

# Benin - Electricity Generation & Distribution

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## Overview

### Identification

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**COUNTRY**

Benin

**EVALUATION TITLE**

Electricity Generation &amp; Distribution

**EVALUATION TYPE**

Independent Impact Evaluation

**ID NUMBER**

DDI-MCC-BEN-IE-ENERGY-2018-01

### Version

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**VERSION DESCRIPTION**

- v01: Edited, anonymous dataset for public distribution.

## Overview

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**ABSTRACT**

To address challenges in Benin's electricity supply, the Millennium Challenge Corporation (MCC) has partnered with the Government of Benin to implement the Benin Power Compact from 2017 to 2022. The compact aims to modernize Benin's electricity network, strengthen SBEE, extend access to electricity, and improve the quality and reliability of the electricity system. MCC has contracted with Mathematica Policy Research (Mathematica) to conduct an evaluation of two of the four compact activities: (1) the Electricity Generation Project, which aims to increase domestic generation capacity through new solar plants and possibly a thermal power plant, and the rehabilitation of an existing hydroelectric plant; and (2) the Electricity Distribution Project. This report outlines the design to impact the Electricity Generation Project and the Electricity Distribution Project.

Mathematica has developed a comprehensive mixed-methods research design. The research design employs data from monitors and smart meters installed on the electricity grid to conduct an Interrupted Time Series (ITS) analysis to evaluate short term grid-level outcomes, combined with high-frequency phone surveys to estimate impacts on household and business end-users. We will also use these data to conduct a pre-post analysis of grid-level and end-user outcomes over the medium and long term as a quantitative performance analysis. Mathematica will also answer research questions related to project implementation and sustainability using (1) an implementation analysis, which will explore the compact's processes and activities through document review and interviews; and (2) a qualitative assessment, which will use interviews and focus group discussions to understand long-term outcomes for households, businesses, and public institutions. In addition, Mathematica has proposed an optional randomized control trial or a regression discontinuity design to rigorously estimate the impacts of different pricing strategies on connecting urban households to the grid and the subsequent impact of connecting on other outcomes.

**EVALUATION METHODOLOGY**

Pre-Post

**UNITS OF ANALYSIS**

Household, enterprise, other

**KIND OF DATA**

Sample survey data [ssd]

**TOPICS**

Topic	Vocabulary	URI
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Topic	Vocabulary	URI
Energy	MCC Sector	

**KEYWORDS**

Benin, Energy, Grid-level outcomes, Interrupted Time Series, Smart Meters, Grid Monitors

## Coverage

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**GEOGRAPHIC COVERAGE**

Capital city, rural project areas

**UNIVERSE**

Households and enterprises in areas affected by the Electricity Distribution Project and Electricity Generation Project

## Producers and Sponsors

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**PRIMARY INVESTIGATOR(S)**

Name	Affiliation
Mathematica Policy Research	

**FUNDING**

Name	Abbreviation	Role
Millennium Challenge Corporation	MCC	

## Metadata Production

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**METADATA PRODUCED BY**

Name	Abbreviation	Affiliation	Role
Millennium Challenge Corporation	MCC		Review of Metadata
Mathematica Policy Research	MPR		Independent Evaluator

**DATE OF METADATA PRODUCTION**

2018-05-09

**DDI DOCUMENT VERSION**

Version 1 (Original 2018-05-09)

**DDI DOCUMENT ID**

DDI-MCC-BEN-IE-ENERGY-2018-01

## MCC Compact and Program

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**COMPACT OR THRESHOLD**

Benin II Compact

**PROGRAM**

The Electricity Generation Project will increase Benin's domestic generation through three activities: (1) the construction of four solar photovoltaic (PV) power plants in the cities of Bohicon, Djougou, Natitingou, and Parakou; (2) the rehabilitation and increase in capacity of the Yeripao hydropower plant, located near Natitingou; and (3) the possible construction of a thermal power plant at Parakou (see Table II.1). Specifically, the solar power activity will provide 45 megawatts (MW) of new power generation capacity through the construction of two 15-MW solar PV plants, one 10-MW PV plant, and one 5-MW PV plant in the northern part of the country, where solar irradiance is the highest. The sites are all located near substations that feed the high-voltage (HV) network, so the new electricity generated can be injected into the national grid. However, the primary beneficiaries of this increased capacity are expected to be households and businesses in the project areas, because the new electricity production will first be used to eliminate daytime load shedding in project areas. As part of the project preparation,

Millennium Challenge Account-Benin II (MCA-B) will acquire the sites, apply for the necessary permits, and prepare the environmental and social impact assessment. Depending on the proposed mitigation strategies, MCA-B, its contractors, or the IPP(s) will address environmental and social risks. The Electricity Generation Project also includes the rehabilitation of the Yeripao hydropower plant. Specifically, MCC will fund project preparation, rehabilitation of the existing generation unit, installation of an additional turbine that will provide an additional 0.5 kW of electricity, rehabilitation and possible expansion of the access road, and removal of sedimentation from the reservoir if necessary (MCC 2015). After these activities, the Yeripao hydropower plant is expected to have 1 MW in generation capacity. MCC had originally planned to rehabilitate several thermal power plants with a capacity of approximately 32 MW (Ksoll et al. 2017). However, the government is now rehabilitating those plants on its own, so MCC is working on a proposal to build a thermal generation unit with 25 MW of capacity in Parakou, as shown in Table II.1, though this activity is currently unsure. The Electricity Distribution Project comprises four activities (see Table II.1 for an overview and Table B.1 in Appendix B for a detailed list of activities): ? For the Regional Grid Strengthening Activity in Djougou, Natitingou, Parakou, and Porto Novo, MCC will replace electricity lines, upgrade substations, install new switchgear connections, build new substations, and construct a new 63-kV connection from Porto Novo to Akpakpa<sup>4</sup>. These activities will be concentrated in the same areas receiving new solar PV plants and will improve the grid's ability to handle increased demand while also reducing technical losses. ? The Cotonou Grid Strengthening Activity aims to improve the capacity and reliability of the grid in Benin's largest city through installation of new switchgears, connections, and busbar feeders, network extensions, and switchgear modifications. ? The National Electricity Dispatch Activity will improve SBEE's ability to manage the national grid and respond to problems through the construction of a national distribution control center (NDCC). The NDCC will include supervisory control and data acquisition (SCADA) equipment.<sup>5</sup> ? General network modifications in the project areas. Overall, these investments aim to increase the capacity of Benin's electricity grid in the project areas, improve the reliability of electricity supply to consumers, and help SBEE identify problems early on and respond to them more quickly.

## **MCC SECTOR**

Energy (Energy)

# Sampling

## Study Population

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Households and enterprises in areas affected by the Electricity Distribution Project and Electricity Generation Project

## Sampling Procedure

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The sample frame will be designed to draw confident causal inference about the impacts attributed to the expansion and maintenance of electricity infrastructure on end users and grid-level outcomes. To monitor these impacts, Mathematica will undertake the following activities:

- High-frequency data collection from roughly 200 grid monitors and roughly 500 smart meters.
- A listing of businesses and households in areas affected by the projects.
- High-frequency data collection from a mobile phone survey of 1500 households, 400 medium and large electrified firms, and 750 small electrified firms.
- Longitudinal data from household heads and business owners.

We will use these data to conduct an Interrupted Time Series Design to measure short-term outcomes, and will combine these data with SCADA (Supervisory Control And Data Acquisition) administrative data, once available, from the Société Béninoise d'Énergie Électrique to conduct a pre/post analysis of medium and long term impacts.

For grid level outcomes, assuming between 10 and 40 grid monitors per project areas, we predict a minimum detectable impact of between 4% and 8% change from mean for percentage of hourly measurements that are overvoltage, and between 3.1% and 1.3% change from mean for percentage of hourly measurements that are undervoltage. However, these estimates are preliminary, and subject to change as the evaluation is implemented.

## Deviations from Sample Design

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Not applicable, as this report outlines the sample design

## Response Rate

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Not applicable, as this report outlines the sample design

## Weighting

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Attrition and low response rates can lead to underpowered and biased impact estimates. We will consider statistical approaches to attrition (such as inverse probability weighting based on observable characteristics) if attrition is indeed a large problem.

# Questionnaires

## Overview

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Questionnaires have not yet been drafted, but we intend to use high-frequency mobile phone surveys, necessitating a brief questionnaire. We will also conduct business and household surveys for the pre-post portion of the evaluation.

## Data Collection

### Data Collection Dates

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<b>Start</b>	<b>End</b>	<b>Cycle</b>
2018-09-01	2018-10-31	Baseline (estimated)
2020-09-01	2018-10-31	Interim (estimated)
2022-09-01	2022-10-31	Endline (estimated)

### Data Collection Notes

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None, as we have not yet collected data

### Questionnaires

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Questionnaires have not yet been drafted, but we intend to use high-frequency mobile phone surveys, necessitating a brief questionnaire. We will also conduct business and household surveys for the pre-post portion of the evaluation.

### Supervision

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N/A, as we have not yet collected the data or procured the data collection

## **Data Processing**

### Data Editing

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N/A, as we have not yet collected the data

### Other Processing

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N/A, as we have not yet collected the data



## **Data Appraisal**

### Estimates of Sampling Error

Not applicable, as this report outlines the sample design