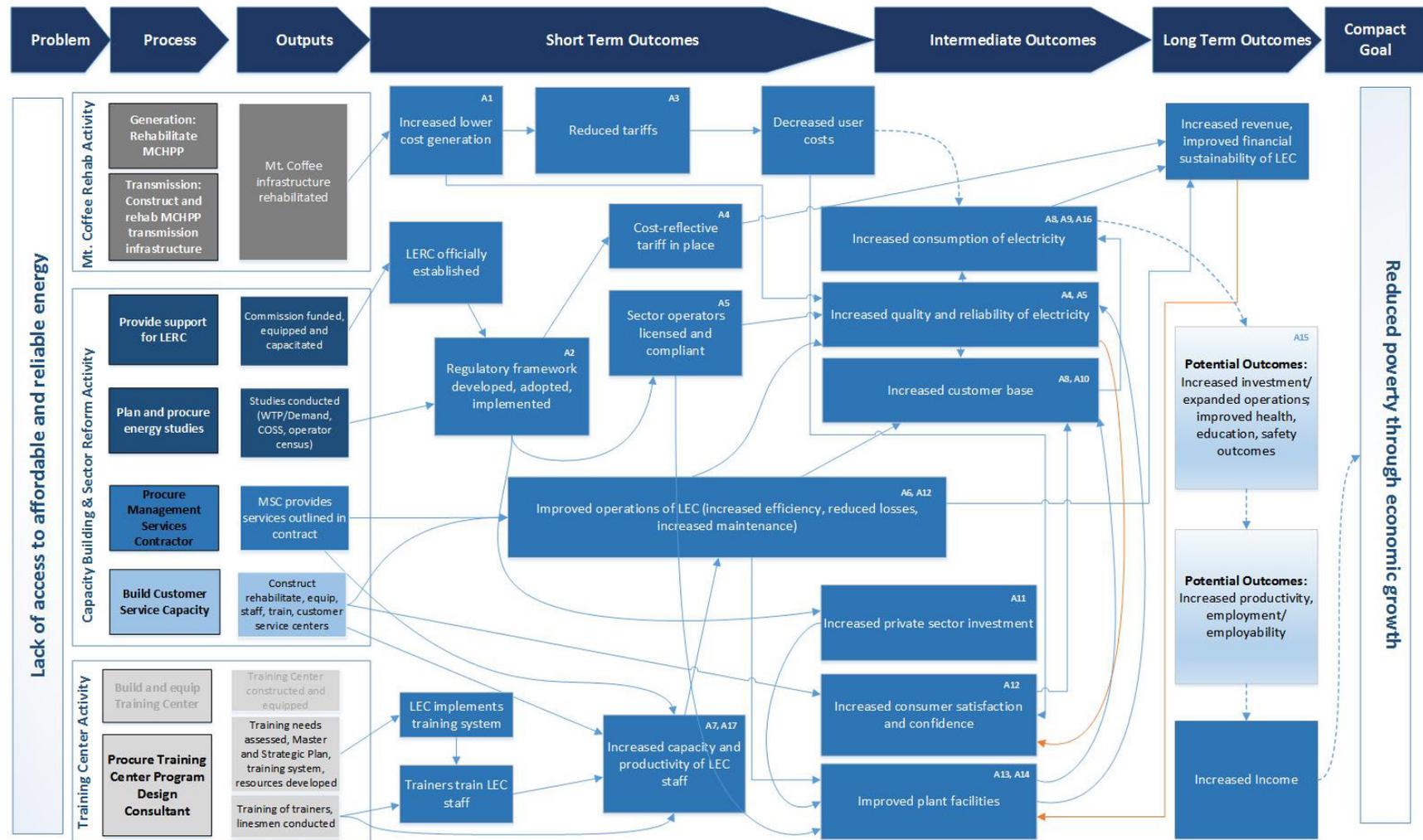


Appendices

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Appendix A: Logic model for the Liberia Energy Project

Figure A.1. Liberia Energy Project logic



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Appendix B: LEC generation, T&D system

Figure B.1. LEC simplified one-line diagram (Tetra Tech)

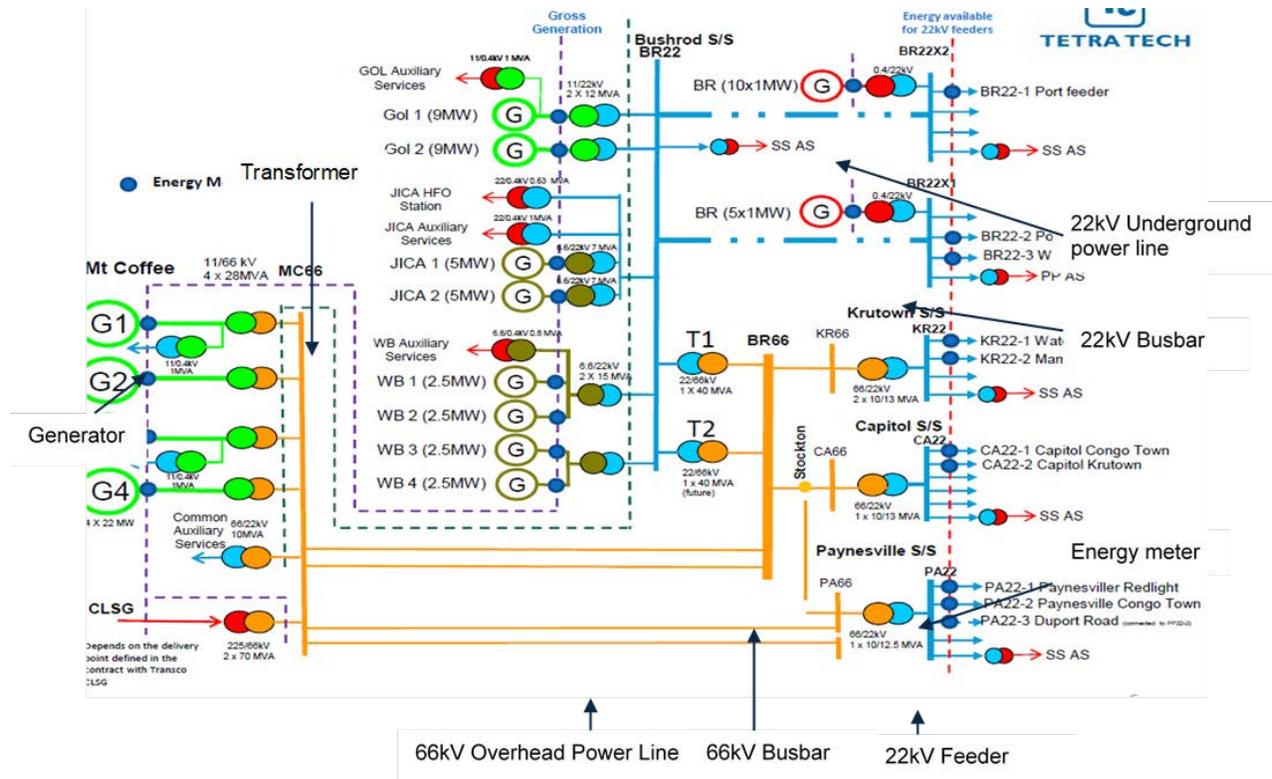
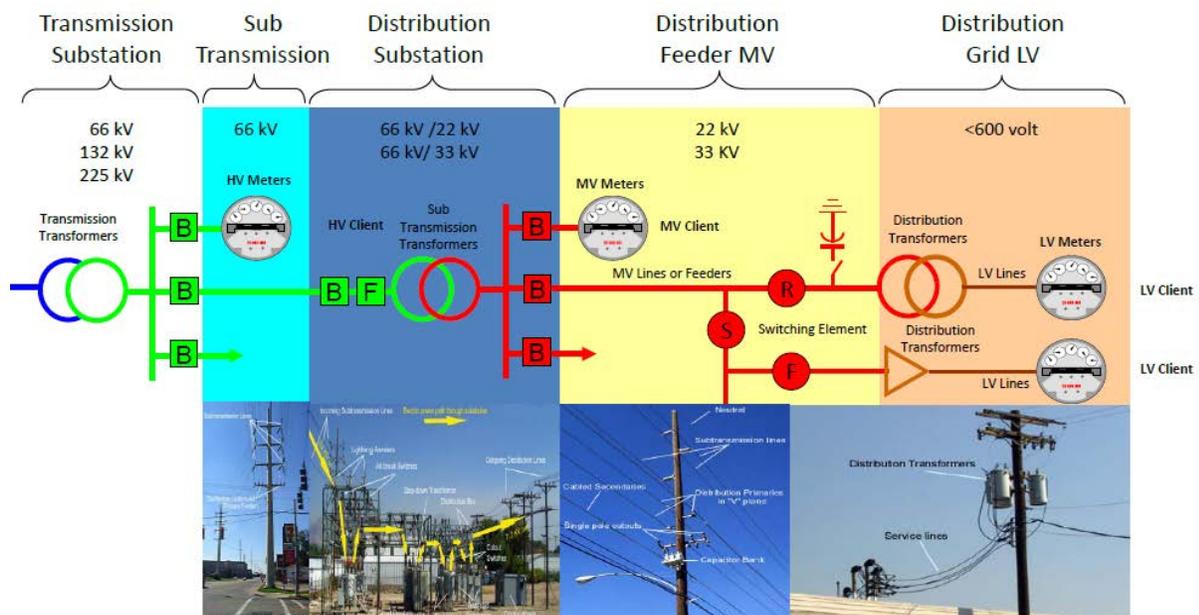


Figure B.2. Diagram of LEC's distribution system (Tetra Tech)



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Appendix C: Evaluation studies

1. Administrative data

The Liberia Electric Corporation (LEC) administrative data helped us develop insights into outcomes at all levels of inquiry, including implementation, and at the utility, energy sector, grid, and end user level.

We recognized that LEC was, by all accounts, a barely functioning utility company that had been unable to carry out standard data collection and management tasks. In 2017, LEC also lacked an integrated data management platform. Given these deficiencies, we subcontracted Tetra Tech to review, assess, validate, and systematize LEC indicators. Tetra Tech had worked with LEC during the interim management period and knew the organization and LEC staff. Tetra Tech examined indicators from the evaluation design report (EDR) and the M&E (monitoring and evaluation) monitoring plan, and determined which indicators could be collected and would be included in its information management system (IMS) (July–September 2018). To facilitate use of data, Tetra Tech created an Excel workbook with charts to show trends for each indicator and provided instructions for LEC so it could use the data with the IMS database (Tetra Tech Final Report 2018). We also asked LEC to comment on data once we had populated the data files and constructed figures.

We kept in contact with LEC as the IMS was developed and populated. We made repeated requests for data for each of the indicators that show utility performance in the areas of electricity generation, transmission and delivery (T&D), and sales, customer coverage, utility performance, quality of service, LEC's finances, and other measures. Mathematica received additional data from LEC post-Tetra Tech contract. In general, the data were supplied at the monthly level, but there were times when we received quarterly data for some measures. The reporting level also varied over time, so in some cases, such as customer categories, we had to aggregate the data so we could compare data across indicators and over time. Most of the data came directly from LEC, but in some cases we compiled historical data from MCA or the contract monitoring consultant (CMC). In addition, we did not monitor how LEC collected, recorded, and cleaned its data internally, so we were not able to validate the accuracy of the data at the source. Finally, we compiled, assessed, and then verified data by triangulating with other sources (quantitative surveys, in-depth interviews (IDIs), and key informant interviews (KIIs).

2. Document review

We reviewed documents including the contracts, reports, work plans, meeting minutes, and news articles in an ongoing process (Table C.1). For each of the documents, we read the material and highlighted key components that provided important context and helped answer research questions. We cross-checked information as needed and frequently referred back to the presentations, spreadsheets, and reports. The materials helped us understand context and processes better to ask more informed questions, to verify and validate processes and challenges, and confirm findings.

Table C.1. Document review materials

Agency or organization	Documents
MCC and MCA-L	Compact, Project Implementation Agreement, Constraints Analyses, Investment Memo, monitoring and evaluation plan, requests for proposals for services such as the CMC, MSC, and studies and subsequent revised versions, economic modeling and analyses documents
MCA	Implementation plan, terms of references, Operator Census report
MCHPP	MCHPP designs, video, summaries, all contracts (Voight, Dawnus, Norplan Fitchner, NCC, Andritz, ELTEL, PSM JV, HOI), MHI's inception, monthly, quarterly, annual and final reports, work plans
Interim Management Team (IMT) (LEC)	High Level Sector Group (HLSG presentations), administrative data spreadsheets
ESBI (MSC) at LEC	Contract, scopes of work, revised scopes for the MSC, reports such as situation assessment, turnaround, master electricity, maintenance, asset, environmental, and other plans (contractual obligations), financial statements, administrative data from spreadsheets, maps, presentations to the Energy Sector Working Group and HLSG presentations, loss prevention presentations, Business Plan 2019 report, presentation and spreadsheet,
Azorom (CMC)	Quarterly and annual reports
Donor organizations (AFDB, EU, EIB, JICA, KfW, NORAD, World Bank, and USAID)	Financing agreements for MCHPP (EIB, KfW) T&D project plans, summaries, and updates; terms of reference for projects; maps of project areas,
Tetra Tech	Inception, monthly, and final reports and presentations on administrative data activities at LEC and indicator spreadsheet and description of calculations
Indra	Presentations on the Information Management System (IMS)
Additional presentations and reports	Such as from Tetra Tech, McKinsey, Voith, Norplan Fitchner
MME	Electricity Law of 2009, Electricity Policy 2015, Power Theft Act 2019, Least Cost Development Plan (prepared by Fitchner for the MME)
LERC	Administrative procedures, licensing regulations and handbook, workshop presentations, draft business plans, issue tracker, timelines
News articles	We set Google alerts to follow articles related to LEC, LERC, Liberia, electricity and Africa, MCC, Power Africa, and George Weah

AFDB = African Development Bank; CMC = contract monitoring consultant; EU = European Union; EIB = European Investment Bank; HOI = Hydro Operations International; JICA = Japanese International Cooperation Agency; KfW = German Development Bank; MSC = management services contract; MCHPP = Mt. Coffee Hydropower Plant; MME = Ministry of Mines and Energy; NORAD = Norwegian Development Agency; PSM JV = Joint Venture of Pan African Group, Sigma Group Inc and Mamba Point Hotel; T&D = transmission and distribution

3. Quantitative surveys to answer research questions at the level of grid and end-user outcomes

a. Sampling

We assessed end-user outcomes by carefully selecting samples of households and businesses with the kinds of experiences that would give us nuanced information unavailable from any other source (Table C.2). For each population that we studied, we implemented rigorous, multi-stage sampling procedures designed to identify and select the study population that would yield the appropriate data to answer the research questions.

The Liberian context presented significant sampling challenges because (1) LEC does not keep customer-level data with names, addresses, and other contact information; (2) LEC has not had up-to-date geocoded data on its electrical infrastructure; (3) many streets in Monrovia have no name, and (4) buildings do not have addresses. Nevertheless, we overcame these challenges and selected samples. We next describe our approach to selecting the study samples, including the study population, stages of sample selection, selection process, sampling frame, stratification approach, sample size, and approach to handling respondents who could not be interviewed. We also present these details in Table C.2 and Table C.5.

Table C.2. Evaluation study samples

Connected communities in Monrovia	Unconnected communities along the Kakata Corridor	Medium and large end-user survey including both connected and unconnected end users
Performance evaluation to longitudinally follow end users over time, with these data collection components: <ul style="list-style-type: none"> • Community survey • Household survey • Small business owner survey • Qualitative focus groups and in-depth interviews 	Pre-post survey to follow end users over time, with these data collection components: <ul style="list-style-type: none"> • Community survey • Household survey • Small business owner survey • Qualitative focus groups and in-depth interviews 	Performance evaluation to longitudinally follow end users over time. Sample includes: <ul style="list-style-type: none"> • Government agencies • Businesses • Nongovernmental organizations • Charities

Connected end users. We employed a two-stage cluster sampling approach to arrive at our study sample. First, we used three independent sources of information to identify communities with high concentrations of connected end users: LEC’s list of communities in Monrovia served by the utility, geocoded data of infrastructure from maps assembled by USAID, and LEC’s list of communities where new electrical infrastructure had been constructed after a 2016 USAID study. Together, they allowed us to identify connected communities eligible to be part of our sample. A key limitation of the data was that they did not allow us to identify the exact location of all infrastructure within enumerated areas (EAs) and communities, including assets constructed after 2016. Hence, we worked with The Khana Group (TKG) to verify EAs with electrical connections before launching data collection.

We ranked 165 communities in Monrovia by the number of existing electrical facilities in each community, given that we did not have data on the number of connected end users in each community. We considered the top 50 communities and randomly selected 35 of them to include in the sample. Thirty of these communities made up the main sample, and the remaining 5 were replacement communities. Within sampled communities, we identified EAs that had no electrical infrastructure before 2016 and verified the location of new electrical infrastructure in selected EAs. We chose the top three EAs in each community with the highest number of electrical facilities and included them in data collection to maximize our efficiency in locating connected end users and to ensure that we met our target sample of 1,500 connected end users.

In the 30 communities, we conducted community-level surveys to learn the context of the catchment areas. Concurrently, we conducted a census in the selected EAs of the 30 communities

to list all the households and small businesses in order to create two sampling frames of end users: (a) connected small enterprises and (b) connected households. For connected small enterprises, we initially planned to conduct stratified random sampling in each selected EA, with strata defined by whether the business was connected to the grid before or after 2016. However, as shown in Table C.5, our listing yielded 384 connected small businesses, far fewer than the 750 connected small businesses we sought to sample in total. (We intended to have 50 percent of the 1,500 connected end users be stand-alone small businesses). We therefore decided to sample all 384 connected small businesses that were listed. For connected households, we conducted stratified random sampling in selected EAs, with strata defined by whether the household was connected before or after 2016, and whether the household had an income-generating activity (IGA). This produced four strata per EA. In each stratum, we selected 32 percent of the households for inclusion in the survey. We chose this percentage of households to obtain our target sample size of 1,500 connected end users, after accounting for the total number of small enterprises to be sampled. After conducting the in-person surveys and checking for duplicate surveys, we achieved a final sample of 1,174 households and 322 small businesses.

Unconnected end users. As we did for the connected end user study, we implemented sampling in two stages. We used two independent sources of information to identify areas for the sampling frame: LEC maps of existing and planned electrical poles for the Paynesville-Kakata-Weala corridor, Liberian Institute for Statistics and Geo-Information Systems (LISGIS) maps of Liberia that delineated the communities, and EAs in the country. Combined with data on planned poles, this information allowed us to select the subset of communities and enumeration areas to visit for the household and small business surveys. For the first stage of sampling, we selected 125 EAs across 25 communities that have the fewest existing electrical poles, but also have plans to construct new electrical infrastructure. We conducted 25 community-level surveys to understand the characteristics of unconnected communities. Concurrently, we conducted a census to list 8,752 unconnected households and small businesses along the roads where the electric poles would be conducted. Then, we randomly sampled 7 or 8 households per EA to obtain a target sample of 875 households. Before the listing yielded only 423 unconnected small businesses, we included all unconnected small businesses in the target sample. After in-person surveys and checks for duplicate respondents, we achieved a sample size of 867 households and 400 small businesses.

Medium and large end users. We used two independent sources of information to identify medium and large enterprises and public institutions: a full list of registered organizations from the Liberia Business Registry that provided the names, addresses, and contact information for 14,694 entities, and LEC's list of medium and large organizations, which consisted of 50 existing customers and 53 potential end users that it is targeting. The two lists served as the sampling frame for our target sample of 500 medium and large organizations for the study.

We sampled all 103 of the existing and potential organizations in LEC's list because this group was most likely to be affected by the Liberia Energy Project. For the rest of the study sample, we conducted stratified random sampling to select enterprises from the list of registered businesses and organizations. To identify the strata for sampling, we used the type of organization indicated in the registry; that is, whether the firm was an NGO, business corporation, branch or subsidiary, limited liability company, sole proprietorship, partnership, foreign corporation, limited partnership, or trust. To arrive at our sample sizes, we used proportional allocation, except for

limited liability companies, partnerships, foreign corporations, limited partnerships, and trusts; because there were relatively few of these entities, we targeted all of them to be sampled for the study. TKG contacted businesses in the list to verify their size and confirm eligibility for the study. To ensure representativeness, we asked TKG to contact businesses from the list in a random order. Due to low response and eligibility rates, we were only able to verify the eligibility of 218 organizations that were included in the target sample. After identifying duplicates, we selected 95 organizations from the LEC list, which resulted in a target sample size of 313. Finally, after conducting in-person surveys, we achieved a sample of 175 medium and large end users.

b. Recalculating MDIs

With the final sample sizes from our surveys, we recomputed the minimum detectable impacts (MDIs) that we can expect from our studies of connected and unconnected end users.¹ Tables C.3 and C.4 provide these MDIs, using electricity consumption as the primary outcome. In general, we remain confident that our studies will have enough power to detect meaningful impacts on end user outcomes. With our household and small business samples in the connected study, we would be able to detect increases as small as 5.2 kWh and 7.1 kWh in monthly grid electricity consumption, respectively, for these end users in our pre-post evaluation. For the unconnected study, we would be able to detect changes as small as 5.1 kWh and 6.5 kWh in electricity consumption for households and small businesses, respectively. As noted in our EDR, these would be small increases, and the actual increase in electricity consumption is likely to be higher. For reference, to consume an additional 9.4 kWh of electricity per month, a household must use one additional 60W incandescent electric bulb for about 5.5 hours each night. These estimates are also lower than the projected monthly increases in grid electricity consumption of around 18.82 kilowatt hours (kWh) for residential customers in the ERR calculations.

Table C.3. Minimum detectable impacts for connected end users

Outcome	Sample size		Baseline mean	MDI	MDI (% change from mean)
	Clusters	End users			
Household sample					
Monthly grid electricity consumption (kWh)	90	1,174	52	5.2	9.9
Small business sample					
Monthly grid electricity consumption (kWh)	90	322	52	7.1	13.7

Notes: Calculations are based on a confidence level of 95 percent, two-tailed tests, 80 percent power, 10 percent nonresponse rate for surveys, a pre-post correlation of 10 percent, and an R-squared of 0.1. Information on baseline mean is from key performance indicator (KPI) data compiled by Tetra Tech for LEC residential customers in 2016. Information on baseline standard deviation is from the MCC Tanzania evaluation (Chaplin et al. 2017). Apart from updating the end user sample sizes, we revised the cluster sample sizes from 30 to 90 because we sampled from 90 enumeration areas instead of 30. kWh = kilowatt-hour.

¹ We do not present MDI calculations for the evaluation of large end users, primarily because we lack reliable information on connected large end users from a comparable context for the MDI calculations.

Table C.4. Minimum detectable impacts for unconnected end users

Outcome	Sample size		Baseline mean	MDI	MDI (% change from mean)
	Clusters	End users			
Household sample					
Monthly grid electricity consumption (kWh)	125	867	6.92	5.1	73.4
Small business sample					
Monthly grid electricity consumption (kWh)	125	400	6.92	6.5	93.3

Notes: Calculations are based on a confidence level of 95 percent, two-tailed tests, 80 percent power, 10 percent nonresponse rate for surveys, a pre-post correlation of 10 percent, and an R-squared of 0.3 for individual level covariates and .1 for cluster level covariates. We assume a cluster ICC of 0.1, and a coefficient of variation of 5. Information on baseline mean is from World Bank WTP survey of unconnected households in Monrovia. kWh = kilowatt-hour; ICC = intra-cluster correlation.

Table C.5. Quantitative sample and sampling approach

Target population	Approach to narrowing the sample frame	Stages of sample selection and selection process; sampling frame; stratification approach	Sample size	Strategy for absent respondents
Connected households and small businesses in Monrovia	<ul style="list-style-type: none"> Challenge was that LEC does not maintain a list of customers with addresses or contact info. Obtained LEC's list of Monrovia communities served by utility; however, list did not have exact locations, street names, or GPS data. Next, obtained geocoded data of electricity infrastructure existing in Monrovia in 2016. Next, LEC provided a list of communities where new electrical infrastructure had been constructed since 2016. Used list of communities served and geocoded data to narrow down communities for the sample frame. 	<ul style="list-style-type: none"> Received lists of communities with infrastructure and geocoded locations; 165 communities had infrastructure. Ranked communities by concentration of users; used infrastructure as best measure of the concentration of connected users, given that we did not have community data on the number of connections. Selected 50 most connected communities, given that the 51st community only had 21 electrical infrastructure assets, so would not have many connected end users. Randomly sampled 30 communities (and 5 replacement communities) from the 50 most connected communities Mapped areas in sampled communities. Verified infrastructure by physically going to communities; we geotagged the poles, providing coordinates of all electrical infrastructure. This allowed us to sample EAs with up-to-date information on connectivity. Sampled EAs within selected communities. Listed all end users Selected all 384 businesses listed. Stratified random sampling in EAs with strata based on connection before or after 2016 and whether household had an IGA; within these four strata, selected 32 percent of households for 1,500 households. 	<ul style="list-style-type: none"> Community profiles: n = 30 End user listing: n = 4,723 Households: n = 1,174 Small businesses: n = 322 	We implemented a sampling-with-replacement approach so that we had a list of households and small businesses that we would systematically select from to ensure we reached our target sample size of 1,500. Note that we included all available small businesses.

Target population	Approach to narrowing the sample frame	Stages of sample selection and selection process; sampling frame; stratification approach	Sample size	Strategy for absent respondents
Unconnected households and small businesses	<ul style="list-style-type: none"> Obtained LEC's maps that provided exact locations of existing and planned electricity poles in the Paynesville-Kakata-Weala corridor. Obtained Liberia Institute of Statistics & Geo-Information Services (LISGIS) census maps with community and enumeration area (EA) boundaries. Combined maps on planned poles with census maps to select communities and enumeration areas for the sample frame. 	<ul style="list-style-type: none"> Overlaid maps of planned poles onto the census maps to identify the 28 communities and 245 EAs where electrical poles will be constructed and connections made in the World Bank-funded Paynesville to Kakata Corridor project. Selected subset of 125 EAs that had the fewest existing electrical poles across 25 communities identified for the sampling frame. Mapped areas, plotting boundaries, streets, and buildings in sampled communities. Conducted a census in selected EAs to list all unconnected households and small businesses along roads where electrical poles would be constructed. Randomly sampled 7 or 8 households per EA to obtain a target sample of 875 households. Initially planned to sample 3 businesses per EA, but there were too few unconnected businesses. All 423 unconnected small businesses were ultimately included in target sample. 	<ul style="list-style-type: none"> Community profiles: n = 25 End user listing: n = 8,752 Households: n = 867 Small businesses: n = 400 	We implemented a sampling-with-replacement approach so that we had a list of households that we would systematically select from to ensure we reached our target sample size of 875. Note that we included all available small businesses.
Medium and large end users	<ul style="list-style-type: none"> Obtained Liberia Business Registry (LBR) list of registered organizations in Monrovia and district of Greater Monrovia. Obtained LEC's list of current and prospective medium and large end users. Two lists together served as the sampling frame. 	<ul style="list-style-type: none"> Sampled all 103 existing and potential medium and large customers from LEC's list because they are most likely to be affected by the Liberia Energy Project. Target sample size from LEC list was later reduced to 95 after eliminating organizations that were concurrently included in the LBR list. Identified sample size for the rest of study sample from LBR list; conducted stratified random sampling to select organizations from the list of registered enterprises and institutions; type of organization indicated in the registry was used as stratum, and proportional allocation used to determine sample size for each strata. Sampled organizations from LBR list were screened over phone to verify organization size and confirm eligibility for the study. Completed 14,700 phone calls and verified eligibility of 218 businesses and institutions. Final target sample size from both lists was 313. 	<ul style="list-style-type: none"> Screening calls: n = 14,700 Medium and large organizations: n = 175 	We included all organizations on the verified LEC list as well as organizations that were screened and verified as eligible in the target sample.

c. Instrument development

We developed nine questionnaires for baseline data collection: two sets of listing, community profile, household, and small business questionnaires for the connected and unconnected studies, and a medium and large end-user questionnaire for connected and unconnected organizations (Table C.6). The instruments were adapted from existing surveys, including MCC's Survey of Electricity Consumption from Nepal, and refined through an iterative process that involved reviews by MCC and MCA-Liberia, revisions based on their input, and a pre-test and pilot in Liberia, followed by further revisions to the instruments. Table C.6 lists the modules included in each instrument. The questionnaires were developed into Computer Assisted Personal Interviewing (CAPI) tools using SurveyCTO software and tested rigorously to ensure the software functioned without glitches.

Table C.6. Quantitative survey modules

Listing	Community profile	Household survey: Connected and unconnected	Small business: Connected and unconnected	Medium and large businesses and organizations
<ul style="list-style-type: none"> • End user information • Household screening • Small business screening 	<ul style="list-style-type: none"> • Respondent information • Community characteristics • Transportation, communication, and housing characteristics • Access to electricity • Access to services • Market activity • Energy and fuel prices • Observations and boundary walk 	<p>Household characteristics</p> <ul style="list-style-type: none"> • Household composition and characteristics of members • Characteristics of household accommodation • Children's education and time use • Time use of household members • Safety 	<p>Business characteristics</p> <ul style="list-style-type: none"> • Business information • Respondent's and owner's characteristics • Business staffing and employment • Operations and financial information • Business consumption and expenditures • Safety 	<p>Organization characteristics</p> <ul style="list-style-type: none"> • Organization information • Directors' and managers' characteristics • Qualitative interviews (only for nonprofit organizations) • Organization staffing and employment • Operations and financial information • Organization's consumption and expenditure • Security and safety

Listing	Community profile	Household survey: Connected and unconnected	Small business: Connected and unconnected	Medium and large businesses and organizations
		<p>Appliances and electricity</p> <ul style="list-style-type: none"> • Energy sources • Electricity connection • Electricity quality (only for connected) • Electricity billing (only for connected) • Sharing electricity (only for connected) • Electricity outages (only for connected) • Equipment and devices used <p>Household finance</p> <ul style="list-style-type: none"> • Household consumption and expenditure • Wage income • Household-owned businesses/income-generating activities • Non-wage income • Household assets 	<p>Appliances and electricity</p> <ul style="list-style-type: none"> • Energy sources • Electricity connection • Electricity quality (only for connected) • Electricity billing (only for connected) • Sharing electricity (only for connected) • Electricity outages (only for connected) • Equipment and devices used 	<p>Appliances and electricity</p> <ul style="list-style-type: none"> • Energy sources • Electricity connection • Electricity quality (only for connected) • Electricity outages (only for connected) • Electricity billing (only for connected) • Unconnected end users • Equipment and devices used

Note: In addition to the above modules, all questionnaires included modules on survey administration, consent and conclusion

e. Field data collection

We contracted TKG, a Liberian survey firm, to conduct baseline data collection. Before starting the fieldwork, the team developed field manuals and presentation materials. TKG trained and tested enumerators on key study points, survey topics, deployment plans, use of GPS devices, interview techniques, and data entry with CAPI tools. Mathematica staff traveled to Liberia to oversee training and pilot activities. After the field piloting, we reviewed the pilot data; the team of enumerators recommended revisions to study instruments, which were made; and CAPI software errors were fixed. Enumerators were briefed on survey revisions and changes to the fieldwork plan before deployment.

Data collection was conducted in two phases (Table C.7). In the first phase, between October 2018 and January 2019, we surveyed Monrovia and Greater Monrovia for the connected users' study. In the second phase, between April 2019 and November 2019, we surveyed the Kakata-Paynesville corridor for the unconnected users' study, collected qualitative data, and surveyed

medium and large end users in and around Monrovia. Data were collected by teams of four to six enumerators and one supervisor, who used CAPI software.

Throughout data collection in the field, supervisors conducted spot checks and monitored the tablets' GPS coordinates. We closely monitored the quality of the data by producing daily reports of any duplicate entries (for example, if the same household was interviewed twice), questions that should have been asked but were not, or any unexpected values. We reported any issues with the data to the TKG team in real time so they could (a) inform their field team to make corrections in the field, and (b) clean the final data appropriately before delivering them to us. TKG shared progress reports with Mathematica daily, and the team worked closely during fieldwork activities to resolve any issues in the field and ensure that high quality data were collected.

While conducting the household survey in Monrovia, we identified a small percentage of households that reported not having an IGA within their household at the time of the survey but had said they did have one at the time of sampling (or vice versa). Because IGA status was one of our stratification criteria when sampling, we reassessed these households in the following weeks to confirm their IGA status, and incorporated the updated data into our analysis.

Table C.7. Surveys and fieldwork details

Phase and activity	Deployment date	Fieldwork details
Phase 1: Connected study		
Listing	October 2018	<ul style="list-style-type: none"> • 4 field supervisors and 20 enumerators • Target sample: All households and small businesses in 90 EAs across 30 communities • Achieved sample: 3,973 households and 410 small businesses listed
Community profile	October 2018	<ul style="list-style-type: none"> • 4 enumerators • Target sample: 30 communities • Achieved sample: 30 community profiles collected
Household questionnaire	November 2018–January 2019	<ul style="list-style-type: none"> • 4 field supervisors and 16 enumerators • Target sample: 1,185 households • Achieved sample: 1,183 households surveyed
Small Business questionnaire	November 2018–January 2019	<ul style="list-style-type: none"> • 2 field supervisors and 8 enumerators • Target sample: 384 businesses • Achieved sample: 330 businesses surveyed
Phase 2: Unconnected users' study, qualitative and medium and large study		
Listing	April 2019	<ul style="list-style-type: none"> • 5 field supervisors and 20 enumerators • Target sample: All households and small businesses in 125 EAs across 25 communities • Achieved sample: 8327 households and 425 small businesses

Phase and activity	Deployment date	Fieldwork details
Community profile	April 2019	<ul style="list-style-type: none"> • 4 enumerators • Target sample and achieved sample: 25 communities
Household questionnaire	May 2019–June 2019	<ul style="list-style-type: none"> • 5 field supervisors and 20 enumerators • Target sample and achieved sample: 875 households
Small business questionnaire	May 2019–June 2019	<ul style="list-style-type: none"> • 5 field supervisors and 20 enumerators • Target sample: 423 businesses • Achieved sample: 402 small businesses surveyed
Medium and large end-user questionnaire	July 2019–November 2019	<ul style="list-style-type: none"> • 10 enumerators • Target sample: 313 medium and large organizations • Achieved sample: 180 medium and large organizations
Qualitative in-depth interviews and focus groups	July–September 2019	<ul style="list-style-type: none"> • 16 interviewers • Target sample and achieved sample: 10 focus groups, 32 in-depth interviews

d. Cleaning, creating constructs, and analyzing data

After completing field data collection, we conducted a detailed cleaning process for each survey. Based on the research questions we aimed to answer about end user outcomes, we developed a series of constructed variables to be used for analysis in both the connected and unconnected user studies and then analyzed each construct in the table. Below, we describe the processes for cleaning the data, creating the constructs, and analyzing the data.

Cleaning. Once we received the survey data sets from TKG, we conducted a thorough quality checking and cleaning process. We ensured that all respondents were part of our sample, and that the expected number of records were in the data set. We also confirmed that all survey questions were present in the data set and coded the data to identify questions that were not relevant to the respondent or were mistakenly missed.

We carefully reviewed the distributions of variables in the data sets to check for outliers. For variables that had large outliers, we replaced values above the 95th percentile with the value of the variable at the 95th percentile. If a value was logically implausible (such as more than 24 hours in a day), we removed the value from the data set. Before using our data sets for analysis, our analytic team reviewed the distributions of each variable to ensure that the distributions were reasonable.

Variable construction and analysis. First, we designed the study instruments to ask consistent questions across households, businesses, and communities in both the connected and unconnected user studies, and so we were able to create variable constructs that were defined in the same ways across different studies, allowing us to provide straightforward comparisons of data from different types of entities (households, businesses, and communities), different locations (Monrovia and Kakata), and different years (2016 and 2018). For example, we collected data and created variables to capture energy sources used, the amount spent on

electricity, the main use of electricity, the type of appliances owned, household members' time use, lighting in the community, and energy theft. For connected households, we generated constructs to capture the connection experience and perceptions of LEC. For unconnected households, we created constructs to indicate the reasons for not having LEC. For businesses (small, medium, and large) in the connected and unconnected user studies, we created constructs for the number of employees, the cost of electricity and other forms of energy, expenditures on generators and surge protectors, revenue, and the effect of various power sources on the business's ability to operate and provide its services.

For communities in the connected and unconnected user studies, we created constructs for the percentage of households receiving electricity from various sources (including LEC in the connected study), number of people living in the community, community characteristics, price of energy sources in the community, type of road access in the community, cell phone ownership, water supply sources, presence of markets, and numbers of vendors and shops. For connected communities, we also created constructs for the presence of LEC in the community as a whole and in specific institutions within the community (such as schools, banks, and pharmacies), number of hours of LEC electricity available per day, and the presence of illegal connections. Finally, in the connected user study, we created constructs for the year 2018 and for retrospective data from the year 2016, whereas in the unconnected user study, we only collected data for the year 2018.

We present means or frequencies for the analytic constructs for each of the outcomes. We compared outcomes across households and businesses, and compared connected households, businesses, and communities to unconnected households, businesses, and communities, respectively. For retrospective data from 2016 in the connected study, we conducted a statistical test (Wald test) to see how much the outcome changed and whether the change was statistically significant. We reviewed the output of our tables to ensure that variables that we expected to sum together did so correctly.

4. Qualitative data to answer research questions at all levels

We conducted a range of qualitative activities. First, we conducted focus group discussions (FGDs) with household members; IDIs with small business owners and public sector respondents from health centers, schools, and local government; and KIIs with energy sector stakeholders. For the FGDs and IDIs, we used the sampling frame from the quantitative studies to select respondents. Table C.8 describes our sampling approach. Next, we conducted KIIs with respondents from across the Liberia energy sector. Finally, we conducted site visits to observe energy sector operations. We describe the data collection and analysis procedures below.

a. Sampling for FGDs and IDIs

We used the following procedures to sample respondents for the FGDs and IDIs (Table C.8). First, we developed a sample of respondents for each activity. For the FGD sample, we used household listing data, and stratified heads of households by gender. We randomly selected respondents to create male-only, female-only, and mixed gender FGDs. We invited selected respondents to participate, and selected alternates to ensure the FGDs had enough participants. Next, for the IDIs of small businesses, we used the list of small businesses in each community and stratified the businesses by type. We purposively selected businesses that would need

electricity to maximize profits and that represented the most common businesses. We randomly selected business owners from each selected type of business to participate in the IDIs. Next, we used the community profile and listing to identify public sector respondents from health centers, schools, and government offices for IDIs. Again, we purposively selected respondents to represent common agencies, and included both male and female respondents.

b. Instrument development

We developed a separate set of qualitative instruments for connected and unconnected communities, including guides for household FGDs and for the interviews with small businesses, local government, health facility, school director, and community leaders. Like the quantitative surveys, the guides were adapted from versions used in the Tanzania energy evaluation, and then refined in an iterative process that involved reviews by MCC and MCA-Liberia and TKG, piloting, and pre-testing. Final revisions integrated input from reviews and from pilot and pre-test exercises in Liberia.

c. Data collection and quality assurance

The field team for FGDs and IDIs located selected household members with help from community leaders, and when needed, used geo-coded location data. After following proper community entry procedures, the team invited the respondents to participate in the FGDs and IDIs. After the team obtained consent from the invited participants, the teams conducted the FGDs and interviews in their respective communities. In total, the field teams conducted 10 FGDs and 52 KIIs in connected and unconnected communities in Greater Monrovia and Kakata. All interviewers used a recording device on their tablets and followed a process whereby audio files were uploaded daily and immediately transcribed. TKG completed quality assurance checks to ensure that files were properly transcribed and fully captured the entire discussion.

The team began with a pilot activity to test the interview guides, gain practice, and receive feedback. After the FGDs and IDIs were conducted, audio files and transcripts were immediately shared with Mathematica for extensive review and comments. TKG and Mathematica also discussed feedback in a team call. The guides were finalized, and TKG completed a pre-test activity that served as a trial run. For each of these FGDs and IDIs, TKG again completed all discussions, immediately transcribed and shared audio files and transcripts, and received detailed feedback from Mathematica. Following this process, which was repeated twice, TKG completed the IDIs and FGDs.

Table C.8. Qualitative sampling approach and samples

Respondent type	Data source for sampling	Sample selection process, sampling frame, and stratification approach	Sample size
FGDs	Monrovia and Kakata listing data	<ul style="list-style-type: none"> Randomly selected five EAs from Monrovia and Kakata listing data Randomly selected potential participants, including replacements For both Monrovia and Kakata, selected males for two EAs, females for two EAs, and both for one mixed-gender EA In the mixed gender EA in Monrovia, we stratified by gender to arrive at an equal proportion of male and female respondents. The Kakata listing did not record gender, so TKG screened potential FGD respondents to achieve equal gender balance. 	n = 5 in Monrovia n = 5 in Kakata In each location, (2 male, 2 female, 1 mixed group) 8–10 participants per FGD
Small business IDIs	Monrovia and Kakata listing data	<ul style="list-style-type: none"> In same EAs as FGDs, tabulated small business types Selected respondents based on business type and project relevancy Within business types, randomly selected respondents Types of businesses included small grocery shops, food business, tailoring/clothing repair, clothing production, cell phone dealer/repair/charging, other electric/electronic repair, market seller or trader medical, facility/clinic/dispensary. 	n = 10 in Monrovia n = 10 in Kakata
Local government IDIs	Monrovia and Kakata community profile data	<ul style="list-style-type: none"> In same EAs that were randomly selected for the FGDs, tabulated types of local government officials Stratified by type and randomly selected respondents Sampled government officials including the town chief or commissioner, and women's leaders 	Monrovia 6 = Local government 2 = Women's leaders Kakata 4 = Local government 3 = Women's leaders
Public sector (health centers, hospitals, schools) IDIs	Monrovia and Kakata community profile data	<ul style="list-style-type: none"> In same EAs that were randomly selected for the FGDs, tabulated types of public sector entities Stratified by type and randomly selected respondents Public sector entities include government senior and junior high schools, post office, bank, dispensary/pharmacy, health center, hospital, local government office, mobile money agent/branch. 	Monrovia 3 = School 3 = Health Kakata 5 = School 6 = Health

Note: We sampled with replacements to achieve desired sample sizes.

d. High-level key informant interviews

We conducted KIIs with stakeholders from across Liberia’s energy sector, including respondents from MCC and MCA-L, officials from MME and LERC, the CEO, CFO, chief operating officer, and other key staff of ESBI, department heads at LEC, contractors including Azorom, Manitoba Hydro International (MHI), Norplan Fichtner, and Hydro Operations International (HOI), and directors at donor agencies including AfDB, EIB, EU, JICA, KfW, NORAD, USAID, and the World Bank (Table C.9). In most cases, we had multiple conversations over several years, and took detailed notes of those conversations. We conducted more formal interviews in October and November 2019. At that point, we could ask respondents to reflect on the overall sector, implementation successes and challenges, and project strengths and weaknesses. We did not develop interview guides, rather we prepared by reviewing all data sources we had collected including reports, news articles, field data collection, and administrative data. We mapped the research questions and outcomes of interest to each respondent to guide the overall focus of the interview. We asked each respondent to reflect on concepts that they were familiar and let interviews progress organically when respondents had discussion points that they thought were useful. We aimed to be as exhaustive as possible, inviting as much participation in the interviews as possible. When necessary, we followed up with respondents to seek clarification, request documentation, confirm findings or validate data collected elsewhere. We took extensive notes during all discussions to produce detailed transcripts for all KIIs.

Table C.9. Qualitative KII respondents’ organizations

MCC	Mt. Coffee	Donors	Utility and supports	Policy and regulatory bodies
MCC-Washington (11)	<ul style="list-style-type: none"> • MCHPP: LEC (3) • Project implementation unit (PIU): Manitoba Hydro International (1) • Owner’s Engineer: Norplan Fitchner (1) • Operations maintenance and training (OMT): Hydro Operations International (5) 	<ul style="list-style-type: none"> • AfDB (1) • EIB (1), EU (1) • JICA (2) • KfW (1) • NORAD (1) • USAID, Power Africa (1) • World Bank (2) 	<ul style="list-style-type: none"> • LEC (6) • MSC (7) • LEC Board (2) • CMC (1) • Indra (3) 	<ul style="list-style-type: none"> • LERC (4) • MME (2)
MCC-Liberia (2)				
MCA (6)				

e. Site visits

We conducted visits in 2017, 2018, and 2019 to sites including the Mt. Coffee Hydropower Plant, Bushrod Power Plant, and five other substations. We were able to observe generation, transmission and delivery (T&D), and commercial operations firsthand and better understand the strengths and challenges of each aspect of the system and the complexity of the plants, the range of materials and parts needed to service the machinery, and the critical importance of preventative maintenance and repairs. At MCHPP, we were able to see the hydroelectric dam generating power and the site where the Cote d’Ivoire, Liberia, Sierra Leone, and Guinea (CLSG) line will eventually be connected to the grid. We observed the SCADA system and administrative operations, and were able to talk with operations, performance monitoring,

training, and maintenance staff. The visit to the Bushrod Power Plant allowed us to better understand complexity across the various generators and see the intricate machinery that makes up the full system. Operators explained the need for critical repairs, indicating key parts that were on order or difficult to obtain, and the process of transferring generators to use heavy fuel oil instead of the more expensive light fuel oil. They also pointed to system problems that had arisen and the need for LEC to develop sophisticated skills to problem-solve when repairing these machines. We also observed how generation data are collected, stored, and shared. Visits to substations revealed the weaknesses and challenges of the system related to mechanics and administrative data collection. During each visit we took notes on processes and photos of machinery to help us understand how the various generation and T&D systems work together and the systemwide impact of even small failures.

f. Analysis

We systematically analyzed the FGD, IDI, and KII transcripts and our notes from site visits. First, TKG sent us the audio files and transcripts for all FGDs and IDIs. We finalized the KII transcripts and notes. For all these data, we began the analysis by listening to all audio files and reading and rereading the transcripts. We focused on the concepts important to the study's research questions, the qualitative guides, our outcome and respondent mapping, the program logic, and the Liberian context. We developed an analytic coding scheme and hierarchy that enabled us to explore, sort, and organize the data into key concepts that emerged. Next, we coded the transcripts word by word according to key themes, using NVivo qualitative data analysis software. We reviewed, organized, and analyzed the data according to the evaluation questions and study themes. We compared responses by respondent type and location to identify similar and disparate reports across groups. The final analysis involved analyzing the coded data, and then synthesizing and validating responses to extract the key findings related to the various study themes and concepts. We repeated this analytical process until we understand the nuances in the data. Next, we triangulated findings across all the data sources, including reports and quantitative components. This process allowed us to identify trends, confirm patterns, detect discrepancies or disparate findings, and synthesize the themes. We present both summary findings and representative quotes to help the reader understand the themes in more detail. The quotes provide a sense of the stakeholder responses, as well as the varying perspectives of respondents on different themes.

5. Plans for future data collection

The interim and endline reports will draw on both quantitative follow-up data and the qualitative data to comprehensively answer the research questions related to the grid-level and end-user outcomes. For the interim quantitative study, we plan to survey communities, households, small businesses, and medium and large organizations that participated in the baseline study between October 2020 and April 2021; Endline survey data for the same group of participants will be collected between January and August 2024. During the interim and endline data collection periods, we will conduct qualitative KIIs and FGDs to strengthen our understanding of connection decisions, end user perceptions, and energy-related behaviors over time. In addition, we have proposed qualitative case studies that closely examine customers' journeys and experiences as they gain access to electricity; for those, we would interview a select sample of households and small businesses annually to deepen our understanding of household and business behavior as grid electricity becomes available, including the evolving decisions about

grid connections; electricity use and experiences and LEC service provision. Table C.10 details the timeline for the interim and endline studies.

Table C.10. Study timeline

Name of round	Data collection	Data cleaning & analysis	First draft report expected	Final draft report expected
Baseline quantitative and qualitative	October 2018–September 2019	July 2019–December 2019	January 2020	March 2020
Connected listing and community survey	October 2018			
Connected household and small business	November 2018–December 2018			
Unconnected listing and community survey	April 2018			
Unconnected household and small business	May 2019–June 2019			
Qualitative	August 2019			
Medium and large	September 2019–November 2019			
Interim quantitative and qualitative	October 2020–April 2021	January–August 2021	August 2021	October 2021
Preparatory fieldwork and community survey	October 2020			
Connected household and small business	November 2020–December 2020			
Unconnected listing and community survey	January 2021			
Unconnected household and small business	February 2021–March 2021			
Qualitative	April 2021			
Medium and large	May 2021–June 2021			
Endline quantitative and qualitative	October 2023–April 2024	January–August 2024	August 2024	January 2025
Preparatory fieldwork and community survey	October 2023			
Connected household and small business	November 2023–December 2023			
Unconnected listing and community survey	January 2024			
Unconnected household and small business	February 2024–March 2024			
Qualitative	April 2024			
Medium and large	May 2024–June 2024			

6. Risks to internal and external validity

In Table C.11, we outline the risks to internal and external validity, and discuss potential mitigation strategies for the quantitative and qualitative studies.

Table C.11. Internal and external validity

Type	Quantitative studies		Qualitative studies	
	Risks	Mitigation strategies	Risks	Mitigation strategies
Internal validity	<p>The evaluation design for the studies of connected, unconnected, and medium and large end users is a performance evaluation. The studies will not identify a rigorous counterfactual for these end users. This limits our ability to attribute changes in end user outcomes to the Energy Project because external events and other factors also influence our study outcomes in a pre-post design. Nonetheless, our design will allow the studies to provide suggestive evidence on what impacts might be plausible for end users.</p>	<p>Although we will not be able to establish a causal relationship between the project and end user outcomes as we could in a randomized control trial, the pre-post design remains a strong evaluation approach because we are tracking the same participants over time and accounting for potentially important unobserved end-user characteristics that can affect outcomes. We are also continuously tracking external events or factors that might affect outcomes relevant to our evaluation and will account for any significant factors we identify in our analysis.</p>	<p>A risk to qualitative data collection is putting too much weight on each individual's response given that there are far fewer qualitative respondents than quantitative. Also, we recognize that we may not have included all demographic categories, and may have missed Liberians with low levels of literacy or confidence in participating in research. We may have inadvertently excluded potential respondents with work and caregiving responsibilities. Further, potential respondents who are actively engaged in energy theft may have opted out of participating.</p>	<p>We employed random sampling to select a representative group of informants across different types of respondents.</p> <p>We implemented rigorous data collection, transcription and analyses in order to fully understand the perspectives of respondents. We were also careful not to place too much weight on each respondent.</p>
	<p>Our ability to provide accurate quantitative evidence on end user outcomes depends on achieving high response rates to the interim and endline household and business surveys. There is potential for low response rates in our follow-up surveys. If that happens, it is possible that only particular types of end users—such as those likely to have positive (or negative) outcomes—will appear in the data and drive findings. This would mean we would have to exercise great caution in drawing conclusions.</p>	<p>We took steps during baseline data collection to ensure high response rates during follow-up surveys. The baseline surveys collected detailed contact information, GPS coordinates, and—in some cases—photos of households and businesses. We will use this information to track and locate end users for the follow-up surveys and consider conducting phone surveys when face-to-face interviews are not possible.</p>	<p>It is possible that respondents felt that in some way, their responses could lead to electricity connections or consequences for theft.</p>	<p>We reminded respondents repeatedly that the research team is not part of LEC and we were conducting independent research.</p>

Type	Quantitative studies		Qualitative studies	
	Risks	Mitigation strategies	Risks	Mitigation strategies
External validity	<p>Our study evaluates end-user outcomes from a sample of end users in Monrovia and unconnected end users in the Kakata-Paynesville corridor. Therefore, the results from our study will not be generalizable to all of Liberia or to investments in the energy sector in other countries.</p> <p>There were low response rates to our survey of medium and large organizations, indicating that our sample is unlikely to be representative of all medium and large end users in Greater Monrovia. The key reasons for a low response rate were difficulty in locating organizations in the sample, organizations declining to be interviewed, and organizations not being in existence during field data collection.</p>	<p>Although our study only includes participants from the Monrovia and Kakata regions, we employed a rigorous two-stage sampling approach—involving randomly selecting communities, listing all households and businesses in these communities, and randomly sampling end users using the listing data—to ensure that our results are generalizable to all end users in the sampled areas. In addition, we will be able to compare our sample characteristics to nationally representative data (if these are available) to investigate whether the results can be generalizable to other regions of Liberia.</p> <p>Although we had low response rates for organizations sampled from the Liberia Business Registry’s list, our sample also include organizations from LEC’s list of existing and potential customers. The impacts on these medium and large customers would be most relevant and are of great interest to LEC.</p>	<p>The qualitative activities are generalizable to residents, business owners, and officials in the communities across Monrovia for the connected study and Kakata for the unconnected study. We do not believe we can generalize to additional communities given that we believe these populations are unique due to their location and economic status.</p>	<p>The qualitative transcripts were rich and comprehensive. We were able to learn about a wide range of topics and could continue to mine them for data. We did not get to the point where there were no new themes captured however, suggesting that additional qualitative studies in other parts of Greater Monrovia or surrounding areas might be warranted.</p>

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Appendix D: Tables with statistics on key variables from quantitative surveys

1. Demographics and characteristics of samples

a. Connected and unconnected communities

Table D.1. Community characteristics: population, type, LEC access, and energy sources available

	Connected N = 30	Unconnected N = 25
Community characterization		
Number of people living in the community	11,836	32,393
Number of households in the community	3,473	4,082
Community type (%)		
Regular/formal settlement (large urban area)	58.6	28.0
Informal settlement (large urban area)	10.3	4.0
Slum settlement	24.1	4.0
Regular/formal settlement (town/small urban area)	6.9	40.0
Rural (village)	0.0	24.0
LEC access		
Community has full access to LEC (%)	93.3	0
Community has partial access to LEC (%)	6.7	20.0
Community currently receives no LEC electricity (%)	0	80.0
Community has low voltage lines connecting households/businesses (%)	76.7	36.0
Energy sources available in community (prices in USD)		
Kerosene (%)	13.3	0.0
Kerosene (average price per gallon)	5	n.a
Diesel (%)	16.7	28.0
Diesel (average price per gallon)	4	4
Petrol (%)	43.3	64.0
Petrol (average price per gallon)	4	3
LPG (propane) (%)	6.7	4.0
LPG (propane) (average price per gallon)	35	30
Firewood (%)	36.7	72.0
Firewood (average price per bundle)	1	1
Charcoal (%)	1.0	96.0
Charcoal (average price per large bag)	3	3

n.a. = not applicable.

Table D.2. Community characteristics: infrastructure, cell phone usage, and water source

	Connected N = 30	Unconnected N = 25
Local infrastructure		
Community is accessible by road		
By paved road (%)	50.0	24.0
By unpaved road (%)	46.7	64.0
Community is not accessible by road (%)	3.3	12.0
Community has streetlights (%)		
On most streets (%)	3.3	0.0
On some streets (%)	66.7	16.0
Community has no streetlights (%)	30.0	84.0
Good cell phone network connectivity		
Throughout the community (%)	83.3	80.0
Some parts of community (%)	16.7	20.0
Cell phone ownership (%)		
Almost all people	90.0	84.0
Some people	6.7	12.0
Very few people	3.3	4.0
No one	0.0	0.0
Three most common sources of water (%)		
Pipe indoors	23.3	8.0
Outdoor tap	23.3	8.0
Private hand pump	33.3	4.0
Public standpipe/tap/hand pump	63.3	84.0
Residential reservoir	0.0	0.0
Neighboring household	0.0	0.0
Water vendor (clean water)	13.3	16.0
Push water vendor	3.3	0.0
Covered well	63.3	60.0
Uncovered well	26.7	48.0
River, lake, or creek	0.0	20.0
Rainwater	3.3	8.0
Mineral (bottled/drum/plastic)	40.0	20.0
Other	0.0	0.0

b. Connected and unconnected households

Table D.3. Characteristics of the household head in connected and unconnected households

	Connected N = 1174	Unconnected N = 874
Characteristics of household head		
Household head is female (%)	31.7	31.3
Age of household head	40.5	42.4
Household head is married (%)	30.6	30.2
Household head's highest level of education (%)		
No school	8.3	19.5
Some elementary	3.6	5.9
Elementary completed	1.1	1.9
Some junior high	6.1	11.0
Junior high completed	1.9	4.7
Some senior high	11.3	11.3
Senior high completed	32.3	23.3
Technical/vocational education	4.9	5.2
Some college/university	17.2	8.4
Completed college/university or higher	13.2	8.9
Household head employment status (%)		
Seeking employment	24.1	13.5
Unemployed, not seeking employment	9.5	19.9
Apprentice/student	4.9	3.8
Retired	2.2	1.5
Other, inactive	4.2	1.4
Employer/self-employed	24.8	44.0
Permanent employee	20.8	8.0
Temporary employee	5.4	0.2
Member of a cooperative	0.5	1.5
Family caregiver	0.4	0.0
Other	3.2	6.1

Table D.4. Housing, income, and expenditures for connected and unconnected households

	Connected N = 1174	Unconnected N = 874
Dwelling and socioeconomic characteristics		
Household socioeconomic status		
# of rooms to sleep in current residence	3.0	2.5
Household roof (%)		
Iron sheets/zinc/tin	93.7	98.0
Concrete	3.8	0.7
Other	2.5	1.2
Household wall material (%)		
Iron/zinc/tin	14.9	1.7
Concrete/cement blocks	83.8	69.2
Other	1.3	29.1
Household floor material (%)		
Earth/mud	3.9	20.0
Concrete/cement tiles	86.2	72.7
Tiles	9.9	7.1
Monetary value of all household assets (USD)	1380	334
Household wage income, annual (USD) (by percentile)		
Mean	624	323
Minimum	0	0
25th percentile	0	0
50th percentile/median	0	0
75th percentile	87	63
Maximum	12412	12000
Household non-wage income, annual (USD) (by percentile)		
Mean	272	204
Minimum	0	0
25th percentile	0	0
50th percentile/median	0	10
75th percentile	50	149
Maximum	13500	6047
Household total income, annual (USD) (by percentile)		
Mean	1250	758
Minimum	0	0
25th percentile	0	0
50th percentile/median	44	114
75th percentile	1205	796
Maximum	46942	32777
Total household expenditures, annual (USD) (by percentile)		
Mean	2321	1380
Minimum	0	0
25th percentile	913	744
50th percentile/median	1904	1200
75th percentile	3119	1800
Maximum	18323	6156

Table D.5. Characteristics of income-generating activities in connected and unconnected households

	Connected N = 1174	Unconnected N = 867
Income-generating activity		
Household has an IGA in 2018 (%)	32.2	23.3
IGA sector of main IGA in 2018 (%)		
Small grocery shop	10.2	12.4
Other food business	31.4	35.6
Other non-food business	58.4	52.0
Number of employees in 2018 (paid and unpaid)	1.7	1.7
Business is registered with Liberia Business Registry (%)	15.1	5.1
Average monthly revenue in 2018 (USD)	681	126
Average monthly profit in 2018 (USD)	479	53

IGA = income-generating activity

c. Connected and unconnected small businesses

Table D.6. Characteristics of connected and unconnected small businesses

	Connected			Unconnected
	2016 N=204	2018 N=322	Two-year change (2016–2018)	2018 N=400
Small business characteristics				
Months business has been operating		66.7		52.5
Business activity (%)				
Small grocery shop		20.8		11.8
Tailoring/clothing repair		7.3		7.4
Clothing production		1.6		4.6
Cell phone dealer/repair/charging		8.6		5.6
Other electric/electronic repair		8.3		2.5
Other food business (restaurant/bar, food seller)		17.2		13.9
Other non-food business (market seller, trader)		25.5		44.3
Medical facility/clinic/dispensary		5.2		5.6
Beauty salon/barber shop		5.5		4.2
Number of paid employees	1.6	0.9	-0.1	0.6
Number of unpaid employees (including family members)	1.6	1.6	0.0	1.5
Business is registered with the Liberia Business Registry (%)		69.5		57.6
Business operations				
Months of operation in past year	11.6	10.8	-0.8***	10.1
Days of operation per week	6.2	6.2	-0.0	6.1
Hours of operation per day	9.9	10.2	0.3	9.7
Average monthly revenue (USD)	3184	1488	-1696	1403
Average monthly profit (USD)	1010	609	-400	344

d. Medium and large end users

Table D.7. Characteristics of medium and large organizations

Outcome	Government and state-owned enterprises	NGOs	Medium private org	Large private org	Other
	N = 20	N = 28	N = 74	N = 9	N = 44
Organization characteristics					
Months organization has been operating	641.7	156.4	139.4	282.1	232.1
Type of activity (%)					
Education (schools, colleges, training centers)	5.0	28.6	36.5	0.0	45.5
Hotel and restaurants	0.0	0.0	4.1	22.2	0.0
Construction	0.0	0.0	9.5	33.3	2.3
Health (clinics, hospitals)	10.0	0.0	4.1	0.0	9.1
Religion	0.0	3.6	1.4	0.0	11.4
Aid/Charity	0.0	60.7	0.0	11.1	0.0
Banking and finance	0.0	0.0	5.4	11.1	9.1
Regulator	20.0	0.0	0.0	0.0	4.5
Security and law	25.0	0.0	8.1	0.0	6.8
Water, sanitation and waste	5.0	3.6	2.7	0.0	2.3
Other	35.0	3.6	28.4	22.2	9.1
Staffing and registration characteristics					
Number of paid employees	404.3	18.2	26.0	234.2	82.1
Number of unpaid employees	18.0	15.2	6.5	5.0	8.4
Organization is from the LBR Registry sample (%)	0	100	89.2	44.4	81.8
Operations					
Months of operation in past year	12.0	11.0	10.8	12.0	11.1
Days of operation per week	5.8	5.3	5.5	5.8	5.5
Hours of operation per day	8.7	7.9	7.8	8.5	8.4
Average monthly revenue in 2018 (USD)	435123	4185	131864	1664895	272821
Average monthly profit in 2018 (USD)	24778		27422	378767	59890

Note: Our survey data included 6 private organizations that we could not classify as either medium or large because they did not report on number of employees. For this table, we assume they are medium organizations. Our survey did not ask whether organizations were registered in the LBR, we are only reporting if the organization came from the LBR's list of organization or LEC's list of organizations; The figure on average monthly revenue for NGOs comes from 1 organization alone. None of the NGOs reported on profit.

2. Spending on electricity and energy

a. Connected and unconnected households and small businesses

Table D.8. Household and small business spending on electricity sources

Outcome	Connected study		Unconnected study	
	Households N=117	Small businesses N=311	Households N=867	Small businesses n.a.
Expenditure on electricity sources from November 2017 to October 2018				
Direct line from LEC	117	277	n.a.	n.a.
Indirect line from LEC	44	39	n.a.	n.a.
Generator (solar)	46	n.a.	n.a.	n.a.
Generator (hydro or wind)	41	n.a.	n.a.	n.a.
Generator (liquid fuel)	39	n.a.	26 ^a	n.a.

^aFor unconnected household, our survey only asked about expenditure on generators in general, not broken down by solar, hydro or wind, or liquid fuel. n.a. = not applicable.

Table D.9. Household and small business spending on other energy sources

Outcome	Connected study		Unconnected study	
	Households N=1174	Small businesses N=311	Households N=867	Small businesses N=400
Average monthly expenditure on non-electric energy sources (USD)				
Kerosene	0	7	0	0
Diesel	1	1	2	9
Petrol	1	2	3	6
LPG	0	0	0	0
Firewood	0	0	0	0
Charcoal	12	5	8	2
D-size dry cell battery (big battery)	2	2	2	2
C-size dry cell battery (medium battery)	0	0	4	0
AA-size dry cell battery (finger battery)	2	0	3	0
AAA size dry cell battery (small battery)	0	0	0	0

b. Medium and large end users

Table D.10. Medium and large end users' spending on electricity sources

	Government and state- owned enterprises	NGOs	Medium private org	Large private org	Other
Outcome	N = 20	N = 28	N = 74	N = 9	N = 44
Expenditure on electricity sources from January 2018 to December 2018					
Direct line from LEC	66940	827	3322	439900	41011
Indirect line from LEC	0	12	34	0	0
Generator (solar)	0	1542	552	375	116
Generator (hydro or wind)	0	0	849	0	55
Generator (liquid fuel)	70884	127	9859	132633	6387

Table D.11. Medium and large end users' spending on other energy sources

	Government and state- owned enterprises	NGOs	Medium private org	Large private org	Other
Outcome	N = 20	N = 28	N = 74	N = 9	N = 44
Average monthly expenditure on non- electric energy sources (USD)					
Kerosene	0	0	0	0	0
Diesel	5327	10	1420	3566	3318
Petrol	8	256	1098	0	337
LPG	0	0	6	0	0
Firewood	0	19	0	0	0
Charcoal	0	1	1	0	0

3. Use of energy-intensive appliances or equipment samples

a. Connected and unconnected households

Table D.12. Household use of energy-intensive appliances or equipment among households

Outcome	Connected study			Unconnected study
	2016	2018	Two-year change (2018-2016)	2018
Household average hours of use:				
Light bulbs	11.4	12.3	0.8**	1.7
Fan (stand/table/wall)	4.3	4.7	0.4	1.0
Ceiling fan	0.1	0.1	-0.0	0.1
Television	3.0	3.1	0.1	0.7
Radio	1.2	1.1	-0.0	2.9
Refrigerator	1.6	1.7	0.1	0.3
Air-conditioner	0.1	0.1	-0.0	0.0
Stoves	0.0	0.0	-0.0	0.0
Electric lantern	0.1	0.1	0.0	1.1
Water pump	0.1	0.1	-0.0	0.0

b. Connected and unconnected small businesses

Table D.13. Small business use of energy-intensive appliances or equipment

Outcome	Connected study			Unconnected study
	2016	2018	Two-year change (2018-2016)	2018
Small business average hours of use:				
Light bulbs	5.1	8.9	3.9***	4.9
Fan (stand/table/wall)	3.1	4.5	1.3**	1.6
Ceiling fan	0.7	0.9	0.1	0.6
Television	1.6	2.3	0.7*	1.0
Radio	0.5	0.7	0.2	1.8
Refrigerator	1.4	2.4	1.0**	0.8
Air-conditioner	0.6	0.6	0.0	0.2
Stoves	0.0	0.0	0.0	0.0
Electric lantern	0.0	0.0	0.0	0.1
Water pump	0.0	0.0	0.0	0.1

c. Medium and large end users

Table D.14. Medium and large organization use of energy-intensive appliances or equipment

	Outcome
Type of appliance or equipment	
Television	3.2
Refrigerator/Freezer	4.7
Air-conditioner	4.5
Telephones	3.6
Computers and accessories	6.6
Water pump	2.4

Appendix E: Summary of IRB requirements and clearances

Mathematica is committed to protecting the rights and welfare of human subjects participating in the evaluation. We ensured that the study meets all U.S. and Liberian research standards for ethical clearance by obtaining approval from an IRB ahead of data collection. The IRB application consisted of three sets of documents: (1) a research protocol, in which we described the purpose and design of the research, and provided information about our plans for protecting study participants, their confidentiality and human rights, including how we would acquire consent for their participation; (2) copies of all data collection instruments and consent forms that we planned to use for the evaluation; and (3) a completed IRB questionnaire that provided information about the research protocol, how we would 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 obtained approval for the first and second phase of data collection from the IRB at the University of Liberia's Pacific Center for Research and Evaluation (UL-PIRE) in September 2018 and February 2019, respectively. UL-PIRE's IRB approval for the first phase of data collection also cleared our study for meeting US research standards. As their accreditation with the US Department of Health and Human Services expired in 2019, we submitted an IRB application for the second phase of data collection to Health Media Lab. The study qualified for expedited review because it presents minimal risk to participants. We received approval in March 2019 which is valid for one year. We will submit annual renewals for approvals for subsequent years, as needed.

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Appendix F: Data access, privacy, and documentation plan

All quantitative and qualitative data was securely transferred from the data collection subcontractor to Mathematica, stored on Mathematica's secure server, and access reserved only to project team members who use the data. As outlined in the EDR, after finalizing the baseline report, we will deliver a package of anonymized quantitative baseline data to MCC in 2020. The package will consist of seven separate, well-documented, Stata data sets, 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. 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. All materials will be provided in English.

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Appendix G: Team roles and responsibilities

Our team brings expertise in electrification projects and has decades of experience in conducting impact and performance evaluations in West Africa. The evaluation team's roles and responsibilities are described in Table G.1.

Table G.1. Evaluation team members

Evaluation team members	Role	Responsibility
Dr. Candace Miller	Project director; primary point of contact for client; co-principal investigator	Overseeing the execution of all evaluation components including, communicating with our client, coordinating with key stakeholders across the Liberia energy sector, leading the evaluation design, managing the project budget, overseeing quantitative and qualitative data collection, managing evaluation team's staffing and priorities. Also, primary responsibility for delivering high quality products that meet MCC's and other stakeholders' needs
Dr. Arif Mamun	Co-principal investigator	Advising on quantitative components of the evaluation design and study sample, providing input on data collection, ensuring research questions are answered with appropriate methods
Dr. Paolo Abarcar	Researcher	Contributing to evaluation design, managing data collection, acting as the primary point of contact for sampling for the end-user outcomes, overseeing quantitative data cleaning and analysis
Ms. Kristine Bos	Researcher	Drafting data collection instruments, supporting data collection activities, coordinating with data collection subcontractor, developing baseline report outline
Ms. Poonam Ravindranath	Analyst	Managing internal administrative matters as well as invoicing and reporting, drafting data collection instruments, coordinating data collection activities, supporting data analysis, drafting baseline report and memos on evaluation design
Dr. Sarah Hughes	Quality assurance reviewer	Providing peer review of all data collection instruments and deliverables, acting as a senior advisor to the evaluation team on data collection approaches
Mr. Jeremy Page	Senior analyst	Supporting selection of participants for study sample, leading cleaning and analysis of survey and administrative data
Mr. Matthew Spitzer, Mr. Johnathan Cook. and Ms. Sara Bryk	Research assistant	Cleaning survey data and conducting quantitative analysis of end-user outcomes, creating maps and figures to display data

Evaluation team members	Role	Responsibility
Mr. Gerald Coleman	Local engineer	Providing contextual information and expertise in using utility data, assisting communication with project stakeholders

Appendix H: Budget

Table H.1. Contract budget and costs by task

Evaluation tasks and estimated spending during the base period and option year 1

Task	Original Budget	Costs Incurred as of Jan 31st 2019
	Total Costs	Total costs
Direct labor (DL)		
Assess Evaluation Plan	\$104,029	\$106,316
Develop Evaluation Design Report	\$285,111	\$282,493*
Develop Baseline Evaluation Materials	\$182,017	\$286,499*
Supervise Baseline data collection	\$167,653	\$424,849*
Develop Baseline Report	\$332,706	\$455,986*
Disseminate Baseline	\$72,828	
Monitor program implementation	\$133,105	\$56,579
Subtotal direct labor	\$ 1,277,449	\$1,452,635
ODCs		
Field data collection, travel, other ODCs	\$ 1,116,001	\$761,791
Total DL and ODCs	\$2,394,450	\$2,214,580
Additional base period and option year one tasks		\$ 179,870
Total obligated through option year one		\$2,394,450

Notes: DL denotes direct labor costs. Expenditures are as of January 31, 2020. MCC has been invoiced as of December 31, 2019. Values are rounded to the nearest dollar for ease of reading.

We expect to exhaust base period and option year one funding with additional charges to these tasks: revisions to the design memos and baseline report, report dissemination, and data collection, analysis, and report writing for Activities 3 and 4 by Mathematica).

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Appendix I: MCC and MCA comments on draft report

Table I.1. Comments from MCC and MCA

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
General		Please refer to the study questions as "evaluation questions" rather than "research questions"	We have revised as suggested.
General		I suggest renaming the report to baseline and interim or just interim. The executive summary doesn't provide much (any?) baseline statistics, so it's quite confusing for the reader. The report (and Executive Summary) can be structured to more clearly delineate between interim findings and baseline conditions. I would start with describing the baseline conditions for connected and unconnected households, and then move to answering the evaluation questions.	We have renamed the report using both terms: baseline and interim. We have also added a sentence to explain to the reader that the report contains several studies and focuses on many evaluation questions. The interim findings focus on evaluation questions for activities that have been underway for several years, and outcomes for households and businesses that have been connected to electricity for years. It also presents baseline findings for a study of households and businesses that have not yet been connected to electricity.

Page No.	Affected Text	Requested Change/Comment	Mathematica’s response
General		<p>While it is true that underfunding of ongoing operations and maintenance may lead to plant failure and possible consequences, the report is silent on the critical underlying factors that may be responsible for underfunding.</p>	<p>We provide detailed context on the macroeconomic situation in Liberia, describing how the country has faced a financial crisis, with inflation, reduced foreign investments and exports, which has impacted the government’s ability to invest in LEC. We also present an in-depth explanation for how LEC management has changed over time, post conflict, during the early years of President Sirleaf’s administration, during the first Management Services Contract (MSC), the Ebola crisis, the Interim Management Team’s stewardship, and the second MSC. We describe the context in much detail, including perceptions of key actors across LEC and the donor community, but we agree that we did not interview high level members of government in the Ministry of Finance and the President’s Office. We would be willing to add this to the next interim report if requested and if the government offices would participate.</p>

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
General		<p>The program logic and Compact didn't in a sense underestimate the problems and weaknesses that persist within the sector but basically used available data at that time to analysis prevailing problems and weaknesses</p> <p>The Compact assumption that increased electricity supply together with improved utility management would quickly increase customer access to less expensive electricity was fundamentally linked with planned connection projects from other donors including the World Bank, European Delegation, African Development Bank (AfDB), etc., The use of the word "quickly" gives an impression of an overly exaggerated assumption which seems not to be the case.</p> <p>The assumption that LEC would be able to cover the cost of MCHPP's operations and maintenance was essentially based on the assumption that donors would increase connections and expansion of LEC customer base would provide the necessary financial sustainability for the utility.</p>	<p>Our analysis is based on extensive interviews with MCC and MCA staff and other country level stakeholders, including each of the donors mentioned here. The consensus was that the major challenges were underestimated and that there was pressure to move to a Compact without an analysis of the political economy. However, we removed the word "quickly", as we do not want to give an exaggerated impression given the complexity of issues.</p>
xiii	ESWG and HLSG	<p>The report does not adequately chronical the evolution of the ESWG and HLSG and these groups' focus on LEC operations at the expense of sector reform. The failure of MLME Minister Sendolo and President Johnson to support implementation of the Electricity Law (and the continued lack luster implementation under the current administration) should be covered in greater detail in this report.</p>	<p>First, we note that this comment is in the executive summary (ES). The full analysis is in Chapter VI (Analysis of Utility-Level Outcomes). We asked all local and donor key informants about the ESWG and HLSG to gather as many insights as possible. We also reviewed all of these documents closely. We would have preferred the opportunity to observe these meetings. Given our access, we felt as though we included as much analysis of these as possible in the report as we had access to. We are open to conducting additional interviews though to explore these issues further.</p>
xv	Modernize Liberia's energy network	Delete	<p>We revised as suggested in the ES and on page 1 of the main report.</p>

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
xvi	However, it lacks resources beyond January 2021	and its future financial resources through a tariff levy are at risk due to LEC's poor financial performance.	We acknowledge this issue particularly in Chapters IV.B.4. and V.B.
xvii	The program logic and Compact underestimated the problems and weaknesses that persist throughout Liberia's energy sector, government, economy, and workforce.	This statement is not accurate. They were not underestimate and the program was designed to coordinate with other donor programs due to the scale of the problem in the sector. MCC would have had to assume responsibility for all other programs and implement new programs to address the basic deficiencies in the sector and governmental corruption.	We used the term "underestimated" because we heard this repeatedly from stakeholders. We revised the sentence to state: "While the program was designed to coordinate with other donors, the program logic and Compact underestimated the problems and weaknesses that persist throughout Liberia's energy sector, government, economy, and workforce."
xvii	A flawed underlying Compact assumption was that increased electricity supply, together with improved utility management, would quickly increase customer access to less expensive electricity.	This statement is not accurate. There is substantially greater access to electricity because the power production from MCHPP and Bushrod is being consumed at a low price. Unfortunately, it is being stolen.	We agree that there is substantially greater access to electricity, but we have not revised this sentence because we state "increased customer access to electricity"
xvii	Another problematic assumption was that LEC would be able to cover the cost of MCHHP's operations and maintenance, ensuring the sustainability of the power plant.	This statement is not accurate. The GOL, not LEC, committed to cover the MCHPP (not MCHHP's) costs through an escrow account. In addition to allowing theft through its connections, not paying for its own electricity consumption and condoning theft by GOL appointees, LEC's financial crisis ongoing. No amount of donor support will enable MCHPP to be properly maintained if the GOL continues its current practices.	We revised to clarify: "Another problematic assumption was that, by drawing on the escrow account, the GOL through LEC, would be able to cover the cost of MCHHP's operations and maintenance, ensuring the sustainability of the power plant." We acknowledge the GOL's shortcomings throughout the report.
xvii	An important oversight was the failure to account for the extent of power theft throughout LEC and Liberia.	This statement is inaccurate. When MCC finished its compact development, theft was not a factor. The cartel is a new phenomenon due to the availability of greater energy supplies. The imposition of the IMT rather than the continuation of the MHI MSC was a major cause of the creation of the cartels. These items were not accounted for because they did not exist.	We found evidence of power theft in Liberia emerging as an issue in 2015, when the losses were about 37 percent and reaching 61 percent in 2017. This is according to the LEC administrative data.

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
xvii	The contract vehicles for MCHPP rehabilitation had several weaknesses.	This statement is not accurate. It was always intended that the new MSC would take over for the PIU. This has happened and all major works have been successfully completed.	We based this statement on analyses of many key informant interviews conducted over several years and a thorough review of contracts, PIU reports, and CMC reports. We acknowledge that the MSC would take over for the PIU, and that most works were successfully completed but there were also weaknesses given some works were not completed and the MSC was not prepared to take ownership of MCHPP.
xix	Missing threat	GoL continues to condone theft and poor oversight of LEC management through inadequate technical expertise and fiduciary commitment on the LEC board.	Revised to clarify as suggested. "Indecision or inaction on the part of the GoL to continue the MSC is a key threat. Further threats include the fact that the GOL appears to continue to condone theft, demonstrate poor oversight of LEC management, provide inadequate technical expertise on the LEC board, and lacks fiduciary commitment to LEC."
xix	Build budgets and contingency plans that assume a catastrophic event to give the program a better chance to succeed.	1. The MCHPP budget did plan for a catastrophic event. The contingency for that event was not used and applied to meet design deficiencies in the project. 2. No amount of budgeting could address the catastrophic results of GOL lack of support for the sector.	We agree that the GOL has been a difficult partner and believe this is clear in the text throughout the report.
xix		Whose primary responsibility would be for better coordination with LEC and the donor community?	We suggest that ESBI as the MSC should have a specific position whose main responsibility is to focus on donor coordination.
xix		Good point about a concession of MCHPP's operation to a private firm.	Thank you.
xix		Good point about the risk of power theft increasing at a high cost to LEC if the Cote d'Ivoire, Liberia, Sierra Leone, and Guinea (CLSG) line becoming operational without an effective loss prevention program in place.	Thank you.

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
xx	It is unclear when the LERC chairmanship position will be filled and what this means for LERC's progress.	Needs updating.	We have revised to acknowledge that the position has not been filled.
xxiv	As noted in the LEC Business Plan, "LEC's system demand has grown on average by 50 percent year-on-year since 2016." This growth trend is expected to continue, placing increasing demand on LEC. Increasing demand intensifies LEC's funding gaps in generator operations and raises maintenance and dry season fuel costs.	This demand growth has occurred in the face of over 50% commercial losses to the system. Future growth will depend upon whether power theft is managed and whether LEC has funds to pay for fuel or purchased power during the dry season. During the dry season, power curtailment in the 2020 dry season will reduce this "demand". I suggest analyzing the nature of the demand with these factors in mind might prove valuable.	We agree with the statement about demand in the face of losses and that future growth depends on how theft is managed and whether LEC can purchase dry season fuel. We believe the analysis so far has considered these factors. We will ensure that we continue to consider these factors as we continue evaluating the Liberia Energy Compact.
xxiv	The combination of MCHPP rehabilitation and ESBI's efforts to repair generators and convert the fuel source from light fuel oil to less expensive heavy fuel oil has increased electricity generation (Figure ES.5). Liberia now had excess generation given T&D limitations.	1. Figure ES.5 is not accurate and confusing. MCHPP does not have 88 MW of generation capacity. Its maximum instantaneous generation capacity is approximately 78 MW. The Total Generation does not equal the sum of the three sources of generation. 2. As noted above, LEC's demand (or really end-user energy consumption) is distorted by the amount of electricity that is stolen. Thus, LEC's T&D capacity may be adequate for paid demand which may have been part of the design criteria. This comment carries over to later assessments of the demand and its impact on the T&D system.	We acknowledge the gap between the optimum MCHPP capacity and maximum instantaneous generation capacity. The data for all LEC figures comes from the administrative data. We agree that these require a data quality review. In the report, we will note that "88 MW is design specification rather than the maximum instantaneous generation capacity."
xxv	LEC's ability to make connections is minimal, despite unused generation capacity in the wet season.	This comment is inaccurate. A more accurate statement would be that "LEC's ability to acquire and manage its connections to customers is minimal".	We have revised as suggested.
2	contributing to the installation of 66 kilovolt (kV) transmission lines from MCHPP to the Paynesville and Bushrod substations.	The transmission lines are 132 kV made up of two 66 kV circuits to each substation	We have revised as follows: "contributing to the installation of 132 kilovolt (kV) transmission line, made up of two 66 KV circuits from MCHPP to the Paynesville and Bushrod substations,"

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
2	MCC joined a field of donors that had begun to rehabilitate MCHPP. MCC became engaged in 2015 following the EVD crisis, and the Government of Norway (GoN), through the Norwegian Development Agency (NORAD), the German Development Bank (KfW), and the European Investment Bank (EIB) had already committed to the rehabilitation of MCHPP in 2011. Their efforts were suspended during the EVD outbreak, and as design issues emerged that slowed progress and increased costs, MCC's investments were necessary to complete the project.	This description of events is not accurate. MCC became engaged before the EVD crisis. Design issues did not slow progress but did increase costs. MCC's investment were necessary to complete the project as originally designed. However, MCC also took the opportunity to expand the generation and distribution systems sooner and complete a project with more safety measures.	We agree that the wording was awkward. We revised "MCC joined a field of donors that had begun to rehabilitate MCHPP. The Government of Norway (GoN), through the Norwegian Development Agency (NORAD), the German Development Bank (KfW), and the European Investment Bank (EIB) had already committed to the rehabilitation of MCHPP in 2011. MCC became engaged in 2014 when it was clear that MCC's investments were necessary to complete the project. MCC took the opportunity to expand the generation and distribution systems and add more safety measures. Soon after MCC engaged, rehabilitation efforts were suspended during the EVD outbreak, and as design issues emerged that slowed progress and increased costs." The latter sentences are based on analysis of PIU reports.
2	The investments aimed to both increase the supply of high quality and reliable electricity and potentially create the conditions necessary to reduce the tariff.	Recommend deleting "potentially".	Revised as suggested.
3	MCC required that an MSC assume management control of LEC as a condition of the Compact	MCC did not require an MSC. MCC required the GOL to select a management plan and they selected an MSC to meet the management resources over the next 5 years. The GOL hoped that this would lead to a concession of the utility after that time.	Revised as suggested. "MCC required the GoL select a management plan as a condition of the Compact.... Given these challenges, the GoL selected an MSC to reform management..."
3	During the EVD crisis...the contract ended	The contract ended after the EVD crisis.	We revised the sentence. "During the EVD crisis, MHI no longer achieved performance targets. The contract ended in late 2015."

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
18 (of doc)	Table III.2	Please refer to the standard methodologies provided in MCC's Evaluation Management Process. You can keep the more detailed descriptions, but we want it to be crystal clear how this evaluation should be categorized in our evaluation MIS. Why are some questions grey?	Under the evaluation approach column we have first specified the type of evaluation (performance evaluation) before going into the details. We have also added a footnote to explain that all questions in grey will be addressed in subsequent reports.
31		The MCC study for the management options for LEC was conducted in 2016 I think, rather than 2017. Please confirm.	Revised as suggested.
31	MCC conducted a study to identify the best management option for LEC,	GOL conducted the study and the GOL decided on the MSC. MCC concurred and used the PSP funding for the contract.	Revised as suggested: "The GoL conducted a study to identify the best management option for LEC as a condition of the Compact."
31	MCC determined that a contract monitoring consultant (CMC) was needed to oversee the MSC given capacity limitations at MCA-L.	LEC, not MCA-L is the accountable entity for the MSC. The CMC is designed to assist the LEC board to carry out its oversight responsibilities. The LEC board, populated with political officials and individuals with little business experience, have limited capacity. The CMC assists both the LEC board and MCA-L in compact oversight.	Revised as suggested: "MCC determined that a contract monitoring consultant (CMC) was needed to assist the LEC board to carry out its oversight responsibilities. The CMC assists both the LEC board and MCA-L in compact oversight."
31	meant that the MSC was not structured with adequate resources to cover operating and capital expenditures or equipped with anticorruption mechanisms	An MSC cannot be expected to have anticorruption mechanisms. However, the MSC should exercise its authority to address fraud and corruption as a party with fiduciary responsibility. Neither MHI nor ESBI used that authority implement effective anti-fraud or corruption in LEC.	Given the literature on fraud and corruption in utility companies, we argue that an MSC must develop anticorruption mechanisms because experience shows there will be corruption in poor countries, especially with hydropower or other new facilities.

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
32	Further, although donors coordinated well to rehabilitate MCHPP, there has been limited coordination to facilitate or force the political will needed for utility reform.	This statement implies that greater donor coordination would have resulted in "utility reform". The political will by the GOL to reform will result in utility reform, not donor coordination. Too many local interests benefit from the lack of reform. While donor coordination can facilitate reform, it cannot force it.	We agree that donor coordination can facilitate reform rather than force it. We still believe that better coordination may have yielded better results. We revised as suggested, removing the word force: "Further, although donors coordinated well to rehabilitate MCHPP, there has been limited coordination to facilitate the political will needed for utility reform."
32	Progress on the LERC activity has been slow and beset by delays.	This paragraph inaccurate states timing of events associated with the initial implementation of the LERC sub-activity. I suggest a conversation to discuss how to correct the misstatements. This paragraph brings up two different issues that are not adequately addressed in the report - the urgency to fund MCHPP and the short pre-EIF period. Nowhere in the report is there a discussion of the results of the requirement to fund MCHPP had on implementation. I recommend a revision to the report with these circumstances fully considered (particularly Section C).	We appreciated the conversation though we do not believe this sentence is inaccurate and in fact it is backed by qualitative interviews. We are open to asking stakeholders further questions about the urgency of funding MCHPP and the short pre-EIF period. We propose following up with key informants for the interim report in 2021.
37	LEC cannot afford the cost of LERC staff and operations, so LERC is currently searching for donor funding.	This reference to the relationship, here and elsewhere, portrays LERC as an extension of LEC. LERC as a regulator is a governmental operation that should be paid for by consumers. Liberian consumers can afford to pay for LERC (they are paying millions of dollars to someone for the stolen electricity) but the GOL has not adequately supported the utility to collect the funds for LEC or LERC operations.	We revised as suggested: "Ultimately LERC would be funded by collecting fees from IPPs. LEC described concerns about covering the cost of LERC staff and operations without additional revenue sources, so LERC is currently searching for donor funding."
37	MCHPP would solve most energy supply needs.	The compact assumed that MCHPP would supply most of the energy during the wet season, that some of the wet season electricity generation could reduce the cost of electricity supplied from CLSG or thermal generation during the dry season. I suggest revising this section - both assumption and 2019 situation.	Given our analysis of all the interviews and documentation, we believe that this statement stands. We also asked stakeholders if they believed this statement that there was a sense that MCHPP would solve most needs for Monrovia.

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
38	A new board chair was appointed, but not yet confirmed as of late 2019.	The new chair was nominated (not appointed) and was rejected by the legislature. No chair is in place.	Revised as suggested: "A new board chair was nominated and rejected, so no chair is in place."
39	There would be a less sophisticated system of theft, and power theft could be reduced by the MSC.	The assumption was that the LEC board and GOL would support the MSC to reduce theft. The LEC board did not support initial measures to reduce theft and the GOL has installed a person who coordinates the theft.	We recognize the situation at LEC and GoL's role in installing this person and have included this issue in the report.

Page No.	Affected Text	Requested Change/Comment	Mathematica’s response
39	<p>For example, the Owner’s Engineer (Norplan Fitchner) is funded throughout the defect notification period in December 2021 (given delays in commissioning the fourth turbine) but MHI exhausted funds by October of 2019. An outstanding problem is that contractors have been late in submitting final documentation (for example, Voith, responsible for hydroelectric generation equipment, and National Contracting Company (NCC), responsible for substation works). MHI should review, validate, and then incorporate the narrative of the final contractor reports into the final PIU project report. MHI reportedly found NCC’s performance challenging throughout its contract and does not expect final documentation from the agency without the resources to follow up. MHI must be willing to work for free to finish the report, and in the absence of final documentation must submit an incomplete report in January 2020.</p>	<p>This text has several inaccurate statements and appears to be an unanalyzed repetition of MHI’s complaints about the program. Some of the inaccuracies are: the OE is not funded through 12/21; the new MSC was designed to take over many of the responsibilities of the PIU once construction was completed; no one expected MHI to work for free.</p>	<p>We disagree with this characterization as we analyzed 64 key informant interviews and conducted multiple interviews with several informants. We also conducted an extensive and systematic document review. Still, we revised as follows: "Second, MHI reported that the PIU contract was not funded until the end of the rehabilitation project. For example, according to the Owner’s Engineer (Norplan Fitchner), their contract is funded throughout the defect notification period but MHI exhausted funds by October of 2019. An outstanding problem is that contractors have been late in submitting final documentation (for example, Voith, responsible for hydroelectric generation equipment, and National Contracting Company (NCC), responsible for substation works). MHI should review, validate, and then incorporate the narrative of the final contractor reports into the final PIU project report. MHI reportedly found NCC’s performance challenging throughout its contract and does not expect final documentation from the agency without the resources to follow up. MHI said they must be willing to work for free to finish the report, and in the absence of final documentation must submit an incomplete report in January 2020. MCC clarified that MHI would not be expected to work for free."</p>

Page No.	Affected Text	Requested Change/Comment	Mathematica's response
40	Unnamed MCHPP contractor complaint	First, the OMT contract was delayed due to procurement problems, not because it was an afterthought. Also, it is unclear how a late OMT start addresses the complaints about QA problems caused by the OE failures.	We revised to add a sentence acknowledging the procurement problems. Because OMT was late, they couldn't play the role they wanted to ensure quality, and this had long term implications.
40	One possible mechanism that may have strengthened the contract is requiring detailed reporting to a donor block, including AfDB, JICA, KfW, MCC, MCA-L, NORAD, USAID, and the WB.	It does not follow that detailed reporting to the donor block would enhance MSC performance. In fact, MSC reporting is shared with all donors. The quote from the unnamed donor states that the MSC is an MCC contract. MCC nor MCA-L has a contractual relationship with ESBI. It is an LEC contract. This problem is inherent in an MSC; it is the utility's contract. The MHI contract had similar problems of interference by the LEC board and GOL.	We acknowledge disagreement with our suggestion of a donor block. We revised: "One possible mechanism that may have strengthened the contract is requiring detailed reporting to a donor block, including AfDB, JICA, KfW, MCC, MCA-L, NORAD, USAID, and the WB. Key informants from the donor community supported this suggestion particularly because they felt they did not receive reports from LEC, however at least one MCC stakeholder did not endorse the suggestion."

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41	This is especially important throughout 2020 because MCC allocated the majority of its resources to MCHPP and now lacks resources to adequately incentivize or leverage the government's political will to reform LEC. Experience has shown that the GoL reacts to threats of investment losses reaching US \$40-\$50 million (for example passage of the Power Theft Law and LERC board appointments).	These two sentences are not logically consistent. The first one talks about incentives and the second sentence talks about threats. The GOL does not respond to incentives. Also, MCC has used resources to incentivize the GOL but it consistently failed act in a way to respond to the incentives (e.g., the matching for the road fund). MCC could threaten to withhold MSC funding but that would reward those in GOL who want to operate LEC as a source of personal gain as has been done with other governmental programs numerous times by the GOL. Then there is question of how MCC could incentivize the GOL in 2020 when they have failed the indicators and a second compact is not possible. Also, there is insufficient time to start and finish major projects in the last year of a compact.	We acknowledge the complexity of the situation and have revised these sentences: "This is especially important throughout 2020 because MCC has already allocated the majority of its Liberia investment to MCHPP and there are limited resources remaining to adequately incentivize or leverage the government's political will to reform LEC. The GoL has not been responsive throughout the Compact, however it has responded to other donors when they threatened investment losses reaching US \$40-\$50 million (for example passage of the Power Theft Law and LERC board appointments). One respondent explained that withdrawing resources from the MSC would only allow the GoL to operate LEC "as a source of personal gain".
41	We systematically describe how implementation deviated from plans and the quality (and perceptions of quality) in Tables IV.3 through IV.5 (HOI, 2017).	There is no distinction in the table between "quality" and "perceptions of quality". The report should be clear about what are considered "objective" statements of quality and those subjective perceptions that are being presented, their prior relationship to the parties and potential biases.	We acknowledge this oversight and have revised the text in this section to clarify that we are describing perceptions of quality given that we did not perform quality checks.
41	Key informants also explained that ESBI's contract funding was insufficient given the expectations and compared to the previous MSC.	These key informants misrepresent the situation. KfW, EU, AfDB and WB projects were fully funded. The MSC was designed to have a projects director to coordinate these programs. The resource program of the ESBI proposal was a known risk but it was the better bid. The problems of the ESBI MSC were very different from MHI. Theft was low because there was little generation. Neither MHI nor ESBI (nor the donors) knew how much damage the IMT had done.	We revised to add clarity "Numerous key informants from MCC, MCA, and LEC also explained that ESBI's contract funding was insufficient given the expectations and compared to the previous MSC."

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42	Although it is "not perfect," the PIU's overall implementation and management of contracts was effective and MCHPP rehabilitation was high quality.	See bullet in line above. Was rehabilitation "high quality" or "suboptimal". How do these contradictions lead to a "baseline" report?	The report aims to acknowledge that most of the rehabilitation was high quality but there were some suboptimal components that were mentioned." Overall, plant rehabilitation was rated as high quality based on documentation, KII reports, and plant functionality. However, the OMT reported there was inadequate supervision over some construction, resulting in suboptimal quality and requiring additional maintenance." Thus, these two sentences are accurate.
43	JICA is doing a major refurbishment	The WB and JICA HFO plants have not functioned satisfactorily since installation. There were design flaws in both and contractor failures. The facts are not related nor their impacts on operations under MHI, IMT or ESBI. Recommend more follow up on this as well as other supervision failures for T&D lines projects.	Agree, we have acknowledged the major failures in the LEC infrastructure throughout the report and wrote the report understanding these limitations.
44	text in light bulb	What is the point of this graphic? How does this enhance the evaluation of the program?	Given the length of the report, we thought the text pulled out and placed in light bulbs might make the report more interesting to read.
45	Two years into ESBI's leadership, LEC's financial situation has worsened. LEC has increased generation, losses, debt, and responsibilities in early 2020 over what they were to 2018.	No one knows what was happening under the IMT. Yes, LEC is in a worse financial position but the implication is that it is due to ESBI leadership only.	We think the report describes in detail the context that ESBI came into. The implementation and utility section describe the full context. This sentence does not stand alone in the table, we also state: "ESBI came into a chaotic, bankrupt utility, and was immediately faced with overwhelming challenges."
45	ESBI's key staff, including the CEO, CFO, and other personnel, resigned in late 2018 and 2019. ESBI was fined, and the posts were filled.	This statement implies that the fines drove ESBI to fill staff positions; they always intended to fill the positions. The change of staff payments is not fines; they are contractual payments.	Revised to clarify as suggested.

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47, 62 and elsewhere		Text says the IMT raised remuneration costs by 58% yet elsewhere in the report it says 30% or 54% on p. 62. Please clarify. Maybe there is a combination of increased salaries and increased numbers of staffing. Please try to be consistent if possible.	We have revised inconsistencies. We now report an increase in payroll of 54% in 2017, as reported in ESBI's initial situation report.
47		Text says that salaries were reduced by 30% in Nov 2019. MCC understands salaries had a 30% deferral (as opposed to being reduced) until LEC's financial situation improves.	Revised to clarify as suggested.
52	The length of the PIU contract was inadequate to complete the project with oversight of all contractors	Incorrect. Oversight from OE and MSC continued after PIU ended.	According to the PIU, OE, MSC, and LEC key informants, the perception was that the project would have benefited from the PIU having a longer contract given that all works had not been completed.
52	MCC did not conduct a political economic analysis before establishing the MSC, and ESBI did not conduct adequate due diligence. No one knew the extent of LEC's financial and infrastructure problems.	LEC deteriorated while the MSC was being procured. MCC recommended extending MHI and Norway would have paid for it but the GOL did not want that. The GOL did not like MHI's constraint on GOL official's ability to commit fraud through procurements. After MHI left, fraud grew more and left LEC in a further crippled state.	We have revised to include this sentence: "However, one informant explained: LEC deteriorated while the MSC was being procured. MCC recommended extending MHI's contract, which Norway would have financed, however the GOL did not agree." We do note throughout the report that the IMT led to extreme problems (pgs. 61-65)
53	Build in preconditions and identify leverage to ensure an adequate board and government accountability.	This was done; review the CPs. MCC would have to be willing to stop funding when there are failures in these areas that result in program termination and not just when there are overwhelming political failures.	We revised to acknowledge there were efforts made, though we acknowledge that we have limited evidence of these efforts.
54	The IMF recently awarded Liberia \$213.6 million which provides an opportunity for the government to pay bills to LEC (New Dawn Liberia 2019).	Implies that it is a grant. It is a loan.	Revised to clarify as suggested.

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54	MCC might want to add government appointments to key positions as a condition in the PIA	This recommendation as a lessons learned statement is confusing. Are they suggesting that we approve ministerial appointments? This is not politically feasible unless we are providing substantial assistance to MME which was never contemplated due to substantial TA from Norway.	The suggestion for future projects in Liberia or similar post conflict contexts is that a condition might be that the donor must be able to reject appointments for key positions. We realize this may be challenging but believe it should be considered given the importance and size of the investment.
56	LERC status	Recommend review of EU long term technical assistance plan if this has not been done.	Thank you, we have reviewed this document and will be sure to include references during the next report.
60	V.3 and V.4	The text does not give a timeframe for this evolution, if such evolution is feasible given the size of the Liberia market, the lack of domestic capital and the fear of foreign ownership. I suggest a more critical analysis of these statements attributed to LERC which is populated with inexperienced commissioners and staff.	Throughout the analysis of LERC, we describe the delays and risks to establishing LERC, including the political nature of the commissioners, lack of domestic capital, and lack of experience in Liberia around regulatory environment. While these figures were provided by LERC, we acknowledge that the figures lack a timeframe and the feasibility of this evolution may not be possible, particularly given the Covid-19 pandemic. We view this analysis of LERC as baseline and will need to collect more qualitative data to deepen this analysis beyond the current report.
61		ESBI took over operations in Jan 2018 not Dec 2017	We have revised as suggested.
64		Graph VI.4. It might be worth adding LEC cash position in 2016 and 2017 to show how much cash drained out of the company during the IMT. At FY-end 2016, there was \$24.6 million and then at FY-end 2017 there was \$18.1 million, before closing FY-end 2018 at \$3.1 million in June 2018.	We agree but unfortunately, we do not have the data on cash position during 2016 and 2017. We will aim to obtain this data for the next report.

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67	Findings	No discussion of staff costs affecting operating costs. Recommend further analysis in this discussion.	Throughout the report we describe how the IMT hired additional staff and inflated staff salaries and how this affected operating costs. We also describe how ESBI made staff reductions to reduce operating costs. This question focuses on the tariff and how much it covers operating costs, so we did not expand on staffing costs here.
69		Is the source of the additional funding of \$77 M from a lowering of the tariff the Macro Consulting report of 2018 or from the LEC Business Plan, where I recall they had also modeled the financial cost of reduced tariffs? If the source is Macro Consulting, then it might also be worth adding a reference to the financial implications noted in the LEC Business Plan.	We mention both plans so have also cited the LEC Business Plan.
77 para 3		Text says: "ESBI can reduce operating costs by..." but perhaps this should say "ESBI can reduce operating costs as % of revenues by ..."	We have revised as suggested.
83	All three works contracts are effective, contractors mobilized (initial contractor disqualified. Supervision engineer contract effective, consultant mobilized	The subsequent statements about the status of this program contradict the characterization of the situation in the Affected Text. How can everything be fine if it has not started?	LEC provided status updates for each project. The main point of the text here is that contracts are in process following many delays. While initial contractor was disqualified, the subsequent contractor is in place and design and procurement activities are ongoing.

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83	As the MSC, ESBI also assumed the role of managing large donor-funded T&D projects worth about \$200 million (excluding MCHPP).	Not correct. MSC has responsibility once the PIU contracts ended. This provision is in the agreement.	We have revised the language to clarify that the MSC assumed the role of coordinating and overseeing donor-funded projects, each of which operated as though LEC was the "owner". LEC did not build the physical infrastructure, but as owner, they have tremendous responsibility which consumes enormous amounts of time. "As the MSC, ESBI also assumed the role of overseeing and liaising with all the large donor-funded T&D projects--given LEC is the official owner of these projects--worth about \$200 million (excluding MCHPP)."
87	With LEC reformed, the power market could be vertically and horizontally unbundled to improve overall performance. Vertical unbundling would entail separating generation, transmission, and distribution into different markets and entities owned and managed by the public and private sectors	Continued discussion of unbundling. The management options analysis at the beginning for the compact articulated the next step for all of LEC would be a concession. Recommend you review the McKinsey report to see how unbundling is not realistic in the foreseeable future.	We agree that the unbundling conversation is critical. We analyzed different stakeholder's thoughts on unbundling and what could be feasible in the Liberia context. We feel that this is a topic that must be dealt with in more detail during the official interim report scheduled for 2021.

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87		In the table under "Communication with MCC, MCA, and other donors", I think that one of the key contributions that MCC made over the 2019 period was to stress the importance of clearly articulating and quantifying the challenges with the LEC operational turnaround. This was done through the elaboration of the LEC Business Plan and Recovery strategy, endorsed by the LEC Board in Aug 2019, cum the development of the Financial Model to quantify the financial implications thereof. In comments on drafts of those materials, MCC stressed the importance of prioritization and sequencing of investments, including associated execution capacity. LEC's Chief Operating Officer was a key interlocutor throughout this process, and he grasped very well the overriding need to use the Business Plan and Financial Model as key tools to enhance the credibility of LEC's plans and its ability eventually to attract donor funding.	Thank you, we have integrated this information into the report in Table ES.2 on page xxiii and in Table VI.5 on page 87.
89		Donor conference will probably be in July rather than "early 2020" (but this was before the COVID-19 crisis)	Noted, thank you.
93		Even before the COVID-19 crisis, LEC was reporting that the CLSG line would not be ready in March 2020 and would be more like June 2020 or possibly later	We have followed the evolving completion date on the CLSG line so that the report reflects the final date.
110, 4th para		Sounds like some words may be missing from this sentence: "We expect to see changes in these households and small businesses once the T&D construction is finished and LEC is offered"	We have revised as suggested.
111		*** Significantly different from zero at the .05/.01/.001 level, two-tailed test.	*** indicate statistical significance at the .05/.01/.001 level with a two-tailed test.
121		Not clear what this sentence means: "77 shows respondents' perception of safety in their communities based on having streetlights."	we have revised as follows: "Figure VIII.35 shows respondents' perception..."