REPORT

Ghana Power Compact: Evaluation Design Report

July 29, 2019

Duncan Chaplin
Delia Welsh
Arif Mamun
Nick Ingwersen
Kristine Bos
Erin Crossett
Poonam Ravindranath
Dara Bernstein
William Derbyshire

Submitted to:

Millennium Challenge Corporation
1099 Fourteenth St, NW
Suite 700
Washington, DC 20005
Project Officers: Shreena Patel, Jeffrey Garnett, and Ishani Desai
Contract Number: 95332418A0018 95332418F0326

Submitted by:

Mathematica Policy Research
1100 1st Street, NE
12th Floor
Washington, DC 20002-4221
Telephone: (202) 484-9220
Facsimile: (202) 863-1763

Project Director: Arif Mamun

Reference Number: 50531.01.200.032.000

This page has been left blank for double-sided copying.

CONTENTS

TABLES

FIGURES

ACRONYMS

AMR	Automatic remote meter reading
AfC	Associates for Change
CAPI	Computer-assisted personal interviewing
CFL	Compact fluorescent lamp
CIS	Customer Information System
CRISIL	Crisil Risk and Infrastructure Sources Limited
DCCN	Data Center and Communications Network
EA	Enumeration area
EC	Energy Commission
ECG	Electricity Company of Ghana
EEDSM	Energy Efficiency and Demand Side Management
EFOT	ECG Financial and Operational Turnaround
ERP	Enterprise Resource Planning
ERR	Economic rate of return
FGD	Focus group discussion
FMMS	Field metering and monitoring studies
GDP	Gross domestic product
GIS	Geographic Information System
GoG	Government of Ghana
GRIDCo	Ghana Grid Company
GSEPS	Ghana Socio-Economic Panel Survey
GSI	Gender and social inclusion
GSS	Ghana Statistical Service
IBES	Integrated Business Establishment Survey
ICC	Intraclass correlation
IEA	International Energy Agency
IPP	Independent power producer
IRB	Institutional review board
ITT	Indicator tracking table
KII	Key informant interview
KPI	Key performance indicators
kWh	Kilowatt hours
LBNL	Lawrence Berkeley National Laboratory

LV	Low voltage
MCC	Millennium Challenge Corporation
MDE	Minimum detectable effect
MDI	Minimum detectable impact
MSME	Micro, small, and medium sized-enterprise
MiDA	Millennium Development Authority
MIS	Management information systems
MSPE	Mean squared prediction error
MW	Megawatt
NEDCo	Northern Electricity Distribution Company
NES	National Electrification Scheme
NFOT	NEDCo Financial and Operational Turnaround Project
OLS	Ordinary least squares
OMS	Outage Management System
PDS	Power Distribution Services Ghana Limited
PFG	Partnership for Growth
PPA	Power purchase agreements
PSP	Private sector participation
PSO	Private sector operator
PSU	Primary sampling units
PURC	Public Utilities Regulatory Commission
R2R&R	Race-to-Retrofit and Renewables
RCT	Randomized control trial
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCM	Synthetic control method
SEAP	Swedish energy audit program
SESCs	Sustainable Energy Services Auditing Centers
SGIP	Social and Gender Inclusion Plan
TOR	Terms of reference
TSTP	Tariff Study and Tariff Plan
USAID	United States Agency for International Development
VRA	Volta River Authority

I. INTRODUCTION

This report presents Mathematica's plans for conducting a decade-long evaluation of the Ghana II Power Compact. This five-year compact between the Millennium Challenge Corporation (MCC) and the Government of Ghana (GoG) entered into force in September 2016 and is aimed at improving the performance of Ghana's power sector. MCC contracted Mathematica to conduct an independent evaluation of this compact. Mathematica's evaluation will capture baseline and early implementation conditions as well as long-term outcomes measured years after the compact has ended. The evaluation's goals include providing MCC with a more complete understanding of project implementation and a deep examination of how and why outcomes materialized over time. Lessons learned from the evaluation will apply to future energy sector investments in Ghana as well as to other countries at a similar juncture in the development of their power sector.

A. Country context

Ghana has made important strides in the area of grid electricity, but major challenges remain. Examples of success include providing grid electricity access to more than 80 percent of the population, being self-sufficient in power generation, making important steps toward energy efficiency, and having a well-developed electricity regulatory system. Indeed, Ghana's system was ranked 5th among 15 countries in sub-Saharan Africa on the recently developed Electricity Regulatory Index (African Development Bank 2018). These are all important steps for developing a well-functioning power sector; however, there remain a number of areas where significant improvements are necessary. In particular, the power sector utilities are still not financially viable in the absence of government subsidies. This is because costs run far above revenues, due partly to high commercial and technical losses and partly to a tariff structure which is unsustainable. The utilities' weak financial health makes it difficult for them to maintain and improve their infrastructure. Finally, efforts to reform the sector are hampered by government intervention and a lack of transparency, as well as by weak management structures, an inability to operate on commercial principles, and degrading infrastructure which affects current and future service delivery.

Almost all customers in Ghana receive electricity from two utilities that face varying challenges—the Electricity Company of Ghana (ECG)[1] and the Northern Electric Distribution Company (NEDCo). ECG serves the southern part of Ghana including Accra and covers about 80 percent of the customers in the country's power market. ECG has a long history of poor operational performance despite a significant amount of donor investment (MCC 2014a; Resource Center for Energy Economics and Regulation 2005). As a result, ECG has not been able to adequately invest in grid maintenance, operations, staff capacity, and customer service. Although its coverage is small, the Enclave Power Company is the power distributor to the Free Zones Enclave in Tema. The rest of the power market in Ghana is served by NEDCo, which covers the northern two-thirds of the country. It services a much lower-income and far less

[1] On March 1 2019 the management of ECG was taken over by Power Distribution Services Ghana Limited (PDS) following a successful transfer on concessionary terms. Most of the staff who worked at ECG are now working for PDS. However, a few shifted to a restructured ECG, which sells power to PDS and owns the assets that PDS manages.

densely populated area than the area served by ECG. Many of the low-income customers have a lifeline connection, meaning that they pay a lower tariff than other customers. In addition, the low population density in Northern Ghana means it is more expensive to provide electricity there.

Ghana's power sector governance is managed by three institutions: the Ministry of Energy, the Energy Commission (EC), and the Public Utilities Regulatory Commission (PURC). The Ministry of Energy formulates, monitors, and evaluates energy sector policies and programs. The EC and PURC are regulatory bodies, with the EC responsible for regulation of technical operations of energy sector service providers and PURC responsible for economic regulation and tariff setting.

MCC works with the GoG through the Millennium Development Authority (MiDA), an entity established by the GoG specifically to manage Ghana's compacts with MCC. MiDA has a Project Management team that works on implementing the compact projects as well as a Monitoring and Evaluation (M&E) team that oversees the progress of the work in a results-based management fashion.

B. Overview of the compact and interventions to be evaluated

The $498 million Ghana II Compact aims to improve the quality and reliability of power distribution systems; support regulatory reforms to promote private sector partnership and long-term financial sustainability; improve access to legal connections for micro, small, and medium-sized enterprises (MSMEs); and promote energy efficiency to manage demand growth. The compact was signed in August 2014, and entered into force in September 2016. It is scheduled to last for five years and end in September 2021. The agreement is part of the U.S. government's strategic collaborations with GoG, which also include targeting power generation through the Power Africa initiative (USAID 2016) and sector reforms through the Partnership for Growth initiative (PFG 2013), although the latter ended in March of 2018. The compact comprised the following projects designed to address critical challenges facing the electricity sector:

- The ECG Financial and Operational Turnaround Project (EFOT) was designed to improve ECG's management and efficiency by introducing private sector participation, reducing outages and commercial and technical losses, and modernizing the electricity distribution system.
- The original design of the compact also covered the NEDCo Financial and Operational Turnaround Project (NFOT) which was designed to improve NEDCo's financial performance and customer service through private sector involvement in operational and commercial capacity building, infrastructure investments, and efforts to improve cost recovery. MiDA was not able to reach an agreement to move forward with this project, so it was de-scoped. Consequently, the funds are being reallocated, and we do not cover the project in this design report.
- The Regulatory Strengthening and Capacity Building Project (hereafter the Regulatory project) is designed to promote sustainability, transparency, and accountability in the power sector through strengthening regulatory institutions and processes, reviewing and restructuring tariffs, and improving the environment for private sector investment.

- The Access Project targets MSMEs in markets and economic enclaves in urban and peri-urban areas with activities to increase legal connections and improve security lighting.
- The Energy Efficiency and Demand Side Management (EEDSM) Project seeks to improve building and appliance efficiency and reduce energy wastage through energy audits; standards and labels for energy efficient devices; upgrades to street lighting; and education and public information activities.
- The original design of the compact also included the Power Generation Sector Improvement (Generation) Project to diversify fuel sources for power generation through support for the gas sector and liquefied natural gas development and to strengthen the enabling environment for independent power producers (IPPs). The need for MCC assistance has been greatly reduced because the GoG is already undertaking reforms with support and technical assistance from USAID. As a result, MCC is not moving forward with this project and we do not cover it in this report.

C. Objectives and organization of this report

This evaluation design report describes the background for our evaluation, the questions we intend to answer, the data we plan to collect and use, and how we will analyze those data. Documenting this information now helps ensure that our results will be viewed as credible, by showing that key analysis decisions were made before we had access to the data. At the same time, we plan to have a flexible design so that we can react to conditions on the ground. To maintain credibility, we will clarify the rationale for any deviations from our original design in our later reports.

1. Evaluation types

We will be conducting two types of evaluations—performance and impact. The performance evaluations will make use of qualitative and quantitative information to provide a comprehensive picture of outcomes associated with the compact and with each of its projects. Although the performance evaluations will not allow us to directly attribute observed outcomes to the projects, they will enable us to make use of multiple sources of data to provide a richer sense of what happened and why, and to cover a much broader set of project components than will be possible with the impact evaluations. We have also included an impact evaluation of one component of the Ghana II compact, an intervention designed to improve energy efficiency in buildings run by a number of government agencies.

The performance evaluations will make use of two types of data: longitudinal quantitative data and qualitative data. The longitudinal data will cover numerous key outcomes coming from administrative sources (financial and grid-based), electricity quality and reliability (that is, outage and voltage fluctuations) data from GridWatch,[2] and a household and enterprise survey. The qualitative data will be collected from major stakeholders, including key staff at entities involved in power supply such as ECG, Power Distribution Services (PDS) Ghana Ltd, and GRIDCo; policy-setting and regulatory bodies such as the Ministry of Energy, EC, and PURC; sector and M&E staff at MiDA; current and potential investors in the electricity sector; MSMEs

[2] GridWatch is a collaboration between The University of California Berkeley's Development Impact Lab and The University of Michigan Lab11.

and large-scale businesses; and households. The performance evaluation will also incorporate impact evaluation results, including those produced by GridWatch estimating impacts of outages on economic outcomes.

The impact evaluation will use data from the utility to estimate impacts of the Race-to-Retrofit and Renewables (R2R&R) initiative designed to save energy in a number of government buildings.

We plan to collect data in three rounds: at baseline (qualitative data in August 2019 and survey data at the end of 2019) to capture early implementation conditions; midline qualitative data at the end of the compact (2021/2022) to cover final implementation and early outcomes; and endline two years after the compact is over (2023/2024) to cover longer-term outcomes.

2. Organization of the report

We present an overview of the compact interventions and our evaluation design in Chapter II. We cover the logic model, each of the projects we are evaluating, and how we deal with gender and social inclusion, and briefly describe how we will answer each research question. Our literature review (Chapter III) covers Ghana's power sector, benefits of reform, and gaps in the current literature. Chapter IV describes how we will conduct our evaluation of the overall compact. Chapters V through VIII describe how we will evaluate each of the four compact projects, including data sources, methods, timeline, and evaluation challenges and mitigation strategies. Our plan to update the economic rate of return calculations is covered in Chapter IX. Chapter X provides details of our data collection plans, including use of local data collection partners and instrument development as well as our plans to address Gender and Social Inclusion (GSI) issues, and our plans to address any challenges we encounter. Chapter XI covers evaluation management issues such as IRB requirements and our dissemination plan.

II. OVERVIEW OF THE COMPACT AND EVALUATION DESIGN

A. Overview of the Ghana Power Compact

As discussed in Chapter I, Mathematica is evaluating four projects under the Ghana Power Compact. Table II.1 presents a summary of MCC's original funding allocation for these projects, including the two that will no longer be part of the compact (NFOT and Generation), and funds allocated for monitoring and evaluation and Compact administration. Notably, EFOT constitutes the majority of compact funding, given ECG's market share and the large project scope.

Table II.1. June 2019 allocation of Ghana compact funding, by project

Project	MCC $	Government of Ghana $	Total $	Percent
EFOT	393,460,000	37,350,000	430,810,000	80.4
NFOT	3,800,289		3,800,289	0.7
Regulatory	3,881,983		3,881,983	0.7
Access	10,000,000		10,000,000	1.9
Generation	0		0	0.0
EEDSM	26,147,799		26,147,799	4.9
Monitoring and evaluation	7,580,000		7,580,000	1.4
Compact administration	53,300,000		53,300,000	10.0
Total	498,200,071		535,550,071	100.0

Source: Ghana II Compact and updates from MCC.

B. Logic model for Ghana compact

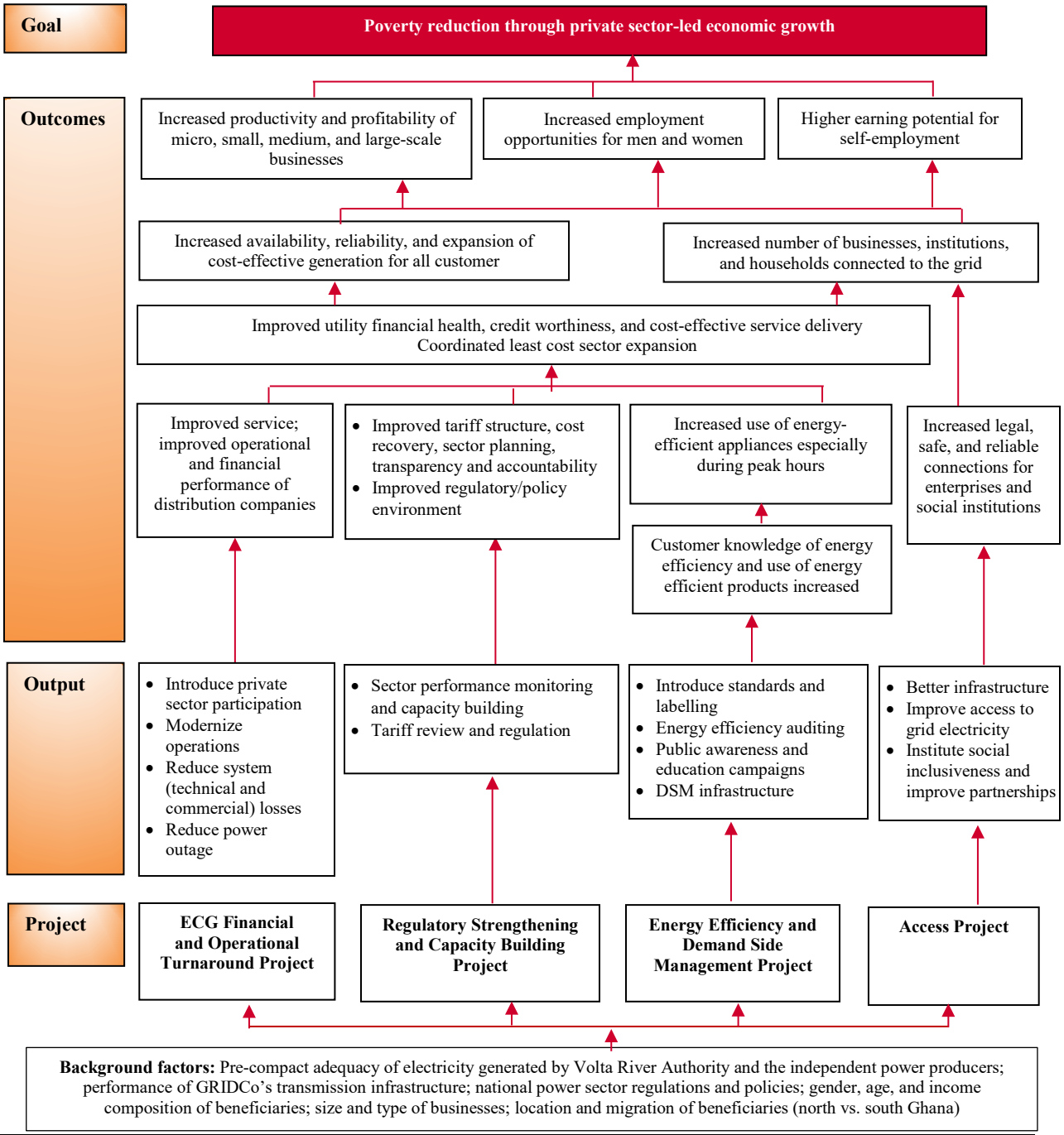
MCC's problem diagnostic identified two main issues limiting the efficiency and effectiveness of the Ghana energy sector: (1) low reliability of electricity supply and (2) insufficient access to power. In direct response to these constraints, MCC designed an overall program logic for the Ghana II Compact, which Mathematica modified as shown in Figure II.1, below. The program logic shows the hypothesized relationship between compact projects, outcomes, and the ultimate goal of reduced poverty through economic growth. In particular, the logic model shows the causal pathway through which compact projects and their activities achieve targeted power sector outcomes of increased availability, reliability, and expansion of cost-effective generation for all customers. The logic model also ties the relevant activities to increased numbers of businesses, institutions, and households connected to the grid.

The program logic also illustrates the complementarities between projects. The core compact activities consist of the EFOT and Regulatory projects: The EFOT project focuses on introducing a private sector concessionaire and modernizing operations, whereas the Regulatory project aims to improve cost-recovery and sector transparency. EFOT is the largest project in terms of compact funding. The Regulatory project uses $3.882 million, a small share of the compact investment, but is designed to have a major effect on the sector. Together, these projects aim to reduce or eliminate sector inefficiencies and reliance on government subsidies, improving

service as a result. If successful, these projects would improve the availability and quality of electricity to consumers while also improving the financial health of the utility.

Power generation is a critical component of Ghana's energy landscape; however, as discussed in Chapter I, it is no longer a focus of the compact, due to reform measures underway between GoG, USAID, and other stakeholders. The compact also originally included plans to reform NEDCo, however this project will not move forward. Both Generation and NFOT projects are excluded from the logic model and our evaluation design.

Figure II.1. Ghana II Power Compact: Program logic



The Access project focuses on MSME access to legal and formal connections in targeted markets and economic enclaves. The EEDSM project seeks to reduce gaps between supply and demand, particularly for peak load management, by improving the efficiency of electricity used.

Together, these projects are aimed at reducing outages, improving the utilities' financial health, increasing legal connections to the grid, improving energy efficiency, and enhancing enterprise profits by reducing energy costs, thereby contributing to economic growth and reduction in poverty.

C. The ECG Financial and Operational Turnaround (EFOT) Project

The EFOT project is designed to improve ECG's management and efficiency by introducing a private sector operator through a concession agreement, reducing outages and commercial and technical losses, and strengthening the distribution system. ECG distributes the majority of Ghana's electricity—around 70 percent—to six administrative regions in southern and central Ghana: Greater Accra, Western, Ashanti, Central, Volta, and Eastern regions. With a budget of nearly $340 million, EFOT is the largest project in the compact. The primary EFOT beneficiaries are customers in the ECG catchment area as well as their household members, enterprise employees, and enterprise customers.[3] We describe below the five main EFOT activities.

1 ECG Private Sector Participation (PSP) activity

The ECG PSP activity focuses on improving managerial and commercial capacity of ECG. In particular, the PSP activity is bringing a fixed-term concessionaire on board to manage ECG operations for the next 20 years. The concessionaire will not be allowed to lay off existing staff but it will be able to hire new staff. This activity consists of transaction advisory services to help bring the concessionaire on board. As of April 2018, MiDA selected a consortium led by Meralco, a Philippines-based firm, to serve as the concessionaire. The consortium, PDS, took control of operations and most of the current ECG staff on March 1, 2019. PDS will provide electricity to the ECG catchment areas while a restructured ECG will continue to operate as the asset owner and a bulk energy trader. Although this is a key activity, it is not expected to require a great deal of additional funding and has a budget of around $6.76 million. However, execution of the agreement was a condition for receiving the second tranche of funding for the compact ($190 million).

2. Modernizing ECG Operations activity

This $58.01 million activity is designed to introduce modern tools to ECG, build the capacity of ECG's staff to use the tools, and provide a robust communication network for ECG. It also includes a number of interventions to support development of the integrated loss management approach to utility turnaround and to help ECG Target Regions within its service territory implement change as well as support ECG with program management of commercial and network improvements. In particular, the activity envisions the development of a Data

[3] ECG customers include households, enterprises, and other social institutions such as schools, hospitals, and other public facilities, but the social institutions are not included in the EFOT logic model.

Center and Communications Network (DCCN), Enterprise Resource Planning (ERP) system, and Geographic Information System (GIS).

3. ECG Commercial Loss Reduction activity

The second largest EFOT activity, the $42.73 million Commercial Loss Reduction activity, targets the utility's financial viability, focusing on installing meters with automatic meter reading (AMR) systems at critical nodes of the distribution network (MMS and AMR Meters sub-activities), and strengthening the ECG Loss Control Unit (the ECG Loss Control Unit sub-activity). There were also plans for replacing legacy meters (the Prepaid Meters sub-activity) and normalizing customer connections (Customer Normalization sub-activity), but funding for those may be reduced or eliminated so they are not a major focus of our evaluation. This activity should increase the revenues associated with providing a given amount of power. It could benefit customers if the utility uses this revenue to improve services.

The current funding for this activity is about $47 million less than originally planned. MCC and MiDA will reduce the planned investments in the Commercial Loss Reduction Activity (CLR) and increase funding for the Technical Loss Reduction Activity. This support new investment in additional infrastructure and support the strength, reliability, and cohesiveness of the network while the private sector operator, PDS, concentrates on the customer-facing side of the business.

4. ECG Technical Loss Reduction activity

The ECG Technical Loss Reduction activity is EFOT's largest activity at $313.29 million. It includes funds for two bulk supply points (BSPs), seven new primary substations, and line bifurcation in ten priority districts. It also covers updating manuals, materials, and equipment specifications with construction best practices. This activity should reduce the costs of providing power and should, therefore, increase net revenue for the utility.

5. ECG Outage Reduction activity

The $10.02 million ECG Outage Reduction activity focuses on supporting network improvements, including building an Outage Management System (OMS) and potentially improving the quality of outage data collected by the utility.

D. The Regulatory Strengthening and Capacity Building Project

The Regulatory project is designed to promote sustainability, transparency, and accountability in the power sector through strengthening regulatory processes, reviewing and restructuring tariffs, and improving the environment for private sector investment. Thus, this Project is designed to ensure that the power sector is financially self-sustaining and relies less heavily on cross-subsidies among tariff categories or other direct or implicit subsidies from the Government. The primary beneficiaries of this project are electric utility customers throughout Ghana, as well as their household members, enterprise employees, and enterprise customers. However, no beneficiary analysis was conducted for this project as all benefits were rolled up into the beneficiary analyses for the EFOT and NFOT projects.

The Regulatory project is composed of two main activities designed to improve regulators' capacity to monitor utility performance and to provide better information to help improve institutional and political support for tariff reform. Below, we describe these two activities and their respective implementation status.

1. The Sector Performance Monitoring and Capacity Building activity

The purpose of this activity is to provide technical assistance to a number of key players in the energy sector of Ghana including the Ministry of Energy (MoEn), the National Development Planning Commission (NDPC), the Ministry of Petroleum, PURC, and EC.

2. Tariff Review and Regulation activity

This activity focuses on providing cost information to deliver power and support for PURC to reduce cross-customer subsidies and other direct or implicit subsidies from the government while also maintaining access for lifeline customers. The activity includes a number of tariff studies known as the Tariff Study and Tariff Plan (TSTP), developed by Fichtner Management Consulting, the contractor for the activity. Fichtner is also working on a number of reports, including a cost-of-service analysis, a lifeline analysis, a willingness-to-pay study, a cost of unserved energy, and also a marginal cost study.

E. The Access Project

The Access Project targets MSMEs in markets and economic enclaves in urban and peri-urban areas with activities to increase legal connections, improve security lighting, and strengthen local institutions. As of July 2018, the eight markets and economic enclaves identified as high-priority investment areas are Madina market, Kaneshie Market, Makola Market, Dansoman Market, Agbogbloshie Market, Tamale Central Market, Accra Timber Economic Enclave, and Tamale Timber Economic Enclave.[4] The combined infrastructure upgrades and security lighting activities will benefit all MSME vendors, particularly those with expanded access to grid electricity. The beneficiaries are the businesses in these areas, their employees, and their customers.

The Access project consists of two interventions—one focused on infrastructure upgrades and another on strengthening institutional partnerships. The infrastructure intervention includes installation of high voltage distribution systems, pole mounted distribution transformers, secondary LV feeders, pole-mounted prepaid meter banks; customer service drops as cable-in-conduit, and security lighting. The infrastructure intervention should provide better access to safe, reliable and legal connections to electricity, and improved lighting for security. The institutional intervention includes a customer information campaign, customer normalization, facilitation assistance, and stakeholder coordination. The intervention should reduce the length of time required to get a connection, streamline the connection process, and improve compliance with wiring standards.

[4] Two additional markets and economic enclaves could be included in the project if there are sufficient funds are added—NijNi Boi man in Accra and Lamashegu in Tamale.

F. The Energy Efficiency and Demand Side Management (EEDSM)

The EEDSM project seeks to improve building and appliance efficiency and reduce energy wastage through the introduction of standards and labels, energy audits and outreach activities. EEDSM beneficiaries include the entire population with access to electricity, an estimated 4.3 million households with 19.6 million people. Below, we describe the four main activities and their respective implementation status.

1. Development and Enforcement of Standards and Labels activity

This activity focuses on the creation of standards and labels for machinery and household electrical appliances and motors, test facilities construction, and field metering and monitoring studies (FMMS). Even though the development of standards and labels should be completed during the compact period, a legislative initiative is necessary to require importers to follow the standards, which can take as long as two years to be completed.

2. Improved Energy Auditing activity

This activity focuses on conducting energy audits and retrofits in a small set of government buildings and setting up two Sustainable Energy Services Auditing Centers (SESCs) that will train energy auditors for the sustainable energy market in Ghana.

3. Education and Public Information activity

This activity focuses on a pilot of energy efficiency school curriculum updates for 30 pre-tertiary schools and direct public education prior to enforcement of standards and labels. The schools are located in the Greater Accra, Ashanti, and Northern regions.

4. Demand Side Management activity

This activity focuses on installing energy-efficient LED street lights in the ECG Accra East and West operational regions.

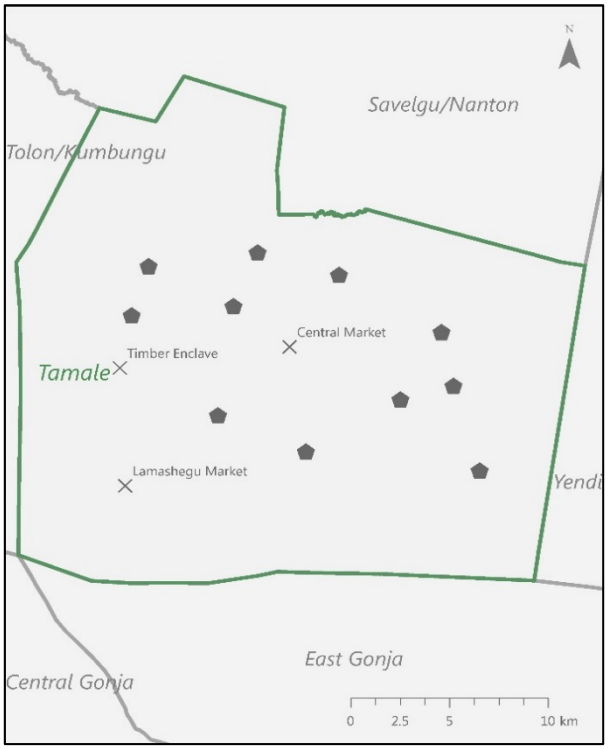
Maps of some of the main compact projects and activities can be found in Figures II.2 and II.3.

Figure II.2. ECG and NEDCo service areas

Note: The NEDCo service area extends southwards a bit into some parts of the Ashanti and Volta regions.

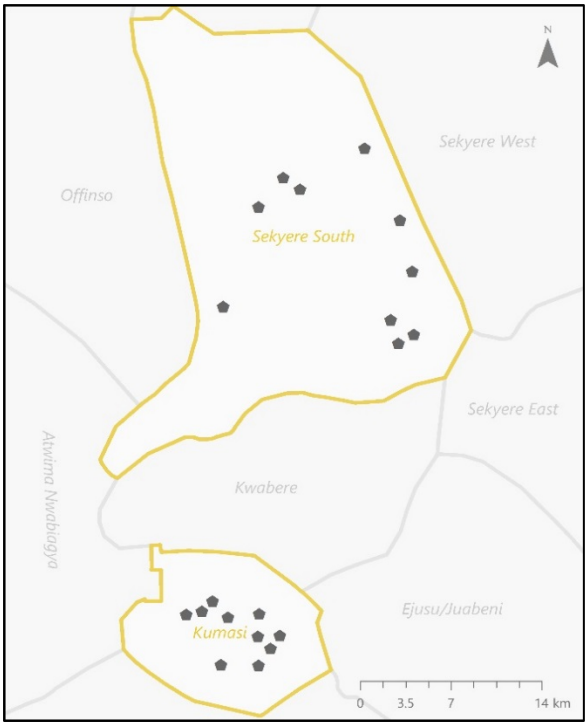
Figure II.3. Selected compact activities in the regions

Access and EEDSM activities in Tamale District

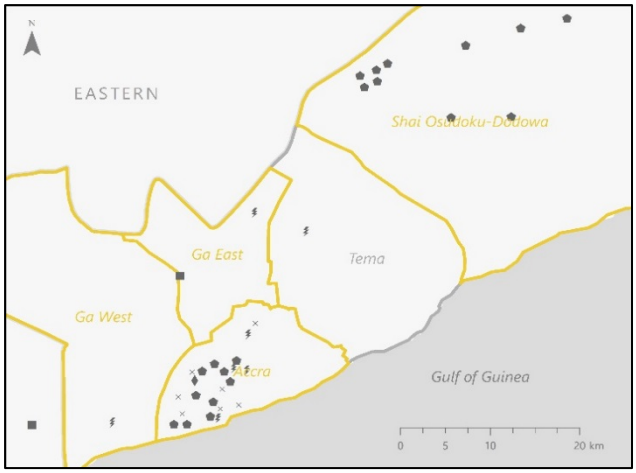


EEDSM activities in Northern region outside of Tamale

EEDSM activities in Ashanti Region



EFOT, Access and EEDSM activities in Accra



Legend
- Schools in Education and Public Information activity
- Markets and Enclaves in Access project
- New Meters in Kaneshie
- Sub-stations
- Bulk supply points

Note: The boundaries included in the maps represent the districts within the Administrative Region of "Greater Accra" as of 2005.

G. Gender and Social Inclusion (GSI)

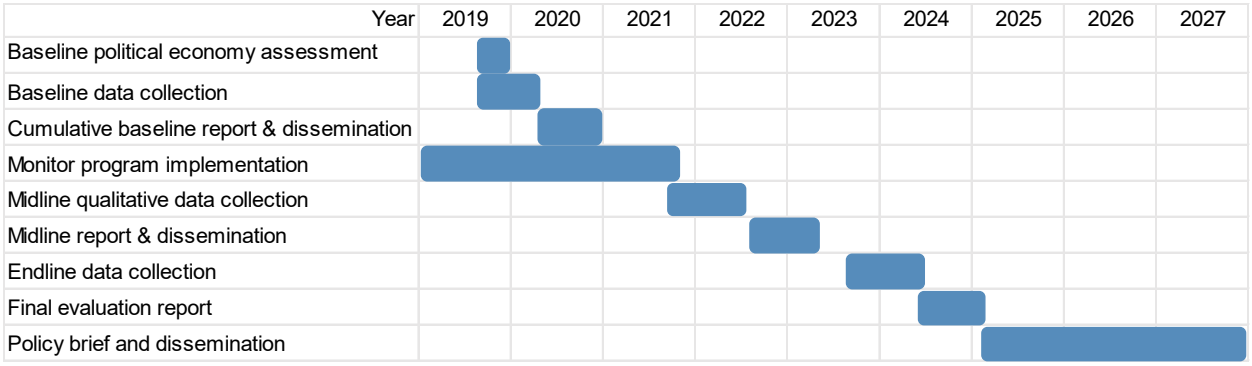
GSI is a cross-cutting effort that will affect the implementation of all compact projects. MCC conducted a GSI assessment at the compact development stage; the more recent Social and Gender Inclusion Plan (SGIP) outlines how GSI can be integrated into compact projects and which indicators to use in measuring progress on GSI outcomes. For example, the EFOT project will conduct gender audits at the utility in order to understand female representation there and increase female employment in the energy sector. The EEDSM project will include targets for female participation in energy efficiency audit teams, and ensure energy efficiency labels have symbols for illiterate people. More broadly, in the performance evaluations we will analyze changes in outcomes by gender to see if disparities changed when the compact interventions were implemented.

H. Evaluation Overview

Mathematica proposes a comprehensive mixed-methods approach to address MCC's key research questions for the Ghana power evaluation, balancing methodological rigor with contextual realities. Table II.2 provides an exhaustive list of the research questions addressed by these evaluations. The questions are grouped together based on whether they address project objectives, implementation, and sustainability.

The performance evaluations will incorporate both qualitative and quantitative data, enabling us to draw upon a wide variety of data sources and provide a comprehensive picture of what happened and why. Qualitative data sources include document review, site observations, and key informant interviews with households, enterprises, and stakeholders in the power generation, transmission, distribution, and government oversight bodies (for example, Ministry of Energy, EC, PURC). Quantitative data sources include a household and enterprise survey, outage data from GridWatch, longitudinal data from administrative sources (both financial and grid-based), and secondary survey data from entities such as the World Bank and Ghana Statistical Service (GSS). Figure II.4 illustrates the evaluation and data collection timeline.

Figure II.4. Overview of evaluation timeline



We propose one impact evaluation that covers the EEDSM project. The proposed impact evaluation relies on an interrupted time series method to evaluate data from the utility on energy use over time in each of the targeted buildings. We describe the performance and impact evaluation designs in detail in Chapters IV through VII.

Table II.2. Research questions, methods, outcomes, and data sources

Compact-level questions	Methods	Key outcomes	Data sources
1. What is the estimated economic impact of the Ghana power compact?	• High-level analysis of the compact's economic impacts and lessons learned for future energy reform projects • Tracking key outcomes over time	• Outages and voltage fluctuations • Economic outcomes	• GridWatch and administrative data • Estimated impacts of outages on economic outcomes • KIIs • Household and enterprise survey
2. What are the lessons learned and are they applicable to other similar projects? 3. What were the political economy (PE) factors that influenced the process and outcomes of introducing regulatory and utility reform?	• Review and compare evaluation results for individual projects • Tracking of themes from KIIs on lessons learned • Political economy analysis	• Perceptions of successes and challenges and political economy factors that influenced them	• KIIs • Project evaluations • Household and enterprise survey

Table II.2 *(continued)*

EFOT project questions	Methods	Key outcomes	Data sources
PROJECT OBJECTIVES			
1. Did the private sector operator result in improved reliability of power and improved financial health of the utility? 2. To what extent did the activities improve operational efficiency and the cost of distributing power? Is it possible to identify which interventions are the most effective? 3. Did technical and commercial losses, power quality, and reliability improve? Do stakeholders perceive that these changes resulted from compact investments versus other investments or policy changes?	• Track key indicators over time • Benchmark key indicators against performance of private sector operators in other countries • Track perceptions and emerging themes from qualitative data • Political economy analysis • Engineering simulations	• Power reliability • Financial health of utility • Maintenance • Collection period • Perceptions of organizational change and operational improvements • Cost of distributing power • Technical and commercial losses	• Implementation documents and utility data • KIIs • Comparison with other countries • GridWatch data • Household and enterprise survey • Administrative data
IMPLEMENTATION			
4. Were project activities implemented as designed? How did implementation (in terms of objectives, activities, and beneficiaries) deviate from the original logic driving the investment, and why? How did changes in implementation affect project performance? What were the implementation successes and challenges? Did the PSP transaction reach financial close by the required deadline (end of Year 2 of the compact)? Was a qualified firm identified, recruited, and brought on board who could improve ECG's financial and operational performance by end of Year 2? What are the lessons learned from the process? 5. Did the private sector operator leverage its own resources to make appropriate upgrades to the distribution system? 6. How did the new management information systems and the other foundational investments affect the operational efficiency and cost of distributing power for the utility? 7. Did the semi-annual review process or other high-level stakeholder engagement contribute to progress on key reform milestones and outcomes? If so, how?	• Comparison of planned vs. actual implementation timeline • Review procurement process and press • Track key indicators over time • Track perceptions and emerging themes from qualitative data	• Implementation progress • Satisfaction of conditions precedent • Private sector participant contracts signed • Private sector resources leveraged for system upgrades • Level of stakeholder engagement	• Implementation documents • Press/news articles • KIIs • Implementation documents • Indicator tracking table
SUSTAINABILITY			
8. Were improvements in project outcomes sustained after the end of the compact? What sustainability planning was done during implementation, and why? What are the critical institutional factors that affected their sustainability? 9. Did the financial health of the utility stabilize over the life of the compact and after the compact was finished? Were improvements driven primarily by tariff increases or by other project activities? If there are no improvements or improvements are minimal, why?	• Track key outcomes over time • Track perceptions and emerging themes from qualitative data • Simulations regarding what drives improvements	• Power reliability • Financial health of utility • Adherence to the Arrears Plan	• Implementation documents and utility data • KIIs • Household and enterprise survey • GridWatch data

Table II.2 *(continued)*

Regulatory project questions	Methods	Key outcomes	Data sources
PROJECT OBJECTIVES			
1. Did the project result in cost-reflective tariffs or tariffs that were on track to be cost-reflective by the end of the compact (cost-reflect means tariffs that tracked inflation, sector costs, macroeconomic performance, and exchange rates)? 2. To what extent were tariff changes driven by reforms to the tariff structure and methodology versus other factors (such as inflation, macroeconomic performance, exchange rates)? 3. Did "hidden costs" drop when project activities were implemented? If so, to what extent can this be attributed to the project activities?" 4. Did the project contribute to improved tariff targeting and greater access to power for the poor? How were the benefits distributed amongst the different stakeholders	• Review project documents examining development of cost-reflective tariff including those from PURC • Track key outcomes over time • Simulation methods to estimate the degree to which tariff changes were driven by the different factors and how they impacted access and benefits for different subgroups • Review financial records on hidden costs and private investments • Qualitative analysis	• Cost reflective tariff in place • Hidden costs • Grid access for low income customers • Perceptions of fairness of tariffs and change in quality of service	• Project records • Administrative data • KIIs • Press records • Household and enterprise survey
IMPLEMENTATION			
5. Were projects activities implemented as designed? How did implementation (in terms of objectives, activities and beneficiaries) deviate from the original logic driving the investment and why? How did changes in implementation affect project performance? What were the implementation successes and challenges? Are distribution utilities meeting performance targets set by the regulator? Why or why not? 6. Does the regulator have the data necessary to measure sector performance? If yes, do those data influence their decisions and how they implement the tariff formula?	• Comparison of planned vs. actual implementation design timeline • Review procurement process and press • Review project documents examining development of cost-reflective tariff • Qualitative analysis	• Implementation progress • Satisfaction of conditions precedent • Transparency of process • Quality of rationale for decisions	• Project records • Administrative data • KIIs • Press articles
SUSTAINABILITY			
7. Were improvements in project outcomes sustained after the end of the compact? What sustainability planning was done during implementation, and why? What are the critical institutional factors that affected their sustainability?	• Track key outcomes over time • Political economy analysis of institutional incentives • Collect data at end of compact and later • Qualitative analysis	• Cost-reflective tariffs sustained over time • Continuous refinement of targeting	• Administrative data • KIIs • Household and enterprise survey

Table II.2 *(continued)*

Access project questions	Methods	Key outcomes	Data sources
PROJECT OBJECTIVES			
1. Was the Access project successful in expanding the number of connections?	• Track key outcomes over time • Track perceptions of the effectiveness of institutions and rationale for investing in legal connections • Enterprise case studies • Simulations to estimate impacts on financial health of utility if projects were to be expanded	• Legal connection rates • Perceptions of governance structures in markets and economic enclaves • Commercial losses • Energy use • Electricity bills paid	• Project records • Administrative data • FGDs • Enterprise survey
IMPLEMENTATION			
2. Were projects activities implemented as designed? How did implementation (in terms of objectives, activities, and beneficiaries) deviate from the original logic driving the investment, and why? What were the implementation successes and challenges? How did changes in implementation affect project performance? 3. To what extent have the interventions improved the effectiveness of governance structures in markets and economic enclaves, and/or enhanced collaboration between market institutions and the utilities?	• Comparison of planned vs. actual implementation design timeline • Review procurement process and press • Track perceptions of implementation	• Implementation progress • Satisfaction of conditions precedent	• Project records • KIIs/FGDs
SUSTAINABILITY			
4. Were improvements in project outcomes sustained after the end of the compact? What sustainability planning was done during implementation, and why? What are the critical institutional factors that affected their sustainability?	• Track key outcomes over time • Collect data at the end of compact and later • Enterprise case studies	• Legal connection rates • Perceptions of success • Sustainability plans	• Administrative data • KIIs • Household and enterprise survey

EEDSM project questions	Methods	Key outcomes	Data sources
PROJECT OBJECTIVES			
1. Have the EEDSM interventions changed consumption of electricity by individual customers? 2. Did the availability and purchases of more energy-efficient appliances increase when standards were implemented? To what extent can these changes be attributed to the new standards? 3. To what extent has the R2R&R intervention affected electricity use and bill payment rates?	• Pre-post analysis • Pre-post analyses of use of energy-efficient appliances for standards and labels (S&L) programs using survey data • Key informant interviews • Impact evaluation using interrupted time series design to estimate impacts of R2R&R on electricity consumption and bill payment	• Energy consumption • Appliance purchases • Percentage of appliances that are compliant	• Survey data • KIIs
IMPLEMENTATION			
4. Were project activities implemented as designed? How did implementation (in terms of objectives, activities, and beneficiaries) deviate from the original logic driving the investment, and why? How did changes in implementation affect project performance? What were the implementation successes and challenges?	• Comparison of planned vs. actual implementation design timeline • Review procurement process and press	• Implementation progress • Satisfaction of conditions precedent	• Project records • KIIs
SUSTAINABILITY			
5. Were improvements in project outcomes sustained after the end of the compact? What sustainability planning was done during implementation, and why? What are the critical institutional factors that affected their sustainability?	• Track key indicators over time	• Energy consumption • Appliance purchases • Percentage of appliances that are compliant • Stakeholder perceptions	• KIIs • Survey data

III. LITERATURE REVIEW

This literature review provides context and evidence relevant to key components of the Ghana Power Compact. It presents a brief overview of the structure of the Ghanaian power sector, its regulatory and policy context, and the status of grid electricity connections. We then discuss evidence relevant for the investments being made under the compact. The chapter concludes with a brief discussion of gaps in the literature that Mathematica's evaluation will help complete.

A. Background on Ghana's power sector

1. Structure of the power sector

The structure of Ghana's power sector today is a product of reforms and an opening of the electricity market in the late 1990s. Today, the sector comprises a number of public and private institutions and a growing number of IPPs, as shown in Table III.1.

Table III.1. Overview of Ghana's energy sector

Generation	Transmission	Distribution	Policy and Regulation
Volta River Authority (VRA) • Wholly government-owned, established in 1961 • Manages over 2,340 MW in installed generation capacity, including the 1,020 MW Akosombo hydropower plant	**Ghana Grid Company (GRIDCo)** • State-owned enterprise responsible for transmission of electricity from Ghana's power plants to the electricity distributors	**The Electricity Company of Ghana (ECG)** • State-owned company created in 1997 • Ghana's largest distribution company, responsible for over 70 percent of the market share. • Distributes power to the Greater Accra, Western, Ashanti, Central, Volta, and Eastern regions	**Ministry of Energy** • Formulates, monitors, and evaluates energy sector policies and programs • Implements the National Electrification Scheme (NES)
Bui Power Authority • Manages the 400 MW Bui hydropower plant		**The Northern Electricity Distribution Company (NEDCo)** • The Northern Electricity Department operated as the distribution arm of the VRA from 1987 to 2012, when it was converted to a wholly-owned subsidiary of VRA • Distributes power to the Northern regions of Ghana	**Energy Commission (EC)** • Responsible for technical regulation of the sector • Advises the Ministry of Energy
Independent power producers (IPPs) • Nine IPPs manage 1,925 MW in installed generation capacity (as of October 2017) • Increasingly important part of the electricity sector		**Enclave Power Company** • Ghana's only private distribution company • Distributes electricity to industrial and commercial customers in the export-processing zones in Tema	**Public Utilities Regulatory Commission (PURC)** • Independent regulatory agency • Responsible for economic regulation, including setting tariff for electricity distribution • Monitors quality of electricity services

Sources: Electricity Company of Ghana n.d. (a); Enclave Power Company n.d.; Komi 2017; Volta River Authority n.d.

2. Regulatory and policy context

As described in Table III.1, the EC and PURC are responsible for regulation of the power sector in Ghana, with the EC responsible for technical regulation and PURC responsible for economic regulation and tariff setting. Ghana is atypical among developing countries in having separate technical and economic regulators. PURC was established as an independent regulatory body but frequently is overruled by government interventions or lacks transparency in its decision making (MCC 2014a). For example, in 2014, after a 79 percent tariff increase, GoG promised to subsidize electricity for small customers by paying part of their bills. The utilities proceeded to collect the share the customers were responsible for, but the GoG never paid the utilities the balance (MCC 2014a). Especially in the absence of such promises, tariffs are largely not recovering costs In fact, PURC recently cut tariffs despite recommendations for increases from the recently commissioned tariff study that is a core component of the Regulatory Strengthening Project (Fichtner Management Consulting 2017). Although the regulatory process provides information to support decision making related to tariffs, no detailed analysis is available for the recent PURC decision to cut tariffs. This is particularly notable because the tariff reduction could pose a critical challenge to the achievement of financial solvency by the electricity distribution utilities. ECG and NEDCo had recently requested that tariffs increase by as much as 200 percent in order to cover their costs. At the same time, the GoG made public commitments to reduce tariffs and supported PURC to implement such reductions (Allotey and Amihere 2018). In addition, the public has low confidence in regulators and mistrusts the rate making process, which can affect consumer behavior and exacerbate political pressure to keep tariffs low.

Other problems with Ghana's tariff structure persist. PURC maintains a lifeline tariff in which all customers receive a discounted rate for the first 50 kWh of electricity consumed per month. This compromises the utilities' ability to recover their costs (Kumi 2017, IFC 2014). A number of tariff studies are planned as part of the compact investments. These include a cost-of-service analysis, a lifeline analysis, a willingness-to-pay study, a cost of unserved energy study, and a marginal cost study.

Overall, Ghana ranks fairly high among countries in sub-Saharan Africa on the recently developed Electricity Regulatory Index, which measures national regulatory development (African Development Bank 2018). The index rates Ghana as being in the intermediate stage, implying that the country has a good regulatory foundation but also room for further strengthening. At the same time, a breakdown of the Electricity Regulatory Index indicates variation in Ghana's relative performance across the three sub-indices: Ghana ranks quite low in the regulatory governance index and the regulatory substance index but leads the regulatory outcome index.

3. Access to and use of legal electricity connections in Ghana

Ghana represents a success story in Africa in terms of access to electricity, with 83 percent of people living in areas served by grid electricity (Ministry of Energy 2018; World Bank 2018). In 1989, when the government established the National Electrification Scheme (NES), only 15 to 20 percent of the population had access to electricity (Kumi 2017). Since then, a number of projects have sought to increase the electrification rate and contribute to NES's goal of universal access to electricity by 2020. One of the first steps was to connect priority towns to the grid

(Kumi 2017). The Self-Help Electrification Programme helped improve access in rural areas by supporting communities within 20 kilometers of an electricity line in installing poles themselves, which reduced the cost to the utilities of expanding electricity access to rural villages (Golumbeanu and Barnes 2013; Bos et al. 2018; Kumi 2017). The Ghana Energy Development and Access Project, funded by the World Bank, also helped increase electrification rates by improving efficiencies in the distribution system (Kumi 2017). These projects have contributed to an access rate that is one of the highest in Africa (World Bank 2018).

Nevertheless, increasing the use of legal electricity connections remains a challenge facing the electricity utilities, particularly in urban and peri-urban areas, for a number of reasons. In many urban areas, particularly slum areas, end user premises often do not meet the utility's wiring codes, and households and businesses are unable to provide the required building permits to receive a formal connection (ESMAP 2011; ch2m 2017). Further, ECG and NEDCo have neglected infrastructure maintenance in many poor urban areas; thus, the infrastructure is particularly vulnerable to theft (ch2m 2017).

The prevalence of unauthorized connections is high among both households and enterprises in urban areas. For instance, in 2017, ECG estimated that 96,000 households in Tema, a city not far from Accra, had some form of illegal electricity connection (Washington 2018). For owners of micro, small, and medium-sized enterprises (MSMEs), the high cost and inconvenience of establishing a legal connection can be prohibitive, causing many MSMEs to use less stable and lower quality irregular connections—either illegal or shared with someone else legally. Some market fires have been attributed to such irregular electricity connections in urban market areas. Further, a sizeable portion of MSMEs have no electricity connection and are thus unable to benefit from the productive potential of electric power. This matters for the economy of Ghana because in Greater Accra, MSMEs account for nearly 40 percent of economic activity (MCC 2014c).

4. Problems with grid electricity in Ghana

Problems with the quality of electricity in Ghana have been highly publicized over the last several years, due to the 2012–2015 energy crisis (coined *dumsor*, a popular Ghanaian term for outages that literally means "off and on"). As an indication of the magnitude of the crisis, the country experienced blackouts during 159 days in 2015 (Clerici et al. 2016). Many of these outages lasted between 6 and 24 hours, and were primarily due to power supply shortage. Although the latest energy crisis was unique in its duration and severity, it was not the first such crisis. Other periods of energy shortages and frequent outages occurred from 1982–1984, 1997–1998, and 2006–2007 (Eshun and Amoako-Tuffour 2016; Clerici et al. 2016). These crises have had a substantial economic impact on the country. The 2006–2007 crisis is believed to have cost the country 1 percent of gross domestic product (GDP) (World Bank 2013). World Bank statistics indicate that 90 percent of firms experienced power outages in 2013 and that the economic cost of those outages was equal to 15.8 percent of sales (World Bank 2018).

Ghana is not alone among developing countries in feeling the economic repercussions of poor-quality electricity. The World Bank estimates that sub-Saharan Africa experiences losses equal to 2.1 percent of GDP due to power outages (Eberhard et al. 2011). A recent study in Pakistan estimated that low electrification rates and poor reliability cost the country approximately 1.7 percent of GDP a year (Samad and Zhang 2018). Other studies have found

that poor electricity infrastructure hinders foreign investment, business operations, and productivity (Andersen and Dalgaard 2013; Mensah 2016; Escribano et al. 2010). Andersen and Dalgaard (2013) estimate that across Africa, a 1 percent increase in outages results in a 2.86 percent reduction in GDP per capita. Khobai et al. (2016) find a causal relationship between power outages and GDP in the long run.

a. Generation

An insufficient and unreliable supply of electricity has been the primary cause cited for Ghana's recurring power outages. As the country's access rate has increased, so too has its gross electricity consumption. Peak load demand increased at slightly more than 4 percent a year over the last decade, from 1,274 MW in 2007 to 2,087 MW in 2016 (Energy Commission 2017a). Drought, which reduces the amount of electricity produced from the country's largest power plant, the Akosombo Hydroelectric Plant, and an unreliable natural gas supply from the West African Gas Pipeline compromised Ghana's ability to meet the rapid growth in demand over this period (Kumi 2017; Energy Commission 2017a; Eshun and Amoako-Tuffour 2016).

However, insufficient supply is no longer a key challenge, because at the same time that Ghana's peak load has increased, generation has increased by even more. Indeed, Ghana's generation capacity has increased rapidly in recent years, doubling over the last decade to more than 4,000 MW of total installed capacity at the end of 2017 (Ministry of Energy 2018). The GoG has made progress on securing power purchase agreements (PPAs), both independently and as part of technical assistance through USAID's Power Africa initiative. GRIDCo recently announced that it would start exporting electricity to Burkina Faso, citing a reserve margin of 95 percent (Ghana News Agency 2018). Ghana's installed capacity from hydropower plants—which account for 42 percent of installed capacity—is still vulnerable to seasonal shortages, and its thermal power plants—which account for 57 percent of installed capacity—are vulnerable to natural gas shortages (Energy Commission 2017a). USAID estimates that actual availability of electricity is rarely more than 2,400 MW (USAID 2017). However, that is still substantially more than the 2,087 MW of peak demand in 2016 (Energy Commission 2017a), so power generation and supply is not a critical challenge in Ghana at present. With the enabling environment for private sector investments through the independent power producers (IPPs) and substantial development assistance to support the power generation sector through USAID's Power Africa initiative, MCC is not planning to make any investments in power generation in Ghana as part of the current compact.

b. Transmission

GRIDCo, a company that began operations in 2008, manages Ghana's high voltage transmission network and provides bulk power to large customers such as ECG, mines, industrial customers, and the West African Power Pool (GRIDCo n.d.; MCC 2014a). GRIDCo's financial position is relatively sound—it has been profitable since 2010—and it maintains low transmission losses (4.4 percent in 2016) (MCC 2014a; Energy Commission 2017a). However, GRIDCo is affected by the challenges facing the distribution arm of the power sector. In December 2016, GRIDCo reported debts totaling GH¢722 million (approximately $150 million) from three state owned enterprises: ECG, NEDCo, and the Volta Aluminum Company (GhanaWeb 2017). ECG and NEDCo, in turn, are constrained by inadequate tariffs and failure

by government entities to pay their bills. These debts impede GRIDCo's ability to invest in construction and maintenance of its aging and congested transmission network (MCC 2014a).

c. Distribution

One of the major reasons for poor reliability and quality of electricity in Ghana is a constrained and inefficient distribution system characterized by total system losses of 23 percent (World Bank 2018). Both of Ghana's state-owned distribution companies, ECG and NEDCo, face numerous challenges, including weak management structures, inability to operate on commercial principles, poor overall financial positions, high system losses, decaying infrastructure resulting in frequent outages, and tariffs that fall below cost recovery (MCC 2014a, 2014b). Both utilities suffer from political pressure for underpricing and other issues (e.g. rigid employment rules) that hamper the running of sound commercial operations. These challenges make it difficult for them to perform basic maintenance in the absence of outside support which is not always forthcoming. Consequently, even though outside funders often provide substantial support for building up the grid, maintenance is often not sufficient to maintain high quality service.

ECG serves the southern part of Ghana, including Accra, and serves around three and a half million customers which is about 80 percent of the country's power market. Government supplied electricity was first introduced in Ghana in 1914. However, ECG wasn't established until 1967, taking over the role of a government department that had been established about 20 years earlier (ECG n.d. [b]). ECG has a long history of poor operational performance despite a significant amount of donor investment (MCC 2014a; Resource Center for Energy Economics and Regulation 2005). By the 1990s, ECG's high levels of debt undermined its performance (Resource Center for Energy Economics and Regulation 2005). In the late 1990s, the GoG restructured the power sector and, with support from the World Bank, offered debt relief to ECG. Nevertheless, ECG has continued to operate at a loss in most years, partially due to a tariff that is not sufficient to cover costs. In addition, the GoG reportedly owes over $650 million to ECG and other power producers.[5] As a result, ECG has not been able to adequately invest in grid maintenance, operations, staff capacity, and customer service.

NEDCo serves an area that covers the northern two-thirds of the country and has around 835,695 customers as of March of 2018. It services a much lower-income and far less densely populated area than ECG (Cook, Hague, and McKay 2016). Indeed, the national grid did not cover this area until 1987, when the Northern Electricity Department (NED) of VRA was established. Until then, ECG was responsible for distribution in the North (ECG n.d.). In 2012, NED became NEDCo and began operating independently (MCC 2014b; NEDCo n.d.).

NEDCo faces specific challenges related to the fact that a high proportion of connected customers in northern Ghana have a lifeline connection, meaning that they pay a lower tariff up to 50 kWh per month. This situation undermines NEDCo's financial performance because these a typical customers consume amounts lower than 50 kWh of electricity and pay less than the cost

[5] In October 2017, Ghana launched a 7-year and 10-year bond sale to repay debts to ECG. The GoG succeeded in selling bonds worth 4.7 billion cedis, about 80 percent of the target sale of 6 billion cedis in the first tranche (Minister for Finance 2017). However, some potential foreign investors indicated that the bonds were too risky because they were not backed by a sovereign guarantee (Reuters 2017).

of supply. NEDCo's financial challenges are compounded by the fact that the GoG applies a national uniform tariff policy which means that NEDCo's higher distribution costs are not adequately reflected in the tariff. Even a tariff that achieves cost recovery for ECG is unlikely to fully cover NEDCo's costs.

d. Demand growth and appliance use

Demand for electricity has grown at a rate of 4 percent per year over the last decade (Energy Commission 2017a). Total energy consumed grew by about 3.5 percent from 2016 to 2017 (Energy Commission 2018). Domestic peak load increased by 14 percent from 2015 to 2016, while total system peak load increased by about 8 percent over the same period and by 5 percent from 2016 to 2017 (Energy Commission 2017b; Energy Commission 2018). The EC estimates that peak demand and annual consumption will increase by about 15 percent in 2018 due to planned increases in exports to Burkina Faso, increased power for the Volta Aluminum Company, expansion of the distribution network, and rural electrification projects (Energy Commission 2018).

A contributing factor to the demand for electricity is the fact that Ghana's market is full of inefficient, banned appliances from the United Kingdom. Both commercial and residential customers use these appliances. Refrigerators, in particular, account for 50 percent of residential energy consumption and contributes 15 percent of peak load in Ghana (Sakah et al. 2018; Lawrence Berkeley National Laboratory 2015). In 2012, the Energy Commission estimated that over two million used refrigerators had been imported, mostly from Europe (BBC 2013).

The GoG has taken a number of actions to curb the influx and sale of second-hand and inefficient appliances. In 2008/2009 the GoG implemented energy efficiency standards and labeling requirements for refrigerators and in 2012 the Energy Commission banned the import of used refrigerators (UNEP 2012; BBC 2013). To promote the use of more energy efficient lighting, Ghana removed import duties and VAT on compact fluorescent lamps (CFLs) in 2003, and in 2007 offered CFLs for free in exchange for incandescent lamps (UNEP 2012). This initiative is estimated to have saved 124 MW in peak load each year (REEEP n.d.). In addition, Ghana's Mandatory Appliance Standards and Labelling regime sets energy efficiency and performance standards and labeling requirements for room air conditioners, refrigerators, and CFLs (Energy Commission n.d.; Energy Commission 2016).

B. Literature relevant to the Ghana Power Compact investments

1. Access to reliable electricity

There are a number of channels through which households and businesses may benefit from electrification. Productivity and, therefore, incomes and business revenue, may increase; household members may spend less time on chores and more time on entertainment or educational activities; businesses may be able to operate into the evening; and health may improve due to reductions in pollutants from other fuel sources. Similar benefits may be observed as a result of an improved electricity supply characterized by reduced outages and improved voltage stability.

a. Household impacts

Impacts on connected households. Households with existing connections can benefit from improved electricity quality. One study in rural India found that households with improved electricity reduced kerosene consumption and time spent collecting biomass fuel. However, these households continued to rely on alternative energy sources given the imperfect electricity supply (Samad and Zhang 2016). Another study in rural India found that better-quality electricity (measured as fewer outages and more hours per day) led to an increase in households' nonagricultural income over a 10-year period (Chakravorty et al. 2014).

Impacts on newly connected households. The literature does not provide a clear consensus on productive electricity use. Several studies show that households with electricity were no more likely to participate in an income-generating activity than unserved households (Bernard and Torero 2009; Wamukonya and Davis 2001; Lenz et al. 2017). However, a study in India showed that electrification increased household per capita income and expenditures, and that the impacts were greater for wealthier households than for low-income households (Khandker et al. 2012b). Other studies have similarly found statistically significant impacts of grid electricity on income and expenditures (Chakravorty et al. 2014; Khandker et al. 2012a; Khandker et al. 2013; Chaplin et al. 2017). Some studies have found stronger evidence of positive impacts on employment for women than for men, though the reverse is also found for other similar outcomes, such as earnings and salaried employment (Khandker et al. 2012b; Grogan and Sadanand 2013; Dinkelman 2011).

Studies in Bangladesh, India, and Tanzania found that boys and girls in electrified households studied one to two hours longer per week than children in non-electrified households (Khandker et al. 2012a; Khandker et al. 2012b; Chaplin et al. 2017), although in Tanzania, the increase in time spent watching television (about 73 minutes per day) was much greater. Overall, the evidence is mixed on whether electricity improves school enrollment and completion (Khandker et al. 2012a; Khandker et al. 2013; Lenz et al. 2017).

In terms of health outcomes, a study in El Salvador found that households that received a voucher for a discounted electricity connection had a significant decrease in the use of kerosene, in indoor air pollution concentrations, and in the incidence of child acute respiratory infections (Barron and Torero 2016). In contrast, Chaplin et al. (2017) observed negative impacts on children's health. They suggest that a combination of increased TV watching (presumably indoors) and no changes in liquid or solid fuel use contributed to this result. Another study found no health benefits of electrification in the Philippines (ESMAP 2002). Bensch et al. (2017) posit that electrification's health impacts may be limited given that many African households are already replacing solid and liquid fuel use with dry cell batteries. However, several studies have found that electrification is related to an increase in access to health information (Barkat et al. 2002; Chaplin et al. 2017; World Bank 2008), as well as improved perceptions of public safety (Wamukonya and Davis 2001; Bensch et al. 2013; Chaplin et al. 2017).

b. Business impacts

Impacts on connected businesses. Overall, the evidence suggests that poor-quality and unreliable electricity hampers *productivity*, particularly for firms in electricity-intensive sectors such as large-scale manufacturing (Adenikinju 2003; Arnold et al. 2008; Escribano et al. 2010).

Outages can negatively affect firms' profits and expenditures (Hardy and McCasland 2017; Adenikinju 2003) and small firms suffer the most from blackouts because they are less likely to have a back-up generation source (Adenikinju 2003). Firms with generators face higher energy costs because self-generation is considerably more expensive than grid electricity (Foster and Steinbuks 2009; Akpan et al. 2013). Unstable electricity—characterized by overloads and voltage drops—can damage electric machinery and equipment, imposing additional costs on firms (Adenikinju 2003; Foster and Steinbuks 2009). In contrast, fewer power outages may stimulate job creation, as documented in West Bengal (International Finance Corporation 2012).

Impacts on newly connected businesses. A study conducted in Rwanda suggests that businesses might benefit from access to electricity through (1) customer attraction from increased entertainment options, (2) longer hours and improved safety from electric lighting, (3) higher quality and new products and financial savings from electrical equipment, and (4) time savings from improved lighting, equipment, and communication. Qualitative findings indicate that electrification impacts were greater where there was a strong business environment, and that some sectors were more likely to connect and benefit than others (Lenz et al. 2017).

Despite the potential for cost savings and increased productivity, a few quantitative studies have found no impact of a new electricity connection on firms' profits. In a study of 274 micro-manufacturers in Benin, Peters et al. (2011) found no evidence that electrification increased profits. Similarly, a study of services and manufacturing microenterprises in peri-urban areas of Ghana found no difference in working hours, labor inputs, or profits between connected and unconnected firms (Peters et al. 2013). Although Grimm et al. (2013) found positive impacts of electrification on the revenue of informal tailors in Burkina Faso's capital city, they found no positive impacts on businesses overall. It is possible that the marginal benefit of electricity over generators or traditional fuel sources is too small to yield measurable impacts on profit.

c. Legal connections

Electricity theft in the form of illegal connections is common throughout the world, including in Ghana. Utility companies worldwide lose approximately $25 billion annually due to power theft, including illegal connections, bypassing energy meters, and tampering with energy meters. (Depuru et al. 2011). These losses undermine the financial position of electricity providers, which hampers their ability to invest in grid maintenance and expansion. In addition, electricity theft drives up fees for legally connected consumers (Smith 2004). Higher levels of electricity theft are often found in countries that have political instability, low government effectiveness, and high levels of corruption. Various projects aimed at reducing electricity theft have had differing levels of success. For instance, Brazil invested $2.1 million in monitoring and inspection of power users to cut down on theft, and successfully recovered $6.2 million through its efforts (Smith 2004). Consumption-based subsidies through the utility have also been used by countries attempting to incentivize citizens to legally connect to the formal power supplies, but with limited success, because poor citizens often are not able to access these services and illegal connections are hard to track and predict, which complicates the design of effective subsidies (Mimmi and Ecer 2010; Urdinola and Wodon 2007). It is important to consider that efforts to reduce illegal connections can often increase financial inequality by charging fees to lower-income citizens who had previously paid lower or no electricity fees when they were using electricity illegally (Delfino and Casarin 2001).

2. Support to utilities

Ghana is not unique in the challenges facing its utilities. Countries throughout sub-Saharan Africa have poor performing, state-owned utility companies that are unable to provide access to affordable and reliable electricity to large swaths of the population (Eberhard et al. 2011). Further, utility companies often fail to adequately manage operations and finances, maintain and invest in new infrastructure, limit technical losses, and set tariffs high enough to cover their operational costs (Kojima and Trimble 2016). In response, African countries have implemented numerous reforms in order to strengthen the performance of utility companies. For example, countries have enacted laws, encouraged private sector participation, privatized utilities, and established regulatory bodies. West African countries such as Cameroon, Gabon, Ghana, and Cote d'Ivoire are signing concession contracts with private firms; the Gambia, Guinea-Bissau, and Togo have signed more limited management services contracts (MSCs). However, a 2011 World Bank report notes that these contracts are not always successful and can be "complex and contentious." Although they have some benefits, such as improving revenue and reducing loss, the contracts are often unsustainable or had slow-developing, incremental improvements that were not visible to the public (Eberhard et al. 2011). Critics of management contractors have argued that MSCs have the freedom to make staffing and collection reforms that utility companies could not make without facing a public backlash. Often governments have viewed management contracts as undesirable obligations that are required to receive donor investments. However, despite the criticisms, it is widely acknowledged that sustainable changes require improved utility management as well as broader sector reforms.

3. Power sector reform, independent regulators, and political economy of reforms

a. Regulatory and power sector reform

The power sector policy and institutional reforms undertaken in Ghana over the last two decades are consistent with the prevailing consensus in recent years that developing country governments should unbundle electricity utilities, establish an independent regulator, and introduce competition and private sector participation (Eberhard et al. 2016).

Ghana's establishment of PURC as an independent regulator in 1997 is consistent with a worldwide movement in support of independent regulators. Since the 1990s, about 200 new infrastructure regulators have been set up around the world (Eberhard et al. 2016). The key tenet of successful regulation is independent decision making, with an emphasis on principles such as accountability, transparency, and public participation (Brown et al. 2006). Despite this important global shift in the structure of energy sector regulators, results have been mixed (Gulen et al. n.d.; Stern and Cubbin 2005; Eberhard et al. 2016). In some cases, regulators have lacked decision-making authority; in others, the regulators themselves have resisted further change in the sector (Brown et al. 2006; Stern and Cubbin 2005).

One of the independent regulator's roles is to set electricity tariffs. In general, tariffs in sub-Saharan Africa are higher than in other regions of the world (Eberhard and Shkaratan 2012). For instance, unit aggregate price of electricity in Sub-Saharan Africa range from $0.021/kWh to $0.51/kWh for industrial customers, whereas in OECD countries in ranges from m $0.058/kWh to $0.198/kWh (Kojima and Trimble 2017). Despite being high, these tariffs are often still below the cost of supply which tends to be high for a number of reasons, including inefficient utilities, low density, and reliance on emergency generation (Eberhard and Shkaratan 2012). The lack of

adequate tariffs has a high economic cost: Eberhard et al. (2011) estimate that underpricing of electricity results in $3.62 billion per year in lost revenues in Africa, which is equal to 0.56 percent of the continent's GDP.

Eberhard and Shkaratan (2012) argue that the tariff should be calculated based on the average incremental cost of new capacity (not historical costs) and should account for the fact that commercial losses will substantially reduce the amount of revenue utilities receive. Despite widespread acknowledgement that underpriced electricity is compromising the ability of utilities to function effectively, electricity pricing remains a highly political topic and governments face intense public pressure to keep tariffs low. Independent regulators also face government pressure and interference in their role of tariff setting.

Another argument against tariff increases is that higher tariffs will harm the poor. Studies in Mali and Senegal found that a 40 percent tariff increase had second-order effects on wages and price. However, the study also found that tariff increases had very little direct effect on low-income households, because of low connection rates among that population (Eberhard et al. 2011). Furthermore, much of the literature has shown that a substantial fraction of pro-poor subsidies actually benefits the rich (Eberhard et al. 2011). For instance, Komives et al. (2005) examined a sample of quantity-based consumption subsidies for water and electricity in several developing countries. The study found that the subsidies were regressive: "in all cases, the share of benefits accruing to the poor is smaller than their share of the population." This occurs because consumption subsidies do not reach the sometimes-substantial fraction of low-income households without an electricity connection and because the quantity of electricity consumed does not perfectly correlate with income and is thus an imperfect targeting mechanism (Komives et al. 2005).

b. Political economy of utility turnaround and regulatory reform

In many developing countries, the power sector utility has often been run as a state-run, vertically integrated monopoly. Governments, often motivated by political benefits, argued that the sector was too large and important to be left to the private sector (Victor and Heller 2009). Governments also cited a moral obligation to provide electricity to the poor, economies of scale, and challenging regulatory requirements as reasons to operate the sector as a state-run monopoly (Victor and Heller 2009). Yet, in the 1980s and 1990s, the state-run power enterprise in many developing countries faced severe financial insolvency and was unable to provide an adequate quantity and quality of electricity to small and large end-users (Lee and Usman 2018).

Based on the successful early reform experience in a few countries, a model approach to power sector reform arose in the 1990s, which was attempted in many countries with mixed success. In the 1970s and 1980s, Chile, Britain, and the U.S. enacted wide-scale market-oriented reforms in the power sector (Bacon 1995; Erdogdu 2014). Through their successful reform experience arose a model known as the "standard model", "textbook model," or "'90s reform model." This model called for governments to carry out the following: (1) unbundling or separating operations into generation, transmission and distribution; (2) establishing an independent regulatory body; (3) opening up parts of the system to multiple private firms; and (4) allowing market forces to operate in some parts (Lee and Usman 2018). Several countries, including India, Tanzania, South Africa, China, and Mexico, attempted these reforms in an effort to transform their flailing power sectors. Yet, due to a variety of political and institutional

factors, including perhaps having less mature systems, many countries were not able to completely reform their power system, with some countries' power sectors ending up with partial reform (Dubash 2002; Laffont 2005; Foster et al. 2017). Countries across sub-Saharan Africa and Asia continue to operate state-owned utilities, having accomplished varying degrees of unbundling, regulation, and private-sector participation (Dubash 2002; Nepal and Jamasb 2015; Eberhard et al. 2016). Despite the difficulty in actually implementing the standard model reforms, they have yet to be succeeded by concrete holistic recommendations in the form of a new model.

Researchers developed country-specific and cross-country frameworks to examine the political and economic factors that determine the outcome of these reform efforts. Victor and Heller (2009) suggested that structural factors like the type of primary energy source (for example, oil, hydroelectricity), amount of investments, reform approach, and government structure (decentralized versus centralized) determine the extent to which the reforms were implemented. Scott and Seth (2013) examined power sector characteristics and governance constraints that can affect outcomes in electricity distribution services and found that the monopolistic and "private good" nature of grid electricity presents significant challenges to reform in countries with weak governance and accountability mechanisms. Eberhard and Godinho (2017) developed a multifactor framework to analyze the political economy of power sector reforms and identified five political economy factors—national structural characteristics, political and economic institutions, reform processes, sector characteristics, and situational factors—as crucial elements for successful power sector reform.

Overall, research found that the following two characteristics of the political economy are key determinants of the level and success of power sector reforms:

- **Political motivation** is often a necessary precondition for reform efforts. For countries in sub-Saharan Africa, like Uganda, Tanzania, and Ghana, public expectation for the state to provide electricity as a public good was a significant factor that constrained standard model reforms (Gore et al. 2018). With elected officials often promising low tariffs as an electoral strategy, governments are unwilling to remove themselves from the process of setting tariffs, and frequently engage in practices to lower power prices (Victor and Heller 2009). As such, governments may need citizens' buy-in as a precondition to enacting tough reforms in the distribution utilities.

- **The strength of a country's institutions** helps determine the outcome of reform efforts. Legal authority along with internal capacity are critical elements for having strong institutions. A strong independent judiciary is needed to give independent regulators the authority to actually enforce orders. At the same time, countries may need strong financial institutions to ensure that when utilities comply with hard budget constraints, thereby exposing the public to the true costs of power supply, they are able to rely on a functioning financial market for future investments (Victor and Heller 2009).

4. Energy efficiency and demand management

As demand for electricity continues to increase rapidly, energy efficiency and demand management represent an important way to ensure quality electricity provision. Energy efficiency measures can have benefits at multiple levels: increasing the output customers get

from a given expenditure on electricity, reducing government expenditure on generation capacity, and slowing the increase in carbon emissions. One advantage of energy efficiency measures is that they are substantially less costly than provision of additional electricity supply—sometimes one-quarter to one-half as expensive—and generate return within a relatively short time frame (Taylor et al. 2008). For example, a survey of 455 energy efficiency investments in 11 countries found that the energy cost savings exceeded investment costs within 30 months for over 80 percent of the projects (Taylor et al. 2008).

International Energy Agency (IEA) has identified a common set of energy efficiency measures that have been implemented around the world: standards and labeling for energy-using products, access to energy assessment and preferential financing, and energy efficiency requirements for suppliers (IEA 2013). Below, we review the literature on interventions similar to those planned under the Ghana Power Compact: appliance efficiency standards and labels, building energy audits, and educational and awareness-building programs.

a. Appliance standards and labeling

It is estimated that annual electricity consumption in developing and emerging economies will increase by 127 percent between 2015 and 2030 given the current pace of demand growth (United for Efficiency 2017b). Appliance efficiency is a major focus of efforts to slow this pace of consumption growth. United for Efficiency reports that five groups of products (room air conditioners, indoor and outdoor lighting, residential refrigerators, electric motors and motor systems, and distribution transformers) account for over one-half of global electricity consumption. Refrigerators alone account for 10 percent of global household electricity consumption and that share may be growing: in 15 countries in Southern Africa, the number of refrigerators is expected to increase by 500 percent between 2011 and 2030 (Steiner 2014). It is estimated that shifting to energy efficient appliances could reduce global energy consumption by 10 percent each year, resulting in 1.25 billion tons of avoided CO2 emissions annually (United for Efficiency 2018).

Appliance standards are intended to remove inefficient products from the market. In Ghana, these standards are meant primarily to prevent the dumping of second-hand, inefficient appliances from other countries (mostly in Europe). History has shown that the implementation of standards can be highly effective in reducing energy consumption. In the U.S., it is estimated that the average amount of electricity consumed by refrigerators declined on average 4 percent per year between 1990 and 2014 due to multiple rounds of minimum efficiency standards (Van Buskirk et al. 2014). Many countries have introduced restrictions against incandescent lamps and have documented substantial reductions in electricity consumption as a result. For instance, Chile phased out incandescent lamps completely and saved almost $500 million in electricity bills (United for Efficiency 2017a). In Ghana, a program to replace incandescent lightbulbs with CFLs is estimated to have reduced peak demand by 200 to 240 MW (Kumi 2017).

Ghana also implemented a program from 2011 to 2015 to reduce the number of second-hand refrigerators on the market. Consumers were encouraged to trade in their refrigerators for vouchers to be used for purchasing new, energy efficient refrigerators. The amount of the voucher increased with the energy efficiency rating of the purchased refrigerator. Through the program, 10,000 customers traded in their refrigerators for vouchers and more than 30,000 used appliances were confiscated. The Energy Commission estimates that the program resulted in 1.1

million tons of CO2 and 400 GWh of electricity saved overall, and that voucher recipients saved on average 385 kWh per year in electricity consumed, or the equivalent of $140 per year in electricity bills.

Appliance labeling is one way of providing information to consumers to help them weigh the costs and benefits of purchasing energy efficient appliances. Labeling requires changes in behavior from consumers, manufacturers, and marketers in order to be fully effective. On the consumer side, the success of labeling can be measured in terms of awareness (do consumers know about the program?), understanding (do consumers make the connection between the label, the desired action, and the potential environmental and personal financial benefits?), and behavior (do consumers act on their understanding—that is, do they purchase the more energy efficient appliance?) (Banerjee and Solomon 2003). On the supply side, manufacturers must agree to have their appliances tested and certified and suppliers must sell those appliances and educate customers about the labeling.

The Lawrence Berkeley National Laboratory (LBNL) explains that "the effectiveness of energy labels is heavily dependent on how they present information to the consumer and on how they are supported by information campaigns, financial incentives, and other related programs" (LBNL 2005). Consistent with that statement, a study of five public and private energy labeling programs in the U.S. found that government programs were far more effective than private programs and that government support was critical to ensuring the program's credibility and financial stability. The study also found that it was important to target specific product classes, and that simple seal-of-approval labels were more effective than complex information-sharing labels (Banerjee and Solomon 2003).

A choice experiment of different labeling options in the U.S. revealed that providing basic information on the economic value of saving energy was the efficiency label component that had the largest effect on consumers' stated choices (Newell and Siikmaki 2013). The study found that information on the amount of energy the appliance uses and the amount of CO2 emissions also had an effect on consumer decisions but was less influential than economic information. Finally, this study found that labels that endorsed a specific model or assigned a rating to a model (in addition to providing objective information) led to a significant increase in energy efficient choices compared to labels that only provided information (Newell and Siikmaki 2013).

b. Energy audits

Energy audits are used to provide firms with a detailed breakdown of their energy consumption along with actionable items to improve efficiency. Audits are most commonly used to identify areas where simple and inexpensive actions can provide immediate energy use or operating-cost savings (Krarti 2011). Auditors may provide basic operating and maintenance recommendations such as replacing broken windows, insulating exposed hot water or steam pipes, and adjusting boiler fuel-air ratio. They may also conduct utility cost analyses to determine dominant utility charges, review the monthly bill structure, or examine possibilities for reducing operating costs (Krarti 2011). Audits are typically carried out in two stages: the first stage is a simple information collection and the second is a more detailed gathering of data to provide specific recommendations and follow-up projects (Taylor et al. 2008). Energy audits have been used in Ghana to maximize energy efficiency, but aren't common. Of 34 factories participating in a 2013 study within the Tema industrial area, only 5 firms had conducted energy

audits within the last 10 years and only 6 firms used monitoring and targeting schemes to manage their electricity use (Apeaning and Thollander 2013).

Various energy audit programs implemented around the world have proven to successfully improve energy efficiency or to at least have the potential to do so. In particular, the Swedish energy audit program (SEAP), a publicly financed program to provide small and medium-sized firms with the funds they need to carry out energy audits, led to an average savings of between 460 and 660 MWh/year among 241 firms (Backlund and Thollander 2015) and a 53 percent implementation rate of all suggested energy efficiency improvement measures. Similarly, Tunisia's government sponsored an energy audit of hotels in Tunis and indicated that 50 percent of total energy consumption could be saved with energy efficiency improvements, resulting in structural changes to lighting, ventilation, and refrigeration systems in the participating hotels (Khemiri and Hassairi 2005). Furthermore, Fleiter et al. (2012) show that the quality of audits impacts the take-up of energy efficient measures and should therefore be maximized to ensure long-term outcomes are achieved.

c. Building awareness of energy efficient practices

The promotion of efficient energy practices to the public is an important part of raising awareness and cutting down on energy consumption (Zografakis 2008). Often, energy efficiency education campaigns are disseminated in schools to target youth and because schools are often inefficient users of electricity. In Ghana, studies have shown that energy efficiency awareness is fairly high among senior high school and university students, although there is room for improvement in a number of areas, including knowledge on refrigerator placement and air conditioner maintenance (Frimpong and Twumasi 2018; Twumasi et al. 2017).

C. Contributions of the evaluation

The evaluation of the Ghana Power Compact will provide evidence on a range of interventions intended to improve utility functioning and financial health, electricity policy and regulation, electricity quality, access to legal electricity connections, and electricity demand profile. The evaluation will provide much-needed evidence on the effectiveness of a private concession in improving the performance of a struggling utility, in a context in which electricity quality and pricing is a highly charged political issue. The evaluation will also answer important implementation and performance questions about tariff setting, the enabling environment for private investment, and the utilities' financial position. Finally, the evaluation may be able to estimate impacts of an energy efficiency intervention on energy use in large government buildings in Ghana. As Ghana's economy continues to grow, consumption of energy is likely to grow so it will be important to learn as much as possible about the effectiveness of interventions like this.

IV. OVERALL COMPACT EVALUATION DESIGN

The Ghana Power Compact projects are designed to transform the power sector in the country by supporting improvements in the quality and reliability of grid electricity, the financial health of the utilities, regulatory reform, access to the grid for MSMEs, and energy efficiency. The performance evaluation will examine whether the compact's four projects—EFOT, Regulatory, Access, and EEDSM—have been successfully implemented, whether they have achieved the ambitious set of reform objectives, and, if so, whether these outcomes are sustained beyond the lifespan of the compact.

In this chapter, we describe the evaluation design for the overall compact. Subsequent chapters describe our plans for each project within the compact. The evaluations will use mixed-methods approaches to assess the program logic for the compact overall and for each of the component projects, and to address the research questions related to program implementation and the contribution of compact activities to key outcomes. We will also develop lessons learned for future investments in power sector reform programs and evaluate the sustainability of the projects over time.

The performance evaluation will explore overarching questions regarding the Ghana compact's estimated economic impacts, as well as lessons learned and their applicability to other power sector reform projects. Answers to these questions will provide an overall assessment of the core compact. Though it is difficult to assess the outcomes of the compact writ large, it is important to consider its economic impact and lessons for implementing institutional reform as MCC considers similar reform projects in other countries. Below, we discuss the compact-level evaluation questions, as well as data sources, analytical approach, and timeline for addressing these questions. The numbering of evaluation questions in this report corresponds to the numbering in Chapter II, Table II.2.

A. Evaluation Questions

1. What is the estimated economic impact of the Ghana power compact?
2. What are the lessons learned and are they applicable to other similar projects?
3. What were the political economy (PE) factors that influenced the process and outcomes of introducing regulatory and utility reform?

B. Data sources

We will consider a number of related outcomes including poverty reduction, private sector growth, increased profits, employment opportunities, and earning potential achieved. The data sources for addressing these questions will include a combination of primary and secondary data from five key sources: (1) electricity quality and reliability (outage and voltage fluctuation, respectively) data from GridWatch, the utility, and the household and enterprise survey planned for the evaluation, (2) estimated impacts of outages on economic outcomes produced by GridWatch, complemented by our own analysis of impacts of electricity quality and reliability on economic outcomes, (3) key informant interviews and focus group discussions with the relevant agencies and stakeholders, (4) results from our evaluations of the compact projects, and (5) a primary household and enterprise survey.

- **Data on outages and voltage fluctuation.** We plan to use data on outages and voltage fluctuation produced by GridWatch. They are using a device called PowerWatch to measure outages. PowerWatch will also capture voltage fluctuations. Ideally we will also get similar data from the utility, and we may try to use data on outages and voltage fluctuations we collect using surveys of households and enterprises.
- **Estimated impacts of outages on economic outcomes.** We plan to use two sources of information on estimated impacts of outages on economic outcomes. The first will be produced by GridWatch. They will use their outage data together with survey data to conduct a study that will estimate the impacts of outages on economic outcomes in some parts of Achimota, a district in ECG's Accra West operational region. Second, we will use our estimates of the impact of outages and voltage fluctuations on economic outcomes in other parts of Accra, as discussed later in this chapter. We will focus in particular on economic outcomes highlighted in the ERR. These include value-added, profits, wages, costs of own generation, and cessation of economic activities.
- **Key informant interviews.** The evaluation team will collect qualitative data from relevant staff and stakeholders for each compact project using key informant interviews (KIIs). These will include representatives from PDS, the restructured ECG, the regulators, and key staff from MCC and MiDA. We will develop protocols for the interviews to address the key issues around reforming the energy sector. The interviews will focus on lessons gleaned throughout the life cycle of the compact project, successes and challenges faced, and recommendations for similar power reform projects.
- **Project evaluation results** from our other performance evaluations of the compact projects, described below. These results will be incorporated into the overarching analysis of lessons learned. We will synthesize key themes from the results related to implementation successes and challenges.
- **Household and enterprise survey.** Working closely with MiDA, we will design and conduct a household and enterprise survey to track key outcomes for households, enterprises, and electricity customers that cannot be captured using administrative or existing surveys. These outcomes include electricity reliability and quality (outages and voltage instability) at the household and enterprise level, connection rates, use of energy-efficient devices, and use of non-electric energy. The survey could also capture longer-term outcomes related to economic well-being, education, time use, and health. Conducting a longitudinal survey of households and enterprises will help reduce the chances that changes over time are due to differences in the composition of our sample.

C. Analytical approach

The performance evaluation of the Ghana compact will provide a high-level analysis of the compact's economic impact and lessons learned for future energy reform projects. By assessing the compact's overall performance in addition to project-specific evaluations, we can assess the relative complementarities and trade-offs between projects. To estimate the economic benefits of the compact, we will use a simulation method that is effectively first estimating impacts of the compact on outages, and then multiplying those by estimates of the impacts of outages on economic outcomes.

To estimate how the compact affects outages we will combine a pre-post analysis that compares outages from before and after the major compact interventions are implemented, with information obtained from stakeholders in the restructured ECG, PDS, GRIDCo, and the Energy Commission, to identify the amount of change that can be attributed to compact activities. We will rely primarily on GridWatch outage data obtained from the PowerWatch devices to measure outages, and also plan to collect outage data in the household and enterprise survey. If available, we may use the DumsorWatch app data from GridWatch as well as administrative data from the utility.

To estimate how outages affect economic outcomes we will use results from GridWatch based on the impacts of line bifurcation in Achimota in combination with estimates that we produce. Our impact analysis will cover a broader set of interventions and geographic areas than those of GridWatch, including all of the major infrastructure investments throughout Greater Accra and nearby districts.

One option for combining the GridWatch results with ours would be to adjust for interactions by enterprise size. More precisely, we would multiply their rigorous estimates of the impacts of outages on economic outcomes by pre-post outage data allowing both to vary by enterprise size. This option depends on GridWatch's ability to produce precise estimates of impacts. It also depends on there being low variation in results by distance from the cutoff point used for the regression discontinuity analysis in Achimota, low variation between Achimota and other areas, and low variation by type of infrastructure.

An alternative to the option above would allow for larger variation in impacts by area and intervention. This model is similar to that of GridWatch in that it is based on an instrumental variable (IV) method where the endogenous variable is outages and one set of instruments are based on the regression discontinuity being used by GridWatch. We would use three additional sets of instruments—(1) a set of dummy variables identifying individual transformers in the areas expected to benefit most from the new infrastructure (new substations, line bifurcation, and bulk supply points), (2) a set of dummy variables identifying individual transformers in other locations, and (3) a set of dummy variables identifying the geographic locations where the major infrastructure investments are expected to have relatively large impacts on outages. The regression discontinuity estimates will serve as the benchmark, and we will test the other instruments against that. We will then assess whether the data support the strength and validity of the instruments. We are hopeful the first set will work well because people are unlikely to predict how much outages will improve by transformer when the new infrastructure is implemented, so that the source of variation will be exogenous. If they perform well, these instruments will enable us to produce estimates that generalize to a larger population than those from the regression discontinuity design.

The household and enterprise survey will oversample enterprises in the areas likely to benefit most from the Access project, new substations, line bifurcation, and bulk supply points, which should help improve the precision of our IV model.[6] We will control for lagged outages

[6] We do not expect the Access project to impact outages but we are sampling enterprises in the Access project areas for our evaluation of that project so we will be taking advantage of those data in our IV model. In addition, some of the EFOT interventions may cover some of the Access project areas.

and lagged economic outcomes, and test for heterogeneity of impacts by baseline enterprise size (micro, small, medium, and large).

We plan to estimate our IV models using the standard two-stage estimation approach.

Stage 1: $O_{it}=X_{it}'\beta_1+IV_{it}'\beta_2+eo_{it}$

Stage 2: $Y_{it}=X_{it}'\beta_3+O_{it}'\beta_4+ey_{it}$

where O_{it} is outages for household or enterprise i at time t, Y_{it} represents an economic outcome, such as household income or enterprise revenue, X_{it} is a set of control variables including lagged outages and lagged economic outcomes, IV_{it} is the set of instrumental variables that are included in Stage 1 but excluded in Stage 2, β_1, β_2, β_3, and β_4 are coefficients to be estimated, and eo_{it} and ey_{it} are error terms capturing other factors that affect outages and economic outcomes.

The measure of outages is the endogenous variable, so in stage 2 the outages will be replaced by their predicted value based on stage 1. In stage 2 we will allow for clustering by transformer since the outage data are clustered at the transformer level.

We will estimate a series of models.

Model 1: We will select the treated set of transformers used by GridWatch to estimate their regression discontinuity models implicitly using transformer dummy variables as the IVs. We will test to see if these results differ from those produced by GridWatch. Thus, we will not be re-estimating the GridWatch models. We will use the Hausman-Wu test to see if results differ across models. Note that the GridWatch results are based on variation between the treated and untreated units. In contrast, ours will be based on variation between transformers within the treated units. If our results are similar to those of GridWatch then we can use the transformer-level variation to estimate impacts away from the cut-points used by GridWatch in Achimota and outside of Achimota.

Model 2: We will do a similar test including the untreated transformers used by GridWatch. We are less confident in this model since it is less clear why outages would change in unexpected ways in these areas.

Model 3: We will include all transformers for which we have data in model 3. More specifically, we will use data for the transformers used in models 1 and 2 (unless our results rejected one of those models) as well as those away from the cut-points in Achimota and those outside of Achimota. We will continue to use the transformer dummies as the instrumental variables. In this model we will control for a dummy variable (T_{it}) identifying whether or not each household or enterprise is expected to be affected to a large degree by a major compact intervention (new substations, line bifurcation, or bulk supply points). Thus, this model will still be identified by variation between transformers within areas that are treated and within areas that are not treated. However, it will not be based on variation between the treated and untreated households or enterprises. We won't test this model against the earlier ones. Rather, we will assume that if model 1 and/or 2 was successful then model 3 should be as well.

Model 4: In this model we will drop T_{it} from Model 3. Thus, T_{it} will become an additional instrumental variable because it is implicitly included in stage 1 since each transformer is either in the treatment areas or not. Unlike model 3, this model will be using variation between the treated and untreated units to estimate impacts, in addition to variation between transformers within each of those areas. We will compare the results in model 4 to those of model 3. If they differ then we will use the results of model 3. If not then we will use the results of model 4 since they are likely to be more precise than those of model 3 due to the use of additional instruments.

Model 5: We will test for heterogeneity of impacts by enterprise size.

Regardless of whether we use our planned IV analysis or rely only the results from GridWatch team's analysis, our final estimates of the impacts of the compact on economic outcomes will be obtained by multiplying the changes in outages that can be attributed to the compact by the estimated economic benefits of outage reduction. The key economic outcomes will be household income and estimated enterprise profits. When combining the two sets of estimates we will take into account any interaction effects found by GridWatch and/or in our own analyses. For example impacts may vary depending on enterprise size, the type of intervention (substations versus line bifurcation), and by location (more baseline outages versus fewer).

Our estimates of the impact of the compact on economic outcomes will also take into account variation over time and non-compact factors. If possible, we will estimate the impacts of the compact on outages at multiple points in time and use an appropriate discount rate at the end to sum the benefits across time periods. For each time period, we will start with a pre-post change in outages. If GridWatch outage data are not available for some periods then we will extrapolate down to the customer level using data on periods when such data are collected, either by GridWatch or in the household and enterprise survey.[7]

To capture lessons learned we will review and compare evaluation results from each of the four compact projects: EFOT, Regulatory, Access, and EEDSM. Each project has research questions focused on identifying lessons learned, so we will pool themes identified across projects, if any, and identify trends over time. In addition, we will conduct a qualitative analysis of observations and reflections from key actors in the projects/activities related to lessons learned and implications for future power sector reform programs. Throughout we will keep an eye out for unintended consequences (positive or negative).

D. Timeline

Table IV.1, below, outlines the timeline for the planned data collection rounds to address the overarching evaluation questions. Baseline data collection will occur in 2019 and 2020, midline in 2021 and 2022, and endline in 2023 and 2024, with the outage data collected in all three

[7] More precisely, we will calculate the level of outages at the household/enterprise level as a function of outages reported at the lowest level where we can get data (perhaps the sub-station, district, or region), and assume that similar ratios would be found in periods when the survey data are not available. We will also allow for the possibility that these ratios change over time due to the compact's interventions. In addition, as noted above, for each period, we will estimate the fraction of change that can be attributed to the compact. For example, in some cases, changes might seem likely due to changes in power generation rather than the compact.

periods and in more periods if possible. We will collect lessons learned during midline and endline. We expect outage data from the GridWatch system to cover the Accra East and Accra West operational regions of ECG and Tema. We may also use primary survey data or administrative data on outages, as shown at the end of the table. More details on the household and enterprise survey and the sample size options are discussed in Chapter X. Appendix B provides the exposure table for the primary data collection activities.

Table IV.1. Key areas of data collection for the compact-level evaluation questions, by data source

	Key areas of focus		
Data source	Baseline (2019)	Midline (2021/2022)	Endline (2023/2024)
Outages from administrative data, and outages and voltage fluctuations from GridWatch	• Outages and voltage fluctuations	• Outages and voltage fluctuations	• Outages and voltage fluctuations
Results for impacts on outages and voltage fluctuations on economic outcomes			• GridWatch impact estimates • Our impact estimates
Project evaluation results	N/A	• Synthesis of findings • Lessons learned	• Synthesis of findings • Lessons learned
Key informant interviews with staff from PDS, restructured ECG, PURC, MCC and MiDA	N/A	• Lessons learned	• Lessons learned
Household and enterprise survey	• Outages		• Outages • Economic outcomes

V. ECG TURNAROUND PROJECT EVALUATION DESIGN

The objective of the EFOT project is to improve the performance and financial health of the utility through the introduction of a concession agreement. According to the compact theory of change, the PSO will bring management expertise and improved accountability of utility operations. This will lead to improvements in customer perceptions of the utility and will improve customer payment rates, thereby reinforcing the financial health of the utility and improving its capacity to invest in service quality. The project will also upgrade existing infrastructure to support improvements in service quality and reliability.

The performance evaluation of this project will focus on assessing the project's implementation, progress toward achieving outcomes, and longer-term sustainability, including financial and grid-based outcomes. Within the EFOT project, we will investigate the utility's financial and operational performance, investments in infrastructure maintenance and improvement, electricity supply quality and reliability, cost of service delivery, losses (technical, commercial, and collections), and the utility's ability to serve as a credible off-taker under power purchase agreements (PPAs).

A. Evaluation questions

We designed the performance evaluation of EFOT to address questions that fall into three broad categories: project objectives, implementation, and sustainability of the project. Implementation questions focus on the quality, fidelity, and timing of project implementation. Project objectives questions focus on whether the outcomes captured in the program logic were achieved, assuming the project was implemented according to plan. The sustainability questions delve into the long-term viability and longevity of these outcomes.

Project objectives questions

1. Did the private sector operator result in improved reliability of power and improved financial health of the utility?
2. To what extent did the activities improve operational efficiency and the cost of distributing power? Is it possible to identify which interventions are the most effective?
3. Did technical and commercial losses, power quality, and reliability improve? Do stakeholders perceive that these changes resulted from compact investments versus other investments or policy changes?

Implementation questions

4. Were projects activities implemented as designed? How did implementation (in terms of objectives, activities and beneficiaries) deviate from the original logic driving the investment, and why? How did changes in implementation affect project performance? What were the implementation successes and challenges? Did the PSP transaction reach financial close by the required deadline (end of Year 2 of the Compact)? Was a qualified firm identified, recruited, and brought on board who could improve ECG's financial and operational performance by end of Year 2? What are the lessons learned from the process?
5. Did the private sector operator leverage its own resources to make appropriate upgrades to the distribution system?

6. How did the new management information systems and the other foundational investments affect the operational efficiency and cost of distributing power for the utility?
7. Did the semiannual review process or other high-level stakeholder engagement contribute to progress on key reform milestones and outcomes? If so, how?

Sustainability questions

8. Were improvements in project outcomes sustained after the end of the compact? What sustainability planning was done during implementation, and why? What are the critical institutional factors that affected their sustainability?
9. Did the financial health of the utility stabilize over the life of the compact and after the compact was finished? Were improvements driven primarily by tariff increases or by other project activities? If there are no improvements or improvements are minimal, why?

B. Data sources

The performance evaluation of the EFOT project will rely primarily on data produced by the projects and the utilities. These include implementation records and administrative data, such as planning documents, engineering reports, financial statements, and indicators related to power reliability. In addition, the evaluation will rely heavily on key informant interviews with program decision makers and those involved in implementation, as well as complementary secondary data sources and the household and enterprise survey.

- **Implementation documents and records.** We will use documents and data produced by the project to assess project implementation and whether private sector resources were invested in the distribution system. These will include documents such as the MiDA M&E plan, MiDA's indicator tracking table (ITT), PDS and the restructured ECG financial statements, project timelines, progress reports, and project progress against key performance indicators (KPI). We will request that PDS, the restructured ECG, and MiDA provide implementation materials including infrastructure planning documents. We will review all secondary data received for completeness and quality. We will draw upon these materials for each research question but they will be most relevant for implementation and outcomes questions.
- **Administrative data.** We will source administrative data already being collected by PDS and the restructured ECG, ideally on financial and operational outcomes. These data will inform questions related to implementation and sustainability. For example, we expect to access and use data related to service reliability and quality such as the system average interruption duration index (SAIDI), system average interruption frequency index (SAIFI), and voltage stability. These data would ideally be available at the customer or transformer level but we understand that this is not likely. We do expect to see data at the district level and perhaps at the substation level. We will also use data on commercial[8] and technical losses,[9] and review

[8] Total distribution system losses minus distribution technical losses.

[9] Estimated MWh of power dissipated in electricity system components such as distribution lines and transformers, divided by total MWh received from the transmission lines.

methods for estimating these losses.[10] In addition, administrative data for the evaluation include financial records (both aggregated and at the customer level) to assess the number of users, energy use, bills paid, maintenance costs, labor costs, and debt costs; operational performance, including improved maintenance response time to faults, maintenance backlog, average collection period, and size of customer base; and data on key performance indicators.

- **Key informant interviews** will enable us to collect targeted information on project implementation, outcomes, and sustainability of compact achievements over time. KIIs will measure perceptions of organizational change, sustainability, and implementation progress and challenges. They will also cover the quality of the private sector operator selection process and stakeholder perceptions of operational efficiency, in addition to the sequencing of project activities and whether private sector resources were invested in the distribution system. Potential key informants include staff from MCC; MiDA; SMEC; PDS (Customer Services, Engineering, Corporate Planning & Finance, and Operations divisions); labor unions, VRA; and regulators.
- **Newspaper articles and media coverage** will provide information on implementation progress of EFOT reforms and stakeholder perceptions of reform. We have created news alerts to receive these updates in real time and have been collecting them since January 2018.
- **Secondary data** will help measure outages and related outcomes. Ideally, GridWatch would provide outage data for the entire ECG catchment area, but at this point we only expect data for Accra East and Accra West operational regions of ECG and Tema. In addition, we may use secondary data to provide an earlier baseline and cover areas not covered in the household and enterprise survey. These sources could include the nationally representative Ghana Living Standards Survey (GLSS) and Integrated Business Establishment Survey (IBES) administered by the Ghana Statistical Service, as well as the Ghana Socio-Economic Panel Survey (GSEPS) and the World Bank enterprise survey.[11] GLSS can provide some limited baseline information for households on electricity access, main sources of energy for light and cooking, outages, voltage fluctuations, major appliance purchases, appliance damage due to voltage fluctuations, lightbulb types, prices of fuels purchased, migration, and socio-economic characteristics such as education, employment, and income. It can also capture migration into and out of the EFOT target areas. Similar but even more limited set of measures for households are also available from the GSEPS. The secondary business and enterprise surveys listed above can provide baseline information for businesses on electricity access, sources and unit costs of energy used, energy consumption and expenditures, number of employees, output, and revenue.

[10] We may choose to focus on overall losses (technical plus commercial) for most of our analyses if it is difficult to separate them. We expect to use of MiDA's February 2019 Data Quality Audit which focused heavily on ECG's estimation of technical losses in Accra East/West as well as any follow-ups done by PDS and PURC.

[11] The GLSS has been conducted for seven rounds, the most recent of which was in 2016–2017. We expect that additional rounds of the GLSS will be administered during the course of our evaluation but our research will not be contingent on that. The IBES has been conducted for only one round to date, in 2015–16, so it is unclear whether a future round of those data will be collected during the course of our evaluation. The GSEPS is a joint effort between the Economic Growth Centre at Yale University and the Institute of Statistical, Social and Economic Research (ISSER) in Accra, Ghana. The first wave of the survey was conducted in 2009-10, and a second wave in 2013. The panel survey is expected to be administered once every three years.

- **Household and enterprise survey.** As indicated earlier, the household and enterprise survey will cover the EFOT target areas. In addition to outages, the survey will also include connection rates at the household and enterprise levels. It will cover utility customers, which are almost entirely households and businesses, as well as noncustomers who might have illegal connections or be potential customers. We plan to oversample enterprises affected disproportionately by key EFOT interventions including substations, line bifurcation, and bulk supply points.

C. Analytical approach

The EFOT analysis will consist of document review, tracking key outcomes over time to examine pre-post changes, assessing implementation progress, analyzing data from KIIs, benchmarking indicators against peer group performance, conducting a political economy analysis, and conducting simulations to determine key drivers of improvement. Further detail is provided on each below.

- **Document review.** We will organize and categorize project documents according to their source and topic to better understand their relation to key compact outcomes and the evaluation questions. We will identify themes, with a particular focus on issues related to the evaluation questions, such as successes and challenges with project implementation and quality of service. We will also document any ideas or issues that emerge from the review that should be explored further in KIIs.
- **Implementation progress.** We will compare implementation plans to actual implementation progress, relying on MCC and MiDA project documents, signed contracts, implementation timelines, and reporting documents, ideally on a quarterly basis. We will flag any notable changes or deviations from the original planning for further inquiry in KIIs.
- **Qualitative data analysis.** We will identify emerging themes from KIIs and compare findings against other data sources, noting commonalities and discrepancies for further inquiry. This analysis will also focus on understanding the varying business processes that the EFOT project is attempting to reform, identifying key stakeholders and decision makers, and locating areas for improvement. The analysis will address the timing and ordering of project activities and examine whether investments supported improvements in the reliability of power and the financial health of the utility. In addition, the qualitative analysis will cover whether investments in the management information systems (MIS) and other foundational investments affected operational efficiency of the utilities. Finally, we will examine whether gender audits occurred at PDS and the restructured ECG and whether they resulted in an increase in the number of women employed in the energy sector.
- **Track key outcomes over time.** Using a pre-post comparison, we will examine indicators such as private sector resources invested in the ECG distribution system, power reliability, financial health, perceptions of organizational change, and bad debts/arrears, particularly from GOG institutions. We will separate out our results for key interventions—in particular the areas likely to be affected most by the substations, line bifurcation, and bulk supply points interventions. We will identify trends and any questionable patterns and flag this information for further clarification in KIIs. In particular, we will examine the following outcomes based on administrative data:

- Financial viability
- Debt PDS and the restructured ECG incurred
- Commercial and technical losses
- Operating cost-recovery ratio (total revenue collected divided by total operating cost)
- Outages from administrative and survey data
- Outage duration as measured by SAIDI
- Outage frequency as measured by SAIFI
- Voltage fluctuations from administrative and survey data
- Customer base: number of legal connections, size of customer base

- **Benchmarking.** In order to examine Ghana's progress in power reform relative to its peer group, we will benchmark indicators against the performance of private sector operators in other countries. These will likely include indicators related to commercial inefficiency (collection losses) and technical inefficiency (transmission and distribution losses). To the extent possible, we will also compare progress in addressing labor inefficiency and financial inefficiency of the utilities. To conduct the analysis, we will select countries that have undertaken power sector reform in the past and are similar to Ghana in terms of overall size of the economy and per capita income.

- **Political economy assessment.** The political economy assessment will delve into the political and institutional incentives and constraints that influence institutional reform decisions and the effectiveness of the reforms envisioned in the compact program logic (Haider and Rao, 2010). This analysis will cover the combined effects of the Regulatory project and the EFOT project, and will provide important context in understanding underlying political constraints and incentives in reforming the utility and in adopting regulatory reforms. The analysis will also focus on implementation and sustainability—specifically to identify and assess barriers to successful implementation, as well as political, institutional, and economic factors that constrain results and prospects for sustained benefits following the compact period.

  With regards to the EFOT project, the analysis will look at how internal decision-making processes -- such as asset management, investment and procurement planning, budgeting, and maintenance planning, and the extent to which these are influenced by internal and external stakeholders. The analysis will also assess whether and how changes within PDS and the planned communications strategy, outreach, and consultation activities affect how regulators and policy setting agencies make decisions on key drivers of PDS's performance including tariffs. The intention will be to determine whether the project has delivered substantial and sustainable improvements in the decision-making framework, and particularly whether there has been any reduction in political pressures for tariffs and costs to deviate.

  To that end, first we will identify the main institutional stakeholders based on information from documents we reviewed and discussions with staff in relevant organizations during the inception trip to Ghana in 2018. We will then conduct a series of KIIs with stakeholders like the restructured ECG, Power Distribution Services (PDS), EC, PURC, MiDA, and others that were involved in the concession process such as the IFC. We will also use these KIIs to identify the means and extent to which other non-institutional stakeholders, particularly representatives of existing and currently unserved consumers, are consulted and the relative weight placed on these 'external' stakeholders as compared to the 'internal' institutional

stakeholders represented by government and its agencies. Our goal will be to gain a broad-based understanding of stakeholders' interests and incentives, existing political and social tensions, formal and informal power structures, information flows and accountability mechanisms. The KIIs will delve into stakeholder perspectives on decision-making processes and the entities who influence or have a stake in these decisions.

We will use information from these baseline KIIs to map actors – their interests, resources and incentives – and existing power structures (Department for International Development [DFID] 2009). From this understanding, we will identify the 'who', 'why' and 'how' of decision-making in the power sector at present. This will then allow us to identify, over time, whether and how this mapping changes as the project proceeds and, from project outcomes, whether these changes are associated with improved or worsened sector performance. This mapping over time will primarily rely on follow up KIIs which will capture information about changes in decision-making processes and the level of influence of different stakeholders.

Analyzing data from these KIIs, we will determine the roles and responsibilities of the different stakeholders, the decision-making processes in which they play a role, potential "wins" and "losses" from the reform process, the legal and bureaucratic framework by which stakeholders must abide when developing, adopting, and implementing reforms, and key bottlenecks in the system (Hudson and Leftwich 2014). Information from the baseline round will be used in our analysis to compare how these processes changed after the introduction of the EFOT and regulatory project activities. The analysis will assess whether the projects have changed internal and external incentives for reform. It will also identify changes in decision making around the tariff structure and perceptions of institutional capacity, as well as investment planning, approvals, and implementation. We would also review information flows between agencies before and after project implementation, and the efficiency of decision-making processes.

- **Engineering simulations:** We will review the methods used to select the types of infrastructure to be built. In particular, we will focus on major compact investments such as substations, line bifurcation, and bulk supply points. We will update the calculations used in the design phase with changes during implementation, and compare the predicted results from simulations to those observed based on other sources of data. We will also use these simulations to try to separate out the degree to which changes in key outcomes, such as outages, might be due to these infrastructure investments. We will use load flow simulations and field measurements, when available, based on methods similar to those used by Wang et al. (2014).

D. Timeline

Table V.1, below, outlines the timeline for addressing the EFOT project questions and the information we expect to collect through the planned data collection rounds. Baseline data collection will start in 2019; the qualitative midline in 2021; and endline in 2023. The three rounds will cover all activities of the EFOT project.

Table V.1. Key areas of data collection for the EFOT performance evaluation, by data source

Data source	Key areas of focus		
	Baseline (2019)	**Midline (2021/2022)**	**Endline (2023/2024)**
Implementation documents and records	*Design details* • Project implementation progress to date • Satisfaction of conditions precedent	*Implementation summary* • Project implementation milestones and successes • Delays and challenges in project implementation • Adherence to proposed implementation plans and timelines • Progress against KPIs	*Sustainability* • Post-compact monitoring reports (if available) • Post-compact progress against KPIs
Administrative data	*Mid-compact outcomes* • Service reliability and quality • Commercial and technical losses • Financial records: number of users, energy use, bill payment rates • Operational performance • Progress against KPIs	*Implementation* • Service reliability and quality • Commercial and technical losses • Financial records: number of users, energy use, bill payment rates • Operational performance • Progress against KPIs	*Sustainability* • Post-compact financial and operational progress against KPIs • Sustainability of grid enhancements
Key informant interviews with MCC, MiDA, SMEC, restructured ECG, PDS, labor unions, regulators	*Expectations for implementation* • Implementation challenges • Perceptions of electricity reliability and quality, maintenance • Perceptions of PSO selection process • Constraints and challenges	*Implementation and outcomes* • Level of stakeholder engagement • Resources leveraged for upgrades • Perceptions of PSO value (enhanced operational and commercial capacity, improved reliability of service) • Perceptions of foundational investment value on operational efficiency and distribution costs	*Sustainability* • Perceptions of biggest contributors to operational efficiency • Challenges to sustainability • Perceptions of sustainability of project outcomes
Newspaper articles and media coverage	*Design details* • Public perceptions of projects and of key institutions including PDS, MCC, MiDA, restructured ECG, PURC, EC and the GOG.	*Implementation* • Public perceptions of projects and key institutions	*Sustainability* • Public perceptions of projects over time
Secondary survey data: GridWatch, GLSS, GSEPS, World Bank enterprise survey	*n.a.*	*Outcomes* • Outages	*Sustainability* • Outages
Household and enterprise survey	• Outages • Voltage instability • Connection rates • Socio-economic outcomes		• Outages • Voltage instability • Connection rates • Socio-economic outcomes

This page has been left blank for double-sided copying.

VI. REGULATORY PROJECT EVALUATION DESIGN

The objective of the Regulatory project is to promote sustainability, transparency, and accountability in the power sector through strengthening regulatory processes, reviewing and restructuring tariffs, and improving the environment for private sector investments. Similar to EFOT, the performance evaluation of the Regulatory project will focus on assessing the project's implementation, progress toward achieving outcomes, and its longer-term sustainability, including the existence of a cost-reflective tariff and greater access to power for the poor.

A. Evaluation questions

We designed the performance evaluation of the Regulatory project to address the following research questions related to the implementation, outcomes, and sustainability of the project. The objectives of the Regulatory project are closely linked to those of the EFOT project. In many cases, addressing the research questions below will capture the combined effects of the projects.

Project objectives questions

1. Did the project result in cost-reflective tariffs or tariffs that were on track to be cost-reflective by the end of the compact (cost-reflect means tariffs that tracked inflation, sector costs, macroeconomic performance, and exchange rates)?
2. To what extent were tariff changes driven by reforms to the tariff structure and methodology versus other factors (such as inflation, macroeconomic performance, exchange rates)?
3. Did "hidden costs" drop when project activities were implemented? If so, to what extent can this be attributed to the project activities?
4. Did the project contribute to improved tariff targeting and greater access to power for the poor? How were the benefits distributed among the different stakeholders?

Implementation questions

5. Were projects activities implemented as designed? How did implementation (in terms of objectives, activities and beneficiaries) deviate from the original logic driving the investment, and why? How did changes in implementation affect project performance? What were the implementation successes and challenges? Are distribution utilities meeting performance targets set by the regulator? Why or why not?
6. Does the regulator have the data necessary to measure sector performance? If yes, do those data influence their decisions and how they implement the tariff formula?

Sustainability questions

7. Were improvements in project outcomes sustained after the end of the compact? What sustainability planning was done during implementation, and why? What are the critical institutional factors that affected their sustainability?

B. Data sources

The evaluation will use a variety of data source for the regulatory project performance evaluation, including a combination of implementation and project records, administrative data, external surveys, and KIIs. The data sources are as follows:

- **Implementation documents and records** will include project timelines and progress reports, quarterly reports and documents showing progress against key performance indicators, and relevant materials commissioned by the Regulatory project, including the Fichtner Tariff Study and Tariff Plan (TSTP), the connection-cost loans study, and the willingness to pay study. We will rely on these records to understand implementation progress and will flag certain discrepancies between implementation plans and actuals for further probing in KIIs. These documents will primarily be used for assessing implementation fidelity and adherence to original design plans.
- **Administrative data** will come from both the regulatory agencies and the utilities. They will consist of tariff rates, including debt ratios and commercial and technical losses, as well as financial data, specifically indicators on cost-recovery ratio. We will also track whether there are any major legislative or regulatory changes affecting the power sector during the evaluation period.
- **KIIs** will be used to ascertain stakeholder perceptions of project implementation and the process of orchestrating a cost-reflective tariff, perceptions of tariff fairness and change in quality of service, and perceptions of critical institutional factors that affected project sustainability. Key informants will include PURC, to discuss the process of changing Ghana's tariff policy and setting of cost-reflective tariffs; the Energy Commission; PDS and the restructured ECG, to discuss the effect of tariff changes on utility revenue projections; and private sector businesses and investors, to discuss whether the project created an enabling environment conducive to private investment.
- **Press records** will be regularly culled and reviewed for key themes and trends related to public conversations about tariff fairness and the process of designing and implementing a cost-reflective tariff. For example, interviews and key quotes from stakeholders involved in the tariff reform efforts as well as beneficiaries of the reform will supplement survey data on public perceptions and help to track changes over time.
- **Household and enterprise survey** will ask electricity customers about their perceptions of the investment climate and whether it improved as a result of the Regulatory reforms.

C. Analytical approach

The methodological approach for the performance evaluation of the Regulatory project relies on tracking key outcomes over time to assess pre-post changes, qualitative data analysis, simulation, and a political economy analysis to understand institutional incentives. We provide further detail on the proposed analysis below.

- **Track key outcomes over time.** Using a before-after comparison, we will examine key indicators such as tariff rates for household/enterprise customers as well as for the independent power producers; tariff targeting, including connection costs, the number of low-income customers with grid access, and the number of lifeline tariff customers;

financial health of the utilities; private sector resources invested in the distribution systems; power quality and reliability; and perceptions of organizational change. We will identify trends and any questionable patterns and flag this information for further clarification in KIIs.

- **Implementation progress.** We will compare implementation plans as outlined in project documents and the TSTP, examining whether the tariff plan is in place, the tariff adjustment formula was applied, and the tariff adjustment was on time. We will also review whether regulatory decisions were made in a transparent manner and supported by appropriate public justifications.
- **Qualitative data analysis.** We will examine KIIs for key themes related to the enabling environment for private investment, specifically perceptions of quality of service and fairness of tariffs. We will also examine key processes of decision making, such as the process of setting tariffs, to better understand individual stakeholder's roles and responsibilities. This will inform our understanding of how regulators implement the tariff formula. We will also examine whether and how women are involved in the tariff-setting process.
- **Simulations.** We will conduct simulations to assess the impacts of tariff changes on the financial well-being of the utilities. These simulations will consider tariffs for customers, connection costs for customers, tariffs for the power producers, other costs of the utilities, and the potential price elasticities of demand (based on other research). To better understand whether improvements in the financial health of the utilities were driven by tariff increases or other factors, we will jointly examine the potential effects of these factors and consider social dimensions of changes in the tariffs.

D. Timeline

Table VI.1 provides additional detail on what specific information will be gathered in each data collection round, disaggregated by data source. As with EFOT, the data collection timeline below assumes that project rollout has already begun.

Table VI.1. Key areas of data collection for the Regulatory project, by data source

	Key areas of focus		
Data source	Baseline (2019)	Midline (2021/2022)	Endline (2023/2024)
Implementation documents and records	*Implementation* • Adherence to project implementation plans • Delays and challenges in tariff adjustment • Satisfaction of conditions precedent	*Implementation summary* • Project implementation milestones and successes • Delays and challenges in tariff adjustment • Adherence to proposed implementation plans and timelines	*Sustainability* • Post-compact monitoring reports (if available) • Post-compact existence of cost-reflective tariff
Administrative data	*Implementation* • Historical tariff rates before project implementation	*Outcomes* • Existence of cost reflective tariff • Reduction in hidden costs • Increase in grid access for low-income customers • Progress against KPIs	*Sustainability* • Post-compact progress against KPIs
Key informant interviews with staff at Ministry of Power, PURC, the Energy Commission, PDS, restructured ECG, and private sector businesses and investors	*Expectations for implementation* • Anticipated challenges to implementation • Constraints and challenges • Perceptions of tariff-adjustment process	*Implementation and outcomes* • Level of stakeholder engagement • Perceptions of fairness of tariffs and change in quality of service • Application of the recommendations in the Fichtner studies	*Sustainability* • Sustainability of cost-reflective tariff • Continued use of the recommendations from the Fichtner studies • Sustainability of lifeline tariff access Perceptions of biggest contributors to operational efficiency • Challenges to sustainability • Perceptions of sustainability of project outcomes • Continuous refinement of tariff targeting
Enterprise component of the Household and Enterprise survey	• Perceptions of investment climate	• Perceptions of investment climate	• Perceptions of investment climate

[a] The sample size for the enterprise component of the Household and Enterprise survey will be finalized in consultation with MCC and MiDA. See Chapter VII for a more detailed discussion.

VII. ACCESS PROJECT EVALUATION DESIGN

The objective of the Access project is to increase MSME access to legal connections and installation of security lighting in markets and economic enclaves to improve security and facilitate more economic activity. With improved access to reliable electricity, MSMEs should be able to generate more revenue and improve their financial position; at the same time, the utilities can expand their customer base. The performance evaluation of Access will address the extent to which the project supports the overall power sector reform objectives of the Compact, as well as the implementation, outcomes, and sustainability of the project itself.

A. Evaluation questions

The evaluation of Access will address questions that focus on changes in legal connections, connection quality, energy consumption, and business outcomes for MSMEs in markets and economic enclaves. The evaluation questions are as follows:

Project objectives questions

1. Was the Access project successful in expanding the number of connections?

Implementation questions

2. Were projects activities implemented as designed? How did implementation (in terms of objectives, activities, and beneficiaries) deviate from the original logic driving the investment, and why? What were the implementation successes and challenges? How did changes in implementation affect project performance?
3. To what extent have the interventions improved the effectiveness of governance structures in markets and economic enclaves, and/or enhanced collaboration between market institutions and the utilities?

Sustainability questions

4. Were improvements in project outcomes sustained after the end of the Compact? What sustainability planning was done during implementation, and why? What are the critical institutional factors that affected their sustainability?

B. Data sources

The evaluation of Access will primarily rely on the following data sources:

- **Implementation documents and records** including project timelines, progress reports, and quarterly reports. These data will be used to understand adherence to project implementation design plans; any deviations will be noted for further probing in KIIs and focus group discussions (FGDs).
- **Administrative data from PDS, restructured ECG, and NEDCo.** We hope to get data from the utilities that cover the Access target areas in Greater Accra and in Tamale although this may not be possible. These data would allow us to measure the number of connections and their electricity consumption.

- **FGDs with MSME owners and investors.** These will provide an understanding of the challenges MSMEs face in obtaining legal connections, MSME power needs, feelings of social inclusion, and the rationale for opting for a legal connection. Additionally, we will probe on their perceptions of service quality, market governance structures, and improved security from the lighting activities. FGDs with enterprise owners will focus on their perceptions of gaining legal access to electricity in markets and economic enclaves, as well as of the key results of lighting interventions.
- **Household and enterprise survey.** We will oversample enterprises within the Access intervention areas and use the survey data to measure energy quality and use, financial outcomes, challenges in obtaining legal connections, and related outcomes. We may also sample a few households in these areas (if there are any) as part of our evaluation of the EFOT project but will not oversample them and will not use them as part of our evaluation of the Access project.
- **GridWatch data.** We will also use GridWatch data on outages and voltage fluctuations as background information for the Access project. We do not expect this project to impact these outcomes but the success of the Access project may depend on the quality of electricity being delivered to these areas.

C. Analytical approach

The performance evaluation for Access will rely on tracking key outcomes over time to assess pre-post changes, qualitative data analysis, enterprise case studies, and simulations, as described below:

- **Tracking key outcomes over time.** Using a before-after comparison, we will examine connection rates and the presence of market lights in administrative data, as well as these outcomes and others in the survey data. We will also try to capture the possibility that customers who formerly had illegal connections may find it challenging to pay for electricity. Where possible, we will also examine the differences in productivity and profitability of businesses by gender.
- **Qualitative data analysis.** We will use our KIIs to examine the Access project's implementation successes and challenges, MSME perceptions of, and rationale for, accessing legal connections, MSME perceptions of any security benefit resulting from Access activities, and perceptions of energy consumption as a result of the Access project.
- **Enterprise case studies.** Case studies will enable us to investigate the decision-making process for a small number of sample MSMEs. Through the enterprise survey and KIIs, we will look at the profitability for MSMEs of investing in legal connections. This review will help assess the program logic for the Access project and help explain why the project was or was not successful in increasing the number of connections in certain markets or economic enclaves. It will also help understand the business case for a small firm's investment in a legal connection and whether there were negative impacts on customers who previously had illegal connections. We will conduct purposive sampling of the respondents to the enterprise module of the household and enterprise survey for the case studies. We will not include any households in these case studies unless they have microenterprises in Access areas.

- **Simulations.** We do not expect the Access project to have a substantial impact on the financial health of the utilities. However, we could use simulations to estimate what impact it might have if it were expanded. They will account for changes in the number of legal connections and electricity use in the Access project areas, as well as key stakeholder opinions on the degree to which these changes might be due to the project. They will also account for possible changes in costs associated with the project. For example, if connection rates rise then the costs of providing certain services may rise as well.

D. Timeline

The timeline for the Access evaluation is summarized in Table VII.1, which provides additional detail on the information we will gather in each data collection round, disaggregated by data source.

Table VII.1. Key areas of data collection for the Access performance evaluation, by data source

	Key areas of focus		
Data source	Baseline (2019)	Midline (2021/2022)	Endline (2023/2024)
Implementation documents and records	*Design details* • Project implementation progress to date	*Implementation summary* • Project implementation milestones and successes • Delays and challenges in project implementation • Adherence to proposed implementation plans and timelines	*Sustainability* • Post-compact monitoring reports (if available)
Administrative data	*Outcomes* • Number of regularized connections	*Implementation and outcomes* • Number of regularized connections • Electricity consumption by new or regularized MSME customer	*Sustainability* • Number of regularized connections • Electricity consumption by new or regularized MSME customer
FGDs with MSME owners and investors	*Implementation* • Challenges to implementation • Cost of new connections • Perceptions of barriers to energy connections • Perceptions of governance structures in markets and economic enclaves • Constraints and challenges • Barriers to electricity in markets and economic enclaves	*Outcomes* • Perceptions of governance structures in markets and economic enclaves • Ability of MSMEs to obtain and maintain legal connections, including costs • Perceptions of legal access to electricity • Perceptions of lighting interventions	*Sustainability* • Challenges to sustainability • Perceptions of sustainability of new or regularized connections • Ability of MSMEs to obtain and maintain legal connections • Perceptions of sustainability of new or regularized connections
Enterprise component of Household and Enterprise Survey	*Implementation* • Connection rates • Connection costs	*Implementation and outcomes* • Connection rates • Connection costs • Business activities	*Sustainability* • Connection rates • Connection costs • Business activities

This page has been left blank for double-sided copying.

VIII. EEDSM PROJECT EVALUATION DESIGN

The objective of EEDSM is to reduce peak demand of electricity in order to achieve greater energy efficiency, minimize power waste, improve customer savings, and reduce infrastructure degradation. The evaluation of the EEDSM project will address the extent to which the project supports the compact's overall objectives of power sector reform, as well as the implementation, outcomes, and sustainability of the project itself.

A. Evaluation questions

The evaluation of the EEDSM project will address the following questions for each of the four interventions designed to reduce energy waste and increase the reserve margin between electricity supply and peak demand. These interventions include (1) a rollout of energy efficiency standards, (2) implementation of the pre-tertiary school curriculum and public information on use of efficient appliances with standards and labels via different media platforms, (3) implementation of an energy auditing and retrofitting activity and an intervention to establish two sustainable energy services centers (SESCs) that will train and certify energy auditors for the country, and (4) installing energy-efficient LED street lights.

Project objectives questions

1. Have the EEDSM interventions changed consumption of electricity by individual customers?
2. Did the availability and purchases of more energy-efficient appliances increase when standards were implemented? To what extent can these changes be attributed to the new standards?
3. To what extent has the R2R&R intervention affected electricity use and bill payment rates?

Implementation questions

4. Were project activities implemented as designed? How did implementation (in terms of objectives, activities, and beneficiaries) deviate from the original logic driving the investment, and why? How did changes in implementation affect project performance? What were the implementation successes and challenges?

Sustainability questions

5. Were improvements in project outcomes sustained after the end of the compact? What sustainability planning was done during implementation, and why? What are the critical institutional factors that affected their sustainability?

B. Data sources

The evaluation of EEDSM will primarily rely on implementation documents and records, KIIs, observational data, administrative data, and the household and enterprise survey.

- **Implementation documents and records,** including project timelines and progress reports, quarterly reports, and documents showing progress against key performance indicators, will

provide an understanding of adherence to project implementation design plans; any deviations will be noted for further probing in KIIs.

- **KIIs with energy auditors** will address research questions about project procurement processes, perceptions of new energy standards, perceptions of whether EEDSM interventions reduced energy consumption, and ultimate sustainability of EEDSM interventions. Additionally, the interviews will cover changes in auditing procedures and tools, changes in building energy practices, and perceptions of energy auditing and education campaigns as a way of reducing peak energy consumption. We will also conduct KIIs with Associates for Change (AfC) regarding the pre-tertiary curriculum intervention and implementation of that intervention.
- **KIIs with staff at schools** implementing the pre-tertiary school curriculum to delve deeper into the level and consistency of implementation of the curriculum and with implementer of streetlight intervention to develop an understanding of the implementation successes and challenges for that intervention.
- **Observational data** on the functioning of street lights will assess the pre-treatment conditions as well as whether the new lights are implemented and functional. We will work with MiDA to obtain a list of streets where these lights will be placed and potentially select a random subset for observation.
- **Administrative data** will come from utility and regulatory bodies and will be used to measure the percentage of electricity consumed during peak hours. For the evaluation of the R2R&R intervention in particular, we will attempt to collect a large number of pre-intervention measurements on electricity usage and payment records for the buildings.
- **Survey data** from the household and enterprise survey will enable us to determine whether EEDSM interventions changed customers' consumption patterns and whether the new standards led to an increase in energy-efficient appliance purchases and use. The survey will include specific questions related to purchase and usage of energy-efficient devises, use of non-electric energy, and at what times households and businesses tend to use electricity most. We will likely build off of or use the FMMS survey.

C. Analytical approach

1. Performance evaluation

The methodological approach for the performance evaluation of EEDSM relies in tracking key outcomes over time, qualitative data analysis, pre-post analysis, and simulations. Further detail is provided below.

- **Document review.** We will examine project documents in order to better understand their relation to key compact outcomes and the evaluation questions. This will include the FMMS baseline report. We will identify themes, with a particular focus on issues related to the evaluation questions, such as project implementation progress and project progress influencing consumption behavior. We will also document any ideas or issues that emerge from the review that should be explored further in KIIs and the household/enterprise survey.
- **Track key outcomes over time.** Using a before-after comparison, we will examine the percentage of electricity consumed during peak hours and the purchase and use of energy-

efficient appliances. We will identify whether consumption and purchasing habits changed as a result of EEDSM interventions and whether these habits persisted over time (post-compact), and will identify interesting patterns or trends for further discussion in KIIs.

- **Qualitative data analysis.** We will use our KIIs to examine the ability of specific EEDSM interventions to influence power demand and consumption, and perceptions of energy auditing and education campaigns. We will also examine whether energy efficiency audit teams met their targets for female participation and included energy efficiency labels to make products accessible to illiterate populations.

2. Impact evaluation

Interrupted time series (ITS) design

The EEDSM project includes an activity focused on building the technical capacity of professional energy efficiency auditors to audit the energy use of large commercial, industrial, and government buildings and recommend and fund energy-efficient retrofits. The impact evaluation will assess the impact of the R2R&R intervention on the electricity consumption. We will measure impacts relative to the pre-treatment period using an Interrupted Time Series (ITS) method which involves comparing outcomes before an intervention is implemented with those after. This evaluation will produce evidence on the potential benefits of future investments in this type of reform in Ghana.

Sampling and power calculations

The sample for the analysis of outcomes from administrative utility data will include the intervention buildings. We must assume that the pre- and post-treatment data on outcomes are comparable. Comparisons may not be valid if major changes take place in data collection systems over the course of the projects that affect the intervention and comparison groups differently.

Our power calculations estimate minimum detectable impacts (MDIs) as a fraction of the mean of the outcome, assuming a simple shift in the mean outcome after the intervention is implemented. In this case statistical power for an ITS model depends on the number of time points of data, the auto-correlation in outcomes, and the coefficient of variation (ratio of the standard deviation of the outcome to its mean). We present results using two ratios of standard deviation to mean—1 and 0.5. These encompass the range of estimates we found on energy use in buildings which went from 0.76 (Hamilton et al. 2013) to 0.49 (Xie et al. 2016). One other paper reported a ratio of 0.57 (Chong 2012). We assume positive auto-correlation and present estimates using both a 0.5 and 0.2 auto-correlation. As table VIII.1 shows the MDIs can be quite large, especially if the ratio of the standard deviation to the mean is high. However it drops as the standard deviation goes down relative to the mean, as the level of auto-correlation falls, as the number of buildings rises, and as the number of time periods rises. Our calculations suggest that if the ratio of the standard deviation to the mean is 0.5, the autocorrelation is 0.2, we have 12 buildings and we can get 48 time periods then we could estimate impacts as small as 0.14 of the mean. We understand that the number of buildings may be somewhat higher than the range presented in this table. This could help improve our statistical precision.

Table VIII.1. Minimum Detectable Impacts (MDIs) for Race-to-Retrofit Evaluation

Ratio of standard deviation and mean	Auto-correlation	Buildings	Time periods	MDIs as a fraction of the mean
0.76	0.5	6	24	0.62
0.50	0.5	6	24	0.41
0.50	0.2	6	24	0.29
0.50	0.2	12	24	0.20
0.50	0.2	12	48	0.14

Note: To calculate the MDIs, we assumed a significance level of 0.05, two-tailed tests, 80 percent statistical power, and that time periods are evenly split between the pre- and post-treatment periods. Our estimates are based on numbers presented in Zhang et al. (2011) with adjustments for differences in the numbers of buildings and time periods and the ratio of the standard deviation to the mean. The numbers highlighted identify what changed from the previous row. Time periods could refer to weeks or months.

D. Timeline

Similar to the other compact projects, EEDSM will rely on three rounds of data collection, which will begin after activity implementation. Table VIII.2 provides additional detail on what specific information will be gathered in each data collection round, disaggregated by data source. For the impact evaluation, we understand that the preliminary energy audits and investment grade energy audits have occurred.

Table VIII.2. Key areas of data collection for the EEDSM performance evaluation, by data source

Data source	Key areas of focus		
	Baseline (2019)	**Midline (2021/2022)**	**Endline (2023/2024)**
Implementation documents and records	*Design details* • Project implementation progress to date	*Implementation summary* • Project implementation milestones and successes for Development and Enforcement of Standards and Labels activity, Improved Energy Auditing activity, Education and Public Information activity, and the Demand-Side Management activity • Delays and challenges in project implementation • Adherence to proposed implementation plans and timelines	*Sustainability* • Post-compact monitoring reports (if available)
Administrative data	*Outcomes* • Peak demand and percentage of electricity consumed during peak hours pre-EEDSM intervention	*Implementation* • Peak demand and percentage of electricity consumed during peak hours post-EEDSM intervention	*Sustainability* • Post-compact progress against KPIs • Sustainability of auditing and labeling
KIIs with intervention implementers	*Expectations for implementation* • Anticipated challenges to implementation • Perceptions of energy consumption • Constraints and challenges	*Outcomes* • Perceptions of energy consumption • Perception of appliance purchases and use	*Sustainability* • Challenges to sustainability • Perceptions of sustainability of project outcomes
Household and enterprise survey	*Outcomes* • Energy consumption • Energy-efficient appliance purchases and use	*Outcomes* • Energy consumption • Energy-efficient appliance purchases and use	*Sustainability* • Energy consumption • Energy-efficient appliance purchases and use

This page has been left blank for double-sided copying.

IX. UPDATING CALCULATIONS OF THE ECONOMIC RATE OF RETURN

A. Background

To determine whether the benefits of a project justify its costs, MCC calculates the ERR of its projects. The ERR is a summary statistic reflecting the economic merits of an investment. Conceptually, it is the discount rate at which the benefits of an intervention are exactly equal to its costs. The higher the benefits relative to costs, the higher the ERR. When developing the Ghana Power Compact, MCC calculated estimates of the ERR of some projects based on each project's expected costs and benefits, using data from the electrical utilities and other sources.

As part of our evaluation, we will compute two post-compact ERRs covering three of these projects, using actual costs incurred and estimates of benefits from the evaluation. We will compute one ERR for the EFOT and Regulatory Projects in the EFOT target areas (estimated together as a single ERR) and, separately, one ERR for the EEDSM Project. These post-compact ERRs will permit a comparison to other investments in addition to enabling MCC and other stakeholders to determine whether the projects have proven to be a sound investment (by comparing each ERR to the hurdle rate of 10 percent). At the time of the compact signing, the estimated ERR was 19 percent for the EFOT/Regulatory projects and 27 percent for the EEDSM Project (MCC 2014b).

We will prepare our post-compact ERRs in the first quarter of 2024, roughly two and a half years after the end of the compact. (The compact is scheduled to end in September 2021, five years after entry into force). As a result, we expect our post-compact ERRs will include roughly three years of post-compact data. The accuracy of our post-compact ERR calculations will depend on the plausibility of the economic modeling assumptions of the ERR models and the precision of the impact estimates we use to calculate program benefits over time. As a result, we plan to test the sensitivity of our ERR estimates to key parameters by using ranges of assumed values—informed by more recent data when possible—and confidence intervals of our impact estimates to estimate bounds of the post-compact ERR values.

We will also conduct beneficiary analyses for the EFOT/Regulatory projects and the EEDSM Project to disaggregate project benefits across different segments of society and identify who benefited most from project activities. These analyses will be critical to determine if the projects are likely to reduce poverty. We will conduct the beneficiary analyses separately for different groups to determine the extent to which marginalized groups benefited from project activities. For each group, we will determine the number of beneficiaries and the present value of benefits accruing to beneficiaries.

In this chapter, we present the details of MCC's ex ante ERR models of the EFOT/Regulatory and EEDSM Projects and describe how we will update those models to conduct our post-compact ERR estimations and beneficiary analyses. We also briefly discuss why we are not conducting such analyses for the other compact projects.

B. EFOT and Regulatory projects

1. Description of ex ante ERR model

a. Beneficiaries

In the ex-ante ERR model, the primary beneficiaries of the EFOT project are businesses, wage employees, household members of business owners and wage employees.[12] Focusing on businesses as the mechanism through which the EFOT project generates beneficiaries aligns with the important role of ECG/PDS in the economic activity of the region. There is consistent evidence that poor quality electricity constrains business productivity, especially for those businesses in electricity-intensive industries (Adenikinju 2003; Escribano et al. 2010; Arnold et al. 2008). Meanwhile, there is little evidence to suggest sizable household-level economic benefits from higher quality or more reliable electricity.

For the beneficiary analysis, MCC identified firm-level beneficiaries only from Accra East and Accra West operational regions of ECG and took into account the size of the firms (large, medium, small, and micro). Within each size category, the beneficiary analysis makes a series of assumptions to estimate the number of business owners and wage employees and their households. To estimate the total number of businesses in in these areas, the beneficiary analysis assumes that business owners have a single medium-sized business, two small businesses, or three micro businesses. Owners of large businesses are excluded from this calculation, presumably because these may be structured as corporations and thus may not have an individual business owner. The beneficiary pool of employees is drawn from the data on the numbers of each type of business, and assumes that micro businesses average 0.5 employees (in addition to the owner), small businesses average 5 employees, medium-sized businesses 10 employees, and large businesses 100 employees. This calculation generates a pool of wage-employed direct beneficiaries in Accra East and West. The direct beneficiaries of business owners and wage-employed beneficiaries total about 1 million. Including the household members of direct beneficiaries brings the total number of direct and indirect beneficiaries to about 4.8 million. The most recent national census in 2010 estimates the total population of the Greater Accra Region at around 4 million; supposing reasonable population growth of about 20 percent over the period 2010 to 2018, the estimated 4.8 million beneficiaries include roughly the total population of Greater Accra (GSS 2010).

MCC's documentation acknowledges that direct beneficiaries (business owners and wage employees) are more likely to be male and more likely to belong to a higher socioeconomic group than either indirect beneficiaries or non-beneficiaries.

b. Benefits and costs

The ERR model assumes that project activities will directly impact outages in Greater Accra for 20 years and that reductions in outages will provide two benefit streams to beneficiaries by: (1) allowing businesses to substitute electricity from the grid for current, expensive energy sources, and (2) allowing businesses to consume more electricity for productive purposes. The model attempts to estimate the benefits accrued by businesses and assumes that the businesses

[12] MCC documentation and discussions with MCC staff suggest that most of the estimates built into the beneficiary analysis for the EFOT Project come from the Institute of Statistical, Social, and Economic Research.

will share the resulting productivity gains with wage employees, either through wage bargaining or through a commission-type mechanism, and the additional profits accrued by owners and wages accrued by wage employees (the direct beneficiaries) will then be used to improve the welfare of household members (the indirect beneficiaries).

The model separates businesses in Accra East and West into one of three categories that correspond to the two benefit streams described above, along with a third group of businesses that do not use electricity: (1) "self-sufficient" large businesses that have access to alternate forms of electricity, (2) "vulnerable" MSMEs that are dependent on the grid for electricity, and (3) MSMEs that do not use electricity (and therefore will not benefit from the reduced outages). MCC estimates the economic benefits of outage reduction for each group of electrified businesses using the following steps. First, the ERR calculation estimates the expected productivity losses due to outages without the project for each year across the 20-year time horizon, based on the total number of businesses in Greater Accra and the hours of disruptions expected to be experienced by businesses (estimated by SAIDI). Electricity demand (and therefore electricity losses) is assumed to increase by 6 percent each year. Second, it estimates electricity losses prevented by the project. MCC assumes that outages will be reduced by 5 percent in the third year of the project and by 10 percent in years 4 through 20 compared to what would have happened in the absence of the project.[13] Third, the ERR calculation estimates the total economic value of the outage reductions for business in Accra East and West by estimating the economic opportunity cost of losing a marginal unit of electricity (kilowatt hour, or kWh, estimation described in next paragraph), multiplying this value by the estimated amount of electricity saved by the project for each year, and totaling the annual benefits across all 20 years.

To estimate the economic opportunity cost of a marginal unit of electricity, the ERR calculation summed the estimated total annual cost of electricity disruptions for large businesses and MSMEs and divided it by the total annual kWh of electricity lost to disruptions. To estimate the annual cost of disruptions for large businesses that are assumed to have alternative sources of power generation, MCC multiplied the estimated number of hours of power disruptions experienced by large businesses in a year by the kWh per hour large businesses use on average and the net difference in cost per kWh between alternative sources of power generation and grid power (assumed to be $0.80 USD per kWh for alternative power generation and $0.30 USD per kWh for grid power).[14] For MSMEs, MCC estimated the total productivity of MSMEs in Greater Accra (contribution to annual GDP divided by the total number of hours worked in a year) and multiplied this by the total hours of power disruption experienced by MSMEs in a year and by the percentage of all MSMEs that are vulnerable to power disruptions (assumed to be 33 percent). MCC assumes that "vulnerable" MSMEs do not have access to alternative forms of power generation and that each hour of disrupted power results in lost production rather than added cost (as it does for large businesses). The estimated economic opportunity cost of a marginal unit of electricity in the model was $1.0 USD per kWh in Greater Accra and $1.4 USD per kWh across all ECG regions. MCC used the average of these two estimates—$1.2 USD per

[13] Formally, MCC assumes that outages will be reduced by 10 percent in year 3 and 20 percent in years 4 through 20, and that 50 percent of these reductions can be attributed to distribution issues improved by the project, as opposed to "upstream" issues that are outside the scope of the project.

[14] All monetary values in the EFOT/Regulatory ERR model are adjusted to 2014 USD/GH.

kWh—to estimate the ERR and used the two estimates as sensitivity tests, along with a more conservative estimate of $0.50 USD per kWh.

The estimated costs in the model include MiDA project costs related to implementation of the EFOT and Regulatory Projects, compact administration and management costs, and annual ECG/PDS costs for maintenance of assets improved by the projects. The compact is assumed to run from years 1-5, along with corresponding administration and management costs. Project implementation is assumed to take place in years 1-3 for the EFOT Project and in year 1 for the Regulatory Project. The annual maintenance costs incurred by PDS are assumed to begin in year 2 (GH₵7.4 million, or $2.6 million USD), rise in year 3 (GH₵14.9 million, or $5.3 million USD) and year 4 (GH₵22.5 million, or $8.0 million USD), and remain at the year 4 value in years 5-20.[15]

c. Results

The estimated ERR for the EFOT and Regulatory Projects is 19 percent (given an assumed opportunity cost of a marginal unit of electricity of $1.2 USD per kWh). This estimate is well over the 10 percent hurdle rate used to evaluate the returns to MCC investments. Sensitivity analyses using opportunity costs of $0.50, $1.0, and $1.4 USD per kWh yielded estimated ERRs of 5, 16, and 22 percent, respectively. Thus, the ability of the ERR to meet MCC's 10 percent hurdle rate is dependent on the assumptions that feed into the model.

2. Updates to the ERR model

As part of the evaluation of the Ghana II Compact, we will conduct a post-compact estimation of the ERR for the EFOT and Regulatory Projects using updated information collected as part of the evaluation. Examples of potential updates to our post-compact model include the following.

a. Benefits

- Using administrative and GridWatch data, we may be able to update the level and pace of outage reductions assumed in the model to match realized reductions across Greater Accra. In addition, we plan to use the GridWatch results to update the estimated impacts of outages on economic outcomes by business type (self-sufficient, vulnerable, and non-users of electricity).
- We will use our household and enterprise survey and our proposed IV results to adjust the GridWatch impact estimates so that they can be used to estimate impacts for Greater Accra and for the different types of investments being made. (GridWatch impact results will only be for some parts of a single operational district, Achimota, and a single intervention, line bifurcation.) This adjustment will be done by using the GridWatch impact results by subgroup (for example by enterprise size) and multiplying those by the subgroup percentages found in our survey data for Greater Accra, and by doing something similar based on our IV results.

[15] MCC assumed an exchange rate of GH₵2.4 to $1 USD.

- We plan to update the annual increase in electricity demand using actual numbers from PDS administrative records at the time that we calculate the ex post ERR. We also plan to use these growth figures to update predictions of growth that will take place over the remainder of the 20-year time horizon.
- We may be able to use qualitative interviews with managers of buildings involved in the improved energy efficiency audit activity of the EEDSM to evaluate the accuracy of the ex-ante assumption of the cost of alternative sources of fuel generation for large businesses.
- We may also be able to use surveys we will conduct with MSMEs as part of the Access Project evaluation to collect information on the prevalence of alternative sources of energy among MSMEs. If the use of alternative sources is substantial, we will incorporate MSMEs with alternative sources into the model and evaluate how including them changes the estimated ERR. To the extent GridWatch is able to identify impacts of reduced outages on MSMEs productivity, its data would also give us an alternative estimate of the opportunity cost of outages for MSMEs, and we will update the ERR accordingly.

b. Costs

- In consultation with MCC and MiDA, we plan to update the amounts and distribution of annual implementation costs of the EFOT and Regulatory Projects, the administrative and management costs incurred by the compact, and yearly maintenance costs incurred during and after the compact using compact and utility records.
- We will also review maintenance records, if available, to evaluate whether there has been proper maintenance of infrastructure. This will provide evidence of whether the 20-year time horizon for project benefits is reasonable or needs to be reduced because of poor maintenance practices.

C. EEDSM Project

1. Description of ex ante ERR model

a. Beneficiaries

The beneficiaries of the ex-ante ERR model of the EEDSM Project include the entire population of Ghana with access to electricity. This is estimated to include 4.3 million households and 19.6 million people at the start of the project. MCC further assumes that all consumers have access to energy-efficient appliances and that population growth will increase at 2.3 percent annually.

b. Benefits and costs

Under the ex-ante ERR model, the EEDSM Project will provide benefits to households in electrical service areas over a 20-year time horizon by increasing the purchases of energy-efficient appliances through the establishment of energy efficiency standards, which will reduce the growth of peak electricity demand. This reduction in demand will in turn lead to an increase in electricity reserve margins, a reduction in power outages, and ultimately an increase in business production. MCC assumes that growth in demand would be 6 percent each year without the project, and that the project will slow demand growth by 0.5 percentage points starting in year 5, 1 percentage point in years 6–10, 0.5 percentage points in years 11–14, and 0.6

percentage points in year 15; and that the project will have no effect on demand growth in years 1–4 and 16–20.

MCC estimated the benefits of the model by running 500 Monte Carlo simulations of the economic losses caused by power outages both with and without the EEDSM Project. The difference between these estimates provided the model's estimate of the project's benefits on business production and therefore on household well-being. MCC also ran these simulations under two regimes—one with low reserve margins and one with more adequate reserve margins—to understand the project's benefits under different operating conditions. The simulations used exponential functions to model changes in the reserve margin following an increase in capacity, which MCC assumed occurs 30 times over the course of the 20-year time horizon at random intervals (the cost of which are included as costs in the ERR model; see description below). MCC estimated the expected amount of outages and economic losses for the simulated reserve margins and averaged the economic losses across all 500 simulations for each year to produce yearly estimates of the project's benefits to production with and without the project. Outages were assumed to reduce by 4 percent for each percentage point of reserve margins (up to 25 percent, when outages are assumed to be reduced by 100 percent).

The costs incorporated into the ERR model included implementation costs of the EEDSM Project, compact administrative and management costs, the cost of increasing system capacity (from the simulations), private purchases of energy-efficient appliances during the compact, and recurring post-project costs associated with maintenance and replacement of those appliances. The project and its associated implementation costs were assumed to run from years 1 through 5, with 80 percent of the costs incurred in the first three years. MCC distributed compact administrative and management costs over the first five years (the lifetime of the project) and assumed that the total administrative and management costs are equivalent to the total cost of EEDSM Project implementation. The ERR calculation estimated the costs of the simulated capacity increases (see description of simulation above), and averaged them across the 500 simulations for each year to produce yearly estimates of the costs of capacity expansion with and without the project. Private purchases were assumed to begin in the last year of the project (year 5) and to total roughly $870 million over 10 years.[16] Recurring costs were also assumed to begin in the last year of the project and continue unchanged through year 20.

c. Results

The estimated ERR for the EEDSM Project is 27 percent (averaging the net benefits estimated under the low and adequate reserve margin scenarios). This estimate is well over the 10 percent threshold used to evaluate the returns on MCC investments. The ERR estimates vary quite a bit under the two reserve margin scenarios. With low reserve margins,[17] the estimated ERR is 39 percent, but with higher reserve margins[18] (and less need to reduce demand) the

[16] As in the EFOT/Regulatory ERR model, all monetary values in the EEDSM model are adjusted to 2014 USD/GH.

[17] In the low reserve margin scenario, the average annual reserve margin ranges from 5 percent to 15 percent over the 20-year time horizon.

[18] In the higher reserve margin scenario, the average annual reserve margin ranges from 9 percent to 37 percent over most of the 20-year time horizon, and over 100 percent in the final three years.

estimated ERR is only 2 percent and does not meet the MCC threshold. The Energy Commission's Energy Outlook for 2018 estimated reserve margins of 6 to 19 percent in January and February 2018, and from 18 percent to 40 percent throughout the remainder of 2018 (Energy Commission 2018). These figures are in line with estimates in the higher reserve margin scenario, in which the average annual reserve margin ranges from 9 percent to 37 percent throughout most of the model's 20-year time horizon. This suggests that the ERR may be much lower than what is needed to reach the MCC threshold of 10 percent.

2. Post-compact updates to the ERR model

We will use updated data from the evaluation to calculate a post-compact estimate of the ERR for the EEDSM Project. Examples of potential updates to our post-compact model include the following:

a. Benefits

- We will recalibrate the reserve margins in the model to match those experienced over the first few years of the compact and predicted for future years given the observed trends and compare those levels to the recommended levels. This update is particularly relevant given the large differences in ERR estimates for lower and higher reserve margins and the evidence that reserve margins have risen in recent years (Energy Commission 2016; Energy Commission 2017; Energy Commission 2018).
- We can also update the relationship between reserve margins and outages in the model's simulation by using observed changes in those outcomes in utilities' administrative data.
- We plan to update the annual increase in electricity demand over the years that have already passed based on the growth in electricity usage estimated from PDS administrative records. We also plan to use measured growth to update predictions of growth that will take place over the remaining years of the 20-year time horizon.

b. Costs

- In consultation with MCC and MiDA, we plan to use compact and project records to update the amounts and distribution of annual implementation costs of the EEDSM Project, the administrative and management costs incurred by the compact, and the cost of increasing system capacity. We will also update estimated private purchases of energy-efficient appliances and recurring post-project costs if we are able to obtain survey data revealing these costs.
- We may be able to update the amount of money private consumers spend on energy-efficient appliances using data collected for the FMMS. If the standards and labels evaluation is implemented, we may also use sales records collected from appliance markets to evaluate the plausibility of the original assumptions in the ERR model.
- Using administrative records from PDS, we may also be able to update the pace of capacity increases, the magnitude of the increases, and the costs involved in implementing them in the simulation model.

D. Other projects

We are not planning to update ERR estimations for the Access, Power Generation, or NFOT projects. An ex ante ERR model was not estimated for the Access project and MCC did not proceed with the Power Generation or NFOT projects.

X. DATA COLLECTION

The performance and impact evaluations will rely on data from a variety of sources to address the full suite of evaluation questions. In this chapter, we describe in more detail the primary data collection for the evaluation, including the household and enterprise survey that will support most of the evaluations proposed. We then describe how we will work with local partners to conduct the data collection, including development of data collection instruments, and our approach to high quality data. We also present an overview of data collection training, timing, and statistical power for the pre-post analysis.

A. Primary data collection

1. Household and enterprise survey

As described in previous chapters, we plan to conduct a longitudinal household and enterprise survey that covers the ECG catchment area and the Access target area in the north and serves both MiDA's monitoring and Mathematica's evaluation purposes. We also plan to coordinate this work with GridWatch. For example, we will design the survey to align with MiDA's plans to monitor key outcomes for households, enterprises, and electricity customers. In addition, the survey will serve as a key data source for our proposed IV estimates of the impacts of outages on economic outcomes. The household and enterprise survey will be designed to capture key outcomes that we are not likely to be able to capture using administrative data or other planned or existing surveys. These include electricity quality (outages and voltage instability) at the customer level, connection rates, use of energy-efficient devices, and use of non-electric energy. We also plan to use the surveys to capture longer-term outcomes related to economic well-being, education, time use, and health.

The survey will cover both households and enterprises, with separate modules tailored to the two types of respondents as well as a module targeted to enterprises in the Access project areas. It will also include a customer module to cover outcomes that are specific to electricity customers. Almost all customers are either households or enterprises; the module will be designed so that it can be administered to both customer types, allowing for a combined analysis of the data. We will work closely with MiDA and the utilities to ensure that the customer module addresses their specific data needs and with GridWatch to ensure that our sample targets locations where they are collecting outage data, when possible, and so that we can avoid surveying the same households and enterprises covered in their baseline survey. The one group of customers not covered by the survey is public buildings such as government offices, hospitals, and schools.

We will work with Ghana Statistical Service (GSS) and the World Bank to develop two sampling frames—one for households and one for businesses. We would then draw the samples in four stages.

1. In the first stage, we would identify the specific geographic areas for oversampling. This would include the Accra East and West operational regions as well as any enclaves or markets targeted by the Access project in the North. As discussed earlier we plan to oversample enterprises and households in areas likely to benefit most from the new substations intervention, the line bifurcation intervention, the bulk supply points

intervention, and the Access project. Some of these geographic areas might overlap, in which case the oversampling rate would be adjusted accordingly and we might be able to add more enumeration areas (EAs).

2. In the second stage, we would select EAs within each of the geographic areas identified above for oversampling, as well as another set of EAs to cover the rest of the ECG catchment area. All EAs would be selected in proportion to the number of households and enterprises in the geographic areas. The EAs selected for households would be independent from those selected for enterprises.
3. In the third stage we would select one transformer within each EA. If this was an area covered by the GridWatch sample we would try to target the transformers they used. Otherwise we would pick transformers randomly in proportion to the numbers of households or enterprises served. We will use lists provided to us by MiDA that include the new transformers that are planned as part of the EFOT project. In addition, we will update those lists in the EAs selected for our survey.
4. In the final stage, we would randomly select households and enterprises in the catchment areas for the relevant transformers. In this stage we will oversample larger enterprises compared to smaller ones in part because the larger ones account for more benefits per firm in the ERR and in part because their outcomes vary more based on our analyses of data from the World Bank Enterprise survey in Ghana.[19]

Because a longitudinal survey of households and enterprises that are present in 2019 would miss newly formed households and enterprises in the endline, we will modify the survey sample to capture and track newly formed households and enterprises in the endline survey. The theory of change for the compact does not anticipate impacts on the formation of households, but if the compact improves electricity, it could affect enterprise formation. In order to be able to survey new households and enterprises, we will collect an update sample frame of households and enterprises prior to endline data collection.

We will also work with MCC and MiDA to finalize the definition of small, medium, and large enterprises, but we assume it will be the same as that used for the ERR. We will stratify our sample based on these categories to ensure that we can address each type of enterprise and oversample larger enterprises given that they are expected to have more benefits per enterprise (based on the ERR) and more variation in outcomes (based on enterprise data from Ghana we have reviewed). The definitions will also be informed by those used for other surveys of

[19] According to the ERR there are only about 1,111 large enterprises in Greater Accra out of a total of 408,887, which comes out to around 0.3% of the population of enterprises. Based on the ERR we estimate that the benefits per enterprise are around $42,471 in the large enterprises versus around $312 in the micro-enterprises. In addition, evidence we found from the World Bank Enterprise survey in Ghana suggests that the variation in benefits may be larger in the larger enterprises than in the smaller ones (for example, over 100 times higher in large enterprises compared to micro-enterprises). Based on this information, we are currently planning to recommend a sample with about 76 large enterprises, 849 medium-sized enterprises, 1,218 small enterprises, and 477 micro-enterprises (including about 255 micro-enterprises through the household survey) in Greater Accra in order to be able to estimate overall benefits with optimal precision. If we did not oversample the large enterprises we would only include about 7 of them. We will also be oversampling medium-sized enterprises for similar reasons. Without over-sampling, we would include only 261 medium enterprises in our sample (instead of 849, as noted above) and the minimum detectable impact would approximately double.

enterprises in Ghana. In addition, we will include an enterprise module in the household component of the household and enterprise survey to capture micro enterprises run by families or individual household members. Since our survey will only cover the ECG and Access target areas, it will not capture migration into and out of those areas. Instead we will use the GLSS and GSEPS to capture that type of migration.

3. Qualitative data collection

Members of the evaluation team will be responsible for conducting KIIs, whereas the data collection firm conducting the household and enterprise survey will be responsible the FGDs. Table X.1, below, describes the entities likely to be included in the KIIs; we will seek input from MCC and MiDA as we develop the specific list of respondents for each round of data collection. For the KIIs, we will attempt to interview the same respondents during each round. If some respondents have changed position or are no longer available, we will attempt to interview their successors. We will conduct the FGDs with MSMEs likely to benefit from the Access project. This process will involve purposively sampling businesses to ensure a wide representation of groups. We will conduct separate focus groups for women and men.

We will collect three rounds of qualitative data at the same time we are conducting each of the survey rounds. Information that we obtain from the survey data collection will also inform the development of semi-structured instruments and guides for subsequent rounds of qualitative data collection.

B. Local data collection partners

Mathematica will work closely with MiDA to help hire, train, pilot, and oversee all aspects of data collection conducted through a local data collection firm. MiDA will be responsible for the data collection contract that covers the baseline data collection, which take place during the compact period. We will support MiDA in leading a competitive procurement process to identify a qualified data collection partner for the baseline household and enterprise survey and for the focus group discussions. We will assist with drafting the scope of work and will be available to advise on the selection process.

Ideally, the firm will have the following desired qualifications: experience with electronic data collection, large-scale surveys, and surveys of households and businesses; an existing pool of qualified enumerators who collectively speak a range of local languages; and the ability to bring together a strong team of supervisors. The selected firm should be experienced in qualitative data collection and in collecting data from MSMEs in the relevant local languages. We would also prefer for the firm's staff to have experience using NVivo or similar qualitative analysis software. In addition, we expect its staff to give input on the protocol and instruments, and provide word-for-word transcriptions of digital recordings of FGDs and key informant interviews. The firm will clean the data; this will include reviewing transcripts for fidelity to the recordings, adding definitions of acronyms and jargon, and adding notes for context. Terms of reference should also include a requirement to provide references for past clients who can verify the quality of previous data collection work. To ensure high quality of data, we recommend formalizing Mathematica's role in reviewing any final data set and providing a formal recommendation of acceptance of deliverables.

The endline data collection will occur after the compact has closed; for that round, Mathematica will be responsible for the data collection contract. As with the baseline, the endline will include both the household and enterprise survey and focus groups. The selection of the firm(s) should depend on the capabilities and cost of the firms that respond to the call for proposals, including their experience in the earlier rounds of data collection. We will oversee all efforts, from identifying and training enumerators to developing teams, conducting interviews, transcribing and translating, preliminary coding, and submitting data for analysis.

C. Approach to collecting high quality data

The evaluation's success depends on the collection of high quality data, particularly the accuracy, reliability, and timeliness of the data. We will actively anticipate risks and minimize threats to quality that are inherent in the data collection process. Prior to undertaking any data collection efforts, we will provide detailed data collection plans, safety measures, and procedures for obtaining all necessary permissions from local authorities. We will submit these to MCC and MiDA for approval prior to any fieldwork and will also submit survey instruments and protocols for review and input.

For survey data collection, we propose using a computer-assisted personal interviewing (CAPI) system on tablets, such as the Survey Solutions or Surveybe platform. CAPI supports high quality data by enabling a continuous review of data and allowing for consistency checks on an ongoing basis. The system is designed to work in low-resource countries by operating with a user-friendly format on a variety of tablets. A CAPI system greatly increases data quality by controlling the skip pattern, removing the need for data entry, and reducing survey administration time. The program will also be password protected and, once synchronized, the data are uploaded to a cloud server and not stored on the tablet, increasing data security and protection of personally identifiable information (PII) in case of loss or theft of the tablet.

We will closely monitor the entire data collection process with the assistance of our local research coordinator, who will help to organize and monitor on-the-ground operations and ensure that Mathematica's data quality standards are met. The research coordinator will participate in regular feedback meetings with the data collection firm and conduct unannounced site visits.

D. Instrument development

We will develop and test all qualitative and quantitative data collection instruments. For qualitative data collection, we will use tailored protocols for each round of data collection. We will develop semi-structured instruments for the KIIs and guides for the FGDs to ensure that we explore the key areas of focus during each round of data collection, as described in Chapter IV. The semi-structured instruments will allow us to gather targeted information on energy sector reform and project implementation and outcomes while permitting an expanded conversation that can lead to unanticipated insights. The FGD guides will allow us to facilitate an open discussion around the actual costs and benefits of investing in a legal connection and perspectives on service quality.

For the quantitative data, we will develop questionnaires by drawing on instruments from established surveys such as the Ghana Living Standards Survey and the Ghanaian Integrated Business Establishment Survey. We will also collaborate with GridWatch to facilitate possible

comparisons of our data with theirs and with PDS if they are planning to conduct any customer surveys. We will include details needed to conduct follow-ups of the same households and enterprises including GPS locations, names, and phone numbers. After we have developed the preliminary instruments, pre-tests will help to verify that the survey will produce valid measures of the outcomes we are seeking to measure and will reliably measure them. Prior to the fieldwork, we will conduct pre-tests to assess whether respondents can interpret the items as intended, the answer options are appropriate, and there is variation in responses. Our local research coordinator will be responsible for overseeing pre-tests of the survey instruments; staff from Mathematica will travel to Ghana to oversee training and observe the pre-tests of survey instruments and protocols.

E. Data collection training

Mathematica will work closely with the local data collection firm to train interviewers and monitor the data collection effort. We will put in place data collection procedures to minimize risks to data quality. As mentioned above, electronic data collection reduces human error; however, it relies on the training and oversight of enumerators during the data collection process. The training will include a thorough review of data collection guides and processes, a description of sampling and recruiting procedures, a discussion and review of high quality transcripts from qualitative data collection, mock and practice interviews, and tool piloting and debriefing. The final selection of supervisors and interviewers will occur after training and will be based on performance on verifiable measures of competency such as tests or field observations during the pre-testing process.

F. Timing of data collection activities

The evaluation will have three rounds of data collection, baseline in 2019, a qualitative midline in 2021 near the end of the compact, and an endline starting in 2023. We propose a single household and enterprise survey at baseline and endline that will cover all project activities that we are evaluating. This will save project resources compared to having multiple surveys for each of the projects or activities.

The baseline will capture early implementation for many interventions and baseline for some. The qualitative midline will capture mid to late implementation for almost all interventions that are completed before the end of the compact period. The endline will capture longer-term outcomes for all interventions completed during the compact period. Table X.1 describes the timing and expected sample for each of the data collection exercises.

Our proposed qualitative baseline data collection is on a slightly different timeline than our survey data collection. The baseline qualitative data collection would occur mid-2019 while the household and enterprise survey will start later in the fall. Activities under the EEDSM, Regulatory, and Access projects have started. In addition, Private Sector Participation Activity of ECG is well underway as PDS took over ECG on March 1, 2019. Some key stakeholders may have altered their behaviors in anticipation of the takeover by that time. Thus, we are hoping to avoid delays in starting baseline data collection in order to capture baseline conditions for key project interventions.

We will coordinate with GridWatch during the baseline survey planning to ensure that we survey households and enterprises covered by the transformers where GridWatch obtains outage data and to avoid surveying the same households and enterprises in their baseline data collection.

At midline there will be no survey. We will be collecting qualitative data within three months of the end of the Compact in order to contact key stakeholders at MiDA before their mandate ends. In addition, we will be collecting administrative data especially from PDS regarding key compact outcomes such as outages and voltage fluctuations, as well as measures of implementation, such as the degree to which the key infrastructure interventions were completed. Our understanding is that many of these interventions will not be complete until very close to the end of the compact. Consequently, the data collection period at midline is extended a few months in order to be able to capture those measures of implementation and short-term success.

Final qualitative and survey data collection will start in 2023 and conclude in 2024. The endline will provide about two additional years of exposure after compact completion, and will measure longer-term outcomes. Based on research we have reviewed impacts of electricity projects often increase substantially after two years of exposure (Bos et al, 2018). We expect exposure to be at least somewhat longer for most compact interventions and perhaps substantially longer for some parts of the EEDSM and Access projects. Appendix B provides an exposure table for primary data collection activities.

Table X.1. Quantitative and qualitative data collection summary

Data collection	Timing (include multiple phases)	Sample unit/ respondent	Sample size
Key informant interviews	Baseline: 2019 Midline: 2021 Endline: 2024	PDS Restructured ECG Private sector operators PURC Energy Commission Ghana Standards Authority MCC MiDA Ministry of Energy MSME owners and investors MMDAs (whose jurisdictions M&EEs are located and are Managers of the markets) Energy auditors School staff NaCCA	40-45 KIIs
Focus group discussions	Baseline: 2019 Midline: 2021 Endline: 2024	MSME owners and investors	20 FGDs
Household and enterprise survey	Baseline: 2019 Endline: 2023-24	Households and enterprises	3,213 Enterprises 774 Households

G. Statistical power and sample sizes for pre-post analyses

We present the minimum detectable effect sizes and differences for the pre-post analyses using the household and enterprise survey data in Table X.2 below. We present 10 rows of data for enterprises in Table X.2 and three more for households. The first four rows for enterprises describe the statistical power we will have for conducting pre-post analyses targeting each of four specific interventions: the Access project (treated as a single intervention), line bifurcation, new substations, and bulk supply points (the last three all under the EFOT project and in Greater Accra). We do not expect large impacts of the Access project on outages but are planning to collect the outage data in those locations to help provide context for our evaluation of that project. We are planning to collect survey data for potential beneficiaries of the last three interventions because we expect these interventions to result in relatively large changes in outages. Our pre-post analyses focused on these interventions will not capture their full impacts because of spillover beyond their target areas. We will try to address this inability of the analysis to account for full impacts through information from interviews with key stakeholders. The fifth and sixth rows of Table X.2 present the MDD and MDEs for the rest of Greater Accra and for Greater Accra (which is based on the same data used in all of the prior lines). The 7th line covers the next 7 largest cities in the ECG catchment area (Kumasi in Ashanti region, Sekondi-Takoradi in Western, Cape Coast in Central, Obuasi in Ashanti, Koforidua in Eastern, Ho in Volta, and Kasoa in Central). The 8th line covers the sample sizes for Greater Accra and the next 7 largest cities combined, line 9 covers the sample sizes for the three Access sites in the North, and line 10 covers the total enterprise sample size. We do not present statistical power for the last three rows because we do not plan to present statistics for those groupings. For households we present only three lines. Those cover Greater Accra, the next 7 largest cities in the ECG catchment area, and the total sample size. The columns under Survey Data present the minimum detectable effects (MDEs) and minimum detectable differences (MDDs) for survey data outcome while the columns under Outage data present the MDEs and MDIs for the outage data from GridWatch. The outage data will only be collected in Greater Accra so the number of PowerWatch devices in those rows is set to 0 and their MDEs and MDIs to NA for not applicable.

Overall, with a planned sample size of 2,394 enterprises in Greater Accra, we are estimating a minimum detectable effect (MDE) of 0.12 standard deviations for enterprises. The minimal detectable differences (MDD) are about half as large as the MDE for binary outcomes such as, whether the entity has a legal connection. This outcome had a mean of around 0.5 in the baseline data for the Access project. This means that we should be able to detect changes in the fraction of enterprises with a legal connection as small as 0.06 between the baseline and follow-up surveys.[20] Given MCC's greater interest in enterprises compared to households we are aiming for a much larger MDE for households, at around 0.21. We are expecting to have slightly larger MDEs, of about 0.24 standard deviations, when considering samples of enterprises from smaller geographic areas—in particular when looking only at one of the geographic areas targeted for each of the interventions listed earlier. We will be able to address the possibility of spillover within Greater Accra somewhat more precisely as we expect an MDE of 0.15 for enterprises there. We will have just a bit less precision when looking at enterprises in the 7 largest cities in

[20] For these MDE/MDD calculations we have ignored the possibility that we will collect at least some enterprise data from households. Adding in those enterprises should improve our statistical power to some degree.

Table X.2. Statistical power for pre-post analyses for survey data

Respondents/Target area	Enumeration areas (EAs)	Total Surveys	Survey Data: Minimum detectable effect size	Survey Data: Minimum detectable difference	Total PowerWatch Devices	Outage Data: Minimum detectable effect size	Outage Data: Minimum detectable difference
Enterprises							
1. Access Project areas in Greater Accra	40	360	0.24	0.12	120	0.56	0.28
2. Line bifurcation in Greater Accra	40	360	0.24	0.12	120	0.56	0.28
3. Substations in Greater Accra	40	360	0.24	0.12	120	0.56	0.28
4. Bulk-supply points in Greater Accra	40	360	0.24	0.12	120	0.56	0.28
5. Rest of Greater Accra	106	954	0.15	0.07	318	0.34	0.17
6. Total for Greater Accra (1+2+3+4+5)	266	2,394	0.12	0.06	798	0.28	0.14
7. Other cities in ECG catchment area	80	720	0.17	0.08	0	NA	NA
8. Grand total for ECG (6+7)	346	3,114	-	-	798		
9. Access Project areas in the North	3	99			0		
10. Grand total for Enterprises	349	3,213			798		
Households							
1. Greater Accra	50	450	0.21	0.11	150	0.50	0.25
2. Other cities in ECG catchment area	36	324	0.25	0.13	0	NA	NA
3. Grand total for ECG catchment area	86	774			150		
Totals for enterprises and households	435	3,987			948		

Notes: Other cities refers to the 7 largest cities in the ECG catchment area that are not in Greater Accra. To calculate the minimum detectable impacts and effect sizes, we assume 80 percent statistical power; a 5 percent level of significance; a response rate of 80 percent for the survey data; an R-squared of 0.30; an intraclass correlation of 0.15; and that the samples in the targeted areas for the four interventions cover about 20 percent of the target population in Greater Accra. The minimum detectable difference is the change we can detect in the fraction for a binary outcome with a mean of 0.5. For outages this could be the mean for the fraction of households that have an outage that shows up at the nearest transformer over a certain period of time. The minimum detectable effect size is in standard deviation units. ECG catchment area refers to the entire ECG catchment area (all nine operational regions). The sample sizes refers to either households or enterprises. There are 9 surveys per EA except for the Access project in the north. MDIs for the outage data are based on the PowerWatch data and there is one transformer per EA. GridWatch uses three PowerWatch devices per transformer. NA means not applicable.

the ECG catchment area outside of Greater Accra, where we expect an MDE of around 0.17. This will enable us to say something about the degree to which PDS has impacts in areas where the MCC infrastructure is less likely to have made a difference.

As noted above, we plan to coordinate with GridWatch so that we can obtain outage and voltage fluctuation data based on the PowerWatch devices for our survey samples in the Greater Accra area. We expect that this will require approximately 798 PowerWatch devices for the enterprise surveys and another 150 for the household surveys for a total of 948 PowerWatch devices. This is based on an assumption that we will have one transformer per EA and three PowerWatch devices per transformer. In doing these calculations we have assumed no overlap between the transformers used for the household and enterprise surveys. In reality, we expect that there will be some overlap which may enable us to add additional EAs and thereby further reduce our MDIs; however, if the number of devices available are near the estimated required number of 948, we recommend deploying them all appropriately between households and enterprises to help improve our ability to capture outages and voltage fluctuations.

H. Gender and social inclusion (GSI)

We will examine GSI elements in the EFOT, Access, and EEDSM projects. This will include using both qualitative and quantitative methods to better understand differences by gender, age, and income in energy related time use and roles. We also expect that women will make up a large share of respondents to the HES used to evaluate these projects. For the Access project in particular, we expect women to make up most of our sample, since seven of the ten markets are predominantly composed of women-focused enterprises. We will also examine differences in productivity and profitability of businesses by gender. For EFOT, we will examine outcomes of the PDS gender policy, whether gender audits occurred at PDS and the restructured ECG, whether they yielded an increase in the number of women employed in the energy sector, whether it helped to ensure equal opportunities for women and men, and whether it improved the workplace environment for women. For EEDSM, we will examine whether energy efficiency audit teams met their targets for female participation and included energy efficiency labels to make products accessible to illiterate populations. For the EFOT and EEDSM projects we will look at the internship and mentoring programs.

I. Risks to the evaluation design and mitigation measures

We expect to be able to conduct thorough performance evaluations of the Ghana II Compact and each of its projects. However, we anticipate a number of challenges related to timing, identifying a comparison group for the full compact, obtaining GridWatch data, and capturing compact impacts if outages are already minimal at baseline. Although we identify these as potential challenges for our performance evaluation, we also outline strategies for dealing with them and do not expect any to pose an insurmountable barrier for the evaluation.

1. Timing

Three timing issues related to determining a baseline date for the compact and collecting baseline quantitative and qualitative data may prove challenging for the evaluation.

Baseline date for compact. It is not clear what date we should use to capture baseline conditions for the compact. The compact was signed in August 2014, but the official start date

(for "entry into force") was not until September 2016. At that time, Ghana was experiencing major outages that have since subsided a great deal in spite of the fact that major components of the compact—including choosing a PSO for ECG—were not in place until after 2018. One likely reason for the decrease in outages is improvements in power generation due to projects outside of the compact. As such, it does not seem sensible to attribute changes in outages between September 2016 and September 2018 to the compact. For this reason, we will work with MCC and MiDA to determine a more appropriate baseline date.

Baseline quantitative data. Even after selecting a date for the baseline, we may not be able to acquire baseline data on many key outcomes. For example, we understand that there is an interest in having customer-level data on outages, and that GridWatch is working on developing a system to obtain such data. Even though these data will be valuable once they are available, they will not enable us to capture a baseline of, say, July 2018. For this reason, we expect to need to rely on currently available data—perhaps from secondary data, such as the GLSS, or at an aggregate level, from the utility—to capture baseline information on outages. We may be able to use GridWatch data later to predict what customer-level outages may have been at baseline. However, to do that, we would need to assume that the relationship between aggregate and customer-level outages remained stable over time. This might not be the case, depending on the types of improvements that are made in the system. To address these concerns, we may simply analyze each data source separately and clarify the strengths and weaknesses of each. Aggregate and secondary survey data on outages will likely be the only sources of data that clearly cover a baseline period. Customer-level data from GridWatch may be the ideal, once it is available, both because it would cover what happens between the aggregate and customer levels and because it may be available with high frequency. If we are able to obtain HES data on outages, those may also be useful, because they may capture outages at the customer level earlier than GridWatch will, though not with as much frequency.

Baseline qualitative data. We expect the baseline data collection will begin in mid-2019. Many interventions may be well underway by that time, so we will not be obtaining baseline information for those interventions. However, we will be able to ask retrospective questions about baseline conditions and, of course, supplement our qualitative data with quantitative data on baseline conditions and ask key stakeholders about their perceptions regarding why key outcomes have or have not changed since baseline.

2. Lack of a comparison group

We will not have a comparison group for the full compact. However, we will be able to conduct a pre-post analysis and also compare progress in Ghana to progress in other countries that are similar to Ghana. We will use data on outcomes such as technical and commercial losses and seek to compare measures of financial and labor efficiency. We will also compare the steps Ghana takes to reform its power sector with those recognized as best practices for power sector reform and turning around utilities.

3. Data quality and availability

Quality of administrative data. The evaluation relies on key indicators such as electricity reliability and quality. It is possible that administrative data may not be complete or of sufficient quality and level of detail to address the evaluation questions. We will mitigate this risk by

comparing administrative data to other sources, such as the GridWatch data and the household and enterprise data on outages and voltage fluctuation. For other indicators, such as operational efficiency and financial health, we will supplement administrative data with interviews from key stakeholders and other implementation documents.

Administrative data availability post-compact. After the end of the compact, the evaluation team may face issues with data access and data availability from the utilities. The evaluation team will work closely with MCC to develop a rapport with the post-compact entity. A good working relationship should help the evaluation team make data requests that are practical and can be efficiently carried out. This will be facilitated by post-compact M&E Plan and reporting to be developed by MCC and MiDA in consultation with key stakeholders, some of whom are targeted for administrative data.

Hesitancy of respondents to talk about sensitive aspects of the reform process. Some respondents may be hesitant to talk about tension in the reform process and their personal or institutional interests. We will mitigate this risk by ensuring the confidentiality of the key informant interviews and making sure respondents are aware of data safeguards. Senior members of the Mathematica research team will also conduct these interviews; we will try to use the same interviewer for each of the data collection rounds. We note that requests to maintain anonymity may weaken some analysis that can be presented but are typical of KIIs.

4. GridWatch data

GridWatch is developing a system to monitor outages in Ghana at the customer level and to estimate impacts of outages on economic outcomes. It is possible that they will not succeed in one or both of these areas. If their method of capturing outages does not work, we will still be able to use data from our household and enterprise surveys to at least capture how outages change between 2019 and 2023. In addition, we may have data on outages at the aggregate level from the utility for a much longer period of time, and hopefully data at the substation level and below from the AMR system at some point. If GridWatch is unable to estimate impacts of outages on economic outcomes in Achimota we may still be able to estimate impacts of outages on economic outcomes using IV analyses, though we would then lack the GridWatch benchmark to test our IV model against. In addition, we will still be able to capture the degree to which the financial health of the utilities changed during the compact period.

5. Few outages

It is possible that outages will already be at a relatively low level with little room for improvement by the time we are able to capture our "baseline" measures. If so, one conclusion will be that the compact was not in a position to reduce outages, given how low they already were. In that situation, we might explore alternative ways in which the compact might have improved the quality of electricity—for example, by reducing voltage fluctuations. GridWatch is expected to provide us with information on voltage fluctuations using their PowerWatch devices. We will also try to capture voltage fluctuations in our household and enterprise surveys and could explore options for estimating impacts of voltage fluctuations on economic outcomes which may be possible if the interventions impact voltage fluctuations but not outages.

This page has been left blank for double-sided copying.

XI. EVALUATION MANAGEMENT

Given the complexity of this multicomponent project and evaluation, careful management of the evaluation and timeline is essential. In this section, we discuss several administrative issues relevant to the conduct of the evaluation and present a timeline for evaluation activities.

A. Summary of IRB requirements and clearances

Mathematica is committed to protecting the rights and welfare of human subjects by obtaining approval from an institutional review board (IRB) for relevant research and data collection activities. IRB approval requires three sets of documents: (1) a research protocol, in which we describe the purpose and design of the research and provide information about our plans for protecting study participants, their confidentiality, and their human rights, including how we will acquire consent for their participation; (2) copies of all data collection instruments and consent forms that we plan to use for the evaluation; and (3) a completed IRB questionnaire that provides information about the research protocol, how we will securely collect and store our data, our plans for protecting participants' rights, and any possible threats to participants resulting from any compromise of data confidentiality. We anticipate the IRB review of this study to qualify for expedited review because it presents minimal risk to participants. IRB approval is valid for one year; we will submit annual renewals for approvals for subsequent years as needed.

We will also ensure that the study meets all U.S. and local research standards for ethical clearance, including submitting our study for approval by Ghana's ethical review committee. We will coordinate with our consultant and data collection partner to submit the full list of required materials, including a description of the methodology, instruments and enumerator manuals, community awareness plan, timeline, budget, and dissemination plan, to the required local agency. Mathematica may request support from MiDA to facilitate the process. If either the U.S. IRB or local authorities recommend changes to protocols or instruments, Mathematica will work together with the survey firm and MCC to accommodate the changes and all parties will agree on the final protocol before data collection begins.

B. Data access, privacy, and file preparation

All data collected for this evaluation will be 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, 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 and we will remove or adjust variables that introduce reasonable risks of deductive disclosure of the identity of individual participants. We will also recode unique and rare data by using top and bottom coding or 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 findings targeted to the energy sector, particularly for policymakers and practitioners. We will present findings from each round of data collection in baseline, interim, and final evaluation reports. We will distribute draft reports to stakeholders for feedback before finalization and will present findings at MCC headquarters in Washington, DC, and MiDA headquarters.

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

D. Evaluation team: Roles and responsibilities

Our team will contribute extensive experience and expertise to meet MCC's evaluation needs. Program manager **Dr. Arif Mamun** will be responsible for managing the team of experts and delivering high quality products to MCC. **Dr. Duncan Chaplin** will serve as the evaluation principal investigator and will lead the design of the quantitative components of the evaluation. **Ms. Delia Welsh** will lead the design and implementation of the performance evaluations and oversee all data collection activities. **Dr. Emmanuel Frimpong** will serve as an expert on grid-based measures as well as on tools for improving energy efficiency and demand-side management in Ghana. **Mr. William Derbyshire** will serve as the power sector expert for evaluations of the regulatory reform and utility turnaround projects. **Dr. Nick Ingwersen** and **Ms. Ale Aponte** will work with Dr. Chaplin on conducting the impact evaluation, simulations, and descriptive analysis for the performance evaluation, as well as household and enterprise survey planning and implementation. **Ms. Poonam Ravindranath** will support the collection of high quality qualitative data and political economy analysis. **Ms. Mavis Amponsah** will serve as the in-country research coordinator to help with the evaluation team's needs to coordinate with MiDA and the implementers. **Dr. Sarah Hughes** will provide quality assurance on all deliverables.

E. Evaluation timeline and reporting schedule

The evaluation activities will be ongoing through September 2027. Administrative data and documentation will be collected on a regular basis. Interviews with businesses, focus group discussions with households, and site visits will be concentrated around the baseline, interim, and endline quantitative data collection efforts. We expect that baseline data collection will occur in 2019, interim data collection starting in 2021 just after compact closeout, and endline data collection in 2023/2024. Table XI.1 provides an overview of the evaluation data collection and reporting schedule.

We will conduct the baseline political economy analysis ahead of the other baseline analysis, and present the preliminary findings to MCC by December 2019. We will then write a baseline report that covers the first round of survey and qualitative data in 2020. At the end of 2022/beginning of 2023, we will produce an interim report that covers the 2021 qualitative data.

We will produce the final evaluation report in 2024 and cover all rounds of data collection. We will conduct dissemination of results through 2025.

We note that the timeline could change as compact implementation evolves. A more detailed work plan for the evaluation can be found in Appendix A and an exposure table can be found in Appendix B.

Table XI.1. Evaluation reporting schedule

Reporting Schedule	Data collection	Data cleaning and analysis	First draft report expected	Final report expected
Baseline Political Economy Analysis	August 2019	September-November 2019	November 2019	December 2019
Baseline Report	August 2019 - January 2020	February - May 2020	May 2020	June 2020
Interim Report	October 2021–January 2022	March–June 2022	July 2022	September 2022
Final Report	October 2023–March 2024	April–September 2024	December 2024	April 2025

F. Evaluation budget

Based on our current estimates, Mathematica expects to be able to implement the evaluation design described in this report within the current budget. We do not anticipate a need for additional labor or other direct costs (ODCs) to complete this evaluation. However, because the specifications around the performance and impact evaluations have changed by a large extent following the awarding of the evaluation contract, we have developed a revised cost estimate for each task under this evaluation contract. We present the revised cost estimates in Appendix C, along with a brief discussion of the underlying changes in assumptions or conditions that explain the major changes in the estimated costs.

This page has been left blank for double-sided copying.

REFERENCES

Adenikinju, Adeola F. "Electric Infrastructure Failures in Nigeria: A Survey-Based Analysis of the Costs and Adjustment Responses." *Energy Policy*, vol. 31, 2003, pp. 1519–1530.

African Development Bank. "Electricity Regulatory Index for Africa 2018." Abidjan, Côte d'Ivoire: African Development Bank Group, 2018. Available at https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Electricity_Regulatory_Index_2018.pdf. Accessed October 29, 2018.

Akpan, Uduak S., Maurice A. Essien, and Salisu R. Isihak. "Impact of Rural Electrification on Rural Micro-Enterprises in Niger Delta, Nigeria." *Energy for Sustainable Development*, vol. 17, 2013, pp. 504–509.

Allotey, Godwin A., and Pius Eduku Amihere. "Utility Service Providers Demand 200% Increase in Tariffs." February 12, 2018. Available at https://citifmonline.com/2018/02/12/utility-service-providers-demand-200-increase-in-tariffs/. Accessed October 29, 2018.

Andersen, Thomas Barnebeck, and Carl-Johan Dalgaard. "Power Outages and Economic Growth in Africa." *Energy Economics*, vol. 38, 2013, pp. 19–23.

Arnold, Jens Matthias, Aaditya Matoo, and Gaia Narciso. "Services Inputs and Firm Productivity in Sub-Saharan Africa: Evidence from Firm-Level Data." *Journal of African Economies,* vol. 17, no. 4, February 2, 2008, pp. 578–599.

Asuamah, S.Y., A.-T. Felix, and B. Darkwa. "What is the Perception of Students Towards Environmental Sustainability?" *Journal of Natural Sciences Research*, vol. 2, no. 10, 2012, pp. 114–122.

Bacon, Robert William. "Privatization and Reform in the Global Electricity Supply Industry." *Annual Review of Energy and the Environment*, vol. 20, no. 1, 1995, pp. 119–143.

Barron, Manuel, and Maximo Torero. "Household Electrification and Indoor Air Pollution." Working Paper, January 2016. Available at https://www.ocf.berkeley.edu/~manuelb/research.html. Accessed October 29, 2018.

BBC. "Ghana Bans Second-Hand Fridges." December 31, 2012. Available at https://www.bbc.com/news/world-africa-20877804. Accessed October 29, 2018.

Bensch, Gunther, Jorg Peters, and Maximiliane Sievert. "Fear of the Dark? How Access to Electric Lighting Affects Security Attitudes and Nighttime Activities in Rural Senegal." *Journal of Rural and Community Development*, vol. 8, no. 1, 2013, pp. 1–19.

Bernard, Tanguy, and Maximo Torero. "Welfare Impact of Rural Electrification: 'Short-Term' Evidence from Ethiopia: A Report for the Ethiopian Electric Power Corporation and the World Bank." Washington, DC: International Food Policy Research Institute, December 2009.

Bos, Kristine, Duncan Chaplin, and Arif Mamun. "Benefits and Challenges of Expanding Grid Electricity in Africa: A Review of Rigorous Evidence on Household Impacts in Developing Countries." *Energy for Sustainable Development,* no. 44, 2018, p. 64–77.

Brown, Ashley C., Jon Stern, Bernard Tenenbaum, and Defne Gencer. "Handbook for Evaluating Infrastructure Regulatory Systems." Washington, DC: The World Bank, 2006.

Ch2m. "Detailed Design of the Access Project Phase III: Project Design Report." Report prepared for the U.S. Army Corps of Engineers in association with the Millennium Challenge Corporation. Englewood, CO: ch2m, December 2017.

Chakravorty, Ujjayant, Martino Pelli, and Beyza Ural Marchand. "Does the Quality of Electricity Matter? Evidence from Rural India." *Journal of Economic Behavior and Organization*, vol. 107, part A, November 2014, pp. 228–247.

Chaplin, Duncan, Arif Mamun, Ali Protik, John Schurrer, Divya Vohra, Kristine Bos, Hannah Burak, Laura Meyer, Anca Dumitrescu, Christopher Ksoll, and Thomas Cook. "Grid Electricity Expansion in Tanzania by MCC: Findings from a Rigorous Impact Evaluation." Report submitted to the Millennium Challenge Corporation. Washington, DC: Mathematica Policy Research, February 24, 2017.

Clerici, Caterina, Marisa Schwartz Taylor, and Kevin Taylor. "Dumsor: The Electricity Outages Leaving Ghana in the Dark." Al Jazeera*,* 2016. Available at https://interactive.aljazeera.com/aje/2016/ghana-electricity-outage-dumsor/index.html. Accessed October 29, 2018.

Cooke, Edgar, Sarah Hague, Andy McKay. *The Ghana Poverty and Inequality Report: Using the 6th Ghana Living Standards Survey,* 2016. Available at: https://www.unicef.org/ghana/Ghana_Poverty_and_Inequality_Analysis_FINAL_Match_2016(1).pdf. Accessed October 29, 2018.

Delfino, Jose A., and Ariel A. Casarin. "The Reform of the Utilities Sector in Argentina." United Nations University World Institute for Development Economics Research, Discussion Paper No. 2001/74, 2001.

Department for International Development. "How to Note: Political Economy Analysis." London: Department for International Development (DFID), July, 2009.

Depuru, S., L. Wang, and V. Devabhaktuni. "Electricity Theft: Overview, Issues, Prevention and a Smart Meter-Based Approach to Control Theft." *Energy Policy*, vol. 39, 2011, pp. 1007–1015.

Dinkelman, Taryn. "The Effects of Rural Electrification on Employment: New Evidence from South Africa." *American Economic Review*, vol. 101, no. 7, December 2011, pp. 3078–3108.

Dubash, Navroz K. (ed.). *Power Politics: Equity and Environment in Electricity Reform*. Washington, DC: World Resources Institute, 2002.

Eberhard, Anton, and Catrina Godinho. "A Review and Exploration of the Status, Context and Political Economy of Power Sector Reforms in Sub-Saharan Africa, South Asia and Latin America." Working Paper, University of Capetown, Graduate School of Business, February 2017.

Eberhard, Anton, Katharine Gratwick, Elvira Morella, and Pedro Antmann. *Independent Power Projects in Sub-Saharan Africa: Lessons from Five Key Countries.* Washington, DC: World Bank Group, 2016.

Eberhard, Anton, Orvirka Rosnes, Maria Shkaratan, and Haakon Vennemo. *Africa's Power Infrastructure: Investment, Integration, Efficiency.* Washington, DC: World Bank Group, 2011.

Eberhard, Anton, and Maria Shkratan. "Powering Africa: Meeting the Financing and Reform Challenges." *Energy Policy*, vol. 42, 2012, pp. 9-18.

Electricity Company of Ghana. "About the Power Sector in Ghana," n.d (a). Available at http://www.ecgonline.info/index.php/about-the-power-sector-in-ghana.html. Accessed October 29, 2018.

Electricity Company of Ghana. "Our History," n.d (b). Available at http://www.ecgonline.info/index.php/our-history.html. Accessed October 29, 2018.

Enclave Power Company. "About EPC." Tema, Ghana: EPC, n.d. Available at http://epcghana.com/about-epc/. Accessed October 29, 2018.

Energy Commission. "2018 Electricity Supply Plan for the Ghana Power System." Accra, Ghana: Energy Commission, 2018.

Energy Commission. "National Energy Statistics 2007–2016 (Revised)." Accra, Ghana: Energy Commission, April 2017a.

Energy Commission. "2017 Energy (Supply and Demand) Outlook for Ghana." Accra, Ghana: Energy Commission, April 2017b.

Energy Commission. "The Success Story of the Ghana Refrigerator Efficiency Project Implemented by the Energy Commission." Accra, Ghana: Energy Commission, December 2016. Available at http://www.energycom.gov.gh/efficiency/the-success-story-of-the-eerp. Accessed October 29, 2018.

Energy Commission. "Ghana Appliance Energy Efficiency Standards and Labelling Programme." Accra, Ghana: Energy Commission, n.d. Available at http://www.energycom.gov.gh/efficiency/standards-and-labelling.Accessed October 29, 2018.

Energy Sector Management Assistance Program (ESMAP). "Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits." Washington, DC: World Bank Group, May 2002.

Erdogdu, Erkan. "The Political Economy of Electricity Market Liberalization: A Cross-Country Approach." *The Energy Journal*, 2014, pp. 91–128.

Escribano, Alvaro, J. Luis Guasch, and Jorge Pena. "Assessing the Impact of Infrastructure Quality on Firm Productivity in Africa." World Bank Policy Research Working Paper No. 5191. Washington, DC: The World Bank, January 2010.

Eshun, Maame Esi, and Joe Amoako-Tuffour. "A Review of the Trends in Ghana's Power Sector." *Energy, Sustainability and Society*, vol. 5, 2016, pp. 1–9.

Fichtner Management Consulting. "Tariff Study and Tariff Plan for and on Behalf of the Public Utilities Regulatory Commission – Ghana: Inception Report." Submitted to the Millennium Challenge Corporation and the Millennium Development Authority, March 3, 2017.

Foster, Vivien, and Jevgenijs Steinbuks. "Paying the Price for Unreliable Power Supplies: In-House Generation of Electricity by Firms in Africa." World Bank Policy Research Working Paper No. 4913. Washington, DC: The World Bank, April 2009.

Foster, Vivien, Samantha Witte, Sudeshna Ghosh Banerjee, and Alejandro Moreno. "Charting the Diffusion of Power Sector Reforms Across the Developing World." World Bank Policy Research Working Paper No. 8235. Washington, DC: The World Bank, November 2017.

Ghana News Agency. "GRIDCo to export electricity to Burkina Faso." February 9, 2018. Available at http://www.ghananewsagency.org/economics/gridco-to-export-electricity-to-burkina-faso--128481-amp.html.Accessed October 29, 2018.

GhanaWeb. "Three Companies Owed GRIDCo GH¢722 million in 2016 – Board Chairman." December 9, 2017. Available at https://www.ghanaweb.com/GhanaHomePage/business/Three-companies-owed-GRIDCo-GH-722-million-in-2016-Board-Chairman-608153.Accessed October 29, 2018.

Golumbeanu, R., and D. Barnes. "Connection Charges and Electricity Access in Sub-Saharan Africa." Policy Research Working Paper 6511. Washington, DC: World Bank, June 2013.

Gore, Christopher D., Jennifer N. Brass, Elizabeth Baldwin, and Lauren M. MacLean. "Political Autonomy and Resistance in Electricity Sector Liberalization in Africa." *World Development*, April 2018. doi: 10.1016/j.worlddev.2018.03.003.

GRIDCo. "Overview." Accra, Ghana: GRIDCo, n.d. Available at http://www.gridcogh.com/en/about-us/overview.php. Accessed October 29, 2018.

Grimm, Michael, Renate Hartwig, and Jann Lay. "Electricity Access and the Performance of Micro and Small Enterprises: Evidence from West Africa." *The European Journal of Development Research*, vol. 25, no. 5, December 2013, pp. 815–829.

Grogan, Louise, and Asha Sadanand. "Rural Electrification and Employment in Poor Countries: Evidence from Nicaragua." *World Development*, vol. 43, 2013, pp. 252–265.

Gulen, Gurcan, Ruzanna Makaryan, Dmitry Volkov, and Michelle Foss. "Improving Regulatory Agency Efficiency and Effectiveness: Best Practices, Processes and Organizational Structures." Working Paper. Austin, Texas: University of Texas at Austin, Center for Energy Economics, n.d.

Haider, H. and S. Rao. "Political and Social Analysis for Development Policy and Practice. An Overview of Five Approaches." Birmingham: Governance and Social Development Resource Centre (GSDRC), 2010.

Hardy, Morgan, and Jamie McCasland. "Lights Off, Lights On: The Effects of Electricity Shortages on Small Firms." Working Paper, January 10, 2017. Available at https://sites.google.com/a/nyu.edu/morganhardy/research. Accessed October 29, 2018.

International Finance Corporation. "Estimating Employment Effects of Powerlinks Transmission Limited Project in India & Bhutan." Washington, DC: International Finance Corporation, Development Impact Department, September 2012.

International Finance Corporation. "Due Diligence and Private Sector Participation Options Study in Ghana's Distribution Sector." Submitted to the Millennium Challenge Corporation. Washington, DC: International Finance Corporation, June 2014.

Jamasb, T., R. Nepal, and G.R. Timilsina. "A Quarter Century Effort Yet to Come of Age: A Survey of Power Sector Reform in Developing Countries, Environment and Energy Team." World Bank Policy Research Working Paper No. 7330. Washington, DC: World Bank, June 2015.

Khandker, Shahidur R., Douglas F. Barnes, and Hussain A. Samad. "The Welfare Impacts of Rural Electrification in Bangladesh." *The Energy Journal,* vol. 33, no. 1, 2012a, pp. 187–206.

Khandker, Shahidur R., Douglas F. Barnes, and Hussain Samad. "Welfare Impacts of Rural Electrification: A Panel Data Analysis from Vietnam." *Economic Development and Cultural Change*, vol. 61, no. 3, April 2013, pp. 659–692.

Khandker, Shahidur R., Hussain A. Samad, Rubaba Ali, and Douglas F. Barnes. "Who Benefits Most from Rural Electrification? Evidence in India." World Bank Policy Research Working Paper 6095. Washington, DC: The World Bank, 2012b.

Khobai, Hlalefang, Sanderson Abel, and Pierre Le Roux. "An Investigation into the Electricity Supply and Economic Growth Nexis for South Africa." *International Journal of Energy Economics and Policy,* vol. 6, no. 4, 2016, pp. 701–705.

Kojima, Msami, and Chris Trimble. "Electricity Tariffs for Nonresidential Customers in Sub-Saharan Africa." Washington, DC: World Bank Group, 2016.

Kojima, Msami, and Chris Trimble. "Making Power Affordable for Africa and Viable for its Utilities." Washington, DC: World Bank Group, 2016.

Komives, Kristin, Vivien Foster, Jonathan Halpern, and Quentin Wodon. "Water, Electricity and the Poor: Who Benefits from Utility Subsidies?" Washington, DC: The World Bank, 2005.

Kumi, Ebenezer Nyarko. "The Electricity Situation in Ghana: Challenges and Opportunities." CGD Policy Paper. Washington, DC: Center for Global Development, 2017. Available at https://www.cgdev.org/sites/default/files/electricity-situation-ghana-challenges-and-opportunities.pdf. Accessed October 29, 2018.

Laffont, Jean-Jacques. *Regulation and Development*. Cambridge University Press, 2005.

Lawrence Berkeley National Laboratory (Berkeley Lab). "Energy Efficiency and Demand Side Management Project." Presentation at MiDA and MCC Implementation Workshop, June 24, 2015.

Lee, Alan David, and Zainab Usman. "Taking Stock of the Political Economy of Power Sector Reforms in Developing Countries: A Literature Review." World Bank Policy Research Working Paper No. 8518. Washington, DC: World Bank, July 2018.

Lenz, Luciane, Anicet Munyehirwe, Jorg Peters, and Maximiliane Sievert. "Does Large-Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda's Electricity Access Roll-Out Program." *World Development,* vol. 89, 2017, pp. 88–110. Liberia Executive Mansion.

Mensah, Justice Tei. "Bring Back Our Light: Power Outages and Industrial Performance in Sub-Saharan Africa." Swedish University of Agricultural Sciences, Paper No. 2016.20. Uppsala, Sweden: Swedish University of Agricultural Sciences, April 2016.

Millennium Challenge Corporation. "Investment Memorandum on Ghana's Proposed Second Compact." Washington, DC: Millennium Challenge Corporation, April 24, 2014a.

Millennium Challenge Corporation. "Millennium Challenge Compact between the United States of America Acting Through the Millennium Challenge Corporation and the Republic of Ghana." Washington, DC: Millennium Challenge Corporation, August 5, 2014b.

Millennium Challenge Corporation. "Ghana Compact II: Estimation of Benefits of Avoiding Disruptions." Washington, DC: Millennium Challenge Corporation. 2014c.

Minister for Finance. "The Budget Statement and Economic Policy of the Government of Ghana for the 2018 Financial Year." Accra, Ghana: Ministry of Finance, November 2017.

Ministry of Energy. "Overview of the Ghana Power Sector." Accra, Ghana: Ministry of Energy, 2018. Available at http://www.energymin.gov.gh/sector-overview. Accessed October 29, 2018.

Mutua, J., and P. Kimuyu. "Household Energy Conservation in Kenya: Estimating the Drivers and Possible Savings." *Environment for Development – Discussion Paper Series*, March 2015.

NEDCo. "NEDCo." Tamale, Ghana, n.d. Available at https://www.vra.com/subsidiaries/northern_electricity_distribution.php. Accessed October 29 2018.

Newell, Richard G., and Juha Siikamaki. "Nudging Energy Efficiency Behavior. The Role of Information Labels." Discussion Paper 13-17. Washington, DC: Resources for the Future, July 2013.

"Our History." *Electricity Company of Ghana Limited*, www.ecgonline.info/index.php/our-history.html. Accessed October 29, 2018.

Peters, J., M. Sievert, and C. Vance. "Firm Performance and Electricity Usage in Small Manufacturing and Service Firms in Ghana*."* In *Productive Use of Energy (PRODUSE): Measuring Impacts of Electrification on Micro-Enterprises in Sub-Saharan Africa*, edited by L. Mayer-Tasch, M. Mukherjee, and K. Reiche. Eschborn. Germany: Deutsche Gesellschaft für Internationale Zusammenarbeit, 2013.

Peters, J., C. Vance, and M. Harsdorff. "Grid Extension in Rural Benin: Micro-Manufacturers and the Electrification Trap." *World Development,* vol. 39, no. 5, pp. 773–783, 2011.

"President Sirleaf Announces Ten Percent (10%) Reduction in Electricity Tariff; Liberia, Germany Sign KfW €15m Grant For 15,000 Connections in Power Supply." Monrovia, Liberia: Executive Mansion, September 5, 2017. Available at http://www.emansion.gov.lr/2press.php?news_id=4160&related=7&pg=sp. Accessed October 29, 2018.

REEEP. "Performance Standards and labelling for LED lighting in Ghana," n.d. Available at https://www.reeep.org/projects/performance-standards-and-labelling-led-lighting-ghana. Accessed October 29, 2018.

Resource Center for Energy Economics and Regulation. "Guide to Electric Power in Ghana." Accra, Ghana: University of Ghana, Institute of Statistical, Social and Economic Research, 2005.

Reuters. "Ghana Sells Less Than Targeted of 10-year Energy Bond." Accra, Ghana: November 6, 2017. Available at https://www.reuters.com/article/ghana-bond-energy/ghana-sells-less-than-targeted-of-10-year-energy-bond-idUSL5N1NC679. Accessed October 29, 2018.

Sakah M, S. de la Rue du Can, F.A. Diawuo, M.D. Sedzro and C. Kuhn. "A Study of Appliance Ownership and Electricity Consumption Determinants in Urban Ghanaian Households." *Sustainable Cities and Society*, 2018. doi: 10.1016/j.scs.2018.10.019.

Samad, Hussain, and Fan Zhang. "Electrification and Household Welfare: Evidence from Pakistan." World Bank Policy Research Working Paper 8582. Washington, DC: World Bank, September 2018.

Samad, Hussain, and Fan Zhang. "Benefits of Electrification and the Role of Reliability." World Bank Policy Research Working Paper 7889. Washington, DC: World Bank, November 2016.

Scott, Andrew, and Prachi Seth. "The Political Economy of Electricity Distribution in Developing Countries." *Journal of Policy and Governance*, vol. 98, 2013.

Smith, Thomas B. "Electricity Theft: A Comparative Analysis." *Energy Policy*, vol. 32, no. 18, pp. 2067–2076, December 2004.

Steiner, Achim. "High-Efficiency Appliances for a Low-Carbon Future." Winnipeg, Manitoba, Canada: International Institute for Sustainable Development, September 23, 2014. Available at http://sdg.iisd.org/commentary/guest-articles/high-efficiency-appliances-for-a-low-carbon-future/ Accessed October 29, 2018.

Stern, Jon, and John Cubbin. "Regulatory Effectiveness: The Impact of Regulation and Regulatory Governance Arrangements on Electricity Industry Outcomes." World Bank Policy Research Working Paper 3536. Washington, DC: World Bank, March 2005.

United for Efficiency (U4E). "Accelerating the Global Adoption of Energy-Efficient Lighting." 2017a. Available at https://united4efficiency.org/wp-content/uploads/2017/11/Lighting-Policy-Brief.pdf. Accessed October 29, 2018.

United for Efficiency (U4E). "Simple Ways to Achieve Energy Efficiency." 2017b. Available at https://united4efficiency.org/wp-content/uploads/2017/11/U4E-EnergyEfficientBrochure-201708-FINAL-HIRES-singlepgs.pdf. Accessed October 29, 2018.

United for Efficiency (U4E). "Savings Potential." 2018. Available at https://united4efficiency.org/. Accessed October 29, 2018.

USAID. "Power Africa Ghana: Country Factsheet." Washington, DC: USAID, December 2017. Available at https://www.usaid.gov/powerafrica/ghana. Accessed October 29, 2018.

Van Buskirk, R.D., C.L.S. Kantner, B.F. Gerke, and S. Chu. "A Retrospective Investigation of Energy Efficiency Standards: Policies May Have Accelerated Long-Term Declines in Appliance Costs." *Environmental Research Letters*, vol. 9, 2014.

Victor, David G., and Thomas C. Heller. *The Political Economy of Power Sector Reform*. Cambridge University Press, 2009.

Volta River Authority (VRA). "Profile of VRA." Accra, Ghana: Volta River Authority, n.d. Available at http://www.vra.com/contact/index.php. Accessed October 29, 2018.

Wamukonya, Njeri, and Mark Davis. "Socio-Economic Impacts of Rural Electrification in Namibia: Comparisons Between Grid, Solar, and Unelectrified Households." *Energy for Sustainable Development*, vol. 5, no. 3, September 2001, pp. 5–13.

Wang Shiju, Zhiying Lu, Shaoyun Ge, and Chengshan Wang. "An Improved Substation Locating and Sizing Method Based on the Weighted Voronoi Diagram and the Transportation Model." *Journal of Applied Mathematics*, 2014. doi: 10.1155/2014/810607.

Washington, Elvis. "Tema: 96,000 Homes Cited for Illegal Electricity Connections in 2017." March 26, 2018. Available at http://citifmonline.com/2018/03/26/tema-96000-homes-cited-for-illegal-electricity-connections-in-2017/. Accessed October 29, 2018.

World Bank. "Project Performance Assessment Report: Lao People's Democratic Republic Southern Provinces Rural Electrification Project." Report No. 42413. Washington, DC: World Bank, February 4, 2008.

World Bank. "Energizing Economic Growth in Ghana: Making the Power and Petroleum Sectors Rise to the Challenge." Washington, DC: World Bank, 2013.

World Bank. "DataBank: World Development Indicators." Washington, DC: World Bank, 2018. Available at http://databank.worldbank.org/data/source/world-development-indicators. Accessed October 29, 2018.

Zhang, Fang, Anikta K. Wagner, Dennis Ross-Degan. "Simulation-based power calculation for designing interrupted time series analyses of health policy interventions." *Journal of Clinical Epidemiology*. vol. 64, June 2011, pp.1252-1261.

This page has been left blank for double-sided copying.

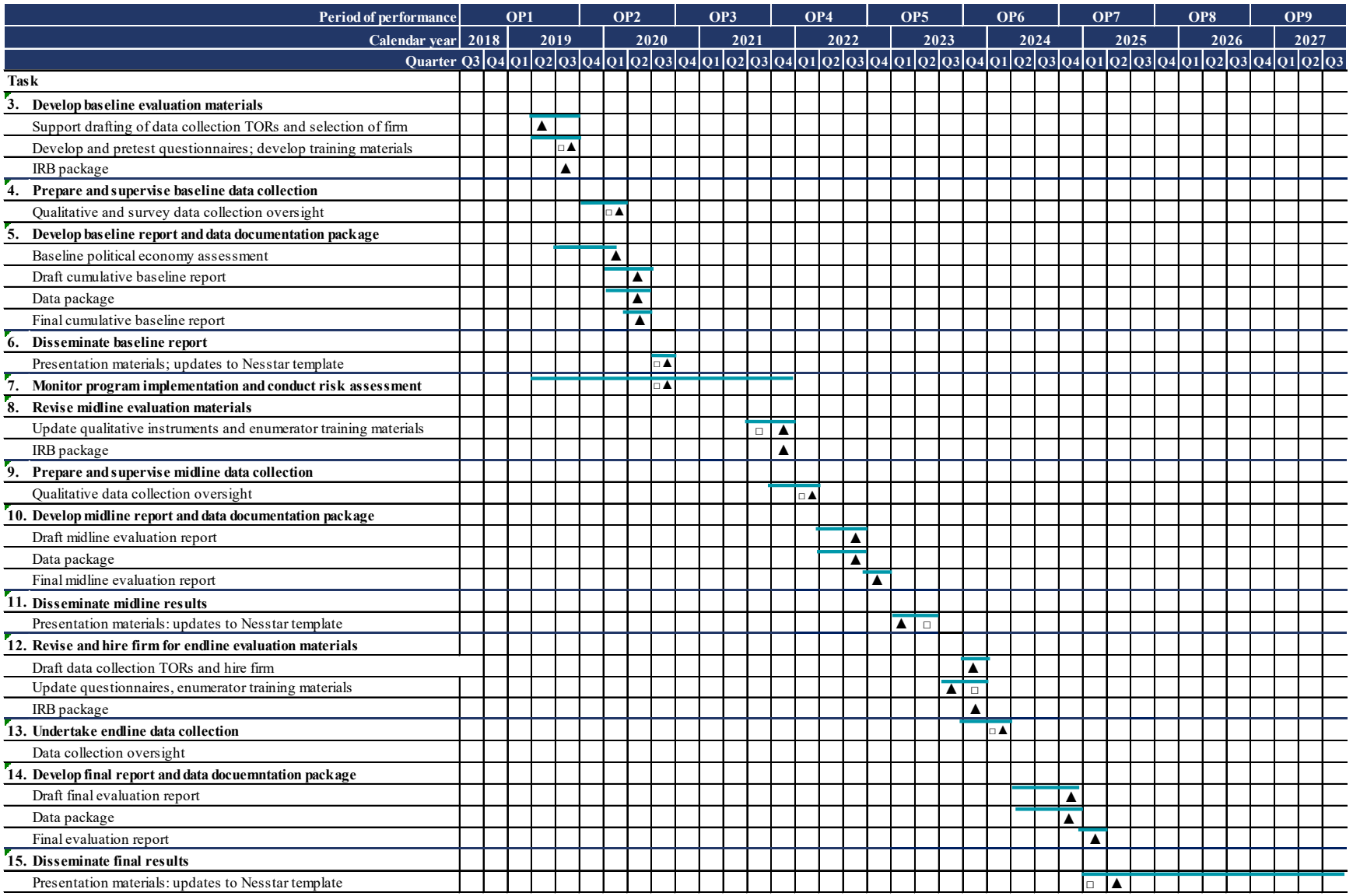
APPENDIX A:

EVALUATION WORK PLAN

This page has been left blank for double-sided copying.

Figure A.1 presents our evaluation activities, including instrument development and data collection, data analysis, report writing, and dissemination for the baseline, interim, and final reports. We will closely monitor risks to completing deliverables on time, including changes to the projects and their implementation schedules. If there are changes to our timeline, we will discuss them in advance with MCC.

Figure A.1. Evaluation work plan



APPENDIX B:

EXPOSURE TIMEFRAME TABLE

This page has been left blank for double-sided copying.

Table B.1. Exposure timeframe table

Data Collection and Timing	Relevant Project/ Activity	Sample Unit/ Respondent	Sample Size	Relevant Instruments/ Modules	2019 Exposure Period	2021 Exposure Period	2023/2024 Exposure Period
Household and Enterprise Survey (2019, 2023/2024)		**Households and enterprises**	**3,987 (3,213 enterprises, 774 households)**				
	EFOT PSP	Households and enterprises	3,987	Customer module	7 months	n/a	4.5 years
	EFOT Commercial Loss Reduction*	Households and enterprises	3,987	Customer module	Probably none	n/a	2-3.5 years
	EFOT Technical Loss Reduction	Households and enterprises	3,987	Customer module	Probably none	n/a	2-3.5 years
	EFOT Outage Reduction	Households and enterprises	3,987	Customer module	Probably none	n/a	2-3.5 years
	Reg. Tariff Review and Regulation	Households and enterprises	3,987	Customer module	Some work finished	n/a	4-4.5 years
	Access Connections and lighting	Enterprises only	459	Enterprise and customer modules	Probably little	n/a	2-3.5 years
	EEDSM Standards and Labels	Households and enterprises	3,987	Household and enterprise modules	Partial (some appliances done, many remain)	n/a	2-5.5 years

Data Collection and Timing	Relevant Project/Activity	Sample Unit/Respondent	Sample Size	Relevant Instruments/ Modules	2019 Exposure Period	2021 Exposure Period	2023Exposure Period
Key Informant Interviews (2019, 2021, 2024)		**Individuals**	**45**				
	EFOT	Individuals from MCC, MiDA, restructured ECG, SMEC, labor unions, regulators	Approx 25	Qualitative protocols	1-2 years	3.5-4.5 years	approx. 5 years
	Regulatory	Individuals from Min of Power, PURC, Energy Commission, EDG, and private sector businesses and investors	Approx 28	Qualitative protocols	1-2 years	3.5-4.5 years	approx. 5 years
	EEDSM	Energy auditors and pre-tertiary school staff	Approx 10	Qualitative protocols	1-2 years	3.5-4.5 years	approx. 5 years
Focus Groups (2019, 2021, 2024)		**Groups**	**Approx 20**				
	Access Connections and Lighting	MSME owners and investors	20	Focus group protocol	No exposure for most activities	0-3.5 years	2.5 to 6 years

Note: We are interpreting exposure period to mean the time from when an intervention is completed to when data are collected. Within each data collection round this will likely vary across geographic areas depending on where and when interventions have been completed. Survey questions surrounding Access connections and lighting apply to Access activities in Greater Accra and in the North.

APPENDIX C:

STAKEHOLDER COMMENTS AND RESPONSES

This page has been left blank for double-sided copying.

Table C.1. Stakeholder comments on earlier drafts of the Ghana power evaluation design report and Mathematica's responses

Page	Comment	Evaluator response
Comments from MCC staff		
3	The last sentence mentioned collecting data in the near future, but it's more likely that the enterprise survey (given the procurement timelines at MiDA) would happen at the end of 2019/early 2020. The qualitative work won't be impacted by MiDA timelines	Agreed. We have revised this text.
4	From our conversation on 4/11, we discussed that it won't be possible for GridWatch to expand their sample (beyond Achimota) and collect additional data for Mathematica. Mathematica should consider if/how it can use the GridWatch's Achimota data. MCC will internally discuss the cost-benefit of a second round of quantitative survey data and discuss further with Mathematica. It will be useful to clearly understand (based on the exposure period), what we're likely to capture 1 year post compact (assuming infra work will be finished right around sept 2021) and how practical it'll be to have Mathematica and GridWatch both in country collecting HH/enterprise data. (4/23 update: We decided to forgo interim HH/enterprise data collection altogether and move the endline to 2023/2024).	We understand that the GridWatch survey will not be implemented outside of Achimota, Dansoman, and Kaneshie and that there will be no midline survey. We have revised our EDR accordingly.
5	Table II - this is the original allocation, but does it also make sure to include the new allocations to depict how the compact has changed (and why the evals have changed?) - i.e. NEDCo amount should decrease, EFOT amount should increase, PGSIP should decrease. Also need to add GoG contributions. See Word doc file with comments.	We have revised based on the Compact Budget worksheet in this file and added in the Government of Ghana contribution.
7, 8	There are relevant descriptive and budget updates to modernizing ECG Ops, ECG Commercial Loss Reduction, and ECG Technical Loss Reduction that can be added here. Note - that the budget changes have affected all EFOT activities. See Word doc file with comments.	We have incorporated the comments you provided us in Word.
12	If it isn't too time-consuming, then these maps could be updated to reflect project updates (i.e. new BSPs, new sub-stations, etc.)	We have updated two maps I Figure II.3 (top left and bottom right).
13	Need to update table. It would be good to separate the baseline (PEA) qualitative and quantitative (enterprise survey); similar for endline. Realistically, baseline report/dissemination would be mid-2nd half of 2020. More input from MCC needed regarding interim survey.	Based on later conversations we had with you we do plan on having a separate political economy analysis report at baseline.
15	In our first round of comments, we noted that research questions on ECG under IMPLEMENTATION, which had appeared in the final Evaluability Assessment, were dropped: *"Did the PSP transaction reach financial close by the required deadline (end of Year 2 of the Compact)? Was a qualified firm identified, recruited, and brought on board who could improve ECG's financial and operational performance by end of Year 2? What are the lessons learned from the process?"* MPR's response to this comment noted these questions were dropped since the PSP is now final -- however, these are still valuable process-related implementation questions, and MCC seeks to identify the lessons that can be learned from the process though after it is effectively complete.	Thank you for the discussion on this question. We have added these questions back in as sub-questions under the first set of questions for implementation of EFOT.
15	A previous comment on the first EDR draft noted that Compact interventions contributing to Commercial loss reduction might include the extent to which GOG institutions are continuing to accumulate large arrears or are paying for electricity use via pre-paid meters and adhering to the Arrears Plan (a major CP for Entry into Force). It would be helpful to consider this as among the possible activities that might contribute to utility financial health under Evaluation Question #9 (under SUSTAINABILITY).	We will included adherence to the Arrears Plan in list of key outcomes.

Page	Comment	Evaluator response
15	One issue to note, re: EFOT Evaluation Question #7 -- the Semi-Annual Review process generally has not occurred at all under the Compact and is unlikely to. Overall, it was felt that the high-level, intense consultations driving the PSP transaction provided the relevant forum for high-level stakeholder engagement on the sector issues needing to be addressed.	Thanks for this information. We will include this explanation in our baseline report.
34	Achimota is a district of Accra (perhaps suburb isn't the right wording)	Thanks for this information. We revised the document accordingly.
34	Why are we sampling equal number of HHs and enterprises? What is the rationale for this? (4/23 update: Note that Mathematica mentioned that the reasoning is to follow UCB's plan for IV analysis, but I'm not sure it makes sense necessarily for the IV approach to determine the HH/enterprise split. The ERR focuses on enterprises, so it would make sense to try to weight the sample more towards enterprises.)	We have revised our plan to sample more enterprises than households.
34	It would be helpful to elaborate more on the types of economic outcomes that will be included in the model, as this is not fully presented elsewhere in the EDR (e.g. see comments below for p. 42).	We have revised our plan to elaborate more on the types of economic outcomes that will be included in our model.
35	For the IV method, please be sure to ground truth the assumptions on the type and location of infrastructure investments whenever the final GIS files / design maps can be provided. Aside from line bifurcation in multiple districts, the compact is investing in 7 primary substations to be newly constructed, and 2 Bulk Supply Points.	Thanks for this information. We are in the process of reviewing those documents now.
37	"Baseline data collection will occur in 2019, midline starting in 2021 and 2022, and endline in 2025 and 2026." This should be updated in light of recent discussions, along with the Table on p. 38 - but it's correct that outage data will be collected continuously throughout all data collection periods, to the extent possible.	We have revised our timeline accordingly.
39	Same comments as for the Eval Qs on p. 15: we need to discuss including - or refining - the questions from the final Evaluability Assessment regarding the PSP process, recruitment of a qualified firm, and lessons learned. Also, critical stakeholders/actors in the PSP process are missing, such as MoE, MoF, IFC, etc. Lastly, see the previous comment regarding the Semi-annual Review Process, which largely has not taken place under the Compact.	See lines 8 and 10 above.
40	"These data [SAIDI/SAIFI] would ideally be available at the customer level, or if not, then at least at the transformer or substation level, but more likely they will only be available at a much higher level such as the region or district." As noted in recent discussions, ECG aggregates outage data from the district level, and at the time has no source of GIS data to link outages to households or assets -- although GIS work is underway and will hopefully be available in future years. Please reference the DQR Report, Section 5.2.3 for details on how SAIDI and SAIFI estimates are currently produced, and limitations. Similarly, for technical vs. commercial losses, note that MiDA's recent Data Quality Audit (Feb 2019, follow-up to the original DQR) focused heavily on ECG's estimation of technical losses in Accra East/West, and has useful findings that can be referenced. Lastly, as noted recently, PDS has secured an agreement with PURC that a "baseline" study of losses (for the Concessionaire's term) should be conducted by an Independent Consultant, followed by a 5-year follow up. We have yet to confirm further details, but expect a baseline study may occur in 2020; we hope to push for support to conduct a '2-year' follow-up in 2022 to assess compact impacts on losses.	Thanks for this information. We have updated the EDR accordingly.
41	The report states that "we will primarily rely on KIIs to discuss their perspective on customer satisfaction for EFOT," referring to power sector stakeholders such as ECG (pre-PDS) staff, regulators, VRA, labor unions, and others. Why would these internal players within the sector be able to provide the best insight (or unbiased perspective) on ***customer*** satisfaction? It's worth noting	We agree. We will rely primarily on our household and enterprise survey to obtain information about customer satisfaction, though we will also ask related questions in our KIIs of ECG staff. We have deleted the relevant sentence in the EDR.

Page	Comment	Evaluator response
	throughout the Dumsor period and as the Concession was being negotiated, ECG customers writ large generally supported the concession and did not necessarily support labor unions (very vocal, public) advocacy against it.	
41	A comment from the original draft EDR asked whether GLSS could actually provide detailed baselines for data such as energy use, outages, and especially voltage fluctuations, lightbulb types, appliance purchases / appliance damages, etc. -- MPR's response acknowledged that GLSS will have some data but possibly not sufficient in this level of detail, and therefore stated the EDR text was revised accordingly; however comparing against the original draft EDR, any changes are not quite clear or evident.	This was an oversight. We have revised the EDR to reflect this point.
42	Under Analytical Approach for the EFOT Project, it lists Qualitative Analysis, PEA, Engineering simulations -- but no mention of quantitative analysis related to Enterprise/HH surveys. It will be helpful to begin to understand MPR's approach to collecting enterprise data specifically that will inform an estimate of productivity impacts of reliability, losses due to outages, firm-level responses to outages (idling of workers, production processes, etc.), and longer-term decision-making around improved reliability (investments, expansion / firm growth, employment, etc.).	We will mainly use the instrumental variables analysis to estimate impacts of the compact on key economic outcomes in the ERR, but we will also assess intermediate outcomes as part of this evaluation. The household and enterprise survey will collect data on outcomes related to enterprise revenue and costs including especially those that are related to energy-use and employment. We have added a footnote in the analytic approach section of the EFOT chapter to clarify that our IV analysis of the compact will cover the EFOT impacts.
43, 44	Thanks for expanding on the PEA work. I think this will be really useful and relevant for MCC, esp as we get more involved in reform projects/work. We really want to learn about what went well/not so well with the concession and what are the process-level implementation lessons learned. I wanted to request Mathematica to add an additional deliverable (the format is flexible) for the PEA so we get it more quickly/can present it to MCC. This can then be appended/added to the baseline report, interim report, etc. after all the quant data is also collected/analyzed. It will also be important to add a few more stakeholders/parties to the concession such as Ministry of Energy, MoF, IFC, (maybe VRA/GridCo), etc. (4/23 update: Mathematica discussed that this may not make sense for the baseline, but after speaking with RCM, there is definitely demand for a separate (more quickly accessible deliverable); given that we will not be doing HH/enterprise data collection in interim period, the qualitative report can be packaged as 1 report in a shorter timeframe)	We have added a separate PEA report at baseline.
44	The report states, "From this understanding, we will identify the 'who', 'why' and 'how' of decision-making in the power sector ***at present***. This will then allow us to identify, over time, whether and how this mapping changes as the project proceeds…" and also notes "Information from the baseline round will be used in our analysis to compare how these processes changed after the introduction of the EFOT and regulatory project activities." It's also important to take into account that the evaluation should try to glean a retrospective assessment of changes that have already occurred since EIF, as part of the PSP transaction. In a sense, very few compact reforms remain outstanding during the final 2 years of the compact (besides the tariff); the PIR intervention can largely be understood to entail front-loaded reforms such as the PSP, arrears plan, and other compact CPs followed by expected institutional improvements (operational and financial) throughout the latter stages of the compact.	We agree and will incorporate this into our design and baseline reports.
45, 50, 53, 59	MCC to provide input into HH and enterprise survey round 2 data collection. (4/23 update: we've decided not to do an interim HH/enterprise survey and move the endline to 2023.)	We have dropped the round 2 survey.

Page	Comment	Evaluator response
47	Our prior comments on the first EDR draft noted a question that had been dropped since the final Evaluability Assessment: "Are distribution utilities meeting performance targets set by the regulator? Why or why not?" Should this question have been added back in? Previous feedback from MPR notes that this is not directly related to the program logic - however, there is a risk that if ECG in particular does not meet KPIs set by PURC, that PURC would limit, forgo, or potentially claw-back any further tariff increases, potentially impacting the financial health and performance of the sector.	We added this question back in.
48	Household and Enterprise surveys: what is entailed in asking customers their perceptions about the investment climate related to the tariff? In Malawi, firms were asked about their (expressed) willingness to pay for higher tariffs in the scenario of certain percentage improvements in reliability. Though not necessarily rigorous, might this be a useful way to gauge attitudes towards tariffs among consumers? Other firms were asked about their attitudes on businesses paying a higher subsidy to help cross-subsidize household customers, as well as the appropriateness of government subsidies to offset electricity costs for all consumers.	These suggestions sound good. We will consider them as we draft our baseline survey instruments.
49	Reference is made to simulations to be used to assess the impacts of tariff changes on the financial well-being of the utilities. An Evaluation Question was included in the final Evaluability Assessment that related to this, but is not included in the final EDR. Will it still be covered as part of the other evaluation questions?	Yes. We still plan to do the simulations discussed at the end of the analysis section of Chapter VI (on the Regulatory project) in our EDR.
51	Under Access, it would see important to explicitly probe whether there were any unintended impacts of the project (positive or negative). This is a core evaluation question listed in the original RFQ that is relevant to the overall compact evaluation, including the Access Project - this could be included with Evaluation Question #2 (under Implementation).	We agree. We have added a new sentence to cover this in the chapter on the overall compact evaluation at the end of the section on our analytic approach.
52	I don't think it makes sense to interview HHs in the Access area (esp. not for the Access project); the focus should be on small firms in markets/Ees that are direct beneficiaries of the intervention. (4/23 update: Mathematica to change language on this - won't actually be surveying "Access HHs".)	We have revised the text to clarify that we are not surveying households for the Access project. Rather, we are designing the household and enterprise survey to collect a representative sample of households in the sampling areas. We may find that there are some households in the enumeration areas that overlap with Access markets and enclaves so the random sample may end up selecting them for the survey.
57	As of now, all the audited buildings will be getting retrofits - I confirmed this with the EEDSM project team.	Thank you for this information. We have revised the EDR accordingly.
57	I'm also not sure if we're expecting bill repayment rates to change. These are gov buildings. The retrofits are to allow the ministries to lower energy costs so the utility doesn't lose as much... although this could change with PDS taking over.	Thanks for this information. We will keep it in mind when looking at the data.
69	We will need to follow-up re the Access project in the Tamale area	Our understanding is that we will be conducting surveys for the Access project in Tamale.
70	The report notes it will confer with MCC and MiDA to "determine the definition of small, medium, and large enterprises and stratify our sample based on these categories to ensure that we can address each type of enterprise." What sampling strategy of small/medium/large firms would be suggested based on the ERR model?	We plan to oversample larger businesses relative to smaller ones in part because the ERR suggests that the benefits per firm increase with firm size. We have revised the EDR accordingly. See the footnote starting, "According to the ERR there are only about 1,111 large enterprises ..."
73	Again, we will need to revisit the timing of these surveys. Early 2020 seems more realistic for baseline data collection. Interim may no longer happen (enterprise and HH) and endline timing may need to change to 2024. As mentioned on page 73, impacts of electricity projects often increase substantially after 2 years of exposure.	We have dropped the round 2 survey and will revise our timeline based on conversations we have had with MCC.
74	Reference to GridWatch for midline data collection will need to change.	We have revised this reference.

Page	Comment	Evaluator response
75	There are no households benefitting from the Access project, even if adjacent to project areas. In general, this sampling scheme is hard to understand given that it refers to 4 interventions, 3 relating to EFOT infra, but ***one*** of which is a separate project (Access) and should have its own sampling considerations (even if relying on a shared survey instrument). Wouldn't it make sense to present the sampling considerations for the 3 types of infrastructure interventions separate from that of the Access project? Similarly, it may be best to exclude households from the sample for Access. Lastly, given that the ERR model relies ***primarily*** on enterprise data, would there not be a strong rationale for including a comparatively larger sample of firms relative to households? The lack of HHs benefitting from Access and the prominence of firm-level outcomes for the ERR model both suggest a greater share of the total sample would be dedicated to enterprises, rather than an even 50/50 share. In the same vein, it would be preferable to prioritize the deployment of GridWatch/PowerWatch devices for the EFOT interventions, rather than for Access. Access is not expected to impact reliability, and given the cost of the technology we prefer to utilize this exclusively for the EFOT evaluation.	See our response in line 28 above regarding households in the Access project areas. We are treating Access differently than the other areas in that we will oversample enterprises in the Access areas but not households. In regards to the ERR model we have revised our overall survey plan (across all projects) to include far more enterprises than households. We agree that PowerWatch devices are not needed to estimate impacts of Access. However, since we are surveying many enterprises there we would like to utilize those respondents to increase the statistical power of our instrumental variables model which is being used to estimate impacts of EFOT. Consequently we think it would be helpful to have PowerWatch devices in the Access project areas.
76	It doesn't make sense for GridWatch to deploy PowerWatch devices in the Access markets/EEs. Also, there aren't really HHs in the Access project area so I'm not sure why this is listed in the table.	We agree that there may be limited places to hook up these devices and that they may be unplugged. However, we are not sure why this would be more common in the Access markets than in similar sized enterprises elsewhere. Having PowerWatch devices in the Access markets within Greater Accra will enable us to use the enterprise survey respondents in those markets in our IV analyses. We agree that there will be very few households in the Access markets and enclaves. See line 28 above. We have clarified in the EDR that this is only being done for the Access project and for the IV analysis and that we are not expecting major impacts of the project in Access areas (unless they are covered by the EFOT infrastructure interventions).
76	What is the rationale behind surveying the rest of the ECG catchment area? I think it makes most sense to stay within Accra East and West (and perhaps Kasoa). (4/24 update: Mathematica explained reasoning for surveying beyond Accra, and it could make sense if it's cost-effective (i.e. it could make sense to sample in Kasoa and Tema area) - otherwise, MCC recommends staying in greater Accra given that the compact benefits are really focused here - the full survey wouldn't apply/make sense in a city like Kumasi.)	We are currently recommending a cost-effective approach of focusing on the 7 largest cities within the ECG catchment area outside of Greater Accra. This will result in very little change in our data collection budget while at the same time enabling us to obtain far more complete information on the perspectives of enterprises and households regarding PDS and the EFOT project in general than would be possible without survey data. We will also be able to explore the potential for impacts of PDS on enterprise and household outcomes in 2023, about 4 years after PDS took over ECG operations. One of the 7 cities is Kasoa so we will also be capturing the bulk supply point there. We have specified the 7 cities and the sample sizes for Greater Accra vs these cities. We are also asking for separate cost estimates in the TOR.
76	The report states that "This will include using qualitative methods to better understand differences by gender, age, and income in energy related time use and roles." How will qualitative methods be utilized here -- given that the Household survey is a quantitative data source? Indeed, we are interested in capturing differences in outcomes along these dimensions.	We have revised the EDR to clarify that we will be using both quantitative and qualitative data to explore differences by gender, age, and income and that we will try to capture the nuances associated with ownership of larger firms.

Page	Comment	Evaluator response
	The report also mentions that "We will also examine differences in productivity and profitability of businesses by gender." A key caveat is that larger firms often have more complex ownership structures and may not be owned by an individual (male or female).	
77	The baseline question is a good one. I would think right before PDS took over (for the PEA work at least) or right before new infra was operational (this seems reasonable for the rest of EFOT and Access). MCC to continue discussing with Mathematica.	It appears that there are different baselines for different parts of each intervention. For example, the interventions designed to get PDS into place have relatively early baselines whereas the major infrastructure (line bifurcation, etc.) has relatively late baselines. We look forward to continuing to engage with MCC on determining the appropriate baselines for each activity as we develop the surveys and qualitative instruments.
79	Regarding voltage quality, what type of metric do you envision for this analysis? The GridWatch team can potentially provide analytics of the raw voltage data by developing certain KPIs capturing the prevalence or incidence of voltage dips, etc., so this should be discussed with them.	We look forward to the response of GridWatch to the suggestions we had for collecting data on voltage fluctuations.
101	See comments in word file regarding timeframe and proposed modules	Thanks. We have revised the timeline and dropped the building surveys.
Comments from MiDA staff		
1	Though very smaller coverage, you still have to mention Enclave Power Company as power distributor to the Free Zones Enclave in Tema.	We have added this point.
2	The Compact Program has a Budget of US$ 498.2 million, and Ghana (GoG) contribution of not less than 7.5% (i.e. US$ 37.4 million), bringing the total Compact Funds to US$ 535.6 million.	We have revised the budget figures based on input from Ishani.
3	R2R is now called R2RR or Race-to-Retrofit and Renewables	We have revised the EDR accordingly.
11	MiDA to explore the possibility of obtaining a map that better reflects the service areas of ECG (now PDS) and NEDCo. Some parts of Ashanti, Volta and Western Regions lie in the NEDCo Service Area. Also, should use the new Map of Ghana showing the six (6) newly created regions.	We will make this revision if we receive the new map in time.
16	Consider including the review of Public Utility and Regulatory Commission (PURC) documents on tariffs (under Methods of Project Objectives)	We have added this to our text.
23	This figure should be revised. The NEDCo Customer Population as at March 2018 was 835,695. Source: NEDCo Quarterly Report	We have revised our text accordingly.
30	What about installation of LED Street lights?	We did not cover this in our literature review but will cover it in our reports.
33	If poverty reduction and employment opportunities are among the number of related impact and/or outcomes, then why not consider the next GLSS data (probably around 2022) from the GSS among the potential data sources?	We are planning to look at GLSS data as stated later in our EDR.
34	Note that the ECG we know is now PDS but there is also Restructured ECG (RECG) which is an Asset Holding Company and a Bulk Purchaser of Power, which they sell to PDS.	We have revised our discussion of ECG accordingly.
34	Wondering how data could be collected from MiDA staff in the event that the Compact has ended and staff are no more working with MiDA at the time of the final evaluation.	This is addressed on page 84 of our current draft.
41	All staff of ECG migrated to PDS except for a few who form the Restructured ECG (RECG) so all the departments listed here are now in PDS	We have revised our discussion of ECG accordingly.
43	Why transmission if at the national level Compact is not affecting transmission that much, except for the GRIDCo sections of the 2 BSPs - Pokuase & Kasoa? Their effects on losses wouldn't be that significant, but rather make significant improvement in voltage quality because of reduced loads on existing and new BSPs.	We are planning to look at voltage quality.

Page	Comment	Evaluator response
43	Presumably, the method to be used in benchmarking will account for other factors that affect these performance indicators.	We plan to try to capture these other factors through the KIIs.
47	Consider defining what is meant by cost-reflective - is it referring to a situation where revenues from separate customer groups reflect the costs allocated to each group, and not when total revenue cover total costs because of cross-subsidies between different customer groups.	This is difficult so we did not try to address this in our EDR. One can probably define a marginal cost for each type of customer but the average cost is not well defined because there is no clear rule for how to divide up the fixed costs.
51	Not clear - Are we looking at expanding the "number of connections" or "new connections"? Because currently in the market "number of new connections" is zero (baseline).	We have gotten rid of the word, "new" to help clarify our plans.
52	This may be a wrong premise! Incidence of illegal connections may not necessarily be borne out of inability to pay. Anecdotal evidence suggests most culprits have the capacity to pay.	We agree. However, we suspect that at least some people with illegal connections will have difficulty paying.
55	These are not exhaustive of interventions/sub-activities under these 2 Activities of the EEDSM Project. Under (2) there is an intervention on public information on use of efficient appliances with standards & labels via different media platforms. This is yet to start. Under (3) there is an intervention to establish at least 2 sustainable energy services centers (SESCs) at 2 tertiary institutions. The SESCs will train and certify energy auditors for the country. This has started.	We have revised the text in the EDR.
55	Race-to-Retrofit and Renewables	We have revised the text in the EDR accordingly.
56	Probably you should also consider KII with National Council for Curriculum & Assessments (NaCCA), the GoG institution MiDA and AfC are collaborating with on this intervention.	
56	Hope you will be considering the following: i. design and supervision consultant, ii. street/public lighting division of PDS and iii. beneficiary Metropolitan, Municipal & District Assemblies (MMDAs).	
57	There is a chance of expanding the number of GoG institutions to include about 19 more Ministries, per MiDA Board request. This is still under consideration by MCC.	We have revised our EDR to mention this possibility.
64	I think this will change due to changes in the EFOT interventions during recent the Mid-Term Review of the Compact between MCC & MiDA. LV bifurcation coverage reduced, replacement of legacy meters with pre-paid meters coverage reduced, sectionalizing studies and loss characterization studies, technical assistance for tariff applications all cancelled; Kasoa BSP added, etc	We agree that the baseline ERR may need to be revised.
71	Since you plan to do a longitudinal study how do you intend to locate same study subjects in subsequent rounds after baseline? If you intend to activate the GPS functionality and take geo-codes of subjects at baseline please indicate where you think it best fits.	We have added text to cover this issue.
72	This is good. But what about the World Bank Enterprise Survey? Note that you even plan to engage them and GSS in developing your sampling frame.	We also plan to consider the World Bank enterprise survey.
72	Great quality control measures here and above sections. However, we yet to see the following: 1. Scripting (from paper to CAPI) - when do you intend to do this? Before or after pilot-testing or both or prior to training? Just need clarity on this. 2. Will training be based on both PAPI and CAPI or just one of the two? 3. Tentatively what duration are you looking at for the training since MPR (and not the local data collection firm) is designing the questionnaire? Want to know duration for quantitative and qualitative separately.	
73	Just for completeness please add that activities under Regulatory strengthening & Capacity Building project has started. Examples are Tariff study and Capacity Scan (CAP-Scan).	We have revised the EDR accordingly.
74	What about beneficiaries of R2R&R, e.g. Ministry of Education and/or Ghana Education Service, University of Ghana, Korle-Bu Teaching Hospital, etc; and the 2 Tertiary institutions to benefit from SESCs and Mobile Test Vans?	

Page	Comment	Evaluator response
76	Will the Indicators for the Internship and Mentoring be factored in here? How about changes after the implementation of the PDS Gender Policy?	We have revised the EDR accordingly.
101	It doesn't seem you've covered EEDSM R2R&R planned Impact Evaluation (via ITS) covered here. Is it because you plan to use secondary (and not primary) data? Just wanted to sure was not an omission.	We plan to use administrative data for the ITS.
106	Assuming MPR will be hiring and paying the local data collection firm, could you also give us (MiDA) an idea of estimates for the 3 rounds of the Enterprise & Household Surveys, since you will be developing the draft TOR? You may leave this out of this EDR, but probably share with us bilaterally. We will finalize it based on our knowledge of local conditions, etc.	We will share this information with you.

Note: The page numbers in this table refer to pages in an earlier draft of the evaluation design report, and may not align with the page numbers in the final version of the report.

This page has been left blank for double-sided copying.

www.mathematica-mpr.com

Improving public well-being by conducting high quality, objective research and data collection

PRINCETON, NJ ■ ANN ARBOR, MI ■ CAMBRIDGE, MA ■ CHICAGO, IL ■ OAKLAND, CA ■ SEATTLE, WA ■ TUCSON, AZ ■ WASHINGTON, DC ■ WOODLAWN, MD