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The Economic Burden of Unreliable Electricity Supply for Businesses in Benin*

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CLEAN AIR TASK FORCE

Abstract

Businesses in African countries not only face challenges with accessing electricity, but also struggle with the cost and reliability of power supply. To cope with frequent power outages and voltage fluctuations, these businesses often spend extra money on power generators, alternative energy sources, and voltage stabilizers. These additional costs can be a financial burden for businesses and are often overlooked when considering total electricity expenses. Our study focuses on assessing the economic and electricity burden implications of unreliable power supply for businesses in developing countries, using Benin as a case study. We found that these extra costs make up a significant portion of businesses' electricity expenses in Benin, with the main contributor being the expenses associated with running power generators. This places a heavy burden on many businesses, especially those operating in the informal sector, with business owners, home businesses, and production activities. Our findings indicate that failure to account for the additional electricity costs associated with defensive strategies results in underestimating the true financial burden of electricity expenditure for businesses. Consequently, this oversight may lead to ineffective approaches in addressing electricity affordability. Our analysis also provides evidence on the factors affecting the electricity burden for businesses. It is crucial to address these extra electricity costs and identify businesses experiencing an electricity burden in order to develop targeted approaches for more effective alleviation measures.

Keywords: Electricity; financial burden; averting actions; reliability; developing countries; businesses.

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SECTION 1

Introduction

This paper examines the economic and electricity burden of unreliable power supply for businesses in developing countries. Unreliable electricity supply forces end-users to use voltage stabilizers, and power generators or alternative energy sources to cope with the adverse consequences. Our work, specifically, probes how these averting costs of unreliable electricity supply, hereafter referred to as 'extra costs', constitute a financial burden for businesses operating in African countries, hereafter 'electricity burden'. To do this, we examine data from Benin as a case study. Benin exhibits characteristics similar to those of other sub-Saharan African (SSA) countries, where, despite efforts to expand access to electricity over the last few decades, power outages, voltage fluctuations, and electricity affordability still pose significant challenges for households and businesses.

Regarding affordability, while access to electricity has doubled from 25.7% in 2000 to 51.4% in 2022 in SSA (WDI, 2024), electricity costs (i.e., user tariffs and connection fees) remain relatively high. For instance, Blimpo and Cosgrove-Davies (2019) found that the electricity price for consumers in many African countries (e.g., US$0.5 in Liberia) is more than double that of high-income countries like the United States (US$0.12/kWh) and far higher than in some emerging countries like India (US$0.08/kWh). This disparity remains in a similar range for businesses. Businesses in Côte d'Ivoire and Cape Verde pay an average electricity tariff of 0.233 $/kWh and 0.198 $/kWh, respectively, much higher than those in the United States and India, which stood at 0.151 $/kWh and 0.129 $/kWh respectively (Global Petrol Prices, 2024). This relatively high cost can negatively affect the economic attractiveness of African countries, especially for sectors with high electricity needs such as manufacturing.

Interestingly, the observed high electricity costs in SSA are inversely related to its reliability. The recent World Bank Enterprise Surveys (2023) estimates that in 2021, 77% of firms operating in Africa were affected by more frequent blackouts than in OECD countries (8.8 vs 0.3 outages per month). As a result, those firms posted economic losses corresponding to 8.4% of their annual sales. Therefore, firms usually take defensive actions, for example, alternative energy sources, voltage stabilizers, and power generators, to cope with the adverse impacts of power blackouts and low-quality of electricity services. These generate extra costs for electricity services, which can be much larger than electricity bills, making it financially burdensome for businesses operating in SSA countries, and can potentially reduce their financial viability. Surprisingly, empirical studies exploring how these electricity reliability issues drive businesses to face the electricity burden are very scarce, specifically in the African context.

Most studies on the electricity burden concentrate on household energy poverty (e.g., see Siksnelyte-Butkiene et al. (2021), Sy and Mokaddem (2022), and Guevara et al. (2023)). Very few papers focus on businesses, and most of them examine the various effects of power outages on businesses' economic performance, including impacts on productivity (Abeberese et al., 2021; Guo et al., 2023), production or sales (Cole et al., 2018; Osei-Gyebi and Dramani, 2023) and cost of running the business, such as expenses related to backup power generators (Oseni, 2012; Diboma and Tatietse, 2013). A few studies also assess the impact of power blackouts on energy intensity (Taimoor et al., 2020) and the sustainability or environmental impact of power blackouts (Farquharson et al., 2018). However, these studies do not address the extra costs induced by voltage fluctuations and power outages and their potential role in exacerbating the electricity burden among businesses. The only exception we identified in the relevant literature is the recent work by Asiedu et al. (2021), which addresses the prevalence of electricity burden for businesses defined as firm energy poverty, referring to firm that reports that electricity is an obstacle for its operations. Specifically, noting that the literature on firms' electricity burden is scant, Asiedu et al. (2021) used self-reported data -a subjective measure- to measure and assess the determinants of electricity burden for businesses. They focus on determining factors that affect the probability that a firm is energy poor, including firm and country characteristics. Here, as well, they do not account for extra costs related to voltage fluctuations, power outages, and electricity affordability challenges, which motivates this article.

Our analysis focuses on the power sector and examines how accounting for extra costs affects the prevalence of electricity burden among businesses in Benin. We use data from a representative national business survey—Enquête sur la consommation de l'électricité au Bénin (ECEB)—conducted in Benin in 2015 by the National Institute of Statistics and Demography (INStaD).[1] We limit our analysis to businesses connected to the electricity grid based on the focus of this study. We adjust the widely used definition of household energy poverty, which is grounded on the economic threshold approach (Boardman, 2013; Bouzarovski and Petrova, 2015; Churchill and Smyth, 2020a), for businesses by proxying income with revenue. Thus, we consider that businesses are in an electricity burden situation if they spend more than 10% of their revenue on electricity services. Within the latter framework, along with examining the composition of extra costs and changes in the distribution of electricity burden among businesses, we explore factors contributing to the electricity burden for businesses through three metrics using correlations: (1) electricity burden without the extra costs; (2) electricity burden including the extra costs; and (3) electricity burden driven by the extra costs.

The analysis yields some compelling results. First, extra costs constitute a significant portion of electricity expenses for businesses in Benin, accounting for 44%, with the largest contributor being the costs of running standalone power generators. This indicates that overlooking these additional costs of defensive strategies can result in underestimating overall electricity expenditures, potentially leading to ineffective approaches to addressing energy affordability. Second, our findings reveal that extra costs push an additional 5% of businesses in Benin (representing 11% of businesses not previously experiencing the electricity burden) into an electricity burden situation due to their spending on defensive strategies, and without accounting for these costs, these businesses would not face the electricity burden. Hence, paying attention to those additional affected businesses could improve the effectiveness of policies aimed at alleviating the electricity burden among businesses. Third, our regression analyses show that the factors affecting businesses' electricity burden differ across the three electricity burden metrics. Business type (formal vs. informal), economic scale (equipment value), and the existence of unplanned blackouts significantly affect the likelihood of a business facing an electricity burden for metrics 1, 2, and 3, respectively. Furthermore, end-use and defensive strategies play a crucial role beyond their impact on the various metrics as they shape how economic, individual, and power supply characteristics affect the electricity burden for businesses.

Overall, our work shows that disregarding extra costs induced by unreliable electricity supply underestimates the true extent of electricity burden among businesses in SSA. The rest of the paper has the following structure:

- Section 2 outlines the data and methods
- Section 3 presents and discusses the results
- Section 4 concludes with some policy recommendations

[1] Note that the former National Institute of Statistics and Economic Analysis (INSAE) changed to INStaD on June 2021.

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SECTION 2

Methodology

This section describes the data used to assess the prevalence of electricity burden among businesses. It also provides a background definition of "extra costs" along with the various metrics and indicators used in the analysis. Subsection 2.2 presents the conceptual framework for how the different explanatory variables interact with electricity burden measures and the supporting methods that evaluate those relationships. We provide more details in Appendix 6.2.

2.1 Data and Variables

Data

This study uses a representative household and business survey data collected in 2015 in Benin by the National Institute of Statistics and Demography (INStaD).[2] The survey considers 3,816 households and 1,324 businesses and focuses on the power sector, specifically on issues surrounding access to and electricity supply. Our analyses use the sub-sample of businesses, which includes 147 businesses operating in the formal sector and 1,177 businesses in the informal sector. Among others, the data includes indicators such as electricity supply, businesses' economic characteristics, access to electricity, and usage. The INStaD (2019) report contains details about the specific survey questions, sample size, and selection criteria (see Appendix 6.1.B). We restrict our analysis to the sub-sample of 1,002 businesses connected to the electricity grid, as we focus on defensive strategies.

What do we call 'Extra Costs'?

Our analysis uses extra costs to refer to the additional costs incurred from using defensive measures to improve electricity quality due to voltage fluctuations and reduce the adverse impact of power outages; it is the electricity expenditure businesses incur in addition to their electricity bills. Consequently, this paper does not consider measures that businesses use that do not aim to address power outages or voltage fluctuations and are,

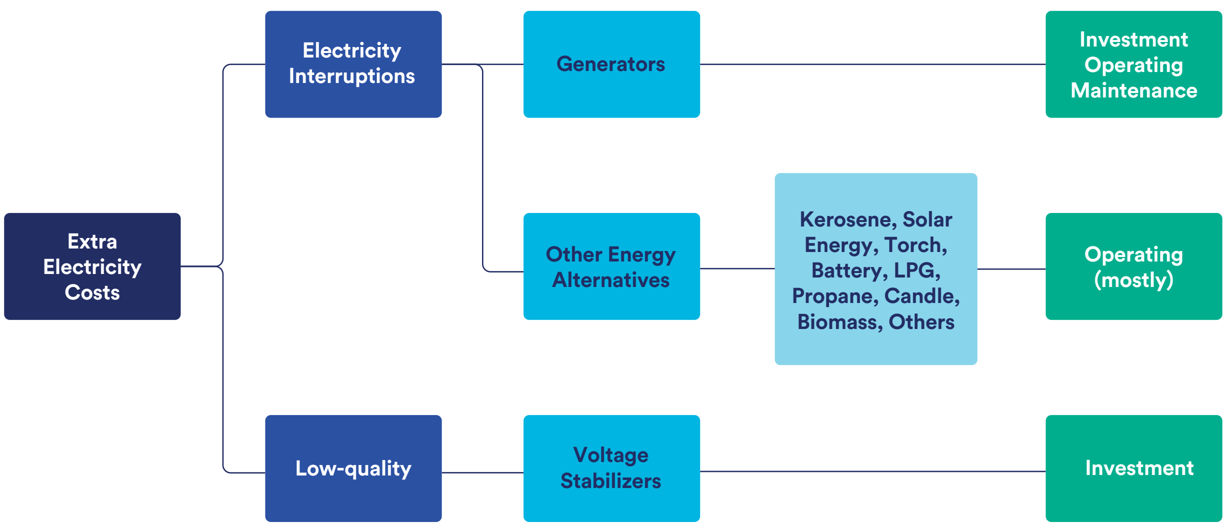
[2] Note that INStaD conducted a follow-up survey in 2020 addressing a similar topic. However, this recent survey does not cover issues around extra electricity costs due to defensive strategies to cope with blackouts and voltage fluctuations, which is the primary focus of this paper. For more details, see http://nada.insae-bj.org/index.php/catalog/55.

therefore, not considered a defensive strategy.[3] In fact, the survey data indicates that businesses mainly resort to voltage stabilizers, power generators, and alternative energy sources to cope with unreliable electricity supply in Benin. Hence, on the one hand, we consider the costs of acquiring voltage stabilizers, which require only an initial investment. On the other hand, we consider the costs of acquiring, operating, and maintaining a power generator. Additionally, we account for expenses related to alternative energy sources such as biomass, kerosene, solar power, torchlights, batteries, liquefied petroleum gas (LPG), propane, and candles (See Figure 1).[4] As in the recent work by Niroomand and Jenkins (2020b), we annualize the initial investment to compute the monthly equivalent, assuming a 10-year lifespan for voltage stabilizers and a 20-year lifespan for generators.[5]

Electricity burden metrics for businesses

After defining the extra costs, we developed three metrics of electricity burden for businesses based on the traditional expenditure-based approach. Boardman (2013) developed the initial concept of energy poverty for households, suggesting that households that spend more than 10% of their income on electricity are energy poor. This means that electricity expenditure becomes a burden for those households when it exceeds this threshold. Many studies widely used this approach, especially considering the case of households (e.g., Heindl and Schüssler, 2015; Phimister et al., 2015; Okushima, 2016). As for households, we extend the definition to businesses by proxying household income with business revenue, reflecting the electricity burden for businesses, that is, the financial burden that electricity expenditures constitute for businesses affecting their financial viability.[6]

Figure 1: Definition of Extra Costs



3 One typical example is that we do not consider as a defensive measure, power generators that businesses used as the main source of electricity.

4 In developing countries, the usage of those energy sources goes beyond their main purpose, such as cooking. It extends to lighting or powering appliances to cope with power blackouts (e.g., for biomass and LPG; see Mills and Jacobson (2011)). This justifies why some businesses in Benin listed them in the survey as alternative energy sources. Thus, we include them in calculating electricity extra costs and restrict them to businesses that only use them to replace electricity but not as fuel stacking.

5 There is no publicly available data on power generator lifetime in Benin. As a proxy, we use the lowest range, as in Niroomand and Jenkins (2020b), which reflects the lack of frequent maintenance and intensive usage due to frequent blackouts in Benin.

6 Note that the 10% threshold extended from households to businesses may not be a fair representation and that we further in the report, consider the possibility of other thresholds.

The first metric (EB1) is a binary variable based on the 10% threshold, where we consider a business facing an electricity burden if its electricity bill exceeds 10% of its revenue. As noted previously, this approach (respectively the metric) fails to account for extra costs resulting from power outages or voltage fluctuations, which are more frequent in developing countries, representing a gap in the existing literature. To address this gap, we propose a second electricity burden metric (EB2), also a binary variable, classifying a business as facing an electricity burden if its electricity expensescincluding both the electricity bill and extra costs—exceed 10% of its revenue. The third metric (EB3), a nominal variable, divides the sample into three groups based on the first two metrics (EB1 and EB2): businesses that are facing an electricity burden regardless of the consideration of the extra costs (recoded 1); businesses that are now facing an electricity burden because of the extra costs (recoded 2); and businesses that are not facing an electricity burden even when extra costs are considered (recoded 0).

Explanatory variables

We identified potential characteristics of businesses that can push them to face an electricity burden and investigated their correlations. Drawing on existing literature, we categorize the explanatory variables for businesses' electricity burden into six groups: economic characteristics, individual characteristics, power supply characteristics, power connection characteristics, end-use characteristics, and defensive characteristics. For each of these categories, we use one or several variables. For instance, economic characteristics include value of equipment the business possesses as a proxy for its size. We expand the individual characteristics to account for the number of working hours, total number of workers, and the type of business (whether informal or formal). The power supply characteristics for businesses incorporate variables such as the number of outages per week, outage duration, and the time of day the outage occurs (morning, midday or evening). Finally, the end-use characteristics indicate whether the business operates from home and the primary activity of the business (production or services). We present in Table 1, a comprehensive overview of these variables and the literature motivating their inclusion in our analysis.

2.2 Methods

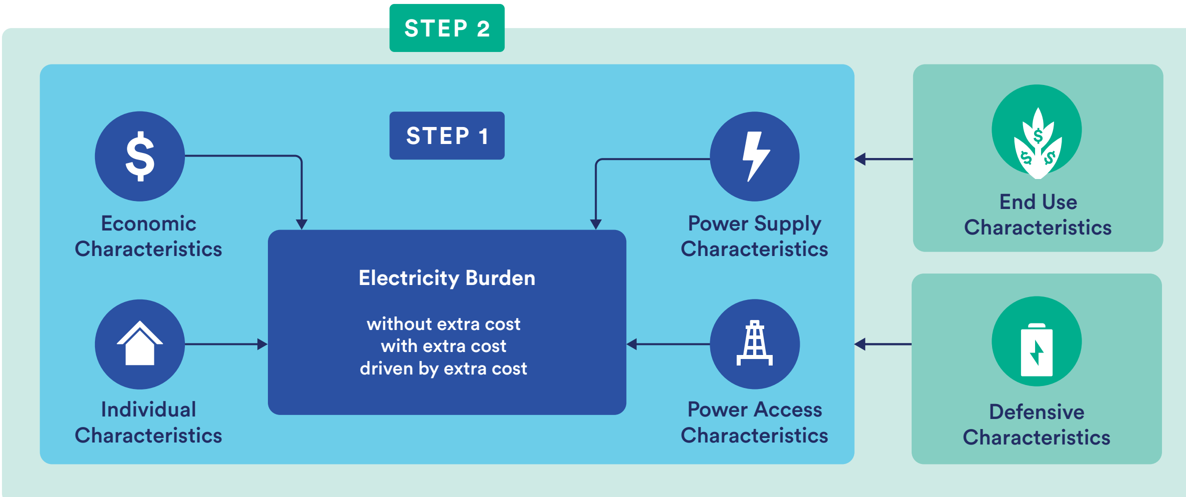
Conceptual framework

To probe factors affecting the electricity burden among businesses, we run two different regressions, as shown in our conceptual framework (see Figure 2). Hence, in the first regression (Step 1), we include the economic, the individual, the power supply, and the power connection characteristics. Those variables are widely used in the literature (See Table 1). In the second step, we then introduce the often-neglected business characteristics in the literature, such as end-use characteristics and defensive characteristics in the regression model. Our rationale for introducing these variables in Step 2 is that factors influencing the electricity burden for businesses go beyond those considered in the initial step. Previous research has highlighted the importance of incorporating these variables to gain a more comprehensive view of the determinants of electricity burden (e.g., Churchill and Smyth, 2020; Lin and Okyere, 2022b).

Table 1: Description of Electricity Burden for Businesses and Variables

Variables	Description	Source
Dependent Variables		
EB1	Electricity burden based on electricity bill (0=No, 1=Yes)	Boardman (1991)
EB2	Electricity burden based on electricity bill and extra costs (0=No, 1=Yes)	Author's contribution based on ECEB 2015
EB3	Electricity burden driven by extra cost (0=No, 1=Yes and not driven by extra costs, 2=Yes and driven by extra costs)	
Economic Characteristics		
Value of Equipment	Equipment Terciles (1=Small, 2=Moderate, 3=High) based on the value of production equipment	Author's contribution based on ECEB 2015
Individual Characteristics		
Age	Age of the business manager	Asiedu et al. (2021)
Sex	Sex of the business manager (0=Female, 1=Male)	
No Education	Business manager has no formal education (No=0, 1=Yes, used as base)	
Primary	Primary level education of business owner (No=0, 1=Yes)	
Secondary	Secondary level education of business owner (No=0, 1=Yes)	
Tertiary	Tertiary level education of business owner (No=0, 1=Yes)	
Working Hours	Total working hours	Asiedu et al. (2021); Kim and Cho (2017)
Total Workers	Total number of workers for the business	
Business Type (Informal)	Sector of the business (0=Formal, 1=Informal)	
Location – Urban	Location of the business (0=Rural, 1=Urban)	
Manager is the Business Owner	Manager is the owner of the business (0=No, 1=Yes)	
Power Supply Characteristics		
Planned Blackout	Informed about blackouts (0=Not informed, 1=Informed)	Asiedu et al. (2021)
Number Outage Per Week	Total number of blackouts in a week	Asiedu et al. (2021); Kupzig (2023)
Length of Power Outages	Average duration of blackouts	Kupzig (2023)
Morning Power Outages	Power outages in the morning (0=No, 1=Yes)	
Mid-day Power Outages	Power outages in the Mid-day (0=No, 1=Yes) – as reference	
Evening Power Outages	Power outage in the afternoon (0=No, 1=Yes)	
Voltage Fluctuation (Yes)	The business experienced voltage fluctuations (0=No, 1=Yes)	
Power Connection Characteristics		
Connection Fee	Extra connection fee paid by the business	
End Usage Characteristics		
Home Business	Business located and operated at home (0=No, 1=Yes)	
Principal Activities	Principal activity of the business (0=Production, 1=Service)	Asiedu et al. (2021); Kim and Cho (2017)
Defensive Characteristics		
Voltage Stabilizer	Usage of voltage stabilizer by the business (0=No, 1=Yes)	
Power Generator	Usage of power generator by the business (0=No, 1=Yes)	Kim and Cho (2017); Kupzig (2023)

Figure 2: Conceptual Framework on the Determinants of Electricity Burden for Businesses



Estimation strategy

For both EB1 and EB2, we use a probit model to investigate factors influencing electricity burden for businesses. This model is appropriate due to the binary nature of the dependent variables, where they take a value of 1 if a business is considered facing an electricity burden, and 0 otherwise (see Section 2.1).

Mathematically, this technique is expressed as:

$\psi^{-1}(p_i) = \sum_{k=0}^{k=n} \beta_k x_{ik}$, where $p_i = 1$ if the business is facing an electricity burden, and 0 otherwise, x_{ik} stands for the k^{th} explanatory variable for the business i, and β_k represent the model's parameters. Furthermore, n is the total number of independent variables in the regression model, while p represents the probability of a business i to be facing an electricity burden.

Regarding EB3, since it consists of three distinct categories, we use the multinomial probit (mprobit) regression model, for which Lin and Okyere (2020) describes a comprehensive methodology.

To check the robustness of the initial results, we perform additional regression analyses using alternative measures of electricity burden for businesses based on electricity expenditure ratios. Additionally, we assess the role of the various explanatory variables across different electricity burden thresholds, from 10% to 15% and 20% to assess the consistency in the determinants of electricity burden for businesses, following the recent works by Adusah-Poku and Takeuchi (2019) and Okyere et al. (2023). Since there is no measure commonly used to assess an electricity burden for businesses, as an additional robustness check, we controlled for the business type, distinguishing between manufacturing and service firms, and used quantile regressions with the ratios of electricity expenses (i.e., with or without additional costs) to the total revenue of businesses. Finally, to address potential endogeneity caused by omitted variable bias, we control for most of the determinants outlined in the conceptual framework on electricity burden for businesses. Thus, given that our study does not investigate a causal inference, we are less concerned about any potential remaining endogeneity bias.

Image credit: Présidence de la République du Bénin

SECTION 3

Results

This section discusses the results emphasizing the distribution of key variables such as extra electricity costs, electricity burden, etc., and the determinants of the prevalence of electricity burden for businesses. We show that the systematic exclusion of extra costs understates the actual extent of electricity burden for businesses in Benin, as defensive strategies drive a considerable number of businesses into electricity burden situation. We find that extra costs represent a substantial burden on businesses (i.e., 44% of electricity expenditure), dominated by the cost of operating power generators. We also identify the typology of businesses that are more vulnerable to the electricity burden, particularly informal businesses, business owners, home businesses, businesses with production activities, etc. Section 3.1 focuses on the distribution of extra electricity cost, highlighting its composition and comparison with electricity bill. Section 3.2 analyzes the electricity burden for businesses from different standpoints. In Section 3.3, we present and discuss factors influencing the prevalence of electricity burden for businesses.

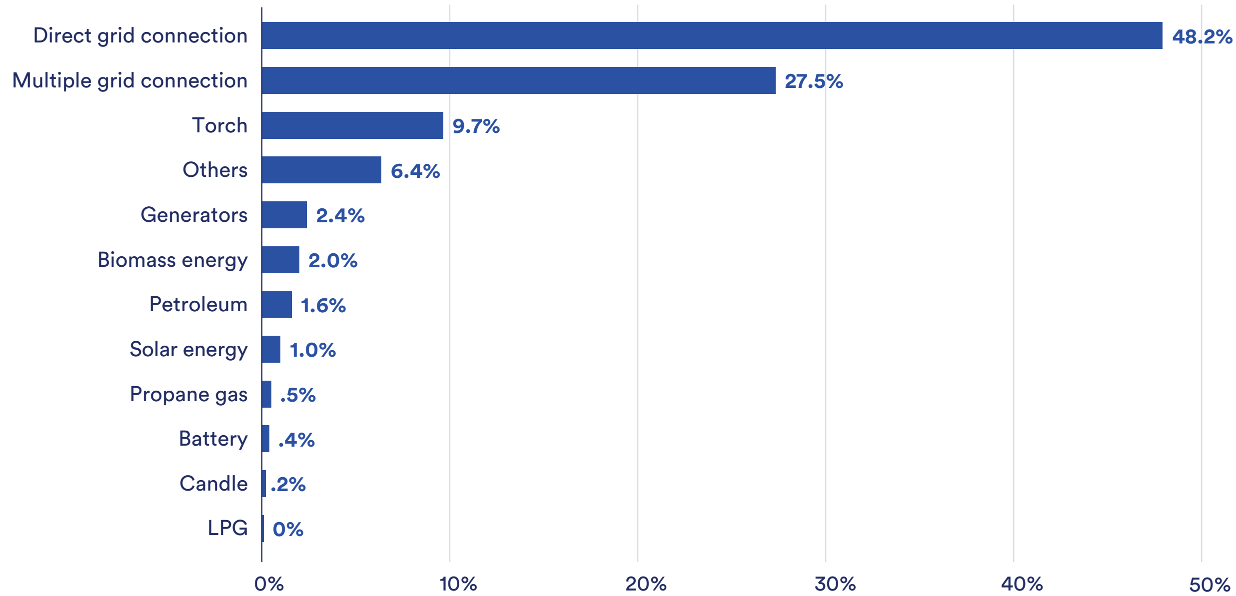
3.1 Distribution of Extra Costs

Distribution of energy sources, power generator and voltage stabilizer usage

Initially, we assess the various energy sources used by businesses. The output, as reported in Figure 3, shows that the top two energy sources for businesses in Benin include the direct connection to the grid (48.2%) and connection through a third-party (27.5%). This is followed by the utilization of torch, which is mainly used by 9.7% of businesses, power generators (2.4%), and biomass energy (2%).[7] Overall, these figures indicate that most businesses in Benin (75.7% in total) rely on grid connections as their main source of energy and are most likely to experience the adverse effects of unreliable electricity supply, which is frequent in Benin.

[7] Given that businesses can use multiple energy sources, energy sources are not mutually exclusive, which justifies why the distribution of energy sources is more than 100%.

Figure 3: Distribution of Energy Sources for Businesses (%)



Secondly, we examine the use of power generators and voltage stabilizers among businesses as defensive strategies. It is worth noting that this analysis only considers businesses that are connected to the grid, as a pre-condition. Doing so, we find no disparity in the adoption of both defensive strategies, since 22% and 21% of businesses reported that they have invested in (and use) voltage stabilizers and power generators, respectively (See Table 2).

Table 2: Distribution of Power Generators and Voltage Stabilizers Usages for Connected Businesses

Voltage Stabilizers	Power Generators		
	No	Yes	Total
No	67% (626)	11% (101)	78% (727)
Yes	12% (108)	10% (90)	22% (198)
Total	79% (734)	21% (191)	100% (929)

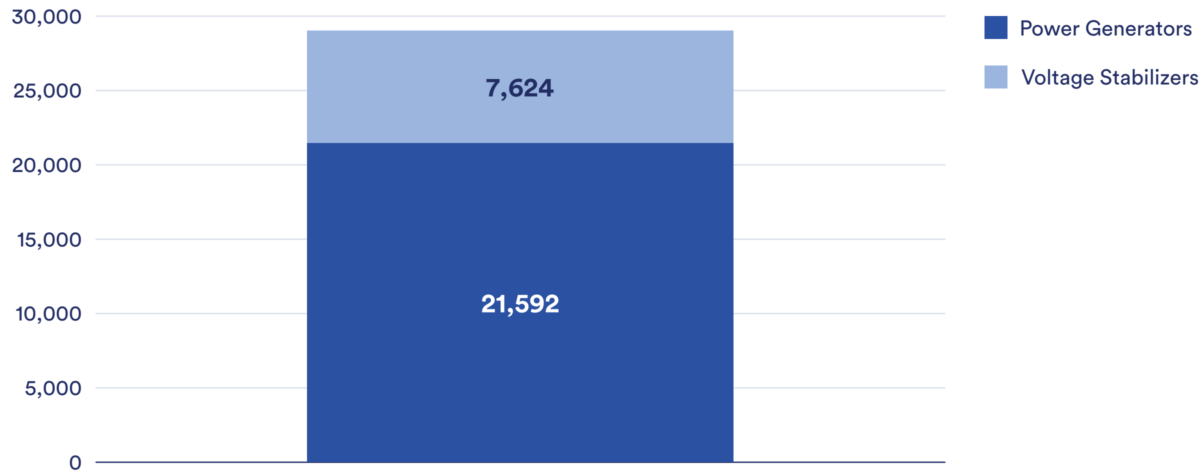
Notes: "No" and "Yes" mean whether voltage stabilizers or power generators are used or not. This is a cross-tabulation reflecting a joint distribution between voltage stabilizer and power generator usage.

Distribution of extra electricity costs

Third, we analyze the breakdown of extra costs by examining their key components and distribution to determine which expenses have the greatest impact on the overall financial burden of electricity for businesses. In terms of investment costs, Figure 4 shows that businesses connected to the grid display average monthly investments of FCFA 7,624 (USD 13) on voltage stabilizers and FCFA 21,592 (USD 37) on power generators (See Box 1 and Appendix 6.1.A that display the economic situation in Benin).[8] This reveals a significant disparity in investment costs between the two defensive measures, with businesses allocating a much larger share of their investment budget, 74%, to power generators, compared to 26% for voltage stabilizers. The latter distribution is likely due to the substantially higher cost of acquiring a power generator relative to a voltage stabilizer.

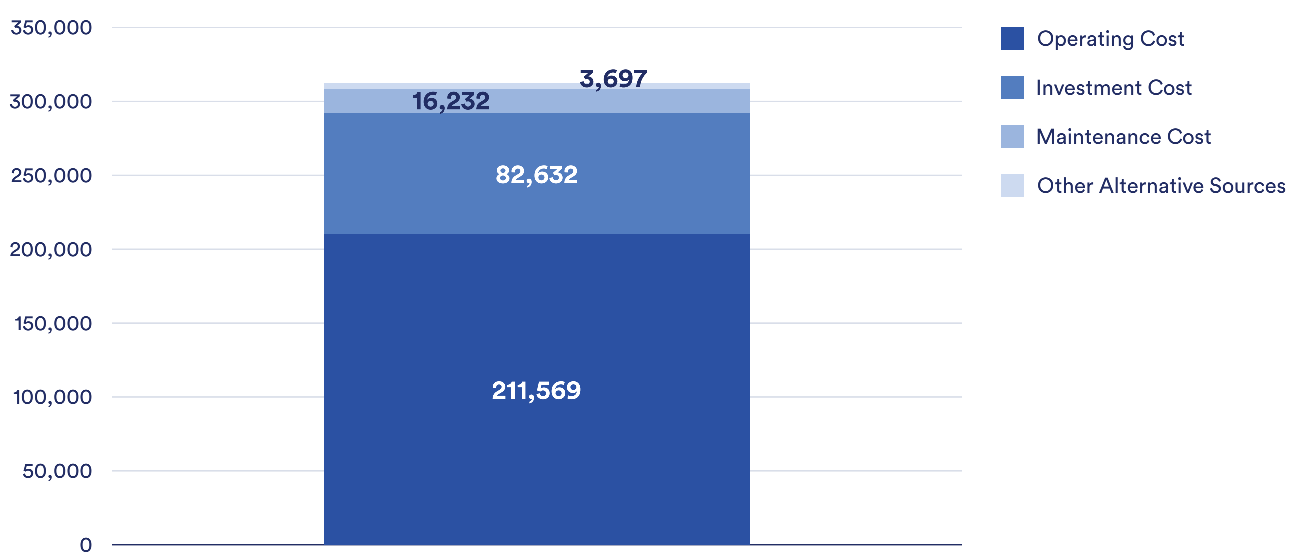
[8] We use a conversion factor of 591.21 provided by the World Bank Development Indicators (See https://data.worldbank.org/indicator/PA.NUS.FCRF?locations=BJ).

Figure 4: Distribution of Investment Costs Across Defensive Actions (CFA)



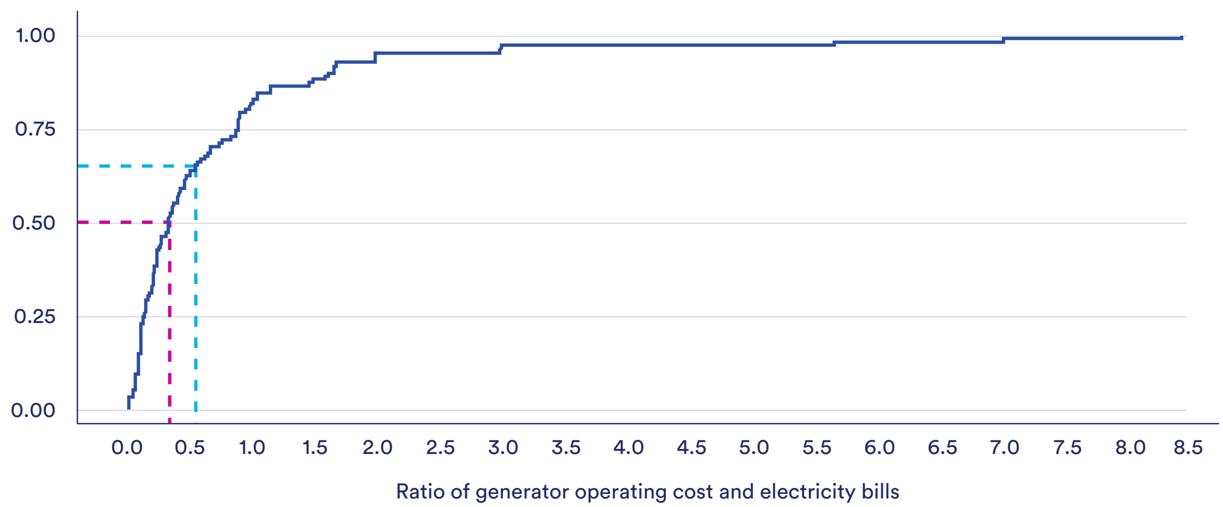
Extra costs, as noted before (see Section 2.1), include not only the initial investment but also maintenance for power generators, operational expenses, and costs for alternative energy sources. The average monthly power generator operating cost is FCFA 211,569 (USD 357), representing 67% of the extra costs, followed by maintenance expenses (see Figure 5). While investing in defensive strategies such as power generators and voltage stabilizers helps ensure more reliable access to electricity, the primary challenge for businesses is managing the ongoing operational costs associated with these strategies.

Figure 5: Distribution of Extra Electricity Costs Across Cost Components (CFA)



It is noteworthy that compared to the conventional electricity bill, the operating cost of power generators constitutes, on average, 180% of electricity bills, reaching significantly higher levels, up to 8.4 times, for certain businesses (see Figure 6).

Figure 6: Ratio of Operating Cost (Power Generators) Divided by Electricity Bill



Box 1: Economic situation in Benin

Source: World Bank (2023), INSTaD (2015, 2023)

Economic Indicators	2015 Benin	Most Recent Benin	Most Recent SSA	Most Recent World
GDP – per capita (PPP, current international $)	2,832	4,248.3 (2023)	4,836.2 (2023)	23,009.8 (2023)
GDP per capita (current US$)	1,041.7	1,434.7 (2023)	1,636.8 (2023)	13,138.3 (2023)
Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population)	50.70	12.7 (2021)	36.7 (2019)	8.8 (2019); 9 (2022)
Inflation, consumer prices (Annual %)	0.2	2.7 (2023)	7.1 (2023)	5.7 (2023)
Distribution of family income – Gini index	47.6	34.4 (2021)	Not Available	Not Available
Household final consumption expenditure (% of GDP)	75	59 (2023)	73 (2022); 80 (2023)	55 (2022)
Monetary poverty	40.1%	36.2%	Not Available	Not Available
Non-monetary poverty	28.70%	Not Available	Not Available	Not Available

The last substantial contributor to extra electricity costs for connected businesses is the expenditure associated with the utilization of alternative energy sources such as torch, kerosene, solar energy, etc. This category of expenditure accounts for only 1% of the extra electricity costs, equivalent to a monthly expense of FCFA 3,697 (i.e., USD 6) (see Figure 5). Thus, additional expenses on alternative energy sources to cope with power blackouts do not represent a considerable share of extra electricity costs. Investments in solar energy, kerosene, and torch, contributing to 41%, 23%, and 14%, respectively, mainly drive this cost (See Table 3).

Finally, as shown in Figure 7, we compare the extra costs to the total electricity expenditure for business. The results indicate that, on average, extra costs represent a substantial share of the total expenditure on electricity, standing at 44%. Hence, despite being connected to the grid, businesses allocate over a third of their total electricity spending toward defensive measures.

To provide a more granular analysis at the individual level, we compute a similar ratio for each business and find an average of 38% for the total extra electricity cost, aligning closely with the previously mentioned percentage based on averages (see Figure 8). Moreover, more than 31% of these businesses spend more than half of their electricity budget on extra electricity costs. However, it is important to note that for certain business, this proportion can be considerably higher, with some businesses dedicating as much as 93% of their electricity budget to cover extra electricity costs. Note that for a significant proportion of businesses that do not adopt defensive strategies, the extra costs of these measures may outweigh the benefits, or they may be constrained for instance by financial limitations.

Table 3: Distribution of Operating Costs Across Alternative Energy Sources

Alternative Energy Sources	Amount of Investment Cost (CFA)	Percentage
Solar Energy	19,500	41%
Kerosene	10,893	23%
Torch	6,682	14%
Biomass	6,440	13%
Propane	1,932	4%
Liquified Petroleum Gas (LPG)	9,12	2%
Battery	750	2%
Candle	699	1%

Figure 7: Distribution of Extra Electricity Costs and Electricity Bill (CFA)

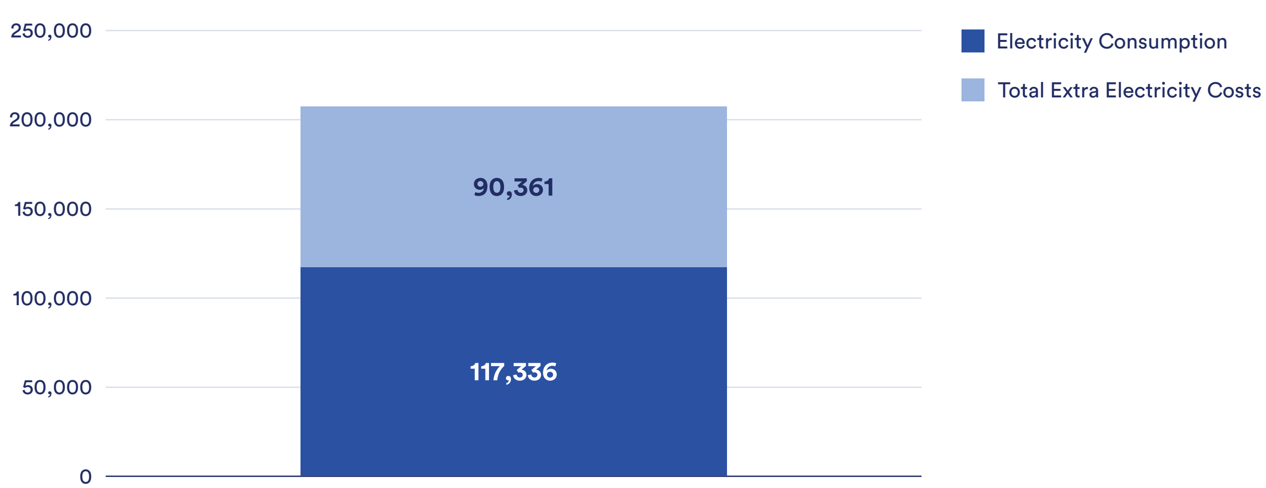
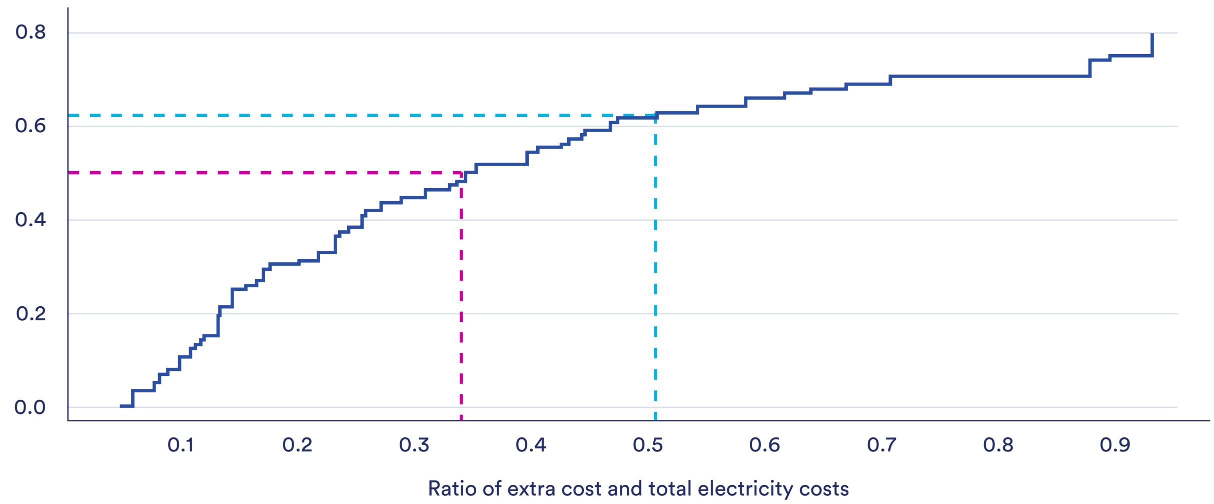


Figure 8: Ratio of Extra Electricity Cost Divided by Total Electricity Expenditure



Overall, our findings in Section 3.1 reveal that extra electricity costs constitute a substantial share of businesses electricity expenditure. The cost of operating generators mainly drives this high preponderance, representing the highest component of the extra electricity costs. This demonstrates that we should not neglect extra costs due to defensive strategies. Otherwise, it results in underestimating the total electricity expenditures.

3.2 Distribution of Electricity Burden for Businesses

Distribution of electricity burden across connected businesses

The assessment of the electricity burden among businesses shows that more than half of businesses (i.e., 55%) are facing an electricity burden based on the traditional approach, which focuses exclusively on electricity bills (i.e., EB1) (see Table 4). This reflects the high electricity price that businesses face or their relatively low revenue, particularly for small businesses that operate with high energy-intensive equipment. Our new electricity burden measures, which additionally consider extra costs to cope with blackouts and voltage fluctuations, reveal that 5% more businesses are driven into an electricity burden situation because they adopt defensive strategies. In total, electricity costs, including extra costs, constitute a high financial burden for 60% of businesses operating in Benin.

Several factors presented in Table 1 correlate differently with the distribution of businesses' electricity cost financial burdens. In the following, we briefly discuss the profile of businesses that are more financially vulnerable to electricity costs.

Table 4: Distribution of the Electricity Burden Status

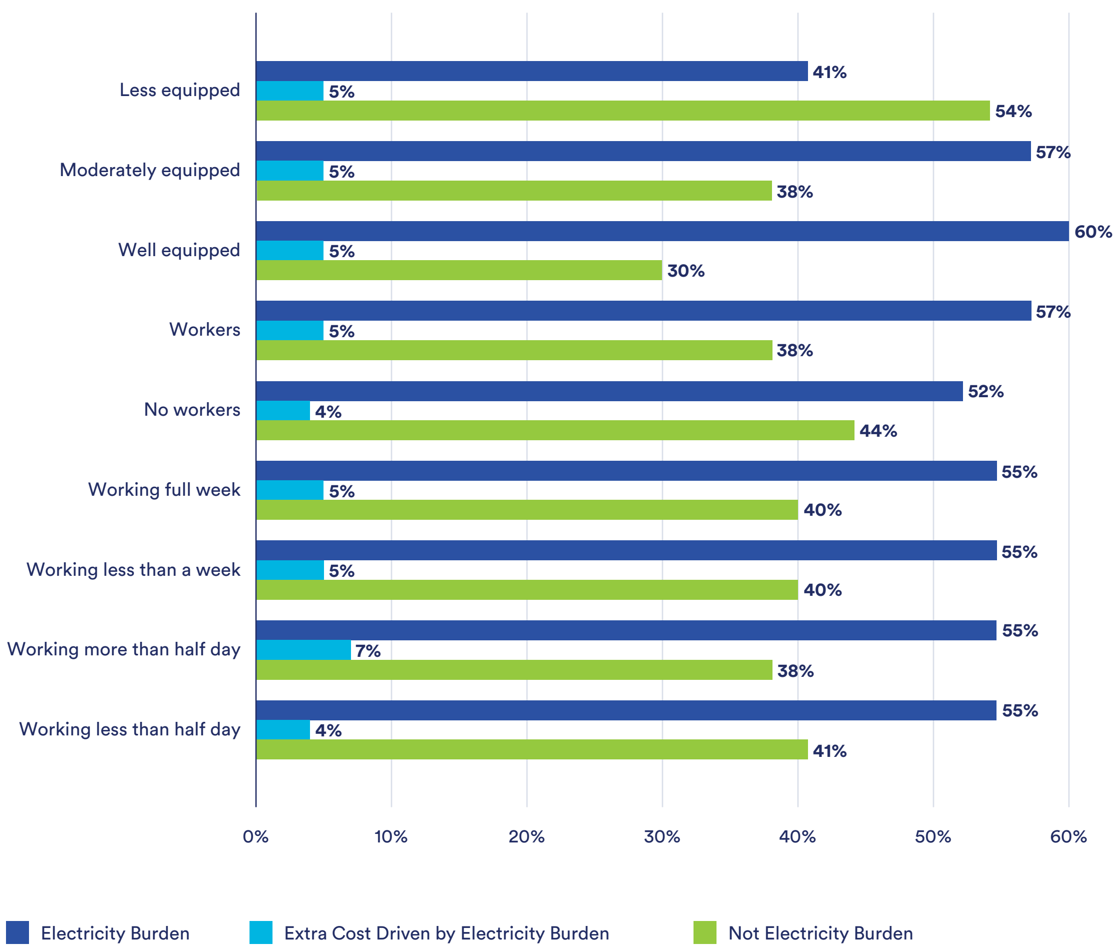
Only Electricity Bill	Including Extra Costs		
	Not Facing Electricity Burden	Facing an Electricity Burden	Total
Not Facing Electricity Burden	40%	5%	45%
Facing an Electricity Burden	0	55%	55%
Total	40%	60%	100%

Distribution of electricity burden across economic factors

On the economic characteristics, we find some disparities among businesses across values of equipment as a proxy for the size of the business, number of workers, and number of days or hours when the business operates (See Figure 9). We find that businesses suffer differently from the electricity burden depending on their size (i.e., the value of production equipment they own). The higher the value of equipment the business has, the more it suffers from the electricity burden, while businesses having a moderate and high value of equipment display a similar electricity burden distribution. We also find that the number of working days and hours does not show disparities in the electricity burden for businesses while the electricity burden is more prevalent among businesses having workers than owner-operated businesses. This is because businesses with more employees often boast larger operations, including expanded production facilities, and greater office space, all of which demand energy for their functioning thereby increasing their electricity burden prevalence, unlike owner-operated enterprises.

Figure 9: Distribution of Electricity Burden for Businesses Across Economic Variables (%)

Note: Level of equipment tercile is categorized as: 1=Less equipped, 2=Moderately equipped, 3=Well equipped. Number of workers is categorized as: Business employs at least a worker, or no workers. The operating hours is categorized as: working a full week, or less than a week; working more or less than a half day.



Distribution of electricity burden for businesses across individual factors

Furthermore, we explore the electricity burden distribution across some individual business characteristics. We find some disparities among businesses facing an electricity burden regarding business ownership, education of the manager of the business, and the type of businesses. The electricity burden is more prevalent among businesses managed by their owners than non-owners. We also find a U-shape relation between the electricity burden and education of the manager. More precisely, the electricity burden prevalence decreases with education level, and then increases for higher education. Businesses operating in the informal sector are also more affected by the electricity burden than formal businesses. However, we have also observed that other individual characteristics such as the gender of the manager and living area do not drive large disparities among businesses facing an electricity burden (See Figure 10).

Figure 10: Distribution of Electricity Burden for Businesses Across Individual Variables (%)

Note: Business ownership is categorized as owner or not owner. Education level of the manager is categorized as: No education, primary education, secondary education, tertiary education. Business type is categorized as informal or formal. Sex of the manager is categorized as Female or Male. The location of the business is categorized as urban or rural.

Figure 10-a

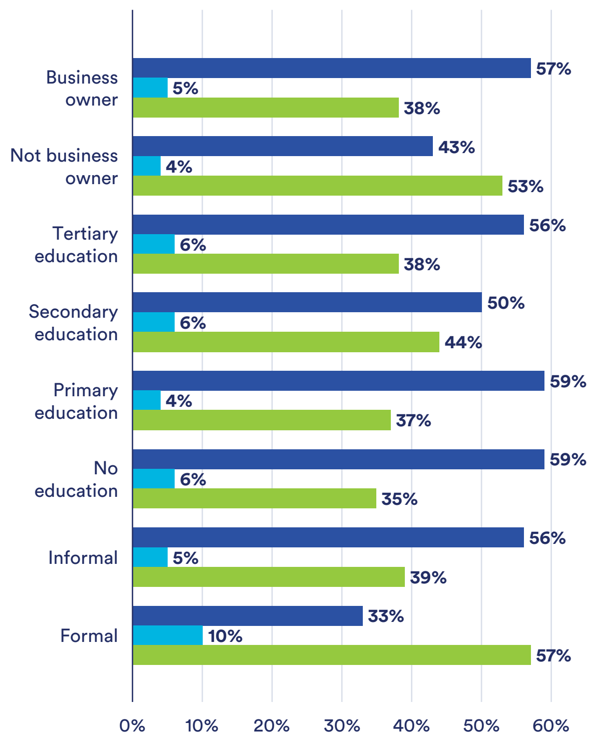
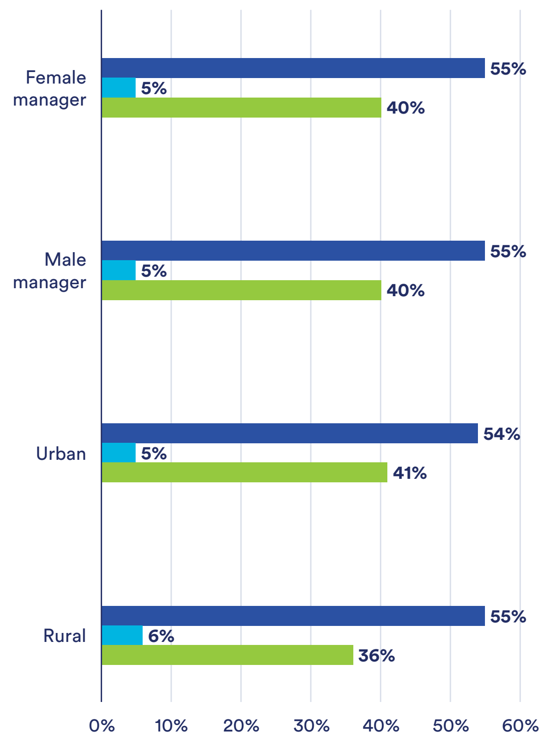


Figure 10-b



Electricity Burden | Extra Cost Driven by Electricity Burden | Not Electricity Burden

Distribution of electricity burden for businesses across power supply and access, end-use and defensive strategies factors

Regarding power usage, we find that most power usage characteristics show disparities among businesses facing an electricity burden. Specifically, businesses using power generators or voltage stabilizers are facing more an electricity burden than those not using them. The type of usage seems to also show some disparities as the electricity burden affects businesses in the production sector and home business more than their counterparts. On the power supply characteristics, we find that the electricity burden affects businesses experiencing voltage fluctuations more than those not suffering from voltage fluctuations. Given that businesses operate more often during the day than at night, when the electricity interruptions occur can matter for the likelihood of the business to be facing an electricity burden. Thus, we find that the electricity burden rate is lower among businesses experiencing evening blackouts than those having morning and afternoon blackouts (See Figure 11). Whether the business is informed in advance of the blackout or not, does not seem to induce large disparities of the electricity burden prevalence among businesses.

Figure 11: Distribution of Electricity Burden for Businesses Across Power Supply, Access, End-Use and Defensive Strategies Variables (%)

Note: Usage of power generators is categorized as: use or non-use of generators. Usage of voltage stabilizers is categorized as: use or non-use of voltage stabilizers. Activities of the business is categorized as: service or production activities. Businesses operating at home is categorized as: home business or non-home business. Existence of voltage fluctuations is categorized as: voltage fluctuations or not. Time of blackouts is categorized as: morning, afternoon, or evening blackouts. Existence of planned blackouts is categorized as: planned blackouts or not.

Figure 11-a

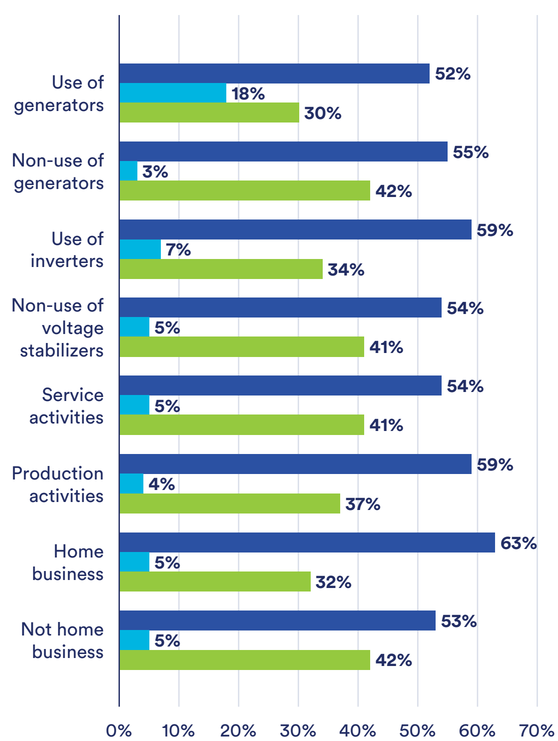
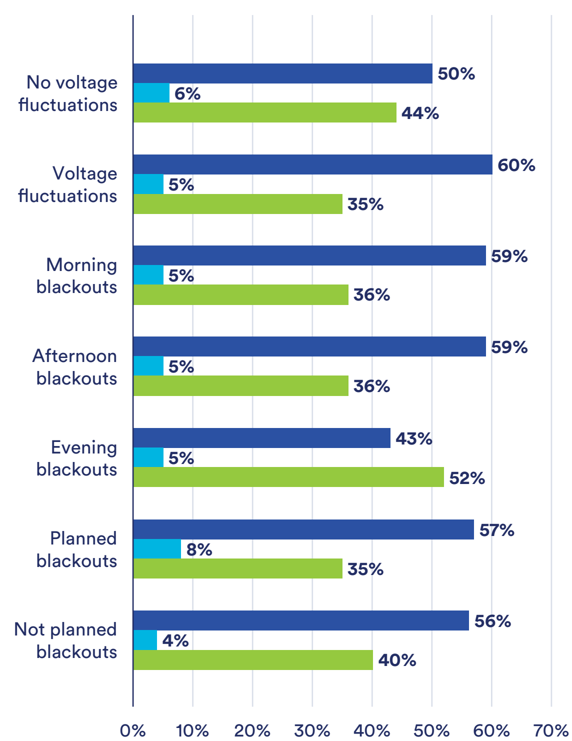


Figure 11-b



Electricity Burden | Extra Cost Driven by Electricity Burden | Not Electricity Burden

3.3 Evaluation of the Influencing Factors

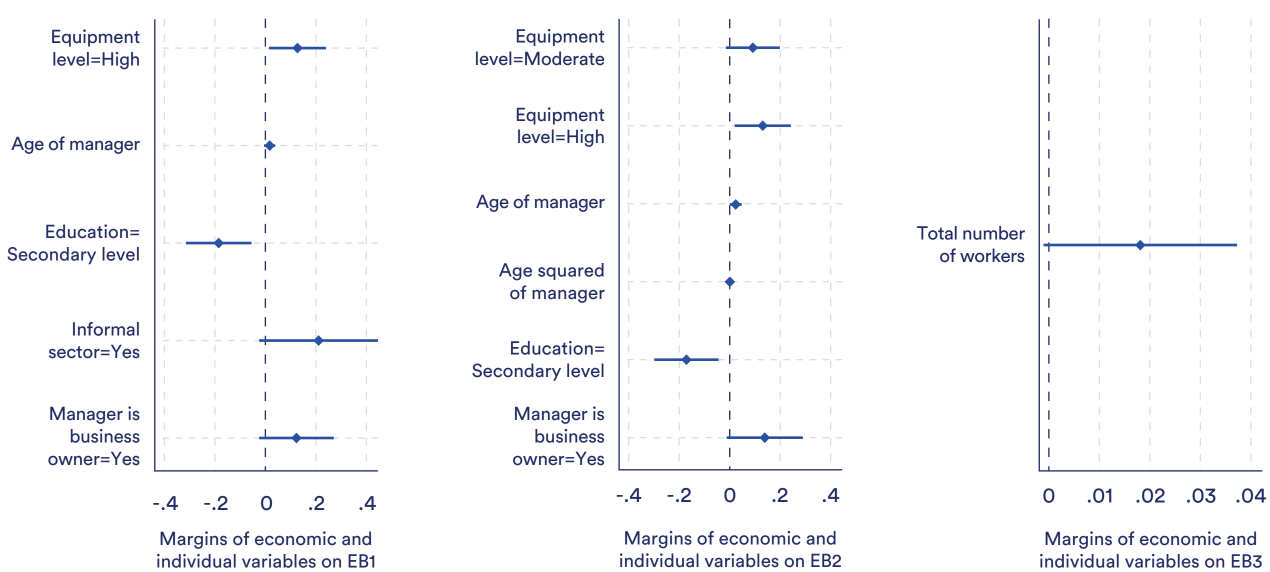
Our assessment of businesses' factors correlating with the likelihood of businesses facing an electricity cost burden in Benin relies on baseline econometric estimations using probit and mprobit models. Figures 12-15 display the corresponding marginal effects of the determinants of the electricity burden (EB1, EB2, and EB3) in two different specifications (See Figure 2). As discussed in Section 3.2, the first specification (see Figures 12-13) considers all the traditional influencing factors, while the regression in the second specification extends the first specification to include end-use and defensive strategies (see Figures 14-15). In addition to the figures, we report the marginal effects and coefficients from all the estimations in the Appendix. Overall, we find that besides economic and individual characteristics, power supply and connection characteristics mainly drive the prevalence of the electricity burden for businesses.

The role of conventional factors: Economic and individual variables

Considering the economic characteristics, we classify businesses in three main economic categories based on the value of production equipment, as described in Section 2.1. The latter indicator emerges as a significant factor influencing the electricity burden prevalence among businesses. Compared to their counterparts that have a smaller value of equipment, businesses possessing higher value of equipment have approximately a 13% higher likelihood of experiencing an electricity burden based on the EB1 and EB2 metrics. For businesses with a moderate value of equipment, we find a 9.5% higher likelihood of facing an electricity burden, based on the EB2 metrics of the electricity burden. The high electricity consumption underlying the use of production equipment by the businesses can explain this finding. Nevertheless, some energy-intensive businesses such as industries and manufacturing may have considered this high electricity consumption in their business model and, thus, one should not classify them as facing an electricity burden. To address this concern, we explore alternative metrics and estimation strategies for robustness checks (see the robustness check results in Figures 16-21).

Furthermore, we assess the characteristics of the business's manager as part of individual factors. Among others, we find that the age of the business owner significantly influences the prevalence of the electricity burden for businesses. Analyzing the EB1 (EB2 resp.) metric of the electricity burden, we find that there is a 2.4% (2.7% resp.) increase in the likelihood of the business experiencing an electricity burden with each passing year of the owner's age. A potential explanation is the fact that older business owners tend to use outdated equipment and technologies, which are less energy-efficient than newer alternatives.

Figure 12: Economic and Individual Factors Influencing the Prevalence of Electricity Burden for Businesses (Step 1)



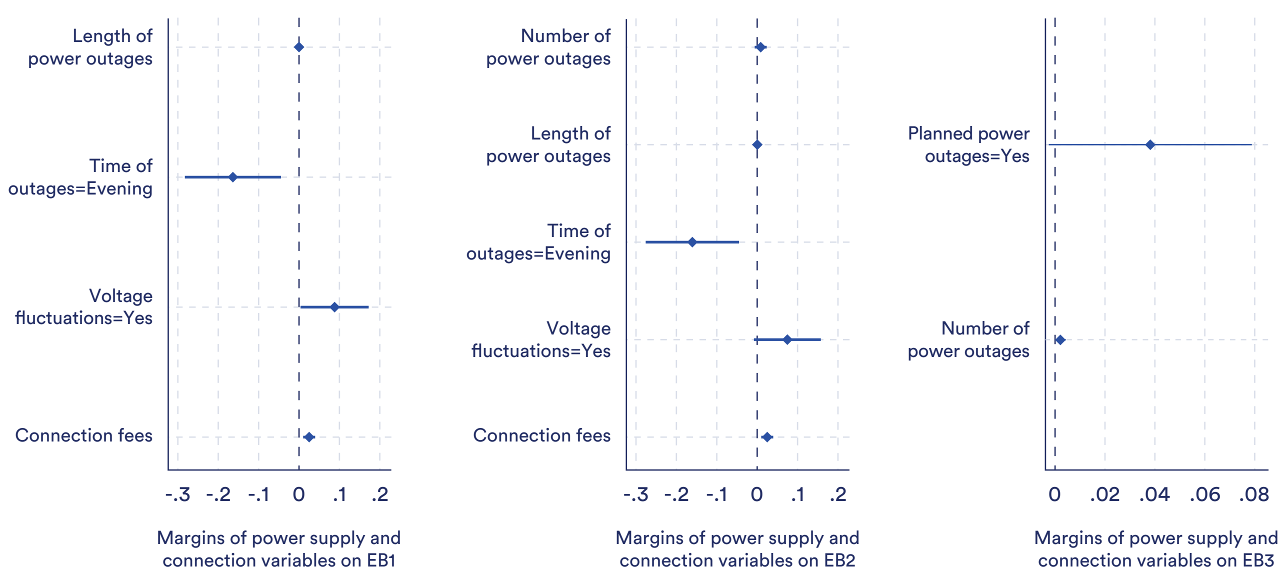
Additionally, older business owners may be less aware of or lack the resources to implement energy-saving opportunities effectively. Similarly, business owners with a secondary level of education face approximately 17.9% and 17.1% lower likelihoods of experiencing an electricity burden compared to their counterparts with no formal education, as indicated by the EB1 and EB2 measures, respectively. This finding can be explained by the substantial role of knowledge in strengthening businesses' decision-making capacity towards efficient energy services. Also, we find that informal businesses are 22% more likely to experience the electricity burden compared to their counterparts in the formal sector, based on the EB1 metric. This emphasizes how electricity consumption is a burden for businesses operating particularly in the informal sector, which can have important social and economic implications in Benin given the preponderance of the informal sector in the country (INSAE, 2016; 2019).

The role of conventional factors: Power supply, and access variables

Regarding the power supply characteristics, the weekly frequency of blackouts is linked to increasing the electricity burden prevalence among businesses in Benin. Specifically, an additional power cut endured by businesses per week leads to a 0.7% and 2% higher likelihood of facing an electricity burden, based on the EB2 and EB3 measures of the electricity burden, respectively. Moreover, the period of day when these outages occur significantly impacts the prevalence of the electricity burden for businesses as well; businesses experiencing power outages in the evenings are approximately 16% less likely to be facing an electricity burden (EB1 and EB2) compared to their counterparts facing blackouts at midday. This is likely because, in Benin, most business opening hours span the day, and, therefore, power cuts occurring in the evening or night may not affect as much economic activities as those that occur during the day. Additionally, we observe that voltage fluctuations significantly increase the prevalence of the electricity burden among businesses. Compared to businesses not facing voltage fluctuations, those dealing with such fluctuations have approximately a 9% and 7.6% higher likelihood of facing an electricity burden (EB1 and EB2).

We also find that power connection characteristics play a crucial role in the electricity burden challenges faced by businesses, as evidenced in the recent work by Asiedu et al. (2021), which uses a country-level indicator of electricity access. Our analysis encompasses this consideration using the extra fees that businesses pay for power connection as an indicator. In doing so, we obtain results suggesting that the higher the extra connection fees, the more susceptible are businesses to experience electricity burden issues (See Figure 13).

Figure 13: Power Supply and Access Factors Influencing the Prevalence of Electricity Burden for Businesses (Step1)

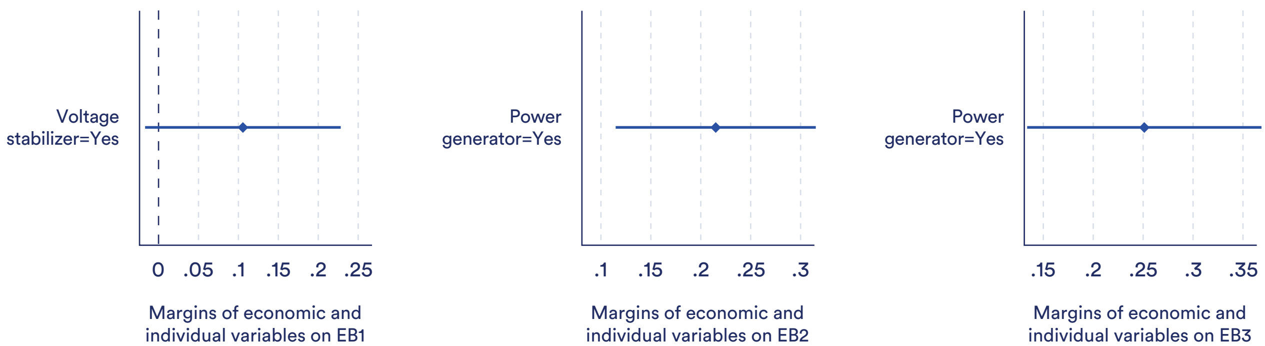


The role of the moderating factors: Power end-usage and defensive strategies

Finally, we investigate the specific influence that end-use and defensive characteristics can have on the prevalence of the electricity burden for businesses. As indicated in Figure 14, we find that none of the end-use characteristics exhibit a significant relationship with the electricity burden prevalence for businesses. In contrast, we find a significant positive influence of defensive characteristics. The utilization of generators has a significant impact on the prevalence of the electricity burden for businesses only when extra costs are considered (i.e., EB2 and EB3).

However, we find that the use of voltage stabilizers only plays a significant role only when ignoring extra costs (i.e., EB1). Compared to their counterparts, businesses utilizing generators are approximately 21.6% and 25.1% more likely to experience an electricity burden for EB2 and EB3 metrics, respectively. Similarly, businesses equipped with voltage stabilizers show about a 10% higher likelihood of facing an electricity burden than their counterparts employing no such strategy. These results are straightforward as, compared to businesses with no defensive measures, acquiring and operating power generators induce extra economic burden for businesses adopting defensive strategies.

Figure 14: End-Use and Defensive Strategies Factors Influencing the Prevalence of Electricity Burden for Businesses



Furthermore, the introduction of end-use and defensive variables in step 2 results in changes to the coefficients, with some increasing, decreasing, or remaining unchanged compared to the coefficients in step 1, as depicted in Figure 15 (see Appendix G for the table of comparison).

Robustness check: Alternative estimation methods and thresholds for the electricity burden for businesses

In addition to the baseline estimation results, we adopt various approaches to test the robustness of our initial results on the determinants of the electricity burden prevalence among businesses in Benin. We provide some supplementary estimates in Figures 16-21 (see Appendix in Section 6.2, for the regression tables) to validate the reliability and consistency of our initial findings.

Those additional estimates include the alternative measures of the electricity burden based on electricity expenditure ratios, diverse cut-offs (15% and 20%) for the electricity burden measures and addressing the heterogeneity among businesses with sectoral classification and quantile regressions.

The results reported in Figures 16-21 (See Appendices B, C, D, and E), support our initial findings and suggest a certain level of heterogeneity. Firstly, we use different electricity burden measures based on the ratio of electricity expenditure to the business's revenue. We applied the fractional regression model, which shows findings that support our initial conclusion (see Figure 16 and Appendix B).

Figure 15: Comparison of Factors Influencing the Prevalence of Electricity Burden for Businesses Across Step 1 and Step 2

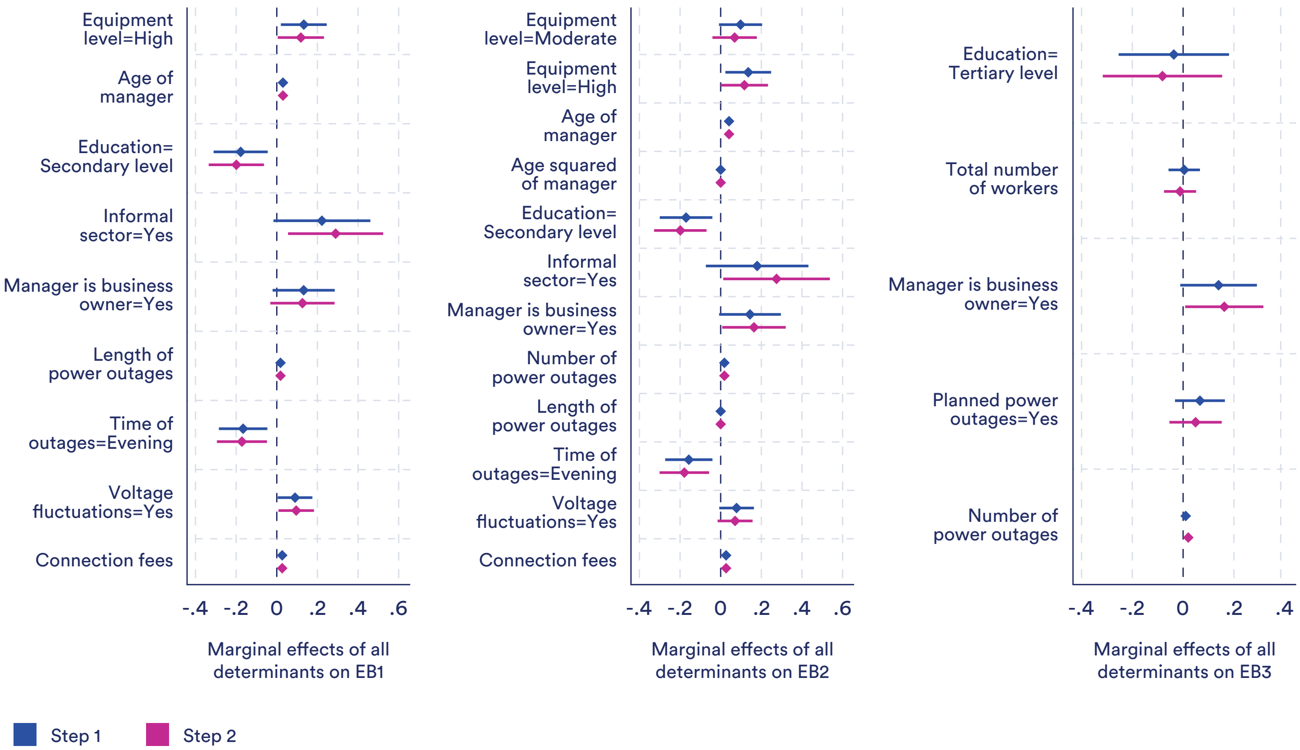


Figure 16: Robustness Check Using Alternative Electricity Burden Measures Based on Electricity Expenditure Ratios (Fractional Regression)

Figure 16-a: Without extra cost

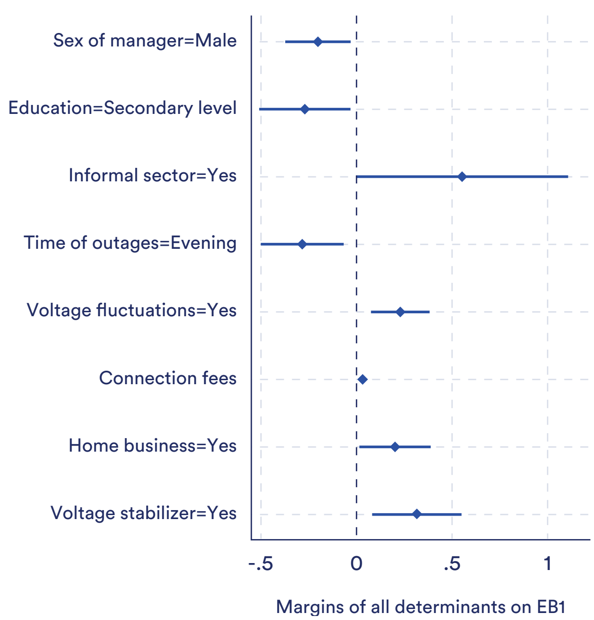
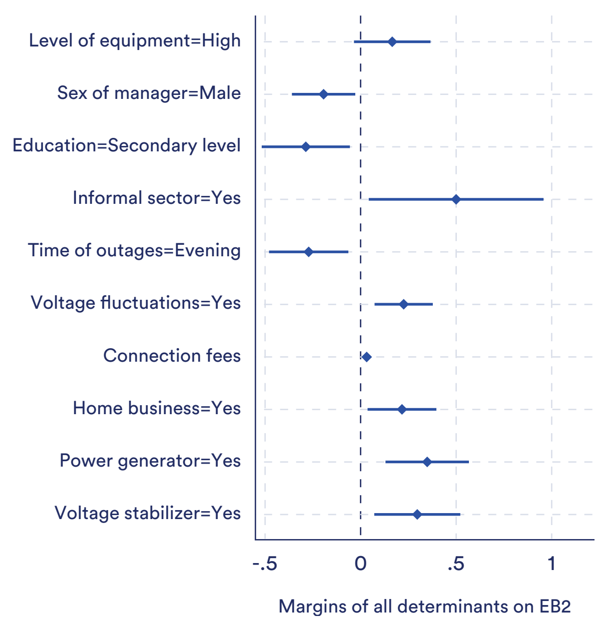


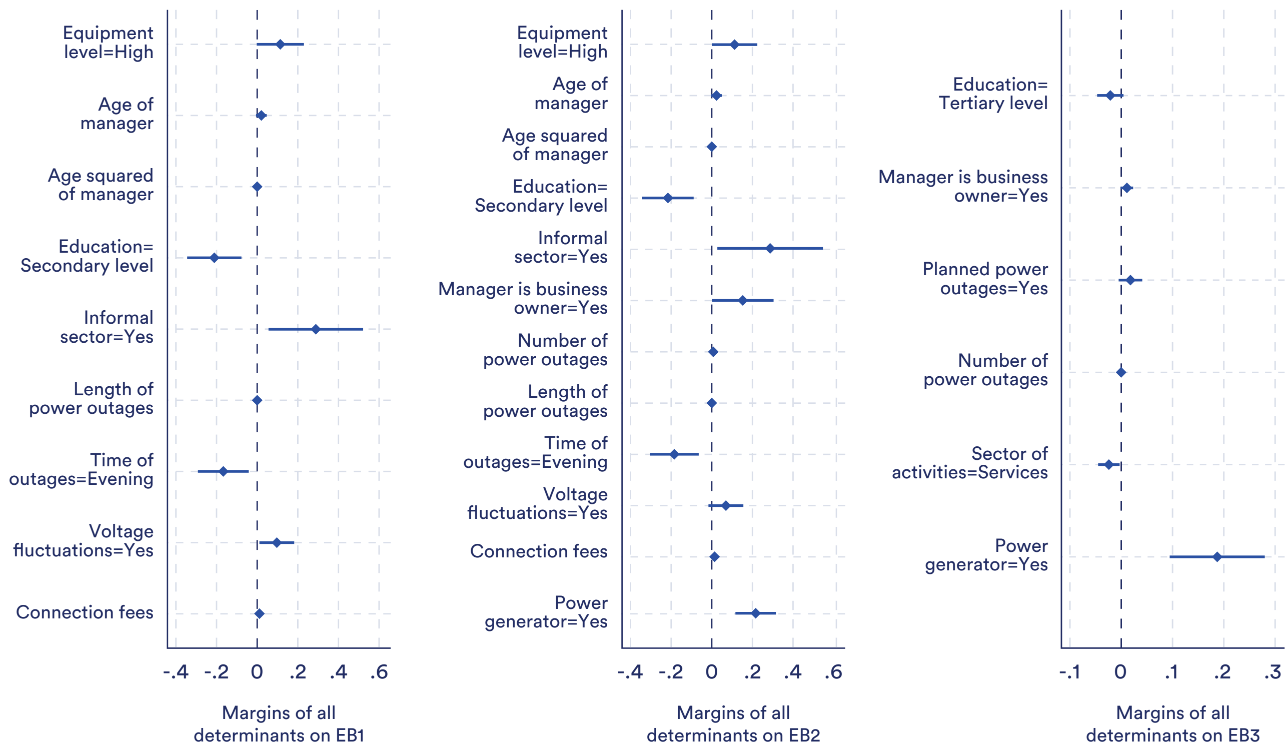
Figure 16-b: With extra cost



Secondly, taking into consideration heterogeneity among businesses, we classify businesses into five groups depending on their main activities, and use the latter as a control variable (see Figure 17 and Appendix C).

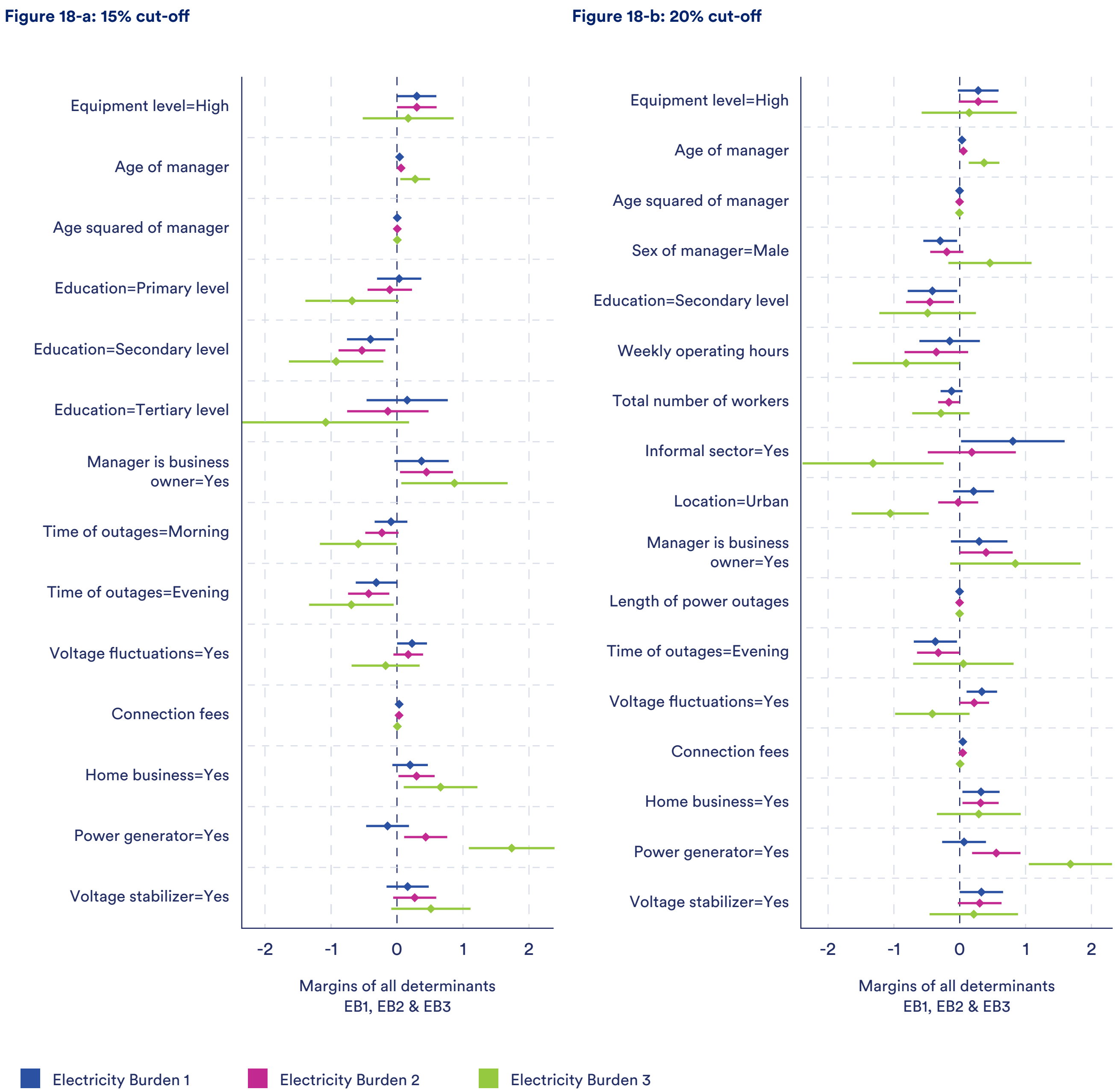
This approach also produces results that demonstrate the robustness of our initial identified determinants of the electricity burden for businesses.

Figure 17: Robustness Check Using 5 Classifications for the Sector of Activities of the Businesses



Thirdly, we use additional 15% and 20% cut-offs and our results reported in Figure 18 and Appendix D support the previous findings regarding the main drivers of the prevalence of the electricity burden for businesses.

Figure 18: Robustness Check Using 15% and 20% Cut-Offs of the Electricity Burden for Businesses



Moreover, from the businesses heterogeneity perspective, controlling for sectors of activities (production and services) may hide between-group disparities, where different characteristics are likely to drive the electricity burden prevalence for businesses. Therefore, we use group analyses which can be very informative, to address this as part of our robustness check strategy (see Figure 19 and Appendix E). Generally, we observe some heterogeneities. For instance, while, among others, businesses' value of equipment, the length of power outages and high connection fees have similar electricity burden implications for both groups of businesses, the age and the education of businesses' managers and the businesses' type (informal vs. formal) only influence the electricity burden status of businesses operating in the service sector. Also, high occurrence of power cuts (i.e., increasing number of power cuts) positively drives electricity burden only for businesses with production activities.

Figure 19: Robustness Check for Group Analysis (Heterogeneity Analysis) for Businesses

Figure 19-a: Production

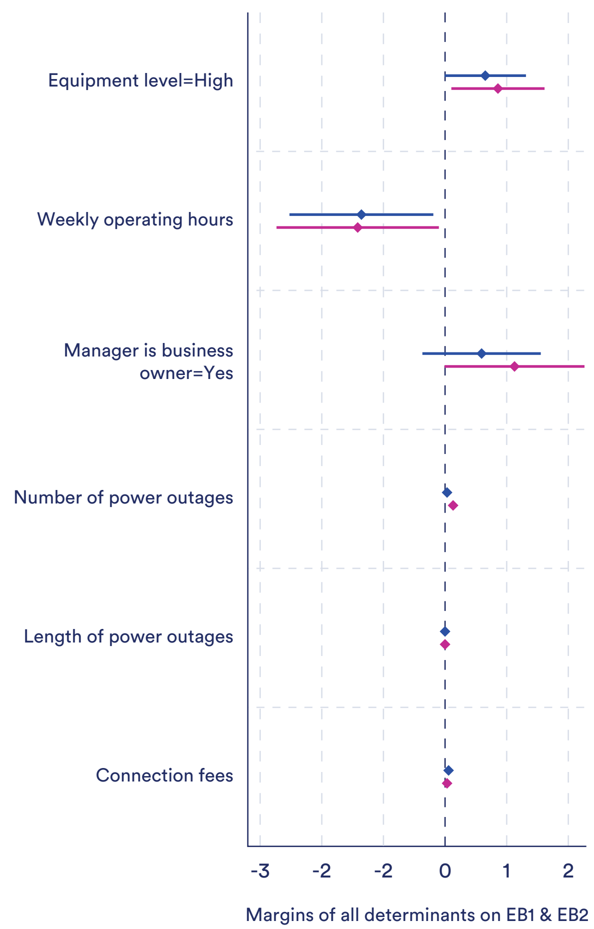
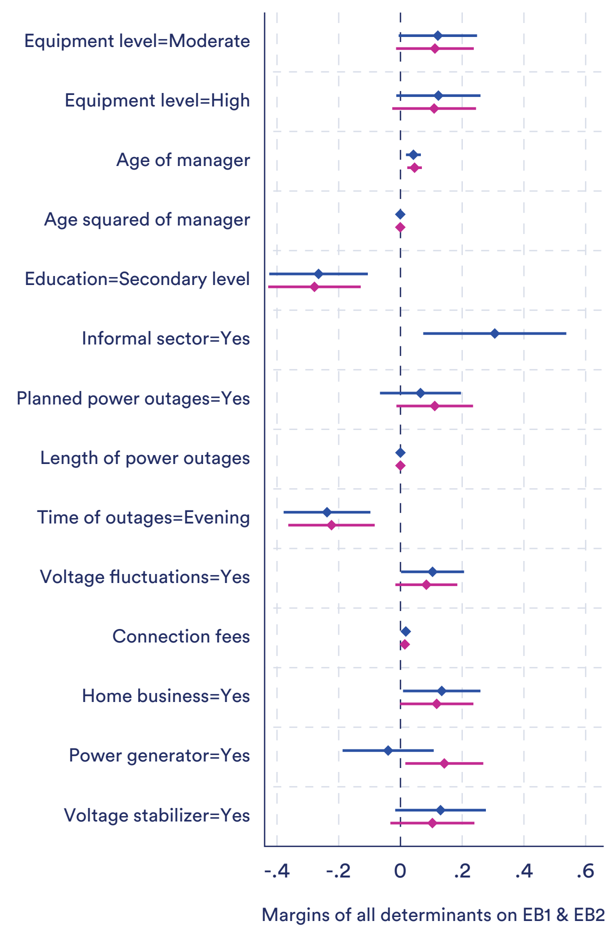


Figure 19-b: Services



Electricity Burden 1   Electricity Burden 2

Finally, while we assumed a 10% cut-off for the electricity burden for businesses, similar to the threshold commonly used for households, it is important to recognize that businesses can have different thresholds. Energy-intensive businesses may have high electricity consumption and already factor its cost into their business models. To address this issue, we use the quantile regression technique to investigate the heterogeneity among businesses. We analyze the determinants at the 10th, 25th, 50th, 75th, and 90th quantiles. It should be noted that our measure of the electricity burden in this context is the ratio of electricity expenses, with or without additional costs, to the total businesses' revenue. We present the results in Figure 20 and Figure 21, and Tables H and I of the appendix. Figure 20 and Table H contains estimates without the extra cost, while Figure 21 and Table I includes results with the extra cost. It can be observed from the Figure 20 and Figure 21 that, except for sex, which was not significant at the 10% cut-off in the baseline estimates for businesses, all other determinants in the baseline explained the electricity burden across different quantiles from the quantile regression. This further reinforce the fact that our estimates are consistent and robust.

Figure 20: Robustness Check Using Quantile Regression for Businesses (Without Extra Cost)

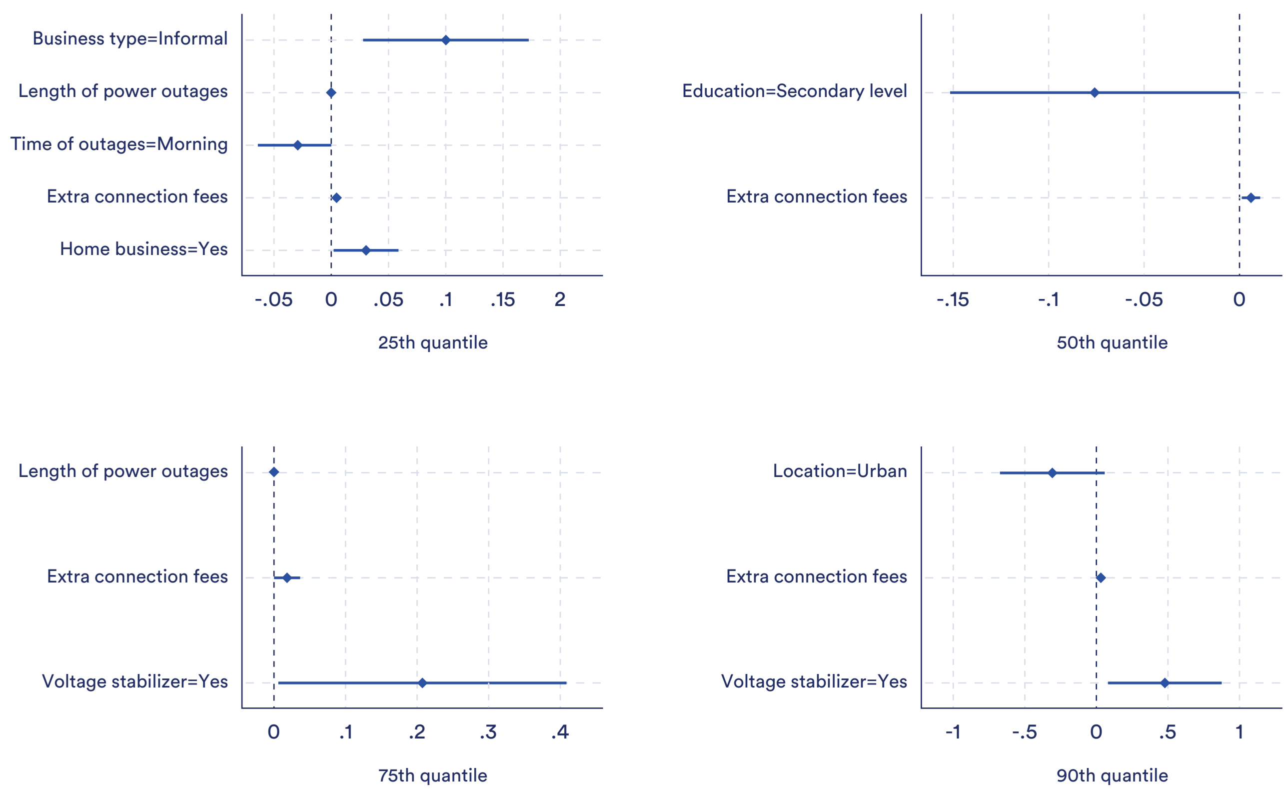


Figure 21: Robustness Check Using Quantile Regression for Businesses (With Extra Cost)

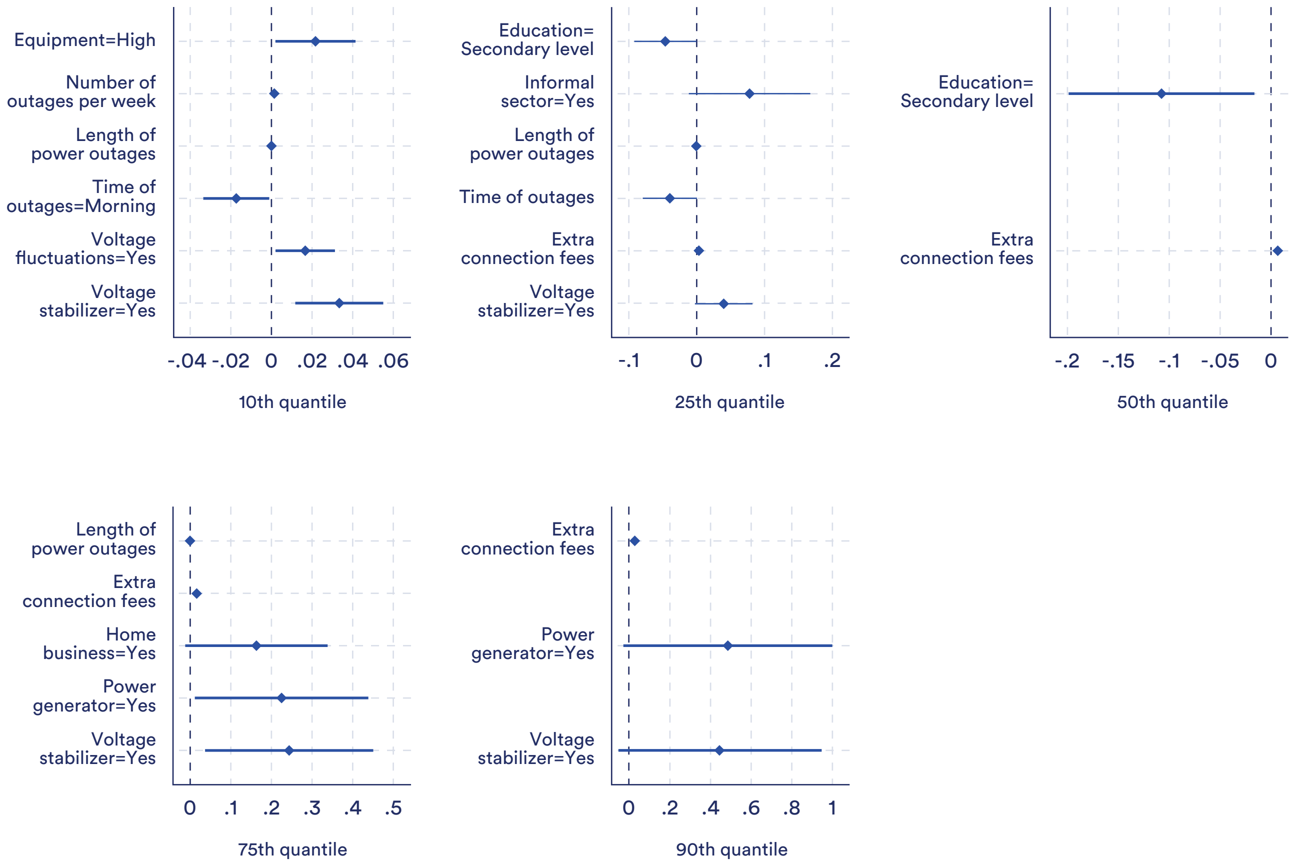


Image credit: Présidence de la République du Bénin

SECTION 4

Conclusion and Policy Recommendations

In addition to electricity access, businesses in African countries face other challenges such as affordability and reliability of power supply. Those businesses often resort to usually expensive defensive strategies such as power generators, alternative energy sources, and voltage stabilizers to cope with frequent blackouts and voltage fluctuations. The additional electricity costs that are often neglected can constitute a financial burden for some businesses when factored into the total electricity costs. We address this challenge in this study by assessing the economic and electricity burden implications of unreliable power supply for businesses in developing countries, using Benin as a case study. Our findings show that extra costs constitute a significant proportion of electricity expenses for businesses in Benin, with the largest contributor being the costs of running power generators. This high level of extra costs pushes a significant proportion of businesses to face an electricity burden, indicating that overlooking extra electricity costs of defensive strategies understates the actual extent of the financial burden of electricity expenditure for businesses, potentially leading to ineffective approaches in addressing the affordability of electricity in developing countries.

Furthermore, our results identify the typology of businesses that are more vulnerable to the electricity burden, particularly informal businesses, business owners, home businesses, businesses with production activities, etc. Our econometric analysis shows that the factors correlating with the electricity burden for businesses differ across the three electricity burden metrics.

As policy recommendations, first, policymakers should address extra costs induced by defensive strategies from businesses while identifying businesses facing an electricity burden, particularly in developing countries like Benin, where electricity interruptions and voltage fluctuations are more severe and frequent. Investment in alternative sources, especially diesel-powered generators, represent demand that could be captured onto the grid. Policies that address investment to keep these customers on the grid and prevent them from embracing averting strategies could lead to more demand and better market dynamics for the power utilities. Not considering these additional costs would prevent the Government from inclusively alleviating the electricity burden for businesses, which will lead to a formulation of public policies that may not be appropriate for the desired targets of businesses. Governments should invest in improving the electricity supply to boost economic activities. However, in case of a limited budget, as often in many developing countries, the Government can provide economic incentives that target businesses facing electricity burden. Part of this policy can also focus on incentivizing those businesses to invest in energy-efficient technologies to reduce their electricity consumption. Policies should extend the consideration of businesses to include households even though the approach may differ.

Second, for more effective policy implementation, policymakers need to streamline those electricity burden alleviation measures to reflect the characteristics of businesses likely to face an electricity burden. They need to balance the standard approach of single measures with a target-specific approach. Because some countries may have limited access to financial support, policymakers can decide to focus subsequently on the different profiles of businesses facing an electricity burden in a programmatic way. Given that the electricity burden affects those profiles differently, policymakers should carefully identify these business characteristics and rely on them to define more effective policy measures to reduce the electricity burden.

This paper has several limitations that need to be addressed in future research. For example, using a uniform economic threshold to evaluate the electricity burden for businesses may hide several disparities. While many studies on energy poverty use a 10% threshold for households, there is limited evidence of how valid it is for businesses. Businesses can have different thresholds, because some energy-intensive businesses have high electricity consumption and already consider its high cost in their business model. We address this issue by investigating the heterogeneity among businesses with different approaches. However, more research must be conducted to find the appropriate distribution of the thresholds across economic sectors and business types. The additional costs should not only cover electricity expenses for businesses that remain connected to the grid but should also extend to those who opt to leave the electricity grid due to power system failures, especially commercial and industrial captive power consumers. Additionally, a cost-benefit analysis is necessary to assess whether defensive electricity costs can justify an investment in existing networks to enhance electricity reliability, considering the significant benefits it would offer end-users. Moreover, updated survey data is required to understand how the findings have evolved since 2015. The observed structural change in Benin has led to an increase in electricity prices[9] despite a slight improvement in power reliability,[10] highlighting the need to consider additional costs. Overcoming these limitations will require a new set of data.

9 https://www.global-climatescope.org/markets/bj/

10 https://www.afrobarometer.org/publication/ad514-still-lacking-reliable-electricity-from-the-grid-many-africans-turn-to-other-sources/#:~:text=Overall%2C%20fewer%20than%20half%20of,mainly%20solar%20panels%20and%20generators

SECTION 5

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SECTION 6

Appendix

6.1 Data

A. The context in Benin

Benin, a country in West Africa, experienced a robust economic growth of 7.2% and 6.3% in 2021 and 2022, respectively, despite external shocks from neighboring countries such as Nigeria and Niger. The tertiary sector played a significant role in supporting this growth, representing 45% of the GDP in the third quarter of 2023, followed by the secondary and primary sectors (15.4% and 31.2%, respectively) (INStaD, 2024). However, the private sector in the country faces challenges such as limited access to finance, an unreliable and expensive energy supply, weak connectivity, a difficult business environment, and the low skill level of the workforce (IFC, 2023).

The informal sector in Benin mostly drives this economic performance as it contributes to 65% of the country's GDP and provides jobs to 85% of the labor force (IFC, 2023). Micro, small, and medium enterprises (MSMEs) dominate the private sector, accounting for 79% of the firms operating in Benin, while large firms with more than a hundred employees represent only 21%. The preponderance of the informal sector also contributes to lower labor productivity in the country, as the GDP per employed person was US$10,729 in 2023 compared to an average of US$12,018 in SSA.

The low contribution of the industrial sector also characterizes the Beninese economy, as it has contributed only 17.3% of GDP in 2023 (WDI, 2024). Benin had a very low industrial processing rate in the past, dominated by cashew nuts, pineapple, cotton, beer, and oil palm fruits (IFC, 2023). The government implemented the Special Economic Zone (SEZ) of Glo Djigbé (GIZ) to improve the industrialization rate in February 2021. According to IFC (2023), GIZ comprises six industrial units for cotton fiber processing, 29 for garment manufacturing, and 14 for cashew nuts processing. This effort is projected to increase exports by US$5 billion to US$10 billion, contributing to a boost in GDP by US$4 billion to US$7 billion and the creation of 300,000–350,000 jobs within ten years.

The government has been enacting multiple policies to support the growth of the private sector and enhance the country's economic performance. This is evidenced by the ambitious reform agenda outlined in the National Development Plan (2018–25), the first Government Action Program (PAG 2016–21), and the second PAG (2021–26), which aims to create 1.3 million jobs by 2026. Benin is focused on prioritizing the private sector to finance its new PAG, with the sector expected to contribute 52 percent of the planned investments, totaling an estimated CFAF 12,011 billion (US$20.5 billion). However, addressing the challenges in the energy sector is crucial to maintain this positive trajectory.

The energy sector in Benin is facing challenges in meeting the growing demand due to the country's development and a historical lack of electricity access. The annual electricity demand is expected to increase by 6.4%, while the demand capacity is estimated at 258MW, higher than the installed production capacity of 218MW in 2019 (IFC, 2023). To address the shortfall, Benin has had to import electricity, primarily from Nigeria and Ghana, which made up 75% of the energy mix in 2019, indicating its heavy reliance on other countries. Despite the government's efforts to improve the energy sector, the percentage of the population with power access increased to 56.5% in 2022 from 29.6% in 2015, surpassing the African average of 51.4% (WDI, 2024). However, there are disparities between rural and urban areas, with urban areas having almost three times more access to electricity than rural areas (56% compared to 19%).

Benin also grapples with issues related to the reliability and cost of electricity. Private sector firms in Benin cite access to electricity as their second biggest challenge (18.8%), experiencing an average of 28 power interruptions per month, resulting in losses amounting to 8% of their annual sales (World Bank Enterprise Surveys, 2023). According to Doing Business data, the cost of a grid connection in Benin is 11,000% of per capita income, compared to 3,000% in Africa. Furthermore, the retail electricity tariff in Benin stands at 0.25 dollars per kWh, exceeding the average tariffs in sub-Saharan Africa and globally (0.17 USD and 0.13 USD per kWh, respectively), despite being set below cost recovery levels. When it comes to cooking and food preservation, a significant number of households in Benin rely on biomass such as firewood and charcoal, used by 36.4% and 33.8% of households, respectively. Access to butane gas is very limited (6.9 kg/year/household), and the usage of improved stoves is also low (17.64%).

B. Survey design, process and data collection and validation:

The INSAE has conducted an extensive survey on electricity consumption in Benin that covers households and businesses as part of the MCC project. This appendix describes the survey design, process, and data collection and validation, specifically focusing on businesses. The survey is representative of Benin and covers all twelve regions of the country, including both rural and urban areas, formal and informal firms, and small, medium and large businesses. The survey's questionnaire encompassed economic profile of the business and other socioeconomic aspects of the business manager. Additionally, it gathered detailed information on their energy access, utilization, and supply. The lowest granular geographic representation is the city district or village, which drives the enumeration areas following their population density. Each of the twelve regions of Benin (Alibori, Atacora, Atlantique, Borgou, Collines, Couffo, Donga, Littoral, Mono, Ouémé, Plateau, and Zou) is stratified into urban and rural, leading to a total of 23 strata.

The sampling for the formal businesses is extracted from the database of Statistical and Fiscal Declarations (DSF) and supplemented by the database of company registrations. The selection follows three steps: (i) firms operating in agribusiness (i.e., processing of pineapple, shea nuts, cashew nuts, corn, cassava, etc.), (ii) largest firms consuming electricity regardless of their activities, (iii) Other firms regardless of their level of electricity consumption to ensure sectoral representativity. The representativity of informal businesses is based on the second Business Census (RGE2) conducted in 2008 in Benin. The survey interviewed the manager of the business or a representative (any person capable of responding on behalf of the manager of the business) across 1,320 businesses out of 1,840 sampled businesses with 11.1% (147) in the formal sector and 88.9% (1,177) in the informal sector, leading to a 71.74% % response rate.

The data collection took place between 16th February and 2nd March 2015, lasting 15 days, and was a computer-assisted personal interview (CAPI). The INSAE implemented appropriate controls to avoid any errors and ensure consistency in the data collection process. After the data collection, the validation process involves checking (i) the completeness of the businesses' responses across clusters and (ii) the completeness of the clusters. After ensuring completeness, they checked the entire sample for intra- and inter-record consistency. A technical team at INSAE clears the final database, which helps eliminate any potential remaining inconsistencies. The INStaD (2019) report provides more details.

C. Full Descriptive Statistics

Variables	Mean / Percentage	Standard Deviation	Min	Max
EB1	0.550	0.500	0	1
EB2	0.601	0.490	0	1
EB3	1.15	0.963	0	2
Economic Characteristics **Asset Tercile (Base: Poor)**				
Value of Equipment	1.99	0.819	1	3
Individual Characteristics				
Age	36.1	10.247	18	76
Education (Base: No Education)				
No Formal Education	0.131	0.337	0	1
Primary Education	0.358	0.479	0	1
Secondary Education	0.341	0.474	0	1
Tertiary Education	0.092	0.289	0	1
Male	0.683	0.465	0	1
Urban	0.857	0.349	0	1
Working Hours	12.479	3.599	1	24
Total Workers	5.062	37.228	0	930
Firm Type (Informal)	0.863	0.343	0	1
Manager is Owner (Yes)	0.896	0.305	0	1
Power Supply Characteristics				
Planned Blackout (=1)	0.253	0.435	0	1
Number of Outages Per Week	5.720	6.271	0	80
Average Length of Outages	43.191	231.545	1	5760
Morning Power Outages	0.404			
Evening Power Outages	0.194			
Voltage Fluctuations (=1)	0.559	0.497	0	1
Power Access Characteristics				
Connection Fee	46,469.62	92,644.18	0	600,000
End Usage Characteristics				
Home Business (=1)	0.209	0.407	0	1
Principal Activity (Services)	0.790	0.407	0	1
Defensive Characteristics				
Voltage Stabilizer (=1)	0.218	0.413	0	1
Power Generator (=1)	0.209	0.407	0	1

Note: Mean is for continuous variables and percentage is for binary variables.

6.2 Estimation Results

D. Coefficients on the Determinants of the Electricity Burden in Benin Using Probit and Mprobit Regression for Businesses

	1	2	3	4	5	6
Variables	**EB1**	**EB2**	**EB3**	**EB1**	**EB2**	**EB3**
Economic Characteristics **Value of Equipment (Base=Small)**						
Moderate	0.216 (0.138)	0.245* (0.139)	0.359 (0.295)	0.186 (0.142)	0.17 (0.143)	0.0953 (0.348)
High	0.341** (0.148)	0.349** (0.15)	0.318 (0.319)	0.307** (0.151)	0.300* (0.155)	0.0361 (0.368)
Individual Characteristics						
Age	0.060** (0.027)	0.071** (0.028)	0.141* (0.083)	0.061** (0.028)	0.070** (0.029)	0.120* (0.071)
Age – Squared	-0.001 (0.000)	-0.001* (0.000)	-0.001 (0.001)	-0.001* (0.000)	-0.001* (0.000)	-0.002 (0.001)
Sex – Male (Base: Female)	-0.165 (0.119)	-0.129 (0.119)	0.069 (0.285)	-0.185 (0.124)	-0.215* (0.124)	-0.413 (0.363)
Primary Education (Base: No Education)	-0.0397 (0.168)	-0.0936 (0.173)	-0.301 (0.37)	-0.0707 (0.172)	-0.134 (0.175)	-0.629 (0.408)
Secondary Education (Base: No Education)	-0.456*** (0.177)	-0.453** (0.181)	-0.314 (0.369)	-0.511*** (0.182)	-0.534*** (0.185)	-0.684 (0.427)
Tertiary Education (Base: No Education)	0.027 (0.305)	-0.103 (0.309)	-0.739 (0.776)	0.063 (0.327)	-0.23 (0.333)	-1.968** (0.865)
Working Hours	-0.189 (0.226)	-0.0892 (0.224)	0.591 (0.467)	-0.223 (0.244)	-0.253 (0.255)	-0.317 (0.445)
Log Total Workers	-0.057 (0.082)	0.009 (0.082)	0.241 (0.157)	-0.086 (0.087)	-0.035 (0.087)	0.223 (0.178)
Business Type – Informal (Base: Formal)	0.561* (0.324)	0.45 (0.323)	-0.215 (0.656)	0.753** (0.345)	0.695** (0.352)	-0.015 (0.818)
Location – Urban (Base: Rural)	-0.047 (0.149)	-0.040 (0.152)	-0.042 (0.325)	0.024 (0.152)	0.051 (0.155)	0.096 (0.363)
Manager is Business Owner (Yes)	0.328* (0.193)	0.360* (0.194)	0.409 (0.439)	0.318 (0.201)	0.414** (0.199)	0.966* (0.512)
Power Supply Characteristics						
Planned Blackouts (Yes)	0.070 (0.133)	0.175 (0.136)	0.574** (0.257)	0.037 (0.14)	0.133 (0.144)	0.646** (0.321)
Number of Outages Per Week	0.011 (0.001)	0.019* (0.011)	0.042** (0.019)	0.008 (0.010)	0.021* (0.011)	0.067*** (0.019)
Length of Power Outages	0.001** (0.000)	0.001* (0.000)	-0.001 (0.001)	0.001* (0.000)	0.001* (0.000)	0.000 (0.001)
Morning Power Outage – Morning (Base: Midday)	-0.085 (0.124)	-0.122 (0.126)	-0.234 (0.283)	-0.072 (0.129)	-0.128 (0.133)	-0.315 (0.327)
Evening Power Outages (Base: Midday)	-0.416*** (0.155)	-0.414*** (0.153)	-0.281 (0.345)	-0.433*** (0.161)	-0.470*** (0.16)	-0.529 (0.381)
Voltage Fluctuation (Yes)	0.229** (0.111)	0.202* (0.111)	0.015 (0.254)	0.240** (0.115)	0.184 (0.117)	-0.257 (0.292)
Power Connection Characteristics						
Log (Connection Fees)	0.051*** (0.011)	0.049*** (0.011)	0.024 (0.025)	0.054*** (0.011)	0.048*** (0.012)	0.003 (0.031)
End Usage Characteristics						
Home Business (Yes)				0.207 (0.142)	0.222 (0.145)	0.185 (0.298)
Principal Activities – Services (Base: Production)				0.0758 (0.141)	0.135 (0.141)	0.36 (0.324)
Defensive Characteristics						
Power Generator (Yes)				-0.045 (0.168)	0.643*** (0.18)	2.492*** (0.342)
Voltage Stabilizer (Yes)				0.274 (0.17)	0.177 (0.172)	-0.153 (0.446)
Intercept	-1.662* (0.872)	-1.970** (0.881)	-6.220*** (2.133)	-1.721* (0.938)	-1.709* (0.973)	-3.787* (2.156)
Observations	598	598	598	573	573	573
Pseudo R2 (Prob > chi2)	0.10 (0.00)	0.10 (0.00)	(0.00)	0.11 (0.00)	0.13 (0.00)	(0.00)

*Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. The corresponding marginal effects are reported in Table 9. Columns 1,2 and 4 and 5 are results of a probit model, while 3 and 6 are from mprobit regression models.*

E. Alternative Electricity Burden Measures Based on Electricity Expenditure Ratios (Fractional Regression)

Variables	EB1	EB2	EB1	EB2
Economic Characteristics **Value of Equipment (Base=Small)**				
Moderate	0.065 (0.098)	0.106 (0.096)	0.037 (0.101)	0.061 (0.097)
High	0.205* (0.105)	0.216** (0.102)	0.163 (0.106)	0.170* (0.102)
Individual Characteristics				
Age	0.010 (0.023)	0.013 (0.023)	0.010 (0.024)	0.014 (0.024)
Age – Squared	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Sex – Male (Base: Female)	-0.185** (0.085)	-0.152* (0.083)	-0.200** (0.087)	-0.191** (0.084)
Primary Education (Base: No Education)	0.044 (0.115)	0.036 (0.112)	0.051 (0.114)	0.032 (0.110)
Secondary Education (Base: No Education)	-0.220* (0.121)	-0.227* (0.118)	-0.268** (0.122)	-0.285** (0.118)
Tertiary Education (Base: No Education)	-0.043 (0.191)	-0.029 (0.186)	-0.152 (0.200)	-0.162 (0.191)
Working Hours	0.083 (0.150)	0.080 (0.149)	0.034 (0.157)	-0.006 (0.156)
Log Total Workers	-0.055 (0.055)	-0.014 (0.053)	-0.089 (0.056)	-0.060 (0.054)
Business Type – Informal (Base: Formal)	0.382 (0.261)	0.261 (0.234)	0.553* (0.284)	0.505** (0.233)
Location – Urban (Base: Rural)	-0.110 (0.110)	-0.127 (0.108)	-0.072 (0.114)	-0.076 (0.111)
Manager is Business Owner (Yes)	0.043 (0.153)	0.107 (0.149)	0.064 (0.155)	0.158 (0.149)
Power Supply Characteristics				
Planned Blackouts (Yes)	0.083 (0.091)	0.072 (0.090)	0.067 (0.095)	0.059 (0.094)
Number of Outages Per Week	0.012* (0.007)	0.010 (0.007)	0.012 (0.007)	0.011 (0.007)
Length of Power Outages	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Morning Power Outage – Morning (Base: Midday)	0.029 (0.086)	0.022 (0.085)	0.033 (0.088)	0.027 (0.086)
Evening Power Outages (Base: Midday)	-0.265** (0.107)	-0.231** (0.104)	-0.286*** (0.108)	-0.267** (0.105)
Voltage Fluctuation (Yes)	0.251*** (0.077)	0.267*** (0.076)	0.229*** (0.077)	0.228*** (0.077)
Power Connection Characteristics				
Log (Connection Fees)	0.033*** (0.008)	0.030*** (0.008)	0.032*** (0.008)	0.028*** (0.008)
End Usage Characteristics				
Home Business (Yes)			0.200** (0.094)	0.223** (0.092)
Principal Activities – Services (Base: Production)			-0.054 (0.098)	-0.031 (0.095)
Defensive Characteristics				
Power Generator (Yes)			0.140 (0.119)	0.353*** (0.112)
Voltage Stabilizer (Yes)			0.318*** (0.118)	0.300*** (0.114)
Intercept	-1.696** (0.674)	-1.642** (0.658)	-1.748** (0.739)	-1.712** (0.709)
Observations	598	598	573	573
Pseudo R2 (Prob > chi2)	0.101 (0.0)	0.045 (0.0)	0.045 (0.0)	0.064 (0.0)

F. Robustness Check Using 5 Classifications for the Sector of Activities of the Businesses

Variables	EB1	EB2	EB3
Economic Characteristics **Value of Equipment (Base=Small)**			
Moderate	0.209 (0.141)	0.193 (0.142)	0.131 (0.355)
High	0.308** (0.150)	0.299* (0.155)	0.001 (0.370)
Individual Characteristics			
Age	0.063** (0.028)	0.072** (0.030)	0.124 (0.076)
Age – Squared	-0.001* (0.000)	-0.001* (0.000)	-0.002 (0.001)
Sex – Male (Base: Female)	-0.167 (0.124)	-0.191 (0.123)	-0.369 (0.362)
Primary Education (Base: No Education)	-0.096 (0.172)	-0.162 (0.175)	-0.610 (0.403)
Secondary Education (Base: No Education)	-0.541*** (0.182)	-0.573*** (0.186)	-0.696 (0.435)
Tertiary Education (Base: No Education)	0.043 (0.324)	-0.253 (0.331)	-1.977** (0.867)
Working Hours	-0.229 (0.249)	-0.262 (0.258)	-0.215 (0.473)
Log Total Workers	-0.065 (0.086)	-0.013 (0.086)	0.256 (0.190)
Business Type – Informal (Base=Formal)	0.776** (0.351)	0.752** (0.358)	0.224 (0.826)
Location – Urban (Base: Rural)	0.015 (0.154)	0.052 (0.158)	0.153 (0.388)
Manager is Business Owner (Yes)	0.299 (0.202)	0.393* (0.201)	0.929* (0.509)
Power Supply Characteristics			
Planned Blackout (Yes)	0.029 (0.140)	0.132 (0.144)	0.687** (0.336)
Number of Outages Per Week	0.007 (0.010)	0.019* (0.011)	0.065*** (0.021)
Length of Power Outages	0.001** (0.000)	0.001** (0.000)	0.000 (0.001)
Morning Power Outage – (Base=Midday)	-0.065 (0.129)	-0.125 (0.132)	-0.331 (0.330)
Evening Power Outages (Base: Midday)	-0.431*** (0.161)	-0.475*** (0.161)	-0.550 (0.386)
Voltage Fluctuation (Yes)	0.252** (0.115)	0.198* (0.116)	-0.230 (0.293)
Power Connection Characteristics			
Log (Connection Fees)	0.052*** (0.011)	0.046*** (0.012)	-0.002 (0.032)
End Usage Characteristics			
Home Business (Yes)	0.225 (0.142)	0.237 (0.145)	0.203 (0.303)
Principal Activities – Services (Base=Clothing Confession)	0.139 (0.313)	-0.007 (0.307)	-9.794*** (0.482)
Principal Activities – Other Services (Ref=Clothing Confession)	-0.002 (0.162)	-0.095 (0.166)	-0.583 (0.476)
Principal Activities – Production Activities (Ref=Clothing Confession)	0.066 (0.156)	0.085 (0.156)	0.116 (0.352)
Principal Activities – Purchasing and Sales (Ref=Clothing Confession)	-0.110 (0.167)	-0.152 (0.168)	-0.346 (0.491)
Defensive Characteristics			
Power Generator (Yes)	-0.031 (0.167)	0.653*** (0.180)	2.519*** (0.343)
Voltage Stabilizer (Yes)	0.254 (0.169)	0.155 (0.171)	-0.186 (0.448)
Intercept	-1.832** (0.932)	-1.879* (0.963)	-4.545** [2166]
Observations	580	580	580
Pseudo R2 (Prob > chi2)	0.11 (0.00)	0.13 (0.00)	(0.00)

*Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Columns 1 and 2 are results of a probit model, while 3 reports results of a mprobit regression model.*

G. Robustness Check Using 15% and 20% Cut-Offs of the Electricity Burden for Businesses

	15% Cut-Off			20% Cut-Off		
Variables	**EB1**	**EB2**	**EB3**	**EB1**	**EB2**	**EB3**
Economic Characteristics Value of Equipment (Base=Small)						
Moderate	0.133 (0.142)	0.142 (0.141)	0.180 (0.328)	0.139 (0.147)	0.121 (0.143)	0.029 (0.336)
High	0.302** (0.150)	0.308** (0.151)	0.178 (0.350)	0.283* (0.155)	0.282* (0.151)	0.142 (0.367)
Individual Characteristics						
Age	0.043* (0.026)	0.066** (0.028)	0.270** (0.113)	0.039 (0.031)	0.066* (0.035)	0.365*** (0.121)
Age – Squared	-0.001 (0.000)	-0.001** (0.000)	-0.004** (0.001)	-0.000 (0.000)	-0.001* (0.000)	-0.005*** (0.002)
Sex – Male (Base: Female)	-0.145 (0.124)	-0.093 (0.122)	0.241 (0.300)	-0.300** (0.128)	-0.198 (0.126)	0.456 (0.320)
Primary Education (Base: No Education)	0.041 (0.171)	-0.102 (0.171)	-0.677* (0.360)	-0.118 (0.178)	-0.085 (0.173)	0.128 (0.372)
Secondary Education (Base: No Education)	-0.402** (0.181)	-0.522*** (0.181)	-0.926** (0.363)	-0.413** (0.188)	-0.446** (0.183)	-0.484 (0.371)
Tertiary Education (Base: No Education)	0.150 (0.313)	-0.142 (0.316)	-1.087* (0.646)	0.019 (0.315)	0.023 (0.314)	0.090 (0.590)
Working Hours	-0.184 (0.224)	-0.297 (0.238)	-0.545 (0.380)	-0.149 (0.231)	-0.352 (0.246)	-0.815** (0.409)
Log Total Workers	-0.091 (0.086)	-0.063 (0.085)	0.080 (0.194)	-0.125 (0.082)	-0.164** (0.083)	-0.286 (0.219)
Business Type – Informal (Base: Formal)	0.279 (0.339)	0.207 (0.329)	-0.117 (0.720)	0.832** (0.399)	0.209 (0.338)	-1.292** (0.545)
Location – Urban (Base: Rural)	0.028 (0.149)	-0.046 (0.151)	-0.402 (0.314)	0.207 (0.155)	-0.022 (0.152)	-1.050*** (0.297)
Manager is Business Owner (Yes)	0.382* (0.210)	0.455** (0.205)	0.873** (0.414)	0.292 (0.215)	0.400* (0.205)	0.839* (0.501)
Power Supply Characteristics						
Planned Blackout (Yes)	0.071 (0.136)	0.127 (0.138)	0.403 (0.275)	-0.019 (0.140)	-0.073 (0.140)	-0.222 (0.325)
Number of Outages Per Week	0.005 (0.009)	0.008 (0.010)	0.020 (0.018)	0.002 (0.010)	0.006 (0.010)	0.015 (0.019)
Length of Power Outages	0.001** (0.000)	0.001** (0.000)	0.001 (0.001)	0.001** (0.000)	0.001*** (0.000)	0.001 (0.001)
Morning Power Outage – (Base: Midday)	-0.087 (0.125)	-0.223* (0.128)	-0.589** (0.298)	0.044 (0.128)	0.038 (0.126)	0.145 (0.290)
Evening Power Outages (Base: Midday)	-0.314** (0.159)	-0.428*** (0.160)	-0.689** (0.326)	-0.365** (0.166)	-0.319* (0.165)	0.056 (0.385)
Voltage Fluctuation (Yes)	0.231** (0.113)	0.174 (0.114)	-0.170 (0.264)	0.329*** (0.116)	0.219* (0.115)	-0.414 (0.285)
Power Connection Characteristics						
Log (Connection Fees)	0.044*** (0.011)	0.040*** (0.011)	0.014 (0.025)	0.046*** (0.011)	0.044*** (0.011)	0.029 (0.024)
End Usage Characteristics						
Home Business (Yes)	0.200 (0.137)	0.303** (0.139)	0.668** (0.283)	0.321** (0.139)	0.316** (0.139)	0.288 (0.323)
Principal Activities – Services (Base: Production)	-0.141 (0.137)	-0.182 (0.138)	-0.259 (0.294)	-0.006 (0.143)	-0.003 (0.141)	-0.017 (0.337)
Defensive Characteristics						
Power Generator (Yes)	-0.139 (0.165)	0.431** (0.167)	1.745*** (0.332)	0.068 (0.168)	0.502*** (0.162)	1.683*** (0.323)
Voltage Stabilizer (Yes)	0.168 (0.163)	0.278* (0.165)	0.523* (0.308)	0.313* (0.166)	0.306* (0.166)	0.204 (0.342)
Intercept	-1,179 (0.887)	-0.984 (0.926)	-5.250** [-2543]	-2.247** [1.005]	-1,348 [1.042]	-5.311** [2.400]
Observations	573	573	573	573	573	573
Pseudo R2 (Prob > chi2)	0.08 (0.0)	0.10 (0.0)	(0.00)	0.10 (0.0)	0.11 (0.0)	(0.00)

*Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Columns 1 and 2 are results of a probit model, while 3 reports results of a mprobit regression model.*

H. Group Analysis (Heterogeneity Analysis) for Businesses

Variables	Production Sector		Service Sector	
	EB1	EB2	EB1	EB2
Economic Characteristics **Value of Equipment (Base=Small)**				
Moderate	-0.123 (0.318)	-0.061 (0.329)	0.305* (0.164)	0.279* (0.165)
High	0.660* (0.374)	0.884** (0.390)	0.318* (0.175)	0.280 (0.178)
Individual Characteristics				
Age	-0.065 (0.079)	-0.075 (0.078)	0.107*** (0.031)	0.119*** (0.032)
Age – Squared	0.001 (0.001)	0.001 (0.001)	-0.001*** (0.0004)	-0.001*** (0.000)
Sex – Male (Base: Female)	-0.403 (0.288)	-0.409 (0.303)	-0.125 (0.146)	-0.151 (0.145)
Primary Education (Base: No Education)	-0.122 (0.362)	-0.225 (0.341)	-0.140 (0.210)	-0.236 (0.214)
Secondary Education (Base: No Education)	-0.284 (0.39)	-0.230 (0.370)	-0.673*** (0.222)	-0.752*** (0.227)
Tertiary Education (Base: No Education)	0.519 (0.817)	0.000 (empty)	-0.152 (0.399)	-0.576 (0.395)
Working Hours	-1.347** (0.679)	-1.413** (0.675)	0.0418 (0.259)	-0.017 (0.275)
Log Total Workers	0.241 (0.230)	0.272 (0.253)	-0.125 (0.101)	-0.065 (0.098)
Business Type – Informal (Base: Formal)	0.000 (omitted)	0.000 (omitted)	0.816** (0.359)	0.675* (0.358)
Location – Urban (Base: Rural)	-0.398 (0.392)	-0.136 (0.436)	0.188 (0.174)	0.175 (0.177)
Manager is Business Owner (Yes)	0.601 (0.523)	1.136* (0.585)	0.286 (0.230)	0.331 (0.227)
Power Supply Characteristics				
Planned Blackouts (Yes)	-0.225 (0.279)	-0.284 (0.292)	0.175 (0.174)	0.302* (0.183)
Number of Outages Per Week	0.046 (0.032)	0.104*** (0.036)	0.002 (0.012)	0.014 (0.012)
Length of Power Outages	0.002 (0.002)	0.002** (0.001)	0.001** (0.000)	0.001** (0.000)
Morning Power Outage (Base: Midday)	0.225 (0.290)	-0.101 (0.312)	-0.049 (0.147)	-0.047 (0.150)
Evening Power Outage (Base: Midday)	0.545 (0.390)	0.285 (0.422)	-0.606*** (0.187)	-0.581*** (0.183)
Voltage Fluctuation (Yes)	0.219 (0.273)	0.033 (0.305)	0.271** (0.132)	0.207 (0.134)
Power Connection Characteristics				
Log (Connection Fees)	0.051* (0.027)	0.032 (0.029)	0.055*** (0.013)	0.052*** (0.013)
End Usage Characteristics				
Home Business (Yes)	-0.246 (0.308)	-0.237 (0.305)	0.349** (0.172)	0.357** (0.175)
Defensive Characteristics				
Power Generator (Yes)	-0.034 (0.424)	0.000 (empty)	-0.087 (0.190)	0.448** (0.199)
Voltage Stabilizer (Yes)	-0.453 (0.401)	-0.638 (0.497)	0.348* (0.201)	0.283 (0.203)
Intercept	4.361** (2.161)	4.186** (2.075)	-3.515*** (1.010)	-3.358*** (1.051)
Observations	140	121	433	433
Pseudo R2 (Prob > chi2)	0.19 (0.03)	0.21 (0.01)	0.14 (0.00)	0.15 (0.00)

*Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

I. Marginal Effects for All the Categories of EB3 Using the Mprobit Regression for Businesses

Variables	EB3	EB3	EB3	EB3
Economic Characteristics **Value of Equipment (Base=Small)**				
Moderate	-0.097* (0.054)	0.085 (0.055)	-0.068 (0.056)	0.069 (0.056)
High	-0.137** (0.057)	0.135** (0.057)	-0.114* (0.059)	0.122** (0.059)
Individual Characteristics				
Age	-0.028*** (0.011)	0.022** (0.011)	-0.027** (0.011)	0.024** (0.011)
Age – Squared	0.0003** (0.0001)	-0.0002 (0.0002)	0.0003* (0.0002)	0.0003* (0.0002)
Sex – Male (Base: Female)	0.051 (0.045)	-0.063 (0.046)	0.082* (0.046)	-0.072 (0.047)
Primary Education (Base: No Education)	0.032 (0.061)	-0.016 (0.062)	0.051 (0.060)	-0.026 (0.062)
Secondary Education (Base: No Education)	0.173*** (0.066)	-0.178*** (0.066)	0.211*** (0.066)	-0.196*** (0.067)
Tertiary Education (Base: No Education)	0.034 (0.111)	0.001 (0.112)	0.066 (0.119)	-0.026 (0.12)
Working Hours	0.03 (0.086)	-0.077 (0.088)	0.095 (0.097)	-0.09 (0.096)
Log Total Workers	0.001 (0.032)	-0.018 (0.032)	0.019 (0.033)	-0.029 (0.034)
Business Type – Informal (Base: Formal)	-0.169 (0.128)	0.227* (0.121)	-0.269** (0.131)	0.299** (0.123)
Location – Urban (Base: Rural)	0.018 (0.057)	-0.018 (0.058)	-0.019 (0.059)	0.016 (0.059)
Manager is Business Owner (Yes)	-0.142* (0.077)	0.134* (0.076)	-0.156** (0.079)	0.14* (0.079)
Power Supply Characteristics				
Planned Blackouts (Yes)	-0.065 (0.05)	0.028 (0.051)	-0.048 (0.053)	0.021 (0.054)
Number of Outages Per Week	-0.007* (0.004)	0.005 (0.004)	-0.007* (0.004)	0.005 (0.004)
Length of Power Outages	0.0002 (0.0001)	0.0003** (0.0001)	0.0002* (0.0001)	0.0002* (0.0001)
Morning Power Outage (Base: Midday)	0.045 (0.046)	-0.035 (0.047)	0.045 (0.049)	-0.036 (0.049)
Evening Power Outage (Base: Midday)	0.16*** (0.059)	-0.164*** (0.06)	0.183*** (0.062)	-0.176* (0.063)
Voltage Fluctuation (Yes)	-0.079* (0.042)	0.09** (0.043)	-0.074* (0.045)	0.091** (0.045)
Power Connection Characteristics				
Log (Connection Fees)	-0.019*** (0.004)	0.02*** (0.004)	-0.019*** (0.004)	0.021*** (0.004)
End Usage Characteristics				
Home Business (Yes)			-0.082 (0.053)	0.082 (0.053)
Principal Activities – Services (Base: Production)			0.049 (0.053)	-0.038 (0.054)
Defensive Characteristics				
Power Generator (Yes)			-0.222*** (0.052)	-0.029 (0.067)
Voltage Stabilizer (Yes)			-0.079 (0.061)	0.09 (0.062)
Observations	598	598	573	573

*Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. These mprobit regressions complement results reported in Table 9 where we only reported the category of interest (EB3).*

J. Comparison of Coefficient Estimates for Businesses Based on Appendix A

Variables	Col 1 vs Col 4	Col 2 vs Col 5	Col 3 vs Col 6
Moderate Value of Equipment	Decreased	Decreased	#
Age	---	---	Decreased
Primary Education	#	#	#
Secondary Education	Decreased	Decreased	#
Business Type – Informal (Base=Formal)	Increased	Increased	#
Length of Power Outages	---	---	#
Evening Power Outage (Base: Midday)	Decreased	Decreased	#
Voltage Fluctuation (Yes)	---	#	#
Log (Connection Fees)	Increased	---	#
End Use	Yes	Yes	Yes
Defensive Strategies	Yes	Yes	Yes

Note: "---" stands for No change; "#" = variables not significant

K. Coefficients on the Determinants of the Electricity Burden (Without Extra Cost) in Benin Using Quantile Regression for Businesses

Variables	q10	q25	q50	q75	q90	q10	q25	q50	q75	q90
Economic Characteristics Value of Equipment (Base=Small)										
Moderate	-0.002 (0.007)	0.006 (0.015)	0.013 (0.027)	0.048 (0.067)	0.065 (0.133)	-0.003 (0.007)	0.003 (0.015)	0.013 (0.022)	0.024 (0.061)	-0.024 (0.116)
High	0.001 (0.009)	0.012 (0.017)	0.041 (0.026)	0.133** (0.066)	0.312** (0.158)	0.001 (0.009)	0.008 (0.016)	0.035 (0.030)	0.130* (0.069)	0.122 (0.147)
Individual Characteristics										
Age	0.001 (0.001)	0.004** (0.002)	0.005 (0.004)	0.009 (0.020)	-0.011 (0.030)	0.001 (0.001)	0.004 (0.002)	0.005 (0.004)	0.009 (0.020)	0.012 (0.028)
Age – Squared	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Sex – Male (Base: Female)	0.004 (0.007)	-0.014 (0.013)	-0.024 (0.023)	-0.075 (0.063)	-0.193 (0.124)	0.0000 (0.009)	-0.02 (0.014)	-0.033 (0.030)	-0.115* (0.067)	-0.145 (0.116)
Primary Education (Base: No Education)	-0.004 (0.012)	-0.011 (0.018)	-0.039 (0.040)	-0.010 (0.080)	0.202 (0.162)	-0.008 (0.011)	-0.009 (0.020)	-0.03 (0.039)	-0.024 (0.074)	0.198* (0.119)
Secondary Education (Base: No Education)	-0.009 (0.013)	-0.024 (0.020)	-0.080** (0.039)	-0.147 (0.090)	-0.031 (0.176)	-0.016 (0.012)	-0.029 (0.021)	-0.076* (0.042)	-0.136* (0.074)	-0.048 (0.122)
Tertiary Education (Base: No Education)	-0.011 (0.027)	-0.001 (0.034)	-0.057 (0.075)	-0.041 (0.157)	-0.006 (0.201)	-0.015 (0.029)	0.012 (0.035)	-0.038 (0.073)	-0.047 (0.129)	-0.115 (0.196)
Working Hours	0.001 (0.012)	0.009 (0.025)	-0.006 (0.042)	0.021 (0.088)	-0.031 (0.178)	0.004 (0.018)	-0.019 (0.027)	-0.018 (0.043)	-0.016 (0.103)	0.123 (0.166)
Log Total Workers	0.002 (0.006)	0.006 (0.010)	-0.006 (0.015)	-0.038 (0.039)	-0.034 (0.071)	0.005 (0.005)	0.007 (0.011)	-0.015 (0.018)	-0.031 (0.041)	-0.110* (0.063)
Business Type – Informal (Base: Formal)	0.021 (0.020)	0.072*** (0.027)	0.095* (0.057)	0.171 (0.151)	0.219 (0.321)	0.035 (0.024)	0.100*** (0.033)	0.082** (0.037)	0.306** (0.133)	0.150 (0.270)
Location – Urban (Base: Rural)	0.008 (0.009)	0.010 (0.013)	-0.003 (0.025)	-0.027 (0.115)	-0.304 (0.315)	0.012 (0.011)	0.015 (0.014)	0.022 (0.025)	0.000 (0.100)	-0.305 (0.255)
Manager is Business Owner (Yes)	-0.003 (0.012)	0.001 (0.017)	0.013 (0.023)	0.040 (0.091)	-0.012 (0.214)	0.001 (0.012)	0.011 (0.017)	0.025 (0.028)	0.102 (0.111)	0.09 (0.187)

Variables	q10	q25	q50	q75	q90	q10	q25	q50	q75	q90
Power Supply Characteristics										
Planned Blackouts (Yes)	-0.001 (0.007)	0.006 (0.015)	0.032 (0.024)	0.076 (0.063)	0.043 (0.152)	-0.002 (0.010)	0.010 (0.016)	0.045* (0.027)	0.048 (0.070)	0.097 (0.154)
Number of Outages Per Week	0.001 (0.001)	0.002 (0.001)	0.001 (0.002)	0.004 (0.009)	0.018 (0.016)	0.001 (0.001)	0.001 (0.001)	0.001 (0.003)	0.010 (0.008)	0.018 (0.015)
Length of Power Outages	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Morning Power Outage (Base: Midday)	-0.009 (0.008)	-0.015 (0.013)	0.005 (0.022)	0.070 (0.054)	0.116 (0.147)	-0.010 (0.009)	-0.008 (0.013)	0.001 (0.024)	0.078 (0.053)	0.228** (0.114)
Evening Power Outages (Base: Midday)	-0.010 (0.009)	-0.029* (0.015)	-0.062** (0.025)	-0.088 (0.057)	-0.053 (0.110)	-0.012 (0.010)	-0.032** (0.016)	-0.047* (0.027)	-0.060 (0.053)	-0.044 (0.110)
Voltage Fluctuation (Yes)	0.000 (0.006)	0.012 (0.012)	0.020 (0.019)	0.087 (0.057)	0.291** (0.142)	0.000 (0.007)	0.012 (0.012)	0.022 (0.020)	0.077* (0.044)	0.210* (0.120)
Power Connection Characteristics										
Log (Connection Fees)	0.001 (0.001)	0.005*** (0.001)	0.007*** (0.002)	0.018** (0.008)	0.035** (0.014)	0.001 (0.001)	0.005*** (0.001)	0.006*** (0.002)	0.014** (0.006)	0.033*** (0.011)
End Usage Characteristics										
Home Business (Yes)						0.007 (0.012)	0.031* (0.016)	0.041 (0.025)	0.102 (0.086)	0.260** (0.106)
Principal Activities – Services (Base: Production)						-0.001 (0.010)	0.002 (0.017)	0.004 (0.030)	-0.031 (0.092)	0.035 (0.151)
Defensive Characteristics										
Power Generator (Yes)						0.000 (0.011)	-0.005 (0.015)	-0.008 (0.029)	0.057 (0.096)	0.119 (0.146)
Voltage Stabilizer (Yes)						0.008 (0.012)	0.020 (0.021)	0.043 (0.045)	0.206* (0.116)	0.479** (0.234)
Intercept	-0.042 (0.047)	-0.141* (0.080)	-0.067 (0.147)	-0.206 (0.500)	0.671 (0.865)	-0.066 (0.063)	-0.112 (0.086)	-0.046 (0.137)	-0.311 (0.538)	-0.211 (0.783)
Observations	598	598	598	598	598	573	573	573	573	573

*Note: *** p<0.01, ** p<0.05, * p<0.1.*

L. Coefficients on the Determinants of the Electricity Burden (With Extra Cost) in Benin Using Quantile Regression for Businesses

Variables	q10	q25	q50	q75	q90	q10	q25	q50	q75	q90
Economic Characteristics Value of Equipment (Base=Small)										
Moderate	0.005 (0.008)	0.010 (0.017)	0.015 (0.023)	0.044 (0.070)	0.031 (0.130)	0.007 (0.009)	0.010 (0.016)	0.007 (0.026)	0.038 (0.065)	-0.008 (0.115)
High	0.019* (0.010)	0.020 (0.019)	0.039 (0.028)	0.144 (0.096)	0.287 (0.218)	0.021** (0.011)	0.011 (0.017)	0.018 (0.033)	0.154* (0.086)	0.219 (0.153)
Individual Characteristics										
Age	0.001 (0.001)	0.005** (0.002)	0.007* (0.004)	0.010 (0.020)	-0.001 (0.032)	0.001 (0.001)	0.004* (0.003)	0.008* (0.004)	0.013 (0.018)	0.009 (0.030)
Age – Squared	0.000 (0.000)	-0.000* (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Sex – Male (Base: Female)	-0.004 (0.007)	-0.015 (0.013)	-0.015 (0.026)	-0.056 (0.066)	-0.104 (0.125)	-0.011 (0.010)	-0.024** (0.011)	-0.032 (0.028)	-0.104* (0.059)	-0.093 (0.125)
Primary Education (Base: No Education)	-0.002 (0.011)	-0.029 (0.021)	-0.028 (0.041)	0.003 (0.092)	0.204 (0.178)	-0.003 (0.013)	-0.025 (0.018)	-0.052 (0.039)	-0.017 (0.088)	0.232 (0.144)
Secondary Education (Base: No Education)	-0.002 (0.013)	-0.038* (0.021)	-0.078* (0.040)	-0.159 (0.100)	-0.012 (0.206)	-0.013 (0.015)	-0.046** (0.023)	-0.107*** (0.040)	-0.146* (0.084)	0.001 (0.155)
Tertiary Education (Base: No Education)	-0.005 (0.031)	-0.009 (0.043)	-0.043 (0.094)	-0.042 (0.171)	-0.169 (0.246)	-0.014 (0.040)	-0.028 (0.047)	-0.042 (0.081)	-0.129 (0.144)	-0.218 (0.189)
Working Hours	0.012 (0.014)	-0.013 (0.027)	0.001 (0.041)	0.007 (0.118)	0.099 (0.224)	0.001 (0.022)	-0.047* (0.027)	0.009 (0.054)	-0.091 (0.118)	0.116 (0.204)
Log Total Workers	0.007 (0.007)	0.011 (0.008)	0.008 (0.017)	-0.008 (0.041)	-0.036 (0.082)	0.006 (0.007)	-0.001 (0.013)	-0.011 (0.019)	-0.004 (0.037)	-0.039 (0.069)
Business Type – Informal (Base: Formal)	0.028 (0.030)	0.059 (0.048)	0.077 (0.072)	0.170 (0.145)	0.185 (0.285)	0.033 (0.032)	0.079 (0.052)	0.100* (0.058)	0.234* (0.133)	0.274 (0.272)
Location – Urban (Base: Rural)	0.012 (0.010)	0.014 (0.016)	-0.005 (0.033)	-0.072 (0.120)	-0.389 (0.291)	0.012 (0.010)	0.025* (0.015)	0.014 (0.030)	-0.070 (0.119)	-0.351 (0.280)
Manager is Business Owner (Yes)	0.000 (0.009)	0.011 (0.014)	0.051** (0.025)	0.096 (0.123)	0.079 (0.312)	-0.001 (0.013)	0.019 (0.021)	0.043 (0.032)	0.111 (0.113)	0.173 (0.201)

Variables	q10	q25	q50	q75	q90	q10	q25	q50	q75	q90
Power Supply Characteristics										
Planned Blackouts (Yes)	0.001 (0.008)	0.010 (0.019)	0.035 (0.027)	0.041 (0.075)	0.053 (0.179)	-0.003 (0.013)	0.017 (0.020)	0.032 (0.027)	0.002 (0.091)	0.112 (0.188)
Number of Outages Per Week	0.001 (0.000)	0.002 (0.001)	0.003 (0.003)	0.000 (0.009)	0.016 (0.015)	0.002** (0.001)	0.002* (0.001)	0.001 (0.002)	0.010 (0.007)	0.019 (0.014)
Length of Power Outages	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Morning Power Outage – Morning (Base: Midday)	-0.015 (0.010)	-0.02 (0.014)	0.005 (0.023)	0.069 (0.064)	0.175 (0.159)	-0.017** (0.008)	-0.016 (0.016)	0.007 (0.026)	0.075 (0.059)	0.156 (0.135)
Evening Power Outages (Base: Midday)	-0.005 (0.011)	-0.033** (0.015)	-0.071** (0.028)	-0.09 (0.066)	-0.071 (0.139)	-0.013 (0.012)	-0.039** (0.016)	-0.053** (0.025)	-0.031 (0.063)	-0.087 (0.128)
Voltage Fluctuation (Yes)	0.007 (0.008)	0.023** (0.011)	0.036 (0.022)	0.155** (0.061)	0.424*** (0.149)	0.016* (0.009)	0.018 (0.014)	0.033 (0.024)	0.105* (0.056)	0.084 (0.125)
Power Connection Characteristics										
Log (Connection Fees)	0.000 (0.001)	0.004*** (0.001)	0.007*** (0.002)	0.021*** (0.007)	0.033** (0.015)	0.010 (0.000)	0.004** (0.002)	0.008*** (0.003)	0.010 (0.007)	0.033** (0.014)
End Usage Characteristics										
Home Business (Yes)						0.007 (0.013)	0.028 (0.018)	0.055 (0.034)	0.165 (0.104)	0.273** (0.138)
Principal Activities – Services (Base: Production)						-0.004 (0.011)	0.005 (0.018)	0.003 (0.029)	-0.011 (0.094)	-0.099 (0.151)
Defensive Characteristics										
Power Generator (Yes)						0.034** (0.014)	0.041 (0.025)	0.048 (0.039)	0.226* (0.133)	0.487** (0.218)
Voltage Stabilizer (Yes)						0.004 (0.015)	0.025 (0.022)	0.052 (0.051)	0.245** (0.119)	0.446* (0.233)
Intercept	-0.088 (0.056)	-0.096 (0.105)	-0.147 (0.172)	-0.160 (0.547)	0.139 (1.010)	-0.068 (0.070)	-0.024 (0.099)	-0.157 (0.174)	-0.081 (0.564)	-0.250 (1.007)
Observations	598	598	598	598	598	573	573	573	573	573

*Note : *** p<0.01, ** p<0.05, * p<0.1.*

M. Marginal Effects of Determinants of the Electricity Burden for Businesses (Baseline Regression)

	1	2	3	4	5	6
Variables	EB1	EB2	EB3	EB1	EB2	EB3
Economic Characteristics **Value of Equipment (Base=Small)**						
Moderate	0.086 (0.055)	0.095* (0.054)	0.012 (0.019)	0.074 (0.056)	0.066 (0.055)	-0.002 (0.014)
High	0.134** (0.058)	0.133** (0.057)	0.002 (0.018)	0.120** (0.059)	0.113* (0.058)	-0.008 (0.013)
Individual Characteristics						
Age	0.024** (0.011)	0.027** (0.011)	0.006 (0.005)	0.024** (0.011)	0.026** (0.011)	0.003 (0.003)
Age – Squared	0 (0)	-0.000* (0)	0 (0)	-0.000* (0)	-0.000* (0)	0 (0)
Sex – Male (Base: Female)	-0.064 (0.046)	-0.048 (0.044)	0.012 (0.016)	-0.072 (0.048)	-0.080* (0.045)	-0.01 (0.0163)
Primary Education (Base: No Education)	-0.015 (0.063)	-0.033 (0.06)	-0.016 (0.024)	-0.026 (0.064)	-0.046 (0.059)	-0.025 (0.021)
Secondary Education (Base: No Education)	-0.179*** (0.067)	-0.171*** (0.065)	0.005 (0.026)	-0.199*** (0.068)	-0.199*** (0.065)	-0.014 (0.024)
Tertiary Education (Base: No Education)	0.01 (0.113)	-0.036 (0.111)	-0.034 (0.030)	0.023 (0.118)	-0.081 (0.121)	-0.04* (0.021)
Working Hours	-0.074 (0.089)	-0.034 (0.085)	0.047 (0.029)	-0.088 (0.095)	-0.095 (0.096)	-0.005 (0.014)
Log Total Workers	-0.022 (0.032)	0.003 (0.031)	0.018* (0.01)	-0.034 (0.034)	-0.013 (0.033)	0.01 (0.006)
Business Type – Informal (Base: Formal)	0.220* (0.121)	0.177 (0.128)	-0.057 (0.081)	0.290** (0.119)	0.272** (0.133)	-0.029 (0.06)
Location – Urban (Base: Rural)	-0.018 (0.058)	-0.015 (0.057)	-0.0002 (0.02)	0.01 (0.06)	0.019 (0.059)	0.002 (0.012)
Manager is Business Owner (Yes)	0.130* (0.076)	0.141* (0.077)	0.009 (0.024)	0.126 (0.08)	0.162** (0.079)	0.017* (0.009)
Power Supply Characteristics						
Planned Blackouts (Yes)	0.027 (0.052)	0.065 (0.05)	0.037* (0.022)	0.014 (0.055)	0.049 (0.053)	0.027* (0.016)
Number of Outages Per Week	0.004 (0.004)	0.007* (0.004)	0.02* (0.001)	0.003 (0.004)	0.008* (0.004)	0.002*** (0.0006)
Length of Power Outages	0.000** (0)	0.000* (0)	0 (0)	0.000* (0)	0.000* (0)	0 (0)
Morning Power Outage (Base: Midday)	-0.033 (0.048)	-0.045 (0.046)	-0.009 (0.017)	-0.028 (0.05)	-0.047 (0.048)	-0.008 (0.011)
Evening Power Outage (Base: Midday)	-0.164*** (0.061)	-0.159*** (0.059)	0.004 (0.025)	-0.171*** (0.063)	-0.180*** (0.061)	-0.007 (0.014)
Voltage Fluctuation (Yes)	0.090** (0.043)	0.076* (0.042)	-0.011 (0.016)	0.094** (0.045)	0.069 (0.044)	-0.017 (0.012)
Power Connection Characteristics						
Log (Connection Fees)	0.020*** (0.004)	0.018*** (0.004)	-0.001 (0.002)	0.021*** (0.004)	0.018*** (0.004)	-0.001 (0.001)
End Usage Characteristics						
Home Business (Yes)				0.08 (0.054)	0.081 (0.052)	0.001 (0.01)
Principal Activities – Services (Base: Production)				-0.03 (0.055)	-0.05 (0.052)	-0.011 (0.014)
Defensive Characteristics						
Power Generator (Yes)				0.018 (0.066)	0.216*** (0.052)	0.251*** (0.058)
Voltage Stabilizer (Yes)				0.105* (0.063)	0.065 (0.062)	-0.011 (0.01)
Observations	598	598	598	573	573	573

*Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. The corresponding coefficients are reported in Appendix A. Columns 1,2 and 4 and 5 are based on a probit model, while 3 and 6 are based on mprobit.*