Evaluation of the Liberia Compact's Mt. Coffee Hydropower Plant Rehabilitation and Capacity Building and Sector Reform: Findings from the Final Round

Final Appendices

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Appendix A

Data Collection and Analysis

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I. 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. Because of 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 monitoring and evaluation (M&E) plan and determined which ones 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.

Mathematica kept in contact with LEC as the IMS was developed and populated, and we continued to collect data on each of the indicators that show utility performance in electricity generation, transmission and distribution (T&D), sales, customer coverage, utility performance, quality of service, LEC's finances, and other measures. In general, LEC supplied data to us at the monthly level, but also provided data on some indicators quarterly. The aggregation 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. To supplement the data we received and to fill gaps, we compiled historical data from MCA and reviewed reports from the contract monitoring consultant (CMC), which contained additional data. Overall, including the baseline period, we collected LEC administrative data spanning 2015 to 2021 (and the first quarter of 2022 for customer billing data). 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. However, we compiled, assessed, and then verified data by triangulating with other sources (quantitative surveys, in-depth interviews (IDIs), and key informant interviews (KIIs). Overall, we found that trends in the administrative data were largely consistent with findings from the quantitative and qualitative data on end-user outcomes and stakeholder perceptions of LEC's operational and financial performance.

II. Document review

We reviewed documents, including the contracts, reports, work plans, meeting minutes, and news articles, in an ongoing process (Table A.1). For each document, we read the material and highlighted key components that provided important context and helped answer evaluation 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 so that we could ask better-informed questions of respondents in KIIs, verify and validate processes and challenges, and confirm findings.

Table A.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; indicator spreadsheet and description of calculations
Indra	Presentations on the Information Management System (IMS)
Additional presentations and reports	Such as from Tetra Tech (the Cost of Service Study and the Willingness to Pay Study), 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.

III. Quantitative surveys

Mathematica partnered with The Khana Group (TKG), a local data collection firm, to collect baseline and follow-up quantitative survey data for the connected, unconnected, and medium and large end-user studies. For the connected study, we conducted a baseline survey of households, small businesses, and community leaders from a sample of end users in Monrovia who were connected to LEC in 2018. We collected follow-up data from these end users in 2020. In Kakata, we collected baseline survey data from a sample of end users who were unconnected in 2019 and conducted a follow-up survey with them in 2021. We also collected two rounds of survey data from a sample of medium and large businesses and public institutions in Greater Monrovia in 2019 and 2021. Below we describe the various activities during the two rounds of data collection.

The baseline surveys employed an in-person approach to data collection. However, because of the health risks posed by the COVID-19 pandemic, Mathematica and TKG used a hybrid telephone and in-person data collection approach for the follow-up surveys. TKG trained enumerators remotely for Monrovia and Kakata, and they administered the surveys by telephone. Enumerators visited a small number of non-respondents to collect updated telephone numbers only after exhausting all available phone numbers. MCC approved this hybrid data collection approach and the Covid-19 risk mitigation measures on November 18, 2020, before data collection started.

A. Sampling

At baseline, we carefully selected samples of households and businesses using rigorous, multi-stage sampling procedures. The Liberian context presented significant sampling challenges because (1) LEC did not keep customer-level data with names, addresses, and other contact information; (2) LEC did not have up-to-date geocoded data on its electrical infrastructure; (3) many streets in Monrovia do not have a name, and (4) buildings do not have addresses. Nevertheless, we overcame these challenges and selected samples. Below, we describe the sampling procedures for each of the studies.

Table A.2. Evaluation study samples

Connected communities in Monrovia	Unconnected communities along the Kakata corridor	Connected and unconnected medium and large end users
Performance evaluation to longitudinally follow end users over time, with these data collection components: • Community leader survey • Household survey • Small business survey	Pre-post survey to follow end users over time, with these data collection components: • Community leader survey • Household survey • Small business survey	Performance evaluation to longitudinally follow end users over time. Sample includes: • Government agencies • Businesses • Nongovernmental organizations • Charities

Connected end users in Monrovia. We used 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. Therefore, before launching data collection, we worked with TKG to verify EAs with electrical connections.

Because we did not have data on the number of connected end users in each community, we ranked 165 communities in Monrovia by the number of its existing electrical facilities. We considered the top 50 and randomly selected 35 to include in the sample. Thirty of these made up the main sample, and the other five were replacements. Within sampled communities, we identified EAs that had no electrical infrastructure before 2016 and verified the location of new infrastructure in selected EAs. To maximize efficiency in locating connected end users and to ensure that we met our target sample of 1,500 connected end users (750 households and 750 small businesses), we chose the three EAs in each community with the most electrical facilities and included them in data collection.

In the 30 communities, we conducted community-level surveys and interviewed community leaders to learn the context of the catchment areas. We also took a census of households and small businesses in these communities to create two sampling frames of end users: (1) connected small businesses, and (2) connected households. For the former, 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, our listing yielded only 384 connected small businesses, far fewer than the 750 we sought to sample in total. Therefore, we 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.

Unconnected end users in Kakata. 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 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 EAs to visit for the household and small-business surveys. For the first stage of sampling, we selected 125 EAs across 25 communities that had the fewest existing electrical poles but also plan to construct new electrical infrastructure. We conducted 25 surveys to understand the characteristics of these 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. We then randomly sampled 7 or 8 per EA to obtain a target sample of 875. As the listing yielded only 423 unconnected small businesses, we included them all.

Medium and large end users. We used two independent sources to identify medium and large enterprises and public institutions: (1) from the Liberia Business Registry, a full list of registered

organizations that provided the names, addresses, and contact information for 14,694 entities; and (2) 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 on 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 used stratified random sampling to selected 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: whether the firm was an NGO, a business corporation, a branch or subsidiary, a limited liability company (LLC), a sole proprietorship, a partnership, a foreign corporation, a limited partnership, or a trust. To arrive at our sample sizes, we used proportional allocation, except for LLCs, partnerships, foreign corporations, limited partnerships, and trusts. Because these entities were relatively few, we targeted all of them to be sampled for the study. TKG contacted businesses on 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 random order. Because of low response and eligibility rates, we were able to verify the eligibility of only 218 organizations that were included in the target sample. After identifying duplicates, we selected 95 organizations from the LEC list, resulting 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. Instrument development

We developed seven questionnaires for each round of data collection: two sets of household, small-business, and community-leader questionnaires for the connected and unconnected studies, and a medium and large end-user questionnaire for connected and unconnected organizations. The baseline data collection also included two additional listing instruments for the census of households and small businesses in Monrovia and Kakata. We developed them by adapting existing surveys, including MCC's Survey of Electricity Consumption from Nepal, and refining them 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. The follow-up surveys for Monrovia and Kakata were revised further for use as phone surveys. To ensure that the software functioned properly, the questionnaires were developed into Computer Assisted Personal Interviewing (CAPI) tools using SurveyCTO software and tested rigorously.

Table A.3. Quantitative survey modules

Community leader survey	Household survey: Connected and unconnected	Small business survey: Connected and unconnected	Medium and large end user survey
• Respondent information • Community characteristics • Transportation, communication, and housing characteristics • Access to electricity • Access to services • Market activity • Energy and fuel prices (only for baseline) • Observations and boundary walk (only for baseline) • Government response to COVID-19 (only for final round)	**Household characteristics** • Household composition and characteristics of members • Characteristics of household accommodation • Children's education and time use • Time use of household members • Safety **Appliances and electricity** • 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 **Household finance** • Household consumption and expenditure • Wage income • Household-owned businesses/income-generating activities • Non-wage income • Household assets **COVID-19 (only for final round)** • Government's response • Effects on households	**Business characteristics** • Business information • Respondent's and owner's characteristics • Business staffing and employment • Operations and financial information • Business consumption and expenditures • Safety **Appliances and electricity** • 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 **COVID-19 (only for final round)** • Government's response • Effects on small businesses	**Organization characteristics** • Organization information • Qualitative interviews (only for nonprofit organizations) • Organization staffing and employment • Operations and financial information • Organization's consumption and expenditure • Security and safety **Appliances and electricity** • 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 **COVID-19 (only for final round)** • Government's response

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

The baseline surveys were conducted in person and required that enumerators make three attempts at interviewing respondents before selecting one from the replacement sample. As the follow-up surveys for Monrovia and Kakata were conducted largely by phone, these instruments contained flowcharts (see Figure A.1 for an example) illustrating the data collection protocol for contacting community leaders, households, and businesses. The protocols differed slightly by study and type of respondent but generally required that enumerators make at least six attempts to reach a respondent via phone, including one that involved calling all available phone numbers for the respondent, including those of relatives. After exhausting the six attempts, an enumerator would visit the respondent's household or business to obtain updated phone numbers. To enhance the response rate, we compensated connected and unconnected respondents who completed the survey with $2 worth of mobile airtime. As some respondents raised concerns about phone scams, we created a temporary website that contained details about the study and contact information for the key data collection personnel. TKG texted the link to the study website to all respondents.

Figure A.1. Protocol for connected household survey attempts
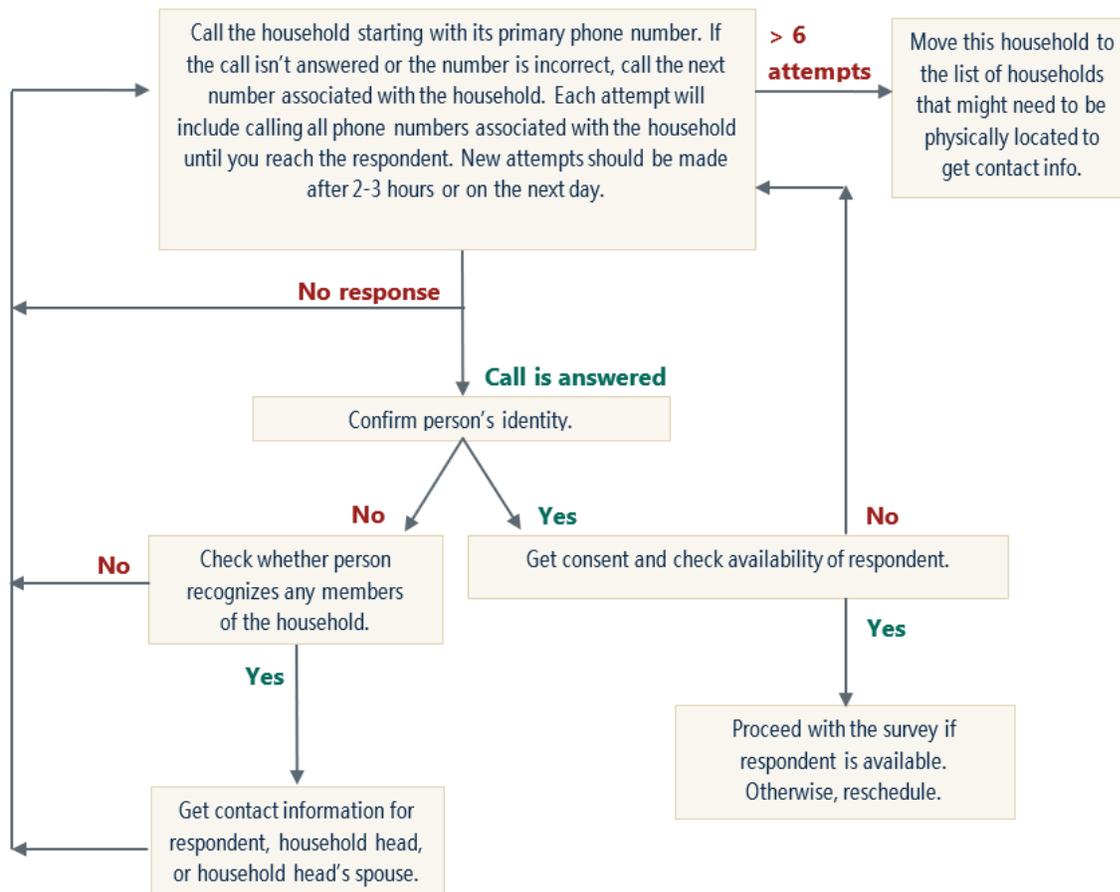
C. Enumerator training

Mathematica and TKG developed training manuals and presentation materials. TKG trained and tested enumerators on key study points, survey topics, phone survey protocol, interview techniques, and data entry with CAPI tools. Because of COVID-19 risks and restrictions, the trainings for the final round of

Monrovia and Kakata data collection activities were held remotely. For the medium and large end-user data collection training, TKG conducted an in-person training following COVID-19 safety protocols for a small team of enumerators. As Mathematica staff could not travel to Liberia to oversee training and pilot activities during the final round of data collection, we joined the training sessions remotely via Zoom. After the training, TKG tested enumerators on the survey protocol and survey topics and finalized the team of enumerators that would conduct the data collection.

As part of training, the enumerators piloted the phone and in-person surveys. After the pilot, Mathematica reviewed the data; the team of enumerators recommended revisions to study instruments, which were made; and CAPI software errors were fixed. Before deployment, enumerators were briefed on survey revisions and changes to the fieldwork plan.

D. Data collection and quality checks

Baseline data collection was conducted in two phases. In the first (October 2018–January 2019), we surveyed Monrovia for the connected-user study. In the second (April–November 2019), we surveyed the Kakata-Paynesville corridor for the unconnected-user study, collected qualitative data, and surveyed medium and large end users in and around Monrovia. The final round of data collection was conducted in three phases (Table A.4). In the first phase (December 2020–January 2021, we conducted phone surveys of respondents from Monrovia and Greater Monrovia for the connected-user study. In the second (May 2021–July 2021), we conducted phone surveys of respondents from the Kakata-Paynesville corridor for the unconnected-user study. In the third (October 2021–November 2021), TKG surveyed medium and large end users in and around Monrovia.

Data were collected through CAPI software by teams of four to six enumerators and one supervisor. Throughout data collection, TKG's supervisors conducted spot checks and back checks to monitor closely the quality of the data. We reported any issues with the data to the TKG team in real time so they could (1) inform their phone survey or field team to make corrections in the field, and (2) clean the final data appropriately before delivering them to us. TKG shared progress reports with Mathematica daily, and the team worked closely during the survey to resolve any issues and ensure that high quality data were collected.

For the final round of data collection, all in-person interviews were completed with strict adherence to TKG's COVID-19 Protocol. During the collection, temperatures of enumerators and respondents were checked before each interview, and during the interview, they maintained two meters distance and wore face masks. Enumerators were also required to sanitize their hands after every interview and asked to report COVID-19 symptoms or exposure to suspected or confirmed cases of COVID-19 at any time during the data collection.

Table A.4. Surveys and fieldwork details

Data collection round	Activity	Team details
Connected study (Monrovia)		
Baseline October 2018–January 2019	• Listing	• 4 field supervisors and 20 enumerators • Target sample: All households and small businesses in 90 EAs across 30 communities

Data collection round	Activity	Team details
		• Achieved sample: 3,973 households and 410 small businesses listed
	• Community profile	• 4 enumerators • Target sample: 30 communities • Achieved sample: 30 community profiles collected
	• Household questionnaire	• 4 field supervisors and 16 enumerators • Target sample: 1,185 households • Achieved sample: 1,183 households surveyed
	• Small business questionnaire	• 2 field supervisors and 8 enumerators • Target sample: 384 businesses • Achieved sample: 330 businesses surveyed
Final December 2020–January 2021	• Community profile	• 1 supervisor and 2 enumerators • Target sample and achieved sample: 30 community leaders surveyed
	• Household questionnaire	• 4 supervisors and 28 enumerators • Target sample: 1,174 households • Achieved sample: 766 households surveyed
	• Small business questionnaire	• 2 supervisors and 14 enumerators • Target sample: 322 businesses • Achieved sample: 188 businesses surveyed
Unconnected-user study (Kakata)		
Baseline April 2019–June 2019	• Listing	• 5 field supervisors and 20 enumerators • Target sample: All households and small businesses in 125 EAs across 25 communities • Achieved sample: 8,327 households and 425 small businesses
	• Community profile	• 4 enumerators • Target sample and achieved sample: 25 communities
	• Household questionnaire	• 5 field supervisors and 20 enumerators • Target sample and achieved sample: 875 households
	• Small business questionnaire	• 5 field supervisors and 20 enumerators • Target sample: 423 businesses • Achieved sample: 402 small businesses surveyed
Final May 2021–July 2021	• Community profile	• 4 enumerators • Target sample and achieved sample: 25 community leaders surveyed
	• Household questionnaire	• 2 supervisors and 12 enumerators • Target sample: 867 households • Achieved sample: 747 households surveyed

Data collection round	Activity	Team details
	• Small business questionnaire	• 2 supervisors and 14 enumerators • Target sample: 400 businesses • Achieved sample: 374 small businesses surveyed
Medium and large end-user study		
Baseline July 2019– November 2019	• Medium and large end-user questionnaire	• 10 enumerators • Target sample: 313 medium and large organizations • Achieved sample: 180 medium and large organizations
Final October 2021– November 2021	• Medium and large end-user questionnaire	• 10 enumerators • Target sample: 175 medium and large organizations • Achieved sample: 125 medium and large organizations

E. Response rates

We achieved high response for the baseline data collection (Table A.4). However, the response rates for the final round of connected and unconnected end-user studies were lower than expected, though they were consistent with rates observed in other phone survey efforts in West Africa (Himelein et al. 2020; Global Poverty Research Lab and Innovations for Poverty Action 2020). TKG attributed non-response among households and businesses to several factors, such as missing or inaccurate contact information, refusals due to privacy or fraud concerns, and refusals stemming from respondents' unwillingness to participate in a survey. To examine how non-response influences the generalizability of our findings, we examined the baseline characteristics of household, small business, and medium and large end-user respondents and non-respondents. We found several statistically significant differences in baseline characteristics between respondents and non-respondents (Appendix B, Sections B, D, and F have further details), but in many cases, the differences were small. Because of the large number of baseline characteristics compared, the observed differences might have occurred by chance.

F. Cleaning, creating constructs, and analyzing data

We conducted a detailed cleaning process for each survey. From the evaluation questions that 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 the 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 impossible (such as more than 24 hours in a day), we removed it from the data set. Before using our data sets for analysis, our analytic team reviewed the distributions of each variable to ensure that they were reasonable.

Variable construction and analysis. We used the survey data to create variables that 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, energy theft, and various other outcomes. Most variables were constructed using data specifications followed at baseline to ensure that outcomes could be compared and differences assessed across the two rounds of study.

We calculated 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. To analyze change over time, we conducted regression analyses to estimate the change in outcomes from baseline (2018-2019) to the final data collection round (2020-2021). For outcomes in which we collected 2016 retrospective data, we also estimated change from this period. The regression analysis incorporated control variables and fixed effects to account for changes in composition of the sample over time. The analysis also included sampling weights to ensure that findings represent the broader population of interest.

4. Qualitative data

We conducted a range of qualitative activities. At baseline, we partnered with TKG to conduct 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. For the final round, TKG conducted IDIs with a mix of connected and unconnected respondents from the baseline qualitative sample, drawing replacements from our baseline quantitative sample when respondents could not be located.

Mathematica staff also conducted KIIs with energy sector stakeholders, including MCC, MCA, LEC, LERC, and donors, during both rounds of data collection. Our team made site visits to observe energy sector operations and regularly attended the Liberia Energy Sector Working Group meetings involving the government of Liberia, LEC, and donors. Below we summarize the qualitative data collection activities and analysis.

G. Sampling for FGDs and IDIs

We used the following procedures to sample respondents for the FGDs and IDIs at baseline (Table A.5). 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.

For the final round, to minimize COVID-related risks we collected qualitative data from end users solely through IDIs. The sample comprised a mix of connected and unconnected respondents drawn from the

baseline qualitative sample. As mentioned previously, we drew replacements from our baseline quantitative sample when TKG's field was unable to locate respondents in the field.

Table A.5. 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	• 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	• 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	• 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	• 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.

H. Instrument development

At baseline, we developed a 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. For the final round, we used the baseline qualitative instruments to develop a set of instruments for IDIs with these respondents in Monrovia and Kakata (Table A.6). The respondents belonged to connected and unconnected communities, and the instruments focused on changes since baseline. As with the quantitative instruments, the qualitative instruments were refined in an iterative process that involved reviews by MCC, MCA-Liberia, and TKG, as well as piloting and pre-testing.

Table A.6. Interview topics

Interview topics	Description
Energy use	Information on specific energy sources, including extent of use, consumption, and spending; Decision-making on use of energy sources; Relative cost of energy sources
Connecting to LEC	Process of applying for LEC; LEC service delivery; tariff and affordability; Decision to connect to LEC
Changes to LEC connection	Reasons for being disconnected; Reconnection process
Barriers to receiving LEC	Barriers to connecting to LEC; Barriers related to poor LEC service delivery
Decision to connect	Tariff and affordability; Perceived benefits of LEC electricity
Customer service	Experience with LEC's customer service center; Satisfaction with LEC's customer service
Electricity quality	Stability and reliability of electricity supply; Seasonal variation in electricity quality; Effects of poor quality of electricity
Appliance and equipment	Investment and use of appliances and equipment; Damage to appliances
Impacts of having LEC	Impacts on health, education, migration, safety, and quality of life
Adult and child time use (household only)	Impacts on household production, chores, watching TV, studying, employment, and time spent inside home
Spillover effects	Benefits to unconnected households, businesses, or institutions in connected communities
Power theft	Prevalence of and reasons for power theft; Quality of illegal connections; Efforts to stop illegal connections

I. Data collection and quality assurance

For both rounds of data collection, Mathematica and TKG conducted a series of in-person trainings for interviewers, including the training of trainers, the training of interviewers for the pretest and pilot, and retraining sessions. Mathematica staff attended the sessions remotely via Zoom to monitor the training and incorporate feedback from interviewers. The sessions included comprehensive training on the instrument and covered topics such as the COVID-19 safety protocol, the interviewer's role and responsibilities, probing techniques, gaining cooperation, avoiding bias, and the deployment plan. The interviewer training also included practice sessions and a pilot of the instruments. Mathematica conducted an extensive review of audio tapes and transcripts from these sessions and worked with TKG to improve interviewers' knowledge of interview topics and probing techniques. After these activities, TKG finalized a team of 10 interviewers for data collection. They began with a pilot activity to test the interview guides, gain practice, and receive feedback.

The baseline FGDs and IDIs were conducted between July and September 2019. For the final round, the TKG team began conducting in-person IDIs starting November 2021 in Monrovia and the Kakata corridor, using geo coordinates, phone numbers, and assistance from community leaders to locate respondents. Interviewers selected respondents from the replacement sample when respondents from the main sample could not be located. As in the in-person component of the quantitative data collection, interviews were conducted following the COVID safety protocols in the data collection plan. TKG continually shared audio tapes and transcripts with Mathematica. TKG and Mathematica staff reviewed audio tapes and transcripts to ensure that all interview questions were covered and probed effectively. The field team completed data collection activities in December 2021.

Overall, we collected qualitative data from 132 respondents across Monrovia and Kakata in each round of data collection, achieving 100 percent of the target sample (Table A.7).

Table A.7. Interviews by respondent type and connection status

Respondent type	Target sample	Achieved sample		
		Monrovia	**Kakata**	**Total**
Baseline				
Households	80	40	40	80
Small Business	20	10	10	20
Health centers and schools	17	6	11	17
Government officials and community leaders	15	8	7	15
Total	**132**	**64**	68	**132**
Final				
Households	80	40	40	80
Small Business	20	10	10	20
Health centers and schools	19	12	7	19
Government officials and community leaders	13	6	7	13
Total	**132**	**68**	**64**	**132**

J. KIIs and energy sector meetings

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 A.8). In most cases, we had multiple conversations over several years, and took detailed notes of those conversations. We conducted formal interviews between October and November 2019 for the baseline study and between April and July 2022 for the final round.

During the KIIs, we asked 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.

Since 2020, we have attended energy sector meetings chaired by the Gesler Murray, Minister of Mines and Energy. The MSC and Transco generally present at meetings. Working group members include LEC Board members and staff, LERC, Transco, donor organizations including AfDB, European Investment Bank, European Union, JICA, KfW, MCC, NORAD, WB, USAID.

Table A.8. Qualitative KII respondents' organizations

MCC is	Mt. Coffee	Donors	Utility and supports	Policy and regulatory bodies
MCC-Washington MCC-Liberia MCA	• MCHPP: LEC • Project implementation unit (PIU): Manitoba Hydro International • Owner's Engineer: Norplan Fitchner • Operations maintenance and training: Hydro Operations International	• AfDB • EiB, EU • JICA • KfW • NORAD • USAID, Power Africa • World Bank	• LEC • MSC • LEC Board • CMC • Indra	• LERC • MME

K. Site visits

In 2017, 2018, 2019, and 2022, we conducted site visits to the Mt. Coffee Hydropower Plant, the Bushrod Power Plant, and all substations, as well as the sites of the Cote d'Ivoire, Liberia, Sierra Leone, and Guinea (CLSG) line, which will eventually be connected to the grid. 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. These visits provided context on the need for critical repairs, indicating key parts that were on order or difficult to obtain, system problems that had arisen, and the need for LEC to develop sophisticated skills to problem-solve when repairing the machines. During each visit, we took notes on processes and photos of machinery to help ourselves understand how the various generation and T&D systems work together and how even small failures can have systemwide impacts.

L. Analysis

We systematically analyzed the IDI and KII transcripts and our notes from site visits. We began the analysis by listening to interview audio files and reading and rereading the transcripts. We focused on the concepts important to the study's evaluation 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 understood the nuances in the data. Next, we triangulated findings across all the data sources, including KIIs, reports, and quantitative data. 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.

Appendix B

Survey Sample Characteristics

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I. Description of survey samples

A. Characteristics of final Monrovia sample

For the study of connected end users in Monrovia, we collected baseline survey data from a sample of households, small businesses, and community leaders in 2018. We collected follow-up survey data from this sample of respondents during the final round of data collection in 2020. Below, we describe the sample characteristics from the final round of data collection. In a subsequent section, we compare the baseline demographic characteristics of the follow-up survey's respondents and non-respondents to assess if non-response in the final round of data collection resulted in bias.

Table B.1. Household characteristics (2020)

Outcome	Mean
Sample size (households)	766
Household has moved its residence since December 2018 (%)	27.8
Household currently receives LEC current (%)	70.6
Number of people currently living in the household	7.0
Household has children currently enrolled in school (%)	77.1
Household has an IGA	28.0
Household head's employment status (%)	
Seeking employment	17.0
Unemployed, not seeking employment	7.6
Apprentice/student	2.0
Retired	2.0
Other, inactive	2.4
Employer/self-employed	40.3
Permanent employee	16.5
Temporary employee	9.4
Member of a cooperative	0.0
Family caregiver	1.0
Other	2.4

Source: 2020 Monrovia household survey.

IGA = income-generating activity, LEC = Liberia Electricity Corporation.

Table B.2. Small business characteristics (2020)

Outcome	Mean
Sample size (businesses)	188
Business has moved its residence since December 2018 (%)	25.4
Business closed (%)	9.0
Business currently receives LEC current (%)	46.1
Business activity (%)	
Small grocery shop	17.3
Tailoring/clothing repair	7.9
Clothing production	1.8
Cell phone dealer/repair/charging	5.0
Other electric/electronic repair	5.4
Other food business (restaurant/bar, food seller)	20.7
Other non-food business (market seller, trader)	24.1
Medical facility/clinic/dispensary	7.8
Beauty salon/barber shop	7.6
Number of paid employees	1.9
Number of unpaid employees (including family members)	2.1
Months of operation in past year	9.6
Days of operation per week	6.0
Hours of operation per day	9.0
Average monthly revenue (USD)	1790
Average monthly profit (USD)	363

Source: 2020 Monrovia small business survey.

LEC = Liberia Electricity Corporation, USD = US dollars.

Table B.3. Community characteristics (2020)

Outcome	Mean
Sample size (communities)	**30**
Demographics	
Number of people living in the community	12,453
Number of households in the community	1,731
Number of people who have moved into the community in the past two years	136
Main reason people have moved into the community (%)	
Work opportunities	30.0
Family reasons	16.7
Access to grid electricity	43.3
Affordable housing/land	36.7
Better access to a market	36.7
Better access to roads	43.3
Better access to public institutions	33.3
School/studies	6.7
Security	33.3
COVID-19	3.3
Other	26.7
Number of people who have moved out of the community in the past two years	103
Main reason people have moved out of the community (%)	
Work opportunities	13.3
Family reasons	16.7
Access to grid electricity	10.0
Affordable housing/land	63.3
Better access to a market	3.3
Better access to roads	10.0
Better access to public institutions	13.3
School/studies	13.3
Security	13.3
COVID-19	0.0
Other	33.3
Infrastructure	
LEC access	
Community has full access to LEC (%)	80.0
Community has partial access to LEC (%)	10.0
Community currently receives no LEC electricity (%)	10.0
Average price of a plot of land in this community (USD)	2,689

Outcome	Mean
Average monthly rent for a two-bedroom apartment or house in this community (USD)	72
Good cell phone network connectivity	
Throughout the community (%)	86.7
Some parts of community (%)	10.0
Cell phone ownership (%)	
Almost all people	73.3
Some people	23.3
Very few people	3.3
No one	0.0
Economic activity	
Major sources of employment in the community (%)	
Farming/gardening	6.7
Fishing	13.3
Small-scale trade and service provision	80.0
Transport	73.3
Commercial industry	6.7
Professional occupations	40.0
Civil service	26.7
Other	26.7
Community has a permanent daily market (%)	43.3
Permanent daily market has LEC current[a] (%)	38.5
Community has a market that does not operate daily (%)	0.0

Source: 2020 Monrovia community leader survey.

[a] This outcome is conditional on having a permanent daily market.

LEC = Liberia Electricity Corporation, USD = US dollars.

B. Comparison of respondents and nonrespondents in Monrovia

During the final data collection in 2020, we achieved a response rate of 66 percent for households (n = 766) and 59 percent for small businesses (n = 188). To determine whether the final sample may have been biased due to this nonresponse, we compared the demographic characteristics of respondents and nonrespondents using baseline data collected in 2018. We found few statistically significant differences between respondents and nonrespondents, as shown in Tables B.4 and B.5. Notably, at baseline, the final sample of small business respondents were less likely to run grocery shops and more likely to run a food business than non-respondents. Other differences are small in magnitude. Given the large number of outcomes compared, it is possible that the few observed differences occurred by chance.

Table B.4. Baseline demographic characteristics of the 2020 household survey's respondents and nonrespondents

Outcome	Full sample at baseline	Respondents in 2020	Non-respondents in 2020	Difference
Sample size (households)	**1,174**	**766**	**408**	
Characteristics of household head				
Household head is female (%)	31.7	31.9	31.2	0.7
Age of household head	40.5	40.8	39.8	1.0
Household head is married (%)	30.6	31.1	29.5	1.6
Household head's highest level of education (%)				
No school	8.3	7.5	9.9	-2.5
Some elementary	3.6	3.0	4.8	-1.8
Elementary completed	1.1	1.1	1.2	-0.2
Some junior high	6.1	4.8	8.6	-3.8**
Junior high completed	1.9	2.0	1.7	0.3
Some senior high	11.3	10.8	12.3	-1.6
Senior high completed	32.3	32.8	31.4	1.4
Technical/vocational education	4.9	5.4	3.9	1.5
Some college/university	17.2	18.3	15.2	3.2
Completed college/university or higher	13.2	14.4	10.8	3.6*
Household head employment status (%)				
Seeking employment	24.1	22.6	26.9	-4.2
Unemployed, not seeking employment	9.5	10.6	7.4	3.2*
Apprentice/student	4.9	6.0	2.7	3.4***
Retired	2.2	2.3	1.9	0.4
Other, inactive	3.2	3.0	3.7	-0.8
Employer/self-employed	24.8	25.3	24.0	1.3
Permanent employee	20.8	20.9	20.7	0.2

Outcome	Full sample at baseline	Respondents in 2020	Non-respondents in 2020	Difference
Temporary employee	5.4	5.1	5.9	-0.8
Member of a cooperative	0.5	0.6	0.3	0.3
Family caregiver	0.4	0.3	0.6	-0.3
Other	3.2	3.0	3.7	-0.8
Household has an IGA	32.2	32.6	31.5	1.1
Household income at baseline USD	1,030	1,007	1,072	-66

Source: 2018 and 2020 Monrovia household surveys.

IGA = income-generating activity.

Table B.5. Baseline characteristics of the 2020 small business survey's respondents and nonrespondents

Outcome	Full sample at baseline	Respondents in 2020	Non-respondents in 2020	Difference
Sample size (businesses)	**322**	**188**	**134**	
Months business has been operating	66.7	66.4	67.0	-0.6
Business activity (%)				
Small grocery shop	20.8	16.3	27.3	-10.9**
Tailoring/clothing repair	7.3	7.2	7.3	-0.1
Clothing production	1.6	1.8	1.4	0.4
Cell phone dealer/repair/charging	8.6	5.9	12.5	-6.6*
Other electric/electronic repair	8.3	7.2	9.8	-2.6
Other food business (restaurant/bar, food seller)	17.2	22.5	9.5	12.9***
Other non-food business (market seller, trader)	25.5	25.2	25.8	-0.6
Medical facility/clinic/dispensary	5.2	5.8	4.4	1.5
Beauty salon/barber shop	5.5	8.0	1.9	6.1**
Number of paid employees	0.9	0.9	0.9	0.0
Number of unpaid employees (including family members)	1.6	1.5	1.9	-0.4
Business is registered with the Liberia Business Registry (%)	69.5	69.1	70.0	-0.9
Months of operation in past year	10.8	10.8	10.8	-0.0
Days of operation per week	6.2	6.2	6.1	0.0
Hours of operation per day	11.5	11.2	11.9	-0.7*
Average monthly revenue (USD)	1,488	1,690	1,175	515
Average monthly profit (USD)	610	744	400	344

Source: 2018 and 2020 small business surveys.

USD = US dollars.

C. Characteristics of final Kakata sample

For the study of unconnected end users in Kakata, we collected baseline survey data from a sample of households, small businesses, and community leaders in 2019. We collected follow-up survey data from this sample of respondents during the final round of data collection in 2021. Below, we describe the sample characteristics from the final round of data collection. In a subsequent section, we compare the baseline demographic characteristics of the follow-up survey's respondents and non-respondents to assess if non-response in the final round of data collection resulted in bias.

Table B.6. Household characteristics (2021)

Outcome	Mean
Sample size (households)	747
Household has moved its residence since May 2019 (%)	13.2
Household currently receives LEC current (%)	41.5
Time since first LEC connection (months)	8.7
Number of people currently living in the household	7.9
Household has children currently enrolled in school (%)	88.4
Household has an IGA	18.5
Household head's employment status (%)	
Seeking employment	15.0
Unemployed, not seeking employment	18.2
Apprentice/student	2.1
Retired	1.5
Other, inactive	0.8
Employer/self-employed	41.0
Permanent employee	7.8
Temporary employee	11.2
Member of a cooperative	0.8
Family caregiver	0.4
Other	0.8

Source: 2021 Kakata corridor household survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

LEC = Liberia Electricity Corporation, IGA = Income-generating activity

Table B.7. Small business characteristics (2021)

Outcome	Mean
Sample size (businesses)	**374**
Business has moved its residence since May 2019 (%)	0.3
Business closed (%)	27.1
Business currently receives LEC current (%)	32.8
Time since first LEC connection (months)	18.7
Business activity (%)	
Small grocery shop	12.1
Tailoring/clothing repair	8.7
Clothing production	4.8
Cell phone dealer/repair/charging	5.8
Other electric/electronic repair	2.8
Other food business (restaurant/bar, food seller)	14.6
Other non-food business (market seller, trader)	43.1
Medical facility/clinic/dispensary	7.5
Beauty salon/barber shop	3.8
Number of paid employees	1.2
Number of unpaid employees (including family members)	2.4
Months of operation in past year	11.0
Days of operation per week	6.1
Hours of operation per day	7.7
Average monthly revenue (USD)	233
Average monthly profit (USD)	183

Source: 2021 Kakata corridor small business survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

LEC = Liberia Electricity Corporation, USD = US dollars

Table B.8. Community characteristics (2021)

Outcome	2021
Sample size (communities)	**25**
Demographics	
Number of people living in the community	1508.3
Number of households in the community	358.6
Number of people who have moved into the community in the past two years	40.1
Main reason people have moved into the community (%)	
Work opportunities	4.8
Family reasons	76.2
Access to grid electricity	14.3
Affordable housing/land	57.1
Better access to a market	0.0
Better access to roads	4.8
Better access to public institutions	0.0
School/studies	4.8
Security	52.4
COVID-19	0.0
Other	4.8
Number of people who have moved out of the community in the past two years	8.7
Main reason people have moved out of the community (%)	
Work opportunities	15.8
Family reasons	52.6
Access to grid electricity	0.0
Affordable housing/land	42.1
Better access to a market	0.0
Better access to roads	0.0
Better access to public institutions	0.0
School/studies	0.0
Security	36.8
COVID-19	0.0
Other	31.6

Outcome	2021
Infrastructure	
LEC access	
Community has full access to LEC (%)	52.0
Community has partial access to LEC (%)	32.0
Community currently receives no LEC electricity (%)	16.0
Average price of a plot of land in this community (USD)	900
Average monthly rent of a two-bedroom apartment or house in this community (USD)	102
Time since community first received LEC connection (months)	38.1
% of community connected	57.7
Hours each day that households typically have current	19.4
Good cellphone network connectivity (%)	
Throughout the community	76.0
Some parts of community	12.0
Cellphone ownership (%)	
Almost all people	80.0
Some people	12.0
Very few people	8.0
No one	0.0
Economic activity	
Most important sources of employment in the community (%)	
Farming/gardening	52.0
Fishing	4.0
Small-scale trade and service provision	84.0
Transport	48.0
Commercial industry	0.0
Professional occupations	8.0
Civil service	24.0
Other	8.0
Community has a permanent daily market (%)	56.0
Permanent daily market has LEC current (%)	7.1

Source: 2021 Kakata corridor community leader survey.

[a] This outcome is conditional on having a permanent daily market.

LEC = Liberia Electricity Corporation, USD = US dollars

D. Comparison of respondents and nonrespondents in Kakata

During the final data collection in 2021, we achieved a response rate of 87 percent for households (n = 747) and 94 percent for small businesses (n = 374). To determine whether the final sample may have been biased due to this nonresponse, we compared the demographic characteristics of respondents and nonrespondents using baseline data collected in 2019. We found several statistically significant differences in baseline characteristics between the final round's respondents and nonrespondents, as shown in Tables B.9 and B.10. Notably, at baseline, the final sample of household respondents were more likely to be married, own an IGA, and earn greater income than nonrespondents. Other differences are small in magnitude. Given the large number of outcomes compared, it is possible that the observed differences occurred by chance.

Table B.9. Baseline demographic characteristics of the 2021 household survey's respondents and nonrespondents

	Full baseline sample	Respondents in 2021	Non-respondents in 2021	Difference
Sample size (households)	**1174**	**747**	**120**	
Household head is female (%)	31.3	31.4	30.4	1.0
Age of household head	42.4	42.6	40.5	2.2
Household head is married (%)	30.2	32.4	16.2	16.2***
Household head's highest level of education (%)				
No school	19.5	18.8	23.9	-5.1
Some elementary	5.9	5.8	6.0	-0.2
Elementary completed	1.9	1.7	2.9	-1.2
Some junior high	11.0	10.5	14.5	-4.0
Junior high completed	4.7	4.5	5.9	-1.4
Some senior high	11.3	10.9	13.8	-3.0
Senior high completed	23.3	23.7	20.3	3.4
Technical/vocational education	5.2	5.4	4.0	1.4
Some college/university	8.4	9.1	3.7	5.4***
Completed college/university or higher	8.9	9.5	4.7	4.8
Household head employment status (%)				
Seeking employment	13.5	13.1	16.4	-3.4
Unemployed, not seeking employment	19.9	18.7	27.4	-8.6
Apprentice/student	3.8	4.1	2.4	1.7
Retired	1.5	1.3	2.5	-1.1
Other, inactive	6.1	6.0	7.2	-1.3
Employer/self-employed	44.0	45.2	36.6	8.5
Permanent employee	8.0	8.2	6.4	1.9

	Full baseline sample	Respondents in 2021	Non-respondents in 2021	Difference
Temporary employee	0.2	0.3	0.0	0.3
Member of a cooperative	1.5	1.7	0.0	1.7***
Family caregiver	0.0	0.0	0.0	0.0
Other	6.1	6.0	7.2	-1.3
Household has an IGA	23.3	24.7	14.7	10.0**
Household income at baseline (USD)	757	803	472	331**

Source: 2019 and 2021 Kakata corridor household surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

IGA = income-generating activity, USD = US dollars

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

Table B.10. Baseline demographic characteristics of the 2021 small business survey's respondents and nonrespondents

Outcome	Full baseline sample	Respondents in 2021	Non-respondents in 2021	Difference
Sample size (businesses)	**322**	**374**	**26**	
Months business has been operating	52.5	53.5	37.2	16.3
Business activity (%)				
Small grocery shop	11.8	11.1	22.9	-11.9
Tailoring/clothing repair	7.4	7.9	0.0	7.9***
Clothing production	4.6	5.0	0.0	5.0***
Cell phone dealer/repair/charging	5.6	6.0	0.0	6.0***
Other food business (restaurant/bar, food seller)	13.9	14.1	11.6	2.4
Other non-food business (market seller, trader)	44.3	43.6	54.1	-10.5
Medical facility/clinic/dispensary	5.6	5.7	3.7	2.0
Beauty salon/barber shop	4.2	4.2	3.8	0.4
Number of paid employees	0.6	0.6	1.0	-0.5
Number of unpaid employees (including family members)	1.5	1.5	1.2	0.3
Business is registered with the Liberia Business Registry (%)	57.6	57.4	61.5	-4.2
Months of operation in past year	10.1	10.2	9.4	0.8
Days of operation per week	6.1	6.1	6.0	0.1
Hours of operation per day	9.7	9.8	9.6	0.1
Average monthly revenue (USD)	1,265	1,182	2,625	-1,443
Average monthly profit (USD)	329	296	803	-507

Source: 2019 and 2021 Kakata corridor small business surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

USD = US dollars

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

E. Characteristics of final medium and large end user sample

For the study medium and large end users in and around Monrovia, we collected baseline survey data from a sample of private and state-owned enterprises, non-governmental organizations, and private institutions in 2019. In 2021, we conducted a follow-up survey to collect a final round of data from these respondents. Below, we describe the sample characteristics from the final round. In a subsequent section, we compare the baseline demographic characteristics of the follow-up survey's respondents and non-respondents to assess if non-response in the final round of data collection resulted in bias.

Table B.11. Medium and large end user characteristics (2021)

Outcome	Mean
Sample size	**125**
Business type (%)	
Government of Liberia-owned organization or state-owned enterprise	13.9
Non-governmental organization	21.3
Private organization	44.3
Other	20.5
Main business activity (%)	
Education	44.5
Hotel or restaurant	1.8
Construction, including sale of construction materials	3.6
Health services	4.5
Religious organization	7.3
Charity/aid	8.2
Banking and finance (including taxes and insurance)	3.6
Regulation	3.6
Security and law	8.2
Water, sanitation, and waste	3.6
Retail	0.0
Other	10.9
Number of paid employees	52.5
Number of unpaid employees	15.6
Number of months operating during 2020	10.5
Average number of days per week operating during 2020	5.5
Average number of hours per day operating during 2020	10.2
Organization owns work location (%)	73.4
Costs and spending during 2020 (USD)	
Purchase of machinery, vehicles, and equipment	9,063
Land and buildings (including expansions and renovations)	11,229

Outcome	Mean
Labor	266,091
Raw materials and goods	93,623
Electricity from any source	25,964
Total operating costs	15,560,051
Net value of assets in 2020 (USD)	3,235,914
Average monthly revenue in 2020 (USD)	394,698
Average monthly profit in 2020 (USD)	31,578

Source: 2021 medium and large end user survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

USD = US dollars

F. Comparison of respondents and nonrespondents among medium and large end users

During the final data collection in 2021, we achieved a response rate of 72 percent for medium and large end users (n = 125). To determine whether the final sample may have been biased due to this nonresponse, we compared the characteristics of respondents and nonrespondents using baseline data collected in 2019. We found a few statistically significant differences in baseline characteristics between respondents and nonrespondents, as shown in Table B.12. Notably, at baseline, the medium and large end user respondents were less likely to be private organizations and have less profit than non-respondents.

Table B.12. Baseline characteristics of the 2021 medium and large end user survey's respondents and nonrespondents

Outcome	Full baseline sample	Respondents in 2021	Non-respondents in 2021	Difference
Sample size	**175**	**123**	**52**	
Business type (%)				
Government of Liberia-owned organization or state-owned enterprise	11.4	13.0	7.7	5.3
Non-governmental organization	16.0	16.3	15.4	0.9
Private organization	47.4	43.1	57.7	-14.6*
Other	25.1	27.6	19.2	8.4
Number of paid employees	88.1	79.5	108.1	-28.6
Number of unpaid employees (including family members)	9.6	11.0	6.3	4.7
Months of operation in past year	11.1	11.1	11.2	-0.1
Days of operation per week	5.5	5.4	5.7	-0.2
Hours of operation per day	8.1	8.0	8.5	-0.5
Average monthly revenue (USD)	302,657	247,474	425,484	-178,009
Average monthly profit (USD)	60,656	33,551	123,579	-90,028**

Source: 2019 and 2021 medium and large end user survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

USD = US dollars

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

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Appendix C, D, E

Detailed Survey Findings on End User Outcomes

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Appendix C

Detailed Findings from Monrovia

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A. Access to electricity

Table C.1. Household and business access to electricity

	2016	2018	2020	Two-year change (2018–2016)	Two-year change (2020–2018)
Sample size (households)	727	760	738		
Sample size (businesses)	118	183	167		
Household access to electricity sources					
Household has LEC electricity (%)	~	100.0	74.1	~	-25.9***
Percentage of households whose main source of electricity is:					
Direct line from LEC	59.2	62.1	43.0	2.9	-19.1***
Indirect line from LEC	24.4	36.0	25.2	11.6***	-10.9***
Own generator	1.7	0.0	6.3	-1.7***	6.3***
Neighbor's generator	0.7	0.0	4.1	-0.7	4.1***
Solar panels	0.0	0.0	0.3	0.0	0.3*
Local minigrid	0.8	0.3	3.9	-0.6	3.6***
Car or motorcycle battery	0.0	0.0	0.0	0.0	0.0
Other	2.4	0.0	1.6	-2.4***	1.6**
None	10.8	1.6	18.0	-9.2***	16.4***
Businesses access to electricity sources					
Business has LEC electricity (%)	~	100.0	44.7	~	-55.3***
Percentage of small businesses whose main source of electricity is:					
Direct line from LEC	50.0	49.7	34.2	-0.2	-15.6***
Indirect line from LEC	15.5	27.9	9.5	12.5***	-18.5***
Own generator	3.4	1.3	16.2	-2.1	14.9***
Neighbor's generator	2.1	3.9	13.6	1.8	9.6***
Solar panels	0.0	0.0	0.5	0.1	0.5
Local minigrid	2.4	3.6	14.0	1.2	10.4***
Car or motorcycle battery	0.0	0.0	0.0	0.0	0.0
Other	0.3	0.5	1.5	0.2	1.0
None	27.0	13.0	16.5	-14.0***	3.5

Source: 2016, 2018, and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

LEC = Liberia Electricity Corporation

~   Not available. Data for the outcome were not collected for the time period so the two-year change cannot be estimated

Table C.2. Community-level access to LEC and other sources of electricity

	2016	2018	2020	Two-year change (2018–2016)	Two-year change (2020–2018)
Sample size	30	30	30		
LEC access					
Community access to LEC electricity (%):					
Full access	~	93.3	80.0	~	-13.3
Partial access	~	6.7	10.0	~	3.3
No access	~	0.0	10.0	~	10.0*
Other energy sources					
Percentage of households receiving electricity from the following sources, as reported by community leaders:					
LEC	56.6	68.9	61.3	12.3**	-7.5
Hours of electricity available for a typical day	18.9	21.2	17.0	2.3	-4.1**
Local minigrid	13.4	2.8	11.1	-10.6***	8.3**
Own generator	4.6	2.8	8.1	-1.8	5.3
Neighbor's generator	0.5	0.5	2.2	0.0	1.7***
Solar panels installed on building's premises	15.9	1.5	0.6	-14.5***	-0.9
Car or motorcycle battery	2.9	0.2	0.0	-2.7	-0.2
No access to electricity	20.9	12.5	40.3	-8.4	27.8***
Percentage of communities with the following services that have access to LEC electricity:					
Government elementary school	13.3	23.3	26.7	10.0	3.3
Private elementary school	46.8	79.3	61.8	32.5***	-17.5*
Government junior high school	6.7	16.7	20.0	10.0	3.3
Private junior high school	50.0	73.3	53.3	23.3**	-20.0*
Government senior high school	6.7	10.0	6.7	3.3	-3.3
Private senior high school	46.7	70.0	33.3	23.3**	-36.7***
Post office	3.3	3.3	3.3	0.0	0.0
Bank	26.7	36.7	17.9	10.0	-18.8*
Police post	23.3	30.0	33.3	6.7	3.3
Dispensary/pharmacy	57.3	90.0	86.7	32.7***	-3.3
Health center	50.0	66.7	46.7	16.7**	-20.0**
Hospital	16.7	16.7	16.7	0.0	-0.0
Local government office	10.0	10.0	10.0	0.0	0.0

Source: 2018 and 2020 Monrovia community leader surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

~ Not available. Data for the outcome were not collected for the time period so the two-year change cannot be estimated.

Table C.3. Households and businesses not connected to LEC electricity in 2020

	Household	Business
Sample size	215	90
Reason respondent does not use LEC electricity now (%)		
LEC electricity is too far from household/LEC electricity not available in area	20.9	22.5
LEC disconnected the household	20.1	14.9
Cost of formal/new connection is too expensive	9.3	8.2
Monthly fee is too expensive	6.7	8.4
Satisfied with energy situation/don't need LEC electricity	0.3	1.1
Renting, landlord decision	0.1	1.1
Service unreliable	2.6	13.0
Administrative procedure for formal/new connection is too complicated	10.4	16.5
Submitted application and waiting for new connection	9.9	7.3
Temporarily disconnected due to issues/failures with grid	32.2	28.4
Does not use any other source of electricity (%)	60.7	30.9
Reason respondent does not use any other source of electricity (%)		
Not available/accessible	32.3	33.5
Cost of connection is too expensive	33.3	22.6
Monthly fee is too expensive	25.2	22.3
Satisfied with energy situation/don't need	2.6	3.7
Renting, landlord decision	4.0	0.0
Service unreliable	5.2	4.3
Administrative procedure is too complicated	10.4	13.8
Submitted application and is waiting for connection	5.6	2.2
Company refused to connect	2.3	3.7
Main disadvantages of not having electricity (%)		
More time needs to be spent on completing household chores	11.5	--
Perishable goods are spoiled	11.6	--
Unable to start a business in the household premises	11.3	--
Difficulty in operating a business in the household premises	10.6	--
Less time spent by children on reading/studying	32.8	--
Less time spent on leisure activities like watching TV, listening to radio	30.5	--
Less security	36.2	--
Increased risk to animal related hazards	3.6	--
Increased risk to health hazards	6.6	--
Meetings/transactions are delayed/slow	--	11.6
Reduced operations or reduced business activities	--	32.3
Turning customers away	--	15.9

	Household	Business
Used more expensive products to deal with not having electricity	--	9.5
Wasted perishable products/Discarded damaged goods	--	0.0
Not affected	9.8	30.3

Source: 2020 Monrovia household and small business surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

--   Not applicable.

LEC = Liberia Electricity Corporation

B. Electricity quality and reliability

Table C.4. Quality of electricity

	Household			Business		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Sample size	752	507		169	77	
Electricity quality						
Wet season:						
No. hours household/business had electricity on normal day	18.9	14.5	-4.4***	14.7	12.9	-1.8
No. times in a week experienced high or low voltage	2.8	4.6	1.7**	3.5	4.5	1.0
No. times in a week electricity went out	3.7	4.0	0.3	4.2	4.0	-0.2
No. hours in total electricity went out in a week	7.0	10.8	3.7	12.9	6.6	-6.3
Dry season:						
No. hours household/business had electricity on normal day	19.5	14.2	-5.3***	15.4	12.4	-3.0
No. times in a week experienced high or low voltage	2.2	4.1	1.8**	2.8	4.3	1.5
No. times in a week electricity went out	3.0	2.9	0.0	3.7	4.3	0.5
No. hours in total electricity went out in a week	5.3	14.0	8.8*	9.3	2.1	-7.2
Quality of electricity service has been the same all year (%)	35.6	54.2	18.6***	~	~	~
Voltage:						
Experienced voltage drops in past year (%)	83.5	76.6	-6.9*	83.6	72.3	-11.3
Frequency of voltage drops (%):						
Everyday	2.1	6.4	4.3	15.3	11.5	-3.8
Two to three times per week	49.2	48.5	-0.7	61.0	59.8	-1.2
A few times per month	48.7	45.1	-3.6	23.7	28.7	5.0

Source: 2018 and 2020 Monrovia household and small business surveys

Note: Data for 2018 and 2020 are for households and small businesses connected to LEC electricity during those years. All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

~   Not available. Data for the outcome were not collected for the time period so the two-year change cannot be estimated.

Table C.5. Negative effects of power outages

	Households			Small businesses		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Sample size	766	525		183	81	
Sample size (household IGA)	377	209		--	--	
Household effects						
Reported effects of power cuts on households (%):						
Higher maintenance costs and/or replacement of equipment/devices for household IGA	14.2	23.0	8.8**	--	--	--
Higher maintenance expenses and / or replacement of appliances or equipment for household use	25.4	28.2	2.8	--	--	--
Destruction of leisure devices	36.4	40.3	3.8	--	--	--
Loss of income related to income-generating activity	9.6	21.8	12.3***	--	--	--
Difficulties working from home	51.7	62.0	10.2*	--	--	--
Difficulty studying	65.7	69.8	4.0	--	--	--
Increasing insecurity	72.2	80.6	8.4**	--	--	--
Failing health	41.2	47.8	6.6	--	--	--
Business and IGA effects						
Reported operational effects of power cuts on household IGA and small business activity (%):						
Continue all operations on backup supply	12.7	43.1	30.4	11.1	26.6	15.5*
Meetings/transactions were delayed	3.8	21.5	17.7	11.3	23.1	11.8
Continue reduced operations on backup supply	0.0	3.7	3.7	5.0	12.0	7.0
Had to turn customers away	51.7	17.5	-34.2	51.3	11.7	-39.7***
Had to send workers home for the day with pay	0.7	0.0	-2.9	0.3	1.3	0.9
Had to send workers home for the day without pay	12.8	0.0	-26.8	0.0	1.5	1.5
Used more expensive alternate energy sources to run appliances	10.9	3.5	-7.4	24.7	12.4	-12.3
Cut back on operations to keep perishables cold	9.5	15.5	6.0	7.3	0.0	-15.1**
Wasted perishable products/discarded damaged goods	7.0	0.0	-10.3	9.7	6.1	-3.6

	Households			Small businesses		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Machines/appliances were damaged in the process	3.1	6.4	3.3	4.7	5.3	0.5
Provided backup electricity to others	25.1	3.9	-21.2	2.7	6.2	3.4
Stop operations and waited for power to return	24.6	1.4	-23.3	14.0	8.3	-5.6
Reported financial costs of power cuts on household IGA and small business activity:						
Business lost revenue due to power cuts in the past year (%)	51.2	62.9	11.7	70.4	42.9	-27.5***
Revenue lost due to power cuts in past year (USD)	311	438	128	412	399	-14
Costs incurred due to power outages (USD)	48	161	113**	142.8	35.5	-107.3
Appliances or equipment were damaged by LEC electricity in the past year (%)	37.0	50.2	13.2***	61.7	61.2	-0.5
Cost of fixing or replacing appliances/machinery damaged by LEC electricity in past year (USD)	28	31	3	519.2	254.8	-264.4
Working hours limited by supply of energy in past year (%)	50.3	33.7	-16.6	55.7	51.0	-4.7

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2018 and 2020. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

--   Not applicable.

IGA = income-generating activity, LEC = Liberia Electricity Corporation, USD = US dollar

Table C.6. Satisfaction with LEC

	2016	2018	2020	Two-year change (2018–2016)	Two-year change (2020–2018)
Sample size (households)	526	764	519		
Sample size (businesses)	43	180	80		
Households					
Percentage who are overall somewhat or very satisfied with quality of LEC customer service	50.0	51.4	42.9	1.3	-8.5***
Percentage who are overall somewhat or very satisfied with quality of LEC electricity	57.7	59.9	58.0	2.2	-1.9
Informed of LEC power cuts in advance (%)	~	1.8	10.9	~	9.1***
How much time after asking for assistance LEC came to fix issue (%):					
A few days	~	24.8	28.0	~	3.2
A week	~	8.9	11.0	~	2.1
More than a week, less than a month	~	29.2	24.2	~	-5.1
More than a month or never	~	37.0	36.9	~	-0.2
Businesses					
Percentage who are overall somewhat or very satisfied with quality of LEC customer service	15.0	19.5	38.3	4.5	18.8**
Percentage who are overall somewhat or very satisfied with quality of LEC electricity	31.8	29.1	62.3	-2.7	33.3***
How much time after asking for assistance LEC came to fix issue (%):					
A few days	~	28.4	11.2	~	-17.2
A week	~	7.0	5.4	~	-1.6
More than a week, less than a month	~	35.9	50.4	~	14.5
More than a month or never	~	28.7	33.0	~	4.3

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

~ Not available. Data for the outcome were not collected for the time period so the two-year change cannot be estimated.

LEC = Liberia Electricity Corporation

Table C.7. Disadvantages of getting electricity from LEC

	Household			Business		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Sample size	766	525		183	81	
Main disadvantages of getting electricity from LEC (%):						
No disadvantage	14.9	15.8	0.9	8.2	14.0	5.8
High connection cost	26.4	24.4	-2.0	27.7	15.1	-12.6
High wiring cost	2.2	8.6	6.4***	5.6	0.5	-5.1
High monthly charge	14.0	7.7	-6.3*	17.5	19.0	1.5
Have to pay bribe	17.0	21.3	4.2	39.6	9.5	-30.1**
Too much paperwork	16.2	15.7	-0.6	4.7	16.7	12.0*
Unreliable service	49.5	32.5	-17.0***	66.8	34.5	-32.4**
No national grid	5.5	0.3	-5.1***	3.9	9.1	5.2
Difficulty filling forms	9.7	6.0	-3.8	3.2	0.8	-2.4

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

LEC = Liberia Electricity Corporation

C. Energy use

Table C.8. Spending on LEC electricity and other sources of energy USD

	Households			Businesses		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Sample size	722	729		157	153	
Annual expenditures						
Expenditures on electricity sources in past year (USD):						
LEC electricity	165	84	-81***	392	311	-81
Other energy sources such as kerosene, candles, biomass, charcoal, etc.	89	117	28*	156	154	-2
Generator	271	187	-84	396	387	-9
Monthly expenditures						
Amount spent on electricity in the most recent month (USD)	15	11	-4	25	25	-1
Average monthly expenditure on non-electric energy sources (USD) (total):	19	25	6	632	0	-1114
Kerosene[a]	0	0	0	628	644	15
Diesel	101	34	-66	3648	3651	3
Petrol	62	128	66	14	260	245
LPG	20	70	50	0	0	0
Firewood	21	54	34	0	0	0
Charcoal	14	11	-4	40	26	-15
D-size dry cell battery	6	9	3	3	12	9
C-size dry cell battery	1	0	-3	0	0	0
AA-size dry cell battery	5	6	1	1	6	5
AAA-size dry cell battery	1	2	1	1	6	5

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2018 and 2020. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

[a] Monthly spending on non-electric energy sources (kerosene through AAA size dry cell batter) is conditional on using that type of energy source.

LEC = Liberia Electricity Corporation, USD = US dollar

Table C.9. Main use of electricity

	2016	2018	2020	Two-year change (2018– 2016)	Two-year change (2020– 2018)
Sample size (households)	536	765	612		
Sample size (businesses)	91	183	140		
Percentage of households whose main use of electricity is:					
Lighting	89.5	74.7	69.9	-14.8***	-4.8*
Fan	0.5	6.2	3.3	5.8***	-3.0**
Air conditioning	0.2	0.2	0.4	0.0	0.2
Heating water	0.0	0.4	0.1	0.4	-0.3
Electronic/electrical appliance	5.7	17.3	25.0	11.6***	7.7***
Other	4.1	1.5	1.3	-2.6**	-0.2
Percentage of small businesses whose main use of electricity is:					
Lighting	83.0	69.0	61.4	-14.1**	-7.5
Operate machinery/tools	4.9	5.8	9.0	0.9	3.2
Freeze goods for sale	4.4	9.2	13.4	4.7	4.2
Air conditioning	0.0	0.0	0.0	0.0	0.0
Pumping water	0.0	0.0	0.0	0.0	0.0
Electrical appliance	8.2	15.2	10.9	7.1	-4.4
Other	0.0	0.8	5.3	1.4	4.4**

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

Table C.10. Use of other energy sources

	Household			Business		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Sample size	766	766		183	171	
Uses non-electric energy source (%):						
Kerosene	0.0	1.3	1.3***	1.6	3.8	2.2
Diesel	1.1	2.5	1.3**	11.8	5.8	-6.0**
Petrol	2.2	9.0	6.8***	18.0	32.5	14.5***
LPG	0.6	3.1	2.6***	0.6	6.7	6.1***
Firewood	0.9	2.4	1.5**	0.3	0.0	-0.3
Charcoal	82.7	92.8	10.1***	18.6	28.5	10.0**
D-size dry cell battery	28.2	32.0	3.8	24.8	22.6	-2.1
C-size dry cell battery	1.7	9.2	7.4***	0.0	8.0	8.0***
AA-size dry cell battery	35.0	51.1	16.1***	12.1	24.0	11.9***
AAA-size dry cell battery	16.5	20.7	4.3**	3.4	10.7	7.3**
Did not use any energy source	6.2	1.3	-4.9***	34.1	23.6	-10.5**

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

D. Safety and security

Table C.11. Safety in community and injuries from LEC electricity

	Household			Business		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Sample size	766	759		182	170	
Community safety						
Enough light in many/all areas near household/business to walk at night (%)	22.4	28.3	5.9*	34.5	23.9	-10.6*
Respondent feels somewhat or very safe walking in community at night (%)	56.1	47.5	-8.6**	51.8	49.8	-2.0
Electricity injuries						
Household member died or seriously injured by LEC electricity in past year (%)	0.7	2.8	2.1**	--	--	--
Household has ever experienced a fire because of LEC electricity (%)	6.5	9.7	3.1	--	--	--

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

--   Not applicable.

E.   Time use

Table C.12. Adult time use

	Female			Male		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Sample size	437	502		307	454	
Employment						
Spent any time on wage labor (%)	16.5	36.6	20.0***	9.5	39.7	30.2***
Hours spent on wage labor	7.4	3.5	-3.9	8.2	7.3	-0.9
Spent any time on non-wage labor (%)	5.2	14.1	8.9	4.1	16.2	12.1**
Hours spent on non-wage labor	4.4	-0.3	-4.7	5.1	-33.6	-38.7
Household production						
Spent any time on cooking/preparing meals; food processing (%)	96.9	92.8	-4.0	29.8	33.9	4.2
Hours spent on cooking/preparing meals; food processing	1.8	2.0	0.3	1.3	1.0	-0.3
Spent any time getting water (%)	73.1	72.9	-0.2	59.6	41.6	-18.0**
Hours spent getting water	0.8	1.1	0.3	0.6	1.9	1.3
Spent any time on household chores (%)	91.3	89.3	-2.0	63.2	49.0	-14.3**
Hours spent on household chores	2.5	3.1	0.6	1.5	1.9	0.3
Leisure						
Spent any time listening to the radio (%)	53.3	47.1	-6.2	81.6	66.1	-15.6***
Hours spent listening to the radio	2.2	3.6	1.4	3.3	3.2	-0.1
Spent any time watching TV (%)	76.1	60.1	-16.0***	68.1	45.2	-22.9***
Hours spent watching TV	3.7	4.2	0.5	2.9	2.4	-0.5
Spent any time on leisure activities (%)	51.0	45.6	-5.4	67.9	55.0	-12.9*
Hours spent on leisure activities	2.0	1.4	-0.6	2.2	1.9	-0.3

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

F.   Economic well-being

Table C.13. Household expenditures and IGA characteristics

Outcome	2018	2020	Two-year change (2020–2018)
Sample size (households)	760	765	
Sample size (households with an IGA)	247	210	
Household consumption			
Household annual food and drink consumption in past year (USD)	1524	1080	-444***
Household business activity			
Household has an IGA (%)	30.5	27.9	-2.6
Number of IGAs household operates	1.2	1.0	-0.2
IGA sector of main IGA (%)			
Small grocery shop	9.5	25.4	15.9
Other food business	27.7	39.2	11.4
Other non-food business	30.9	19.3	-11.6
Average monthly revenue (USD)	484	333	-151
Average monthly profit (USD)	245	135	-110
Electricity is used in the operation of the IGA (%)	56.9	31.4	-25.5***
Main source of electricity (%)			
Direct line from LEC	70.2	44.9	-25.3
Indirect line from LEC	25.0	39.9	14.9
Own generator	1.2	0.0	-1.4
Neighbor's generator	0.4	6.6	6.3
Solar panels	0.0	0.0	0.0
Local minigrid	0.9	6.4	5.5
Car or motorcycle battery	0.0	0.0	0.0
Other	2.3	2.3	0.0
Business expenditure on electricity in the past year	172	67	-105

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for household fixed effects and control variables. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2018 and 2020. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

IGA = income-generating activity, LEC = Liberia Electricity Corporation, USD = US dollar

Table C.14. Small business operations

	2016	2018	2020	Two-year change (2018–2016)	Two-year change (2020–2018)
Sample size (businesses)	94	188	188		
Business operations					
Business closed (%)	--	--	9.0	--	--
Number of paid employees	1.0	0.9	1.7	-0.1	0.8***
Number of unpaid employees (including family members)	1.4	1.4	2.0	0.1	0.6***
Months of operation in past year	11.0	10.8	9.7	-0.2	-1.1***
Days of operation per week	6.2	6.2	6.1	0.0	-0.1**
Hours of operation per day	11.9	11.3	8.8	-0.6	-2.4***
Average monthly revenue (USD)	3736	1038	1649	-2698*	611
Average monthly profit (USD)	1029	380	133	-649	-247

Source: Baseline and interim small business surveys

Note: All means and estimated changes are regression adjusted for business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

-- Not applicable

USD = US dollar

Table C.15. Types of small businesses and monthly profit by business type

	Share of business type (%)			Monthly profit (USD)		
	2018	**2020**	**Two-year change (2020– 2018)**	**2018**	**2020**	**Two-year change (2020– 2018)**
Sample size	359	188				
Business type:						
Small grocery shop	18.2	19.2	1.0	546	508	-38
Tailoring/clothing repair	7.7	7.7	0.0	285	0	-402
Clothing production	1.7	1.7	0.0	2428	162	-2266
Cell phone dealer/repair/charging	6.0	5.1	-0.9	84	246	162
Other electric/electronic repair	6.5	5.1	-1.3	181	6	-175
Medical facility/clinic/dispensary	7.1	7.1	0.0	378	1797	1419
Beauty salon/barber shop	8.2	8.2	0.0	87	676	589
Other food business (restaurant/bar, food seller)	21.1	20.2	-0.9	275	443	168
Other non-food business (market seller, trader)	23.6	23.3	-0.3	434	149	-285

Source: 2018 and 2020 Monrovia household and small business surveys

Note: All means and estimated changes are regression adjusted for business fixed effects and control variables. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2018 and 2020. The change in monthly profit is estimated among businesses that do not change business type over time. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

Table C.16. Types of IGAs and monthly profit by IGA type

	Share of IGA type (%)			Monthly profit (USD)		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Sample size	247	169		51	22	
IGA type:						
Small grocery shop	9.5	25.1	15.6	295	344	49***
Other food business (restaurant/bar, food seller)	27.7	40.7	13.0	316	0	-445
Other non-food business (market seller, trader)	30.9	18.6	-12.3	243	0	-470

Source: 2018 and 2020 Monrovia household surveys

Note: All means and estimated changes are regression adjusted for business fixed effects and control variables. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2018 and 2020. The change in monthly profit is estimated among IGA that do not change IGA type over time. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

IGA = income-generating activity

G. COVID-19

Table C.17. Effects of COVID-19 on households and household IGAs

	2020
Sample size	766
Education	
Any school-aged children have missed school because of COVID-19, since March 2020 (%)	88.7
Any school-aged children are participating in distance learning (%)	28.5
School-aged children are spending less time on education compared to before COVID-19 (%)	73.9
Challenges limiting time children spend on education (%)	
Lack of access to television	13.6
Lack of access to radio	8.0
Lack of access to internet	21.8
Lack of access to educational programs	44.1
Lack of access to textbooks or learning materials	46.1
Lack of access to mobile phone/tablets	15.6
Lack of motivation	13.7
Lack of support from teachers and schools	22.9
Children are working to earn money	3.0
Children are taking care of their siblings	4.3
Children are doing housework	13.3
Lack of supervision from adults in the household	8.6
There is not a good/quiet place to study	5.9
Children need to spend their time doing other things	7.2
No challenges	7.4
Energy usage	
Change in LEC electricity consumption since COVID-19 (%)	
Increased	25.5
Decreased	20.9
Stayed the same	53.6
Change in consumption of other energy sources since COVID-19 (%)	
Increased	33.5
Decreased	18.3
Stayed the same	48.2
Household economic situation	
COVID-19 has affected household member's employment status (%)	47.6
COVID-19 has affected household member's ability to commute to work (%)	52.2
Household's income has decreased since COVID-19 (%)	64.6

	2020
Effects of COVID-19 on ability to conduct IGA (%):	
Had to cease operations	50.3
Had to change type of activity	21.3
Did not affect operations	28.4
Effects of COVID-19 on IGA revenue (%):	
Increased	7.2
Decreased	75.6
Stayed the same	17.3
Effects of COVID-19 (%)	
Forced to sell off assets	8.6
Forced to borrow	30.5
Forced to stop paying loans	7.4
None of the above	61.8
Government response	
Household has received food, cash or other support from the government that it does NOT usually receive (%)	
Food	93.7
Cash	0.5
Personal protective equipment	5.8
Water	1.9
Soap	29.5
Free LEC electricity	6.0
Somewhat or very satisfied with government's response to COVID-19 in Liberia (%)	42.3

Source: 2020 Monrovia household survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

LEC = Liberia Electricity Corporation

Table C.18. Effects of COVID-19 on small businesses

Outcome	2020
Sample size	171
Energy usage	
Change in LEC electricity consumption since COVID-19 (%)	
Increased	9.0
Decreased	39.3
Stayed the same	51.7
Change in consumption of other energy sources since COVID-19 (%)	
Increased	23.2
Decreased	29.9
Stayed the same	46.9
Business operations and finances	
Effects of COVID-19 on business operations (%):	
Had to cease operations	59.5
Reduce working hours	79.2
Change type of business	7.0
Employees had to work from home	13.5
Employees had to wear personal protective equipment	77.7
Lay off employees	18.3
Reduce wages	10.7
Effects of COVID-19 on business profit (%):	
Increased	5.9
Decreased	83.6
Stayed the same	10.5
Effects of COVID-19 (%)	
Forced to sell off assets	22.0
Forced to borrow	26.6
Forced to stop paying loans	13.2
None of the above	50.3
Government response	
Business has received food, cash or other support from the government that it does NOT usually receive (%)	
Food	89.2
Cash	3.5
Personal protective equipment	24.7
Water	3.5
Soap	28.6
Free LEC electricity	3.5

Outcome	2020
Somewhat or very satisfied with government's response to COVID-19 in Liberia (%)	47.1

Source: 2020 Monrovia small business survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

LEC = Liberia Electricity Corporation

Table C.19. Effects of COVID-19 on communities as reported by community leaders

Outcome	2020
Sample size (communities)	30
Movement into, out of, and within community	
Change in migration into community since COVID-19 (%)	
Increased	26.7
Decreased	3.3
Stayed the same	70.0
Change in migration out of community since COVID-19 (%)	
Increased	10.3
Decreased	13.8
Stayed the same	75.9
Community was instructed to stay home due to COVID-19 (%)	96.7
Energy supply	
COVID disrupted power supply (%)	17.9
Business and organization closures	
Locations or activities that closed during the past year due to COVID-19 (%)	
Schools	93.3
Markets	43.3
Bank	20.0
Shops	66.7
Restaurants	23.3
Entertainment Centers	96.7
Religious Centers	96.7
Barber Shops, Beauty Salons	56.7
Public Transport	33.3
Post Office	3.3
Police Office	10.0
Health Centers	26.7
Hospitals	0.0
Dispensary/Pharmacy	43.3
Local Government Office	16.7
Street Selling	26.7
Mobile Money Agents	26.7
Government and donor response	
Community received extra support from government due to COVID-19 (%)	66.7
COVID-19 support received from government (%)	
Food	1.0

Outcome	2020
Cash	0.0
Personal protective equipment	35.0
Water	5.0
Soap	40.0
Free LEC electricity	15.0
Other	50.0
Community received extra support from donors due to COVID-19 (%)	53.3
COVID-19 support received from donors (%)	
Food	50.0
Cash	6.3
Personal protective equipment	56.3
Water	0.0
Soap	68.8
Free electricity	0.0
Other	25.0
Community members can obtain masks in the community (%)	96.7
Number of people in community who wear masks in public spaces (%)	
None	0.0
Very few	56.7
Some	16.7
Almost all	26.7
All	0.0

Source: 2020 Monrovia community leader survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

LEC = Liberia Electricity Corporation

H.   Subgroup analysis

Table C.20. Household business activity by subgroup

Outcome	2018	2020	Two-year change (2020–2018)
Sample size	760	765	
Household business activity			
Household has an IGA (%)	30.5	27.9	-2.6
Female-headed	34.8	32.5	-2.3
Male-headed	28.6	25.8	-2.8
Below mean consumption	27.0	26.8	-0.2
Above mean consumption	35.1	29.0	-6.0*
Average monthly profit (USD) (all)	245	135	-110
Female-headed	235	75	-160*
Male-headed	250	173	-78
Below mean consumption	241	147	-94
Above mean consumption	249	131	-118

Source: 2020 Monrovia household survey

Note: All means and estimated changes are regression adjusted for household fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

IGA = income-generating activity

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Appendix D

Detailed Findings from Kakata

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A. Access to electricity

Table D.1. Household and business access to electricity

	2019	2021	Two-year Change (2019-2021)
Sample size (households)	747	747	
Sample size (businesses)	374	274	
Household access to electricity sources			
Household has LEC electricity (%)	0.0	50.6	50.6***
Percentage of households whose main source of electricity is:			
Direct line from LEC	0.0	47.1	47.1***
Indirect line from LEC	0.0	3.0	3.0**
Own generator	9.4	5.5	-3.9
Neighbor's generator	0.9	1.4	0.5
Solar panels	0.8	0.4	-0.4
Local minigrid	8.4	0.0	-8.4***
Car or motorcycle battery	0.0	0.0	-1.1
Other	0.1	1.7	1.6
None	80.4	41.6	-38.8***
Business access to electricity sources			
Business has LEC electricity (%)	**0.0**	**34.9**	**34.9***
Percentage of small businesses whose main source of electricity is:			
Direct line from LEC	0.0	25.9	25.9***
Indirect line from LEC	0.0	7.4	7.4***
Own generator	12.3	5.7	-6.6**
Neighbor's generator	4.8	8.1	3.3
Solar panels	0.2	0.8	0.6
Local minigrid	24.8	8.6	-16.2***
Car or motorcycle battery	0.0	0.0	0.0
Other	0.5	0.9	0.4
None	57.3	47.5	-9.8*

Source: 2019 and 2021 Kakata corridor household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2019 and 2021.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

LEC = Liberia Electricity Corporation

Table D.2. Community-level access to LEC and other sources of electricity

	2019	2021	Two-year Change (2019-2021)
Sample Size	25	25	
LEC access			
Community access to LEC current (%)			
Full access	0.0	52.0	52.0***
Partial access	20.0	32.0	12.0
No access	80.0	16.0	-64.0***
Other energy sources			
Percentage of households receiving electricity from the following sources, as reported by community leaders			
LEC	1.9	57.7	55.8***
Hours of electricity available for a typical day	14.5	19.4	4.9
Local minigrid	0.8	1.0	0.2
Own generator	0.9	1.2	0.2
Neighbor's generator	0.2	0.7	0.5***
Solar panels installed on building's premises	0.5	0.8	0.3*
Car or motorcycle battery	24.0	23.8	-0.2
No access to electricity	3.8	2.0	-1.8***
Percentage of communities with the following services that have access to LEC electricity			
Government elementary school	8.0	24.0	16.0
Private elementary school	4.0	64.0	60.0***
Government junior high school	4.0	28.0	24.0**
Private junior high school	8.0	60.0	52.0***
Government senior high school	4.0	32.0	28.0***
Private senior high school	12.0	40.0	28.0**
Post office	0.0	0.0	0.0
Bank	0.0	0.0	0.0
Police post	8.0	44.0	36.0***
Dispensary/pharmacy	12.0	72.0	60.0***
Health center	8.0	68.0	60.0***
Hospital	0.0	4.0	4.0
Local government office	4.0	32.0	28.0***

Source: 2019 and 2021 Kakata corridor community surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

LEC = Liberia Electricity Corporation

Table D.3. Households and businesses not connected to LEC electricity

	Household	Business
Sample size	460	186
Reason respondent does not use LEC current now (%)		
LEC current is too far from household/LEC current not available in area	35.8	61.1
LEC disconnected the household	0.5	~
Cost of formal/new connection is too expensive	12.8	13.7
Monthly fee is too expensive	9.5	7.9
Satisfied with energy situation/don't need LEC current	0.5	4.3
Renting, landlord decision	1.5	3.3
Service unreliable	4.2	10.5
Administrative procedure for formal/new connection is too complicated	5.8	1.0
Submitted application and waiting for new connection	8.3	5.9
Temporarily disconnected due to issues/failures with grid	1.7	9.8
Does not use any other source of electricity (%)	82.7	54.8
Reason respondent does not use any other source of current (%)		
Not available/accessible	35.0	40.3
Cost of connection is too expensive	46.7	17.2
Monthly fee is too expensive	40.9	29.4
Satisfied with energy situation/don't need	0.3	1.0
Renting, landlord decision	1.5	1.9
Service unreliable	1.1	6.2
Administrative procedure is too complicated	1.1	0.9
Submitted application and is waiting for connection	0.1	2.1
Company refused to connect	1.1	0.0
Main disadvantages of not having current (%)		
More time needs to be spent on completing household chores	8.8	~
Perishable goods are spoiled	3.8	~
Unable to start a business in the household premises	9.9	~
Difficulty in operating a business in the household premises	14.4	~
Less time spent by children on reading/studying	37.8	~
Less time spent on leisure activities like watching TV, listening to radio	30.2	~
Less security (theft, etc.)	35.4	~
Increased risk to animal related hazards	26.9	~
Increased risk to health hazards	27.8	~
Meetings/transactions are delayed/slow	~	28.1
Reduced operations or reduced business activities	~	35.7
Turning customers away	~	7.7

	Household	Business
Used more expensive products to deal with not having electricity	~	18.8
Wasted perishable products/Discarded damaged goods	~	4.9
Not affected	8.8	24.5

Source: 2021 Kakata corridor household and small business surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

~   Not applicable.

LEC = Liberia Electricity Corporation

B. Electricity quality and reliability

Table D.4. Quality of electricity

	Household	Business
Sample size	287	374
Electricity quality		
Wet season:		
No. times in a week experienced high or low voltage	2.4	1.7
No. hours in total electricity went out in a week	20.0	5.5
Dry season:		
No. times in a week experienced high or low voltage	2.8	3.7
No. hours in total electricity went out in a week	22.2	6.1
Voltage:		
Experienced voltage drops in past year (%)	61.0	42.8
Frequency of voltage drops (%)		
Everyday	8.2	6.2
Two to three times per week	72.2	34.7
A few times per month	19.6	59.1
Respondent has a ready board	5.3	1.0

Source: 2021 Kakata corridor household and small business surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

Table D.5. Negative effects of power outages

	Households	Small businesses
Sample size (households)	284	83
Sample size (household income generating activity (IGA))	50	
Household effects		
Reported effects of power cuts on households		
Higher maintenance costs and/or replacement of equipment/devices for household IGA	10.4	--
Higher maintenance expenses and / or replacement of appliances or equipment for household use	16.0	--
Destruction of leisure devices (TV, Radio, etc.)	15.9	--
Loss of income related to income-generating activity	16.4	--
Difficulties working from home	51.6	--
Difficulty studying	63.6	--
Increasing insecurity	63.9	--
Business and IGA effects		
Reported operational effects of power cuts on household IGA and small business activity (%)		
Percentage experiencing power cuts in the past month	46.0	36.0
Continue all operations on backup supply	5.4	5.4
Meetings/transactions were delayed	9.3	20.1
Continue reduced operations on backup supply	0.0	15.0
Had to turn customers away	40.8	17.4
Had to send workers home for the day with pay	0.0	0.0
Had to send workers home for the day without pay	0.0	3.1
Used more expensive alternate energy sources to run appliances	6.7	5.6
Cut back on operations to keep perishables cold	2.5	0.0
Wasted perishable products/discarded damaged goods	14.8	0.0
Machines/appliances were damaged in the process to	4.7	11.7
Provided backup electricity to others	3.4	0.0
Stop operations and waited for power to return	11.1	2.7
Reported financial costs of power cuts on household IGA and business:		
Business lost revenue due to power cuts in the past year (%)	56.5	63.0
Revenue lost due to power cuts in past year (USD)	208	215
Costs incurred due to power outages (USD)	108	88
Appliances or equipment were damaged by LEC current in the past year (%)	23.3	46.1
Cost of fixing or replacing appliances/machinery damaged by LEC current in past year (USD)	104	112
Working hours limited by supply of energy in past year (%)	41.3	31.2

Source: 2021 Kakata corridor household and small business surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

--   Not applicable.

IGA = income-generating activity, LEC = Liberia Electricity Corporation, USD = US dollar.

Table D.6. Satisfaction with LEC

	2021
Sample size (households)	282
Sample size (small businesses)	87
Households	
Percentage who have contacted customer service in the past year	21.7
Method of contacting customer service (%)	
In person	39.2
By phone	61.7
By email	2.9
Other	0.0
Reason for contacting customer service (%)	
Request for new connection	15.1
Request to cancel connection	5.7
Billing error or question	10.2
Account change (name, payment information, etc.)	10.3
Outage	15.7
Voltage problems	28.3
Stolen meter	0.9
Damaged equipment	10.0
Involuntary disconnection	0.8
Other	9.0
Percentage Whose issue was resolved by customer service	79.9
Percentage who are somewhat or very satisfied with quality of LEC customer service related to billing	72.7
Percentage who are somewhat or very satisfied with quality of LEC customer service related to repair or breakdowns	47.1
Percentage who are somewhat or very satisfied with quality of LEC customer service related to connection time	63.0
Percentage who are somewhat or very satisfied with quality of LEC customer service related to complaint management	50.4
Percentage who are overall somewhat or very satisfied with quality of LEC customer service	67.0
Percentage who are overall somewhat or very satisfied with quality of LEC electricity	78.4
Businesses	
Percentage who have contacted customer service in the past year	19.5
Method of contacting customer service (%)	
In person	83.2
By phone	30.5
By email	0.0
Other	0.0

	2021
Reason for contacting customer service (%)	
Request for new connection	42.8
Request to cancel connection	0.0
Billing error or question	7.9
Account change (name, payment information, etc.)	10.6
Outage	5.7
Voltage problems	59.0
Stolen meter	10.6
Damaged equipment	28.7
Involuntary disconnection	0.0
Other	5.3
Percentage Whose issue was resolved by customer service	63.8
Percentage who are somewhat or very satisfied with quality of LEC customer service related to billing	62.9
Percentage who are somewhat or very satisfied with quality of LEC customer service related to repair or breakdowns	25.2
Percentage who are somewhat or very satisfied with quality of LEC customer service related to connection time	34.8
Percentage who are somewhat or very satisfied with quality of LEC customer service related to complaint management	28.0
Percentage who are overall somewhat or very satisfied with quality of LEC customer service	43.9
Percentage who are overall somewhat or very satisfied with quality of LEC electricity	56.3

Source: 2021 Kakata corridor household and small business surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

LEC = Liberia Electricity Corporation

Table D.7. Disadvantages of getting electricity from LEC

	Households	Businesses
Sample size	287	88
Main disadvantages of getting electricity from LEC (%)		
No disadvantage	36.7	31.5
High connection cost	10.2	25.3
High wiring cost	4.7	12.8
High monthly charge	3.2	5.1
Have to pay bribe	17.0	13.9
Too much paperwork	10.7	2.0
Unreliable service	18.7	18.7
No national grid	0.6	0.0
Difficulty filling forms	4.1	4.6

Source: 2021 Kakata corridor household and small business surveys

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

LEC = Liberia Electricity Corporation

C. Energy use

Table D.8. Spending on LEC electricity and other sources of energy

	Household			Business		
	2019	**2021**	**Two-year Change (2019-2021)**	**2019**	**2021**	**Two-year Change (2019-2021)**
Sample size	616	600		94	69	
Monthly expenditure						
Expenditures on other non-LEC electricity sources in past month (USD)						
Own generator	51	0	-56	113	144	31
Neighbor's generator	12	3	-9	56	51	-5
Solar	9	259	250	0	871	871
Local mini-grid or community current	25	30	5	41	57	16
Average monthly expenditure on non-electric energy sources (USD) (total) [a]	18	14	-4	44	39	-6
Kerosene	33	19	-14	5	8	3
Diesel	128	0	-438	201	0	-477
Petrol	28	0	-112	59	61	2
LPG	~	19	~	~	114	~
Firewood	1	9	8	67	0	-76
Charcoal	10	9	-1	14	31	17
D-size dry cell battery (big battery)	4	9	4	10	16	6
C-size dry cell battery (medium battery)	5	0	-16	2	14	12
AA-size dry cell battery (finger battery)	4	9	6	2	3	0
AAA size dry cell battery (small battery)	2	1	-0	1	17	16
Electricity sharing						
Other users are connected to meter (%)	--	21.9	--	--	13.5	--
Number of users connected to meter	--	3.0	--	--	2.5	--

Source: 2021 Kakata corridor household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2019 and 2021. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

~   Not available. Data for the outcome were not collected for the time period so the two-year change cannot be estimated.

--   Not applicable as sample was not connected to LEC in 2019.

LEC = Liberia Electricity Corporation, USD = US dollar

Table D.9. Main use of electricity

	2019	2021	Two-year Change (2019-2021)
Sample size (households)	143	366	
Sample size (businesses)	160	170	
Percentage of households whose main use of electricity is:			
Lighting	87.5	73.2	-14.3
Fan	0.0	2.7	2.7
Air conditioning	1.7	0.0	-2.1
Heating water	0.0	0.0	0.0
Electronic/electrical appliance	9.5	23.2	13.7
Other	3.0	0.9	-2.1
Percentage of small businesses whose main use of electricity is:			
Lighting	58.2	45.4	-12.8*
Operate machinery/tools	7.5	0.0	-7.4
Freeze goods for sale	7.3	15.6	8.3
Air conditioning	2.5	0.0	-2.9
Pumping water	0.0	0.0	0.0
Electrical appliance	12.8	34.3	21.6***
Other	11.7	1.3	-10.5**

Source: 2021 Kakata corridor household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2019 and 2021. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

Table D.10. Use of other energy sources

	Household			Business		
	2019	**2021**	**Two-year change (2019–2021)**	**2019**	**2021**	**Two-year change (2021–2019)**
Sample size	747	747		374	374	
Uses non-electric energy source (%):						
Kerosene	0.7	0.0	-1.6	1.0	0.7	-0.3
Diesel	1.5	0.0	-2.4**	5.0	0.7	-4.3**
Petrol	9.9	8.3	-1.6	15.8	20.5	4.7
LPG	0.1	-0.0	-0.1	0.0	0.8	0.8
Firewood	16.1	11.0	-5.2	0.5	0.2	-0.3
Charcoal	88.7	85.3	-3.4	17.2	9.4	-7.7**
D-size dry cell battery	42.1	20.6	-21.5***	17.7	14.5	-3.1
C-size dry cell battery	2.7	0.0	-2.9	1.2	6.9	5.7***
AA-size dry cell battery	57.6	16.0	-41.5***	14.7	12.8	-1.8
AAA-size dry cell battery	4.6	6.7	2.0	1.8	0.3	-1.5
Did not use any energy source	1.6	1.5	-0.2	48.7	44.5	-4.2

Source: 2019 and 2021 Kakata corridor household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2019 and 2021.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

D. Safety and security

Table D.11. Safety in community and injuries from LEC electricity

	Household			Business		
	2019	**2021**	**Two-year change (2021–2019)**	**2019**	**2021**	**Two-year change (2021–2019)**
Sample size	733	727		373	267	
Community safety						
Enough light in many/all areas near household/business to walk at night (%)	7.5	18.1	10.7	10.1	27.8	17.6
Respondent feels somewhat or very safe walking in community at night (%)	35.5	64.5	29.0***	40.7	43.2	2.5
Number of security problems per year	~	~	~	1.0	1.2	0.2
Electricity injuries						
Household member died or seriously injured by LEC electricity in past year (%)	~	0.5	~	~	~	~
Household has ever experienced a fire because of LEC electricity (%)	~	1.8	~	~	~	~

Source: 2019 and 2021 Kakata corridor household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

~   Not available. Data for the outcome were not collected for the time period so the two-year change cannot be estimated.

LEC = Liberia Electricity Corporation

E. Time use

Table D.12. Adult time use

	Female			Male		
	2018	**2020**	**Two-year change (2020–2018)**	**2018**	**2020**	**Two-year change (2020–2018)**
Sample size	452	445		311	446	
Employment						
Spent any time on wage labor (%)	39.6	28.0	-11.5	36.4	31.9	-4.5
Hours spent on wage labor	6.5	5.6	-1.0	6.9	7.9	1.0
Spent any time on non-wage labor (%)	32.4	23.0	-9.4	20.7	10.3	-10.4
Hours spent on non-wage labor	3.7	4.7	0.9	5.1	3.8	-1.3
Household production						
Spent any time on cooking/preparing meals; food processing (%)	90.0	84.7	-5.3	29.3	35.7	6.4
Hours spent on cooking/preparing meals; food processing	1.9	1.8	-0.0	1.4	2.1	0.7
Spent any time getting water (%)	70.9	74.5	3.7	44.2	63.6	19.4
Hours spent getting water	0.5	0.3	-0.2	0.4	0.4	-0.1
Spent any time on getting fuel (%)	6.0	11.2	5.2	9.1	13.0	3.8
Hours spend getting fuel	0.7	0.0	-3.5	0.4	1.6	1.1
Spent any time on household chores (%)	89.9	80.2	-9.8	54.5	50.7	-3.8
Hours spent on household chores	2.1	2.3	0.2	1.5	2.9	1.4
Leisure						
Spent any time listening to the radio (%)	46.1	57.1	11.1	78.3	72.9	-5.4
Hours spent listening to the radio	3.4	1.7	-1.7	4.3	4.7	0.4
Spent any time watching TV (%)	18.2	13.8	-4.4	17.3	34.4	17.2
Hours spent watching TV	2.3	6.2	3.9	2.1	1.5	-0.6
Spent any time on leisure activities (%)	43.2	48.2	5.1	57.8	69.0	11.2
Hours spent on leisure activities	1.8	2.1	0.3	2.3	1.8	-0.5

Source: 2019 and 2021 Kakata corridor household and small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

F. Economic well-being

Table D.13. Household expenditures and IGA characteristics

	2019	2021	Two-year Change (2019-2021)
Sample size (all households)	747	743	
Sample size (households with an IGA)	202	140	
Household consumption			
Household annual food and drink consumption in past year (USD)	102	69	-32
Household business activity			
Household has an IGA (%)	24.8	17.4	-7.3
Number of IGAs household operates	1.1	1.2	0.1
IGA sector of main IGA (%)			
Small grocery shop	13.4	2.0	-11.4
Other food business	38.8	57.8	19.0
Other non-food business	23.6	31.9	8.3
Average monthly revenue (USD)	123	356	232
Average monthly profit (USD)	54	125	71
Number of months in operation during past year	8.1	9.2	1.1
Electricity is used in the operation of the IGA (%)	16.3	23.4	7.1

Source: 2019 and 2021 Kakata corridor household surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

IGA = income-generating activity, LEC = Liberia Electricity Corporation

Table D.14. Small business operations

	2019	2021	Two-year Change (2019-2021)
Sample size	374	374	
Business operations			
Business closed (%)	--	27.1	--
Number of paid employees	0.5	0.6	0.0
Number of unpaid employees (including family members)	1.5	1.6	0.1
Months of operation in past year	10.2	10.9	0.7**
Days of operation per week	6.1	6.2	0.1
Hours of operation per day	9.8	8.8	-1.0*
Average monthly profit (USD)	293	124	-169**
Average monthly revenue (USD)	1,160	233	-927

Source: 2019 and 2021 Kakata corridor small business surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

-- Not applicable as sample consisted of small businesses operational in 2019.

USD = US dollar

Table D.15. Reasons households had no IGAs

	2021
Sample size	588
Reason household had no IGAs during past 12 months (%)	
Don't need the income	3.2
Insufficient financial resources to start one	68.3
Lack of grid electricity	4.8
Lack of clean water	1.1
Lack of access to good roads	2.2
Lack of market for product	3.2
Required cost of water is too expensive	0.3
Required cost of electricity is too expensive	0.4
Required costs such as rent are too expensive	0.2
Don't know how to start an IGA	0.3
Don't have time	16.2
Due to COVID-19	2.7
Previous IGA has become a stand-alone business	0.0

Source: 2019 and 2021 Kakata corridor household surveys

Note: All means and estimated changes are regression adjusted for household or business fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

IGA = income-generating activity

G. COVID-19

Table D.16. Effects of COVID-19 on households and household IGAs

	2021
Sample size	747
Education	
Any school-aged children have missed school because of COVID-19, since March 2020 (%)	72.8
School-aged children are spending less time on education compared to before COVID-19 (%)	28.3
Challenges limiting time children spend on education (%)	
Lack of access to television	2.1
Lack of access to radio	2.5
Lack of access to internet	9.4
Lack of access to educational programs	19.9
Lack of access to textbooks or learning materials	27.5
Lack of access to mobile phone/tablets	6.4
Lack of motivation	5.7
Lack of support from teachers and schools	8.7
Children are working to earn money	3.0
Children are taking care of their siblings	1.2
Children are doing housework	5.8
Lack of supervision from adults in the household	3.8
There is not a good/quiet place to study	4.4
Children need to spend their time doing other things	7.1
No challenges	24.2
Energy usage	
Change in LEC electricity consumption since COVID-19 (%)	
Increased	32.0
Decreased	18.6
Stayed the same	49.3
Change in consumption of other energy sources since COVID-19 (%)	
Increased	27.6
Decreased	27.7
Stayed the same	44.8
Household economic situation	
COVID-19 has affected household member's employment status (%)	37.5
COVID-19 has affected household member's ability to commute to work (%)	42.4
Household's income has decreased since COVID-19 (%)	61.9

	2021
Effects of COVID-19 on ability to conduct IGA (%):	
Had to cease operations	51.3
Had to change type of activity	15.6
Did not affect operations	33.2
Effects of COVID-19 on IGA revenue (%):	
Increased	10.9
Decreased	72.3
Stayed the same	16.8
Effects of COVID-19 (%)	
Forced to sell off assets	16.2
Forced to borrow	42.0
Forced to stop paying loans	7.6
None of the above	48.3
Government response	
Household has received food, cash or other support from the government that it does NOT usually receive (%)	
Food	90.4
Cash	0.9
Personal protective equipment	8.7
Water	0.8
Soap	4.5
Free LEC electricity	1.4
Somewhat or very satisfied with government's response to COVID-19 in Liberia (%)	438.02.3

Source: 2021 Kakata corridor household survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

IGA = income-generating activity, LEC = Liberia Electricity Corporation

Table D.17. Effects of COVID-19 on small businesses

	2021
Sample size	274
Energy usage	
Change in LEC electricity consumption since COVID-19 (%)	
Increased	22.0
Decreased	42.8
Stayed the same	35.2
Change in consumption of other energy sources since COVID-19 (%)	
Increased	21.5
Decreased	31.8
Stayed the same	46.6
Business operations and finances	
Effects of COVID-19 on business operations (%):	
Had to cease operations	66.9
Reduce working hours	84.4
Change type of business	5.0
Employees had to work from home	7.3
Employees had to wear personal protective equipment	86.3
Lay off employees	12.7
Reduce wages	9.4
Effects of COVID-19 on business profit (%):	
Increased	5.8
Decreased	82.7
Stayed the same	11.4
Effects of COVID-19 (%)	
Forced to sell off assets	17.7
Forced to borrow	34.8
Forced to stop paying loans	13.6
None of the above	55.3
Government response	
Business has received food, cash or other support from the government that it does NOT usually receive (%)	
Food	74.5
Cash	25.5
Personal protective equipment	0.0
Water	0.0
Soap	0.0
Free LEC electricity	0.0

	2021
Somewhat or very satisfied with government's response to COVID-19 in Liberia (%)	20.8

Source: 2021 Kakata corridor small business survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

LEC = Liberia Electricity Corporation

Table D.18. Effects of COVID-19 on communities as reported by community leaders

Outcome	2020
Sample size (communities)	25
Movement into, out of, and within community	
Change in migration into community since COVID-19 (%)	
Increased	9.1
Decreased	4.5
Stayed the same	86.4
Change in migration out of community since COVID-19 (%)	
Increased	8.0
Decreased	8.0
Stayed the same	84.0
Community was instructed to stay home due to COVID-19 (%)	1.0
Energy supply	
COVID disrupted power supply (%)	8.0
Business and organization closures	
Locations or activities that closed during the past year due to COVID-19 (%)	
Schools	96.0
Markets	44.0
Bank	12.0
Shops	32.0
Restaurants	60.0
Entertainment Centers	84.0
Religious Centers	96.0
Barber Shops, Beauty Salons	28.0
Public Transport	32.0
Post Office	12.0
Police Office	8.0
Health Centers	12.0
Hospitals	12.0
Dispensary/Pharmacy	28.0
Local Government Office	20.0
Street Selling	28.0
Mobile Money Agents	20.0
Government and donor response	
Community received extra support from government due to COVID-19 (%)	16.0
COVID-19 support received from government (%)	
Food	1.0

Outcome	2020
Cash	0.0
Personal protective equipment	0.0
Water	0.0
Soap	0.0
Free LEC electricity	0.0
Other	0.0
Community received extra support from donors due to COVID-19 (%)	4.0
COVID-19 support received from donors (%)	
Food	1.0
Cash	0.0
Personal protective equipment	0.0
Water	0.0
Soap	0.0
Free electricity	0.0
Other	0.0
Community members can obtain masks in the community (%)	72.0
Number of people in community who wear masks in public spaces (%)	
None	0.0
Very few	12.0
Some	48.0
Almost all	20.0
All	20.0

Source: 2021 Kakata corridor community survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse

H. Subgroup analysis

Table D.19. Households' main use of electricity by subgroup

	2019	2021	Two-year change (2021-2019)
Sample size	108	263	
Percentage of households whose main use of electricity is:			
Lighting (all)	87.5	73.2	-14.3
Has IGA	85.6	62.6	-22.9
Has no IGA	88.3	79.6	-8.8
Female-headed	93.8	44.1	-49.8
Male-headed	84.9	94.3	9.4
Below mean consumption	83.6	99.4	15.8
Above mean consumption	89.7	61.1	-28.5
Fan (all)	0	2.7	2.7
Has IGA	0	0.0	0.0
Has no IGA	0	4.0	4.0
Female-headed	0	0.0	0.0
Male-headed	0	4.2	4.2
Below mean consumption	0	0.0	0.0
Above mean consumption	0	4.6	4.6
Air conditioning (all)	1.7	0.0	-2.1
Has IGA	5.2	0.0	-10.1
Has no IGA	0.2	0.2	0.0
Female-headed	0.0	0.0	0.0
Male-headed	2.3	0.3	-2.0
Below mean consumption	2.5	0.0	-2.5
Above mean consumption	1.2	0.0	-2.0
Heating water (all)	0	0	0
Has IGA	0	0	0
Has no IGA	0	0	0
Female-headed	0	0	0
Male-headed	0	0	0
Below mean consumption	0	0	0
Above mean consumption	0	0	0
Electronic/electrical appliance	9.5	23.2	13.7
Has IGA	8.3	46.3	38.0

	2019	2021	Two-year change (2021-2019)
Has no IGA	9.9	12.5	2.6
Female-headed	6.2	55.9	49.8
Male-headed	10.8	0.0	-11.5
Below mean consumption	11.4	1.1	-10.2
Above mean consumption	8.4	32.4	24.0
Other	3.0	0.9	-2.1
Has IGA	6.1	0.0	-15.1
Has no IGA	1.7	3.9	2.2
Female-headed	0.0	0.0	0.0
Male-headed	4.2	2.1	-2.1
Below mean consumption	5.0	0.0	-5.5
Above mean consumption	1.9	1.9	0.0

Source: 2021 Kakata household survey

Note: All means and estimated changes are regression adjusted for household fixed effects and control variables. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2019 and 2021. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

Table D.20. Household business activity by subgroup

Outcome	2019	2021	Two-year change (2021–2019)
Sample size	560	559	
Household business activity			
Household has an IGA (%)	24.8	17.4	-7.3
Female-headed	31.6	0.0	-33.3***
Male-headed	21.6	30.0	8.4
Below mean consumption	25.6	12.0	-13.6*
Above mean consumption	23.9	21.9	-2.0
Average monthly profit (USD) (all)	54.0	125.0	71.1
Female-headed	68.5	85.1	16.6
Male-headed	42.5	161.2	118.7
Below mean consumption	44.2	156.3	112.1
Above mean consumption	65.8	41.6	-24.2

Source: 2021 Kakata household survey

Note: All means and estimated changes are regression adjusted for household fixed effects and control variables. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2019 and 2021. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

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Appendix E

Detailed Findings on Medium and Large End Users

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A. Access to electricity

Table E.1. Access to electricity

	2016	2019	2021	Three-year change (2016–2019)	Two-year change (2019–2021)
Sample size	727	760	738		
Medium and large end user access to electricity sources					
End user has LEC electricity (%)	~	55.9	64.7	~	8.8
Percentage of medium and large end users whose main source of electricity is:					
Direct line from LEC	33.1	44.9	60.0	11.8***	15.2***
Indirect line from LEC	1.3	2.3	2.5	1.0	0.2
Own generator	44.4	36.9	22.5	-7.4	-14.5***
Neighbor's generator	4.0	3.0	2.4	-1.0	-0.6
Solar panels	0.0	-0.3	2.2	-0.3	2.4**
Local minigrid	6.6	4.6	4.3	-2.0	-0.3
Car or motorcycle battery	0.7	0.6	0.0	0.0	-0.8
Other	0.7	0.7	2.4	0.1	1.7*
None	9.3	7.2	3.9	-2.1	-3.2

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between years. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

LEC = Liberia Electricity Corporation

The sample comprised medium and large enterprises and organizations located in and around Monrovia.

Table E.2. Medium and large users not connected to LEC electricity

	2021
Sample size	125
Reason for not having LEC connection (%)	
Too far/not available	40.9
Connection cost too expensive	6.8
Monthly fee too expensive	0.0
Satisfied with energy situation	2.3
Renting/landlord decision	0.0
Service unreliable	18.2
Complicated administrative procedures	11.4
Submitted application, waiting	13.6
LEC refused to provide connection	6.8
LEC disconnected the business	4.5
Temporarily disconnected	15.9
Connection requires bribes	4.5
Some other reason	6.8

Source: 2021 medium and large end user survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

LEC = Liberia Electricity Corporation

B.   Electricity quality and reliability

Table E.3. Quality of electricity

	2019	2021	Two-year Change (2021-2019)
Sample size	97	80	
Seasonal outcomes			
Wet season:			
Number of hours of electricity on normal day	14.4	10.9	-3.5*
Number of times in a week experienced high or low voltage	7.0	7.5	0.5
Number of times in a week electricity went out	4.7	4.3	-0.4
No. hours in total electricity went out in a week	13.7	20.3	6.6
Dry season:			
Number of hours of electricity on normal day	14.1	12.4	-1.7
Number of times in a week experienced high or low voltage	4.3	2.5	-1.8
Number of times in a week electricity went out	4.5	5.0	0.5
No. hours in total electricity went out in a week	15.5	27.8	12.3
Power cuts			
Organization experienced an outage during the previous month (%)	74.7	80.2	5.5
Number of step-up and step-down stabilizers owned	18.9	17.0	-1.8
Frequency with which business is informed of LEC power cuts (%)			
Never informed of power cuts	96.9	93.3	-3.6
Often not informed of power cuts	0.0	1.8	1.8
Sometimes informed of power cuts	3.1	1.3	-1.8
Always informed of power cuts	0.0	3.6	3.6
Frequency of power cuts during the past year			
Everyday	4.7	10.1	5.4
Two or three times per week	51.6	40.8	-10.8
A few times per month	28.1	41.6	13.5
Never	15.6	7.5	-8.1

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

LEC = Liberia Electricity Corporation

Table E.4. Negative effects of power outages

	2019	2021	Two-year Change (2021-2019)
Sample size	71	81	
Reported operational effects of power cuts on medium and large end users (%)			
Continue all operations on backup	56.3	34.7	-21.6
Meetings/transactions were delayed	23.9	13.1	-10.8
Reduced operations on backup supply	21.1	4.9	-16.2
Turn customers away	8.5	13.9	5.4
Send workers home with pay	1.4	6.8	5.4
Send workers home without pay	1.4	0.0	-2.7
Used more expensive alternate energy source	63.4	30.9	-32.4**
Cut back on operations	1.4	1.4	-0.0***
Wasted perishables/discarded damaged goods	0.0	2.7	2.7
Damaged machines/appliances	8.5	19.3	10.8
Provide backup electricity to others	2.8	0.0	-5.4
Stop operations and wait for power	8.5	24.7	16.2
Could not provide aid/services	5.6	11.0	5.4
Could not execute key services	0.0	5.4	5.4
None	4.2	12.3	8.1
Appliances or equipment were damaged by voltage fluctuations in past year (%)	48.1	63.5	15.4
Costs of fixing/replacing damaged equipment in the past year (USD)	1,980	1,838	-143
Working hours limited by power supply during the past year (%)	38.0	46.1	8.1

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2019 and 2021. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

USD = US dollar

Table E.5. Satisfaction with LEC

	2016	2019	2021	Three-year change (2019–2016)	Two-year change (2021–2019)
Sample size	32	96	81		
Percentage who are overall somewhat or very satisfied with aspects of LEC service:					
Customer service	37.5	39.1	39.4	1.6	0.3
Quality of electricity	25.0	37.2	59.4	12.2	22.2**
Billing	~	33.7	39.8	~	6.1
Repair of breakdowns	~	26.0	14.9	~	-11.1
Connection time	~	33.7	31.7	~	-2.0
Complaint management	~	18.9	26.5	~	7.5

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

~   Not available. Data for the outcome were not collected for the time period so the two-year change cannot be estimated.

LEC = Liberia Electricity Corporation

Table E.6. Disadvantages of getting electricity from LEC

	2019	2021	Two-year Change (2021-2019)
Sample size (connected)	97	81	
Sample size (unconnected)	78	44	
Main disadvantages of getting electricity from LEC (%)			
No disadvantages	9.3	16.4	7.1
High connection cost	19.6	12.4	-7.1
High wiring cost	3.1	3.1	0.0
High monthly charge	11.3	7.8	-3.6
Have to pay bribe	16.5	11.1	-5.4
Too much paperwork	2.1	11.0	8.9*
Unreliable service (power cuts, low current or high current, etc.)	79.4	43.7	-35.7***
No national grid	0.0	0.0	0.0***
Difficulty in filling paperwork	1.0	1.0	0.0
Poor customer service	35.1	36.8	1.8
Slow to respond to problems or complaints	52.6	31.1	-21.4*
Other	2.1	7.4	5.4
Disadvantages of not getting electricity from LEC (%)			
Meetings/transactions are delayed/slow	35.9	13.3	-22.6
Reduced operations or reduced business activities	46.2	52.6	6.5
Turning customers away	3.8	7.1	3.2
Used more expensive sources of energy	62.8	62.8	0.0
Wasted perishable products/Discarded damaged goods	3.8	0.6	-3.2
Not affected	3.8	3.8	0.0
Safety and security issues	~	6.8	~
Other	33.3	10.8	-22.6*

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

~   Not available. Data for the outcome were not collected for the time period so the two-year change cannot be estimated.

LEC = Liberia Electricity Corporation

Table E.7. Experience with LEC customer service

	2021
Sample size	79
Contacted or visited LEC customer service in the past year (%)	74.7
Method of getting in touch with LEC customer service (%):	
In person	55.9
By phone	32.2
By email	1.7
Other	10.2
Reason for contacting customer service (%):	
Request for new connection	13.6
Request to cancel connection	0.0
Billing error or question	13.6
Account change (name, payment information, etc.)	1.7
Outage	20.3
Voltage problems	44.1
Stolen meter	13.6
Damaged equipment	27.1
Involuntary disconnection	8.5
Other	1.7
Customer service was able to resolve the issue	57.6

Source: 2021 medium and large end user survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

C. Energy use

Table E.8. Spending on LEC electricity

	2019	2021	Two-year Change (2021-2019)
Sample size	96	104	
Expenditure on LEC electricity			
Amount spent on LEC electricity in most recent purchase or electricity bill (USD)	13,920	13,065	-855
Electricity consumption on last LEC bill (kWh)	70,321.6	67,201.6	-3,119.9
Amount spent on LEC electricity in past year (USD)	42,973	15,636	-27,337
Recipient of electricity service payment (%):			
LEC	40.6	55.7	15.1
Pre-paid meter card seller	56.3	35.5	-20.8*
Community/village/municipality	0.0	1.9	1.9
Relative	0.0	0.0	0.0
Neighbor	0.0	0.0	0.0
Landlord	1.0	0.0	-1.9
Bank	0.0	0.0	0.0
No one	0.0	0.0	0.0
Other	2.1	7.7	5.7
Type of billing (%):			
Post-paid	30.1	4.6	-25.5***
Pre-paid	58.1	67.9	9.8
Flat rate	10.8	18.6	7.8
Other	1.1	8.9	7.8

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2019 and 2021. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

LEC = Liberia Electricity Corporation, USD = US dollar

Table E.9. Spending on other energy sources

	2018	2021	Two-year Change (2018-2021)
Sample size	179	124	
Amount spent on rent, fee, or lease payment generator use in past year (USD)	19,340	2,400	-16,940***
Amount spent on minigrid electricity in past year (USD)	1,736	0	-2,269
Amount spent on non-electric energy sources in past month (USD)	2,762	29,764	27,002

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects. Reported means are censored at 0 so the estimated change over time may not match the difference in reported means between 2019 and 2021. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

USD = US dollar

Table E.10. Main use of electricity

	2016	2019	2021	Three-year change (2019-2016)	Two-year change (2021–2019)
Sample size	137	162	112		
Percentage of end users whose main use of electricity is:					
Lighting	69.3	56.0	29.8	-13.4***	-26.2***
Operate machinery/tools	6.6	9.7	4.5	3.1	-5.2*
Freeze goods for sale	0.0	0.0	1.0	0.0	1.0
Air conditioning	0.7	1.1	0.7	0.4	-0.4
Pumping water	0.7	0.7	0.7	0.0	0.0
Electrical appliance	8.0	11.7	36.8	3.7	25.1***
Technology	12.4	18.4	20.7	6.0	2.3
Other	2.2	2.3	5.8	0.2	3.4*

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

D. Safety and security

Table E.11. Safety in community and injuries from LEC electricity

	2019	2021	Two-year Change (2021-2019)
Sample size	173	124	
Community safety			
Enough light in many/all areas near respondent's location to walk at night	60.5	67.2	6.7
Respondent feels somewhat or very safe walking in community at night (%)	52.6	53.4	0.8
Number of security problems experienced during the past year	1.2	2.3	1.1*
Electricity injuries			
Employees were injured by electricity in the past year (%)	1.2	2.9	1.7

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/*** Estimated change is statistically significant at the 10/5/1 percent level of significance.

E. Economic well-being

Table E.13. Medium and large business operations

	2016	2019	2021	Three-year change (2019–2016)	Two-year change (2021–2019)
Sample size (businesses)	165	172	120		
Business operations					
Number of paid employees	79	88	78	9**	-10**
Number of unpaid employees (including family members)	9	10	16	1	6
Months of operation in past year	~	11.1	10.5	~	-0.6*
Days of operation per week	~	5.5	5.6	~	0.1
Hours of operation per day	~	8.1	10.0	~	1.9***
Average monthly revenue (USD)	140,125	192,348	592,821	52,224	400,472**
Average monthly profit (USD)	87,692	52,031	62,908	-35,661*	10,876

Source: 2019 and 2021 medium and large end user survey

Note: All means and estimated changes are regression adjusted for end user fixed effects and control variables. Sample sizes are for the outcome in the table with the most observations. Actual sample sizes vary because of item nonresponse.

*/**/***   Estimated change is statistically significant at the 10/5/1 percent level of significance.

~   Not available. Data for the outcome were not collected for the time period so the three-year change cannot be estimated

F. COVID-19

Table E.14. Effects of COVID-19 on medium and large end users

	2021
Sample size	125
Effects of COVID-19 on the organization (%)	
Temporarily cease operations	60.8
Reduce working hours	70.4
Change type of activity	24.8
Have everyone work from home	24.8
Have everyone wear protective equipment such as masks and gloves	94.4
Lay off employees	24.8
Reduce wages	12.0
Serve fewer customers/clients/students	32.8
Serve different customers/clients/students	12.0
Effect of COVID-19 on profits (%)	
Increased	1.4
Decreased	84.9
Stayed the same	13.7
Measures taken to cover costs during COVID-19	
Forced to sell off assets	5.6
Forced to borrow	19.2
Forced to stop repaying loans	12.0
Forced to apply for additional/emergency grant	20.0
None of the above	60.0
Effect of COVID-19 on electricity consumption (%)	
Increased	17.3
Decreased	40.7
Stayed the same	42.0
Effect of COVID-19 on consumption of other energy sources (%)	
Increased	16.2
Decreased	41.9
Stayed the same	41.9
Somewhat or very satisfied with government response to COVID-19 in Liberia (%)	39.2

Source: 2021 medium and large end user survey

Note: Sample sizes are for the outcome in the table with the most observations. Actual sample sizes may vary per outcome because of item nonresponse.

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Appendix F

IRB Requirements and Data Documentation

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A. Summary of IRB requirements

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 a compromise of data confidentiality.

We obtained approval for the quantitative and qualitative data collection from the IRB at the University of Liberia's Pacific Center for Research and Evaluation in November 2020. In order to meet U.S. research standards, we submitted a request to renew our standing IRB approval from Health Media Lab. We received IRB approval in November 2020 and received approval for a further year in September 2021.

B. Data access, privacy, and documentation plan

All quantitative and qualitative data were securely transferred from the data collection subcontractor to Mathematica and stored on Mathematica's secure server, where access was 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 data to MCC in September 2022. The package will consist of seven separate, well-documented, Stata data sets, user manuals, and codebooks for each round data collection. 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

Evaluation questions

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A. Mapping evaluation questions to the EDR

The evaluation questions presented in this report are organized and worded differently compared to the questions in the Liberia Evaluation Design Report (EDR). In the table below, we document these changes and note where the relevant findings are presented in the final evaluation report.

Table G.1. Mapping evaluation questions to the EDR

Evaluation questions in the EDR	Evaluation questions in the final report	Findings chapter
Implementation questions		
1. Were the activities implemented as planned?	A1. Were the activities implemented as planned?	Chapters IV and V
2. What was the quality of implementation of the activities?	A2. What was the implementation quality?	
3. What lessons can be drawn from implementation of the activities?	A3. What lessons can be drawn from implementation of the activities?	
4. To what extent, if any, does comparing the assumptions made in the forecasted economic model, actual program implementation, and evaluation findings generate lessons that can be applied to future economic models?	A4. To what extent, if any, does comparing the assumptions made in the forecasted economic model, actual program implementation, and evaluation findings generate lessons that can be applied to future economic models?	Chapter VII
Grid-level questions		
1. To what extent, if any, has increased electricity generation contributed to increased reliability of Liberia's electricity supply, such as a reduction in planned and unplanned outages and improved voltage stability?	C1. How have MCC's investments affected electricity generation, T&D, reliability?	Chapter V
2. To what extent has capacity strengthening and sector reform improved LEC's operations and maintenance of the grid, so that increased generation leads to reduced outages and voltage stability? (Revised by MPR.)	C4. To what extent, if any, has LEC's management improved since the new management contract became effective? C1. How have MCC's investments affected electricity generation, T&D, reliability?	
3. To what extent, if any, have energy sector reform activities contributed to improvements in electricity regulation, policy formulation, and monitoring? How sustainable are these improvements?	B3. To what extent, if any, have energy sector reform activities contributed to improvements in electricity regulation, policy formulation, and monitoring? How sustainable are these improvements?	Chapter IV
Energy-sector questions		
1. What effect, if any, have LERC activities to regulate the legal, economic, and technical environment, or changes in the availability and reliability of electricity, had on IPPs operations?	B2. Have LERC activities (regulating the legal, economic, and technical environment or changes in the availability and reliability of electricity) had any effect on IPPs' operations?	Chapter IV
2. What new energy policies, laws, and legal, economic, and technical regulations have been enacted or adopted, given the LERC's activities and support from the donor community? How have these contributed to modernizing the energy sector and making the sector financially viable?	B1. What new energy policies, laws, and legal, economic, and technical regulations have been enacted or adopted, given the LERC's activities and support from the donor community? How have these contributed to modernizing the energy sector and making the sector financially viable?	

Evaluation questions in the EDR	Evaluation questions in the final report	Findings chapter
Utility-level questions		
1. How has the electricity tariff changed since MCHPP was rehabilitated? To what extent does it cover the costs of electricity generation and other operating costs?	C2. How has the electricity tariff changed since MCHPP was rehabilitated? To what extent does it cover the costs of electricity generation and other operating costs?	Chapter V
2. To what extent, if any, has LEC's management improved since the new management contract became effective? What progress has the GoL made toward establishing a longer-term management arrangement for LEC?	C4. To what extent, if any, has LEC's management improved since the new management contract became effective? C5. What progress has GoL made toward establishing a longer-term management arrangement for LEC? How sustainable is LEC as a utility? What are the biggest barriers to its sustainability?	
3. How sustainable is LEC as a utility? What are the biggest barriers to its sustainability?	C5. What progress has GoL made toward establishing a longer-term management arrangement for LEC? How sustainable is LEC as a utility? What are the biggest barriers to its sustainability?	
End-user questions		
1. To what extent, if any, have the Mt. Coffee Rehabilitation and Capacity Building and Sector Reform Activities affected the number of users connecting to the grid and the demand for electricity?	C3. To what extent have the MCHPP Rehabilitation and Capacity Building and Sector Reform Activities affected the number of users connecting to the grid and the demand for electricity?	Chapter V and Chapter VI
2. To what extent do customers invest in energy-intensive appliances or equipment? What is the effect of energy on time use (household production, leisure, schoolwork, and employment)? What, if any, are the spillover effects on non-electrified households? How do all of these impacts vary by differences in gender, socioeconomic status, and other demographic characteristics?	D3. To what extent do customers invest in energy intensive appliances or equipment? What is the effect of energy on time use (household production, leisure, school, work, and employment)? D4. What, if any, are the spillover effects on non-electrified households? D5. How do impacts vary by differences in gender, socioeconomic status, and other demographic characteristics?	Chapter VI
3. How did new households, commercial, industrial, and other consumers decide to connect? For potential consumers, why have they not connected? What barriers do potential customers face when trying to connect to the grid? How have changes in the reliability of electricity affected connected and unconnected households' perceptions of the quality of electricity? Are there differences in these issues by respondents' gender and socioeconomic status?	D1. How do customers decide to connect, and why have other potential end users not connected? What barriers do potential customers face when trying to connect to the grid? D2. How have MCC's investments affected connected and unconnected households' perceptions of the quality of electricity? D5. How do impacts vary by differences in gender, socioeconomic status, and other demographic characteristics?	

Appendix H

Stakeholder comments and evaluator responses

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Table H.1. MCC comments and evaluator responses

Reviewer division	Page or reference number	Comment	Evaluator response
M&E Lead	Page xli "LEC can accommodate increased dry season demand, withs enough staff, skill, materials, and operational capacity to fulfill connection requests."	This has a green plus, but this doesn't seem to have been achieved.	Thanks for noticing this. We changed it to yellow given that LEC has been able to fulfill more connection requests (as evidenced by the new connections) but it wasn't able to meet dry season demand up through August 2022. Note, once CLSG was online, LEC gained considerable ability to accommodate dry season demand.
M&E Lead	Page 157	Shouldn't there be O&M costs in the CBA?	Yes, these are factored into the model through average unit costs. We have now also revised the model to include repair costs for maintaining the turbines, which are at risk of failure.
M&E Lead	Page 157	Do you think the benefits will persist for 20 years given the findings in the rest of the report?	Good question and hard to say. We do know that WB is covering the costs of Unit 1 repairs and the full sector has learned the importance of OMT given the unit failure.
MCC/Evaluation Lead	xviii+	When first introducing the project in the Exec Summary and the main body, please specify the Project Objective. I suggest quoting it from the Compact so that the report is explicit about how the project had framed success.	Revised using the Compact quote throughout the report.
MCC/Evaluation Lead	xx	It's hard to see how this is a finding, so I think the heading needs to be adjusted to indicate how it fits into targeted results: Electricity "Supply Board International (ESBI) served as the (management services contract) MSC for 4.5 years (3 years with Compact funding and 1.5 years with World Bank (WB) funding). "	Thanks for noticing this. We fully revised the section.
MCC/Evaluation Lead	xx	I had trouble understanding this heading: Among newly connected communities in the Kakata corridor, we found a substantial increase in new connections. Since these are newly	Revised and clarified.

Reviewer division	Page or reference number	Comment	Evaluator response
		connected communities, what is the increase of HH connections in comparison to? Please specify	
MCC/Evaluation Lead	xxi	This statement is worded in a way that could be received as offensive: MCC launched Compact preparation efforts in Liberia in 2015, entering an energy sector that lacked a strategy, policies, data, modern skills, and technical capacity (Liberia Energy Policy 2009). I'm also confused by the parenthetical. I assume their policy didn't describe their sector in this way so is this Mathematica's assessment of the policy? Please consider adjusting the language.	Revised, though most all stakeholders would agree that a strategy, policies, skills and capacity is needed. This is not a loaded, nor offensive statement in Liberia. The Ministry of Energy wants an official strategy for example, though it hasn't yet been created.
MCC/Evaluation Lead	Executive Summary	I suggest cutting Section C of the Executive Summary - those key findings felt extremely broad and high-level and I think the conclusion did a much better job of summarizing key takeaways. I would also combine Section D with the answers to the quality of implementation questions. I found Sections C and D a bit hard to follow, but the rest of the ES was clear.	We edited and streamlined sections C and D as suggested to improve clarity.
MCC/Evaluation Lead	Figure I.5	is it possible to indicate which outcomes relate to the project objective on the logic diagram here (and elsewhere)?	We believe all of the short and medium term outcomes in the logic lead to the project objective to "provide access to more reliable and affordable electricity." Each of the components (and more) are on the causal pathway. The long term outcomes do aim to achieve the Compact goal to "reduce poverty through economic growth".
MCC/Evaluation Lead	88	I understood that MCC was not paying for connections, so what contractual targets are being referenced. How did Mathematica attribute connections to the sector reform investments? This statement is definitive about attribution but without much support for that attribution: MCC's investments in MCHPP Rehabilitation and Capacity Building Sector Reform activities increased new-customer connections and exceeded contractual targets. I suggest explaining how attribution was determined or adjust the wording.	The MSC had key performance indicators in their contract, including the number of new connections. The MSC improved utility operations, which enabled new end user connections. Revised to make this clear.
MCC/Economist	Page 154	Some of the most striking evaluation findings relate to the financial unsustainability of the utility: "LEC's grave financial	Thank you. We have revised the CBA model to incorporate these suggestions.

Reviewer division	Page or reference number	Comment	Evaluator response
		situation, coupled with growing demand across an increasing customer base with low average consumption, reduced revenue with the low tariff, will cause a further downward spiral at LEC." "LEC has been in a grave situation with all financial measures worsening and cumulative losses growing." "Currently LEC is an unsustainable utility which could collapse at any time. Additionally, MCHPP is at further risk of catastrophic failure without adequate OMT support." It seems like the effects of this financial unsustainability should be reflected in the CBA. In particular, the evaluation findings suggest a situation that seems likely to result in insufficient maintenance of existing equipment and investment in new equipment, and therefore increasing technical losses and eventual catastrophic failure of generation and distribution equipment. This could be modelled as reduced incremental energy available with the project and/or increased costs resulting from poor life-cycle maintenance of equipment.	To further account for the financial situation of the utility, we have revised our estimate of the long run average unit cost of energy production from $0.24 to $0.36 per kWh. Our original estimate was based on the Cost of Service Study (Tetra Tech 2020). As noted in our report, however, this estimate was likely over optimistic as it assumed that technical and commercial losses would fall to 23 percent by 2030. By the end of 2021, combined technical and commercial losses were still at 56 percent. Therefore, we have scaled the average unit cost to account for 33 percentage points more technical and commercial losses in the long run, changing it from $0.24 to $0.36. To further incorporate the failure of Unit 1 at MCHPP and the potential catastrophic failure of additional MCHPP generation turbines because of design flaws, we have included the costs to repairing/maintaining these in the model. In our evaluation, we estimated repair costs to be $4 million for Unit 1. In the revised model, we included costs of $4 million in 2021 to repair Unit 1, and the same costs every four years to account for the risk that other turbines might fail (it took four years for the first unit to fail).
MCC/Economist	CBA Model, "Mathematica CBA" tab, row 168	MCC's revised 2020 Power Sector CBA Guidance notes that, when "modelling effects of electrification on currently non-electrified consumers or the effects of large price changes on currently electrified consumers, assuming a linear demand curve is likely to substantially overstate project benefits. On balance, log-linear demand should be considered the default functional form in most applications in which prices or consumption are likely to change substantially for a typical project beneficiary." (See the "Demand Curves and Elasticities" section of MCC's Power Sector CBA Guidance for additional detail and guidance for implementing this change)	Thank you, we were made aware of this guidance and did in fact try to calculate the consumer surplus using integrals (i.e. a non-linear demand curve) instead of linear approximation. However, we ended up with implausibly large values for the consumer surplus in each period so we decided to revert back to using a linear approximation to calculate the surplus. We would be happy to reshare these calculations and have now described this issue in a note in our CBA model. We cannot pinpoint exactly why using a non-linear demand curve in the model produces implausibly large values, but we suspect that this is because we are using empirical rather than projected data. The core issue is that using a non-

Reviewer division	Page or reference number	Comment	Evaluator response
		Please adjust the consumer surplus calculations to apply a non-linear demand curve	linear demand curve requires specifying a particular functional form (like p=KQ^n) between two points, which does not work well if the points in the data do not quite follow this functional form. This results in strange parameter values and, in our case, much larger consumer surplus than if we calculated it using linear approximation. Note that this issue does not exist with projected data because by design, the points are projected to follow the functional form. The problem which exacerbates the issue is that in some years we have a situation where the data describe a demand curve where tariffs went down, but consumption per capita also went down. This may seem strange but can be empirically explained by many other things that happened during the project: there was a surge in newly connected consumers who likely consumed much less than previous consumers, there was a pandemic, and the cost of fuel went up, dampening demand. It may be possible for us to arrive at a more normal-looking demand curve if we are able to disaggregate consumption per kWh by new and existing customers because it is the new customers that is driving the consumption per capita of existing customers down, but this is challenging. We are only able to give the same value of consumption per kWh for the two types because we only have aggregate consumption data and customer counts. At this point, it will be hard to impose reasonable assumptions on what these values could be. At the same time, we do not think it will fully resolve the issue described above. Nor does it address the other factors that dampened demand during the time. The advantage of a linear approximation in this case is that it does not impose a strict functional form for each time period (two data points) in the model.

Table H.2. Stakeholder comments and evaluator responses

Reviewer organization	Page or reference number	Comment	Evaluator response
LERC	xvi	The new tariffs which took effect on January 1, 2022, was not arbitrary but based on empirical evidence and is cost reflective. The author of the report did not provide any evidence-based counter argument from his or her sources, that proves otherwise. Please note that besides JEP, all the 345 unlicensed operators mentioned in the report do not meet the minimum requirement for a permit or license as per LERC regulations.	Thank you for the comments. The first issue is tariffs: Our analysis is based on 8 years of LEC data, numerous key informant interviews conducted over years, an analysis of the Cost of Service Study and other data sources. We show how the assumptions in the Cost of Service Study (LEC income projections, the mix of customers, rates of power theft, the growth in customers, the cost of thermal generation, the loss of one turbine, and other factors) mean that the tariff is not cost reflective. We understand that LEC can come to LERC to negotiate the tariff and they stated that they will do so because their revenue is so low with the adjusted tariff. The second issue is operators: We have revised to show the updated understanding that the 2021 National Operator Census enumerated 263 operators engaged in electricity generation, transmission, distribution, sales, or import/export (199 operators 100-500 kW, 64 operators >500 kW). However, these informal operators indicate they are using internally, rather than selling. They do not have business registrations and are not prepared for licensing.

Reviewer organization	Page or reference number	Comment	Evaluator response
LERC	xix	The criteria set by the operator census for identification of operators was flaw. This is because the census was done before the development of regulatory instruments, especially the licensing regulations. As a result, 99.4% of the 345 operators did not meet the minimum requirement for a license or permit.	Thank you for the clarification. We have revised the report.
LERC *(Continued)*	xxiv	*The report states: "While the number of connections have increased, average customer consumption has declined over time. By April 2022, 97 percent of connections were residential and average consumption was less than 50 kWh per month (ranging from 22 to 40 kWh) (Figure ES.8). The 2022 tariff reduction approved by LERC means that LEC will only earn $0.15 per kWh for electricity sold to most customers, despite operating costs hovering around $0.47 per kWh in 2021 (prior to the sharp escalation in fuel prices)".* The statement in red texts above is incorrect because there was major generation deficit during the first two quarters of 2022 leading to massive load shedding. LEC could only generate no more that 14 MW with a peak load of 60 MW in the midst of expansion in distribution and increase in customers' connection. Some areas went without power for two weeks, to three weeks, even up to a month or more. This led to customers reluctance to purchase prepaid token in high amounts, thus placing them in the social tariff category. **See below in blue texts findings from LERC's assessment of LEC's situation in the first two quarters of 2022 (January to April/May):** *1. The CLSG Power Purchase Agreement wasn't signed in the first quarter as promised. Additionally, significant amount of the thermal generations at Bushord were not available for production, coupled with the low capacity at Mt. Coffee during the dry season. 2. The absence of CLSG and reduction in generation from the hydro thermal plants led to less than 50% generation during these two quarters. These events contributed to unprecedented load shedding from January to May 2022, thereby putting almost all the residential customers in the social customer category due to very low purchases and consumptions. 3. As generation became significantly low, commercial, and large customers reverted to self-generation which had an adverse effect on LEC's revenue generation. However, the poor performance wasn't as an effect of the new tariffs but due to the under-supply of power to the grid.* **The following texts in blue are copied verbatim from LEC's communication to LERC, dated February 14, 2022 in response to LERC queries about massive LEC load shedding.** *Thank you for your letter of February 9th regarding the above. As always LEC welcomes the advice and direction of LERC and endeavors to comply where, technically, physically, and financially possible. Unfortunately, the current load shedding situation is not one of those situations.*	Thank you for the comment. We present the increasing number of customer connections and the average consumption per customer based on class. Residential connections account for more than 90% of customers and consume about 48% of electricity. This is consistent with the literature that documents how new customers across Africa tend to have low consumption and use electricity for lighting for their first few years of being connected. There were outages indeed, but the trend data shows that the trend in average consumption persists beyond these outages. Also, the report also shows that operating costs and the actual costs of hydro, thermal, and CLSG generation, T&D exceed the tariff, even if large customer consumption increases. We agree that it is surprising that LEC had not appealed the tariff given the extreme financial stress they are facing. Based on the dissemination meeting on 11 May 2023 in Monrovia, we expect they will now submit an application to LERC.

Reviewer organization	Page or reference number	Comment	Evaluator response
LERC *(Continued)*	xxiv	*As you undoubtedly know LEC is currently forced to implement Extreme Load Shedding measures which are causing between 75% and 80% of the city to be off load at any one time.* *This unprecedented situation is due to a combination of factors:* • *The successful connection of over 37,000 new customers in 2021 and over 4,000 in January 2022 which has increased demand to a new system peak of over 60 MW.* • *The early arrival of Dry Season (in December 2021) resulting in an unusually rapid reduction in the water levels at the Mt. Coffee Hydro Power Plant, which has effectively wiped out the Plant's power generation capability.* • *LEC's now total reliance on Bushrod Thermal Power Plant which as you know has a maximum nameplate rating (before auxiliary loads) of 33MW, far less than the 60 MW required.* • *This, 33MW capacity is further reduced by 9MW as GOL No1 Generator is out of service due to a cracked liner- a major fault. (LEC teams are working day and night to affect a repair under the expert supervision of Billy Richardson ED Generation)* *• Perhaps most importantly, LEC's constrained finances, due to unsustainably high levels of power theft, reduced revenue per kWh sold and delayed payments by our largest customer, have made it impossible to procure sufficient fuel to run all available generators at Bushrod.* • *Lastly the reluctance of donors to consider fast track firm energy (24/7/365) options within Liberia (in particular CCGT) has allowed demand to exceed capacity.* *LEC is therefore constrained to run only 12–14 MW of generation at this time.* *We at LEC had hoped that the CLSG would have been online at this time. In fact, LEC has done everything necessary to technically take energy from CLSG and have successfully taken energy for test and commissioning purposes.*	

Reviewer organization	Page or reference number	Comment	Evaluator response
LERC *(Continued)*	xxiv	*The PPA and TSA proposed by CI Energies and Transco's have been reviewed by the board of LEC and rejected due to onerous nature of the entry into force conditions and general lack of affordability. These matters have been deemed so serious as to have been escalated to the Shareholder (Government of Liberia), where we are honored to have both the Minister of Finance and Development Planning and HE President George Manneh Weah engaging on Liberia's behalf.* *Please be assured that LEC is doing everything within its power to improve the availability of electricity in Liberia. LEC teams are working tirelessly to repair Unit 1 GOL at Bushrod. The Hon. Minister of Finance and Development Planning is working tirelessly along with HE President Weah and the Hon. Chairman of the Board to achieve a resolution to the PPA & TSA impasse which will allow energy to flow, and of course we are managing what little water is available at MCHPP to give short bursts (3-4 hours) of added energy injection where prudent operating practices permit.* *We are of course aware of LERC's mandate to impose penalties for non-compliance; however, we appeal to LERC to see the evidence of both LEC's and GOL's herculean efforts and to act with generosity in this case.*	
LERC	43	Please note that the tariff review process, which took about six months to reach a decision was based on LEC's application and proposal. LEC provided all supporting documents, including assumptions, loss reduction trajectory, load growth (three-year projection) including CLSG injection, customer growth, etc. for the three-year tariff period (2022 to 2024). The statement that the new tariff was not validated is erroneous as there was public hearing and multiple follow-up meetings to validate information provided in LEC's application. Notwithstanding, LEC and all other regulated entities have the right under the law and regulations to debunk, challenge and/or reject the tariff decision through judicial review. Please note that Decisions of the Commission (LERC) are subject to appeal to the Civil Law Courts and any other subsequent court of competent jurisdiction in the Republic of Liberia. LEC did not take advantage of this remedy or process because they did not have the require skills to empirically validate the tariff decision. The statement attributed to LEC that *"LERC needs to make sure to have a competent team doing the tariff models"* is very disrespectful and insulting. Besides having qualified and competent staffs, LERC have had regulatory experts (policy, legal, technical and economic) embedded full time at its offices since 2019 with technical support from the European Union. This is why LERC has now moved up from 37th position in 2021 to 10th position in 2022 in the Electricity Regulatory Index (ERI) for Africa. The fact that LEC did not challenge the tariff decision, or provide evidence on the contrary makes them more incompetent.	Thank you for the comment and additional explanation. We agree that this sentence may be interpreted as offensive. This was a direct quote from a stakeholder. Nevertheless, we shortened the quote and removed the sentence. We acknowledge that LERC has made excellent progress, LERC has lacked timely data, regulatory commissions usually take 10 years to become independent, and LEC did not push back on the tariff change. We do have numerous qualitative interviews where respondents from ESBI and LEC indicated they agreed the tariff needed to be lowered, but they were surprised by new rates.

Reviewer organization	Page or reference number	Comment	Evaluator response
LERC	78-79	The tariff decision was not financially irresponsible and influenced by political pressure from the Government as claimed in the report, but LEC's inability to perform and deliver as per the data submitted and approved by LERC prior to the tariff decision is the cause for financial irresponsibility, which can be solely attributed to LEC. The fact that LEC could supply only 12 - 14 MW of power to about 157,000 customers with a peak load of over 60 MW calls for concerns. It seems this report relied fully on LEC's comments or inputs without checking with LERC for verification. At no time did the Government of Liberia interfere in LERC's decision making process or instructed LERC to make regulatory decisions.	We based the assessment that the tariff was due to political pressure based on the inputs of many stakeholders who indicated that this had happened. And the literature on regulatory commissions describes the risks that commissions face if they do not have independent financing. The evaluation team conducted interviews with LERC multiple times over years. We also wrote to LERC in June 2022 to clarify, however we did not hear back. We apologize, we should have kept trying so that we could get your input on the findings.
LERC	80	If LEC's payroll continues to account for a high percentage of operating costs, particularly as LEC has far more staff than necessary (843 employees), yet lacks critical skills and capabilities based on an analysis of LEC staffing, as claimed in the report, then why keep it that way as a corporate (business) entity in financial stress? LEC should operate as a business and must be able to take business decisions for its financial viability. This is one of the reasons why LEC cannot not break even or has not been financially viable. This situation also contributes to high tariff because LEC needs to generate sufficient revenue from end-users to meet up with its high operating costs.	We agree, however the situation is very complicated because of the union and because LEC is sued and does not have adequate support from the Ministry of Labor. The fact that politicians require LEC to hire unqualified staff is well documented. LEC needs MoL support and backing to reshape the staff to have only the capabilities needed to operate the facility.

Reviewer organization	Page or reference number	Comment	Evaluator response
LEC	Entire Report	The conclusions on the state of the utility no longer align with the current trends and may therefore be misleading. There is a need to update the report. I.e. power losses are now down to 29.6%, energy sales are projected to increase from 109k kwh in 2022 to 200k kwh in 2023 (YTD Actuals confirm projection), revenue projected to increase from 24m in 2022 to 44m in 2023 (YTD actuals confirm projection with 9.24m revenue already reported). Robust power theft campaign highly successful.	The evaluation team acknowledges the important updates since the evaluation data collection concluded in August of 2022. If it were in our scope to continue data analyzing, triangulating, and synthesizing LEC data, we would continue. We strongly suggest that LEC, and donor partners, continue populating the figures to capture changes in generation, T&D, commercial, operations, and management. We have the figures and template available if LEC would like to continue this work.
LEC	Section on LERC	LEC has commenced payment of regulatory fees making LERC more effective.	The evaluation team acknowledges payment of these fees. Again these important updates occurred after the evaluation data collection period ended so we have heard confirmation of payment during KIIs but do not have any financial data.
LEC	XVI	Ref. to MCHPP. While output may be 76MW, it should be stated that total installed capacity is 88MW (4.22MW)	We acknowledge this and mention it throughout the report. We added sentence to the ES.
LEC	XVII	Ref. fault with Unit 1. Root cause analysis was not conclusive. It indicated that any number of causes enumerated could have caused the fault either singly or in combination. Most current estimated cost of repair from Voith is around $4m.	We acknowledge the inconclusive root cause and most recent update and have made updates to the report.

Reviewer organization	Page or reference number	Comment	Evaluator response
LEC	Sections on MSC	There were some issues with MSC performance that were overlooked and should be considered. Refer to Azorom reports. ESBI also did not do a very good job at preparing a successor management team, while oversight of donor projects was weak resulting in delays in the completion of several projects.	We assessed a wide range of issues related to ESBI's performance. We used all monthly, quarterly, and annual reports from Azorom, as well as KIIs throughout the energy sector. We added more language on their lack of progress preparing a successor management team. We do think we explained that ESBI's oversight of donor projects was weak. They were unprepared for that aspect and their contract was mostly silent on it.

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Appendix I

Evaluation gender type

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A. Background

MCC originally developed the following typology to document which of its independent evaluations produced "gender data" in accordance with its 2015 commitment to publish all such data in support of the Data 2X initiative.[5] These categories were later included in the agency's Women's Economic Empowerment Learning Agenda, which was adopted in 2019, to help identify and consolidate findings about the extent to which gender issues have been incorporated into the design, implementation, evaluation, and learning related to MCC's investments.

A Gender Type will be assigned by the MCC Evaluation Management Committee (EMC) for each MCC evaluation at two points in time:

1. Upon approval of Evaluation Design Reports (EDRs)

2. During review of final evaluation reports in case changes to the program or evaluation have implications for the original assignment

This assignment will be recorded in MCC's evaluation pipeline database for management and reporting purposes.

B. Definitions of MCC's Gender Types

- **Type 1:** Gender is/was part of the logic and evaluation design of the program being evaluated[6]

- **Type 2:** Gender is/was not part of the logic of the program being evaluated, but the evaluation design incorporates gender issues, e.g., in the evaluation questions or data collection methods

- **Type 3:** Gender is/was not part of the logic or evaluation design of the program being evaluated, but sex-disaggregated data will be/were collected

- **Type 4:** Gender is/was not part of the logic or evaluation design of the program being evaluated, and sex-disaggregated data will not be/were not collected

- **N/A:** This applies if interventions will not be evaluated or if an evaluation is canceled before an Evaluation Design Report has been approved

C. Assigned Gender Type

At the time of final evaluation report completion, the EMC determined the Liberia Energy Project evaluation's Gender Type to be 2 based on the definitions above.