Final Report

Evaluation of the Benin Power Compact's Electricity Generation and Distribution Projects: Baseline Report

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Sarah M. Hughes, Christopher Ksoll, Kristine Bos, Anthony Harris, Serge Kennely Wongla, Dara Bernstein, Cullen Seaton and Galina Lapadatova

Submitted to:

Millennium Challenge Corporation
1099 Fourteenth St, NW
Suite 700
Washington, DC 2005
Project Officers: Julian Glucroft and Shreena Patel
Contract Number: 95332418C0129

Submitted by:

Mathematica
1100 1st Street, NE, 12th Floor
Washington, DC 20002-4221
Phone: (202) 484-9220
Fax: (202) 863-1763

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ACRONYMS

AFD	Agence Française de Développement
ARE	Autorité de Regulation de l'Electricité
CCIB	Chambre de Commerce et d'Industrie du Bénin
CEB	Communauté Electrique du Benin
CODIR	Comité de Direction
CP	Condition precedent
DGE	Direction Générale des Ressources Energétiques
ERR	Economic rate of return
ESP	Environment and social performance
GoB	Government of Benin
GPS	Geospatial positioning system
GSI	Gender and social inclusion
HV	High voltage
INSAE	Institut Nationale de la Statistique et de l'Analyse Economique
IRB	Institutional Review Board
IPP	Independent power producer
ITS	Interrupted time series
ITT	Intent-to-Treat
JESA	Jacobs Engineering S.A.
kWh	Kilowatt-hour
LAAEDD	Laboratoire d'Anthropologie Appliquée et d'Education au Développement Durable
LV	Low voltage
M&E	Monitoring and Evaluation
MCA-B	Millennium Challenge Account-Benin II
MCC	Millennium Challenge Corporation
MV	Medium voltage
MW	Megawatt
MWh	Megawatt hour

NDCC	National Distribution Control Center
PAP	Project-affected people
PPA	Power purchase agreement
PV	Photovoltaic
RCD	Resident Country Director
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SBEE	Société Béninoise d’Energie Electrique
SCADA	Supervisory control and data acquisition
TOR	Terms of reference
UN	United Nations

I. INTRODUCTION

Like many countries in sub-Saharan Africa, Benin suffers from weak electricity infrastructure, with critical deficiencies in access, installed capacity, and overall consumption. In recent years, Benin has ranked among the lowest in total net electricity generation globally (World Bank 2016). Furthermore, Benin depends heavily upon imported fuel and electricity. Recent data from SBEE show that in 2019, approximately 97 percent of the country's total supply came from imports (SBEE 2019). Only 32 percent of Beninese households have access to electricity (Power Africa 2018), while a 2016 survey found that 60 percent of Beninese businesses cite a lack of reliable electricity as a constraint to their operations (World Bank 2016). In addition, Benin's infrastructure is aging and undersized for demand. The distribution network is characterized by technical and commercial loss rates that ranged from 20 to 24 percent (combined) in 2019, as well as frequent overloads and excessive voltage fluctuations (Cardno and Fichtner 2014; SBEE 2019). Due to its reliance on imports and its inadequate electricity infrastructure, Benin has until recently suffered from a widespread scarcity of electricity. This situation changed somewhat in 2016 and 2017 when the Government of Benin (GoB) installed electricity generation capacity in the form of rented, diesel-powered generators, at a substantial cost to the government (MCC 2019).

Benin's electricity supply challenges are compounded by the weak financial condition of the electric utility, Société Béninoise d'Energie Electrique (SBEE), whose tariff structure keeps electricity retail prices low, even though the cost of supplying electricity exceeds the tariff paid by consumers. This situation has led to deficits and restricted maintenance for SBEE, which in turn has resulted in further deterioration of the electricity infrastructure and equipment, an inability to prevent electricity shortages, and inadequate resources to expand the grid. Although SBEE's financial situation has improved modestly in recent years, both the cost of service and the deficit have been increasing (World Bank 2017). Overall, the weak electricity sector hinders economic growth in Benin, as businesses, public institutions, and households are constrained by power outages and lack of access to the grid.

On September 19, 2015, MCC and the GoB signed a $375 million compact agreement to improve Benin's electricity network, the financial position of the national utility, and the quality and reliability of the electricity system[1]. The compact, which entered into force on June 22, 2017, comprises four projects: (1) the Electricity Generation Project, intended to increase Benin's domestic generation capacity; (2) the Electricity Distribution Project, designed to rehabilitate Benin's declining distribution infrastructure and build a national electricity distribution control center in Cotonou; (3) the Policy Reform and Institutional Strengthening Project, expected to support the regulatory authority, strengthen SBEE, encourage private investment, and work to establish a cost-reflective tariff, among other activities; and (4) the Off-Grid Electricity Access Project, expected to support policy reforms and infrastructure financing for off-grid projects. In 2019, the compact was modified to reflect changes to the Electricity Generation Project and the Electricity Distribution Project. These changes are described below.

[1] The $375 million amount does not reflect the GoB's contribution of $28 million and 609(g) funding.

MCC contracted with Mathematica to conduct an independent evaluation of two of the four compact activities: (1) the Electricity Generation Project and (2) the Electricity Distribution Project. In this report, we present baseline findings for the evaluation from both quantitative and qualitative data collected from June 2019 to August 2019. In the chapters that follow, we summarize our data sources and sampling methodology, present descriptive statistics for the survey sample, and provide baseline results that show electricity use and electricity-related constraints for end users–that is, households, businesses, and public institutions. In addition, we present updates on the status of project implementation as of the date of this report.

A. Overview of the Electricity Generation and Distribution Projects

The Electricity Generation Project, as modified in 2019, is expected to increase Benin's domestic electricity generation through support to IPPs to construct up to 50 megawatts (MW) of solar photovoltaic (PV) generation capacity. The Photovoltaic Generation Activity, the only activity within the project, anticipates that IPPs will construct two 15 MW solar PV plants and two 10 MW solar PV plants in the northern part of the country, where solar irradiance is the highest, near the cities of Bohicon, Djougou, Natitingou, and Parakou. The sites are all located near substations that feed the high-voltage (HV) network, so the new electricity generated can be injected into the national grid. The primary beneficiaries of this increased capacity are expected to be households and businesses in the project areas, because the new electricity production will first be used to eliminate daytime load shedding in project areas. MCC investments will support the IPP transactions for these four plants through funding for the transaction advisory fees, land acquisition and resettlement, environmental and other preliminary studies of the project sites, and fees for credit enhancement mechanisms[2] (MCA-Benin II 2019).

The Electricity Distribution Project comprises three activities:

1. For the Regional Grid Strengthening Activity in Djougou, Natitingou, Parakou and Bohicon, the compact investments will support the replacement of electricity lines and transformers, substation upgrades, installation of new switchgear connections, construction of new substations, and a 63 kV line from Sèmè to Tanzoun.[3] These activities will be concentrated in the same areas that are receiving new solar PV plants and will improve the grid's ability to handle increased demand while also reducing technical losses.
2. The Cotonou Grid Strengthening Activity aims to improve the capacity and reliability of the grid in Benin's largest city through the installation of new switchgears, connections, and bus bar feeders; network extensions; and a redundant 63 kV line between Cotonou and Porto Novo, Benin's political capital.

[2] The original design of the Electricity Generation Project included rehabilitation of three existing thermal generating units and rehabilitation of the Yeripao hydropower plant. These activities have since been excluded from compact activities due in part to the GoB taking on the activities itself and in part to implementation challenges and an insufficient estimated economic rate of return (ERR).

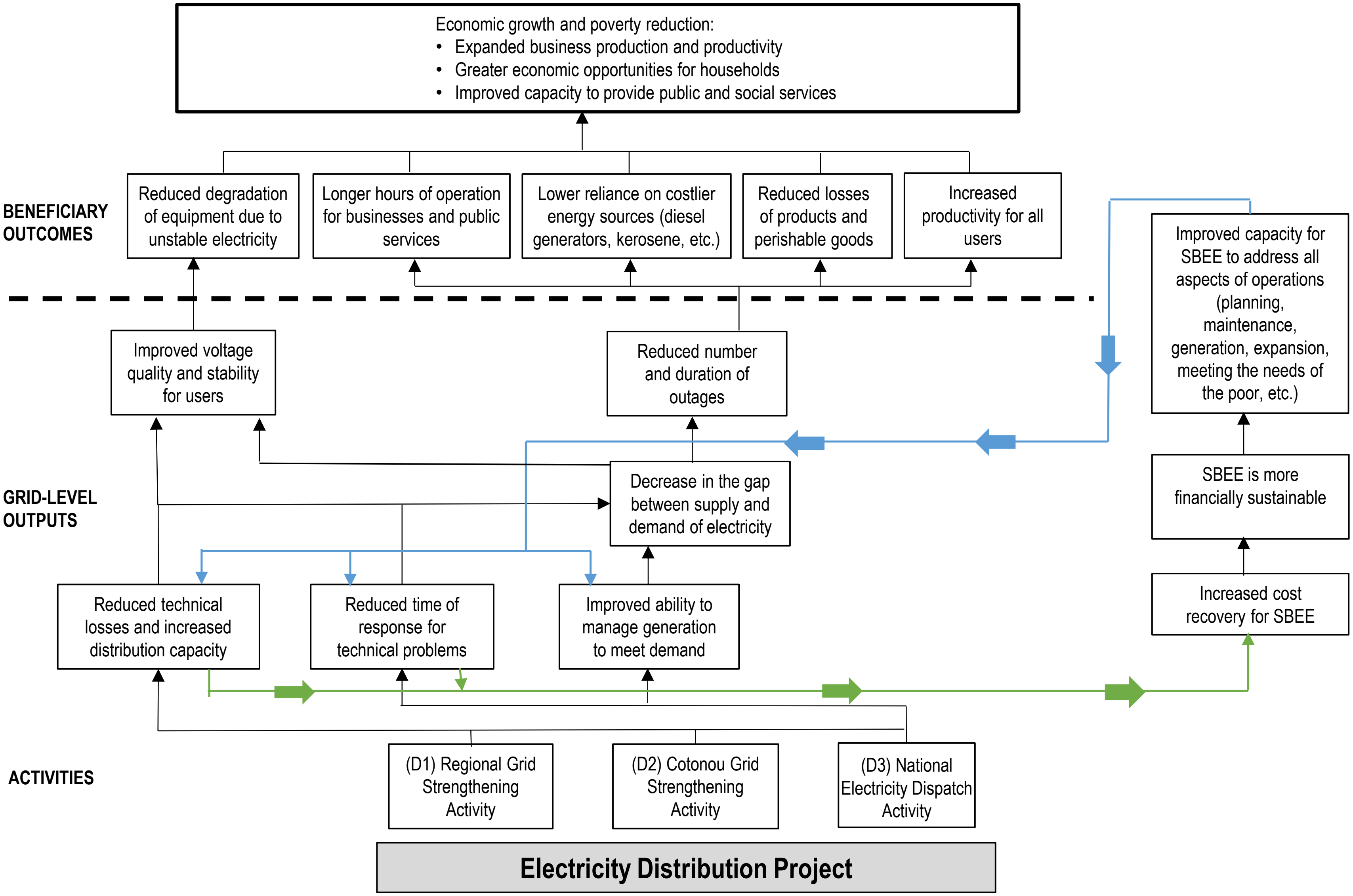
[3] Given the increased costs of other components of the Electricity Distribution Project, the 63 kV line from Sèmè to Tanzoun (part of Lot D) is unlikely to be funded.

3. The National Electricity Dispatch Activity will improve SBEE’s ability to manage the national grid and respond to problems through the construction of a national distribution control center (NDCC). The NDCC will include supervisory control and data acquisition (SCADA) equipment as well as installation of advanced metering infrastructure and automatic meter reading for large industrial customers.

The activities planned under the compact are designed to contribute, individually or in combination, to increased economic growth and reduced poverty through the following: (1) expanded business production and productivity, (2) additional economic opportunities for households, and (3) improved capacity to provide public and social services. MCC’s compact program logic (not shown here) outlines how each of the four compact projects is expected to contribute to the compact’s goals (MCC 2015).

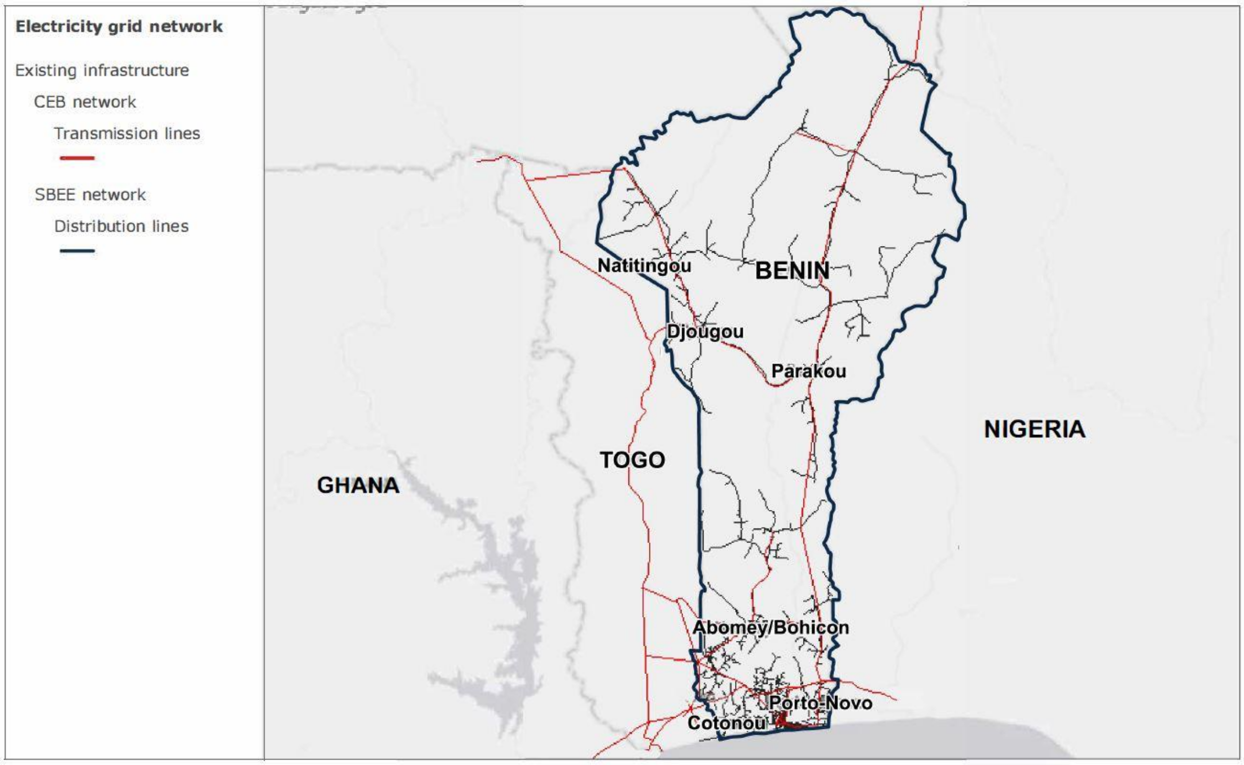
Mathematica’s evaluation will primarily investigate the effects on beneficiaries that flow from the activities of the Electricity Distribution Project. The detailed program logic in Figure I.1 illustrates the activities, outputs, and medium- and long-term outcomes related to the Electricity Distribution Project, with the horizontal dashed line separating grid-level outputs from beneficiary outcomes. Mathematica’s evaluation of the generation activities will primarily focus on changes to the design of the Electricity Generation Project and changes in the supply of electricity due to the IPP mechanism. We will not estimate the effects of the additional generation capacity on beneficiaries because the plants are unlikely to be finished by the end of the compact and because we believe the main effect will be to substitute for the more expensive rental thermal generation capacity Benin has increasingly relied on during the past five years.

Figure I.1. Electricity Distribution Project program logic



Overall, these investments aim to increase the capacity of Benin's electricity grid in the project areas, improve the reliability of electricity supply to consumers, and help SBEE identify technical problems early and respond to them more quickly. A map of the project regions and planned activities is presented in Figure I.2.

Figure I.2. Map of project regions and updated project activities



Source: Data extracted from MCA-Benin II geospatial oversight tool.

B. Overview of the evaluation

Mathematica's evaluation of the Electricity Generation and Distribution Projects includes a comprehensive mixed-methods approach, which seeks to measure the impacts of and understand the changes in quantity and quality of electricity from these projects. Our evaluation design is described in more detail in the Evaluation Design Report (Ksoll et al. 2018).

We will use quantitative data to address several research questions (listed in Table I.1) through an impact analysis (using an interrupted time series [ITS] approach) and a performance evaluation (using a pre-post analysis). We also will conduct a qualitative performance evaluation to answer the remaining research questions related to implementation and outcomes. Where relevant, we will disaggregate the evaluation by key demographic dimensions to understand the projects' effects on women and vulnerable populations.

Our evaluation is organized around the program logic (Figure I.1). Specifically, we are testing the causal links (the arrows) in the theory of change to determine whether the activities and inputs of the Electricity Distribution Project have an impact on grid-level outputs and whether any changes in these outputs result in changes in beneficiary outcomes. We divided the evaluation questions into three categories that correspond to the different levels of the program logic: (1) implementation and sustainability, (2) grid-level outcomes or project outputs, and (3) end users. A full list of the evaluation questions and the evaluation methods and data sources used to answer them is provided in Table I.1.

Table I.1. Evaluation design overview: Summary of research questions, methods, and data sources

Evaluation question	Evaluation method	Key outcomes	Data source
Overarching research questions (RQs)			
RQ1. How were projects implemented, and what were the implementation successes and challenges? a) What changes occurred to the original design and why did they occur? How did those changes influence the ability of the program to reach its objectives? b) How well were the projects implemented? Did the way in which they were implemented help or hinder their success? c) The Distribution and Electricity Generation Projects were intended to be complementary. To what extent was this complementarity maintained through implementation?	• Qualitative performance evaluation	• Project design and changes over time • Implementation plan and changes over time • Implementation successes and challenges • Complementarity of Electricity Generation and Distribution Projects	• Review of project documents • Interviews with MCA-Benin II staff, SBEE staff, Ministry of Electricity staff, and project engineers • Site visits and beneficiary consultations
RQ2. What are stakeholders' perceptions of the sustainability of the outcomes achieved through the compact projects? a) To what extent are MCC's maintenance expectations for the new infrastructure works being met? b) To what extent does SBEE maintain and use the grid-monitoring equipment?	• Qualitative performance evaluation	• Perceptions of sustainability • Maintenance of infrastructure • Usage and maintenance of grid-monitoring equipment	• Review of project documents • Interviews with MCA-Benin II staff, SBEE staff, Ministry of Electricity staff, project engineers, and members of the Energy Sector Donor Roundtable, and beneficiary consultations • Site visits
RQ3. How and to what extent have factors outside of the compact (such as availability of energy imports from Ghana and Nigeria, completion of the North-South 161 kV line, the role of the Communauté Electrique du Benin [CEB], increases in overall demand, and so on) influenced the ability of the projects to meet their expected outcomes?	• Qualitative performance evaluation	• Availability of energy imports • Completion of North-South 161 kV line • Role of CEB • Other government, donor, or private-sector energy investments • Increases in domestic energy demand	• Review of project documents • Interviews with SBEE staff, Ministry of Electricity staff, and members of Energy Sector Donor Roundtable, as well as beneficiary consultations

Evaluation question	Evaluation method	Key outcomes	Data source
RQ4. What are the estimated benefits and costs, and the ex-post ERR of MCC's investment in the electricity projects?	• Impact analysis using ITS • Pre-post analysis • Qualitative performance evaluation	• Impacts on beneficiary outcomes • Final project costs	• High-frequency measurement of grid outcomes from grid monitors installed on the distribution system and smart meters • Surveys of households and businesses • Review of project documents
RQ5. What lessons can be drawn from analysis of the design, assumptions, implementation and delivery, and impact analyses of the Benin II Distribution and Electricity Generation Projects to inform future projects?	• Synthesis of evaluation analyses	• Design and implementation plans, changes, successes, and challenges • Impacts on beneficiary outcomes • Impacts on grid-level outcomes	• Mathematica evaluation analyses • Review of compact closeout documents • Interviews with stakeholders
Questions related to grid-level outcomes			
RQ7. What is the impact of compact activities on the reliability and quality of electricity, and on technical losses?	• Impact analysis using ITS • Qualitative performance evaluation	• Outage frequency and duration • Measures of electricity quality • Technical losses	• High-frequency measurement of grid outcomes from grid monitors and smart meters • High-frequency telephone surveys of businesses and households • Review of SBEE data
RQ8. To what extent did the response time to technical problems on the grid change after the projects were implemented?	• Impact analysis using ITS • Pre-post analysis • Qualitative performance evaluation	• Duration of outages caused by technical problems • Response time to business and household service calls	• High-frequency measurement of grid outcomes • High-frequency telephone surveys of businesses and households • Review of SBEE data • Interviews with staff at public institutions • Interviews with SBEE line staff
Questions related to end user outcomes			
RQ9. What are the impacts of the project activities on business outcomes (output, profits, hours of operations, energy sources, investment in energy-intensive equipment, degradation of grid-connected equipment, spoilage)? How did these impacts vary by type, formality, or sector of business?	• Impact analysis using ITS • Pre-post analysis • Qualitative performance evaluation	• Time use, hours of operation, work disruptions • Energy sources and expenditures • Investment in and degradation of electrical equipment • Losses of products and perishable goods • Productivity and revenue	• High-frequency telephone surveys of businesses • Smart meters • Surveys of businesses

Evaluation question	Evaluation method	Key outcomes	Data source
RQ10. What is the impact of the project on household outcomes (productivity, time use, sources of energy, investment in energy-intensive appliances, degradation of grid-connected appliances, spoilage of perishable food)? Did these effects vary by subgroups (gender, income)?	• Impact analysis using ITS • Pre-post analysis • Qualitative performance evaluation	• Productivity • Time use • Energy sources and expenditures • Investment in and degradation of appliances • Losses of products and perishable goods	• High-frequency telephone surveys with households • Smart meters • Surveys of households
RQ11. To what extent did the outcomes for public and social services (for example, health facilities, schools) change after the projects were implemented?	• Qualitative performance evaluation	• Hours of operation • Usage of electrical equipment • Investment in and degradation of equipment • Perception of electricity reliability and quality • Perception of electricity as constraint	• Interviews with public institutions and institutions providing social services

Note: We removed RQ12 on the impact of new connections on household and small business outcomes because this is no longer a planned activity (Ksoll et al. 2018). We have removed RQ6 on changes in the supply-demand gap as any power supplied by solar plants constructed through IPPs is expected to substitute for thermal generation rather than change overall production. We have removed RQ7a on the contributions of the different project components, including generation, to the impacts of the project (Ksoll et al. 2018) for two reasons: (1) the generation activities were significantly reduced under the updated compact and thus cannot be quantified separately from the distribution activities and (2) the compressed project timeline will not allow us to separate the impacts of each project component because the components will be completed too close in time to distinguish their independent impacts.

1. Quantitative evaluation methodology

The quantitative evaluation has three components: (1) an ITS analysis, (2) a pre-post analysis, and (3) economic rate of return (ERR) and beneficiary analysis.

The ITS analysis will estimate impacts on short-term, grid-level, and end user outcomes by using high-frequency data from three sources: (1) grid monitors, (2) smart meters, and (3) telephone surveys. At the grid level, the ITS analysis will estimate impacts on measures related to (1) electricity generation, (2) electricity reliability, (3) electricity quality, and (4) technical losses. At the end user level, the ITS analysis will address business and household outcomes in the following key domains: (1) outages; (2) satisfaction with SBEE; (3) total energy use; (4) operating hours; (5) profits, costs, and losses; (6) equipment failure; and (7) time use. These end user outcome domains, as well as the ITS analysis sample size for end users are summarized in Table I.2 below. The baseline data that we describe in this report represent the first round of data collection for the ITS analysis.

The pre-post analysis will use data from in-person surveys to measure changes over a longer period of time. For grid-level outcomes, we will investigate the changes in electricity generation, electricity reliability, electricity quality, and technical losses over the medium and long term by using the same short-term outcomes described for the ITS. At the end user level, we have collected in-person survey data during this baseline round (prior to the start of construction and at least one year before project beneficiaries were expected to start benefitting from the intervention) and will collect additional in-person survey data during an interim (medium-term) follow-up just after compact close and a final (long-term) follow-up a few years post-compact (Figure 1.3). These data will form a longitudinal panel of a sample of households and businesses. This sample will be a subset of the sample used in the ITS analysis. The sample and key outcome domains for households and businesses are summarized in Table I.2.

Table I.2. Data sources and data collection plans for quantitative analysis

Data sources	Sample size[a]	Timing	Relevant instruments/modules
ITS analysis (short-term outcomes)			
Telephone survey of male and female business owners and managers	1,089 electrified businesses (756 small and 333 medium and large businesses)	Quarterly surveys between baseline and interim data collections for the pre-post survey (and perhaps beyond)	• Outages • Satisfaction with SBEE • Energy use • Operating hours • Costs and losses • Equipment
Telephone survey of male and female household heads	1,496 electrified households	Quarterly surveys between baseline and interim data collections for the pre-post survey	• Outages • Satisfaction with SBEE • Energy use • Costs and losses • Equipment • Time use
Pre-post analysis (medium- and long-term outcomes)			
Pre-post survey of male and female business owners and managers	300 small businesses	• Baseline (pre-intervention) • Interim (two to three years of exposure) • Final (three to five years of exposure)	• Profitability • Input mix and capital investment • Energy costs • Spending on equipment to address unreliable power • Spending on equipment damaged due to poor quality electricity • Expectations of reliability and quality of electricity supply
Pre-post survey with male and female household heads	300 households	• Baseline (pre-intervention) • Interim (two to three years of exposure) • Final (three to five years of exposure)	• Grid and non-grid electricity and substitute energy consumption • Reliability and quality of electricity • Operation of businesses outside of the home • Adult time use • Child time use

[a] The actual sample size for the telephone survey may be smaller depending on sample attrition.

The final component of the quantitative evaluation is to update the economic rate of return (ERR) and conduct a beneficiary analysis. When developing the compact, MCC calculated estimates of the ERR of the Electricity Generation and Distribution Projects based on their expected costs and benefits by using data from a nationwide survey measuring households' and businesses' willingness to pay for electricity. At the time of the compact signing, the estimated ERR for all compact activities (excluding off-grid activities) was 11.5 percent. MCC has since updated its calculations to reflect changes in the projects' activities and now estimates a compact ERR (excluding off-grid) of 10.5 percent (MCA-Benin II 2019). Because we have not yet received the updated ERR model, we cannot determine to what extent the data we have collected can be used to recalculate the ERR.

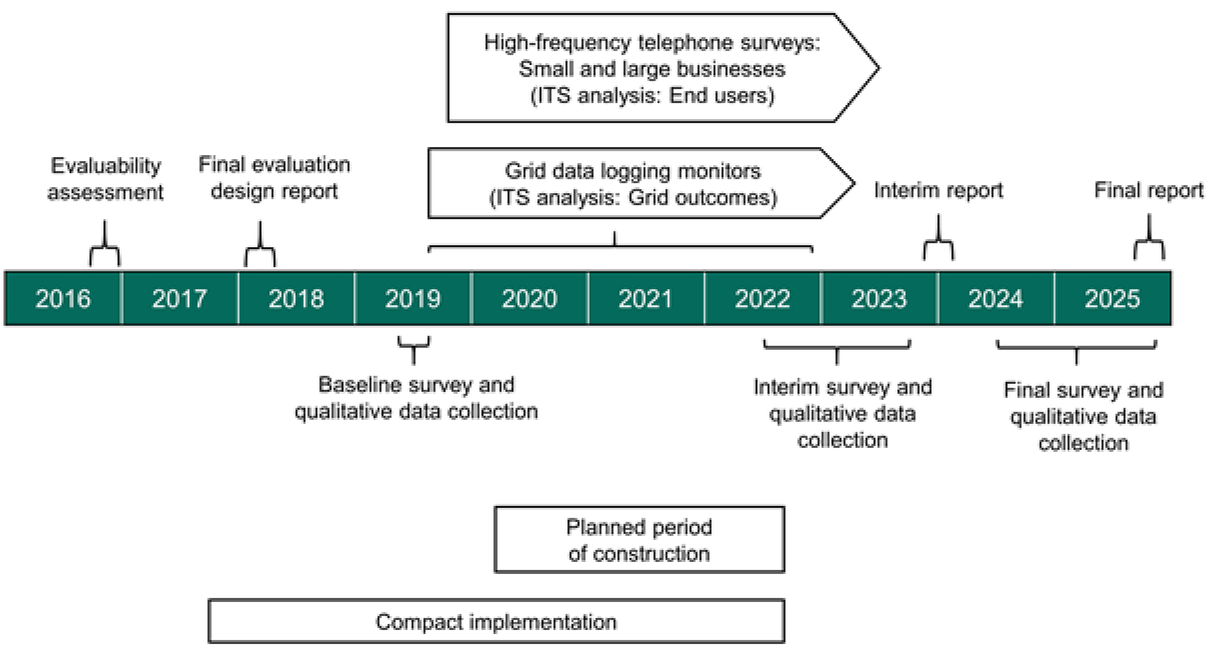
2. Qualitative evaluation methodology

We complement the quantitative evaluations with a qualitative performance evaluation that includes two components. The first component is an implementation analysis of the Electricity Generation and Distribution Projects, which will provide valuable insights into research questions about the processes, activities, and overall operations of the compact projects. The second component is a qualitative assessment of the effects of the projects on improvements in electricity quality and reliability for connected public institutions.

3. Timeline for data collection, evaluation, and project activities

The baseline in-person survey data collection took place from June 2019 to August 2019, approximately six months before the first distribution network improvements were expected to commence. In Figure I.3, we show the planned timing of data collection for the evaluation along with the anticipated timing of distribution project activities.

Figure I.3. Timeline for data collection, evaluation, and project activities



C. Key baseline findings

In Table I.3, we present key findings from the baseline analysis and provide updates to the evaluation. We provide more detailed findings in the subsequent chapters and in the appendices to this report.

Table I.3. Key findings at baseline

Outcomes and outputs	Updates to the evaluation
Project design and implementation	
• Revisions to the project horizon from 2025 to 2035 led to higher cost estimates for the Cotonou Grid Strengthening Activity and the Regional Grid Strengthening Activity • The Electricity Generation Project has been re-scoped to include only support for the Photovoltaic Generation Activity as IPP transactions; the new timeline envisions that the financial close for these projects will be approximately March 2021. • $120 million will be reallocated from the Electricity Generation Project to the Electricity Distribution Project to accommodate changes in the project designs • GoB has made progress on meeting the remaining preconditions for the disbursement of $80 million in conditional funding for the Electricity Distribution Project; however, the conditions precedent for the IPPs and the final steps for implementing tariff reform were still outstanding at the date of this report. • Modifications to the Electricity Distribution Project have resulted in delays related to procurement, environmental impact, and social protection.	• Due to the significant reduction in the scope of the Electricity Generation Project, Mathematica's evaluation will focus on changes to the design of the project and an analysis of the IPP mechanism.
Grid-level analysis	
• Outages and voltage fluctuations occur, although less frequently than a few years ago • Aging equipment and poor maintenance practices are cited by stakeholders in the Benin energy sector as some causes of outages • Aging infrastructure leads to high technical losses • Lack of spare parts and storage of spare parts in a central location lead to longer outages when parts need to be replaced, particularly in outlying areas. [At the time of this report, we have not begun receiving data from grid monitors or smart meters, therefore our reports on grid-level outcomes are based on qualitative interviews, only.]	• Mathematica and GOPA-Intec, MCA distribution design consultant, have agreed on the indicators from the grid monitors that will be provided to Mathematica. The indicators include number and length of outages as well as other measures of electricity quality. Measures of harmonic distortions have not yet been defined. • Delays in smart meter procurement and grid monitor installation have pushed back the start of the grid-level data collection that supports the ITS design. Because of these delays, we do not present baseline results here. At the time of this report, the grid monitors are physically installed at substations but are not yet transmitting measurements to the central platform. Smart meters are scheduled for installation in mid-2020.

Outcomes and outputs	Updates to the evaluation
End user analysis	
• Outages and voltage fluctuations continue to impose financial costs on households and businesses of all sizes through spoilage, damage to equipment, and expensive backup generation costs. • Medium and large businesses face substantial financial costs as a result of poor quality electricity and often spend considerable amounts to pay for backup generation. • Just over half of households reported being satisfied or very satisfied with the quality of SBEE electricity whereas businesses, especially larger businesses, are unsatisfied with the quality of SBEE electricity • Poor quality and unreliable electricity affects the ability of public institutions to provide high quality services and lowers their productivity, including cutting back on non-essential services during power outages	• Businesses were reluctant to provide information on monthly revenue and profits in the baseline survey. Thus, some profit indicators were measured with error. This will pose a challenge as we try to estimate the effects of the grid improvement on business outcomes. We will adapt the telephone survey instrument based on our baseline findings to improve our firm profit measure. • Measurement of power consumption was accurate for households that received a bill from SBEE, but it was difficult for respondents to estimate over a seven-day recall period. Respondents had an easier time estimating consumption and expenditures when the period aligned more closely with the billing cycle. We will consider adapting the telephone survey instrument to reflect this finding and will pre-test to determine the best approach. • Businesses are already open most days and weeks. We will consider revising this outcome because we found that in spite of problems with outages, businesses were already operating more than six days per week.

Overall, the findings support the Benin Energy Compact's program logic. The problems that the energy sector, households, businesses, and public institutions face at baseline align with the outcomes that the Electricity Distribution Project and Electricity Generation Project aim to improve. The only notable exception is business hours of operation; businesses report operating six days per week, on average, so improvements in electricity are unlikely to increase the hours of operation.

D. Road map of the report

This baseline report contains three sections with corresponding implementation updates and baseline results for outcomes we will examine over time. Chapter II summarizes changes to the compact design and provides an implementation update. Chapter III provides information about grid-level outcomes. Chapter IV presents baseline information on end user outcomes. Chapter V includes a brief description of the evaluation's institutional review board (IRB) clearances, data submission procedures, and dissemination. The appendices include information about our methodologies for primary data collection, additional tables with disaggregated findings, a summary of the baseline levels of the telephone survey indicators, and responses to stakeholder comments (forthcoming).

II. ANALYSIS OF PROJECT DESIGN AND IMPLEMENTATION

In this chapter, we report on the status of project implementation as of November 2019 and describe changes to the initial project design. These findings will form the baseline for answering the following research questions:

1. How were projects implemented, and what were the implementation successes and challenges?
   a. What changes occurred to the original design and why did they occur? How did those changes influence the ability of the program to reach its objectives?
   b. How well were the projects implemented? Did the way in which they were implemented help or hinder their success?
   c. The Electricity Distribution and Generation Projects were intended to be complementary. To what extent was this complementarity maintained through implementation?

We provide a snapshot of initial plans and compare them to the current project status using information from implementer reports, project and compact plans, schedules, MCA-B biweekly reports, and key informant interviews with the MCA-B implementation team, SBEE staff, project implementers, and MCC staff. Table II.1 identifies the data sources informing our baseline analysis of project implementation and outlines the key areas of focus we explore at baseline.

Table II.1. Data sources and areas of focus

Data source	Data type and sample size (for each round)	Key areas of focus
Project implementation plans and progress reports	Document review	*Project design* Project implementation plans
MCA-Benin II representatives in the energy, contracting, and monitoring and evaluation (M&E) departments; MCC Resident Country Mission staff; National Coordinator; Gender and Social Inclusion (GSI) and Environmental and Social Performance (ESP) experts; and other relevant staff	11 interviews	*Project design* • Changes to the initial project design *Early compact conditions* • Perceptions of electricity reliability and quality, maintenance • Constraints and challenges to implementation
SBEE policy, management, and engineering staff; staff at Ministry of Electricity and regulatory bodies	6 interviews	*Project design and expectations for implementation* • Anticipated challenges to implementation • SBEE's role in the design and implementation of infrastructure interventions *Early compact conditions* • Perceptions of electricity reliability and quality, maintenance • Constraints and challenges

Data source	Data type and sample size (for each round)	Key areas of focus
Engineers and contractors from the implementing organizations responsible for design and construction of the infrastructure, and project deliverables	6 interviews	*Project design* • Anticipated changes to the project design • Anticipated challenges to implementation

A. Findings on project design

In response to changing conditions in Benin's energy sector, the compact has undergone some significant modifications since its entry into force. These modifications include changes to the scope of the Distribution and Generation Projects, and the reallocation of compact funding between projects and activities. The following findings are drawn from the March 2019 compact modification summary paper (MCC 2019), periodic MCA status updates, and interviews with key stakeholders involved in the project planning and implementation.

Scaling electricity distribution investments to support projected electricity demand through 2035 has resulted in much higher cost estimates than initially anticipated. The original budget estimates were based on feasibility studies for the Electricity Distribution Project conducted in late 2014 and early 2015, which were conducted over a compressed time frame and planned only for changes to the distribution infrastructure with a 10-year planning horizon and using a projection of electricity demand up to 2025. MCC later supplemented these studies with a second, more rigorous study using a 20-year projection of demand—up to 2035—and found that the capacity of the initially planned infrastructure was insufficient to support demand over this horizon. In particular, the distribution design consultant recommended doubling all stretches of the planned 63 kV lines in Greater Cotonou and placing them underground rather than overhead. Moreover, the engineer recommended a 50 percent increase in planned substation capacity to support increased projected electricity demand through 2035.

The expected costs for this rescoped infrastructure are substantially higher than planned. In its original form, the budget for the Distribution Project called for approximately US$110 million dollars of investment across three activities: regional grid strengthening (US$8 million of MCC funding plus US$18 million of matched contributions from the GoB), Cotonou grid strengthening (US$73 million from MCC plus US$5 million from the GoB), and national electricity dispatching (US$27 million). The modifications to the project were expected to cost an additional US$120 million at the time requests for proposal (RFPs) were issued for these investments, with the bulk of the additional investment going to support the two grid strengthening activities. Specifically, the budget for the Regional Grid Strengthening Activity was increased from US$8.2 million to US$65.6 million, Cotonou Grid Strengthening Activity from US$73.4 to US$125.1 million, and the National Electricity Dispatch Activity from US$28.1 million to US$36.2 million.

Construction under the Distribution project is divided into four lots. As of November, 2019 three of these lots are still scheduled to begin construction, but the fourth (Lot D) is unlikely to be implemented due to lack of resources. Lot D consists of medium voltage lines in the Porto Novo area connecting Tanzoun to the Sèmè substation.

The increased costs associated with the Distribution Project will be partially funded by a reduction in the scope of the Generation Project. The initial conception of the generation project included funding for thermal, photovoltaic, and hydroelectric generation, for a combined 78 MWp of new capacity. Together, these activities were projected to cost $133 million. However, three developments have led to a considerable reduction in compact investments in electricity generation. First, in 2016, the newly elected president of Benin took action to remedy the country's frequent blackouts by allocating funds from the Beninese treasury to rehabilitate thermal generation facilities. This action unilaterally accomplished many of the goals of the proposed Thermal Generation Activity before the compact entered into force. Consequently, the planned $12 million investment in thermal generation was no longer needed. Second, MCA and GoB agreed to satisfy the objectives of the Photovoltaic Generation Activity through power purchase agreements (PPPs) with IPPs rather than fully funding construction of the solar plants. This decision was enabled by a surge of private sector interest in Benin's power sector around the time of the compact's entry into force. As a result, MCA will be able to increase the planned photovoltaic capacity from 45 MWp to 50 MWp while reducing planned investment in generation by $119 million. The modified compact will reserve $13 million to cover transaction costs with IPPs, including acquiring credit support, site acquisition, and resettlement. Total cost savings to the compact from the changes to the Photovoltaic Generation Activity will be $106 million. Third, MCC's independent engineer conducted a new technical analysis of the Hydroelectric Generation Activity and determined that initial forecasts underestimated the cost to complete the activity. Consequently, MCA has decided not to implement this activity and reallocated its $1.3 million budget.

Together, these three modifications to the compact will reduce investments in the Generation Project by about $120 million. This funding will be reallocated to cover part of the aforementioned shortfall of funding for the Distribution Project.

SBEE has taken steps to meet expectations specified in the compact. SBEE management contributed considerable input to the initial plans for new infrastructure, including planning for electricity demand through 2025. SBEE is expanding its organizational chart to include departments of loss reduction and environmental and social management as well as a monitoring and evaluation (M&E) unit. SBEE recently instituted a health and safety operational plan, satisfying a condition for disbursement of Distribution Project funding. Finally, it is engaged in an effort to provide prepaid meters to customers, although these efforts have been delayed due to procurement problems. Key informants report that SBEE agents are more receptive to MCA now than in the early days of compact planning.

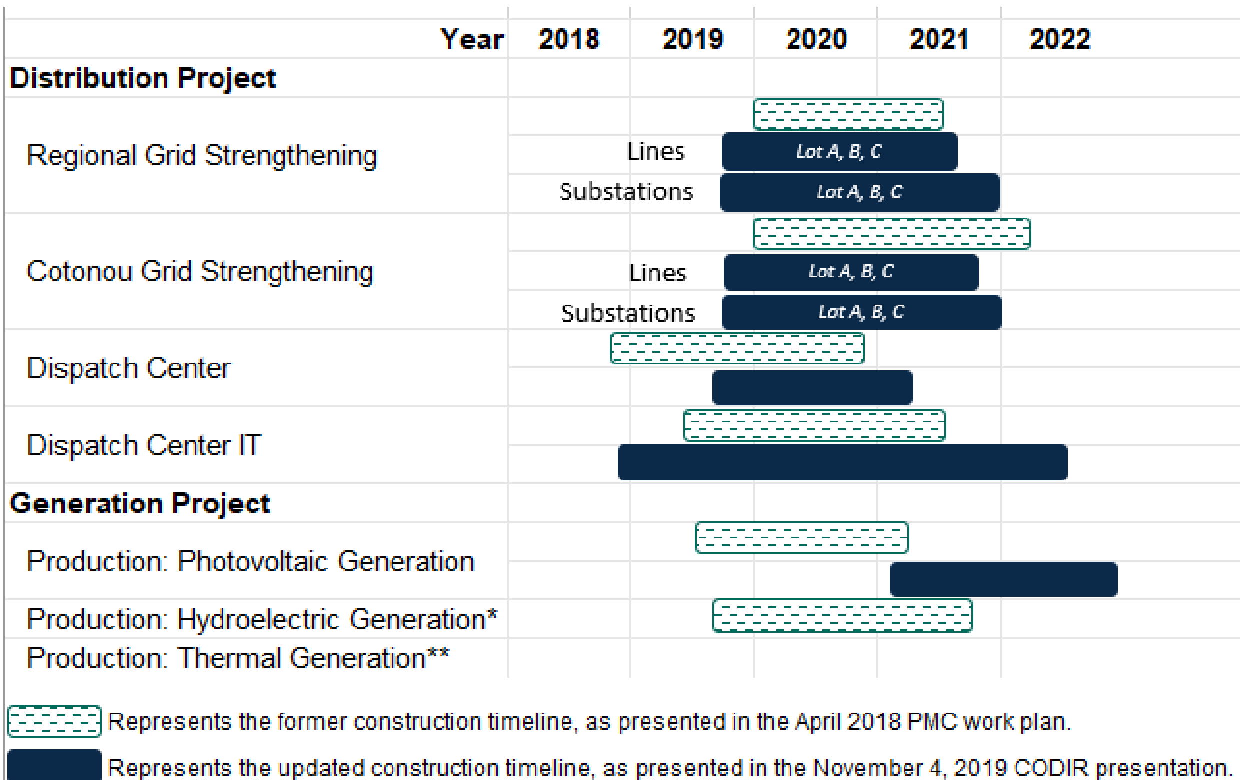
The Government of Benin has made progress toward meeting the preconditions for the disbursement of $80 million in conditional funding for the Distribution Project. The compact outlines three condition precedents (CPs) for the disbursement of funds to support the on-grid projects—specifically, $80 million to support the Distribution Project. The CPs are (1) adoption of an IPP framework, (2) implementation of tariff reform, and (3) progress on settling SBEE arrears. The first and third of these conditions already have been satisfied; the tariff reform process has not concluded as of November 2019, although several steps have been completed.

The independent regulator Autorité de Régulation de l'Électricté (ARE) has received the tariff reform proposal, but final approval from the Council of Ministers is still pending.

B. Findings on early implementation status

Although preparation for activities within the Distribution Project has been ongoing since compact entry into force (EIF) in June 2017, the original project schedule has experienced delays. Many changes in the workplan can be attributed to compact modifications to the Distribution Project discussed in Section II.A. Other changes to the workplan are associated with procurement and with implementation of environmental and social protections. Figure II.1 provides a high-level summary of delays in project implementation by contrasting the current timeline as laid out in the March 2019 modification summary report with the project timeline proposed in July 2017, just after EIF.

Figure II.1. Evolution of Generation and Distribution Project timelines



Notes: * These activities have been removed from the compact.

** This activity was eliminated in 2016 and was therefore not shown in the 2018 PMC project work plan.

The decision to pursue the photovoltaic plants as IPPs requires a new implementation timeline for the Electricity Generation Project. MCA will accept IPP bids through May 2020. The original goal was to reach financial close by September 2020 so that construction could begin shortly after; however, delays in the procurement process may result in a change to the timeline. The plants are not expected to become operational until after the compact period is complete.

Modifications to the Distribution Project have resulted in delays because many of the changes required new feasibility studies, including environmental and social impact studies. All of MCC's investments are required to meet international standards on environmental and social performance (such as International Finance Corporation performance standards). The modifications to the Distribution Project required new environmental impact studies and mitigation plans before the projects could proceed. Completing the studies has pushed back the timeline for construction. For example, in the course of revising the Distribution Project, project managers determined that burying lines underneath roads would be the most cost-effective approach, in part because overhead lines require a much wider easement than underground lines. The wide easement under overhead lines in an urban center like Cotonou would greatly increase the number of project-affected persons and displacements, and thus costs. To lay the medium-voltage lines underground, MCA and MCC have carried out new studies to determine the environmental impacts of subterranean lines, which differ from those of the originally planned overhead lines.

Compensation to project-affected persons has taken longer than anticipated, in some cases. To compensate affected business owners who may experience a reduction in commerce due to construction activities, the compact will provide monetary payments. MCC's preferred method of compensation is to transfer money securely to bank accounts, which some project affected persons (PAPs) do not possess. Efforts to provide accounts to unbanked community members have been challenging, in some cases because of a lack of viable identification documents. The GoB has agreed to work with affected communities to provide appropriate forms of identification, but this effort will take time. As of November 2019, studies of compensation for project-affected persons in some project areas were still underway.

Construction of the NDCC building is not yet underway. The National Electricity Dispatch Activity is designed to provide real-time network monitoring, control, and data collection in the electricity distribution network. MCA received bids for the construction project in November 2018 and signed a contract with the winning bidder in February 2019. As of November 2019, construction permits had been approved but construction had not yet begun. At that time, MCC was still waiting to receive detailed construction plans from the contractor. Work on the NDCC IT components began in November 2018 and is ongoing.

Modifications to the Distribution Project have resulted in some new protocols and tasks, increasing costs. For example, the project will now test for contamination in the soil along the subterranean lines and transport contaminated soil to a new landfill and waste treatment facility that is being constructed with compact funding. In addition, the decommissioned substations will be removed and relocated to a second waste treatment facility for hazardous material, also being constructed with compact funding. The formal process for certifying the waste sites was ongoing as of November 2019.

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III. ANALYSIS OF GRID-LEVEL OUTCOMES

Mathematica is using an ITS approach to estimate impacts on short-term grid-level outcomes, and a pre-post analysis to measure changes in grid-level outcomes over a longer period of time. These approaches will provide inputs into an economic assessment of MCC's investments in grid infrastructure and allow us to study the effects of improvements in distribution infrastructure on grid-level reliability and electricity quality.

Baseline data will inform our analysis of grid-level outcomes in multiple ways. First, the data will establish the pre-project status of grid-level constraints along the project's logic model pathways. Second, these data will provide the quantitative pre-intervention data necessary to conduct the ITS and pre-post analyses. Third, qualitative data collected at baseline will be used to document the functioning of the electricity distribution system before the planned upgrades are implemented. In Table III.1, we list the research questions guiding the analysis of grid-level outcomes and summarize the role of baseline data for addressing each grid-level evaluation question.

Table III.1. Role of baseline data for the grid level analysis, by evaluation question

Evaluation question	Evaluation method	Data sources	Role of baseline data
RQ4. What is the ex-post ERR of MCC's investments?^	• Impact • Performance	• Grid monitors • Smart meters • SBEE data • Document review	• Establish a baseline on frequency of unreliable and low quality electricity for ITS and pre-post analyses.
RQ7. How did the project impact electricity reliability, quality, and technical losses?	• Impact • Performance	• Grid monitors • Smart meters • SBEE data • Interviews with SBEE line staff	• Establish a baseline on frequency of outages, quality of electricity for ITS and pre-post analyses. • Describe pre-construction condition of infrastructure and its effects on grid electricity quality
RQ8. How did the response time to technical problems change?	• Performance	• Grid monitors • SBEE data • Interviews with SBEE line staff	• Establish a baseline on duration of outages caused by technical problems for pre-post analysis. • Describe pre-construction processes around responding to technical problems on the grid

^ MCC's initial ERR model derived the main benefit stream primarily from generation. With the rescoping, the ERR now relies on benefits from improved distribution infrastructure. We have not yet received this revised ERR model, so we are unable to map our indicators to the ERR inputs.

As of November 2019, when the first draft of this report was developed, we have not received baseline grid-level quantitative data. Mathematica's grid-level analysis is dependent on accessing the grid monitor data and obtaining information on causes of outages from SBEE and/or GOPA-Intec, the MCA-Benin II (MCA-B) design consultant. We expect to provide baseline grid-level quantitative data in an update to the baseline report at a future time.

In Section A, we present the definition of project areas, sampling of grid monitors and qualitative data, and planned sampling for smart meter placements. In Section B, we define the key indicators we plan to use for answering grid-related research questions. In Section C, we present results from the analysis of baseline qualitative data on grid-level outcomes.

A. Sampling for grid-level outcomes

1. Definition of project areas

The interventions under the distribution project are concentrated in five main areas: Djougou, Bohicon (including the neighboring city of Abomey), Parakou, Natitingou, and the greater Cotonou area (including Abomey-Calavi and Porto-Novo), and surrounding suburbs. Although benefits will also accrue to peri-urban communities and other towns, Mathematica expects the benefits to be largely concentrated in these areas. To focus sampling for both grid-level and end user outcomes on those areas expected to receive the greatest benefits (see Chapter IV for end user outcomes), Mathematica consulted with MCA-B to delimit the urban areas that would primarily benefit from the project. The sampled areas are only those that are already connected to the grid where pre-existing electricity lines or substations were to be rehabilitated under the Compact. Areas that would be connected to the grid in the future through new electricity infrastructure investments were excluded. Because the project areas follow the electricity network, which does not necessarily follow administrative boundaries, these project areas are not aligned with arrondissement-level boundaries.

2. Sampling for placement of grid monitors

We used a stratified random sampling approach to sample the locations where grid monitors were placed. To draw conclusions about how grid performance has changed across all project areas and the effect of MCC investments on all potential beneficiaries, we stratified all distribution substation infeeds by project area, based on lists of them provided by the design consultant for the Distribution Project, and drew an initial random sample of infeeds. The final selection of grid monitor locations reflects discussions held between GOPA-Intec, Mathematica, MCA-B II, and MCC. Overall, 80 grid monitors were placed on arrival and infeed lines.[4]

- Sampled locations of monitors: We sampled 63 infeed lines for placing grid monitors. These lines included all 18 infeed lines located in substations in Djougou, Parakou, Natitingou, and Bohicon/Abomey; 45 infeed lines from the remaining substations in the Greater Cotonou area were selected at random, with the number of lines selected per substation proportional to the total number of those at the substation.
- Other locations of monitors: 17 arrival lines in the Greater Cotonou area were selected non-randomly, based on recommendations of GOPA-Intec.

In Table III.2, we show the total number of arrival and infeed lines in each project area, and the number ultimately sampled for placement of grid monitors. As of the date of drafting this report, 60 grid monitors have been installed but they have not yet been connected to the SBEE servers

[4] Arrival lines are the lines feeding power from the transmission and subtransmission network into the substation and infeed lines are the lines feeding power into the low voltage distribution network.

and are not transmitting data. With very few exceptions, the actual placement of monitors on lines matches the recommended sample.

Table III.2. Sample size of infeeds and arrival lines for grid monitors, by project area

Project area	Total number of arrival lines	Number of arrival lines sampled	Total number of infeeds	Number of infeeds sampled	Capacity/energy supply covered by sampled infeeds^
Greater Cotonou[a]	17	17	67	45	
Bohicon and Abomey	2	0	6	6	
Djouogu	2	0	4	4	
Natitingou	3	0	4	4	
Parakou	4	0	4	4	
Total	**28**	**17**	**85**	**63**	

^ Infeed capacity will be added when data become available after grid monitors are connected to the grid.

[a] Greater Cotonou comprises Cotonou, Porto-Novo, and Abomey-Calavi.

3. Sampling for placement of smart meters

In addition to grid monitors, the evaluation will rely on smart meters installed at beneficiary (end user) premises. The sampled beneficiaries for the smart meters will be drawn from the respondents to our household and business survey, described in Chapter IV. Because the smart meters are linked to end users, and survey sampling weights allow for the sample to be made representative of households and businesses in the project areas, the information we collect will allow for calculating the system average interruption frequency index (SAIFI) and the system average interruption duration index (SAIDI).

4. Sampling for qualitative data

The qualitative assessment of grid-level outcomes in this baseline report identifies the status of such outcomes before infrastructure improvements were implemented and outlines constraints in the logic model as perceived by key stakeholders in the energy sector in Benin. The analysis draws on interviews with key stakeholders regarding the reliability and quality of electricity in Benin, and changes in the supply and quality of electricity since the development of the compact (see Table III.3). The sampling approach for the qualitative data collection is described detail in Appendix A.

Table III.3. Qualitative data sources and areas of focus

Respondents	Sample size	Interview topics
MCA-Benin II representatives in the energy, contracting, and M&E departments; MCC Resident Country Mission staff; National Coordinator; GSI and ESP experts; and other relevant staff	11 interviews	• Perceptions of pre-construction electricity reliability and quality, maintenance • Pre-construction constraints and challenges
BEE policy, management, and engineering staff; staff at Ministry of Electricity and regulatory bodies	6 interviews	• Perceptions of pre-construction electricity reliability and quality, maintenance • Pre-construction constraints and challenges
SBEE line workers and customer service	7 interviews	• Perceptions of pre-construction electricity reliability and quality, maintenance • Pre-construction constraints and challenges

B. Baseline data sources and outcome definitions

We have worked with GOPA-Intec, SBEE, and MCA-B to define the set of outcomes to be measured with the grid monitors and ensure that monitor placement allows for a representative view of the grid's performance. Table III.4 outlines the key indicators to be collected, the source of the data, and definitions of the indicators. The key indicators will be collected over a reference period (e.g. 1 week, 1 day) to be determined in collaboration with GOPA-Intec and SBEE.

Table III.4. Key indicators for grid-level outcomes

Key indicator	Data source	Definition
Outages (number): Unplanned outages Planned outages (repairs) Planned outages (load shedding) Total number of outages	Data collection platform (GOPA-Intec) SBEE information on source of outage	Total number of outages per reference period, classified by cause of outage
Duration of outages (time): Unplanned outages Planned outages (repairs) Planned outages (load shedding) Total duration of outages	Data collection platform (GOPA-Intec) SBEE information on source of outage	Total duration of outages per reference period, classified by cause of outage
Voltage fluctuations: Maximum voltage Duration of overvoltage Minimum voltage Duration of undervoltage	Data collection platform (GOPA-Intec)	Duration of under- or overvoltage measured as the duration over which voltage is above or below the tolerance level per reference period Maximum and minimum voltage reported over the reference period

Key indicator	Data source	Definition
Frequency fluctuations: Maximum frequency Duration of high frequency Minimum frequency Duration of low frequency	Data collection platform (GOPA-Intec)	Duration of high or low frequency measured as the duration over which voltage is above or below the tolerance level per reference period Maximum and minimum voltage reported over the reference period
Harmonic distortions Current harmonics Voltage harmonics	Data collection platform (GOPA-Intec)	TBD
Total consumption (MwH)	Data collection platform (GOPA-Intec)	Amount of power consumed per reference period. Total consumption should be calculated over a 5 minute period.
Unmet demand	Data collection platform (GOPA-Intec) SBEE calculations, with support from GOPA-Intec	Sum of unmet demand during periods of outage, measured by summing up the demand from the last similar day with uninterrupted power per reference period. Demand profiles should be used to calculate uninterrupted demand over 15-minute intervals.
Losses: Total losses Technical losses	Data collection platform (GOPA-Intec) SBEE, with input from GOPA-Intec	Total losses will be calculated by taking the difference between power fed into the network and billing information. Technical losses will be calculated by GOPA-Intec and SBEE on the basis of combining power fed into the network with loss factors across the network determined by GOPA-Intec and SBEE.
SAIDI and SAIFI	Telephone survey data Smart meter data	We will use data from the telephone survey to directly estimate the number of interruptions customers face (SAIFI) and the associated duration (SAIDI). This information will be validated using the smart meter data.

Note: The timing of receiving baseline grid-level quantitative data is pending connection of grid monitors and smart meters, and the transmission of their data.

The reference period, the tolerance for the key indicators of quality (voltage and frequency) and the indicators for harmonic distortions are still pending agreement with GOPA-Intec. We expect that GOPA-Intec and SBEE will provide key indicator summary data quarterly. They will calculate technical losses and provide loss information for different parts of the network. In addition to the key indicator summary data, we expect to receive disaggregated data on outages, including start and end times for outages and their cause; and data on the amount of electricity delivered by infeed in five-minute increments. These data will be used to estimate the demand profile over the course of the day to estimate unmet demand.

C. Qualitative assessment of baseline status of electricity infrastructure

The use of rental generation capacity has substantially reduced the number of outages. Key stakeholders in the energy sector in Benin noted that, historically, Benin has been plagued by frequent blackouts stemming largely from the country's low total generation capacity. Many end users consider either a gas-powered generator or solar panels to be a must. Officials from public institutions throughout Benin highlighted that the backup electricity sources are an expensive alternative to grid electricity due to the cost of fuel and the risk of theft, but public institutions requiring electricity to function are left with no other options. Schools, health facilities, and government offices all reported using backup generators to maintain basic operations during blackouts. These officials and staff from SBEE noted that in past years, the use of rental generation capacity has greatly reduced the number of outages linked to insufficient generation. Respondents attributed this reduction to the president's authorization of the rehabilitation of diesel turbines and the use of rental generation capacity to increase the amount of electricity available on the grid. However, energy sector stakeholders also noted that the use of rental generation has a negative effect on the sector's viability.

Aging infrastructure and poor maintenance continue to cause outages. Officials from SBEE and MCA-B reported that, independent of low generation capacity, many blackouts are caused by the failure of distribution infrastructure components. These failures can be linked to poor maintenance practices and may worsen as the grid infrastructure continues to age. The following are aspects of poor maintenance practices:

- **Lack of regular maintenance.** Regular preventive maintenance of the electric grid has not always been a common practice. A few SBEE agency leads reported that preventive maintenance of the electric grid is not conducted until a problem with the grid occurs.
- **No central log of maintenance records.** SBEE personnel observed that no central maintenance database currently exists, limiting the utility's ability to plan routine maintenance.
- **Lack of replacement parts.** SBEE respondents reported that SBEE does not own a sufficient number of replacement transformers and circuit breakers. This lack of needed equipment to address network issues, especially when several occur simultaneously, can lead to prolonged outages when equipment failure occurs. SBEE reported that network repair is more efficient when it does not require new electrical equipment. Generally, SBEE aims to address a problem—for example an outage—within a couple hours; however, the completion of repairs may take considerably longer.
- **Spare parts are stored centrally.** Some interviewees suggested that poor or slow maintenance is a symptom of inventory problems at SBEE. In particular, they noted that spare parts are stored at a central location and are often not readily available when needed in remote locations.

Aging infrastructure and poor maintenance also lead to poor quality electricity. Officials from public institutions referred to the poor quality of electricity as encompassing electricity surges and persistent low-voltage service, which can lead to end user equipment failure. Many of the same factors that contribute to frequent blackouts also contribute to low quality electricity, including aging infrastructure and sub-par maintenance practices. Equipment failure can cause sudden spikes in voltage that can damage end user appliances. Some of the quality problems are due to the quality and variability of the electricity imported from neighboring countries, particularly electricity transmitted by the main supply line from Nigeria, according to respondents working in the energy sector in Benin.

The aging infrastructure also leads to high technical losses. The Beninese grid is subject to high technical losses caused by the aging distribution infrastructure, meaning that users farthest removed from the point of generation often receive perpetually low-voltage electricity. SBEE reports that between 20 and 24 percent of electricity is lost between generation and consumption (this figure refers to both technical and nontechnical losses) (SBEE 2019). Thus, the problem of technical losses may be particularly pertinent for users in remote areas of the Northern region. One informant suggested that the North-South 161 kV line will improve the situation for consumers in the north.

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IV. END USER OUTCOMES AT BASELINE

Mathematica is using quantitative and qualitative methods to measure changes in outcomes for households, businesses, and public institutions before and after the distribution infrastructure investments. The objectives of these analyses are to (1) study the effects of improved electricity quality and reliability on end user outcomes; (2) provide inputs into an economic assessment of MCC's investments in grid infrastructure; and (3) disentangle, to the extent possible, the contributions of various MCC-funded investments.

Baseline data will inform our end user analyses in multiple ways. First, the data presented here will establish a baseline for the electricity constraints found along the logic model pathways for households, businesses, and public and social institutions. Second, the data will provide the quantitative pre-intervention information necessary to conduct the ITS and pre-post analyses. In Table IV.1, we summarize for each end user evaluation question the corresponding evaluation method and data source and the role of the baseline data collection in answering the question.

The ITS approach will estimate the causal impact of improvements to the local electricity distribution infrastructure by analyzing time series data before and after the project activity is completed and by assessing to what extent end user outcomes change immediately after the completion of the project activity relative to a possible preexisting trend. The ITS analysis will focus on outcomes that we expect to change in the short term, including (1) outages; (2) satisfaction with SBEE; (3) total energy use; (4) operating hours; (5) profits, costs, and losses; (6) equipment failure; and (7) time use. The baseline data presented here are the first observations in what will be a series of pre-intervention outcomes. The pre-post analysis will focus on outcomes that take longer to materialize, such as fixed capital investments in electricity-intensive appliances, strategies to mitigate poor electricity quality, profitability and income (for businesses), and purchases of electrical appliances and time use (for households). The analysis will use the baseline data presented here as well as data from the interim and final data collections (see Ksoll et al. 2018 for additional methodological details).

Table IV.1. Role of baseline data for the end user analysis, by evaluation question

Evaluation question	Evaluation method	Data source	Role of baseline data collection
RQ4. What are the estimated benefits and costs, and the ex-post ERR of MCC's investment in the electricity projects?	• Impact • Performance	• Grid monitors • Smart meters • SBEE data • Document review	• Establish a baseline on frequency of unreliable and low quality electricity for ITS and pre-post analyses.
RQ7. How did the project impact electricity reliability, quality, and technical losses?	• Impact • Performance	• Grid monitors • Smart meters • Telephone surveys • SBEE data	• Establish baseline of household- and business-reported electricity reliability and quality for ITS and pre-post analyses.

Evaluation question	Evaluation method	Data source	Role of baseline data collection
RQ8. How did the response time to technical problems change?	• Impact • Performance	• Grid monitors • Telephone surveys • SBEE data • Interviews with public institutions • Interviews with SBEE line staff	• Establish baseline of SBEE customer service, as reported by households and businesses, for ITS and pre-post analyses. • Describe pre-construction status quo, as reported by public institutions and SBEE line staff.
RQ9. What are the impacts of the projects on business outcomes?	• Impact • Performance	• Telephone surveys • Smart meters • In-person surveys of businesses	• Establish baseline of business outcomes for ITS and pre-post analyses.
RQ10. What are the impacts of the project on household outcomes?	• Impact • Performance	• Telephone surveys • Smart meters • In-person surveys	• Establish baseline of household outcomes for ITS and pre-post analyses.
RQ11. To what extent did the outcomes for public institutions and social services (for example, health facilities, schools) change after the projects were implemented?	• Performance	• Interviews with public and social service institutions	• Describe pre-compact electricity usage and challenges among public and social services.

A. Sampling for end user outcomes and baseline characteristics

1. Definition of sample for end users

The quantitative analyses of end user outcomes rely on data from in-person surveys with households, small businesses, and large businesses. To draw our household and small business sample, we conducted a listing of households and small businesses from a sample of blocks[5] in the project areas. In coordination with MCC and MCA-Benin II, we established the geographic extent of the project areas, which were defined as the urban areas that were expected to benefit from the SBEE distribution network upgrades (refer to Section III.A.1 for further details on how the project areas were defined). From the listed households and businesses, we selected a sample of electrified households and small businesses to participate in the full baseline data collection and the telephone survey. The household businesses in our sample came from households that reported having a household business on the premises that used electricity. To obtain our sample of medium and large businesses, we used a list of businesses provided by the Chambre de Commerce et d'Industrie du Bénin (CCIB), the Beninese chamber of commerce. In the remainder of this report, we refer to these businesses as the CCIB sample. We provide the full details of the household, small business, and CCIB business sampling in Appendix A.

[5] Blocks were defined arbitrarily by the data collector as geographic areas that contained approximately 50 structures. Blocks were used to divide each of the project areas into units that could be easily listed.

(continued)

2. Baseline characteristics of household and business sample

The basic characteristics of the households and businesses that we are studying are shown in Tables IV.2 (households) and IV.3 (businesses). About 20 percent of the households were led by a female and 10 percent of the households operated a business out of the household premises.[6] Most of our households were located in the Greater Cotonou area (defined in this report as Cotonou, Porto-Novo, and Abomey-Calavi), which reflected the relative population size across the project areas. Just over half of households had a direct SBEE connection, while the rest relied on indirect connections to the grid.

Table IV.2. Baseline characteristics of the household sample

Outcome	Mean
Household head is female (%)[a]	20.3
Household size (number of people)	4.64
Household business on premises (%)[a]	10.0
SBEE connection (%)	
Direct	53.7
Indirect[b]	46.3
Project area (%)	
Greater Cotonou[c]	78.9
Bohicon and Abomey	8.6
Djougou	2.4
Natitingou	1.5
Parakou	8.6
Sample size	**1,496**

Source: Benin energy infrastructure baseline household survey.

Note: Sample sizes for individual indicators may be smaller due to missing data.

[a] Indicates a stratifying variable.

[b] Households with an indirect connection to SBEE are those without a meter connected directly to the electricity line; rather, they receive electricity from a neighbor (with or without a meter).

[c] Greater Cotonou is comprised of Cotonou, Porto-Novo, and Abomey-Calavi.

In our business samples, both household businesses and stand-alone small businesses were very small, with an average of 1.97 employees (including unpaid family members). CCIB businesses had on average 45 employees, although there was a large range of 1 to 1,551 total employees. Household businesses and small businesses were largely concentrated in the retail sector (64.4 percent and 51.0 percent, respectively), while CCIB businesses were fairly evenly distributed across the retail, manufacturing, and service sectors. About 72 percent of household business owners were female, compared to just 10 percent of CCIB businesses that were majority female-

[6] These two variables were used to stratify our household sample.

owned. A significant portion of businesses across all three samples was located in Greater Cotonou, followed by Bohicon and Abomey, and then Parakou.

Table IV.3. Baseline characteristics of business samples

	Household business	Small business	CCIB business
Sector (%)			
Retail	64.4	51.0	38.7
Manufacturing	19.6	14.3	27.0
Service	16.1	34.7	34.2
Size (number of employees)	1.97	1.97	45.25
Female-owned[c] (%)	72.4	48.5	10.4
SBEE connection (%)			
Direct	53.2	45.8	100.0
Indirect[a]	46.8	54.2	0.0
Region (%)			
Greater Cotonou[b]	83.1	84.9	61.0
Bohicon and Abomey	11.1	5.6	19.2
Djougou	1.4	1.2	2.1
Natitingou	2.8	1.5	7.2
Parakou	1.6	6.7	10.5
Sample size	**117**	**756**	**333**

Source: Benin energy infrastructure baseline household, small business and large business survey.

Note: Sample sizes for individual indicators may be smaller due to missing data.

[a] Businesses with an indirect connection to SBEE are those who do not have a meter connected directly to the electricity line; rather, they receive electricity from a neighbor (with or without a meter).

[b] Greater Cotonou is comprised of Cotonou, Porto-Novo, and Abomey-Calavi.

[c] This indicator is defined as “business is majority female-owned” for CCIB businesses.

B. Baseline data sources and outcome definitions

1. Quantitative analysis

The data sources for the quantitative analyses of end user outcomes are the in-person surveys we conducted among households, small businesses, and CCIB businesses. These surveys collected baseline information on end user outcomes for both the ITS analysis, which will focus on short-term outcomes, and the pre-post analysis, which will focus on outcomes that take longer to materialize. These outcomes are summarized in Table IV.4.

Table IV.4. Household and business outcomes

Outcome domain	Outcome measures for ITS analysis		Outcome measures for pre-post analysis	
	Businesses	Households	Businesses	Households
Outages	Frequency of outages Duration of outages	Frequency of outages Duration of outages	Perceptions of reliability and quality of electricity	Perceptions of the reliability and quality of electricity
Satisfaction with SBEE	Satisfaction with power provision from SBEE Satisfaction with SBEE customer service	Satisfaction with power provision from SBEE Satisfaction with SBEE customer service	n.a.	n.a.
Energy use	Amount and cost of grid electricity Amount and cost of generator-produced electricity	Amount and cost of electricity consumed from the grid Amount and cost of electricity consumed from generators	Costs of grid and non-grid electricity Ratio of electricity costs to total costs Ratio of electricity costs to revenues	Grid and non-grid electricity consumption and expenditures, and consumption of non-electric energy
Hours of operation	Weekly hours business is open	n.a.	n.a.	n.a.
Profits, costs, and losses	Weekly or monthly profits (depending on size of firm) Cost of spoilage Revenue lost from stopped production Cost of restarting production	Cost of spoilage	Profitability Input mix (including number of employees) and capital investment	n.a.
Equipment	Occurrence of equipment and appliance failure Cost of replacing or repairing defective equipment and appliances	n.a.	Investment in mitigation equipment (for example, generators and surge protectors) to mitigate issues regarding unreliable power Spending on equipment damaged due to poor quality electricity	Investment in and ownership of generators, protective equipment, and electric appliances
Time use	n.a.	Hours worked Hours of study (for one child in the household)	n.a.	Hours worked Hours of study

n.a. = not applicable

2. Qualitative analysis

The main data sources for our analysis of the effects of power quality on public institutions are interviews with representatives from schools, universities, and health clinics, and interviews with local community leaders. The sample includes interviews with representatives from mayors' offices, tax authorities, social security authorities, and chambers of commerce- all drawn from across the five project areas. Because developing a representative sample of such institutions was outside the available budget, we selected a range of institutions across the project areas for in-depth interviews. Details on the sampling approach are provided in Appendix A. The key areas of focus for each of these respondents are presented in Table IV.5.

Table IV.5. Qualitative data sources and areas of focus

Data source	Sample size	Key areas of focus
Directors and managers from schools, health clinics, and other public institutions	12 interviews	*Pre-compact activities status quo and perceptions* • Energy use and expenditure • Expectations for benefits of improved electricity • Equipment damage and losses due to power outages and surges • Consequences of lack of reliable and high quality electricity
Local community leaders, local officials, and/or representatives from energy associations who interact with SBEE and implementers	12 interviews	*Pre-compact activities status quo and perceptions* • Satisfaction with quality and reliability of grid electricity • Consequences of lack of reliable and high quality electricity

C. Baseline status of end user outcomes

Below we present our baseline results for households, businesses, and public institutions. Household and business outcomes are presented for the overall sample, weighted to be representative of the project areas. In this section, we highlight our primary outcomes (indicated in bold) and secondary outcomes and present some key indicators to contextualize the baseline outcomes. The tables in Appendices B and C present these outcomes as well as additional indicators and show outcomes disaggregated by region and gender of household or business head. The tables in Appendix D present baseline results for indicators we will follow via the telephone survey.

1. Household outcomes

Key observations

- Households and businesses face problems with the quality and reliability of electricity, including outages (three outages per week on average for households and small businesses and five outages per week on average for CCIB businesses) and voltage fluctuations (35 percent of households and small business and 56 percent of CCIB businesses report experiencing at least one voltage fluctuation per week).
- Households and businesses invest in backup generation and purchase equipment to mitigate the costs associated with poor quality and unreliable electricity.
- Households with a direct connection to SBEE spend on average CFA15,155 (US$26) per month on electricity.

Households in our sample faced challenges related to the reliability and quality of grid electricity (Table IV.6). On average, households experienced fewer than three outages per week, each lasting about one hour. Although the majority of the sample (65.4 percent) reported never experiencing voltage fluctuations, 8.5 percent reported daily fluctuations and another 5.1 percent reported fluctuations two to three times per week. There were small differences in electricity reliability across regions, as presented in Appendix Table B.1.2.

Table IV.6. Reliability and quality of electricity supply reported by households

Outcome	Mean
Outages	
Number of outages in past 7 days^	2.75
Duration of outages in past 7 days^ (hours)	3.24
Average duration of outages in past 7 days^[a] (hours)	1.12
Number of outages in past 30 days	7.16
Duration of outages in past 30 days (hours)	9.15
Average duration of outages in past 30 days (hours)	1.55
Voltage fluctuations	
Frequency of voltage fluctuations: Never (%)^	65.4
Frequency of voltage fluctuations: Daily (%)	8.5
Frequency of voltage fluctuations: Two to three times per week (%)	5.1
Frequency of voltage fluctuations: Few times per month (%)	20.9
Sample size	**1,477**

Source: Benin energy infrastructure baseline household survey.

Note: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

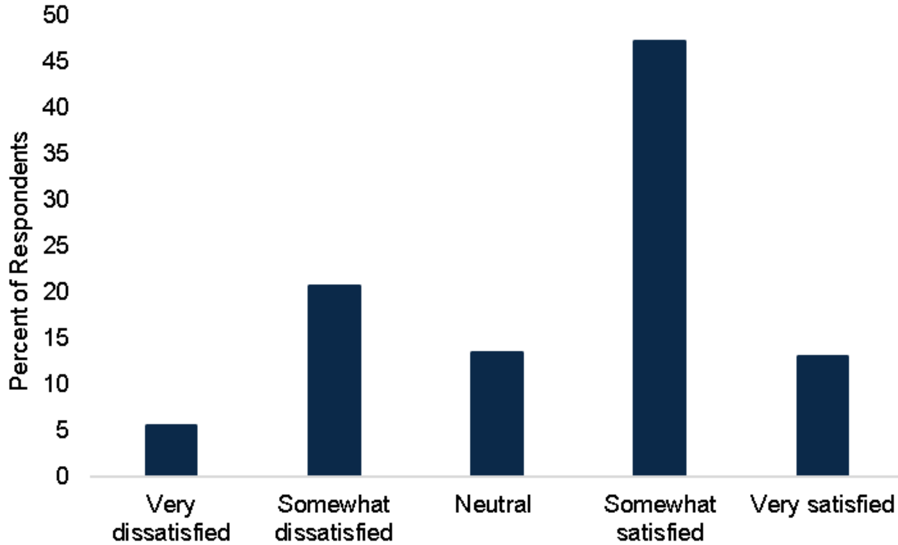
^ Indicator to be collected in telephone surveys and used in the ITS analysis.

[a] Average duration is calculated by dividing the respondent-reported total duration of outages during the reference period by the respondent-reported total number of outages during that period.

Our baseline data show some measurement problems across different outage indicators. The number of outages reported over the past 30 days appears to be roughly three times the number reported over the past 7 days. We would expect the ratio to be roughly four times if outages were happening with regular frequency, or about 12 outages in the past 30 days. This unexpected result might indicate that households are overcounting outages in the past 7 days or they may be undercounting the number of outages over the past month. Overall, we believe that the numbers reported over the past 7 days are likely more accurate than those reported over the past 30 days. Therefore, the telephone survey will include questions about outages in the past 7 days. The data we collect from smart meters placed on the lines of sample members will provide an objective measure of outages and will be a useful point of comparison for these outcomes.

Just over half of households reported being satisfied or very satisfied with the quality of the SBEE electricity they received, as evaluated by voltage stability and likelihood of equipment damage (Figure IV.1). About 30 percent of household respondents reported being very or somewhat dissatisfied with their quality of electricity. These numbers reflect an improvement in recent years, as 73 percent of households reported that electricity quality has improved since 2016 and 2017, a period prior to GoB's leasing of emergency generation capacity (results not shown).

Figure IV.1. Household satisfaction with quality of SBEE electricity



Source: Benin energy infrastructure baseline household survey.

Note: Respondents are asked, "What is your overall degree of satisfaction with the quality of SBEE electricity, in terms of changes in voltage and equipment damage?"

Households with a direct SBEE connection (53.7 percent of the sample) spent nearly four times more for electricity than households with an indirect connection (Table IV.7). Households with a direct connection had either a conventional (postpaid) meter (76.5 percent) or a prepaid meter (23.4 percent); over 95 percent had a bill or receipt from SBEE. Most households with an indirect SBEE connection (46.3 percent of the sample) either had a meter (62.7 percent) that tracked their usage or received electricity as part of their rent or without paying the utility.

Households are vulnerable to poor quality electricity and are willing to pay to mitigate its effects. The prevalence of backup energy source use and ownership of protective devices suggests that households are vulnerable to electricity outages and voltage fluctuations and that they are willing to pay to insulate themselves from the negative effects of outages and voltage fluctuations. About 44 percent of households reported using a backup energy source during an outage (Table IV.7). This included 10 percent of households that reported using their own generator during an outage, as well as households that used other sources such as dry cell batteries, petrol, or candles. Only 10.5 percent of households owned a surge protector, while 26.9 percent owned a voltage stabilizer.

Table IV.7. Household energy profile

Outcome	Mean
SBEE electricity expenditures and consumption	
Amount spent on SBEE electricity in past 30 days, direct connection (CFA)^	15,155
Amount spent on SBEE electricity in past 30 days, indirect connection (CFA)^	3,984
Amount spent on SBEE electricity in past 30 days (postpaid bill) (CFA)[a]	15,447
Amount spent on SBEE electricity in past 30 days (prepaid) (CFA)	12,857
Amount spent on SBEE electricity in past 30 days (respondent estimate) (CFA)[b]	9,888
Amount of SBEE electricity consumed in past 30 days (kWh)^	73.30
Amount of SBEE electricity consumed in past 30 days (kWh, postpaid bill)[a]	104.13
Amount of SBEE electricity consumed in past 30 days (kWh, prepaid)	51.27
Amount of SBEE electricity consumed in past 30 days (kWh, respondent estimate)[b]	74.77
Protection against poor quality electricity	
Owns a surge protector (%)	**10.5**
Owns a voltage stabilizer (%)	**26.9**
Number of surge protectors owned[c]	1.16
Number of voltage stabilizers owned[c]	1.21
Use of backup energy sources during outages	
Uses any backup energy source in case of outage (%)	44.3
For households that use a backup energy source:	
Uses generator owned by the household as backup energy source during an outage (%)	1**0.0**
Uses home solar system as backup energy source during an outage (%)	9.5
Uses petrol as backup energy source during an outage (%)	11.3
Uses dry cell batteries (D, C, AA, AAA) as backup energy source during an outage (%)	44.8
Uses candle as backup energy source during an outage (%)	27.7
Uses a backup light source when there is an outage (%)	10.7
Use of backup energy sources in the past 7 days	
Used any backup energy source in case of outage in past 7 days (%)	28.9
For households that used a backup energy source in the past 7 days:	
Used generator owned by the household as backup energy source during an outage in past 7 days (%)^	**11.1**
Used home solar system as backup energy source during an outage in past 7 days (%)	10.6
Used petrol as backup energy source during an outage in past 7 days (%)	12.1
Used dry cell batteries (D, C, AA, AAA) as backup energy source during an outage in past 7 days (%)	42.7

Outcome	Mean
Used candle as backup energy source during an outage in past 7 days (%)	28.3
Used any other source as backup energy source during an outage in past 7 days (%)	8.1
Contextual indicators	
Direct SBEE connection (%)	53.7
Direct SBEE connection: Conventional meter (%)	66.8
Direct SBEE connection: Supplemental conventional meter (%)	9.7
Direct SBEE connection: Prepaid card meter (%)	21.0
Direct SBEE connection: Supplemental prepaid card meter (%)	2.4
Direct SBEE connection: Decompteur (%)	0.1
Direct connection: Receives an SBEE bill (%)	95.1
Indirect connection: Has a meter (%)	62.7
Other users are connected to electricity meter (%)	29.0
For households that share electricity with another user:	
Number of other users connected to meter	2.74
Shares electricity with relative (%)	52.3
Shares electricity with own business (%)	5.4
Shares electricity with neighbor (%)	46.9
Sample size	**1,496**

Source: Benin energy infrastructure baseline household survey.

Note: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1= 576.64 CFA).

^ Indicator to be collected in telephone surveys and used in the ITS analysis.

[a] 457 respondents had an SBEE bill available to reference during the survey. [b] Costs and quantities of electricity consumption are estimated only by respondents who could not provide consumption information based on a bill, prepaid receipt, or other source of information.

[c] Conditional on owning this equipment.

Electricity sharing is relatively common: 29 percent of households reported sharing electricity with another user. On average, those who shared electricity did so with 2.74 other users, such as relatives, neighbors, and a household business. This means that the electricity consumption and expenditure averages among households with direct connections may overstate their own consumption because they may also include the consumption of other users connected to the same meter.

Households reported frequent negative consequences of poor quality electricity, particularly related to equipment damage, but they did not spend much on backup generation (Table IV.8). About 19 percent of households reported having equipment in need of repair in the last three months; the average cost of repairing or replacing that damaged equipment was CFA3,751 (US$6.50) for the whole sample, including those without any equipment damage.

Damaged equipment accounted for 6.9 percent of all pieces of equipment owned. On the other hand, household expenditures for backup sources of generation were fairly low.

Table IV.8. Consequences of unreliable and poor quality electricity for households

Outcome	Mean
Cost of backup energy sources and outages	
Total cost of backup energy source use in past 7 days (CFA)[a]	981
Total cost of using any backup energy source in past 30 days (CFA)[a]	1172
Total cost of using any generator in past 30 days (CFA)^[b]	3526
Cost of loss of perishable goods, past 7 days (CFA)^	622
Equipment damage	
Any equipment in need of repair in past three months, in general (%)^	19.4
Cost of repair or replacement of damaged equipment in past three months (CFA)^	3,751
Any equipment in need of repair due to voltage fluctuations in past three months (%)[c]	20.5
Proportion of equipment damaged due to voltage fluctuations: Number of pieces (%)[d]	6.85
Proportion of equipment damaged due to voltage fluctuations: Value (%)[e]	0.05
Sample size	**1,494**

Source: Benin energy infrastructure baseline household survey.

Note: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^ Indicator to be collected in telephone surveys and used in the ITS analysis.

[a] Conditional on using backup sources of energy.

[b] Conditional on using a generator (n=39).

[c] This outcome differs from the similar primary outcome in that it was constructed from a roster of equipment types and asks specifically about damage due to voltage fluctuations. We found that the roster resulted in a higher reporting of equipment damage than a simple question about all equipment damage, likely because the roster included interior and exterior lights as a type of equipment.

[d] This outcome is defined as the number of pieces of equipment that the household reports having been damaged due to voltage fluctuations in the past three months divided by the total number of pieces of equipment owned.

[e] This outcome is defined as the total value of the equipment that the household reports having been damaged due to voltage fluctuations in the past three months divided by the total value of all pieces of equipment owned.

Baseline results on adult time use, collected by household, show that men, on average, spent most of their time during the work week on paid work outside of the home, while women, on average, spent the same amount of time across paid work and work for a family business (Table IV.9). On an average school day, children spent a little over a half hour studying at home during the day and just under an hour studying at home at night.

Table IV.9. Adult and child time use

Outcome	Male	Female
Adult time use		
Hours per day primary adult spent on paid work outside of home^	**7.00**	**3.64**
Hours per day primary adult spent on work for a family business^	**1.47**	**3.82**
Hours per day primary adult spent on cooking/preparing meals, food processing	0.38	1.96
Hours per day primary adult spent on other household chores	0.56	2.14
Hours per day primary adult spent on listening to radio	1.54	0.96
Hours per day primary adult spent on watching TV	1.75	1.67
Child time use		
Hours per day student spent studying at home during daylight hours^	**0.65**	**.55**
Hours per day student spent studying at home at night^	**0.94**	**0.87**
Hours per day student spent cooking/preparing meals or food processing	0.14	0.47
Hours per day student spent on paid work outside of the home	0.02	0.11
Hours per day student spent on work for a family business	0.10	0.34
Hours per day student spent on household chores	0.71	0.80
Hours per day student spent on play/other leisure and entertainment	3.12	2.05
Hours per day student spent on watching TV	1.75	1.54
Hours per day student spent on playing on the Internet	0.20	0.10
Hours per day student spent on playing video games or on the computer	0.30	0.14
Contextual indicators		
Hours per day primary adult spent on sleeping	6.58	6.95
Hours per day primary adult spent on other leisure and entertainment	1.12	0.65
Hours per day student spent on sleeping	7.73	7.65
Hours per day student spent at school	4.96	4.74
Sample size (adults)	**1,030**	**1,093**
Sample size (children)	**506**	**510**

Source: Benin energy infrastructure baseline household survey.

Note: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^ Indicator to be collected in telephone surveys and used in the ITS analysis.

2. Business outcomes

This section reports outcomes for all three types of businesses (household, small and large), presenting the results side by side. Exceptions to this display are outcomes for household businesses on grid-level constraints (Table IV.11) and energy profile (Table IV.12), which are captured and reported as part of the household analysis above. Our sample included a range of business types. CCIB businesses were by definition formal businesses that were larger and more likely to have a bank account; on average, they were in operation for over twice as long as small businesses (Table IV.10). Small businesses and household businesses were similar in size but differed in terms of sector and formality. Across the sample, businesses operated for at least six days per week on average.

Table IV.10. Business operations

Outcome	Household business	Small business	CCIB business
Business sector (%):			
Retail	64.4	51.0	38.7
Manufacturing	19.6	14.3	27.0
Service	16.1	34.7	34.2
Number of employees:			
Permanent paid	0.15	0.80	28.33
Temporary paid	0.4	0.39	16.39
Unpaid, including family members	1.82	0.84	1.28
Total	1.97	1.97	45.25
Percentage of business owners that are female	N/A	47	11.54
Business has a bank account (%)	10.4	26.9	84.9
Business is registered with the chamber of commerce (%)	N/A	25.4	100.0
Business is one of multiple locations (%)	N/A	11.0	27.4
Number of years business has been in operation	N/A	6.76	15.85
Number of months that business functioned in 2018	11.64	11.34	11.57
Number of days business operates per week^	**6.40**	**6.11**	**6.00**
Sample size	**117**	**756**	**333**

Source: Benin energy infrastructure baseline household, small business and large business survey.

Note: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^ Indicator to be collected in telephone surveys and used in the ITS analysis.

N/A = not available.

Both small businesses and CCIB businesses in our sample faced a substantial number of outages per week (Table IV.11). CCIB businesses reported experiencing about twice as many outages in the past week and in the past 30 days than small businesses reported; however, they reported a slightly lower average duration of outages. CCIB businesses also reported a higher frequency of voltage fluctuations than small businesses did. Overall, 19.7 percent of CCIB businesses reported daily voltage fluctuations and another 16.2 percent reported fluctuations two to three times per week.

Table IV.11. Grid-level constraints for surveyed businesses

	Small business	CCIB business
Outages		
Number of outages in past 7 days^	**2.71**	**5.22**
Duration of outages (hours) in past 7 days^	**3.37**	**5.00**
Average duration of outages (hours) in past 7 days^[a]	**1.40**	**1.18**
Number of outages in past 30 days	6.98	18.14
Duration of outages (hours) in past 30 days	8.00	18.20
Average duration of outages (hours) in past 30 days[a]	1.44	1.40
Voltage fluctuations		
Frequency of voltage fluctuations: Never (%)^	**66.1**	**43.6**
Frequency of voltage fluctuations: Daily (%)	**9.1**	**19.7**
Frequency of voltage fluctuations: Two to three times per week (%)	**8.9**	**16.2**
Frequency of voltage fluctuations: Few times per month (%)	**15.9**	**20.4**
Sample size	**729**	**314**

Source: Benin energy infrastructure baseline small business and large business survey.

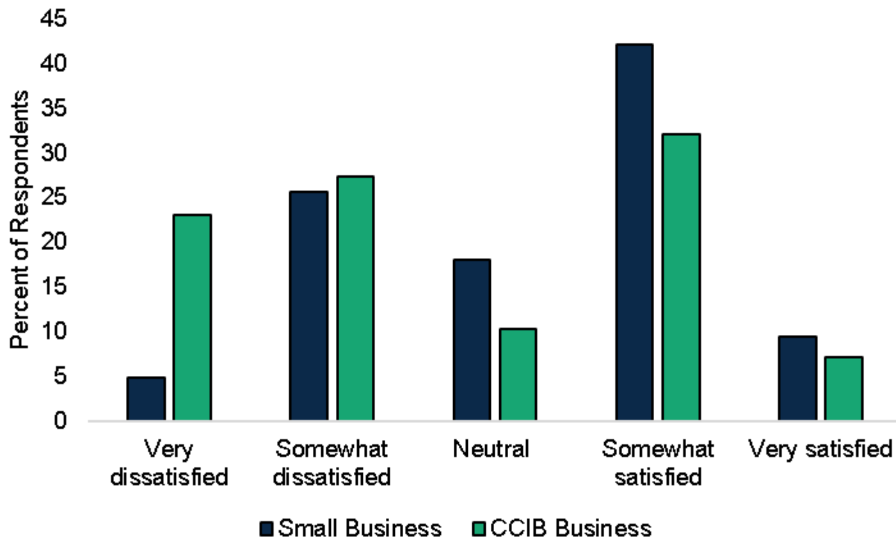
Note: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^ Indicator to be collected in telephone surveys and used in the ITS analysis.

[a] Average duration is calculated by dividing the respondent-reported total duration of outages during the reference period by the respondent-reported total number of outages during that period.

Businesses, especially larger businesses, are unsatisfied with the quality of SBEE electricity. Businesses’ satisfaction (Figure IV.2) with the quality of SBEE electricity, in terms of voltage fluctuations and equipment damage is low. Approximately half of CCIB businesses and about 30 percent of small businesses reported being very or somewhat dissatisfied with SBEE electricity quality. Fewer than 10 percent of businesses were very satisfied.

Figure IV.2. Business satisfaction with quality of SBEE electricity



Source: Benin energy infrastructure baseline small business and large business survey.

Note: Respondents are asked, “What is your overall degree of satisfaction with the quality of SBEE electricity, in terms of changes in voltage and equipment damage?”

Small businesses consumed 185 kWh in the past 30 days and CCIB businesses consumed 35,000 kWh in the past 30 days, but both types of business must rely heavily on backup energy to meet their energy needs (Table IV.12). Businesses with a direct connection spent considerably more on SBEE electricity in total than businesses with an indirect connection. In addition, businesses with a postpaid meter spent more per month in total than businesses with a prepaid meter. Overall, small businesses were not well protected against poor quality electricity. Only 6.5 percent of small businesses owned a surge protector, while 18.2 percent owned a voltage stabilizer. In addition, only 25.6 percent of small businesses reported using a backup energy source in the case of outages. Among small businesses that used a backup energy source, generators and dry cell batteries were the most common backup sources.

About 53 percent of CCIB businesses that reported an outage in the past seven days said that they used a backup energy source. Of those businesses, 93.9 percent reported using a generator and 5.4 percent reported using a solar energy system. Other backup sources were uncommon among CCIB businesses.

Table IV.12. Business energy profile

Outcome	Small business	CCIB business
SBEE electricity expenditures and consumption		
Amount spent on SBEE electricity in past 30 days, direct connection (1000s CFA)^	20.74	3,817.73
Amount spent on SBEE electricity in past 30 days, indirect connection (1000s CFA)^	3.59	n.a.
Amount spent on SBEE electricity in past 30 days (postpaid bill) (1000s CFA)[a]	21.94	n.a.
Amount spent on SBEE electricity in past 30 days (prepaid) (1000s CFA)	12.23	n.a.
Amount spent on SBEE electricity in past 30 days (respondent estimate) (1000s CFA)	14.74	n.a.
Amount of SBEE electricity consumed in past 30 days (kWh)^	184.54	35,108.91
Amount of SBEE electricity consumed in past 30 days (kWh, postpaid bill)[a]	152.43	n.a.
Amount of SBEE electricity consumed in past 30 days (kWh, prepaid)	80.32	n.a.
Protection against poor quality electricity		
Owns a surge protector (%)	6.5	33.9
Owns a voltage stabilizer (%)	18.2	54.3
Number of surge protectors owned[b]	1.47	8.81
Number of voltage stabilizers owned[b]	1.45	5.95
Use of backup energy sources		
Used any backup energy source in case of outage in past 7 days (%)	17.5	53.3
For businesses that used a backup energy source in the past 7 days:		
Used generator owned by the business as backup energy source during an outage in past 7 days (%)^	44.8	93.9
Used mini grid as backup energy source during an outage in past 7 days (%)	0.0	0.7
Used home solar energy system as backup energy source during an outage in past 7 days (%)	3.9	5.4
Used diesel (other than for a generator) as backup energy source during an outage in past 7 days (%)	N/A	2.0
Used petrol as backup energy source during an outage in past 7 days (%)	1.9	N/A
Used dry cell batteries (D, C, AA, AAA) as backup energy source during an outage in past 7 days (%)	27.9	N/A
Used candle as backup energy source during an outage in past 7 days (%)	21.0	N/A
Used other source as backup energy source during an outage in past 7 days (%)	9.5	N/A
Sample size	**756**	**333**

Source: Benin energy infrastructure baseline small business and large business survey.
Note: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA). We assumed that all CCIB businesses had a direct SBEE connection.
^ Indicator to be collected in telephone surveys and used in the ITS analysis.
N/A = not available; n.a. = not applicable
[a] 163 small business respondents and 217 CCIB respondents had a bill available to reference during the survey.
[b] Conditional on owning this equipment.

Electricity sharing was relatively common among small businesses: 29.2 percent of small businesses reported sharing electricity with another user. On average, these businesses shared with 2.44 other users, such as the business owner's household or relative, an employee, or a neighbor. This means that the electricity consumption and expenditure averages among small businesses with direct connections may be overstated because they may include not only the small business's own consumption but also that of the other users connected to the same meter.

Costs due to outages are substantial for businesses that experienced costs and many businesses own their backup generators. Although not all businesses experienced financial consequences from outages, the costs were substantial for those that did (Table IV.13). The cost of canceled orders seemed to be the largest source of financial losses for both small and CCIB businesses. Overall, the cost of lost revenue due to electricity outages in the past 30 days ranged from CFA2,611 (US$4.52) for household businesses to CFA7,623 (US$13.21) for small businesses to CFA913,126 (US$1,582.26) for CCIB businesses. Businesses also spent a considerable amount of money running backup energy sources during outages. In the past 30 days, small businesses reported expenditures of CFA4,080 (US$7.07) for backup energy, while CCIB businesses reported costs of CFA1,065,679 (US$1,846.61) for backup energy.

In addition to these direct financial costs, businesses also experienced equipment damage due to poor voltage stability, and thus faced additional costs associated with repair or replacement of damaged items. Almost 28 percent of small businesses and 50.8 percent of CCIB businesses reported damaged equipment (for any reason) in the past three months alone.

Table IV.13. Consequences of unreliable and poor quality electricity for businesses

Outcome	Household business	Small business	CCIB business
Financial consequences of outages			
Cost of spoiled products:			
Past 7 days (1.000 CFA)^	**0.2**	**1.2**	**276**
Incurred any costs in past 7 days (%)	5.3	4.2	13.0
Past 30 days, for any reason (1000s CFA)	0.67	2.67	560.68
Incurred any costs in past 30 days (%)	11.0	7.2	20.7
Past 30 days, due to poor electricity (conditional on incurring costs in past 30 days) (1000s CFA)[a]	3.37	21.30	2,430.01
Cost of salary paid to inactive workers:			
Past 7 days (1000s CFA)^	**0.16**	**0.23**	**20.37**
Incurred any costs in past 7 days (%)	0.2	1.6	5.9
Past 30 days, for any reason (1000s CFA)	0.16	2.11	80.43
Incurred any costs in past 30 days (%)	0.0	3.2	8.4
Past 30 days, due to poor electricity (conditional on incurring costs in past 30 days) (1000s CFA)[a]	0.0	11.70	62.41

Outcome	Household business	Small business	CCIB business
Cost of canceled orders:			
Past 30 days, for any reason (1000s CFA)	1.70	40.90	3,259.06
Incurred any costs in past 30 days (%)	9.2	9.1	11.5
Past 30 days, due to poor electricity (conditional on incurring costs in past 30 days) (1000s CFA)[a]	5.01	147.54	24,468.63
Cost of lost revenue in past 30 days due to poor electricity (1000s CFA)^[b]	**2.61**	**7.62**	**913.13**
Incurred any lost revenue in past 30 days due to poor electricity (%)	18.8	21.8	19.0
Total cost of backup energy source use in past 7 days (CFA)[c]	**N/A**	**2.70**	**174.84**
Total cost of using any backup energy source in last 30 days (CFA)[c]	**N/A**	**4.08**	**1,065.68**
Total cost of using any generator in past 30 days (1000s CFA)^[d]	**N/A**	**8.44**	**758.96**
Equipment damage			
Any equipment in need of repair in past three months, in general (%)^	N/A	27.7	50.8
Cost of repair or replacement of damaged equipment in last three months (1000s CFA)^	N/A	10.16	1,035.28
Any equipment in need of repair due to voltage fluctuations in past three months (%)[e]	N/A	18.1	34.8
%: Number of equipment damaged due to voltage/number of all equipment owned[f]	N/A	9.20	39.57
%: Value of equipment damaged due to voltage/value of all equipment owned[g]	N/A	0.08	0.08
Effects of power outages in the past year (%)			
Continue with backup supply	5.2	9.6	38.7
Meetings or transactions delayed	0.4	1.8	14.4
Reduced operations on backup supply	7.4	3.1	15.3
Turn customers away	39.8	24.7	14.1
Use expensive alternative energy source	3.1	1.9	21.6
Cut back on operations or holding cold perishables in stock	7.5	6.9	6.6
Waste products or discard damaged goods	10.0	3.7	6.3
Machines or appliances damaged	9.8	13.6	31.2
Stop operations and wait for power to return	42.3	34.6	30.0
None	30.9	42.3	19.8
Sample size	**117**	**756**	**333**

Source: Benin energy infrastructure baseline household, small business and large business survey.

Note: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1= 576.64 CFA).

^ Indicator to be collected in telephone surveys and used in the ITS analysis.

N/A = Not available.

[a] Conditional on having incurred any such expense in the past 30 days, for any reason.

[b] Lost revenue includes the cost of canceled orders but may also include other sources of lost revenue such as reduced operating hours and inability to accept new customers.

[c] Conditional on having used a backup energy source in the past 7 days.

[d] Conditional on using a generator in the past 30 days (n = 47 for small businesses, n = 86 for CCIB businesses).

[e] This outcome differs from the similar primary outcome in that it was constructed from a roster of equipment types and asked specifically about damage due to voltage fluctuations. We found that using the roster resulted in a higher reporting of equipment damage than a simple question about all equipment damage, likely because the roster included interior and exterior lights as a type of equipment.

[f] This outcome was defined as the number of pieces of equipment that the household reported as damaged due to voltage fluctuations in the past three months divided by the total number of pieces of equipment owned.

[g] This outcome was defined as the total value of equipment that the household reported as damaged due to voltage fluctuations in the past three months divided by the total value of all pieces of equipment owned.

Other consequences of electricity outages for businesses included delaying meetings and transactions, refusing customers, wasting or discarding products, and reducing or stopping operations. Thirty percent of CCIB businesses reported having to stop operations completely during an outage.

To better understand the effect of the current electricity quality on businesses, we interviewed representatives of chambers of commerce in Benin. Representatives reported that, in addition to the costs to businesses of backup electricity sources, the lack of reliable electricity can be a deciding factor for businesses to not start operations in a particular region, which results in fewer taxes collected in the region and more inequality. Further, small businesses might not have backup electricity sources (perhaps due to cost) and therefore can be particularly vulnerable to power disruptions, which can lead to loss of productivity, loss of goods and produce that need refrigeration, and ultimately loss of profit. Occasionally, according to one respondent, spoiled goods are sold to customers, thus creating a public health problem. In order to keep a steadier energy supply, some small businesses opt for solar panels in lieu of SBEE electric service.

Energy expenditures and the costs associated with poor quality power vary in magnitude relative to firms' profits and revenues. Energy expenditures range from about 15 percent of revenue for household businesses to 3.3 percent of revenue for CCIB businesses, while the cost of lost revenues due to electricity outages ranges from 3 percent of average monthly revenue for household businesses to 1 percent of monthly revenue for CCIB businesses (see Table IV.14).

Table IV.14. Business revenues, costs, and profits (for small share of businesses that reported data)

	Household business	Small business	CCIB business
Cost of electricity from any source in past 30 days (1000s CFA)[a]	8.21	12.65	3,191.41
Revenue in the past 30 days (1000s CFA)^	53.56	525.14	94,234.82
Average revenue per month during past year (1000s CFA)	80.62	641.47	70,742.13
Profit in the past 30 days (business-reported) (1000s CFA)^	22.34	128.75	3,099.84
Average profit per month during past year (1000s CFA)	36.18	79.66	27,043.25
Profit in the past 30 days (from revenue and costs) (1000s CFA)[b]	26.90	165.63	27,336.60
Business can provide some profit figure (%)	93.1	59.7	52.3
Sample size	**117**	**756**	**333**

Source: Benin energy infrastructure baseline small business and large business survey.

Notes: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^ Indicator to be collected in telephone surveys and used in the ITS analysis.

[a] This indicator combines the cost of SBEE electricity in the past 30 days with the cost of other backup electricity sources, such as generators or solar panels, in the past 30 days.

[b] This indicator is calculated from business-reported costs and revenue.

[c] This indicator shows the percentage of businesses for which we had at least one of the three profit figures.

We note that estimating revenues, costs, and profits, especially in the CCIB and small business samples, was challenging. Respondents were often reluctant to provide sensitive financial information about their business or were unable to provide an estimate for profits in the past 30 days. Average profits calculated from estimated revenues and costs are about CFA 27 million (roughly US$47,000), while profits over the last 30 days as estimated by firms are CFA 3 million (US$5,371). This discrepancy is partly due to a difference in the set of firms providing answers to both questions, but it is also due to differences in the construct. Of the 53 firms for which we have both measures, we find that profits constructed from estimated revenues and costs are on average lower than profits estimated by the firm. As we develop the telephone and follow-up survey instruments, we will pilot alternative question wording to improve our firm profit measure.

3. Public institutions

Interviews with representatives of public institutions such as schools, health clinics, and municipal social security and mayoral offices in Cotonou and in municipalities in other regions revealed challenges from poor quality electricity similar to those experienced by businesses.

Public institutions reported high expenditures for backup sources, such as generators, and therefore had to make choices about the types of services and operations they could provide during electricity outages. SBEE was the main energy source for all public institutions we interviewed. In the event of a power outage, most institutions used generators as a backup source. However, representatives of the public institutions reported that running generators could cost four to five times more than grid electricity. Although most public institutions had generators, they prioritized critical operations during power outages, such as powering refrigerators to preserve medicines and powering maternity units, operating rooms, and administration offices. Larger institutions require more than one generator to provide backup for equipment and services. Some smaller health clinics do not use air conditioning units and other nonmedical equipment during grid outages in order to reduce generator costs. A handful of institutions without generators installed solar panels to power lighting during outages; however, the power generated from the solar panels was not sufficient to cover all of these institutions' needs. Some respondents identified theft as a problem preventing them from using solar panels as a backup source.

Although public institutions reported a reduction in the frequency and duration of power outages in recent years, these institutions continued to experience equipment damage due to unstable electricity. Public institutions reported improvements in the frequency and duration of outages compared to prior years, when power outages could last for days and even months. Currently, outages last anywhere from 30 minutes up to a day, according to these respondents. Despite improvements in electricity service in recent years, public institutions continued to experience damage to air conditioning units, refrigerators, freezers, electric meters, oxygen machines, and other lab equipment, particularly during power surges and brownouts. Replacing the damaged equipment was an expenditure that some representatives of public institutions stated they could not afford. To reduce the extent of damage to devices of greatest sensitivity (and perhaps of greatest value), public institutions reported using regulators, surge protectors, and other protective devices. However, some institutions noted that these protective devices were not effective in preventing damage to the equipment when there were sudden drops or surges in power tension. In some instances, they limited the use of certain equipment to avoid potential damage from brownouts. For example, government administrative offices may not use desktop computers during the day, when voltage instability is high. Rather, they use battery-powered laptops, if available.

In addition to equipment damage, power outages caused service delays that negatively affected public institutions' operations and productivity. Primary, secondary, and tertiary education institutions reported that power outages led to interruptions in exams conducted in the late afternoon or evening, when there is reduced daylight; practical sessions that required the use of electric equipment and classroom lighting; and any other school activities that required electricity. Time lost during power outages is rarely recovered, according to school representatives, and is a particular problem for technical schools. Without advance notification of planned power interruptions, educators report that making adjustments to the daily curriculum is difficult. Teachers may struggle to complete the required annual curriculum when classes are dismissed early due to power outages. School directors reported that power interruptions negatively affect students' performance and staff productivity. Health institutions reported that "almost everything comes to a standstill when there is an outage." Surgeries must be rescheduled because doctors don't trust the reliability of generators to support the operations. These losses are less common now, according to hospital officials, because larger hospitals in Benin have multiple energy backup sources. Other public institutions, such as tax authorities, social security authorities, and mayor’s offices reported that power outages and other service disruptions prevented them from completing their required work and negatively affected their productivity levels. In addition, administrative offices reported loss of data when machines shut down or experience damage as a result of unstable electric current.

V. EVALUATION ADMINISTRATION

Given the complexity of this multicomponent project, careful management of the evaluation, including the timeline, is essential to our success. In this section, we discuss several administrative matters relevant to conducting the evaluation.

A. Summary of IRB requirements and clearances

Mathematica has ensured that the study meets all U.S. and Beninois research standards for ethical clearance. Mathematica submitted an application to its U.S.-based IRB prior to conducting the listing activity and provided updated materials for the baseline survey and qualitative data collection prior to conducting each of those data collection activities. The U.S. IRB approval required three sets of documents: (1) a research protocol that described the purpose and design of the research and provided information about our plans for protecting study participants and their confidentiality and human rights, including how we acquired consent for their participation; (2) copies of all data collection instruments and consent forms that we used for the evaluation; and (3) a completed IRB questionnaire that provided information about the research protocol, how we will securely collect and store our data, our plans for protecting participants' rights, and any possible drawbacks for participants that might result from any breach of data confidentiality. The study qualified for expedited review because it presents minimal risk to participants. The IRB approval is valid for one year. We will submit annual renewals for approvals for subsequent years, as needed. We received IRB approval for another year in March 2019.

Mathematica also submitted the study for approval by the Institut National de la Statistique et de l'Analyse Économique (INSAE), Benin's national statistics agency. To obtain the certification required to conduct social sciences research in Benin, Mathematica's local research team submitted to INSAE the required application materials, including a description of the study methodology, the instruments and enumerator manuals, a community awareness plan, the timeline, the budget, and a dissemination plan. We submitted materials and received approval for the listing activity, baseline survey, and qualitative data collection prior to conducting each data collection activity. The local research team met with INSAE's review board in Cotonou and responded to all questions about the study design and survey protocols, with assistance from Mathematica.

B. Preparing data files for access, privacy, and documentation

All data collected for this evaluation are securely transferred from the data collection firm to Mathematica, stored on Mathematica's secure server, and accessible only to project team members who use the data. After producing and finalizing each of the final evaluation reports, including this baseline report, we will prepare corresponding de-identified data files, user manuals, and codebooks based on the quantitative survey data. We understand that these files could be made available to the public; therefore, the data files, user manuals, and codebooks will be de-identified according to MCC's most recent guidelines. Public use data files will be free of personal or geographic identifiers that would permit unassisted identification of individual respondents or their households. In addition, we will remove or adjust variables that introduce a reasonable risk of deductive disclosure of the identity of individual participants. We will also recode unique and rare data by using top and bottom coding or by replacing these observations with missing values. If necessary, we will also collapse any variables that make an individual highly visible, because of geographic or other factors, into less easily identifiable categories.

C. Dissemination plan

To ensure that the results and lessons from the evaluation reach a wide audience, we will work with MCC to increase the visibility of the evaluation and its findings within the energy sector, particularly among policymakers and practitioners. We will present findings from each round of analysis in the baseline, interim, and final evaluation reports. We will distribute draft reports to stakeholders for feedback before finalization and will present findings to MCC headquarters in the District of Columbia and at MCA-Benin II headquarters in Benin.

We expect the broader research community to have a strong interest in the findings from the evaluation. To facilitate wider distribution of the findings and lessons learned, we will collaborate with MCC and other stakeholders to identify additional forums—such as conferences, workshops, or publications—for disseminating the results and will encourage other donors and implementers to integrate the findings into their programming.

D. Evaluation team: Roles and responsibilities

Our team brings expertise in electrification in Africa; an understanding of grid engineering, electricity distribution, and maintenance management; and decades of experience from conducting impact and performance evaluations in West Africa. The evaluation team includes the personnel described in Table V.1.

Table V.1. Evaluation team members

Evaluation team members	Role	Responsibility
Dr. Sarah Hughes	Project director/primary point of contact for client	Communicating with client, coordinating with key stakeholders in the Benin energy sector, overseeing evaluation budget, overseeing survey and qualitative data collection, managing evaluation team staffing and priorities, primarily responsible for delivering high quality products that meet MCC's and other stakeholders' needs
Dr. Christopher Ksoll	Principal investigator	Leading the evaluation design and data analyses, overseeing the execution of the quantitative components of the design and data collection, managing quantitative data analysis, providing oversight of measurement, ensuring research questions are answered with appropriate methods
Dr. Anthony Harris	Researcher	Supporting the analysis and data collection, acting as the primary point of contact for sampling for the grid-level outcomes, managing quantitative data cleaning and analysis
Dr. Arif Mamun	Quality assurance reviewer	Providing peer review of all deliverables, supporting evaluation design decisions and data collection approaches, acting as a senior advisor to the evaluation team

Evaluation team members	Role	Responsibility
Ms. Kristine Bos	Researcher	Supporting the analysis and data collection, coordinating data collection subcontractors
Mr. Cullen Seaton	Analyst	Supporting the analysis and data collection, coordinating data collection and subcontractors
Ms. Dara Bernstein	Research assistant	Managing internal administrative matters as well as invoicing and reporting, supporting data collection and analysis
Mr. Denzel Hankinson	Energy economist	Providing technical expertise on energy sector in design and reporting phases
Mr. Serge Kennely Wongla	Local research coordinator and data quality expert	Assisting communication with MCA-Benin II and project implementers; identifying and overseeing local data collection partners to ensure international standards for fieldwork, ethics compliance, and data quality
Mr. Mawuena Adjogah	Consultant and electrical engineer	Assisting with collecting and interpreting grid data, including SAIDI/SAIFI, voltage quality, and blackout data; helping the team with the technical aspects of implementation activities

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Appendix A:
Overview of primary data collection

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A. Quantitative data collection

For this baseline report, we collected survey data from households, small businesses, and businesses registered with CCIB, Benin's Chamber of Commerce. Mathematica procured a local data collection firm—a consortium of Fidexi-Conseil and Innovative Hub for Research in Africa (Fidexi-IHfRA)—to conduct this work, which proceeded in two phases: (1) creating a listing of electrified households and small businesses; and (2) conducting in-person surveys with electrified households, small businesses, and CCIB businesses. In this appendix, we describe the sampling and data collection procedures for the baseline study.

1. Listing of households and small businesses

After defining the project areas, as described in Section III.A above, Mathematica, in consultation with Fidexi-IHfRA, subdivided the selected areas into blocks for sampling. This subdivision was accomplished using satellite imagery to select logical subdivisions (based on roads and other landmarks) with roughly 50 structures within them. Mathematica manually removed the few blocks that had fewer than 10 structures visible with satellite imagery and those that clearly contained government buildings or very large businesses or industrial areas.

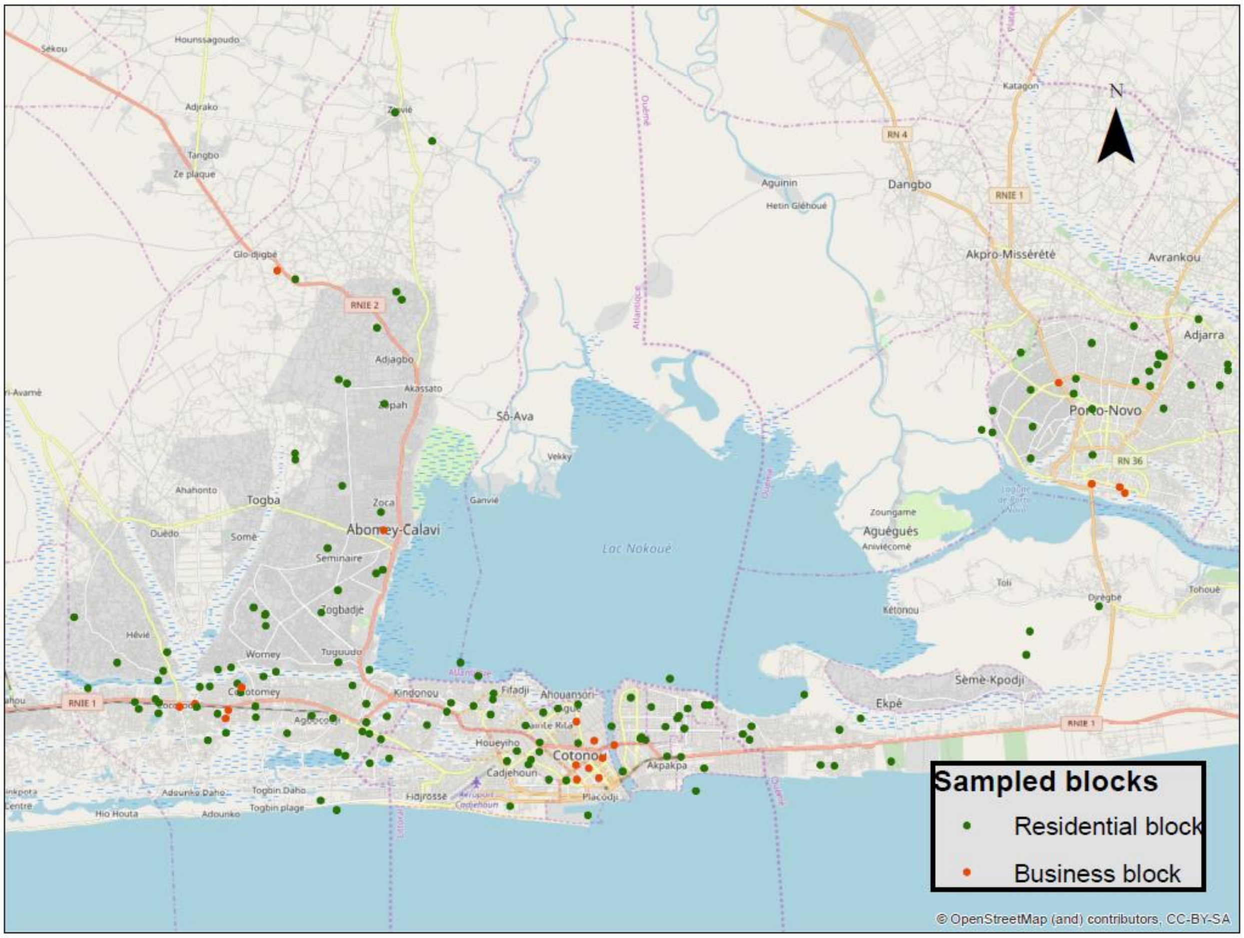
To begin, we selected all 34 "business blocks" that contained key markets, such as Dantokpa in Cotonou. From the remaining 5,694, which we call "residential blocks," we randomly selected a fixed number of blocks from each project area. The resulting sample of blocks is displayed in Table A.1.

Table A.1. Sampled blocks, by project area

	Sampled blocks	Nonrandomly sampled business blocks	Total
Bohicon	14	8	22
Djougou	22	2	24
Greater Cotonou	82	19	101
Natitingou	17	1	18
Parakou	22	4	26
Total	**157**	**34**	**191**

In Figure A.1. we show the approximate location of the sampled residential and business blocks in the Greater Cotonou area.

Figure A.1. Approximate location of sampled blocks in Greater Cotonou



Note: Due to concerns over revealing personally identifiable information through maps, we randomly altered the precise locations of the blocks.

The purpose of the listing was to develop a sample frame of all SBEE-electrified households and small businesses in the sampled subsections of the project areas. This data collection effort differed from a traditional listing, in that Mathematica developed a short survey to be administered to each entity encountered rather than simply recording the presence of every dwelling unit in the selected enumeration area. The purpose of this survey was to determine whether the household or business was eligible for inclusion in the evaluation sample and collect information to stratify our survey sample. The listing survey included separate modules for households and businesses. Table A.2 shows the information collected in the listing survey.

Table A.2. Listing survey content

Households	Businesses
Household head name, sex, employment status	Business owner name, sex
Number of household members	Number of employees

Households	Businesses
Electricity source (direct/indirect connection SBEE, generator, solar, minigrid)	Electricity source (direct/indirect connection SBEE, generator, solar, minigrid)
If SBEE connection, type of meter	If SBEE connection, type of meter
Housing floor, wall, and roof materials	Business floor, wall, and roof materials
Presence of a business operated within the household premises, number of employees, and sector of business	Business activity and sector
Household phone numbers and GPS coordinates	Business phone numbers and GPS coordinates

The data collection team conducted a pre-test of tools in late August 2018. Mathematica participated in the training of enumerators and the pre-test activity from August 28–August 31, 2018. The data collection team trained a small group of enumerators to use the listing survey tool as well as the maps and procedures to be used to identify the block boundaries and ensure that they contacted all buildings within a given block. The pre-test was conducted for one day in areas of Cotonou not selected for inclusion in the main data collection. Following the pre-test, Mathematica and Fidexi-IHfRA discussed lessons learned and decided on revisions to the survey instrument and listing procedures. The full enumerator training for the listing activity occurred from October 23–26, 2018 and included a one-day pilot in Cotonou; the Mathematica team participated in both the training and the piloting of the instruments and protocols.

The data collection team was instructed to list electrified households and businesses in the residential blocks and only electrified businesses in the business blocks. In the high-density business blocks, such as those containing Dantokpa market, enumerators were instructed to list only a fraction of businesses to ensure the listing could be completed in a timely manner. The proportion of businesses sampled for the listing ranged between one in five and one in three businesses, depending on the size of the market.

The listing data collection occurred from November 13, 2018 to January 9, 2019. In total, 19,325 households and 9,992 businesses were listed.

2. Survey sample of households and small businesses

Following completion of the listing and data cleaning, Mathematica constructed the sample frame for the household and small business in-person surveys. To do so, we removed any household or small business from our sample frame if (1) the household or small business did not consent to the listing survey, (2) the household or small business did not have a direct or indirect SBEE connection, (3) the variables on which we intended to stratify the sample were missing, or (4) the respondent did not provide sufficient contact information to locate them again. We also eliminated any household or small business from the sample frame whose GPS coordinates were more than five meters outside of the designated blocks, using ArcGIS software.[7] Finally, we

[7] The average margin of error for the GPS function used for the interviews was slightly less than five meters. We assumed that any households or businesses located more than five meters outside of the block boundary had been listed in error.

dropped any block that had fewer than 10 eligible households. The resulting sample frame included 12,310 households across 147 blocks and 5,051 small businesses across 158 blocks.

For the household survey, we randomly selected 10 households per block, stratified by gender of the household head and household business operation. The numbers of households sampled per block by strata are displayed in Table A.3. Some blocks had insufficient numbers of households in one or more strata. For these blocks, we first reallocated within the gender of a household head category. If another household with the same gender of household head was unavailable, we then sampled a household with the same business strata but for which the household head was a different gender. If neither a household with the same business status or same gender of household head was available, we sampled a household with a different gendered household head and business status. The number of households sampled for each stratum was the same in each region except for Abomey-Calavi, where we sampled two additional male-headed households without a household business to balance out the sampling weights.

Table A.3. Sampling strata for households

	Female	Male
Household business	1	2
No household business	2	5 (7 in Abomey-Calavi)

Unlike the household survey, the small business survey was administered in two types of blocks: residential blocks (which contained a mix of households and small businesses), and business blocks, which contained large markets and other businesses. Within each block, we then stratified based on whether a business was within a market or stand-alone. Stand-alone businesses were defined as those not operated from a market or out of a household. Almost no residential blocks contained a market, and several market blocks had no stand-alone businesses, so a single block commonly contained only one stratum. In rare cases, blocks could contain at least two types of businesses, which usually occurred because a smaller market had not been identified during the process of defining business and residential blocks.

We determined our business sampling rates as follows:

For businesses within markets, we manually assigned a number of businesses to be sampled per market. For example, for a large market like Dantokpa we sampled 25 businesses, whereas for smaller markets like the Grand Marché de Porto Novo, we sampled only 4 businesses.

For stand-alone businesses, we used the following rules:

1. Our sampling rate was not to be less than 8 percent of eligible stand-alone businesses in residential blocks and not less than 7.5 percent of eligible stand-alone businesses in business blocks.
2. We sampled at least four enterprises per residential block and at least three per business block.

3. We sampled a maximum of 10 businesses per block if the total number of eligible businesses in the block was less than 200.
4. We sampled 20 businesses per block if there were more than 200 eligible businesses in the block.

The resulting target sample sizes for the household and small business baseline in-person surveys are shown in Table A.4.

Table A.4. Survey sample size: households and small businesses

Project area	Households	Small businesses
Bohicon	140	64
Djougou	195	63
Greater Cotonou	772	452
Natitingou	160	69
Parakou	227	107
Total	**1,494**	**755**

3. Survey sample of medium and large businesses

In the design report, we defined small businesses as those with fewer than 20 employees and medium and large businesses as those with 20 or more employees, consistent with the World Bank Enterprise Survey's definition. For our survey of medium and large businesses, we considered two potential data sources from which to construct our sample frame. The first source was SBEE's list of medium-voltage (MV) customers in the greater Cotonou area. However, this source of data was not suitable for our survey because it excluded businesses outside of Cotonou and included MV customers we did not wish to survey, such as embassies and schools. To obtain our sample, we instead used a list of medium and large businesses provided by CCIB. The list contained a number of registered businesses throughout Benin, along with associated contact and sector information. After dropping businesses located in rural areas, we initially drew a random sample of 400 businesses from the CCIB list, stratified by project area. However, the data collection team faced difficulties in locating many of the businesses, despite the address and contact information, and in gaining the cooperation of businesses in CCIB's list. In the end, the team attempted to contact and interview all 634 businesses from the CCIB list. The distribution of these businesses by project area is shown in Table A.5. We describe the actual sample obtained in Section 1.e below.

Table A.5. Survey sample size: medium and large businesses

Project area	Target sample size	Sample frame
Bohicon	77	106
Djougou	8	8
Greater Cotonou	240	428
Natitingou	30	33
Parakou	45	59
Total	**400**	**634**

4. Sampling for placement of smart meters

We plan to place smart meters with 275 households, 129 small businesses, and 31 CCIB businesses who have low-voltage (LV) connections. In addition, we intend to place smart meters at 45 MV customers, if possible. Smart meter placement is scheduled to take place in the summer of 2020.We have worked closely with MCA-Benin II and its contractors to specify the requirements for these smart meters. Specifically, the smart meters should record outages, over- or under-voltage events, voltage, consumption, load, and reactive energy (for MV customers).

We will use our baseline survey data to create the sample of end users who will receive smart meters. One key criterion for inclusion in the smart meter sample will be that the household or business has a direct connection to SBEE with a meter. The smart meter sample will comprise a subset of the telephone survey sample.

In Table A.6, we show the distribution of smart meters across project areas, by LV and MV customers. We also show the distribution of the baseline survey sample for comparison.

Table A.6. Distribution of baseline survey sample and proposed smart meter sample

	Parakou	Natitingou	Djougou	Bohicon	Cotonou/ Porto Novo	Total
Survey sample						
Households	229	161	195	141	770	1,496
Small businesses	106	69	63	64	454	756
CCIB businesses	35	24	7	64	203	333
Smart meters—LV customers						
Households	46	31	39	28	131	275
Small businesses	20	15	16	12	66	129
Total	*64*	*46*	*55*	*40*	*197*	*404*
Smart meters—CCIB businesses (LV and MV customers	5	5	5	7	54	45

Note: This table reflects the final sample shared with MCA-Benin II and its contractor.

We will allocate smart meters to the different project areas according the following criteria:

- We will place the largest number of smart meters in Cotonou and the surrounding area (Seme, Porto-Novo, Abomey-Calavi) because that is where the largest proportion of MCC's investments are located. This area is also the one with the largest number of potential beneficiaries.
- Parakou has a larger number of MV customers than other project areas outside of Cotonou and therefore will receive slightly more smart meters at MV customers.
- Smart meters will be placed across the remaining project areas based on the relative population distribution. We will place the minimum number of smart meters needed to estimate changes over time, so some project areas will be oversampled compared to the distribution of baseline survey respondents.

5. Survey data collection

Following completion of the listing activity, Mathematica cleaned the listing data and conducted sampling for the household and small business baseline surveys. Mathematica developed three separate survey instruments for each of the three types of respondents: households, small businesses, and CCIB businesses. The small business and CCIB business instruments contained the same modules, though some of the questions in the CCIB business survey were specifically tailored to larger businesses. Table A.7 shows the modules included for households and businesses.

Table A.7. Baseline survey content

Household	Business
Respondent and household information	Business information
SBEE grid electricity consumption and expenditures	SBEE grid electricity consumption and expenditures
SBEE grid electricity quality	SBEE grid electricity quality
Backup source of electricity	Backup source of electricity
Non-electric energy use	Non-electric energy use
Electrical appliances	Electrical appliances
Adult time use	Financial information
Child time use	
Household assets	
Household small business operations	
Telephone survey preparation	Telephone survey preparation

The start of data collection was delayed per the initial work plan in part because of the U.S. government shutdown in December 2018 through January 2019 and in part because of the parliamentary elections in Benin in April 2019. Similar to the listing data collection, Fidexi-

IHfRA conducted a pre-test training and pre-test of the instruments from March 19–23, 2019, followed by the main interviewer training from May 20–26, 2019. Mathematica participated in both trainings and in the post-training pilots. Data collection launched on June 17, 2019. The household and small business data collection concluded on August 11, 2019; the CCIB business data collection concluded on August 21, 2019.

6. Survey response rates and replacement procedures

Mathematica provided the data collection team with the list of sampled households and small businesses, and a randomly ordered list of replacements within each sampling stratum. The team drew from the list of replacements, in order and within the same sampling strata, when one of the originally sampled households or businesses was deemed ineligible for one of the following reasons:

- Not found
- Not available, after a minimum of three visits on different days/times[8]
- Refused
- No longer had SBEE electricity

In the event that a household or business had moved since the listing activity but had been replaced by another eligible household or business, the data collection team interviewed the new household or business. Overall, the team contacted 1,888 households and 1,337 small businesses from the initial sample and list of replacements, and successfully completed surveys with 1,496 electrified households and 756 electrified small businesses. The nonresponse rates, by reason, are shown in Table A.8 below.

As mentioned above, Mathematica provided Fidexi/IHfRA with the full sample frame of CCIB businesses (634 businesses). The data collection team tried to locate and arrange a meeting with every business from that list but was able to successfully interview only 333 businesses, for a response rate of 52.5 percent.[9] Because some of these businesses were quite small (as defined by number of employees)[10], we refer to this sample as the CCIB business sample rather than the medium and large business sample.

As shown in Table A.8, the most common reasons for CCIB business nonresponse were that businesses could not be found—in some cases because they were never actually located in the specified physical location, or no longer existed because they went out of business. Other businesses refused to participate or did not have SBEE electricity.

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[8] This code is only applicable for the household and small business sample as these respondents had been previously contacted as part of the listing.

[9] For comparison, the World Bank Enterprise Survey in Benin (2016) successfully completed interviews with 44 percent of contacted businesses (World Bank 2016).

[10] The World Bank defines small businesses as those with fewer than 20 employees. 55.5 percent of CCIB businesses had 19 or fewer employees.

Table A.8. Baseline survey nonresponse, by survey

Reason	Household		Small business		CCIB business	
	Original sample	Replacements	Original sample	Replacements	Original sample	Replacements
Number contacted	1,494	394	755	582	396[a]	226[a]
Not found/no longer exists	72 (4.82%)	147 (37.31%)	72 (9.50%)	283 (48.63%)	150 (37.88%)	105 (46.46%)
Not available	52 (3.48%)	26 (6.60%)	40 (5.30%)	56 (9.62%)	n.a.	n.a.
Refused	17 (1.14%)	1 (0.25%)	14 (1.85%)	60 (10.31%)	14 (3.54%)	5 (2.21%)
No SBEE	70 (4.69%)	7 (1.78%)	48 (6.36%)	8 (1.37%)	9 (2.27%)	6 (2.65%)
Completed surveys	1,283 (85.88%)	213 (54.06%)	581 (76.95%)	175 (30.07%)	223 (56.31%)	110 (48.67%)
Total sample size	**1,496**		**756**		**333**	

Notes: The response rate among replacements is significantly lower than among the original sample because the data collectors did not exert the same effort to find replacement households/small businesses as they did for the original sample. Likewise, they did not exert the same effort to gain cooperation among replacement small businesses as they did among the original sample.

[a] Because of some duplicates in the original list, the number of unique businesses in the original sample and the replacements was slightly lower than the 400 originally sampled and the 234 original replacements.

n.a. = not applicable

7. Data quality checks

During data collection, both Fidexi-IHfRA and Mathematica conducted data quality checks. Fidexi-IHfRA's checks consisted of field supervision, back-checks, and high-frequency checks of the data. Mathematica conducted extensive testing of the computer-assisted personal interview (CAPI) survey instrument before deployment of the field teams. During data collection, Mathematica downloaded the data as they were uploaded to the server and conducted checks on key data quality indicators. As part of these checks, Mathematica did the following:

- Analyzed GPS coordinates to ensure that enumerators were located in the correct enumeration areas and households and businesses surveyed were the same as those sampled from the listing
- Examined survey duration and prevalence of "don't know/refused" responses by enumerator
- Monitored tabulations of key variables
- Verified that unique identifiers were in fact unique
- Verified that mobile phone numbers (critical for follow-up telephone survey rounds) were obtained
- Verified that key billing data for linking survey data with SBEE account information was obtained

Fidexi-IHfRA and Mathematica remained in close contact during data collection and data cleaning to discuss and resolve any problems found in the data.

B. Qualitative data collection from officials in public institutions

1. Data collection sample size and procedures

As described in Chapters I and II, our assessment of the effects of the Electricity Generation Project and the Electricity Distribution Project on public institutions relies on a purposively selected sample of public institutions and an in-depth qualitative interview guide rather than a representative sample and quantitative survey instrument. For the data collection, we selected seven communities across the project areas and that differ based on socioeconomic and urban/rural status. We selected one urban and one rural community from the northern project areas (Djougou, Natitingou, and Parakou) and urban communities in Cotonou, Porto Novo, Abomey-Calavi, and Bohicon from the southern project areas, where project activities will be concentrated in urban areas. Within the selected communities, we identified SBEE-connected public institutions well positioned to respond to questions about the impacts of electricity quality on public services, businesses, and the community as a whole. Thus, we selected representatives from education and health institutions, mayors' offices, tax authorities, social security authorities, chambers of commerce, and SBEE agency leads and service managers. Table A.9 indicates the public institutions sample by type of institution and geographical coverage of the interviews.

Table A.9. Qualitative sample size, by data source

Data source	Sample size	Regions
Primary school director	2	Cotonou, Natitingou
Secondary school director	3	Cotonou, Djougou, Bohicon
University representative	1	Parakou
Health clinic representative	4	Cotonou, Natitingou, Djougou
Hospital representative	2	Parakou, Natitingou
Local Ministry of Health representative	1	Natitingou
Social Security authority representative	2	Parakou, Cotonou
Mayor's office representative	6	Bohicon, Djougou, Abomey-Calavi, Parakou, Porto-Novo, Natitingou
Tax authority representative	2	Cotonou, Parakou
Chamber of Commerce representative	1	Parakou
SBEE technical service manager	5	Cotonou, Natitingou, Bohicon, Parakou
SBEE Agency lead	2	Cotonou, Djougou
Total interviews	**31**	

Mathematica contracted with the *Laboratoire d'Anthropologie Appliquée et d'Education au Développement Durable* (LAAEDD), a research organization based at the University of Abomey-Calavi with experience conducting qualitative data collection for social policy purposes.

2. Development of key informant interview guides

Mathematica drafted the key informant questionnaires using the study domains, research questions, and program logic model. MCC reviewed the interview guides and provided feedback on the types of institutions included in the sample and on the interview topics. LAAEDD also provided feedback on the questionnaires and conducted a two-day pre-test of all final interview guides a week before the start of the in-country training. The pre-test was conducted among participants with similar characteristics to those of the target study population. After the pre-test, LAAEDD conducted a cognitive debrief with the pre-test participants to assess the reliability and pertinence of the questionnaires and to identify problems with question wording or data collection protocols. The information collected during the pre-test was used to finalize the key informant interview guides and prepare for the in-country training.

3. Data collector training

Together with LAAEDD's staff and our local research coordinator, we conducted a five-day training workshop in Cotonou. The training developed a common understanding of the key informant interview guides, data collection protocols, and supporting systems for field operations. We led sessions explaining the MCC power compact activities in Benin, scope of the evaluation, roles of the interviewers and note takers, importance of ethics and confidentiality, sampling and recruiting procedures, and interview techniques. The interviewers and supervisors participated in detailed reviews of the interview guides, conducted practice and mock interviews, and reviewed best practices for transcribing and cleaning data. LAAEDD's director led most training sessions, supported by two Mathematica evaluation team members and our local research coordinator. During the last day of the training workshop, the team conducted a pilot test with respondents similar to the target sample. Final revisions to the key informant interview guides and preparations for the fieldwork took place after the pilot test.

4. Field data collection

The qualitative data collection field staff was divided into two teams, each comprising three interviewers and three note takers. One team was assigned to the northern regions (Parakou, Djougou, and Natitingou); the second team was assigned to the southern regions (Cotonou, Porto-Novo, Abomey-Calavi, and Bohicon). In each location, the team leader obtained the necessary approvals before proceeding with scheduling the interviews. Before the start of each interview, the interviewer sought consent to collect data and digitally record the interview. After the interviews, the field staff transcribed all digital recordings into French transcripts.

Mathematica closely monitored the data collection with the assistance of our local research coordinator, who helped organize and monitor on-the-ground operations and ensure that the team met Mathematica's data quality standards. LAAEDD staff checked all transcripts against the audio recordings to ensure quality and accuracy before sending the transcripts and audio files to Mathematica. Mathematica performed quality assurance checks of the transcripts before advancing to the analysis stage.

C. Qualitative data collection with key stakeholders

In addition to collecting data from officials in public institutions, we conducted key informant interviews with stakeholders who possess a deep knowledge of the Electricity Generation and Distribution Projects, such as MCC staff, MCA-Benin II staff, SBEE management, and project implementers. The purpose of these interviews was to understand the status of implementation and reasons for any changes to the work plan and create a baseline for the eventual implementation analysis. In Table A.10, we list the interviews conducted with these key stakeholders. Key Mathematica project staff conducted the interviews with key stakeholders in person in Cotonou; Benin; Washington, DC; and virtually.

Table A.10. Interviews with other key stakeholders

Data source	Sample size	Interview location
MCC RCD and Deputy RCD	2	Cotonou, Benin
MCC Environmental & Social Performance	1	Washington, DC
MCC Procurement	1	Washington, DC
MCC Energy Practice Group	1	Virtual
MCA-Benin II, Gender & Social Inclusion	1	Cotonou, Benin
MCA-Benin II, Operations	1	Cotonou, Benin
MCA-Benin II, Environmental & Social Performance	1	Cotonou, Benin
MCA-Benin II, Distribution staff	2	Cotonou, Benin
MCA-Benin II, Procurement	1	Cotonou, Benin
GOPA Engineer	1	Virtual
Consultant to AECOM Consultants Inc.	1	Virtual
Jacobs Engineering S.A. (JESA) Head of Mission	1	Virtual
UNOPS, program management expert	1	Virtual
Groupement Plan Libre, La Société d'Electricité Industrielle et du Bâtiment (SEIB) & L'Enterprise Nationale de Bâtiment et Travaux Publics (ENSBTP), Head of Project	1	Virtual
Agence française de développement (AFD)	1	Cotonou, Benin
SBEE Management	2	Cotonou, Benin
Total interviews	**19**	

Appendix B:
Additional descriptive tables for household data, disaggregated by project area and by gender of household head

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The following sections report mean values for key variables disaggregated by project area and by gender of the household head. The tables report variables by domain and correspond to Tables in Chapter IV.

A. Descriptive household data by project area

The following tables report mean values for key variables disaggregated by project area. We divide the sample into households located in Greater Cotonou (Cotonou, Abomey-Calavi and Porto Novo) and in the northern project area (Natitingou, Parakou, Bohicon and Abomey).

Table B.1.1. Description of household sample (by project area)

Variable	Mean	
	Greater Cotonou	Northern project areas
Located in Greater Cotonou (%)	100	0
Household head is female (%)*	20.9	18.1
Household head's age	43.17	43.31
Household head's age: 17-29 years (%)	15.7	15.1
Household head's age: 30-39 years (%)	27.1	30.4
Household head's age: 40-49 years (%)	27.4	23.3
Household head's age: 50-59 years (%)	15.2	15.7
Household head's age: 60+ years (%)	14.7	15.5
Household head's employment status: seeking work (%)	0.6	0.6
Household head's employment status: unemployed (%)	1	0.5
Household head's employment status: student or apprentice (%)	1.9	2.1
Household head's employment status: retired (%)	7.2	6.4
Household head's employment status: other, inactive (%)	1.4	3.6
Household head's employment status: self-employed (%)	63.7	57.3
Household head's employment status: permanent employee (%)	17.3	19.9
Household head's employment status: temporary employee (%)	5.2	8
Household head's employment status: other (%)	1.7	1.4
Household head's education level: none (%)	14.4	15.9
Household head's education level: preschool (%)	0	0.2
Household head's education level: primary (%)	21.8	22.1
Household head's education level: secondary 1 (%)	18.8	19.5
Household head's education level: secondary 2 (%)	14.8	11.3
Household head's education level: superior (%)	28.8	26.5
Household head's education level: technical/vocational (%)	1.4	4.5
Household head can read and write in French (%)	77.9	71.9
Male head or spouse can read and write in French (%)	81.7	78.3
Female head or spouse can read and write in French (%)	63.4	52.8
Number of household members	4.59	4.82
Number of children 18 or younger in household	1.9	1.89
Number of enrolled children age 6-15	0.94	0.85
Number of rooms in household used for sleeping	2.15	2.46

Variable	Mean	
	Greater Cotonou	Northern project areas
Household owns dwelling (%)	47.4	49.9
Household rents dwelling (%)	43.2	35.1
Principal source of lighting is SBEE electricity (%)	99.8	99.7
Principal source of cooking is SBEE electricity (%)	3.7	22.5
Principal source of cooking is propane (%)	33.4	11.7
Principal source of cooking is firewood (%)	6.1	6.7
Principal source of cooking is charcoal (%)	56.4	57.3
Household is connected to SBEE electricity (%)	100	100
Household uses SBEE for lighting (%)	99	99.9
Household uses SBEE for fan (%)	56.9	40.7
Household uses SBEE for air conditioning (%)	4.6	0.4
Household uses SBEE for heating spaces (%)	0	0
Household uses SBEE for heating water (%)	3.2	2.7
Household uses SBEE for pumping water (%)	3.9	1.9
Household uses SBEE for cell phone or appliance (%)	97.8	95.9
Household operates a business on home (%)	10.2	9.3
Poverty Probability Index (PPI) Score	51.01	55.97
Probability that household falls below $2.50 poverty line (PPI)	54.12	45.22
Sample size	**770**	**726**

Notes: Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

[a] Greater Cotonou is comprised of Cotonou, Porto-Novo, and Abomey-Calavi.

*Indicates a stratifying variable.

Table B.1.2. Grid-level constraints for households (by project area)

Variable	Mean	
	Greater Cotonou	Northern project areas
Outages		
Number of outages in past 7 days, any length^	2.36	4.16
Duration of outages (hours) in past 7 days, any length^	3.28	3.11
Average duration of outages (hours) in past 7 days, any length^[a]	1.22	0.8
Number of outages in past 30 days, any length	5.99	11.21
Duration of outages (hours) in past 30 days, any length	9.32	8.64
Average duration of outages (hours) in past 30 days, any length	1.68	1.14
Voltage fluctuations		
Frequency of voltage fluctuations:		
Never (%)	64.6	68.3
Daily (%)	9.4	5.3
Two to three times per week (%)	5.2	5
Few times per month (%)	20.8	21.4

Variable	Mean	
	Greater Cotonou	Northern project areas
Most common time for voltage fluctuations:		
Morning (%)	2.1	2.3
Afternoon (%)	7.2	8.4
Evening (%)	90.7	89.3
Sample size	**760**	**717**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^Denotes an ITS indicator to be collected through the telephone survey.

[a] Average duration is calculated by dividing the respondent-reported total duration of outages during the reference period by the respondent-reported total number of outages during that period.

Table B.1.3. Household energy profile (by project area)

Variable	Mean	
	Greater Cotonou	Northern project areas
SBEE electricity expenditures and consumption		
Amount of SBEE electricity consumed in past 30 days (kwh)^	68.72	49.89
Amount of SBEE electricity consumed in past 30 days (kwh, postpaid bill)[a]	114.35	62.06
Amount of SBEE electricity consumed in past 30 days (kwh, prepaid)	54.25	43.92
Amount of SBEE electricity consumed in past 30 days (kwh, respondent estimate)	61.99	53.44
Amount spent on SBEE electricity in past 30 days, direct connection (CFA)^	17229	7921
Amount spent on SBEE electricity in past 30 days (postpaid bill –net a payer) (CFA)[a]	17020	8946
Amount spent on SBEE electricity in past 30 days (prepaid) (CFA)	14730	6709
Amount spent on SBEE electricity in past 30 days (respondent estimate) (CFA)	10768	6418
Amount spent on SBEE electricity in past 30 days, indirect connection (CFA)^	4239	2884
Use of backup energy sources		
Uses any backup energy source in case of outage (%)	46	38.2
Uses generator owned by the household as backup energy source during an outage (%)	10.9	6.1
Uses home solar system as backup energy source during an outage (%)	9	11.9
Uses petrol as backup energy source during an outage (%)	13.5	1.7
Uses drycell batteries (D, C, AA, AAA) as backup energy source during an outage (%)	41.8	58
Uses candle as backup energy source during an outage (%)	32.2	7.8
Uses a backup light source when there is an outage (%)	8.8	19.2
Use of backup energy sources in the past 7 days		
Used any backup energy source in case of outage in past 7 days (%)	30.4	23.9

Variable	Mean	
	Greater Cotonou	Northern project areas
For households that used a backup energy source in the past 7 days:		
Total cost of backup energy source use in past 7 days (CFA)	794	1587
Used generator owned by the business as backup energy source during an outage in past 7 days (%)^	10.8	12.3
Used home solar system as backup energy source during an outage in past 7 days (%)	8.7	18.5
Used petrol as backup energy source during an outage in past 7 days (%)	14.4	2.3
Used drycell batteries (D, C, AA, AAA) as backup energy source during an outage in past 7 days (%)	41.4	48
Used candle as backup energy source during an outage in past 7 days (%)	32	13.2
Used other as backup energy source during an outage in past 7 days (%)	6.4	15.4
Protection against poor quality electricity		
Owns a surge protector (%)	11.5	6.9
Owns a voltage stabilizer (%)	28.1	22.4
Number of surge protectors owned[b]	1.16	1.14
Number of voltage stabilizers owned[b]	1.21	1.19
Average cost of surge protectors owned (CFA)	33152	20932
Average cost of voltage stabilizers owned (CFA)	36178	20979
Contextual indicators: Connection to SBEE network		
Direct SBEE connection (%)	52.7	57.5
Direct SBEE connection: conventional meter (%)	68.5	61.3
Direct SBEE connection: supplemental conventional meter (%)	9.2	11.5
Direct SBEE connection: prepaid card meter (%)	20.4	23
Direct SBEE connection: supplemental prepaid card meter (%)	1.9	3.9
Direct SBEE connection: decompteur (%)	0.1	0.3
Direct connection: receives an SBEE bill (%)	96.8	88.9
Indirect connection: has a meter (%)	65.9	49.3
Other users are connected to electricity meter (%)	26.5	38.9
For businesses that share electricity with another user:		
Number of other users connected to meter	2.58	3.18
Shares electricity with relative (%)	49.8	59
Shares electricity with own business (%)	6.9	1.1
Shares electricity with neighbor (%)	47.1	46.1
Number of years dwelling has been connected to SBEE electricity	9.9	10.5
Indirect connection with no meter: fixed monthly payment (%)	37.1	36.7
Indirect connection with no meter: fee based on appliance use (%)	7.4	4
Indirect connection with no meter: fee based on estimated consumption (%)	34.6	35.6
Indirect connection with no meter: included in rent (%)	0	3.2
Indirect connection with no meter: provided for free (%)	20.9	19.8

Variable	Mean	
	Greater Cotonou	Northern project areas
Indirect connection: pays SBEE (%)	6.9	9.3
Indirect connection: pays prepaid seller (%)	0.5	1.8
Indirect connection: pays relative (%)	5.1	13.9
Indirect connection: pays neighbor (%)	33.4	29.1
Indirect connection: pays landlord (%)	40.2	45.5
Indirect connection: pays nobody (%)	13.9	0.4
Contextual indicators: Electrical equipment owned		
Electrical equipment owned: interior lighting (%)	97.6	99.3
Electrical equipment owned: exterior lighting (%)	72.8	73.4
Electrical equipment owned: fan (%)	48.9	37.2
Electrical equipment owned: television (%)	72	71.7
Electrical equipment owned: satellite receiver (%)	23.8	29.6
Electrical equipment owned: DVD player (%)	11.3	14.9
Electrical equipment owned: radio (%)	33.9	33.3
Electrical equipment owned: stereo, cd player, or digital music player (%)	8.6	3.8
Electrical equipment owned: computer (%)	9.7	8.2
Electrical equipment owned: refrigerator or freezer (%)	12.4	4.4
Electrical equipment owned: air conditioner (%)	0.9	0.1
Electrical equipment owned: electric stove (%)	0.4	0
Electrical equipment owned: washing machine or dryer (%)	0.2	0
Electrical equipment owned: iron (%)	4.4	4.3
Electrical equipment owned: water pump (%)	0.3	0.1
Electrical equipment owned: soldering iron or welding machine (%)	0.3	0
Electrical equipment owned: sewing machine (%)	0.1	0.6
Electrical equipment owned: millstone (%)	0.2	0.5
Sample size	**770**	**726**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^Denotes an ITS indicator to be collected through the telephone survey.

[a] 457 respondents had an SBEE bill available to reference during the survey.

[b] Conditional on owning this equipment.

Table B.1.4. Consequences of unreliable and poor quality electricity for households (by project area)

Variable	Mean	
	Greater Cotonou	Northern project areas
Cost of backup energy sources and outages		
Total cost of all backup energy sources used in past 7 days (CFA)[a]	123	178
Total cost of all backup energy sources used in past 30 days (CFA)[a]	1227	919
Total cost of using a generator in past 30 days, conditional on using generator for backup (CFA)^[b]	3648	2500
Uses any backup energy source in case of outage (%)	46	38.2
Equipment damage		
Any equipment in need of repair in past 3 months, in general (%)^	20.3	15.9
Cost of repair or replacement of damaged equipment in last 3 months (CFA), any reason^	3615	4252
Any equipment in need of repair due to voltage fluctuations in past 3 months (%)[c]	23.2	11.5
Proportion of equipment damaged due to voltage (number of pieces) (%)[d]	7.63	4.19
Proportion of equipment damaged due to voltage (value) (%)[e]	0.05	0.03
Any equipment in need of repair in past 3 months due to voltage fluctuations (%)	56.4	35.1
Cost of repair or replacement of damaged equipment in last 3 months (CFA) due to voltage fluctuations	2795	927
Sample size	**769**	**726**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^Denotes an ITS indicator to be collected through the telephone survey.

[a] Conditional on using backup sources of energy.

[b] Conditional on using a generator.

[c] This outcome differs from the similar primary outcome in that it was constructed from a roster of equipment types and asks specifically about damage due to voltage fluctuations. We found that the roster resulted in a higher reporting of equipment damage than a simple question about all equipment damage, likely because the roster included interior and exterior lights as a type of equipment.

[d] This outcome is defined as the number of pieces of equipment the household reports having been damaged due to voltage in the past 3 months divided by the total number of pieces of equipment owned.

[e] This outcome is defined as the total value of the equipment the household reports having been damaged due to voltage in the past 3 months divided by the total value of all pieces of equipment owned.

Table B.1.5. Adult and child time use (by project area)

Variable	Mean: Greater Cotonou	Mean: Northern project areas
Adult time use (male)		
Hours per day primary male adult spent on paid work outside of home^	7.26	6.03
Hours per day primary male adult spent on work for a family business^	1.49	1.4
Hours per day primary male adult spent on cooking/preparing meal, food processing	0.41	0.28
Hours per day primary male adult spent on other household chores	0.55	0.57
Hours per day primary male adult spent on listening to radio	1.51	1.63
Hours per day primary male adult spent on watching TV	1.67	2.06
Hours per day primary male adult spent on other leisure and entertainment	1.06	1.34
Hours per day primary male adult spent on sleeping	6.83	5.66
Adult time use (female)		
Hours per day primary female adult spent on paid work outside of home^	4.11	1.83
Hours per day primary female adult spent on work for a family business^	3.73	4.13
Hours per day primary female adult spent on Cooking/preparing meal, food processing	1.87	2.32
Hours per day primary female adult spent on other household chores	2.06	2.46
Hours per day primary female adult spent on listening to radio	1.02	0.71
Hours per day primary female adult spent on watching TV	1.68	1.63
Hours per day primary female adult spent on other leisure and entertainment	0.61	0.81
Hours per day primary female adult spent on sleeping	7.12	6.29
Child time use (male)		
Hours per day boy attending school spent on sleeping	7.98	6.56
Hours per day boy attending school spent at school	4.73	6
Hours per day boy attending school spent studying at home during daylight hours^	0.63	0.72
Hours per day boy attending school spent studying at home at night^	0.9	1.12
Hours per day boy attending school spent cooking/preparing meals or food processing	0.14	0.15
Hours per day boy attending school spent on paid work outside of the home	0.02	0.04
Hours per day boy attending school spent on work for a family business	0.09	0.14
Hours per day boy attending school spent on household chores	0.74	0.55
Hours per day boy attending school spent on playing/other leisure and entertainment	3.15	3
Hours per day boy attending school spent on watching TV	1.81	1.52
Hours per day boy attending school spent on playing on the internet	0.24	0.02

Variable	Mean	
	Greater Cotonou	Northern project areas
Hours per day boy attending school spent on playing videogames or on the computer	0.35	0.11
Child time use (female)		
Hours per day girl attending school spent on sleeping	7.91	6.56
Hours per day girl attending school spent at school	4.53	5.62
Hours per day girl attending school spent studying at home during daylight hours^	0.5	0.79
Hours per day girl attending school spent studying at home at night^	0.84	1.01
Hours per day girl attending school spent cooking/preparing meals or food processing	0.42	0.66
Hours per day girl attending school spent on paid work outside of the home	0.13	0.02
Hours per day girl attending school spent on work for a family business	0.37	0.22
Hours per day girl attending school spent on household chores	0.79	0.86
Hours per day girl attending school spent on playing/other leisure and entertainment	2.1	1.84
Hours per day girl attending school spent on watching TV	1.63	1.17
Hours per day girl attending school spent on playing on the internet	0.12	0.01
Hours per day girl attending school spent on playing videogames or on the computer	0.17	0.05
Sample size	**572**	**521**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^Denotes an ITS indicator to be collected through the telephone survey.

B. Descriptive household data by gender of household head

The following tables report mean values for key variables disaggregated by gender of household head. We divide the sample into households where the head of household is female and the head of household is male.

Table B.2.1. Description of household sample (by gender of household head)

Variable	Mean	
	Female household head	Male household head
Located in Greater Cotonou (%)	81.2	78.3
Household head is female (%)*	100	0
Household head’s age	48.36	41.92
Household head’s age: 17-29 years (%)	9.8	17
Household head’s age: 30-39 years (%)	19.3	29.9
Household head’s age: 40-49 years (%)	23.1	27.3
Household head’s age: 50-59 years (%)	20.9	13.9

Variable	Mean: Female household head	Mean: Male household head
Household head’s age: 60+ years (%)	26.9	11.9
Household head’s employment status: seeking work (%)	0.1	0.7
Household head’s employment status: unemployed (%)	2.3	0.5
Household head’s employment status: student or apprentice (%)	0.7	2.3
Household head’s employment status: retired (%)	8.2	6.7
Household head’s employment status: other, inactive (%)	4.6	1.2
Household head’s employment status: self-employed (%)	70.4	60.3
Household head’s employment status: permanent employee (%)	10.6	19.7
Household head’s employment status: temporary employee (%)	0.9	7.1
Household head’s employment status: other (%)	1.9	1.5
Household head’s education level: none (%)	30.5	10.7
Household head’s education level: preschool (%)	0.2	0
Household head’s education level: primary (%)	22.4	21.7
Household head’s education level: secondary 1 (%)	20.7	18.5
Household head’s education level: secondary 2 (%)	13.3	14.2
Household head’s education level: superior (%)	12.7	32.3
Household head’s education level: technical/vocational (%)	0.2	2.5
Household head can read and write in French (%)	58.9	81.2
Male head or spouse can read and write in French (%)	79.6	81.2
Female head or spouse can read and write in French (%)	58.9	61.9
Number of household members	3.78	4.86
Number of children 18 or younger in household	1.37	2.03
Number of enrolled children age 6-15	0.65	0.99
Number of rooms in household used for sleeping	2.06	2.26
Household owns dwelling (%)	56	45.9
Household rents dwelling (%)	33.1	43.6
Principal source of lighting is SBEE electricity (%)	100	99.8
Principal source of cooking is SBEE electricity (%)	7.1	7.8
Principal source of cooking is propane (%)	29.5	28.7
Principal source of cooking is firewood (%)	6.4	6.2
Principal source of cooking is charcoal (%)	56.2	56.6
Household is connected to SBEE electricity (%)	100	100
Household uses SBEE for lighting (%)	100	99
Household uses SBEE for fan (%)	44.7	55.7
Household uses SBEE for air conditioning (%)	1.3	4.3
Household uses SBEE for heating spaces (%)	0	0
Household uses SBEE for heating water (%)	1.9	3.4
Household uses SBEE for pumping water (%)	0.7	4.2
Household uses SBEE for cell phone or appliance (%)	94.4	98.2
Household operates a business on home (%)	14.7	8.8
Poverty Probability Index (PPI) Score	53.48	51.72

Variable	Mean	
	Female household head	Male household head
Probability that household falls below $2.50 poverty line (PPI)	48.17	53.25
Sample size	**392**	**1103**

Notes: Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

[a] Greater Cotonou is comprised of Cotonou, Porto-Novo, and Abomey-Calavi.

*Indicates a stratifying variable.

Table B.2.2. Grid-level constraints for households (by gender of household head)

Variable	Mean	
	Female household head	Male household head
Outages		
Number of outages in past 7 days, any length^	2.68	2.77
Duration of outages (hours) in past 7 days, any length^	3.11	3.27
Average duration of outages (hours) in past 7 days, any length^[a]	1.12	1.13
Number of outages in past 30 days, any length	7	7.2
Duration of outages (hours) in past 30 days, any length	9.62	9.03
Average duration of outages (hours) in past 30 days, any length	1.58	1.54
Voltage fluctuations		
Frequency of voltage fluctuations:		
Never (%)	61.7	66.4
Daily (%)	8.1	8.6
Two to three times per week (%)	13.3	3
Few times per month (%)	16.9	22
Most common time for voltage fluctuations:	2.9	2
Morning (%)	8.3	7.1
Afternoon (%)	88.8	90.9
Sample size	**387**	**1089**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^Denotes an ITS indicator to be collected through the telephone survey.

[a] Average duration is calculated by dividing the respondent-reported total duration of outages during the reference period by the respondent-reported total number of outages during that period.

Table B.2.3. Household energy profile (by gender of household head)

Variable	Mean: Female household head	Mean: Male household head
SBEE electricity expenditures and consumption		
Amount of SBEE electricity consumed in past 30 days (kwh)^	53.9	68.37
Amount of SBEE electricity consumed in past 30 days (kwh, postpaid bill)[a]	85.2	109.56
Amount of SBEE electricity consumed in past 30 days (kwh, prepaid)	34.11	56.24
Amount of SBEE electricity consumed in past 30 days (kwh, respondent estimate)	52.17	62.60
Amount spent on SBEE electricity in past 30 days, direct connection (CFA)^	10930	16247
Amount spent on SBEE electricity in past 30 days (postpaid bill –net a payer) (CFA)[a]	12334	16293
Amount spent on SBEE electricity in past 30 days (prepaid) (CFA)	5383	14721
Amount spent on SBEE electricity in past 30 days (respondent estimate) (CFA)	7690	10435
Amount spent on SBEE electricity in past 30 days, indirect connection (CFA)^	3418	4130
Use of backup energy sources		
Uses any backup energy source in case of outage (%)	39.8	45.5
Uses generator owned by the household as backup energy source during an outage (%)	2.3	11.7
Uses home solar system as backup energy source during an outage (%)	5.5	10.4
Uses petrol as backup energy source during an outage (%)	10.2	11.6
Uses drycell batteries (D, C, AA, AAA) as backup energy source during an outage (%)	44.9	44.8
Uses candle as backup energy source during an outage (%)	34	26.3
Uses a backup light source when there is an outage (%)	12.2	10.4
Use of backup energy sources in the past 7 days		
Used any backup energy source in case of outage in past 7 days (%)	25.2	29.9
For households that used a backup energy source in the past 7 days:		
Total cost of backup energy source use in past 7 days (CFA)	860	1011
Used generator owned by the business as backup energy source during an outage in past 7 days (%)^	3.6	12.8
Used home solar system as backup energy source during an outage in past 7 days (%)	11.8	10.3
Used petrol as backup energy source during an outage in past 7 days (%)	10.6	12.4
Used drycell batteries (D, C, AA, AAA) as backup energy source during an outage in past 7 days (%)	44.6	42.3
Used candle as backup energy source during an outage in past 7 days (%)	34.7	26.9
Used other as backup energy source during an outage in past 7 days (%)	4	9

Variable	Mean	
	Female household head	Male household head
Protection against poor quality electricity		
Owns a surge protector (%)	4.7	12
Owns a voltage stabilizer (%)	22.4	28
Number of surge protectors owned[b]	1.07	1.17
Number of voltage stabilizers owned[b]	1.19	1.21
Average cost of surge protectors owned (CFA)	22570	32089
Average cost of voltage stabilizers owned (CFA)	27146	34761
Contextual indicators: Connection to SBEE network		
Direct SBEE connection (%)	53.1	53.9
Direct SBEE connection: conventional meter (%)	70.1	66
Direct SBEE connection: supplemental conventional meter (%)	6.7	10.4
Direct SBEE connection: prepaid card meter (%)	20.4	21.1
Direct SBEE connection: supplemental prepaid card meter (%)	2.8	2.3
Direct SBEE connection: decompteur (%)	0	0.1
Direct connection: receives an SBEE bill (%)	96.7	94.7
Indirect connection: has a meter (%)	59.7	63.4
Other users are connected to electricity meter (%)	27.3	29.4
For households that share electricity with another user:		
Number of other users connected to meter	2.86	2.71
Shares electricity with relative (%)	62.3	50
Shares electricity with own business (%)	7.9	4.8
Shares electricity with neighbor (%)	38.5	48.7
Number of years dwelling has been connected to SBEE electricity	10.79	9.83
Indirect connection with no meter: fixed monthly payment (%)	43.6	35
Indirect connection with no meter: fee based on appliance use (%)	7.6	6.2
Indirect connection with no meter: fee based on estimated consumption (%)	24.7	38
Indirect connection with no meter: included in rent (%)	0	1
Indirect connection with no meter: provided for free (%)	23.9	19.6
Indirect connection: pays SBEE (%)	3.5	8.3
Indirect connection: pays prepaid seller (%)	0	0.9
Indirect connection: pays relative (%)	12.4	5.3
Indirect connection: pays neighbor (%)	31.4	32.9
Indirect connection: pays landlord (%)	43.9	40.5
Indirect connection: pays nobody (%)	8.8	12.1
Contextual indicators: Electrical equipment owned		
Electrical equipment owned: interior lighting (%)	98.5	97.8
Electrical equipment owned: exterior lighting (%)	70.6	73.5
Electrical equipment owned: fan (%)	35.7	49.2
Electrical equipment owned: television (%)	59.8	75

Variable	Mean	
	Female household head	Male household head
Electrical equipment owned: satellite receiver (%)	15.3	27.5
Electrical equipment owned: DVD player (%)	9.2	12.8
Electrical equipment owned: radio (%)	31.8	34.3
Electrical equipment owned: stereo, cd player, or digital music player (%)	3.3	8.7
Electrical equipment owned: computer (%)	7.5	9.8
Electrical equipment owned: refrigerator or freezer (%)	9.3	11.1
Electrical equipment owned: air conditioner (%)	0	0.9
Electrical equipment owned: electric stove (%)	1.5	0
Electrical equipment owned: washing machine or dryer (%)	0	0.2
Electrical equipment owned: iron (%)	3	4.8
Electrical equipment owned: water pump (%)	0	0.3
Electrical equipment owned: soldering iron or welding machine (%)	0	0.3
Electrical equipment owned: sewing machine (%)	0.1	0.3
Electrical equipment owned: millstone (%)	0.2	0.3
Sample size	**392**	**1103**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^Denotes an ITS indicator to be collected through the telephone survey.

[a] 457 respondents had an SBEE bill available to reference during the survey.

[b] Conditional on owning this equipment.

Table B.2.4. Consequences of unreliable and poor quality electricity for households (by gender of household head)

Variable	Mean	
	Female household head	Male household head
Cost of backup energy sources and outages		
Total cost of all backup energy sources used in past 7 days (CFA)[a]	860	1011
Total cost of all backup energy sources used in past 30 days (CFA)[a]	965	1219
Total cost of using a generator in past 30 days, conditional on using generator for backup (CFA)^[b]	3047	3556
Uses any backup energy source in case of outage (%)	39.8	45.5
Equipment damage		
Any equipment in need of repair in past 3 months, in general (%)^	16.5	20.1
Cost of repair or replacement of damaged equipment in last 3 months (CFA), any reason^	4262	3619
Any equipment in need of repair due to voltage fluctuations in past 3 months (%)[c]	26	19

Variable	Mean	
	Female household head	Male household head
Proportion of equipment damaged due to voltage (number of pieces) (%)[d]	11.43	5.59
Proportion of equipment damaged due to voltage (value) (%)[e]	0.08	0.04
Any equipment in need of repair in past 3 months due to voltage fluctuations (%)	52.9	51.7
Cost of repair or replacement of damaged equipment in last 3 months (CFA) due to voltage fluctuations	2494	2334
Sample size	**392**	**1102**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^Denotes an ITS indicator to be collected through the telephone survey.

[a] Conditional on using backup sources of energy.

[b] Conditional on using a generator.

[c] This outcome differs from the similar primary outcome in that it was constructed from a roster of equipment types and asks specifically about damage due to voltage fluctuations. We found that the roster resulted in a higher reporting of equipment damage than a simple question about all equipment damage, likely because the roster included interior and exterior lights as a type of equipment.

[d] This outcome is defined as the number of pieces of equipment the household reports having been damaged due to voltage in the past 3 months divided by the total number of pieces of equipment owned.

[e] This outcome is defined as the total value of the equipment the household reports having been damaged due to voltage in the past 3 months divided by the total value of all pieces of equipment owned.

Table B.2.5. Adult and child time use (by gender of household head)

Variable	Mean	
	Female household head	Male household head
Adult time use (male)		
Hours per day primary male adult spent on paid work outside of home^	6.64	7.04
Hours per day primary male adult spent on work for a family business^	0.32	1.58
Hours per day primary male adult spent on cooking/preparing meal, food processing	0.44	0.38
Hours per day primary male adult spent on other household chores	0.98	0.52
Hours per day primary male adult spent on listening to radio	0.79	1.6
Hours per day primary male adult spent on watching TV	1.97	1.73
Hours per day primary male adult spent on other leisure and entertainment	1.66	1.07
Hours per day primary male adult spent on sleeping	6.91	6.55
Adult time use (female)		
Hours per day primary female adult spent on paid work outside of home^	4.04	3.5
Hours per day primary female adult spent on work for a family business^	3.85	3.8

Variable	Mean	
	Female household head	Male household head
Hours per day primary female adult spent on Cooking/preparing meal, food processing	1.81	2.02
Hours per day primary female adult spent on other household chores	1.97	2.21
Hours per day primary female adult spent on listening to radio	1.49	0.77
Hours per day primary female adult spent on watching TV	1.43	1.76
Hours per day primary female adult spent on other leisure and entertainment	0.69	0.63
Hours per day primary female adult spent on sleeping	7.08	6.9
Child time use (male)		
Hours per day boy attending school spent on sleeping	7.65	7.74
Hours per day boy attending school spent at school	5.72	4.81
Hours per day boy attending school spent studying at home during daylight hours^	0.54	0.67
Hours per day boy attending school spent studying at home at night^	1.13	0.9
Hours per day boy attending school spent cooking/preparing meals or food processing	0.15	0.14
Hours per day boy attending school spent on paid work outside of the home	0.04	0.02
Hours per day boy attending school spent on work for a family business	0.07	0.1
Hours per day boy attending school spent on household chores	0.9	0.67
Hours per day boy attending school spent on playing/other leisure and entertainment	2.56	3.23
Hours per day boy attending school spent on watching TV	1.75	1.75
Hours per day boy attending school spent on playing on the internet	0.12	0.21
Hours per day boy attending school spent on playing videogames or on the computer	0.3	0.31
Child time use (female)		
Hours per day girl attending school spent on sleeping	7.77	7.64
Hours per day girl attending school spent at school	5.27	4.65
Hours per day girl attending school spent studying at home during daylight hours^	0.63	0.54
Hours per day girl attending school spent studying at home at night^	0.95	0.86
Hours per day girl attending school spent cooking/preparing meals or food processing	0.65	0.44
Hours per day girl attending school spent on paid work outside of the home	0.26	0.08
Hours per day girl attending school spent on work for a family business	0.57	0.3
Hours per day girl attending school spent on household chores	0.96	0.78
Hours per day girl attending school spent on playing/other leisure and entertainment	2.03	2.05
Hours per day girl attending school spent on watching TV	1.37	1.57

Variable	Mean	
	Female household head	Male household head
Hours per day girl attending school spent on playing on the internet	0.23	0.08
Hours per day girl attending school spent on playing videogames or on the computer	0.11	0.15
Sample size	**368**	**927**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^Denotes an ITS indicator to be collected through the telephone survey.

Appendix C:
Additional descriptive tables for business data, disaggregated by project area and by gender of household head

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A. Descriptive business data tables by project area

The following tables report descriptive statistics by project area. We divide the sample into businesses located in Greater Cotonou (Cotonou, Abomey-Calavi and Porto Novo) and in the northern project areas.

Table C.1.1. Business operations (by project area)

	Mean					
	Household business		Small business		CCIB business	
Outcome	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Located in Greater Cotonou (%)*[a]	100	0	100	0	100	0
Sector (%):						
Retail	62.1	75.3	50	56.5	32.5	48.5
Manufacturing	19.1	21.8	14.2	15.3	33.5	16.9
Services	18.8	2.9	35.8	28.3	34	34.6
Number of permanent paid employees	0.14	0.2	0.81	0.73	41.7	5.61
Number of temporary paid employees	0	2.6	0.41	0.31	23.5	5.52
Number of unpaid employees, including family members	1.89	1.45	0.85	0.8	1.08	1.6
Number of employees, total	2.03	1.68	2	1.84	64.12	13.46
Percent of business owners that are female	N/A	N/A	48	45	13.73	8.65
Business owner is female (%)[b]*	69.6	86.3	49.1	45.3	12.4	7.8
SBEE connection (%):						
Direct	52.8	55.1	44.2	54.9	100	100
Indirect[c]	47.2	44.9	55.8	45.1	0	0
Business has a bank account (%)	10.4	10.6	28.6	17.7	96.4	66.7
Business is registered with the chamber of commerce (%)	N/A	N/A	24.1	32.6	100	100
Number of years business has been in operation	N/A	N/A	6.89	6	17.38	13.42
Business is one of multiple locations (%)	N/A	N/A	11.4	8.7	28.0	26.4

	Mean					
	Household business		Small business		CCIB business	
Outcome	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Number of months that business functioned during 2018	11.71	11.3	11.32	11.45	11.55	11.6
Number of days business operates per week	6.46	6.12	6.08	6.3	5.87	6.21
Sample size	**67**	**50**	**454**	**302**	**203**	**130**

Notes: Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^Denotes an ITS indicator to be collected through the telephone survey.

N/A = not available

[a] Greater Cotonou is comprised of Cotonou, Porto-Novo, and Abomey-Calavi.

[b] This indicator is defined as “Business is majority female-owned” for CCIB businesses.

[c] Businesses with an indirect connection to SBEE are those who do not have a meter connected directly to the electricity line; rather, they receive electricity from a neighbor (with or without a meter).

Table C.1.2. Grid-level constraints for surveyed businesses (by project area)

	Mean			
	Small business		CCIB business	
Outcome	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Outages				
Number of outages in past 7 days, any length^	2.42	4.41	5.28	5.11
Duration of outages (hours) in past 7 days, any length^	3.24	4.08	5.76	3.77
Average duration of outages (hours) in past 7 days, any length^[a]	1.38	1.49	1.46	0.73
Number of outages in past 30 days, any length	6.06	11.84	19.96	15.3
Duration of outages (hours) in past 30 days, any length	7.92	8.46	21.28	13.47
Average duration of outages (hours) in past 30 days, any length[a]	1.52	1.03	1.58	1.15
Frequency of voltage fluctuations:				
Never (%)	65.9	67.2	37.6	52.8
Daily (%)	9.6	6.4	24.9	12
Two to three times per week (%)	9.2	7.2	15.9	16.8
Few times per month (%)	15.3	19.2	21.7	18.4
Most common time for voltage fluctuations:				
Morning (%)	5.3	1	N/A	N/A
Afternoon (%)	37.3	32.8	N/A	N/A
Evening (%)	57.4	66.1	N/A	N/A
Sample size	**438**	**291**	**189**	**125**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^Denotes an ITS indicator to be collected through the telephone survey.

N/A = Not available

[a] Average duration is calculated by dividing the respondent-reported total duration of outages during the reference period by the respondent-reported total number of outages during that period.

Table C.1.3. Business energy profile (by project area)

Outcome	Mean			
	Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
SBEE electricity expenditures and consumption				
Amount of SBEE electricity consumed in past 30 days (kwh)^	195.3	127.08	60449.65	322.98
Amount spent on SBEE electricity in past 30 days, direct connection (1000s CFA)^	20.82	20.41	n.a.	n.a.
Amount spent on SBEE electricity in past 30 days, indirect connection (1000s CFA)^	3.44	4.66	n.a.	n.a.
Amount spent on SBEE electricity in past 30 days (postpaid bill - net a payer) (1000s CFA)	22.54	19.71	n.a.	n.a.
Amount spent on SBEE electricity in past 30 days (prepaid) (1000s CFA)	9.71	33.76	n.a.	n.a.
Amount spent on SBEE electricity in past 30 days (respondent estimate) (1000s CFA)	14.86	14.13	n.a.	n.a.
Amount spent on reactive power in the past 30 days (1000s CFA)			66.91	0.00
Amount of SBEE electricity consumed in past 30 days (kwh, postpaid bill)	158.31	131.11	n.a.	n.a.
Amount of SBEE electricity consumed in past 30 days (kwh, prepaid)	56.4	240.26	n.a.	n.a.
Amount of SBEE electricity consumed in past 30 days (kwh, respondent estimate)	214.31	116.43	n.a.	n.a.
Contextual Indicators : Connection to SBEE network				
Direct SBEE connection (%)	44.2	54.9	100	100
Direct SBEE connection: conventional meter (%)	55.9	74.1	73.6	72.3
Direct SBEE connection: supplemental conventional meter (%)	11.4	7.6	3.5	10.8
Direct SBEE connection: prepaid card meter (%)	31	11.9	13.9	19.2
Direct SBEE connection: supplemental prepaid card meter (%)	1.8	4.7	n.a.	n.a.
Direct SBEE connection: decompteur (%)	0	1.7	1.5	3.8
Direct SBEE connection: repartiteur (%)	n.a.	n.a.	7.5	0
Direct connection: receives an SBEE bill (%)	97.2	87.5	91.6	92.5
Indirect connection: has a meter (%)	29.6	45.2	n.a.	n.a.
Other users are connected to electricity meter (%)	27.4	37.5	9	15.4
For businesses that share electricity with another user:				
Number of other users connected to meter	2.4	2.6	3.07	2.17
Shares electricity with business owner's household or relative (%)	28.1	36.1	55.6	50
Shares electricity with employee (%)	4	6.4	0	35
Shares electricity with neighbor (%)	62.9	33.9	22.2	20

Outcome	Mean			
	Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Shares electricity with no relationship (%)	23.6	25.2	N/A	N/A
Number of years dwelling has been connected to SBEE electricity	7.21	5.73	16.75	13.52
Indirect connection with no meter: fixed monthly payment (%)	24.5	23.1	n.a.	n.a.
Indirect connection with no meter: fee based on appliance use (%)	4.7	2.6	n.a.	n.a.
Indirect connection with no meter: fee based on estimated consumption (%)	24.7	19.9	n.a.	n.a.
Indirect connection with no meter: included in rent (%)b	3.4	19.9	n.a.	n.a.
Indirect connection with no meter: provided for free (%)	42.2	32.7	n.a.	n.a.
Indirect connection: pays SBEE (%)	6.6	9.4	n.a.	n.a.
Indirect connection: pays prepaid seller (%)	1.6	0	n.a.	n.a.
Indirect connection: pays relative (%)	1	1.3	n.a.	n.a.
Indirect connection: pays neighbor (%)	4.4	9.6	n.a.	n.a.
Indirect connection: pays landlord (%)	29.8	19.9	n.a.	n.a.
Indirect connection: pays nobody (%)	54.7	56.5	n.a.	n.a.
Protection against poor electricity				
Owns a surge protector (%)	6.1	8.3	42.0	21.7
Owns a voltage stabilizer (%)	19.6	10.4	66.8	35.4
Number of surge protectors owned[a]	1.5	1.37	11.25	2.22
Number of voltage stabilizers owned[a]	1.43	1.62	7.47	2.04
Average cost of surge protectors owned (1000s CFA)a	27.42	21.52	1,128.04	197.28
Average cost of voltage stabilizers owned (1000s CFA)a	37.91	23.10	152.74	86.55
Use of backup energy sources				
Total cost of backup energy source use in past 7 days (1000s CFA)	2.42	4.13	237.32	15.17
Uses any backup energy source in case of outage (%)	25.7	25.3	N/A	N/A
For businesses that use any backup source				
Uses generator owned by the business as backup energy source when there is an outage (%)^	42.7	8.2	N/A	N/A
Uses home solar system as backup energy source when there is an outage (%)	4.6	2.2	16.7	31.5
Uses petrol as backup energy source when there is an outage (%)	11.4	0.6	N/A	N/A
Uses drycell batteries (D, C, AA, AAA) as backup energy source when there is an outage (%)	35.7	54	N/A	N/A

Outcome	Mean			
	Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Uses candle as backup energy source when there is an outage (%)	18.1	10.8	N/A	N/A
Uses a backup light source when there is an outage (%)	4	30	N/A	N/A
Used any backup energy source in case of outage in past 7 days (%)	18.2	14.4	70.1	27.5
For businesses that used a backup energy source during an outage in past 7 days				
Used minigrid (owned by private company or community) as backup energy source during an outage in past 7 days (%)	0	0	0	3.3
Used generator owned by the business as backup energy source during an outage in past 7 days (%)	48.5	23.7	99.1	73.3
Used home solar system as backup energy source during an outage in past 7 days (%)	3.5	5.9	0.9	23.3
Used diesel (for use other than in a generator) as backup energy source during an outage in past 7 days (%)	0	0	0.9	6.7
Used petrol as backup energy source during an outage in past 7 days (%)	2	1.2	0	0
Used drycell batteries (D, C, AA, AAA) as backup energy source during an outage in past 7 days (%)	25.8	40.1	0	0
Used candle as backup energy source during an outage in past 7 days (%)	22.3	13.8	0	0
Used other as backup energy source during an outage in past 7 days (%)	7.8	19.3	0	0
Contextual indicators: Electrical equipment owned				
Electrical equipment owned: Interior lighting (%)	90.9	95.3	N/A	N/A
Electrical equipment owned: Exterior lighting (%)	66.6	73.4	N/A	N/A
Electrical equipment owned: Fan (%)	31.8	28	N/A	N/A
Electrical equipment owned: Computer (%)	10.8	6.8	69	37.7
Electrical equipment owned: Refrigerator or freezer (%)	19.8	19	15.3	24.6
Electrical equipment owned: Air conditioner (%)	4.1	0.8	54.2	22.3
Electrical equipment owned: Electric stove (%)	0.6	0.5	N/A	N/A
Electrical equipment owned: Washing machine or dryer (%)	0.2	1.4	N/A	N/A
Electrical equipment owned: Iron (%)	3.8	1.8	N/A	N/A
Electrical equipment owned: Water pump (%)	0	0.2	N/A	N/A
Electrical equipment owned: Soldering iron or welding machine (%)	3.2	1.6	4.9	4.6
Electrical equipment owned: Sewing machine (%)	4.5	7.6	3	0
Electrical equipment owned: Millstone (%)	1.5	4.8	N/A	N/A
Electrical equipment owned: Clippers or beard trimmer (%)	4.4	1	N/A	N/A

Outcome	Mean			
	Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Electrical equipment owned: Printer or photocopy machine (%)	5.9	5.4	47.3	23.1
Electrical equipment owned: Ventilation (%)	N/A	N/A	27.6	51.5
Electrical equipment owned: Forge (%)	N/A	N/A	0	1.5
Electrical equipment owned: Metal press (%)	N/A	N/A	1	3.1
Electrical equipment owned: Saw (%)	N/A	N/A	2	10.8
Electrical equipment owned: Conveyor belt system (%)	N/A	N/A	3	0.8
Electrical equipment owned: Production line machinery (%)	N/A	N/A	20.7	6.2
Sample size	**454**	**302**	**203**	**130**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^Denotes an ITS indicator to be collected through the telephone survey.

N/A = Not available, n.a. = not applicable

[a] Conditional on owning this equipment.

Table C.1.4. Consequences of unreliable and poor quality electricity for businesses (by project area)

Outcome	Mean					
	Household business		Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Cost of backup energy sources and outages						
Cost of spoiled products:						
Incurred in past 7 days (1000s CFA)^	0.26	0.18	0.46	1.65	478.42	6.54
Incurred in past 7 days: YES (%)	5.4	4.5	4.1	1.7	12.2	14
Incurred in past 30 days, for any reason (1000s CFA)	0.46	1.71	1.76	3.69	968.62	21.04
Incurred in past 30 days, for any reason: YES (%)	8	26.1	7.3	6.2	18.5	23.6

Outcome	Mean					
	Household business		Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Incurred in past 30 days, due to poor electricity (1000s CFA)[a]	4.00	2.41	18.28	33.78	4,790.12	69.90
Incurred in past 30 days, due to poor electricity: YES (%)[a]	79.9	33.9	54.4	84.9	93.3	63.3
Cost of salary paid to inactive workers :						
Incurred in past 7 days (1000s CFA)^	0.00	0.93	0.08	0.14	33.72	1.66
Incurred in past 7 days: YES (%)	0	1.2	1.3	1.3	9	1.6
Incurred in past 30 days, for any reason (1000s CFA)	0.00	0.93	1.43	2.62	136.52	3.26
Incurred in past 30 days, for any reason: YES (%)	0	1.2	2.8	3.4	11	4.8
Incurred in past 30 days, for any reason, no zeroes (1000s CFA)[a]	N/A	N/A	51.01	77.68	1,235.87	67.92
Incurred in past 30 days, due to poor electricity (1000s CFA)[a]	N/A	N/A	0.98	4.10	68.59	44.92
Cost of canceled orders:						
Incurred in past 30 days, for any reason (1000s CFA)	1.01	5.07	46.82	55.21	4,683.86	1,304.38
Incurred in past 30 days, for any reason: YES (%)[a]	10.1	4.4	9.1	7.6	11.4	11.6
Incurred in past 30 days, due to poor electricity (1000s CFA)[a]	0.00	61.18	161.55	28.78	40,152.28	4,303.93
Cost of lost revenue in past 30 days due to poor electricity (CFA)^[b]	2.26	4.28	7.94	10.70	1,160.00	568.80
Uses any backup energy source in case of outage (%)	N/A	N/A	25.7	24	N/A	N/A
Total cost of all backup energy sources used in past 7 days (1000s CFA)[c]	N/A	N/A	4.22	7.35	1,324.94	109.09
Total cost of using a generator in past 30 days, conditional on using generator for backup (1000s CFA)^[c]	N/A	N/A	7.95	8.39	951.61	65.44

Outcome	Mean					
	Household business		Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Equipment damaged						
Any equipment in need of repair in past 3 months, in general (%)^	N/A	N/A	29.6	31	57.8	40
Any equipment in need of repair due to voltage fluctuations in past 3 months (%)[d]	N/A	N/A	19.9	18	40.1	26.6
Proportion of equipment damaged due to voltage (number of pieces)[e]	N/A	N/A	10.34	7.69	60.99	7.1
Proportion of equipment damaged due to voltage (value) (%)[f]	N/A	N/A	0.09	0.07	0.09	0.07
Needed to repair/replace in the past 3 months (any reason)						
Refrigerator or freezer (%)	N/A	N/A	27.8	10.9	27.6	28.1
Sewing machine (%)	N/A	N/A	75.5	58	N/A	N/A
Clippers or beard trimmer (%)	N/A	N/A	40.7	39.3	N/A	N/A
Printer or photocopy (%)	N/A	N/A	22.6	29.1	36.2	36.7
Air conditioner (%)	N/A	N/A	N/A	N/A	40.9	17.2
Computer (%)	N/A	N/A	N/A	N/A	38.4	34.7
Compressor (%)	N/A	N/A	N/A	N/A	55.6	20
Saw (%)	N/A	N/A	N/A	N/A	75	64.3
Production line machinery (%)	N/A	N/A	N/A	N/A	61	37.5
Interior lighting (%)	N/A	N/A	36.5	32.8	N/A	N/A
Exterior lighting (%)	N/A	N/A	32.7	26.1	N/A	N/A
Fan (%)	N/A	N/A	14	13.3	N/A	N/A
Phone (%)	N/A	N/A	N/A	N/A	17.6	14.6
Ventilation (%)	N/A	N/A	N/A	N/A	21.4	13.4
Cost of repair per item damaged by voltage						
Interior lighting (1000s CFA)	N/A	N/A	0.21	0.16	N/A	N/A
Exterior lighting (1000s CFA)	N/A	N/A	0.19	0.09	N/A	N/A

Outcome	Mean					
	Household business		Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Fan (1000s CFA)	N/A	N/A	0.69	0.93	N/A	N/A
Computer (1000s CFA)	N/A	N/A	3.76	4.63	24.68	15.69
Refrigerator or freezer (1000s CFA)	N/A	N/A	3.10	0.84	298.25	14.53
Air conditioner (1000s CFA)	N/A	N/A	0.09	0.11	29.36	5.66
Iron (1000s CFA)	N/A	N/A	0.00	0.00	N/A	N/A
Soldering iron or welding machine (1000s CFA)	N/A	N/A	0.71	7.44	0.00	11.67
Sewing machine (1000s CFA)	N/A	N/A	0.23	0.00	0.00	0.00
Millstone (1000s CFA)	N/A	N/A	0.00	1.08	N/A	N/A
Clippers or beard trimmer (1000s CFA)	N/A	N/A	2.24	3.48	N/A	N/A
Printer or photocopy machine (1000s CFA)	N/A	N/A	1.36	1.56	23.73	18.87
Phone (1000s CFA)	N/A	N/A	N/A	N/A	24.81	0.00
Ventilation (1000s CFA)	N/A	N/A	N/A	N/A	2.02	0.96
Compressor (1000s CFA)	N/A	N/A	N/A	N/A	351.56	0.00
Forge (1000s CFA)	N/A	N/A	N/A	N/A	7.50	7.50
Metal press (1000s CFA)	N/A	N/A	N/A	N/A	0.00	0.00
Saw (1000s CFA)	N/A	N/A	N/A	N/A	17.50	2.14
Conveyor belt system (1000s CFA)	N/A	N/A	N/A	N/A	0.00	0.00
Production line machinery (1000s CFA)	N/A	N/A	N/A	N/A	154.62	43.75
Effects of outages in past year						
Continue with backup supply (%)	5.2	5.2	8.7	14.7	48.3	23.8
Meetings/transactions delayed (%)	0	2.6	1.6	2.5	20.7	4.6
Reduced operations on backup supply (%)	5.8	15.7	3	2.8	21.7	5.4
Turn customers away (%)	41.4	32.2	25.3	27.3	8.9	22.3
Send workers home for the day without pay (%)	0	1.7	1.4	2.7	5.9	3.1
Send workers home for the day with (%)	0	0.7	0	0.2	3.4	0.8
Use expensive alternative energy source (%)	3.7	0.5	1.9	2.3	32	5.4
Cut back on operations or not cold perishables (%)	8.4	3.4	6.9	6.5	6.9	6.2

Outcome	Mean					
	Household business		Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Waste products or discard damaged goods (%)	10.2	8.7	3.9	3.5	6.4	6.2
Machines or appliances damaged (%)	10.8	5.1	14.6	15.4	36	23.8
Provide backup electricity to others (%)	0	0	0	0.1	0.5	2.3
Stop operations and wait for power to return (%)	44.6	30.6	34.4	39.1	28.6	32.3
None (%)	30.3	33.8	42.7	34.6	13.3	30
Sample size	**67**	**50**	**454**	**372**	**203**	**130**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^Denotes an ITS indicator to be collected through the telephone survey.

N/A = Not available

[a] Conditional on having any expenses.

[b] Lost revenue includes the cost of canceled orders but may also include other sources of lost revenue such as reduced operating hours and inability to accept new customers.

[c] Conditional on using backup sources of energy

[d] This outcome differs from the similar primary outcome in that it was constructed from a roster of equipment types and asks specifically about damage due to voltage fluctuations. We found that the roster resulted in a higher reporting of equipment damage than a simple question about all equipment damage, likely because the roster included interior and exterior lights as a type of equipment.

[e] This outcome is defined as the number of pieces of equipment the household reports having been damaged due to voltage in the past 3 months divided by the total number of pieces of equipment owned.

[f] This outcome is defined as the total value of the equipment the household reports having been damaged due to voltage in the past 3 months divided by the total value of all pieces of equipment owned.

Table C.1.5. Business revenue, cost, and profits (by project area)

Outcome	Mean					
	Household business		Small business		CCIB business	
	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas	Greater Cotonou	Northern project areas
Amount spent on goods or merchandise in past 30 days (1000s CFA)	7.17	8.12	57.76	71.13	86,172.45	1,520.30
Amount spent on raw materials and goods used in production in past 30 days (1000s CFA)	4.47	14.88	30.06	130.62	67,189.81	758.23
Amount spent on water, gas, and fuel in past 30 days (1000s CFA)	2.72	4.13	5.00	5.15	5,761.60	166.66
Amount spent on interest paid for a loan in past 30 days (1000s CFA)	0.08	2.68	2.32	2.75	33,914.55	18.26
Amount spent on salary of employees and apprentices in past 30 days (1000s CFA)	4.61	0.22	168.40	27.24	7,284.64	391.07
Amount spent on other expenses in past 30 days (1000s CFA)	6.36	3.64	17.04	14.90	637,645.85	155.88
Cost of business's electricity in past 30 days (1000s CFA) [a]	7.72	36.63	12.63	12.82	5,137.07	108.04
Revenue in past 30 days (1000s CFA)^	56.07	40.32	558.94	363.40	176,596.88	4,605.52
Average monthly revenue in past year (1000s CFA)	85.50	54.47	674.08	478.34	115,352.46	10,774.15
Profits in past 30 days (business-reported) (1000s CFA)^	24.20	12.05	144.81	57.54	5,239.92	484.20
Profits in past 30 days (from revenue and costs) (1000s CFA) [b]	30.49	7.86	63.48	155.36	50,952.01	1,024.88
Average monthly profit in past year (1000s CFA)	39.70	17.88	187.18	62.30	42,995.99	219.10
Has at least one source of profit information (%)[c]	94.1	88.6	57.9	69.9	49.3	56.9
Sample size	**67**	**50**	**454**	**302**	**203**	**130**

Notes: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^ Indicator to be collected in telephone surveys and used in the ITS analysis.

[a] This indicator combines the cost of SBEE electricity in the past 30 days with the cost of other backup electricity sources, such as generators or solar panels, in the past 30 days.

[b] This indicator is calculated from business-reported costs and revenue.

[c] This indicator shows the percentage of businesses for which we had at least one of the three profit figures.

B. Descriptive business data tables by gender of business owner

The following tables report descriptive statistics by the gender of the business's owner. For CCIB business, female owned businesses are those where a majority of businesses owners are female.

Table C.2.1. Business operations (by gender of business owner)

	Mean					
	Household business		Small business		CCIB business	
Outcome	Female owner	Male owner	Female owner	Male owner	Female owner	Male owner
Located in Greater Cotonou (%)*[a]	79.9	91.6	86.2	84.3	67.7	55.6
Sector (%):						
Retail	79.9	23.6	70	34.1	45.2	39.1
Manufacturing	9	47.3	11.6	18.1	12.9	27.8
Services	11.1	29.1	18.4	47.8	41.9	33.1
Number of permanent paid employees	0.05	0.42	0.44	0.95	12.42	23.4
Number of temporary paid employees	0.4	0.6	0.14	0.62	3.5	10.79
Number of unpaid employees, including family members	1.64	2.27	0.86	0.84	1.23	1.33
Number of employees, total	1.7	2.69	1.44	2.3	17.29	33.65
Percent of business owners that are female	N/A	N/A	97	0	86.94	2.75
Business owner is female (%)[b]*	100	0	100	0	100	0
SBEE connection (%):						
Direct	51	59.1	34.7	55.6	100	100
Indirect[c]	49	40.9	65.3	44.4	0	0
Business has a bank account (%)	10.7	9.6	24.1	28.6	80.6	83.6
Business is registered with the chamber of commerce (%)	N/A	N/A	16.2	32.3	100	100
Number of years business has been in operation	N/A	N/A	6.01	7.21	14.61	15.37

	Mean					
	Household business		Small business		CCIB business	
Outcome	Female owner	Male owner	Female owner	Male owner	Female owner	Male owner
Business is one of multiple locations (%)	N/A	N/A	4.5	15.7	22.6	24.5
Number of months that business functioned during 2018	11.53	11.95	11.27	11.36	12	11.48
Number of days business operates per week	6.46	6.26	6.1	6.13	6.03	6
Sample size	**91**	**26**	**338**	**372**	**31**	**266**

Notes: Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

^Denotes an ITS indicator to be collected through the telephone survey.

N/A = Not available

[a] Greater Cotonou is comprised of Cotonou, Porto-Novo, and Abomey-Calavi.

[b] This indicator is defined as “Business is majority female-owned” for CCIB businesses.

[c] Businesses with an indirect connection to SBEE are those who do not have a meter connected directly to the electricity line; rather, they receive electricity from a neighbor (with or without a meter).

Table C.2.2. Grid-level constraints for surveyed businesses (by gender)

Outcome	Mean			
	Small business		CCIB business	
	Female owner	Male owner	Female owner	Male owner
Outages				
Number of outages in past 7 days, any length^	2.44	2.89	4.13	5.34
Duration of outages (hours) in past 7 days, any length^	4.09	2.84	4.14	5.23
Average duration of outages (hours) in past 7 days, any length^[a]	1.77	1.11	1.04	1.26
Number of outages in past 30 days, any length	6.63	7.16	13.75	17.83
Duration of outages (hours) in past 30 days, any length	8.62	7.53	17.3	17.89
Average duration of outages (hours) in past 30 days, any length[a]	1.72	1.22	1.54	1.25
Frequency of voltage fluctuations:				
Never (%)	64.2	70	40	45.2
Daily (%)	11.2	6.8	33.3	17.1
Two to three times per week (%)	7.7	10.1	16.7	16.7
Few times per month (%)	16.9	13.1	10	21
Most common time for voltage fluctuations:				
Morning (%)	1.4	9.2	N/A	N/A
Afternoon (%)	32.8	44.5	N/A	N/A
Evening (%)	65.8	46.3	N/A	N/A
Sample size	**326**	**358**	**30**	**252**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas.

N/A = Not available

[a] Average duration is calculated by dividing the respondent-reported total duration of outages during the reference period by the respondent-reported total number of outages during that period.

Table C.2.3. Business energy profile (by gender)

	Mean			
	Small business		CCIB business	
Outcome	Female owner	Male owner	Female owner	Male owner
SBEE electricity expenditures and consumption				
Amount of SBEE electricity consumed in past 30 days (kwh)^	85.67	241.03	1796.15	33479.35
Amount spent on SBEE electricity in past 30 days, direct connection (1000s CFA)^	16.82	22.04	n.a.	n.a.
Amount spent on SBEE electricity in past 30 days, indirect connection (1000s CFA)^	2.39	5.22	n.a.	n.a.
Amount spent on SBEE electricity in past 30 days (postpaid bill - net a payer) (1000s CFA)	13.21	26.31	n.a.	n.a.
Amount spent on SBEE electricity in past 30 days (prepaid) (1000s CFA)	14.72	6.01	n.a.	n.a.
Amount spent on SBEE electricity in past 30 days (respondent estimate) (1000s CFA)	10.66	16.55	n.a.	n.a.
Amount spent on reactive power in the past 30 days (1000s CFA)	n/a	n/a	44.08	55.54
Amount of SBEE electricity consumed in past 30 days (kwh, postpaid bill)	88.23	186	n.a.	n.a.
Amount of SBEE electricity consumed in past 30 days (kwh, prepaid)	93.14	33.34	n.a.	n.a.
Amount of SBEE electricity consumed in past 30 days (kwh, respondent estimate)	79.73	275.39	n.a.	n.a.
Contextual Indicators : Connection to SBEE network				
Direct SBEE connection (%)	34.7	55.6	100	100
Direct SBEE connection: conventional meter (%)	58.4	61.9	74.2	71.1
Direct SBEE connection: supplemental conventional meter (%)	12.5	10.7	3.2	6.8
Direct SBEE connection: prepaid card meter (%)	26.1	24.8	16.1	17.7
Direct SBEE connection: supplemental prepaid card meter (%)	2.3	2.5	n.a.	n.a.
Direct SBEE connection: decompteur (%)	0.8	0.1	3.2	2.6
Direct SBEE connection: repartiteur (%)	n.a.	n.a.	0	4.9
Direct connection: receives an SBEE bill (%)	91.5	96.9	96.2	91.1
Indirect connection: has a meter (%)	25.8	38	n.a.	n.a.
Other users are connected to electricity meter (%)	32.8	25.7	6.5	12.9
For businesses that share electricity with another user:				
Number of other users connected to meter	2.31	2.62	2.5	2.63
Shares electricity with business owner’s household or relative (%)	36.6	23.5	50	52.9
Shares electricity with employee (%)	4.6	4.1	50	17.6

Outcome	Mean			
	Small business		CCIB business	
	Female owner	Male owner	Female owner	Male owner
Shares electricity with neighbor (%)	57.4	59.1	50	20.6
Shares electricity with no relationship (%)	15.8	26.3		
Number of years dwelling has been connected to SBEE electricity	6.22	7.41	13.54	15.27
Indirect connection with no meter: fixed monthly payment (%)	18.5	34.2	n.a.	n.a.
Indirect connection with no meter: fee based on appliance use (%)	2.1	8.9	n.a.	n.a.
Indirect connection with no meter: fee based on estimated consumption (%)	17.9	33.2	n.a.	n.a.
Indirect connection with no meter: included in rent (%)[b]	5.5	4.9	n.a.	n.a.
Indirect connection with no meter: provided for free (%)	54.9	18.7	n.a.	n.a.
Indirect connection: pays SBEE (%)	0.8	9.6	n.a.	n.a.
Indirect connection: pays prepaid seller (%)	0	2.7	n.a.	n.a.
Indirect connection: pays relative (%)	1.4	0.5	n.a.	n.a.
Indirect connection: pays neighbor (%)	8.9	2	n.a.	n.a.
Indirect connection: pays landlord (%)	36.4	23.8	n.a.	n.a.
Indirect connection: pays nobody (%)	50.3	59.2	n.a.	n.a.
Protection against poor electricity				
Owns a surge protector (%)	5.1	7.2	30	32.2
Owns a voltage stabilizer (%)	14.7	21.8	50	51.9
Number of surge protectors owned[a]	1	1.38	2	8.15
Number of voltage stabilizers owned[a]	1.24	1.49	3.13	5.35
Average cost of surge protectors owned (1000s CFA)[a]	20.80	24.57	67	841.83
Average cost of voltage stabilizers owned (1000s CFA)[a]	25.20	42.71	57.2	146.88
Use of backup energy sources				
Total cost of backup energy source use in past 7 days (1000s CFA)	1.23	2.85	42.08	185.21
Uses any backup energy source in case of outage (%)	28.3	24	N/A	N/A
For businesses that use any backup source				
Uses generator owned by the business as backup energy source when there is an outage (%)^	7.1	71.5	N/A	N/A
Uses home solar system as backup energy source when there is an outage (%)	6.4	2.3	16.1	23.7

Outcome	Mean			
	Small business		CCIB business	
	Female owner	Male owner	Female owner	Male owner
Uses petrol as backup energy source when there is an outage (%)	18.3	1.1	N/A	N/A
Uses drycell batteries (D, C, AA, AAA) as backup energy source when there is an outage (%)	60.9	13	N/A	N/A
Uses candle as backup energy source when there is an outage (%)	26.4	7.8	N/A	N/A
Uses a backup light source when there is an outage (%)	8.3	8	N/A	N/A
Used any backup energy source in case of outage in past 7 days (%)	16.6	17.2	48	49.3
For businesses that used a backup energy source during an outage in past 7 days				
Used minigrid (owned by private company or community) as backup energy source during an outage in past 7 days (%)	0	0	0	0.9
Used generator owned by the business as backup energy source during an outage in past 7 days (%)	18.8	70.1	83.3	93.7
Used home solar system as backup energy source during an outage in past 7 days (%)	3.8	4.6	8.3	5.4
Used diesel (for use other than in a generator) as backup energy source during an outage in past 7 days (%)	0	0	8.3	1.8
Used petrol as backup energy source during an outage in past 7 days (%)	4.4	0	0	0
Used drycell batteries (D, C, AA, AAA) as backup energy source during an outage in past 7 days (%)	41.4	14.9	0	0
Used candle as backup energy source during an outage in past 7 days (%)	35	8.2	0	0
Used other as backup energy source during an outage in past 7 days (%)	11.5	9.6	0	0
Contextual indicators: Electrical equipment owned				
Electrical equipment owned: Interior lighting (%)	94.3	88.4	N/A	N/A
Electrical equipment owned: Exterior lighting (%)	76.1	59.6	N/A	N/A
Electrical equipment owned: Fan (%)	19.5	40.4	N/A	N/A
Electrical equipment owned: Computer (%)	3.1	15.4	58.1	54.5
Electrical equipment owned: Refrigerator or freezer (%)	25.8	15.3	41.9	17.7
Electrical equipment owned: Air conditioner (%)	0.6	5.7	38.7	39.1
Electrical equipment owned: Electric stove (%)	0	1.1	N/A	N/A
Electrical equipment owned: Washing machine or dryer (%)	0.7	0	N/A	N/A
Electrical equipment owned: Iron (%)	2.9	4.4	N/A	N/A

Outcome	Mean			
	Small business		CCIB business	
	Female owner	Male owner	Female owner	Male owner
Electrical equipment owned: Water pump (%)	0	0	N/A	N/A
Electrical equipment owned: Soldering iron or welding machine (%)	0.1	5.7	6.5	4.5
Electrical equipment owned: Sewing machine (%)	2.7	7.6	0	1.9
Electrical equipment owned: Millstone (%)	0	3.6	N/A	N/A
Electrical equipment owned: Clippers or beard trimmer (%)	1.6	5.4	N/A	N/A
Electrical equipment owned: Printer or photocopy machine (%)	2.3	7.9	38.7	36.8
Electrical equipment owned: Ventilation (%)	N/A	N/A	41.9	39.1
Electrical equipment owned: Forge (%)	N/A	N/A	0	0.8
Electrical equipment owned: Metal press (%)	N/A	N/A	0	2.3
Electrical equipment owned: Saw (%)	N/A	N/A	0	6.4
Electrical equipment owned: Conveyor belt system (%)	N/A	N/A	0	2.3
Electrical equipment owned: Production line machinery (%)	N/A	N/A	16.1	14.3
Sample size	**338**	**372**	**31**	**266**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^Denotes an ITS indicator to be collected through the telephone survey.

N/A = Not available; n.a. = not applicable

[a] Conditional on having any expenses.

[b] Conditional on using backup sources of energy.

[c] This outcome differs from the similar primary outcome in that it was constructed from a roster of equipment types and asks specifically about damage due to voltage fluctuations. We found that the roster resulted in a higher reporting of equipment damage than a simple question about all equipment damage, likely because the roster included interior and exterior lights as a type of equipment.

[d] This outcome is defined as the number of pieces of equipment the household reports having been damaged due to voltage in the past 3 months divided by the total number of pieces of equipment owned.

[e] This outcome is defined as the total value of the equipment the household reports having been damaged due to voltage in the past 3 months divided by the total value of all pieces of equipment owned.

Table C.2.4. Consequences of unreliable and poor quality electricity for businesses (by gender)

	Mean					
	Household business		Small business		CCIB business	
Outcome	Female owner	Male owner	Female owner	Male owner	Female owner	Male owner
Cost of backup energy sources and outages						
Cost of spoiled products:						
Incurred in past 7 days (1000s CFA)^	0.34	0.00	0.66	1.65	25.14	30.09
Incurred in past 7 days: YES (%)	7.3	0	6.2	1.7	13.8	13.8
Incurred in past 30 days, for any reason (1000s CFA)	0.91	0.04	1.31	3.69	27.22	245.54
Incurred in past 30 days, for any reason: YES (%)	15	0.7	7.8	6.2	14.8	23
Incurred in past 30 days, due to poor electricity (1000s CFA)[a]	3.43	0.00	7.75	33.78	95.25	734.90
Incurred in past 30 days, due to poor electricity: YES (%)[a]	62.7	0	27.1	84.9	50	80
Cost of salary paid to inactive workers :						
Incurred in past 7 days (1000s CFA)^	0.00	0.57	0.07	0.14	2.70	24.93
Incurred in past 7 days: YES (%)	0	0.7	1.7	1.3	10	6.1
Incurred in past 30 days, for any reason (1000s CFA)	0.00	0.57	0.52	2.62	15.23	97.63
Incurred in past 30 days, for any reason: YES (%)	0	0.7	2.1	3.4	16.7	8.3
Incurred in past 30 days, for any reason, no zeroes (1000s CFA)[a]	N/A	N/A	24.42	77.68	91.40	1,171.60
Incurred in past 30 days, due to poor electricity (1000s CFA)[a]	N/A	N/A	0.64	4.10	50.00	65.86
Cost of canceled orders:						
Incurred in past 30 days, for any reason (1000s CFA)	0.48	4.90	29.62	55.21	43.03	1,064.67
Incurred in past 30 days, for any reason: YES (%)[a]	6	17.6	9.3	7.6	16.7	10.9
Incurred in past 30 days, due to poor electricity (1000s CFA)[a]	0.13	9.35	284.43	28.78	25.20	4,702.92
Cost of lost revenue in past 30 days due to poor electricity (CFA)^[b]	1.44	5.61	4.80	10.70	143.00	554.67
Uses any backup energy source in case of outage (%)	N/A	N/A	28.3	24		
Total cost of all backup energy sources used in past 7 days (1000s CFA)[c]	N/A	N/A	1.16	7.35	475.63	942.33
Total cost of using a generator in past 30 days, conditional on using generator for backup (1000s CFA)^[c]	N/A	N/A	5.26	8.39	164.31	495.87
Equipment damaged						
Any equipment in need of repair in past 3 months, in general (%)^			24.3	31	48.4	50

Outcome	Mean					
	Household business		Small business		CCIB business	
	Female owner	Male owner	Female owner	Male owner	Female owner	Male owner
Any equipment in need of repair due to voltage fluctuations in past 3 months (%)[d]	N/A	N/A	18.3	18	30	34.3
Proportion of equipment damaged due to voltage (number of pieces)[e]	N/A	N/A	10.87	7.69	5.39	47.3
Proportion of equipment damaged due to voltage (value) (%)[f]	N/A	N/A	0.09	0.07	0.08	0.08
Needed to repair/replace in the past 3 months (any reason)						
Refrigerator or freezer (%)	N/A	N/A	33.8	10.9	23.1	28.9
Sewing machine (%)	N/A	N/A	63	58	N/A	N/A
Clippers or beard trimmer (%)	N/A	N/A	12.8	39.3	N/A	N/A
Printer or photocopy (%)	N/A	N/A	20.8	29.1	66.7	34
Air conditioner (%)	N/A	N/A	N/A	N/A	50	29.8
Computer (%)	N/A	N/A	N/A	N/A	38.9	36.4
Compressor (%)	N/A	N/A	N/A	N/A	100	43.8
Saw (%)	N/A	N/A	N/A	N/A	70.6	70.6
Production line machinery (%)	N/A	N/A	N/A	N/A	40	59.5
Interior lighting (%)	N/A	N/A	34.7	32.8	N/A	N/A
Exterior lighting (%)	N/A	N/A	35.1	26.1	N/A	N/A
Fan (%)	N/A	N/A	17.2	13.3	N/A	N/A
Phone (%)	N/A	N/A	N/A	N/A	0	17.5
Ventilation (%)	N/A	N/A	N/A	N/A	7.7	17.3
Cost of repair per item damaged by voltage						
Interior lighting (1000s CFA)	N/A	N/A	0.19	0.16	N/A	N/A
Exterior lighting (1000s CFA)	N/A	N/A	0.23	0.09	N/A	N/A
Fan (1000s CFA)	N/A	N/A	0.10	0.93	N/A	N/A
Computer (1000s CFA)	N/A	N/A	0.00	4.63	15.71	26.16
Refrigerator or freezer (1000s CFA)	N/A	N/A	4.47	0.84	109.09	168.51
Air conditioner (1000s CFA)	N/A	N/A	0.00	0.11	27.93	22.69
Iron (1000s CFA)	N/A	N/A	0.00	0.00	N/A	N/A
Soldering iron or welding machine (1000s CFA)	N/A	N/A	7.44	7.44	0.00	6.36

Outcome	Mean					
	Household business		Small business		CCIB business	
	Female owner	Male owner	Female owner	Male owner	Female owner	Male owner
Sewing machine (1000s CFA)	N/A	N/A	1.19	0.00	0.00	0.00
Millstone (1000s CFA)	N/A	N/A	1.08	1.08	N/A	N/A
Clippers or beard trimmer (1000s CFA)	N/A	N/A	0.00	3.48	N/A	N/A
Printer or photocopy machine (1000s CFA)	N/A	N/A	1.56	1.56	9.09	18.88
Phone (1000s CFA)	N/A	N/A	N/A	N/A	0.00	13.21
Ventilation (1000s CFA)	N/A	N/A	N/A	N/A	0.00	1.37
Compressor (1000s CFA)	N/A	N/A	N/A	N/A	1,000.00	303.33
Forge (1000s CFA)	N/A	N/A	N/A	N/A	7.50	7.50
Metal press (1000s CFA)	N/A	N/A	N/A	N/A	0.00	0.00
Saw (1000s CFA)	N/A	N/A	N/A	N/A	5.88	5.88
Conveyor belt system (1000s CFA)	N/A	N/A	N/A	N/A	0.00	0.00
Production line machinery (1000s CFA)	N/A	N/A	N/A	N/A	0.00	175.22
Effects of outages in past year						
Continue with backup supply (%)	4.8	6.2	4.5	14.7	35.5	37.6
Meetings/transactions delayed (%)	0	1.6	1.1	2.5	6.5	14.7
Reduced operations on backup supply (%)	10.3	0	3.4	2.8	6.5	15
Turn customers away (%)	42.2	33.5	23.2	27.3	12.9	15
Send workers home for the day without pay (%)	0.4	0	0.1	2.7	6.5	4.1
Send workers home for the day with (%)	0.2	0	0	0.2	0	1.9
Use expensive alternative energy source (%)	3.2	3	1.3	2.3	25.8	19.2
Cut back on operations or not cold perishables (%)	10.4	0	7.7	6.5	19.4	4.9
Waste products or discard damaged goods (%)	13.4	0.9	4	3.5	16.1	5.6
Machines or appliances damaged (%)	6.6	18.2	12.3	15.4	35.5	30.5
Provide backup electricity to others (%)	0	0	0	0.1	0	1.1
Stop operations and wait for power to return (%)	42.2	42.3	31.1	39.1	38.7	29.3
None (%)	27.7	39.3	48.7	34.6	22.6	21.1
Sample size	**91**	**26**	**338**	**372**	**31**	**266**

Notes: Bold font denotes a primary outcome. Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^Denotes an ITS indicator to be collected through the telephone survey.

N/A = Not available

[a] Conditional on having any expenses.

[b] Lost revenue includes the cost of canceled orders but may also include other sources of lost revenue such as reduced operating hours and inability to accept new customers.

[c] Conditional on using backup sources of energy.

[d] This outcome differs from the similar primary outcome in that it was constructed from a roster of equipment types and asks specifically about damage due to voltage fluctuations. We found that the roster resulted in a higher reporting of equipment damage than a simple question about all equipment damage, likely because the roster included interior and exterior lights as a type of equipment.

[e] This outcome is defined as the number of pieces of equipment the household reports having been damaged due to voltage in the past 3 months divided by the total number of pieces of equipment owned.

[f] This outcome is defined as the total value of the equipment the household reports having been damaged due to voltage in the past 3 months divided by the total value of all pieces of equipment owned.

Table C.2.5. Business revenue, cost, and profits (by gender)

	Mean					
	Household business		Small business		CCIB business	
Outcome	Female owner	Male owner	Female owner	Male owner	Female owner	Male owner
Amount spent on goods or merchandise in past 30 days (1000s CFA)	8.20	5.21	45.67	70.50	2,871.71	35,438.37
Amount spent on raw materials and goods used in production in past 30 days (1000s CFA)	6.17	5.44	26.49	25.90	229.29	46,708.80
Amount spent on water, gas, and fuel in past 30 days (1000s CFA)	1.64	6.32	2.93	6.54	254.29	3,351.42
Amount spent on interest paid for a loan in past 30 days (1000s CFA)	0.62	0.18	3.06	1.89	34.09	22,411.01
Amount spent on salary of employees and apprentices in past 30 days (1000s CFA)	0.09	13.77	12.03	38.39	442.57	3,561.87
Amount spent on other expenses in past 30 days (1000s CFA)	4.14	10.39	7.92	23.57	118.02	393,005.82
Cost of business's electricity in past 30 days (1000s CFA) [a]	13.45	2.00	8.36	16.32	457.49	2,789.07
Revenue in past 30 days (1000s CFA)^	46.20	70.29	137.84	306.42	3,596.67	80,862.16
Average monthly revenue in past year (1000s CFA)	64.62	118.27	190.98	445.66	67,640.00	61,068.11
Profits in past 30 days (business-reported) (1000s CFA)^	19.83	27.72	29.16	47.81	228.96	2,400.44
Profits in past 30 days (from revenue and costs) (1000s CFA) [b]	26.12	28.64	42.92	116.90	-748.58	29,453.98
Average monthly profit in past year (1000s CFA)	33.69	41.62	28.79	158.00	348.64	29,737.31
Has at least one source of profit information (%)[c]	90.9	99	61.7	59.6	54.8	56
Sample size	91	26	338	372	31	266

Notes: Bold font denotes a primary outcome. The sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

^ Indicator to be collected in telephone surveys and used in the ITS analysis.

[a] This indicator combines the cost of SBEE electricity in the past 30 days with the cost of other backup electricity sources, such as generators or solar panels, in the past 30 days.

[b] This indicator is calculated from business-reported costs and revenue.

[c] This indicator shows the percentage of businesses for which we had at least one of the three profit figures.

Appendix D:

Values at baseline for outcomes selected for telephone survey

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The following table and figure report mean baseline values for outcomes that will be collected during the telephone surveys. We will survey household and business sample members 3-4 times per year beginning in January 2020 and continuing into the post-compact period. These data will be used for ITS analysis of end-user outcomes.

Table D.1. Telephone survey outcomes at baseline

Outcome	Household sample	Small business sample	CCIB sample
Outages			
Number of outages in past 7 days	2.75	2.71	5.22
Duration of outages (hours) in past 7 days	3.24	3.37	5.00
Average duration of outages (hours) in past 7 days[a]	1.12	1.40	1.18
Frequency of voltage fluctuations: Never (%)	65.4	66.1	44.3
Energy use			
Amount spent on SBEE electricity in past 30 days, direct connection (CFA)	15,155	20,744	3,817,731
Amount spent on SBEE electricity in past 30 days, indirect connection (CFA)	3,984	3,588	n.a.
Amount of SBEE electricity consumed in past 30 days (kwh)	73.30	184.54	35,108.91
Used generator owned by the household as backup energy source during an outage in past 7 days (%)[c]	11.1	44.8	93.9
Hours of operation			
Number of days business operates per week	n.a.	6.11	6.00
Profits, costs, and losses			
Total cost of using any generator in past 30 days (CFA)[b]	3,526	8,441	758,961
Cost of loss of perishable goods, last 7 days (CFA)	622	12,000	276,000
Cost of loss due to salary paid to inactive workers (CFA)	n.a.	232	20,370
Revenue in the past 30 days (CFA)	n.a.	525,143	94,234,817
Profit in the past 30 days (business-reported) (CFA)	n.a.	128,747	3,099,843
Equipment			
Any equipment in need of repair in past 3 months, in general (%)	19.4	27.7	50.8
Cost of repair or replacement of damaged equipment in last 3 months (CFA)	3,751	10,160	1,035,283
Time use			
Hours per day primary adult spent on paid work outside of home (Male)	7.00	n.a.	n.a.

Outcome	Household sample	Small business sample	CCIB sample
Hours per day primary adult spent on work for a family business (Male)	1.47	n.a.	n.a.
Hours per day primary adult spent on paid work outside of home (Female)	3.64	n.a.	n.a.
Hours per day primary adult spent on work for a family business (Female)	3.82	n.a.	n.a.
Hours per day child attending school spent studying at home during daylight hours (Male)	0.65	n.a.	n.a.
Hours per day child attending school spent studying at home at night (Male)	0.94	n.a.	n.a.
Hours per day child attending school spent studying at home during daylight hours (Female)	0.55	n.a.	n.a.
Hours per day child attending school spent studying at home at night (Female)	0.87	n.a.	n.a.

Notes: Sample sizes for individual indicators may be smaller due to missing data. Means are weighted to be representative of the project areas. Monetary values expressed in CFA can be converted to US$ using the conversion rate from July 1, 2019 (US$1 = 576.64 CFA).

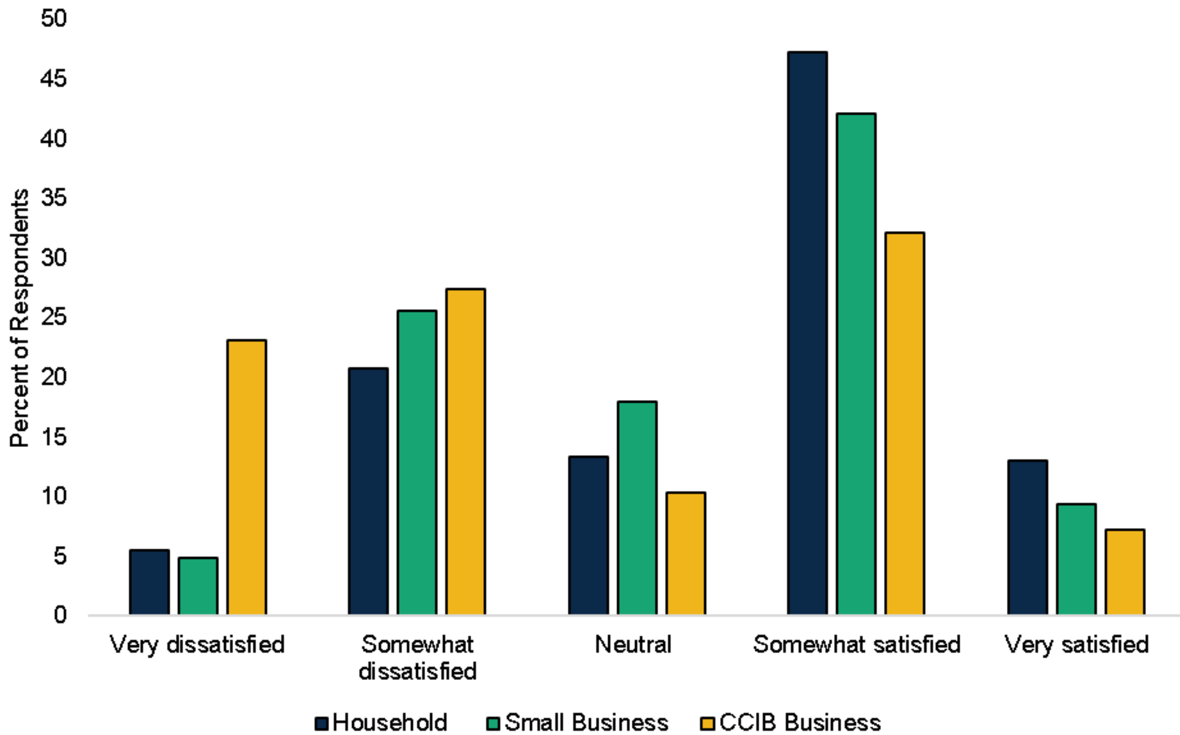
[a] Average duration is calculated by dividing the respondent-reported total duration of outages during the reference period by the respondent-reported total number of outages during that period.

[b] Conditional on using a generator.

[c] For small business and CCIB business this variable is conditional on using backup energy in the past 7 days.

n.a. = not applicable.

Figure D.1. Household and business satisfaction with quality of SBEE electricity



Note: Respondents are asked, "What is your overall degree of satisfaction with the quality of SBEE electricity, in terms of changes in voltage and equipment damage?"

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Appendix E:
Stakeholder Comments and Responses

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Table E.1. Stakeholder comments on earlier drafts of the baseline report and Mathematica's responses

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
M&E/PM	Page 1, 3rd sentence	Sentence on total supply from imports referring the DGRE report understates how much electricity in Benin comes from imports. figure 4 on page 24 indicates it was 69.9% in 2017. More recent data from the indicator tracking table shows that percentage is closer to 97%.	We have updated the text on page 1 to reflect this more recent data.
M&E/PM	Page 1	*Re: technical and commercial losses – more recent ITT data from SBEE.*	The text has been updated.
MCA/other stakeholder	Presentation (and report page 1)	*Include footnote in report that amount does not reflect Government of Benin contribution of $X and 609(g) funding.*	This footnote has been added.
MCC/Energy Practice Group	Page 2, Section I.A	Paragraph 1 refers to the 63 kV line from Seme to Tanzoun. This was in Lot D of the procurement for Lignes (DAO2) and, as such, was the lowest priority of the 4 lots (A-D). Given increased costs for lots A-C, there is no funding available for Lot D and MCA-Benin is not pursuing contract negotiations for that lot.	A footnote has been added that uses the language suggested below - that Lot D is unlikely to receive funding.
M&E/PM	Page 3, last sentence	What is the source or basis of the statement that the main effect of the new generation capacity is to substitute for more expensive thermal generation? That is certainly a desired effect, but it is also to increase generation capacity and output.	This is something that we learned during our design trip to Benin, so we don't have a citation for it but we have revised the text slightly: we believe the main effect will be to substitute for the more expensive rental, thermal generation capacity Benin has increasingly relied on in the past five years.
M&E/PM	Page 8	"Approximately one year before the intervention" – this should be more specific. Does the intervention start when construction starts, when it ends, or something else?	We have edited this sentence for clarity.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
MCC/Energy Practice Group	Page 10, Section I.B.3	The statement is made that the survey data collection took place from June-August 2019, six months before the first distribution network improvements were expected to come online. As coming online implies completion (which will not be until 2021 or 2022), replace coming online with commence. Construction contracts are to be signed between December 2019 and February 2020. Contracts have 18-22 month durations, depending on whether they are for lines or substations. [And for the NDCC IT Project, the contract has a 42 month duration running from December 2018 to June 2022.]	This change has been made to the text.
M&E/PM	Page 11, Table I.3., 2nd bullet	"an IPP transaction" –should be plural.	This change has been made to the text.
M&E/PM	Page 11, Table I.3., 4th bullet	Not just tariff reform was pending but also CP related to IPPs	This change has been made to the text.
MCC/Energy Practice Group	Page 11, Section I.C, Table 1.3	The table mentions the timeline for financial close of the IPP transaction being September 2020. With the release of the solicitation document in late December, the expectation is that the financial close would be closer to March 2021.	This change has been made to the text.
M&E/PM	Page 11, Table I.3.,	"MCA's design consultant" should be replaced with the "MCA distribution design consultant".	This change has been made to the text.
M&E/PM	Section C	It would be useful to include a sentence or two summarizing whether the data shows the problems the projects are aiming to solve are actually problems. It seems that is the case with the possible exception of operating hours of businesses. Also, satisfaction with the quality of electricity is not as bad as one might expect. However, it's not great, and as you note, satisfaction may be relatively higher due to reduced outages as SBEE resorted to energy generation.	We have added a short discussion to this effect immediately following the Table I.3.
M&E/PM	Page 14, 2nd paragraph	"design engineer" should be "distribution design consultant"	This change has been made to the text.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
MCC/Energy Practice Group	Page 14, Section II.A	In the third paragraph on Findings on project design, it shows an initial project budget for the Regional Grid Strengthening Activity of $8 million. While that is the correct amount of MCC Funding, that activity was also allocated $18 million of the GoB matching contribution for a total initial budget of $26 million. Also, the Cotonou Grid Strengthening Activity was allocated $5 million of GoB funding.	This change has been made to the text.
M&E/PM	Page 14, 4th paragraph	Instead of saying Lot D has been canceled, it is more accurate to say it is unlikely to be implemented.	This change has been made to the text.
MCC/Energy Practice Group	Page 15, Section II.A	In the paragraph re SBEE, the comment is made that SBEE now has a Board of Directors. As written, this implies that this is a relatively new development. SBEE has had a Board of Directors for many years – although the composition of the Board may have changed, the existence of the Board is not new.	We have revised the text.
MCC/Energy Practice Group	Page 16, Section II.B, Figure II.1	The design of the Distribution Project includes the three activities shown in the figure – Regional Grid Strengthening, Cotonou Grid Strengthening, and National Dispatch Activity. However the regional and Cotonou were repackaged for procurement purposes into separate procurements for substations and lines but each of those procurements contained multiple lots that could be traced back to regional and Cotonou but the timelines should be modified to reflect the different timelines for substations and lines (22 months and 18 months respectively) contracts (all with start dates hopefully between December 2019 and February 2020). The updated timeline for dispatch IT reflects the 42 months. The timeline for dispatch buildings should be changed.	We have updated the figure based on this information and based on our understanding of the timeline from the latest CODIRs.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
MCC/Energy Practice Group	Page 16, Section II.B	Last paragraph – indicates that MCA will accept bids for the IPP through the end of 2019. Note that the solicitation is under the jurisdiction of the DNCMP – national procurement agency (not MCA) and the solicitation documents were not issued until December 20, 2019. The rest of the timeline is off as a result.	The draft baseline evaluation was written in the fall of 2019 and was based on the best available information at that time. We have updated the text to reflect the status as of March 2020 but note that the closing date for the RFP was recently extended to May of 2020 and may be subject to more changes after the present report is published.
MCC/Energy Practice Group	Page 17, Section II.B	Next to the last paragraph – Please make a distinction between NDCC IT and NDCC buildings. The comments in the paragraph pertain to the timeline for the buildings. There was some work – site clearing, etc. before the end of 2019. Work on the IT project is underway.	Revised header to specify that the text refers to the NDCC building, and added a sentence clarifying that work on NDCC IT is ongoing.
MCA/other stakeholder	Page 21	Dans le rapport il est mentionné que les zones échantillonnées ne sont que celles où des lignes ou stations préexistantes ont été réhabilitées, plutôt que celle où des nouvelles infrastructures seront construites. Il faudrait mieux clarifier dans le rapport cette partie, pour mieux expliquer la zone d'échantillonnage.	We have clarified this in the report.
M&E/PM	Page 23, 1st paragraph	"regular basis" should be "quarterly"	This change has been made to the text.
	Page 23, Section III.B	There is a comment below Table III.4 that MPR expects that GOPA and SBEE will provide key indicator summary data on a regular basis. Please check statement for accuracy as the GOPA contract may be coming to an end once all the grid monitors and smart meters have been installed and connected. Additional comment: Please ignore this for now (referring to the above comment).	As suggested, we are not making changes for now.
M&E/PM	Page 23, last paragraph	I would recommend mentioning that the use of rental generation capacity may reduce the number of outages (due lack of supply), but that their use has a negative effect on the sector's viability.	This has been added to the text.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
M&E/PM	Page 24, last paragraph	You may reference ITT data, which indicates that total distribution losses are: 22.29% (Jan-Mar 2018), 23.37% (Apr-Jun 2018), 23.79% (Jul-Sept 2018), 21.97% (Oct-Dec2018), 22.21 (Jan-Mar 2019), and 20.80 % (Apr-Jun 2019). SBEE source document can be provided to Mathematica.	We have added a more precise range to the text and have cited the ITT
MCA/other stakeholder	Presentation	Repréciser les notions de « connexion directe » et « connexion indirecte » des abonnés.	We define this distinction in table notes in the report.
MCA/other stakeholder	Presentation	Clarifier le comportement d'atténuation des utilisateurs finaux, tel que mentionné dans le rapport.	This is likely a translation issue. We are referring to behaviors to cope with or mitigate the effects of poor electricity quality (e.g. use of a generator).
MCC/Energy Practice Group	Page 30, Section IV.C.1	The text box summarizes observations about outages and voltage fluctuations experienced by households/small businesses and businesses. It is interesting that CCIB businesses report higher levels of both outages and voltage – is that because they are more observant of such incidents (due to the consequences thereof) and are more apt to collect data in real time for such incidents than households that may be relying on memory of frequency. Could/should this difference be explored? See also pages 37 and 38 for similar question about business experience with outages and voltage fluctuations.	We suspect that either of those hypotheses could account for higher rates of outages and voltage fluctuations reported by CCIB businesses than by smaller businesses. This is something that we could explore in the midline data collection and/or in future rounds of qualitative data collection.
M&E/PM	Page 30, 3rd bullet in box	Can this be expressed as percentage of monthly income? USD equivalent should be included.	The USD equivalent has been included; however, we did not collect household income or consumption.
M&E/PM	Page 31, 2nd paragraph	Comment for interim – has the team considered dropping questions about outages and voltage fluctuations every 30 days? The data you have collected suggest they have limited value (especially with the integration of phone surveys and smart meter data).	This is a question we will consider when we prepare the interim surveys.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
MCC/Energy Practice Group	Page 31, Section IV.C, Table IV.6	Are there locational differences in the data reported for reliability and quality of electricity supply? Is that information being gathered (by monitor/meter or by city/district)?	Our survey data show that households in the northern project areas (Djougou, Natitingou, Parakou, and Bohicon) reported more outages in the past 7 and past 30 days than households in the Greater Cotonou area (see Table B.1.2). However, the average duration of outages appeared to be longer for households in Greater Cotonou. The frequency of voltage fluctuations was similar across regions. The smart meters and grid monitors will provide additional data on these indicators, by project area.
M&E/PM	P33, Table IV.7.	The section on 'user of back up energy sources was a bit confusing at first. I would recommend having a clearer division between the first set of stats on '…in case of outage' and the second set on 'in case of outage in past 7 days'.	We have added an additional table header to make this distinction clearer. This change has also been made in the business tables and appendix tables as needed.
M&E/PM	P34, Table IV.7.	'Contextual indicators' use bold or indentation to clarify that "Direct SBEE connection: Conventional meter (%)" and others are a part of Direct SBEE Connection.	This change has been made in all relevant tables.
M&E/PM	P34, first paragraph	The report states that households with direct connections may overstate consumption, because it may include the consumption of others using their electricity. What can be done to address this data issue?	We asked respondents who share electricity to report on (or estimate) the amount that other users paid them for their use of electricity and the amount those others consumed in the past 30 days. However, there was a large amount of missing data (27% of electricity sharers didn't know how much other users pay them, and 65% didn't know how much other users consumed). For that reason, we opted not to report on net expenditures and consumption.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
M&E/PM	P35, Table IV.8.	Total cost of backup energy use in the last 30 days is only slightly higher than in the past 7 days. Is there an explanation? (See comment on potentially dropping questions using 30-day time period)	There are two possible reasons for the discrepancy. First, households/businesses may overestimate in the near term or underestimate over longer periods of time (as discussed in the report). Second, the outcome construction differs: the 30 day outcome was constructed as the sum of respondents' estimates of spending on individual energy sources, while the 7 day outcome was constructed from respondents' estimates of their spending on all energy sources combined.
M&E/PM	P35, Table IV.8.	"Any equipment in need of repair…" – This is repair needed in general or due to poor electricity quality? Please specify in table.	This is repair in general and has been specified in all relevant tables.
M&E/PM	Page 35, last paragraph	Are the hours per day based on workdays (MON-FRI) or weekends as well?	Respondents were asked about workdays/school days. This has been clarified in the text.
M&E/PM	P 37, Table IV.10.	There seems to be a missing value for "Business is one of multiple locations (%)" for CCIB sample	This has been added to the table. 27.4% of CCIB businesses reported being one of multiple locations.
M&E/PM	P 40, Table IV.12.	"Amount spent on SBEE electricity in past 30 days (estimate)" – It was not immediately clear what was meant by 'estimate'. Perhaps, say 'respondent estimate'	We have revised to "respondent estimate" in all relevant tables.
M&E/PM	P 40, Table IV.12.	Why are there so many N.A.s for the CCIB sample?	The N/A responses are due to two factors: (1) some of the questions asked of small businesses were not applicable for larger businesses. For instance, we assumed that all CCIB businesses had a direct SBEE connection. (2) Gaining consent and participation from owners and managers of large businesses was more difficult than for small businesses, so we made cuts to the survey instrument to keep it as short as possible.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
M&E/PM	P 40, Table IV.12.	Be consistent with n.a. vs N/A.	In the report tables, we define “N/A” as “not available” and “n.a.” as “not applicable.” This is to distinguish a quantity that is missing because data are missing or were not collected and a quantity that is missing because it is illogical (e.g. due to a skip pattern in the survey). We have made some revisions to the tables to ensure that the correct notation was used in each instance.
MCC/Energy Practice Group	Page 40, Section IV.C.2	Table IV.12 -- For CCIB businesses, were questions about protection against poor quality electricity not asked? Table shows N/A in the response column. It would be interesting to compare against experiences of households and small businesses.	These numbers have been added to the tables.
M&E/PM	P41, PP2	Provide footnote defining canceled orders and lost revenue? The concepts are quite similar.	We added the following footnote to this and other relevant tables: "Lost revenue includes the cost of canceled orders but may also include other sources of lost revenue such as reduced operating hours and inability to accept new customers."
M&E/PM	P42, Table IV.13.	Why is the cost of canceled orders due to poor electricity higher than the cost of canceled orders overall? The former would seem to be a subset of the latter.	The two measures have different samples. The cost of canceled orders overall is measured among all respondents and includes those respondents who report no cost of canceled orders. The cost of canceled orders due to poor quality electricity is conditional on the respondent reporting any cost of canceled orders overall. This has been clarified in the table.
M&E/PM	P42, Table IV.13.	Under equipment damage, what does ‘H1’ and ‘H2’ refer to?	H1 and H2 refer to the question in the survey. This has been removed from the tables.
M&E/PM	P43, Table IV.14.	The ‘average profit per month during past year’ for CCIB business is 9 times larger than the average profit of the last 30 days. Are these numbers correct?	The numbers are correct - please see paragraph following the table for a discussion of the large differences.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
M&E/PM	P46, paragraph 3	Please specify whether the current visa statisique covers the phone data collection and whether a separate visa statisique will be requested.	The phone data collection was mentioned in our communications with INSAE for the listing and baseline data collection approval. We are in communication with INSAE to determine if an amendment to the visa is required since we have changed data collection firms.
M&E/PM	A.3.	Would it be possible to include one or several maps showing the sampled blocks?	We've included a map that shows the approximate locations of the sampled blocks in Greater Cotonou.
M&E/PM	A.8.	It will be important to make sure smart meter installer is aware of reallocation of two MV meters between Djougou and Bohicon.	Since submitting the report, we have been in close contact with the smart meter installer who is aware of the reallocation. We have replaced the original table with the reallocation.
MCC/Energy Practice Group	Page A.8	Text following Table A.6 – Based on earlier comment about Seme, consider number of meters to be placed there. Should be discussed with MCA, SBEE, and GOPA (although the latter would not necessarily know the outcome of the procurements and funding issues).	MCC has confirmed that the Compact will no longer fund any infrastructure (lines or posts) in Porto-Novo or Seme. Our evaluation sample includes households, small-businesses and large (CCIB) businesses in these areas who will now no longer benefit from any infrastructure investments (they will still benefit from the National Electricity Dispatch Activity). We plan to retain these households and businesses in our sample for now and will continue collecting data from them via the telephone survey and smart meter monitoring. We plan to place the same number of smart meters in each block, so the overall number of smart meters in Seme and Porto-Novo will be driven by the number of sampled blocks in those areas. The effect of this change will not affect the representativeness of our sample (we will use the sub-sample from Cotonou and Abomey-Calavi), but it will reduce the statistical power of our impact estimates based on the telephone survey. Depending on whether the investments from Lot D are funded through other means, the sample from Porto-Novo and Seme could be used as a comparison group or benchmark with which to compare the remaining project areas.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
M&E/PM	A.9, second to last paragraph	Please indicate the percentage of the CCIB sample that were small businesses (as defined by having a specified number of employees).	We have added a footnote those with this statistic.
M&E/PM	Table A.10	“MCC ~~Compact development/~~Energy Practice Group”	This revision has been made.
	Page A.13	What is basis for selecting the Groupement for the NDCC buildings for an interview as opposed to GE, the supplier of the NDCC IT project (more critical, more expensive)? Given the timing of the interviews with key stakeholders, it is understandable that no other works contractors were included but, once those contracts are signed, would it make sense to have a round of interviews with those companies – e.g., Cegelec, Eiffage, GE Grid Solutions, Siemens? Additional comment: Yes, it makes sense. KIIs should include some of the construction firms and supervisory engineer.	We will plan to include these actors during the interim data collection.
M&E/PM	General	Replace all. MCA Benin with MCA Benin II	This change has been made throughout the document.
M&E/PM	B.1.1.	I wonder why there are so many more people in the North who use SBEE electricity for cooking. Verify number.	We have verified the numbers. This situation seems to be driven by Parakou and Bohicon (25% and 31% of respondents, respectively, use SBEE for cooking in those regions).
M&E/PM	B.1.1.	Spell out PPI.	We made this change in all relevant tables.
M&E/PM	Page B6, Table B.1.1.	Typo - prepaid card meter	We made this change in all relevant tables.
M&E/PM	Page B6, Table B.1.1.	The percentage for direct and indirect connections exceeds 100. Does that mean that a household could have a direct connection and an indirect connection? Include a footnote if necessary.	The outcome "Indirect connection: has a meter" is the percentage of households with an indirect connection that have a meter. Direct and indirect connections are mutually exclusive in our survey and we do not present the percent of households with an indirect connection.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
M&E/PM	Table C.1.1.	The decimals seem to be incorrect for the percent of small business owners who are women.	This has been corrected.
M&E/PM	Table C.1.1.	The ‘Number of days business operates per week’ is more than seven for the CCIB sample. How is that possible?	This has been corrected.
M&E/PM	Table C.1.3.	How many respondents had a bill they used to provide responses on electricity consumption (KWH and CFA)?	These sample sizes have been added as footnotes in all relevant tables.
MCC/Energy Practice Group	Page C.4, Carryover of Table C.1.1	Please check the data reported – now shows CCIB businesses functioning around 6 months during 2018 and operating around 11 days per week. Could the numbers be reversed – would make more sense if that were so (functioning ~11 months and operating ~ 6 days per week).	The numbers were indeed swapped; this has been corrected.
M&E/PM	General	The baseline report should have a budget annex. You can update your budget based on what you have learned about the costs so far, especially as data collection budgets are known.	We have inserted an appendix with the latest budget.
M&E/PM	General	For key findings reporting monetary values, I would suggest including the US Dollar equivalent.	We have included the USD equivalent for key findings.
MCC/Energy Evaluation Lead	20	It’s not obvious to me what defines an infeed vs. arrival line (I haven’t heard these terms in other energy projects). Please add a definition, perhaps in a footnote.	We have added a footnote with this definition: Arrival lines are the lines feeding power from the transmission and subtransmission network into the substation and infeed lines are the lines feeding power into the low voltage distribution network
MCC/Energy Evaluation Lead	33	It would be helpful to add the USD conversions for the average expenditures in Table IV.7 (and others with CFA values)	We have included the USD equivalent for key findings and for monetary values that appear in the report text. We included the suggested exchange rate as a footnote for all tables with monetary values.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
Gender Social Inclusion	General	There is a rich amount of gender data in the report, especially in the annexes. I hope we will be able to use this moving forward to understand the impacts of the compact work on women and other vulnerable groups.	We plan to conduct subgroup analyses based on gender and socio-economic status.
MCA/other stakeholder	Presentation	Considérer également le taux de réclamation des abonnées pour mieux apprécier les interruptions. Explorer davantage les causes des interruptions sur le réseau. Plusieurs facteurs entrent en jeu dans ces cas. Certains facteurs ne sont pas imputables à la SBEE. Il convient donc d'intégrer tous ces paramètres pour mieux apprécier la qualité du réseau. La SBEE fournira toutes informations requises par Mathématica pour enrichir les données de l'évaluation.	At the moment, *taux de reclamation* is not included in the evaluation design since service interruptions will most accurately and directly be assessed through the client-level smart meters. However, if SBEE collects reliable data on this indicator that is provided to the evaluator, then it could be included in the interim report analysis. We thank SBEE's commitment to providing data that will be useful this evaluation. The quality of this evaluation depends on it. Indeed, understanding the causes of outages would have to come from SBEE as clients do not always know the cause.
MCA/other stakeholder	Presentation	Le centre de dispatching a un effet national sur tout le réseau interconnecté. Pourquoi l'échantillonnage ne se base seulement sur les lignes et postes qui seront réhabilité ?	Although the NDCC is expected to benefit the whole of Benin, the evaluation focuses on the areas where the project benefits are most likely to accrue. Mathematica consulted with MCA-Benin to identify the urban areas that are expected to receive the greatest benefits from the Electricity Distribution Project; those areas comprise the evaluation areas.
MCA/other stakeholder	General	Le rapport ne fournit que des statistiques descriptives. Pourquoi n'y-t-il pas d'analyse des corrélations ? Pourquoi n'avez-vous pas analyser les relations entre les résultats au niveau du réseau avec ceux au niveau des bénéficiaires ?	The baseline report reflects the analysis we propose to conduct in the design report, which does not include a correlation analysis. Once we have data from the interim and final data collection rounds, we will conduct a deeper analysis, including methods such as multivariate regression analysis, which will consider important correlations in the data. At the interim and final analysis stages we will analyze network level and beneficiary data together.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
MCA/other stakeholder	Presentation	Faut-il une méthodologie différente pour évaluer l'impact de (i) la mise à niveau des tensions au niveau régional à 33Kv ; (ii) l'installation des lignes pour 63Kv et, (iii) le NDCC ? Les trois intervention étant différentes.	The grid monitor covers both types of lines.
MCA/other stakeholder	Presentation	Comment appréciez-vous la différence entre la fiabilité des entretiens en personnes et des données des équipements de télésurveillance ?	Smart meters are more reliable than responses. As long as they are configured correctly and functional, they provide an exact measure of electricity consumed and duration/frequency of service interruptions. These devices are not always used, because their cost can be prohibitive. The interim evaluation report could actually show the difference in precision of self-reported outages and actual outages.
MCA/other stakeholder	Presentation	L'enquête étant principalement téléphonique, quelles sont les dispositions prises pour mitiger les risques liés à la mobilité/disparition des individus de l'échantillon?	We discuss this risk and proposed mitigation strategies in the evaluation design report. We have worked with our local data collection firm to develop a strategy in which we take several measures to minimize attrition in our longitudinal sample. During the baseline survey (conducted in person), respondents were asked to confirm their willingness to participate in a multi-year telephone survey with periodic follow-ups and to provide their preferred days and times to receive these calls. The survey itself is designed to be completed in ten minutes or less so as to minimize the burden on the respondents. Finally, there will be an in-person follow-up survey at the end of each wave to include any respondents who were not reachable on the phone.
MCA/other stakeholder	Presentation	Corriger la répartition des lots (A, B, C) entre Cotonou et Régional puisque le dimensionnement de ces lots a été repris. Le projet fournira les infos actualisées au Consultant.	We welcome updated information on the division of Lots A, B, and C.
MCA/other stakeholder	Presentation	Nuancer : l'augmentation des coûts n'est pas du fait de la reprise des simulations mais plutôt du fait de la modification du périmètre du projet et d'autres aspects techniques.	This has been noted.

Commenter name or division	Reference (Page and Question #)	Comment	Evaluator response
MCA/other stakeholder	Presentation	Nuancer : dans le report, il est mentionné dans le scope initial du projet, les lignes devraient être aériennes et que c'est suite aux travaux de conception que les lignes souterraines ont été intégrées. C'est une contre réalité à corriger. Se rapprocher du projet pour précisions.	Our understanding from MCC's summary document of modifications to the Benin Power Compact (March 2019) is that, "all new 63 kV lines should be placed underground (the 2015 feasibility study had assumed significant portions would be overhead) in order to prevent the cost and delay of large-scale population resettlement." We are happy to revise the report text if there is updated information about the project and the placement of these lines.
MCA/other stakeholder	Presentation	Se rapprocher également de l'équipe projet pour avoir les informations précises relatives au permis de construire du NDCC.	We have clarified in the report that work on the NDCC IT components began in November 2018 and is ongoing. We welcome any additional information on construction permits.
MCA/other stakeholder	Presentation	Le HAZMAT est présenté dans le rapport comme une nouveauté issue de la reprise des simulations. Il faut nuancer. Se rapprocher du Projet pour plus de clarification.	We welcome clarification on this issue from the project team.
MCA/other stakeholder	Presentation	Intégrer dans le rapport les sessions relatives (i) aux limites de l'évaluation et l'impact de ces dernières sur les résultats de l'évaluation, (ii) aux difficultés rencontrées lors de la collecte des données et les mesures de mitigations implémentées pour les surmonter, (iii) les leçons apprises du processus de l'étude de référence. Ces aspects sont utiles pour la documentation et l'apprentissage.	This is not included in MCC's baseline report template, but such a section could be included in the interim evaluation report.

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