural gas price following the war in Ukraine in 2022. The severity of these shocks and high prices can partly be explained by the low short-term price elasticity of electricity demand and supply. The effects of these events were exacerbated by coinciding with other supply-side shocks, such as low levels of wind, low water levels in hydropower reservoirs, high coal prices, and extended outages in nuclear plants in parts of Europe.

Following the Corona shock, there has been calls for reforming the electricity market design to better prepare them for the future and address socio-economic effects of higher prices, while some member countries declared that the market design was not the cause of the crisis and had generally worked well. Nonetheless, the market design had not prevented the markets from being exposed to sudden shocks. This is not to suggest that the electricity markets no longer work, but to revisit and overhaul their design in an already evolved context and continuous technological progress, mass connection of renewables, and a reorientated energy policy towards security of supply. Even prior to the shocks, the electricity market design was ripe for an overhaul.

The short-term electricity markets ensured short-term security of supply, albeit with high prices affecting affordability. This effect was amplified when the hedge positions of many retailers were not sufficient. This has resulted in calls for revisiting the market design to consider measures such as price caps, redistributive mechanisms for windfall profits, increased demand flexibility, integrating more renewables, and active networks. Meanwhile, it remains imperative to balance the three objectives of the energy trilemma: sustainability, supply security, and affordability.

The EU has acknowledged the need for finding pathways to tackle price volatility, accelerate investments in renewables, and enhance flexibility and resilience of the power system. This paper revisits the role, design, and policy aspects of the EU wholesale electricity markets in the context of recent shocks. It also discusses the changing market context and design challenges facing the markets and how this affects maintaining the energy trilemma pillars.

2. A short account of the research performed

In this paper we briefly revisit the premise of organized electricity markets, their main technical and economic characteristics, and how they differ from most commodity markets. We then point out that the purpose of electricity markets has gradually undergone a paradigm shift from the pursuit of economic efficiency as the prime objective towards becoming an instrument for cost-effective delivery of various policy targets.

The paper argues that the three pillars of energy Trilemma of sustainability, security of supply, and affordability have characteristics of public goods and markets alone will not deliver these targets without some forms of intervention. We then discuss the main market allocation mechanisms in the electricity sectors and in particular focus on the important role of long-term markets.

The paper reviews some recent market-based and non-market remedies proposed in response to the electricity markets crisis and how to improve their design. This is then followed by discussing some

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redistribution mechanisms that are relevant and important to consider in the anticipated electricity market design reforms. These, among others, include negative prices, missing money, windfall taxes, and price caps.

3. Main conclusions and policy implications of the work

In conclusion, we reiterate that a market design reform with a view to the future was ripe before the emergence of the two crises. There is a need to better understand the design of long-term markets and their interaction with the short-term markets. This includes both long-term contracts between private parties and contracts for differences (CfDs) between governments and private actors. Price caps cannot be ruled out on political economy grounds and short-term distributional reasons in extraordinary circumstances. The new market design can aim to distinguish between the inframarginal rents, windfalls, and renewable resource rents. While most attention has been on the market design, there are also non-market instruments to consider, such as sector coupling with the gas and future hydrogen sectors, locational factors related to networks, and promotion of demand flexibility services.

At governance level, an independent strategic authority, such as the Future System Operator (FSO) being considered in the UK, can assume the responsibility for long-term planning and investment. Security of supply can be a mandate of this authority and long-term markets. Finally, we point out that the choice of instruments should be with a view to the pros and cons of these in relation to the elements of the energy Trilemma. Finally, in the Appendix we present a comprehensive table of the main instruments related to market design reform and their pros and cons in relation to the pillars of the energy Trilemma.

Policy Reversals in Transitional Markets: The Effect of Changing Marginal Cost to Physical Order Dispatch in the Mexican Power Sector

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1. Motivations underlying the research

The purpose of this research is to analyze the implications of the 2021 Mexican Electric Reform, which proposed a transition from a marginal-cost-based power dispatch system to a command-and-control physical system. This reform aimed to prioritize power generation from the state power company (CFE) over other market competitors. The study was motivated by the need to understand the potential effects of this policy change on the Mexican power sector's generation mix, energy emissions, and market structure.

2. A short account of the research performed

Using the GENeSYS-MOD techno-economic energy model, our research analyzed the impact of the reform considering two main scenarios: Merit Order Dispatch (MOD) and Ownership & Physical Order Dispatch (OPOD). While MOD optimizes the energy sector without changing the merit order, OPOD changes the dispatch from the merit order to the physical delivery dispatch with priority for CFE-owned power plants until 2050. We considered the changes in the generation mix, energy emissions, and market structure of the Mexican power sector.

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3. Main conclusions and policy implications of the work

The study's findings reveal a significant shift in Mexico's energy landscape due to the 2021 Mexican Electricity Reform, particularly the transition from marginal-cost-based to command-and-control physical order dispatch. Initially, this shift led to an increase in the share of electricity generation derived from fossil fuels, along with a rise in CO₂ emissions. However, as time progressed, this trajectory gradually converged with the MOD scenario. This convergence primarily stemmed from the replacement of old state-owned power plants with renewable facilities. It's important to note that this alignment occurred after the year 2030.

Nonetheless, despite eventual alignment, a critical finding centers on the reduction in renewable energy within the OPOD scenario. This translates to the missed opportunities to harness existing renewable facilities and the consequent upsurge in emissions. These missed opportunities represent untapped renewable energy potential amounting to 189 TWh of capacity. Furthermore, the policy change precipitates a marked increase in emissions. In order to compensate for reduced renewable energy, state-based fossil fuel-based electricity generation experiences a surge, resulting in an additional 188.93 million metric tons of CO₂ emissions—an alarming environmental concern.

Another notable outcome pertains to the shifting dynamics of market power. The transition to the OPOD scenario has the potential to significantly bolster CFE's market share, potentially reaching 67% by 2050. This shift in market dynamics carries significant implications for regulatory and competition policies within the sector.

In addition, it is vital to underscore that, despite initial adverse impacts, both scenarios ultimately converge in terms of the generation mix and emissions trajectory after the year 2030. This convergence primarily stems from the replacement of outdated and less efficient state-owned power plants with cost-competitive renewable alternatives.

Regarding the policy implications, firstly, it is essential to recognize that while both scenarios ultimately lead to emission reductions over the long term, through the phasing out of polluting facilities in favor of cleaner renewables, there exists an initial missed opportunity in utilizing existing renewable capacity within the first decade in the OPOD scenario. This underscores the imperative for decision-makers to contemplate and implement additional measures to offset this initial setback, should the policy change be implemented. Furthermore, understanding the evolving market dynamics and the expanding market dominance of CFE holds critical importance for shaping regulatory and competition policies within the energy sector. Legal considerations, particularly those related to competition, legal security, and environmental sustainability, warrant further exploration in future research.

In conclusion, the 2021 Mexican Electric Reform's proposal for transitioning to command-and-control physical order dispatch signifies a pivotal juncture in Mexico's energy transition. This policy shift introduces a spectrum of challenges and opportunities within the broader context of evolving energy markets. The research conducted through the application of energy system modeling unveils potential consequences, including initial increases in fossil fuel utilization and CO₂ emissions, alongside shifts in market dynamics. In a world increasingly dedicated to combatting climate change, comprehending the far-reaching implications of such policy changes assumes paramount importance. It underscores the necessity for judicious policymaking, informed decision-making by industry stakeholders, and continuous research efforts to adeptly navigate the ever-evolving energy landscape and realize sustainable energy objectives.

Does adaptive capacity reduce funding costs of municipalities that are exposed to climate change risk?

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1. Motivations underlying the research

Its scale and complex interactions make climate change a potential source of systemic risk in the financial system. The potential impact of this risk is higher when asset prices do not reflect climate change risks. Acute or chronic climate hazards could abruptly inform investors on the true economic condition of the asset and might lead to a sudden repricing. This sudden repricing may then turn into significant losses in a leveraged financial system.

In a world with perfect information on climate risks and assets' exposure to those risks, asset prices would reflect climate change risks. However, climate change risks are driven by uncertainty on the precise timing and magnitude of climate hazards and market participants have limited information on the exposure of financial assets to climate hazards. This has attracted the interest of academics who empirically analyse the pricing of climate change risks. Evidence exists for climate risks being priced in the stock, real estate, and (municipal) bond markets, although some disagreement about the results exists. Most of the studies focus on physical exposure as the single determinant of physical risk from climate change. However, substantial physical exposure to climate risk might lead to little physical risk if a socioeconomic system has a high adaptive capacity. The adaptive capacity of a socioeconomic system represents its resources available for adaptation, as well as its ability to use these resources effectively. To the best of our knowledge, previous studies have not recognized adaptive capacity as a determinant of physical risk. Additional research is needed to understand whether market participants are aware of the mitigating influence of adaptive capacity on physical risk. Hence our research question: is adaptive capacity recognized as a determinant of physical risk in financial markets? More specifically, we focus our research on the question whether adaptive capacity is priced in the municipal bond market. Previous studies have found evidence for physical risk being priced in municipal bond markets.

2. A short account of the research performed

We follow a previous study that found that climate risk was priced in municipal bonds issued by American counties that face risk from rising sea levels. Given this, we examine whether adaptive capacity is priced in the bonds of these municipalities as well. We expect the funding costs of municipalities with higher adaptive capacity to be lower than the funding costs of municipalities with lower adaptive capacity. Therefore, this study is a first attempt to examine whether adaptive capacity is priced. We study a sample of only American cities known to face risk from rising sea levels. Though we cannot form any general conclusions from this sample, we can at least observe whether a higher adaptive capacity would reduce funding costs for those cities at risk.

We analysed a sample of more than 9,000 municipal bonds issued by the counties wherein lie the 22 American coastal cities that are physically exposed to climate risk between 2015 and 2020. For the bonds we obtained our dependent variable issuance cost, and its components yield at issuance and gross spread. We use various bond related independent control variables such as amount issued, time to maturity, and credit risk. More crucial, we use readiness scores from the Urban Adaptation Assessment database of the University of Notre Dame as a proxy for adaptive capacity. The readiness score is not referred to as adaptive capacity in the Urban Adaptation Assessment database. Instead, it is a readiness score, which is defined as "the capacity of an urban society to mobilize adaptation investments from private sectors, and to target investments more effectively". This aligns with our definition of adaptive

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capacity. Readiness is a score between 0 and 1. In our sample, Oakland is the city with the highest readiness score (0.799) and Los Angeles with the lowest (0.219).

3. Main conclusions and policy implications of the work

We do find a significant negative relation between municipal bond issuance costs and adaptive capacity, supporting the view that adaptive capacity is indeed recognized as an offsetting determinant of physical risk faced from climate change. Furthermore, the influence of adaptive capacity is stronger for bonds with more time to maturity. We explain this by investors being more uncertain about whether observed adaptive capacity is effective in the long run and that demand for longer term bonds is lower for that reason. We conclude that adaptive capacity seems to be priced in addition to climate risk.

We acknowledge some shortcomings in our study, among which are not using a measure for adaptive capacity that was designed for climate risk and our focus on U.S. cities only. However, we do conclude from our results that cities having policies to improve adaptive capacity are likely to be rewarded by lower funding costs. This should stimulate policy makers to focus (more) on climate change adaptation such as to facilitate the adaptation of firms and people, adapt land use and protect critical public assets and services, and help firms and people cope with and recover from disasters and shocks. Policies to improve the adaptive capacity of a municipality increases the financial sustainability of that municipality as funding costs (yields) decline and the willingness to invest increases as spreads (search costs) decrease.

Regulatory impact on Quality of Electricity Distribution Services: The case of Latin America and the Caribbean

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1. Motivations underlying the research

Low quality through frequent and prolonged interruptions can constitute a barrier to economic development and competitiveness, causing high costs, business losses, and negative effects on the population's quality of life. According to the 2018–2019 survey of the Latin American Public Opinion Project (LAPOP), power outages are a concern for more than 34% of respondents.

The avoidance of interruptions in the electricity supply depends on the proper functioning and coordination of the entire chain: generation, transmission, and distribution. In this study, we focus on distribution companies, where the existence of *good regulation* plays the most important role. Due to economies of scale, a single distribution company provides electricity for each geographical area, acting as a natural monopoly in each zone. Given the absence of intra-zone competition in distribution and the difficulty of creating a cost-effective decentralized option for most consumers, the market structure does not provide enough incentives for service quality. In this context, regulatory frameworks are essential tools for promoting quality of service.

In the 2000s, most European countries introduced service quality incentives based on a rewards and penalty scheme. Something similar happened in Latin America and the Caribbean (LAC), with some early adopters, such as Peru in 2004, and some very late ones, such as Brazil in 2018. The type of quality regulation we consider here is what is generally called *incentive regulation*, as it provides financial incentives for the provision of service quality, regardless of whether the incentive is a fine that goes to the government or compensation for or a rebate to consumers. In the last two decades, there has been a substantial increase in access to electrification together with an improvement in the quality of electricity

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services in LAC. However, improvements in quality have been lower than the improvements observed in other regions.

2. A short account of the research performed

The international standard for measuring quality as continuity of service comes from the IEEE Std 1366–1998 Guide for Electric Power Distribution Reliability Indices, updated in 2012. The IEEE (2012) defines the System Average Interruption Duration Index (SAIDI) as the total number of minutes of service interruptions in a year divided by the number of customers served. Similarly, it defines the System Average Interruption Frequency Index (SAIFI) as the total number of customer interruptions in a year divided by the customers served.

In this study, we examine whether the implementation of quality regulation has an impact on quality as defined by the SAIDI and SAIFI indicators. With this purpose, countries with at least two electricity distributors and a single regulator were chosen for the analysis.^a Of 160 companies surveyed, only 143 had data on SAIDI and SAIFI, which we use as dependent variables in our econometric estimation. Then, looking at the history of regulations, as well as the implementation of continuity indicators compatible with international quality standards, we consider the year of the most important incentive quality regulation as the explanatory variable in our model.^b We also consider in our estimation the importance of ownership for quality results. We use panel data with firms across years and include both firm fixed effects and year variables. The independent variable regulation is a dummy variable that starts taking the value 1 the year immediately after the key quality regulation measure is approved (and 0 otherwise). This is the case because in general, there is a small delay between the approval of a measure and its actual implementation. We use the two-stage least squares (2SLS) method since we are confronted with two problems. First, the implementation of a quality regulation may be motivated by the existence of poor quality. This is what is generally known as reverse causality. Second, it is likely that the implementation of quality regulation is due to administrative changes in regulatory authorities that simultaneously influence service quality and the implementation of the regulation itself.

3. Main conclusions and policy implications of the work

Our main result is that incentive quality regulation had a positive and significant effect on quality improvement for the case of the distribution companies operating in LAC. Moreover, we calculate that between 2003 and 2019, in a sample of 143 electricity distributors, the SAIDI and SAIFI decreased after the implementation of the quality regulation by an average of 40% and 45%, respectively. We also estimate that on average, private firms outperformed public ones in terms of quality; however, since their performance was more disperse, the worst firms in terms of quality were also private.

Few papers have empirically estimated the impact of regulation on quality. They mostly do so on a country-by-country basis and for developed countries. Moreover, their results are not aligned, as they study different types of regulatory instruments that have been applied in different contexts and regions. The results of this research point to the importance of regulation for the quality of electricity service implemented in LAC countries. In this regard, it is in line with most of the theoretical literature on the matter, as well as with empirical studies for Italy and the United State. In contrast to the findings for the UK, quality regulation in LAC has been sufficient to increase electricity quality measures in terms of continuity of service. The lack of stylized facts on the matter underlines the importance of continuing efforts to understand the impact of regulation on quality as well as the best way to formulate that regulation to achieve the optimal quality of electricity services.

Our results are particularly relevant for policymakers since they highlight the need to implement incentive regulation to improve quality in countries that do not yet have it. Moreover, they offer elements for comparison between regulators and between distribution companies in the region.

a The selected companies are in the following countries: Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Panama, and Peru.

b *Incentive regulation* in the sense that it includes some type of penalty paid by the company in the case of an outage.

Quality Matters: Power Reliability and Grid Connection in Rural Guatemala.

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1. Motivations underlying the research

Even though worldwide access to electricity has been rising from 82% in 2008 to 90.4% in 2020, almost 750 million people still remain in darkness (World Bank, 2022). This is a particularly pronounced problem in rural settings, whose access rate is 15 p.p. less than in urban ones. Although many rural households have benefited from off-grid energy devices like solar panels, more research is needed to study the barriers that impede them from fully exploiting all the advantages the electricity grid provides.

In this paper, we empirically study the role of the lack of reliability as a barrier for rural households to get a connection to the grid or, discourage those already connected from continuing with the service. Poor quality could also provoke conflicts in the form of theft and illegal connections or unpaid bills, triggering a “vicious circle” for a utility company: decreasing firm revenues and, therefore, increasing outages (Dzansi et al., 2018). This issue concerns from a public policy perspective since the investment done to spread the low voltage grid needs social returns. Our results show that these efforts could end up wasted if quality decreases because of, for example, insufficient complementary investments (e.g., transmission and distribution lines).

Guatemala is a good country to focus on. Considered an upper middle-income country by the World Bank, ended a civil war in 1996 and started a reform process, enhancing the rural electricity access rate from 48% to 74% in a decade. However, in 2021, total energy consumption from the residential sector came 90% from firewood and only 5% from electricity even with subsidies to electricity consumption (MEM, 2021). Firewood, mainly used for cooking and heating in rural areas, is typically associated with indoor pollution, and hence, with well-documented negative health consequences.

2. A short account of the research performed

To address our research question, we use data from the National Electric Power Commission of Guatemala (CNEE), which we combine with two household-level datasets, namely, the National Survey of Living Conditions (ENCOVI) of 2011 and 2014, and the 2018 National Population Census. The particular variation of quality observed in time will help us with the identification strategy: after 2011 the number of outages suddenly increased in rural Guatemala. We take advantage of this plausible exogenous shock to analyze the causal relationship between power reliability on rural households’ disposal to connect to the grid.

The objective quality measure provided by the CNEE is the System Average Interruption Duration Index (SAIDI). Our main estimates, which are robust to using an instrumental variable strategy, suggest that households affected by severe outages are about 13-17 p.p. less likely to get a connection to the grid. We further check this result by combining household-level data from the 2018 Census with a complete register of electricity quality service. Although 2018 was a good year in terms of quality, a 1% increase in the number of outage hours affected the probability of connection by 3 p.p.

3. Main conclusions and policy implications of the work.

The main conclusion of this paper is that **households are not captive consumers**. Non-payment, illegal connections, and vandalism are all possible unwanted consequences. In the case of Guatemala, the upsurge of service cut-offs because of non-payment was notorious. To achieve genuine access to electricity and reap its benefits (e.g., clean cooking, improved productivity through better assets, and reduced gender disparities), **maintaining good-quality service is as important as extending the grid**. The importance of rural infrastructure and maintenance cannot be underestimated when it comes to

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rural electrification. These factors, along with road connectivity, are instrumental in driving the growth of microenterprise (Chaurey and Lee, 2022).

Finally, and as an indirect outcome of our research, we also strongly recommend **a revision of the current subsidy and taxation structure** within the Guatemalan electricity system. The fixed lump-sum fee charged by numerous municipalities for public lighting ultimately undermines the efficacy of subsidies in promoting electricity consumption, leading to a regressive impact. Remarkably, in some municipalities, up to 50% of the bill paid by a very poor household is allocated as a Public Light Fee.

Determinants of energy poverty: Trends in Spain in times of economic change (2006–2021)

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1. Motivations underlying the research

Energy poverty, a situation in which households struggle to keep their homes warm and to afford other energy goods and services required for individual welfare, is by no means a new phenomenon in Spain or, for that matter, in many other countries of Europe. According to Eurostat data, 6.5% of Spanish households in 2011 were unable to keep their homes adequately warm; ten years later this figure has risen to 14.2% (2021), well far of the 4% target set for 2025 by the Spanish National Strategy against Energy Poverty.

During the last decade, a large part of the academic literature has focused its efforts on understanding the concept and on proposing metrics of energy poverty; however, the identification of its drivers is still widely debated with conflicting and heterogeneous results. Indeed, while many studies have been attempted, they tend to present a somewhat static account of energy poverty in a given period and, as such, fail to provide a complete picture of the overall problem.

2. A short account of the research performed

The study undertakes an analysis of the critical drivers of households falling into a situation of energy vulnerability and seeks to identify new dimensions and profiles affected by this structural problem. To achieve these objectives, we undertake an econometric analysis, based on an exhaustive sample of more than 300,000 households taken from the Spanish Household Budget Survey (HBS) for the period 2006–2021. The HBS database allows us to use different energy poverty indicators based on the expenditure approach, where domestic energy expenditure is compared and distinguish different economic periods between the years 2006 and 2021, including the initial impact of the COVID-19 pandemic and the global energy crisis.

3. Main conclusions and policy implications of the work

Our empirical results confirm that energy poverty in Spain remains a chronic problem with a tendency to worsen during periods of economic crisis, such as the global recession caused by the COVID-19 pandemic. Average energy poverty increased during the 2008 crisis and in the period of austerity between 2009 and 2014, but as the economy recovered there was a gradual decrease in energy poverty in Spanish households, a trend that would be interrupted by the outbreak of the COVID-19 pandemic.

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Our results suggest that the socio-economic characteristics of a household are the main drivers of being energy poor in Spain. In particular, the retired and women living alone are at high risk of finding themselves trapped in energy poverty. In contrast, being highly educated is associated with less exposure to energy vulnerability, meaning that measures taking an eminently behavioural approach (provision of information and training of consumers by means of energy schooling, energy audits, tariff comparators, etc.) can improve problems related to energy poverty. Our empirical results also highlight the importance of the economic activity performed by household members in determining the probability of being energy poor, especially during periods of crisis.

The results reported here should be of great use to politicians for understanding how the main drivers of energy poverty have evolved in recent distinct economic periods and for helping them to implement appropriate policy measures. First, in order to maximize the scope of their policies, it is essential that the target audience be more precisely defined and that the mechanism via which vulnerable households might obtain aid be suitably designed. Second, to address the effects of the pandemic and the current energy crisis, a series of emergency measures have been adopted, but these are only temporary measures. This means that once these temporary measures are withdrawn, an increase in the incidence of energy poverty might well be seen. Then, it is thus critical to address the roots of the problem of energy poverty, which means designing new tools that can have a real impact in the medium and long term. Finally, the need to ensure a fair, decarbonized, sustainable energy transition requires the participation of all economic agents (that is, firms, social entities, administrations, universities, and citizens alike). Indeed, the challenge of identifying ways in which the quality of life of the most vulnerable households can be improved needs to be addressed by working in a network made up of representatives of these various actors. Such collaboration should give rise to far-reaching policies that manage to reach that part of society at greatest risk.

Electricity Access, Gender Disparity, and Renewable Energy Adoption Dynamics: The Case of Mountain Areas of Bangladesh

Sakib Bin Amin,^a Tooraj Jamasb,^b Farhan Khan,^c and Rabindra Nepal^d

The United Nations underlines that “achieving gender equality and empowering all women and girls” is vital for an economy to attain its full potential, making gender equality a “critical element” in the development goal. However, it has been argued that there is still a considerable discrepancy in gender engagement due to a lack of policy implementations. In order to promote gender equality, certain initiatives have been focusing on women’s economic engagement, i.e. empowerment. These include financial inclusion, political participation, and property rights among others.

Energy and gender equality are linked as recent literature points to the positive impact of electricity access on women’s empowerment, especially in the case of developing countries. Energy access has disproportionately favoured women in developing economies because women spend more time in operating the household than men. Therefore, gaining access to electricity is expected to empower women through an increase in labour supply in non-household activities as well as overall economic autonomy and economic decision-making abilities.

Women and girls in the Indian sub-continent facing inequality due to existing social norms has been long observed. The results of gender discrimination prove to be multifaceted such as from being less educated than men and boys and having less access to information, skills, training, and labour markets, to facing greater risks of violence and harmful practices. These factors, overall, constrain wom-

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en's chances of empowerment both at household and non-household activities, which is linked with regional economic development. Thus, women empowerment is intuitively perceived as a major driver of economic development in these regions. Moreover, in mountain regions such as the Chittagong Hill Tracts (CHT) of Bangladesh, women have experienced more disadvantages than those in flatlands due to inadequate access to energy and infrastructures.

The government and private entities have taken initiatives to generate renewable electricity from devices such as Solar Home System (SHS) in the CHT to electrify the vast off-grid areas as grid connectivity is challenging due to the combinations of steep hills and narrow valleys. These projects improve access to services and increase the quality of essential social services for women and children. Some unique ways in which women have been empowered are through income-generating activities at night. Household income also increased as a result while such initiatives have also improved the living standards of marginalised women by uplifting their social and economic conditions. Nevertheless, issues of high price, lack of appropriate finance, and maintenance costs seem to restrict the multiplier effect of such initiatives in the CHT districts, contributing to the persistence in gender disparity. Therefore, we aim to explore the relationship between electricity access, gender disparity, and renewable energy adoption in the mountain areas of Bangladesh.

We develop a theory-driven empirical framework for the paper's analysis. The empirical analysis uses a novel set of micro-level data obtained from a holistic survey conducted in the CHT districts in 2022. The empirical analysis is divided into three distinct phases, where robust non-experimental and quasi-experimental econometric methods are applied.

In the first phase of the empirical analysis, we reveal that access to electricity has a strong positive impact on women empowerment indices, such as economic freedom, economic decision, household decisions, and mobility and agency in total and split samples (i.e., urban and rural sub-samples). Keeping the aforementioned findings in mind, in the second phase of the empirical analysis, we confirm that the average effect of access to electricity on the women empowerment indices does not significantly differ for grid-electricity-connected households and households outside the grid coverage. This finding leads us to the third phase of the empirical analysis. In the third phase, we find that the earlier insignificance arises because off-grid households are utilising renewable energy devices (i.e. SHS) for ensuring reliable access to electricity. We further show that the likelihood of renewable energy device adoption declines due to a surge in different non-food expenditures in the CHT households, where the poorer households suffer the most. Moreover, it was observed that issues of instalments issues and high cost of maintenance tend to act as barriers for facilitating smooth outreach of renewable energy devices in the CHT districts.

The success of off-grid electrification initiatives could be strengthened by collaborating with renewable energy actors in a public-private partnership to acquire green funds to establish a mechanism for providing after-installation services of the distributed SHS in the CHT remote households to reduce upward pressure on income-expenditure. Moreover, we argue in favour of innovative financial schemes to facilitate renewable energy device adoption in the off-grid areas of CHT districts. Policies should increase the reach of microfinance in the CHT areas similar to the districts in the flat lands. Besides, a policy push by the government to facilitate a customised green mobile banking scheme in collaboration with microfinance institutions should be introduced to overcome the geographical barrier. We also advocate in favour of purposeful surveys in rural Bangladesh. Implementing such surveys on large scale or integrating our survey materials in the existing national surveys can contribute to better policy design for remote and less-connected areas to improve the energy landscape.

The methodology of the study can be used to research other aspects of ESG in the future. Another avenue of extension could be to design Randomised Control Trial (RCT) studies to understand the heterogeneity dynamics of women empowerment in different parts of Bangladesh.

Economic efficiency and CO₂ impact of a clean cooking program in Ecuador

Daniel Davi-Arderius^a, and Moises Obaco^b

1. Motivations underlying the research

Climate change has adverse effects on income inequality, agriculture, natural resources, and lifestyles. The United Nations Global Sustainable Development Agenda (SDGs) considers access to clean cooking a priority; however, in low- and middle-income countries, many families still use polluting cooking technologies that emit CO₂ and can also affect health and increase the risk of carbon monoxide poisoning. In 2020, approximately 2 billion people had access to some form of electricity but still cooked using biomass fuel. As a solution, clean cooking programs have been implemented in many countries, with the aim of replacing polluting fuel technologies.

In 2014, Ecuador launched a clean cooking program called “*Programa de Eficiencia Energética para la cocción*” to improve environmental conditions for its population, reduce the large financial burden of liquid petroleum gas subsidies. This program includes the replacement of LPG-powered cookstoves and boilers by electric devices fed by electricity produced with hydropower. When this program started in 2015, households accounted for 75% of national LPG consumption. The price of LPG cylinders (1.6 USD) for households only covered 10% of the real cost, and 90% was subsidized by the public budget. During the PCE program (2015-2021), subsidies of LPG amounted to 2.1 billion USD. Initially, the Ecuadorian government planned to enroll about 3 million families in the PCE, but the final take-up was under 700,000 families.

To our knowledge, the environmental and economic impacts of this program have not been widely analyzed yet. Despite the participation rate not being as high as expected by the government, it is essential to study whether the subsidies spent in this program have been recovered by savings in LPG subsidies. Moreover, it is necessary to quantify the environmental benefits in terms of CO₂ emissions related to households burning less LPG. These results are crucial for the identification of the strengths and weaknesses of this program and to identify potential areas of improvement for future cooking programs. In Latin America, the potential of Renewal Energy Sources from hydropower, wind, and solar is significant and can be part of the solution to deal with climate change.

2. A short account of the research performed

In this paper, we analyze the economic and environmental impacts of the Ecuadorian clean cooking program. To do so, we use official macro-data (2015-2021) instead of surveys, which is not common in the literature on these programs and provides consistent and robust results. The empirical approach we are following is an ARIMA model including the lagged endogenous variable. To avoid a potential bias related with the least squares method in the presence of lagged dependent variables, we use maximum likelihood estimators to perform all estimations. We control seasonality through the inclusion of dummy variables for quarter and year.

Our results show that residential electricity consumption acts a substitute good for LPG, and this effect increased during the program, highlighting its efficiency in replacing LPG devices by electricity. We find that this program saved 978,470 ktons of CO₂ between 2015-2021 and reduced Ecuadorian LPG consumption by 3,845,808 barrels, resulting in a positive effect on the Ecuadorian balance of trade of 151 million USD. However, the economic rate of return of the subsidies spent on the program was below one, coming in at only 0.72463.

We also determine that the subsidized electricity in this program was indeed generated with hydropower, as the government had promised. Our results confirm that electricity generation has not led to

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additional CO₂ emissions, which can be explained by the use of dispatchable hydropower plants. However, the use of hydropower in Latin American countries may be affected by the environmental effects known as “*El Niño*” and “*La Niña*”, which could alter hydropower generation. This may not be the case if other types of renewable production, i.e., wind or solar generation, are used instead.

3. Main conclusions and policy implications of the work

Based on our results, we provide several regulatory recommendations. First, we highlight the need to evaluate the national economic and environmental impacts of these programs using macro-data instead of local surveys or forecasts based on future scenarios and provide interesting results that can be used to improve the design of future programs. This study thus represents a step beyond the many studies based on local surveys or the forecasting of future scenarios.

Second, households require efficient economic incentives to switch from one energy source to another and the replaced fuel cannot remain highly subsidized, as was the case in Ecuador. The government and the regulator predicted excessive growth in future electricity consumption and allocated many economic resources to reinforcing the grids and commissioning new electricity-generation plants. This misguided allocation of resources limited, for example, the possibility of funding the purchase of induction stoves for the poorest households.

Finally, the generation technology used to cover subsidized electricity must be renewable in order to avoid problematic trade-offs. However, this requires a clear correlation between consumption and renewable generation profiles. In Ecuador, this worked because the energy was generated by dispatchable hydropower, but this could be different in the case of photovoltaics or wind power.