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Final Report

Evaluation of the Liberia Power Compact's Mt. Coffee Hydropower Plant Rehabilitation and Capacity Building and Sector Reform: Baseline and Interim Findings

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ACRONYMS

AT&C	Aggregate technical and commercial loss
AfDB	African Development Bank
ACMS	Asset and Customer Mapping Study
CBA	cost-benefit analysis
CLSG	Cote d'Ivoire, Liberia, Sierra Leone, and Guinea
CMC	contract monitoring consultant
CMS	Commerical Management System
DMS	distribution management system
EIB	European Investment Bank
ERR	economic rate of return
EIB	European Investment Bank
ESWG	Energy Sector Working Group
ERP	enterprise resource planning
ESBI	Electricity Supply Board International
EU	European Union
GoL	Government of Liberia
GoN	Government of Norway
GSI	Gender and Social Inclusion
HFO	heavy fuel oil
HLSG	High Level Stakeholder Group
IDI	in-depth interview
IMS	information management system
IMT	Interim Management Team
IPP	independent power producer
KII	key informant interview
KfW	German Development Bank
KPI	key performance indicators
kWh	kilowatt hour
LEC	Liberia Electricity Corporation
LERC	Liberia Electricity Regulatory Commission
LFO	Light fuel oil
LISGIS	Liberian Institute for Statistics and Geo-Information Systems
MCA-L	Millennium Challenge Account Liberia
MCC	Millennium Challenge Corporation
MCHPP	Mt. Coffee Hydropower Plant
MHI	Manitoba Hydro International (previous Management Services Contract)

M&E	monitoring and evaluation
MME	Ministry of Mines and Energy
MSC	management services contract
MW	megawatt
MWh	megawatt hour
NCC	National Contracting Company
NORAD	Norwegian Development Agency
OMT	Operations, management, and training
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index
SCADA	supervisory control and data acquisition
T&D	transmission and distribution
PIU	program implementation unit
USAID	United States Agency for International Development
WB	World Bank
WTP	willingness to pay

EXECUTIVE SUMMARY

"Electricity Is Life."

Program overview

MCC's $257 million Liberia Compact (2016–2021) aims to encourage economic growth and reduce poverty by improving access to reliable and affordable electricity. The $202 million Energy Project was designed to generate low-cost power, improve the quality and reliability of the power system, and expand access to electricity. The Energy Project comprises Activity 1, enhancing power generation by rehabilitating the Mt. Coffee Hydro Power Plant (MCHPP) ($147 million); and Activity 2 which includes two Sub-activities: (1) strengthening the capabilities of the utility with a management services contract (MSC) for the Liberia Electricity Corporation (LEC) ($12.2 million), and (2) supporting the establishment of an independent electricity regulator, the Liberia Electricity Regulatory Commission (LERC) ($3.35 million). MCC's underlying theory is that these Activities will address the three main causes of Liberia's unreliable and unaffordable grid electricity: insufficient supply, weak sector capacity, and an inadequate policy and regulatory environment.

The Energy Project's program logic indicates that Activity 1 investments should increase production and distribution of lower cost electricity, reduce tariffs and user costs, and increase consumption of quality electricity by more customers. Investments in Activity 2, Sub-Task 1 are intended to reform LEC so it becomes an operationally efficient and financially viable utility that can increase customer connections and maintain the electricity infrastructure. Investments in Activity 2, Subtask 2 are intended to create a regulatory environment that accelerates investment and incentivizes independent power producers to help increase generation and meet the energy demands of Liberians. These Activities and their short-term and intermediate outcomes aim to foster positive social and economic outcomes in the long term.

Evaluator description

MCC commissioned Mathematica to conduct an independent impact and performance evaluation of the Liberia Energy Project. Although this is the first report produced for this evaluation, the

advanced stage of the Activities and Sub-activities meant that we could collect detailed data on outcomes across each level of inquiry, including the energy sector, utility and grid levels, and end-user level. For this report, we analyzed and synthesized interim findings for activities that have been underway for several years and for households and businesses that have been connected to electricity for years. We also analyzed baseline findings for a study of households of businesses that have not yet connected to the grid.

Key findings

- The rehabilitation of MCHPP was successful. The hydropower plant is Liberia's largest electricity asset. However, ongoing operations and maintenance is underfunded increasing the risk of turbine or plant failure and possible consequences including performance losses, extended outages, higher rehabilitation costs and potential emergency situations such as the loss of life or property (Canale et al. 2017).
- A careful analysis indicates that ESBI has been successful in diagnosing and beginning to solve critical problems. Although performance has not met stakeholders' expectations, ESBI assumed responsibility when LEC was in a grave financial situation. The utility requires increased funding for operations and capital expenses, a systematic response to theft and corruption, and support from the Government of Liberia and donors to implement the reform needed to sustain the utility.
- LERC has made progress in establishing the regulatory commission in 2019 however it lacks resources beyond January 2021. Commissioners believe that donor financing is essential to LERC being an independent, transparent, accountable, and sustainable agency.
- Liberians frequently say, "Electricity Is Life" indicating how much they value and demand "LEC current". Liberians report that they prefer to pay for a legal connection. However, they will collect illegally if they feel there is no other option. And while electricity improves quality of life and feelings of security, insufficient education and low-quality infrastructure present important dangers and safety risks, including fires and electrocution.

Evaluation questions and detailed findings

Implementation

Liberia's devastating 14-year conflict, followed by a harrowing Ebola epidemic, were pivotal events in the country's history. They had long-term and widespread consequences, placing the country in a fragile political and economic position, and complicating the execution of power reform projects and other interventions. Liberia has weak and ineffectual ministries; insufficient accountability across government, donor agencies, and the population; and inadequate human resource capacity given the large-scale departure of private-sector workers. Further, Liberia has deep macroeconomic challenges, its economy has slowed, tax revenues have fallen, and there is limited foreign direct investment.

Were the program logic and Compact designed appropriately for the Liberian context? Were the underlying assumptions appropriate (given the political and macroeconomy)?

While the program was designed to coordinate with other donors, the program logic and Compact underestimated the problems and weaknesses that persist throughout Liberia's energy sector, government, economy, and workforce. The Liberia Compact is MCC's first energy compact in a post-conflict country and includes sub-activities new to MCC's portfolio. As such, the Liberia Compact presented unprecedented challenges.

A flawed underlying Compact assumption was that increased electricity supply, together with improved utility management, would increase customer access to less expensive electricity. Generation increased substantially, and the cost per kilowatt hour (kWh) of hydropower is less than thermal generation. However, the rate of new customer connections is much slower than anticipated. Liberia has a power surplus because of extensive problems with the transmission and distribution (T&D) network and delays in donor-funded projects.

Another problematic assumption was that, by drawing on the escrow account, the GOL through LEC would be able to cover the cost of MCHHP's operations and maintenance, ensuring the sustainability of the power plant. However, LEC's financial "crisis is existential" with "chronic illiquidity." LEC cannot afford the necessities of a utility corporation. LEC operating costs have increased with additional staff, new connections to maintain, assets to manage, and additional T&D infrastructure, requiring maintenance and repairs. Without donor support, MCHPP will not be properly maintained.

An important oversight was the failure to account for the extent of power theft throughout LEC and Liberia. The LEC cartel appears to be "a sophisticated operation" that supports wide-scale theft from large end users. Loss reduction requires intensive political will, new equipment, and materials. Liberians describe extreme levels of pent-up energy demand across Monrovia.

Finally, Liberia's limited capacity makes it unlikely that all planned activities will be finished within a five-year Compact period.

Were the contract vehicles designed to achieve Compact goals?

The contract vehicles for MCHPP rehabilitation had several weaknesses. The term length of the project implementation unit (PIU), which provides oversight of all contractors, was inadequate because it ended before all works were completed. The PIU cannot ensure quality and technical standards without being onsite. Additionally, stakeholders reported that more oversight was needed from MCC and the Millennium Challenge Account-Liberia to anticipate and solve problems, and that onerous financial processes led to delays. Insufficient resources for ongoing operations and maintenance are a persistent problem.

There were weaknesses in the contract with Electricity Supply Board International (ESBI, the management services contractor) because it did not account for the Liberian context. Key informants across all organizations reported that they underestimated LEC's operations and functionality, which proved to be extremely limited, and did not fully appreciate how LEC, as a failed utility, would be resistant to reform. Overall, inadequate knowledge of the true situation of LEC—including its dire financial state, the culture of corruption, and the decrepit, poorly

maintained, and overloaded infrastructure and assets—meant that the MSC was not structured with adequate resources to cover operating and capital expenditures or equipped with technical, legal, and political anticorruption mechanisms and tools to overcome these grave challenges.

Were contracts implemented as planned, and what was the quality of implementation?

MCHPP rehabilitation was implemented generally as planned, albeit with delays and cost overruns. Overall, plant rehabilitation was rated by LEC, ESBI, and contractors as high quality. However, the operations, maintenance, and training contractor (OMT), Hydro Operations International (HOI) reported there was inadequate supervision over some construction, resulting in suboptimal quality and requiring additional maintenance. Many stakeholders observed that contractors often do not assign high-caliber workers to Liberia.

Further, the OMT is not operating as planned or with the quality required because LEC has not paid the contractor. This threatens MCHPP's long-term sustainability.

The MSC has been unable to turn around LEC as planned. Two years into ESBI's leadership, and despite important operational improvements, LEC's financial situation has worsened. LEC has increased generation, losses, debt, and responsibilities. LEC's severely constrained resources undermine progress. Generator and grid maintenance are ongoing but inadequate due to shortages of equipment, materials, vehicles, and parts. However, ESBI has improved operations at LEC, and although outcomes are far below expectations, no one fully understood the extend of LEC's problems pre-MSC.

Although LERC was delayed by several years, by 2019 LERC commissioners were confirmed, and there is a functioning regulatory board with an active, knowledgeable managing director. LERC is funded until Compact closure in January 2021. LEC cannot afford the cost of LERC staff and operations, so LERC is currently searching for donor funding.

What lessons can be drawn from implementation of the activities?

Table ES.1 outlines our overall assessment of lessons learned from the implementation, highlights successes and challenges, and recommends areas for improvement.

Table ES.1. MCHPP and LEC/ESBI: implementation lessons

	MCHPP	LEC/ESBI
Successes	• MCHPP is a fully rehabilitated and operational hydropower plant. • MCHPP "is a miracle," "like a phoenix rising from the ashes," according to one key informant. MCHPP has both emotional and economic value. To Liberians, it is a symbol of rebirth, modernization, and hope for the future. • MCHPP generates high quality, inexpensive electricity. • MCHPP stimulated a high level of donor coordination.	• Without ESBI in place at LEC: • There would likely be fewer connections, lower quality electricity, and more theft. • Stakeholders would lack accurate data and information on operations, and there would even less coordination of donor investments in generation and T&D projects. • Although ESBI's performance has not met stakeholders' expectations, a careful review of data, procedures, systems, and management over time indicates that ESBI has been successful in diagnosing and beginning to solve critical problems.

	MCHPP	LEC/ESBI
Challenges (most salient)	• The length of the PIU contract was inadequate to complete the project with oversight of all contractors. • More MCC/MCA-L oversight and easier financial processes were needed to anticipate and solve problems. • There are insufficient resources for ongoing operations and maintenance.	• MCC did not conduct a political economic analysis before establishing the MSC, and ESBI did not conduct adequate due diligence. No one knew the extent of LEC's financial and infrastructure problems. • ESBI has insufficient resources for operating and capital expenses and support from the LEC board and the government of Liberia (GoL). • ESBI's contract is structured to fund fewer staff over time, reducing level of effort as challenges persist. • There has been no comprehensive analysis of the sources and drivers of corruption and loss. • The donor community has not been adequately coordinated in working with LEC.
Opportunities	MCHPP is Liberia's greatest human-made asset. Organizations are interested in operations contracts or concessions. There are opportunities to ensure MCHPP's sustainability by renegotiating HOI's contract to maximize the value of the OMT's presence; identifying additional funding to maintain MCHHP until LEC can cover costs; or unbundling and concessioning MCHPP to a private firm.	• There are opportunities to use all new data and learning, in coordination with donors, to address issues raised. This is the time to optimize interest particularly the African Development and World Bank, to fund the MSC beyond January 2021. • ESBI to use the donor meetings to communicate priorities and obtain operating and capital resources. • Stakeholders may seize opportunity to advocate for composition needed on LEC board to improve governance and oversight. Board to conduct full and subcommittee meetings focused on problem solving. • Build on current understanding of losses and identify all drivers and sources of corruption at LEC. Develop theory- and evidence-based approaches, both technical and behavioral, to reduce theft and losses. Involve all stakeholders, LEC board, donors, and GoL • Add a contracts manager to ESBI to oversee all T&D plans. This could accelerate new connections.
Threats	• If LEC staff lacks skills or parts needed to maintain and repair MCHPP, the turbines will go offline as parts are pillaged. • Without oversight from PIU or owner's engineer, the warranty periods for defective parts and service will lapse without resolution, leaving LEC to cover the cost of repairs. This would lead to the plant falling into disrepair.	• Indecision or inaction on the part of the GoL to continue the MSC is a key threat. Further threats include the fact that the GOL appears to continue to condone theft, demonstrate poor oversight of LEC management, provide inadequate technical expertise on the LEC board, and lacks fiduciary commitment to LEC. • Trying to reduce losses without a thorough analysis of all sources of corruption and theft may miss key sources and drivers. • Continuing to assume that ESBI can reach key performance indicators without adequate operating and capital resources. • If the Cote d'Ivoire, Liberia, Sierra Leone, and Guinea (CLSG) line becomes operational without an effective loss prevention program in place, power theft will increase at a high cost to LEC.

	MCHPP	LEC/ESBI
Lessons learned	• Donor collaboration on infrastructure rehabilitation can be successful, though the consortium structure can improve. • Ensure that contracts are for the full length of the project. • Establish clear lines of authority for each agency (donor/contractor/LEC) regarding who should manage different issues. • Plan as systematically for the operation period as for the rehabilitation works. • Build budgets and contingency plans that assume a catastrophic event to give the program a better chance to succeed.	• Conduct a utility-level and country-level political economic analysis before investing to understand the context. • Build Compact and contracts to account for context and high likelihood of corruption. Assume MSC will face immense challenges and apply all lessons from the literature when designing Compact and contracts. • In a complex context such as Liberia, structure contracts with adequate level of effort. Build in preconditions and identify leverage to ensure board and government accountability. • Operate as a donor block in post-conflict countries characterized by dire poverty.

Energy sector

Liberia's overall governance, institutional capacity, and public sector management were decimated by the prolonged civil war and diaspora. The energy sector was a clear casualty, incapacitated and purposeless given the lack of energy generation, assets, and investments. Liberia's energy sector has had minimal institutional capacity, limited strategic and master planning, no regulatory framework, and inadequate accountability (Liberia Energy Policy 2009). The poorly performing public utility company has a monopoly on generating, transmitting, distributing, and selling electricity. Since 2015, even though Liberia has increased generation (from 22 megawatts (MW) to 141MW of hydro and thermal power) and increased the number of connected households and businesses (from about 30,000 to about 52,000) progress in energy sector reform—including building the country's Department of Energy, developing a sector-wide strategy, and regulating the sector—has lagged. However, well-designed reforms, such as establishing an independent regulatory agency and enabling privatization, have been shown to boost energy sector performance and increase access to power (Imam, 2019). These energy sector reforms could prove critical given Liberians' extreme pent-up (and unserved) demand for power. Liberians agree: "Electricity is life."

What new energy policies, laws, and legal, economic, and technical regulations have been enacted given the LERC's activities? How have these contributed to modernizing the energy sector and making the sector financially viable?

Although LERC has more work to do to articulate economic, technical, and commercial quality regulations, the agency has made important progress over the course of 2019. Moving forward, two important challenges loom. First, the LERC chairman was confirmed by the Senate as the executive governor of the Central Bank of Liberia, thus leaving his LERC post vacant. The LERC chairmanship position has not been filled and it is unclear what this means for LERC's progress. Second, LERC is funded through MCA-Liberia until Compact closing in January 2021. The annual operating costs of LERC are not yet clear, but when fully staffed, LERC would have 30 positions. In theory, LEC would cover LERC's costs through regulatory fees, but it is a bankrupt utility, so this is unlikely in the foreseeable future. It is unlikely that the GoL will cover costs as the government is cash-poor and unable to pay current civil servants on

time, even at the highest levels. Consequently, the managing director and commissioners are working on securing resources with a business plan and donor mapping activities, but they only have the rest of 2020 to identify resources. Their belief is that donor funding is the only option to ensure that LERC is an independent agency, particularly in the early years.

Utility level

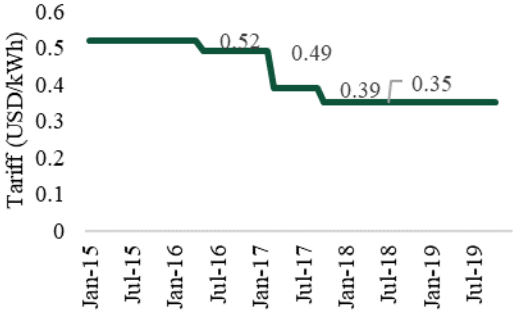
As described previously, when ESBI assumed the operations of LEC in December 2017, the utility was in a destitute financial situation, with a negative operating and profit margin and low liquidity. An interim management team (IMT) left LEC with financial liabilities, including $21 million of debt, minimal inventory, suboptimal contracts, burned records, accounts in disarray, no list of assets, and assets in disrepair. The IMT had increased staffing and raised salaries, resulting in a 54 percent increase in total remuneration costs. It had also reduced the tariff from $0.55 per kWh to $0.35 per kWh. In ESBI's assessment, LEC's 22 kV network lacked capacity for new connections; the low voltage network was of "limited standard"; and LEC had a shortage of materials, equipment, and tools. Dependent on donor agencies, LEC was only able to carry out basic emergency maintenance. Without an increase in operational or capital expenditures, LEC would soon gain responsibility for additional assets, including MCHPP and the OMT contract, 66 and 22 kilovolt (kV) lines, substations, 230-volt distribution lines, and customer connections.

LEC is governed by the LEC board of directors. The revived board's first meeting took place in June 2018, six months into ESBI's first year.

How has the electricity tariff changed since MCHPP was rehabilitated? To what extent does it cover the costs of generating electricity and other operating costs?

Liberia's current electricity tariff, at $0.35 per kWh plus a 10 percent goods and services tax ($0.385 per kWh) for residential, commercial, and public corporation customers, has changed since MCHPP was rehabilitated. Figure ES.1 illustrates the tariff level from January 2015 until October 2019. The average tariff was reduced in 2017, when the IMT led LEC, and as MCHPP began generating hydropower at a lower cost than the thermal plants. Note that even at the cost of $0.385 per kWh, LEC's high tariff is preferable to thermal generation for most customers, yet out of reach for many Liberians.

Figure ES. 1. LEC tariff over time



In response to pressure from the GoL to reduce the tariff, ESBI has modeled a reduced tariff of $0.30 per kWh for the first 20 units of electricity consumed by all residential customers. A $0.30 per kWh tariff would require "additional funding of US$77 million" over five years (Macro Consulting 2018). According to ESBI: "Due to the magnitude of such impacts and the prevailing financial circumstances, ESBI does not recommend any tariff reductions during the period" (LEC Business Plan 2019).

To what extent has LEC's management improved since the new management contract became effective? What progress has the Government of Liberia made toward establishing a longer-term management arrangement for LEC?

First, governance of LEC by the LEC board has been inadequate. By the end of 2019, most stakeholders agreed that the LEC board—operational for just over one year—had not provided the oversight, support, and accountability required at LEC. The board has been ineffective at approving procurements and budgets and at planning or monitoring and controlling treasury activities. The board had not identified risks and helped LEC manage them.

ESBI's management has improved some outcomes, such as supply, but others have worsened. ESBI's priority KPIs focus on aggregate technical and commercial losses (AT&C), operating cost per kilowatt billed, network performance, and number of new connections. Improved network performance is the only KPI that ESBI has achieved.

- LEC has had an almost fourfold increase in total electricity supply (in MWh per month) from 2015 to 2019, but total electricity sold has only doubled (Figure ES.2). The modest sales given the supply is due to LEC's inadequate T&D infrastructure, limited capacity to connect new customers, and delays in donor-funded customer connection projects.
- Technical losses increased from about 500,000 megawatt hours (MWh) in January 2015 to 1.9 million MWh in September 2019 (Figure ES.3). More strikingly, commercial losses increased from 1 million MWh in January 2015 to 10.8 MWh in January 2019. These are the primary source of LEC's major financial losses. Since 2018, commercial losses have steadily risen and stabilized around 58 percent, for a total loss rate of about 70 percent.
- LEC's operating costs per kWh sold is a KPI in the MSC contract, with the baseline agreed value of $0.64 per kWh and a target of $0.45 for 2018. Figure ES.4 shows that operating costs were high during the previous MSC, decreased during the IMT, and increased in spikes with ESBI. Note that data were missing for May to January 2017; however, the IMT's action to increase LEC salaries raised operating costs, as this expense accounts for 50 percent of operating costs during the dry season.

We present an overall assessment of LEC management with ESBI as the MSC in Table ES.2.

How sustainable is LEC as a utility? What are the biggest barriers to its sustainability?

Currently, LEC is on an unsustainable path. The purpose of the MSC was to stabilize LEC's operations with enhanced management and oversight so the utility was better able to deliver inexpensive electricity to more customers, reduce aggregate total losses and operating expenditures per kWh, and improve electricity quality and reliability. Beyond stabilization, the MSC would prepare the utility for growth and profitability, so the private sector would see LEC as an attractive partner. However, Liberia presents the exact context in which corruption proliferates: weak governance, poverty, poor utility management, high energy demand, and high tariffs. As a result, LEC has one of the highest rates of commercial losses in the world, with a thriving cartel responsible for grand electricity theft and small-scale, but widespread power theft in communities. LEC is beset by technical inefficiencies, an inability to connect customers

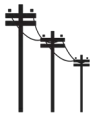
despite excess generation capacity, expanding corruption, and unsafe infrastructure. The utility requires increased funding for operations and capital expenses, a systematic response to theft and corruption, and support from the Government of Liberia and donors to implement the reform needed to sustain the utility. The steps are likely necessary before establishing public-private energy sector partnerships to meet the goal of connecting 35 percent of the country by 2030.

Table ES.2. Overall assessment of LEC's management

Has LEC's management improved with ESBI as the MSC (current status)?	
Overall management	Although LEC's underperformance persists. ESBI has made significant progress in diagnosing its problems, normalizing customer lists, developing human resource policies, (re)creating financial systems, revising contracts, improving utility data and records, and launching the Senior Resource Pool training.
Operations: electricity supply, sales, losses, billing, and collections	Though operations are better with ESBI, there are still critical flaws in the management of supply, sales, losses, and collection. LEC does not have a reasonable plan to take over MCHHP and is not paying the OMT contractor (~$300k per month), thus risking MCHPP's long-term sustainability. ESBI has repaired thermal generators but lacks fuel for the dry season. ESBI is renegotiating the cross-border power purchasing agreement, but it is not clear that LEC can prevent losses and manage connections once the line is operational. The asset and customer management study, loss prevention strategies, and information management system should help with reducing losses and improving sales, billing, and collections.
Commercial operations and cost recovery	This is the MSC's most serious challenge. Although it is impossible to know for certain, respondents (including LEC staff, donor agencies, and contractors) believe that LEC's finances would be worse if the MSC were not in place. Given the extensive problems the IMT left behind, it is unlikely that the IMT could perform better than ESBI. The MSC is collecting and using data and information to identify and solve problems.
Customer coverage and service	Customer coverage is less widespread than anticipated and does not meet expectations; however, it is unlikely that LEC would operate at a higher caliber without ESBI.
Technical capacity and staff development, retention, and productivity	ESBI brings strong technical expertise. In 2018, there was minimal staff development, but in 2019 ESBI began involving LEC department heads in weekly meetings and brought on a director of human resources. ESBI's performance in staff development has not yet met expectations; however, LEC without the MSC would be unable to develop and execute a suitable training plan or improve human resource manuals, policies, procedures, and systems.
Use of data and IMS to improve operations	The World Bank-funded IMS was developed under ESBI's leadership. The IMS includes the commercial management system, distribution management system, and enterprise resource planning. There modules are live, there is a dedicated server, and LEC staff are being trained.
T&D, electricity quality, maintenance, and repairs	T&D and electricity quality have unquestionably improved from the IMT period, and there are improvements in both the quality and reliability of electricity. Measures of overall grid performance would improve if ESBI/LEC could overcome challenges such as lack of redundancy, overloaded transformers, no backup, and the limited skills of staff.
Donor project management	ESBI's management of donor projects has been weak. ESBI readily admits it has not been staffed to manage $195.8 million dollars in donor T&D contracts and needs a contract manager. The lack of communication means that donors have invested in connection projects that are misaligned with LEC's needs, exceed the grid's capacity, and exacerbated power theft.

Has LEC's management improved with ESBI as the MSC (current status)?	
Communication with MCC, MCA, and other donors	ESBI's materials for meetings of the High-Level Stakeholder and Energy Sector Working Group are detailed and clear about progress, challenges, and needs, and represent a clear improvement over IMT materials. In addition, LEC's Chief Operating Operator (COO) was key to the elaboration of the LEC Business Plan and Recovery Strategy and development of the Financial Model to quantify the financial implications of the recovery strategy. The COO was instrumental in supporting MCC's position that the Business Plan and Financial Model are key tools to enhance the credibility of LEC's plans and its ability to eventually to attract donor funding. However, ESBI has not yet established communication effective enough for donor agencies to believe they understand ESBI's efforts and needs and can adequately support them.

Grid level



The Liberia electricity infrastructure is concentrated in Monrovia and surrounding communities. Assets consist of thermal generators and MCHPP, with 66 kV and 22 kV transmission and a low-voltage distribution system. As ESBI articulated in its initial situation report, turnaround plan, and subsequent LEC and CMC quarterly and annual reports, Liberia's generation and T&D rehabilitation needs were far more extensive and expensive than anticipated. Liberia's thermal generators and T&D infrastructure suffer from frequent mechanical failures. Most generators are donated, and T&D infrastructure has been rebuilt piecemeal through donor contributions. The fragmented system is fraught with mechanical and commercial challenges. As noted in the LEC Business Plan, "LEC's system demand has grown on average by 50 percent year-on-year since 2016." This growth trend is expected to continue, placing increasing demand on LEC. Increasing demand intensifies LEC's funding gaps in generator operations and raises maintenance and dry season fuel costs.

To what extent have MCHPP rehabilitation and Capacity Building and Sector Reform (MCC's investments) affected the reliability of the electricity supply, planned and unplanned outages, and voltage stability?

The combination of MCHPP rehabilitation and ESBI's efforts to repair generators and convert the fuel source from light fuel oil to less expensive heavy fuel oil has increased electricity generation (Figure ES.6 on the next page). Liberia now has excess generation given T&D limitations.

LEC has made progress, despite grave challenges and resource constraints, in reducing outages and improving the reliability of electricity. LEC's outages, or the system average interruption frequency index (SAIFI) and system average interruption duration index (SAIDI), are KPIs in the MSC contract and are plotted in Figure ES.2. Although LEC's SAIDI and SAIFI measures are high compared to those of other utility companies across Africa and the world, the baseline level was 500 hours, so LEC's result of 183 hours per customer in 2018 is a marked improvement. Note that the peak in outages in 2019 occurred during the dry season because of fuel shortages.

Figure ES.2. System average interruption frequency and duration index (SAIDI and SAIFI)

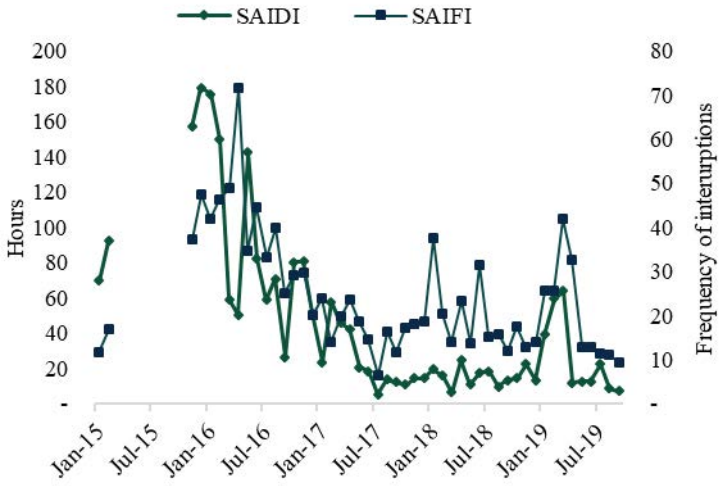


Figure ES.3. Total electricity supply, electricity sold, and peak demand

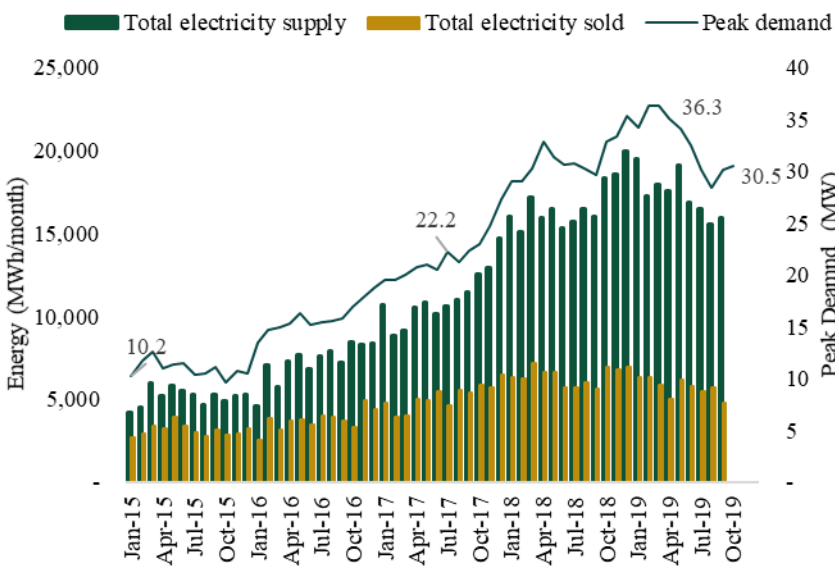


Figure ES.4. Total electricity supply and losses in MWh

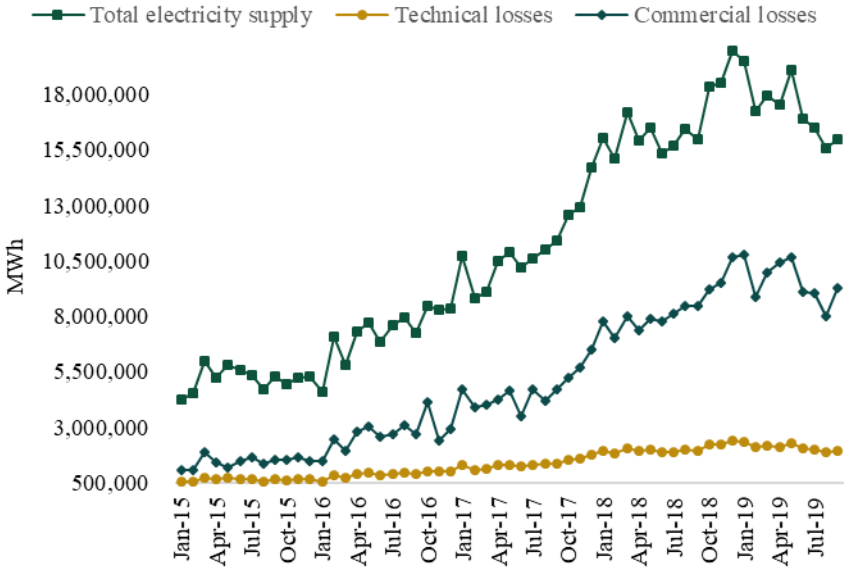


Figure ES.5. Operating costs per kWh sold

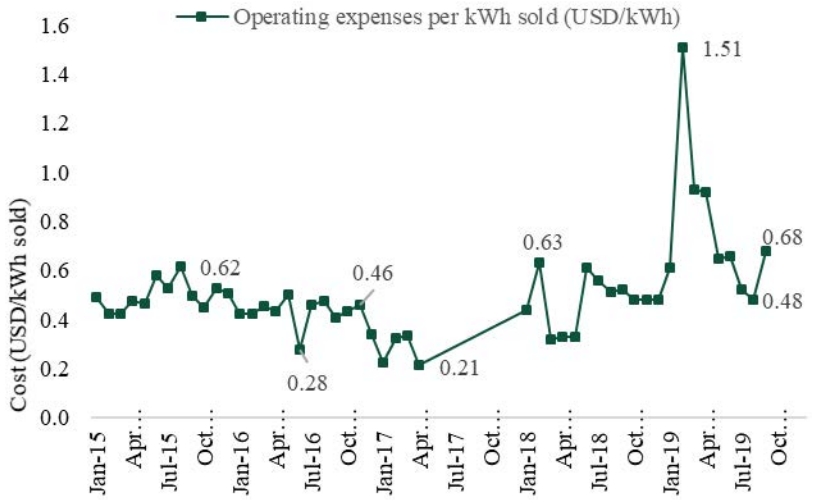
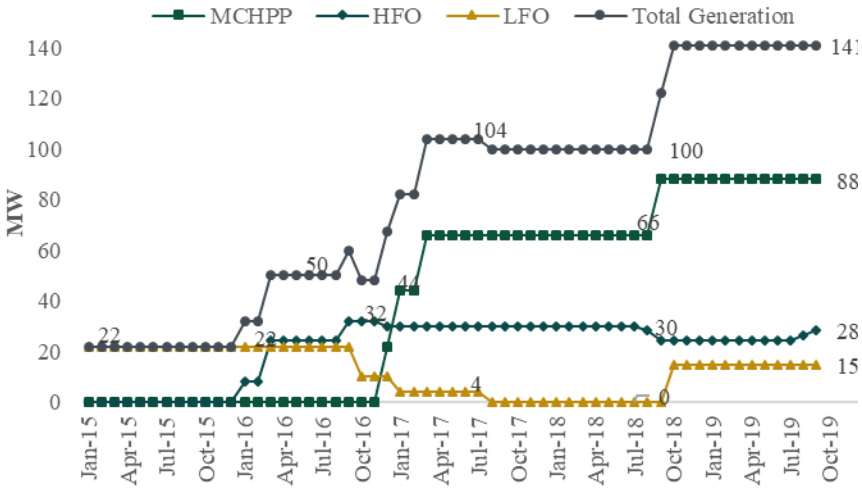


Figure ES.6. LEC generation 2015-2019



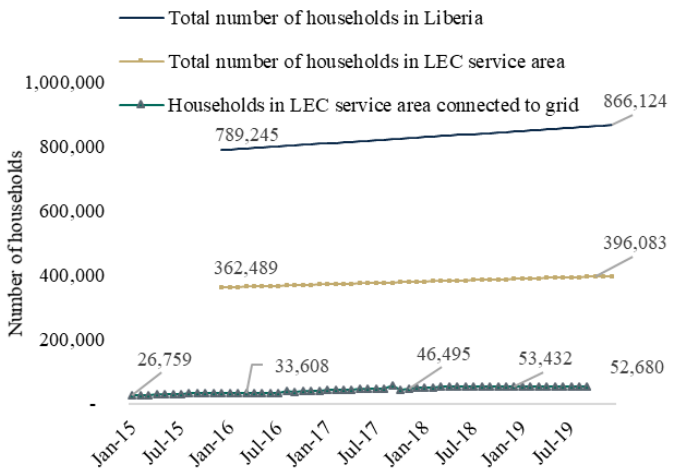
Note: 88 MW for MCHPP is the design specification rather than the maximum instantaneous generation capacity.

End user

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?

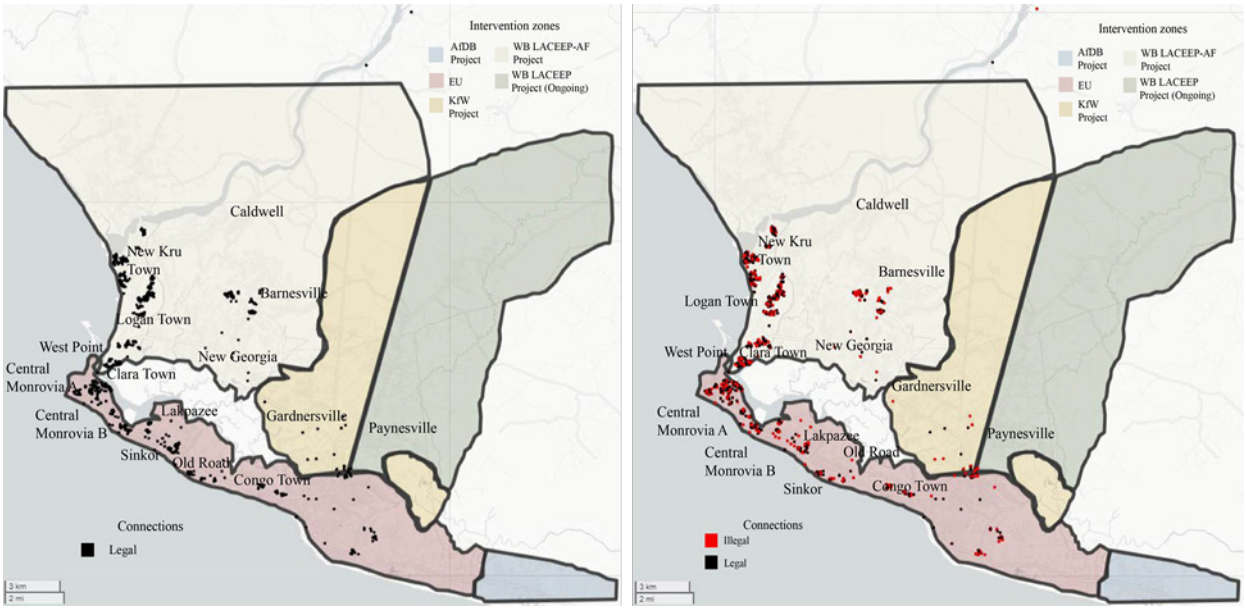
LEC's ability to acquire and manage its connections to customers is minimal, despite unused generation capacity in the wet season. The expectation had been that once MCHPP was rehabilitated, and donor projects were underway, LEC would connect 2,000–4,000 new customers per month (MCC 2017). T&D failures undermined new connections, quality, and reliability. Many residential customers say they are willing and able to pay, though informal connections and theft among large customers increased. LEC cannot cover fuel costs for thermal generation, and so cannot accommodate increased demand during the dry season; CLSG delays also impede consumption. Since MCHPP rehabilitation, there are modest increases in paying customers, but large increases in theft. (Commercial losses more than doubled, from 4.7 to 10.7 million MWh between 2017 and 2019.)

Figure ES.7. Trend data on annual number of customers



Energy theft among residential and business end users has increased, partially due to donor projects that connected some but not all potential customers in a community. Electricity failed to saturate communities: only a portion of households and businesses connected (as shown in Figure ES.7). As a result, end users have connected illegally. Illegal connections also result from the high cost of bribes charged by LEC for connections. Focus group participants warned that this pattern will continue if they are not offered legal connections. Figure ES.8. presents the distribution of legal and illegal connections in 2018.

Figure ES.8. Distribution of legal and illegal connections



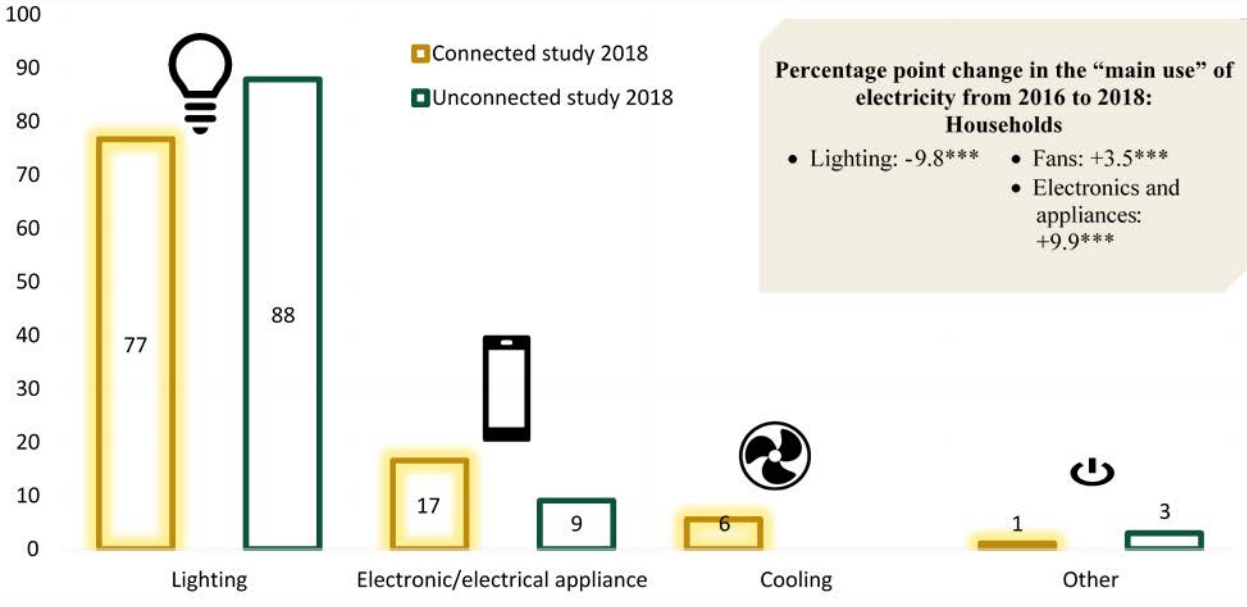
Maps are based on our data collection among connected households in Monrovia.

How do LEC customers change their behavior, such as investing in appliances and use of time?

LEC customers emphasized the importance of access to LEC electricity. LEC is cheaper and better-quality power than generators or mini-grids can provide. LEC customers describe behavior changes such as developing businesses and starting income-generating activities IGAs. Most respondents reported that their main use of electricity was lighting (Figure ES.9). However, from 2016 to 2018, households, small businesses, and medium and large end users reported a shift away from lighting as the main use of electricity. Among households, there was a 9.9 percentage point increase in electronics and appliances as the main use, and a 3.5 percentage point increase in the use of fans. Among small businesses, respondents shifted toward using freezers (4.4 percentage point increase). Medium and large end users shifted toward technology (6.7 percentage point increase) and machinery (4.5 percentage point increase.)

When asked how their use of time had changed, about 3 percent of women in connected households reported spending more time on wage labor, 11 percent spent more time on cooking, and 16 percent spent more time on leisure from 2016 to 2018. Just over one-quarter (27 percent) of men in connected households reported spending more time listening to the radio, and 25 percent reported spending more time on leisure activities.

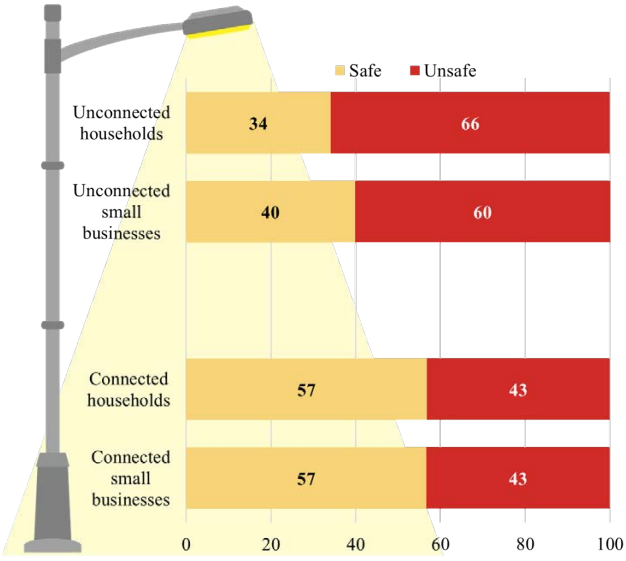
Figure ES.9. Main use of electricity in connected and unconnected households



***Statistically significant. The connected study values are not shown. However, 77 percent reporting lighting as the main use in 2018 is reduced from 87 percent in 2016.

What are the other effects of electricity on connected end users, and what are the spillover effects on non-electrified households?

Figure ES.10. Reported feeling safe when walking in community at night



An important spillover effect in both connected and unconnected communities was the benefit of streetlights. Seventy-two percent of respondents in connected households and 78 percent of respondents in unconnected households thought that streetlights provided some protection against crime and animals. Figure ES.10 shows respondents' perceptions of how safety in their communities has been affected by streetlights. Respondents in better lit communities are more likely to say they feel safe.

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?

Respondents from households and small businesses listed a variety of barriers to connecting to LEC electricity. The most common was that the power lines were too far from the respondent's home or business. This suggests that once distribution lines are built near more homes, potential customers will connect. Among large

organizations, 19 percent of respondents reported that they had submitted an application and were waiting for a connection, 18 percent said that LEC had refused to connect the building (likely due to a meter shortage or overloaded transformers), and 19 percent said the application procedures were too complicated.

How have MCC's investments affected connected and unconnected households' perceptions of the quality of electricity?

LEC customers generally report that LEC provides good quality electricity, but there are outages that have negative effects. Household customers appear to have the highest quality of electricity, with fewer outages than small businesses and medium and large end users. Virtually no customers were notified of outages: 99 percent of household customers and 97 percent of businesses and organizations said that LEC never informs them of outages in advance.

Evaluation methods

We designed mixed-methods evaluation studies to examine the evaluation questions and provide nuanced information at each outcome level. The comprehensive study designs use rigorous approaches to sampling, data collection, and analysis. In this report on baseline and interim findings, we provide a status update on implementation, energy sector, utility, and grid-level outcomes. For end-users, we present a retrospective review of outcomes that occurred before data collection, establish a baseline after which new outcomes will unfold, and follow outcomes and processes in the future. As we examined each evaluation question, we analyzed all data and validated findings across outcome levels so findings could be supported by multiple data sources. Table ES.3 summarizes our evaluation approach.

Table ES.3. Compact activities and evaluation questions by level of outcome

Outcome level	Evaluation approach
Overarching implementation	• Implementation evaluation with longitudinal analysis of administrative data, document review, qualitative interviews, and site visits • Recomputation of economic rate of return using administrative data and a document review
Energy sector Utility Grid	• Longitudinal analysis of administrative data • Performance evaluation using a document review, quantitative surveys of end users, qualitative interviews, and site visits
End user	• Longitudinal analysis of administrative data • Performance evaluation with a document review, qualitative activities, and site visits • Quantitative pre-post surveys with five samples: - Connected households in Monrovia - Connected small businesses in Monrovia - Unconnected households along the Kakata Corridor - Unconnected small businesses along the Kakata Corridor - Medium and large end users

Study timeline

The design and the timeline for data collection—along with ongoing document and administrative data reviews, monitoring the Liberia energy sector, and conducting key informant interviews and site visits as required—allow us to answer each of the study's evaluation questions. As shown in Table ES.4, we still propose three rounds of data collection—at baseline in 2018–2019, interim in 2020–2021, and endline in 2023–2024—to form a panel that will enable us to collect information on households, small businesses, and medium and large end users; and to measure changes in a broad range of outcomes such as energy demand and consumption, time use, and economic well-being. We will also conduct repeated rounds of qualitative data collection on the same schedule.

Table ES.4. Study timeline

Name of round	Data collection	Data cleaning & analysis	First draft report expected	Final draft report expected
Baseline quantitative and qualitative	December 2018–November 2019	May 2019 – January 2020	January 2020	March 2020
Interim	November 2020–June 2021	January–July 2021	August 2021	October 2021
Endline	November 2023–June 2024	January–July 2024	August 2024	January 2025

Note: The timeline is designed to maximize observation of outcomes for the largest number of users, who are connected on a rolling basis. The exposure time for outcomes may range from months to years.

Next steps

We look forward to sharing the draft report with MCC, MCA-Liberia, and all energy sector stakeholders for review and discussion. We aim to present findings to the Liberia Energy Team in Washington, to MCC and MCA-Liberia in Liberia, and to stakeholders in Liberia, including donor partners, policymakers, ESBI, and LEC. We will seek feedback, revise the report in response to stakeholder comments, and finalize it. We will conduct additional analyses or draft materials from the report findings as requested and as funding permits.

Then, we plan to continue with program monitoring activities, including conducting an ongoing document review, key informant interviews, and site visits as needed. We also plan to begin the interim data collection toward the end of 2020 and produce an interim report in August of 2021.

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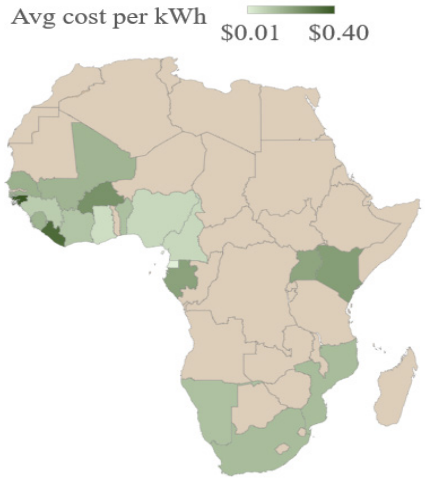
I. INTRODUCTION

Liberia's inadequate supply of affordable and reliable electricity is a critical impediment to its economic growth. The country has one of the lowest electrification rates and highest tariffs in the world, with only 22 percent of the population accessing electricity (WB 2019) at $0.35 per kWh (I.1). In addition to low connectivity and the high cost per kilowatt, planned and unplanned outages are a frequent occurrence (Cooper 2017).[1]

Figure I.1. Comparative electricity costs



Providing 64 megawatts of power, the Mt. Coffee Hydropower Plant (MCHPP) was Liberia's single largest power source before 1989. It was providing 98 percent of the country's total power when it was destroyed during Liberia's 14-year civil war. By the end of the war in 2003, Liberia's entire transmission and distribution (T&D) system had been severely damaged by widespread looting. The public and private sectors, including the Liberia Electricity Corporation (LEC), lost both technical and management capacity when an estimated 800,000 Liberians fled the country and approximately 200,000 were killed during the wars. The Ebola Disease Virus (EDV) outbreak in 2014 further reduced the workforce—neighboring Sierra Leone lost 50 percent of its private workforce—and damaged the fledgling economy.

Country	Avg cost per kWh US$	Access to electricity % (2017)
Benin	0.13	40
Cote D'Ivoire	0.12	66
Ghana	0.06	79
Guinea	0.10	35
Liberia	0.35	22
Nigeria	0.07	54
Senegal	0.17	62
Sierra Leone	0.16	23

To address these challenges, the Millennium Challenge Corporation (MCC) partnered with the Government of Liberia (GoL) to fund the $202 million Energy Project. The Energy Project aims to generate low-cost power, improve the quality and reliability of the power system, and expand access to electricity. The Energy Compact comprises four activities:

- **Activity 1:** The **Mt. Coffee Rehabilitation Activity** was designed to repair and expand the Mt. Coffee Hydro Power Plant (MCHPP) to increase Liberia's supply by adding 88 megawatts (MW) of renewable power to the country's 22 MW of thermal generation.
- **Activity 2:** The **Capacity Building and Sector Reform Activity** funds a management services contract to operate and strengthen the capacity of the LEC, supports the establishment of an independent regulatory agency—the Liberia Electricity Regulatory Commission (LERC)—and strengthens capacity at the Ministry of Mines and Energy (MME).

[1] Data is from GlobalPetrolPrices.com, United4Efficiency.org, and the World Bank Sustainable Energy for all database.

- **Activity 3:** The **Mt. Coffee Support Activity** addresses environmental and social risks associated with the rehabilitation of MCHPP and aims to increase productive uses of electricity.
- **Activity 4:** The **LEC Training Center Activity** aims to improve the capacity of the LEC workforce.

In this chapter, we provide an overview of the Compact and project activities and describe the program logic for Activities 1 and 2. In Chapter II, we describe the Liberian context and review literature relevant to the Liberia energy sector and project investments. Chapter III presents the evaluation components, including the study methodology and data sources. Chapter IV presents the overall implementation findings for the MCC Compact in Liberia. Chapters V, VI, VII, and VIII reveal findings related to the energy sector, utility, grid, and end user outcomes. Chapter IX concludes next steps and the appendices provide additional background data and study details.

A. Overview of the Compact

The $257 million Liberia Compact, designed to stimulate economic growth and reduce poverty in Liberia through investments in energy and roads, entered into force in January 2016. MCC identified three main causes contributing to Liberia's unreliable and unaffordable grid electricity: (1) a weak policy and regulatory environment, (2) insufficient supply and distribution of electricity, and (3) weak capacity across the sector. The $202 million Liberia Energy Project aimed to address these challenges. Next, we briefly describe its activities.

Liberia Energy Project

The Liberia Energy Project consists of four separate activities designed to address the main challenges to the energy sector and contribute to the Compact's long-term goal of reducing poverty through economic growth. We begin by describing Activities 1 and 2.

Activity 1: The Mt. Coffee Rehabilitation Activity is the largest component of the Energy Project (see Figure I.2). The $147 million activity involves rehabilitating the hydropower plant and contributing to the installation of 132 kilovolt (kV) transmission lines, made up of two 66 KV circuits, from MCHPP to the Paynesville and Bushrod substations, enabling electricity to be distributed throughout Greater Monrovia.

MCC joined a field of donors that had begun to rehabilitate MCHPP. The Government of Norway (GoN), through the Norwegian Development Agency (NORAD), the German Development Bank (KfW), and the European Investment Bank (EIB) had already committed to the rehabilitation of MCHPP in 2011. MCC became engaged in 2014 when it was clear that MCC's investments were necessary to complete the project. MCC took the opportunity to expand the generation and distribution systems and add more safety measures. Soon after MCC engaged, rehabilitation efforts were suspended during the EVD outbreak, and as design issues emerged that slowed progress and increased costs.

MCHPP was designed to generate 88 MW[2] of electricity, and, according to the economic model, to increase the number of connections from approximately 35,000 customers across Monrovia and surrounding areas in 2015 to 94,000 by 2020 and to 106,000 by 2025. The investments aimed to both increase the supply of high quality and reliable electricity and create the conditions necessary to reduce the tariff.

Figure I.2. MCHPP before rehabilitation (Photo credit MCC)

MCHPP, pictured before rehabilitation, is located on the St. Paul River, 27 kilometers northeast of Monrovia.

Constructed in the 1960s, MCHPP expanded in the 1970s to a capacity of 64 MW (Norplan Fitchner 2013). In 1990, the National Patriotic Front of Liberia took control of MCHPP. Soon after, the dam was breached, and the plant was destroyed. All electrical equipment was destroyed or stolen.

Activity 2: The Capacity Building and Sector Reform Activity is designed to bolster Liberia's energy workforce and support energy-sector institutions to address the weak policy and regulatory environment.

- **Installing a management services contract (MSC) to improve LEC's management capacity.** MCC required the GoL select a management plan as a condition of the Compact because, as of 2015, LEC managed few assets, generated only 22 MW of power distributed to 2 percent of Liberians, charged the highest tariff in the region, lost 32 percent of its generation capacity to theft and technical deficiencies, was donor-reliant, and perpetually operated at a loss (Tetra Tech 2018) (Figure I.3). Given these challenges, the GoL selected an MSC to reform management and operations in the state-owned utility and transform LEC into a financially viable and operationally efficient company.
- **Establishing the Liberia Electricity Regulatory Commission (LERC).** The LERC activity was designed to establish an independent, transparent, and accountable regulatory agency that would be equipped to develop a favorable policy and regulatory environment for the generation, T&D, and sale of energy. Once established, the LERC would use energy studies funded by the Millennium Challenge Account-Liberia (MCA-Liberia) in its decision making,

[2] Throughout the report, the figure of 88MW of MCHPP generation capacity refers to the design specification rather than the maximum instantaneous generation capacity.

strategic and master planning. The studies yielded information on power producers and operators, customer demand, and willingness to pay.

Figure I.3. Liberia Electricity Corporation, Waterside Monrovia

In 2010, Manitoba Hydro International (MHI), was the MSC at LEC. MHI generally achieved connection targets but was unable to reduce nontechnical losses.

During the EVD crisis, MHI no longer achieved performance targets. The contract ended in late 2015.

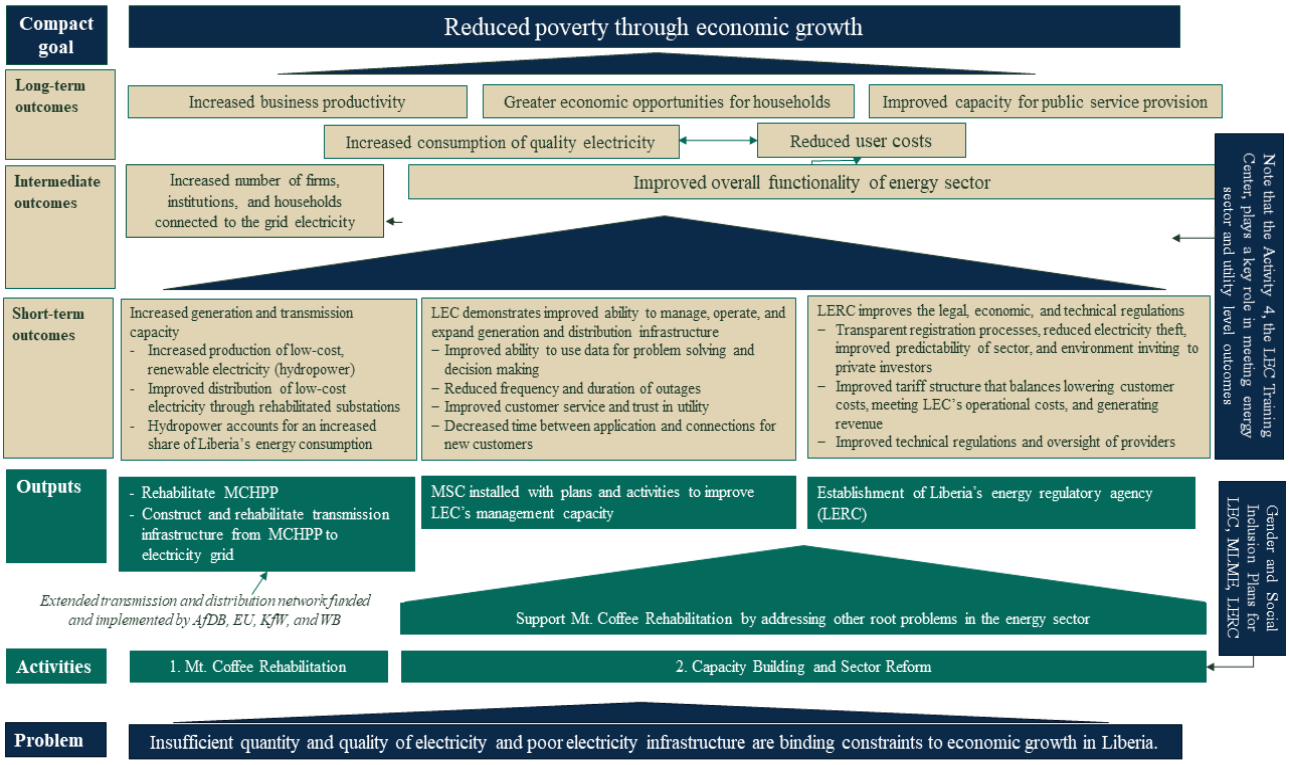
An interim management team of local Liberians managed LEC from January 2017 until December 2017, during which time LEC's financial and operational capabilities deteriorated.

B. Program logic

MCC developed both a high-level program logic for the full Energy Project and a more detailed program logic for Activity 1 (See the Evaluability Assessment for earlier versions.) We revised the model in the Evaluation Design Report to show the mechanisms by which investments can lead to outcomes (Figure I.4.). More recently, MCC revised its program logic for Activities 1, 2 and 4[3] to reflect changes to the Energy Project since the start of the Compact. (Revisions are shown in Appendix A). Recognizing revisions to the Compact activities, and in the interest of space, we focus on a representation the logic that captures the interactions and dependencies between Activity 1 and Activity 2.

[3] Note that because of delays in the design and implementation of Activity 4, the LEC Training Activity, we submitted a design report for it in November 2019. We expect to collect baseline data in early 2020. By the time of the midline evaluation report, we will include Activity 4 results with results from Activities 1 and 2.

Figure I.4. MCC revised program logic



Energy project

The project logic illustrates how Activity 1 is designed to address constraints in Liberia's electricity generation by investing in rehabilitating MCHPP (outputs level) and high voltage transmission infrastructure. In theory, investments will lead to increased production and distribution of electricity (short-term outcome level) cheaper electricity, reduced tariffs and user costs, and increased consumption of quality electricity by more customers (intermediate- to long-term outcomes). These outcomes will lead to positive economic and social outcomes among customers and enable LEC to be a financially viable utility.

Activity 2 involves two main subtasks. First, Activity 2 also strengthens and improves the functioning of the electrical utility by procuring a management services contract for LEC. This investment would improve LEC's operational and management capacity to oversee electricity generation and distribution in a financially sustainable way. In turn, the base of satisfied, connected customers would grow, accelerating positive social and economic outcomes in the long term. Activity 2 also involves the establishment of an independent regulatory body, the Liberia Electricity Regulatory Commission (LERC). LERC will develop a stable regulatory environment that accelerates investment and incentivizes independent power producers to help increase generation and meet the energy demands of Liberians. A clear and stable regulatory environment should help achieve universal access to adequate, reliable, and efficient electricity. Also, technical and quality regulations should improve the safety and quality of electricity.

Note that although MCC's program logic does not illustrate the inputs of the donor community in Liberia, donors—including the African Development Bank (AfDB), the EIB, the European

Union (EU), KfW, NORAD, the Japanese International Cooperation Agency (JICA), the Swedish International Development Cooperation Agency (SIDA) and the United States Agency for International Development (USAID) —have played a critical role in advancing Liberia's energy sector in the past. Donor-funded projects and supports are also critical to realizing the goals of MCC's Compact and the short, intermediate-, and long-term outcomes along the causal pathway. For example, achieving improved electricity quality and reliability and a larger customer base hinges heavily on the $195.8 million in donor-funded investments in T&D repairs, installation of new distribution infrastructure, and materials and equipment.

Donors in Liberia have played a role in these energy sector activities (MCC 2015a):

- Developing and adopting a national energy policy (USAID in 2009)
- Implementing a 2010 willingness-to-pay study (WB)
- Installing HFO generators (JICA and WB)
- Developing the Electricity Law of 2015
- Rehabilitating MCHPP, begun in 2014 (NORAD, KfW, and EIB)
- Investing in rural and renewable off-grid projects (USAID, WB, EU, and SIDA)
- Establishing the Rural and Renewable Energy Agency and the Rural Energy Fund in 2015 (EU)
- Developing a Rural Energy Strategy and Master Plan in 2016 (EU)
- T&D investments, including connecting households and businesses (WB, AfDB, KfW, GoN)
- Capacity and other supports to the MME (EU, GoN)
- Financing training programs for LEC and MCHPP (AfDB, EU, GoN, and WB)

Assumptions are inherent in program logic. However, unknown, overlooked, and misunderstood factors may undermine the success of interventions. For instance, the causal linkages in the logic model depend heavily on the adequacy of the T&D infrastructure to withstand additional electricity demand and the MSC having the capability to effectively manage LEC's staff and finances. The evaluability assessment discusses the legitimacy and relevancy of assumptions in the original logic model (Miller et al. 2018), and this baseline study provides another opportunity to assess assumptions. We assess the program logic in detail in Section IV.B.2.

C. Link to ERR and Beneficiary analysis

MCC developed an economic rate of return (ERR) model before the Compact that includes several benefit and cost components directly linked to the Energy Project activities, but the benefits in the ERR model are described by MCC as benefits of the MCHPP Activity. These benefits are directly related to the increased supply and reliability of electricity. The first is the benefit accruing to newly connected households and firms from increased electricity consumption. The second is the benefit accruing to already-connected households and firms from lower expenditures on electricity and increased consumption of, both resulting from tariff reduction. Both benefit streams are calculated using a consumer surplus model, where the surplus for each consumer is based on the difference between consumers' willingness to pay (WTP) for electricity consumption and the actual price paid, or the tariff rate. The assumption is that the WTP measures how a consumer internalizes all the benefits attached to increased electricity consumption. Given that we are at the end of the baseline phase, we have limited end user data to answer questions about the ERR, so we do not present an analysis of the model in this report.

II. LITERATURE REVIEW OF THE EVIDENCE

In this chapter, we describe the Liberian context and review evidence relevant to Compact activities and anticipated outcomes.

A. Political and economic context

Liberia's devastating 14-year conflict, followed by a harrowing Ebola epidemic, are cited as pivotal events in the country's history. It is important to explicitly state the long-term and widespread consequences of these events, which are critical to consider when investing in power reform projects. Both war and EVD placed the country in a fragile political and economic position (Hettinger 2020). Liberia has weak and ineffectual ministries; insufficient accountability across government, donor agencies, and the population; and inadequate human resource capacity given the large-scale departure of private-sector workers (Liberians and expatriates).

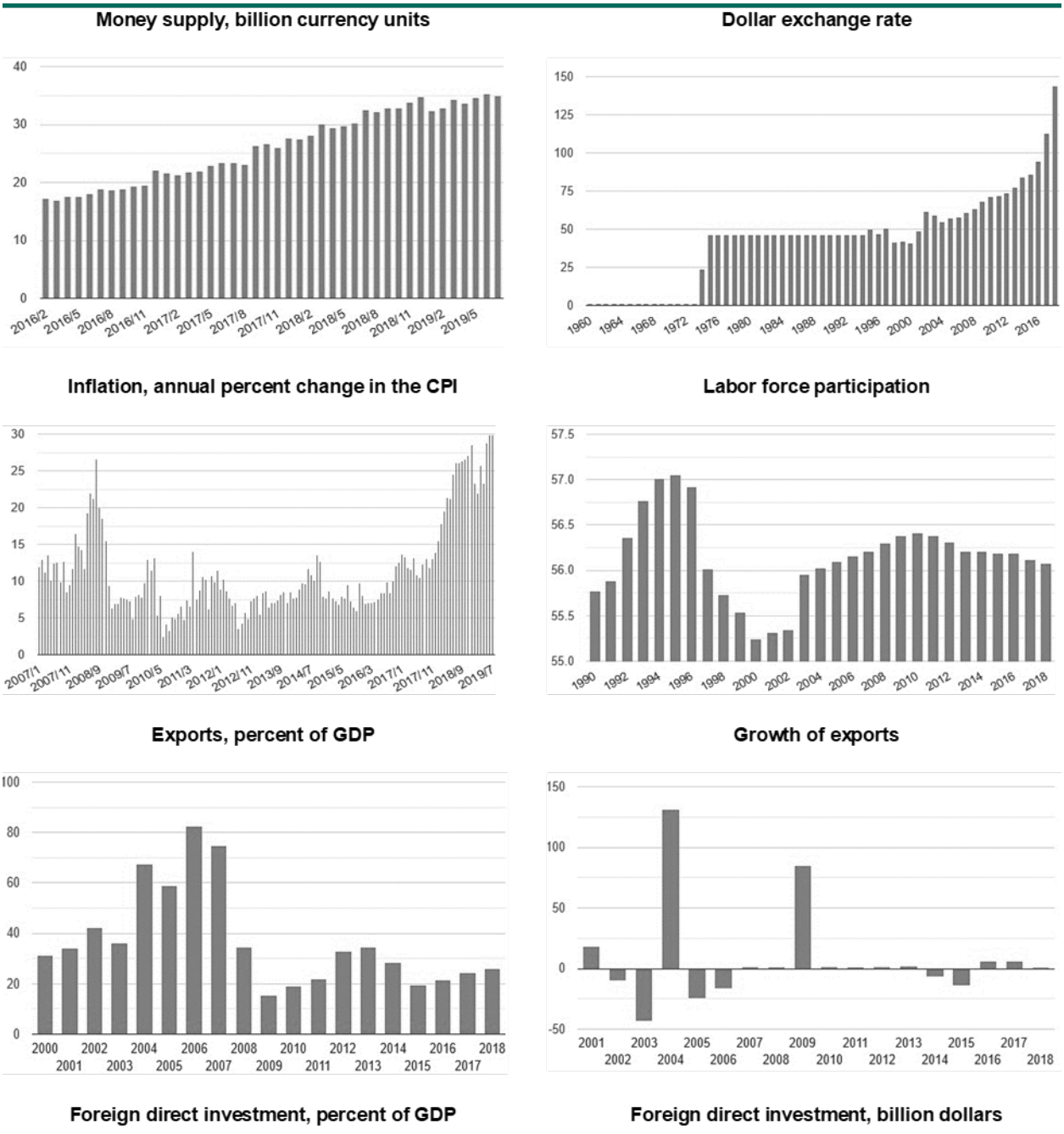
The country has deep macroeconomic challenges, its economy has slowed, tax revenues have fallen, and there is limited foreign direct investment. Figure II.1 shows a range of Liberia's macroeconomic indicators for the years in which data are available. The figures within the reveal Liberia's stagnant growth in money supply, which has worsened since 2019, and the precipitous depreciation of the currency (particularly in the last few years). Inflation has increased dramatically since 2017, and exports have steadily declined. Foreign direct investment accounts for 26 percent of GDP yet represents few actual dollars. Consequently, GoL cannot pay its bills, from civil servant salaries to basic materials, equipment, rent, and utility debts (Ballah 2019, APA 2019). Across GoL operations, from the Liberia Electricity and Water and Sewer Corporations to the Police and Fire Protection Services, offices have vacant positions and lack supplies. Efforts to rebuild the sectors destroyed during the war have stalled. In turn, Liberians have little faith that the GoL will manage basic service delivery, and often take matters such as electricity connections into their own hands (Johnson 2019). Prolonged frustration with insufficient government functionality supports an environment where corruption can thrive despite its negative impacts on future growth (Ackerman 1996). This stark political and economic context should be considered during each stage of program planning, monitoring, and evaluation given the extensive implications context has for outcomes.

B. Energy sector policy and regulatory reform

1. Overview of Liberia's energy sector

Liberia's energy sector has had minimal institutional capacity, limited strategic and master planning, no regulatory framework, and inadequate accountability (Liberia Energy Policy 2009). The poorly performing public utility company has a monopoly on generating, transmitting, distributing, and selling electricity. With one of the highest rates of commercial losses in the world, Liberia has a thriving cartel responsible for both petty and grand electricity theft. LEC's technical inefficiencies, inability to connect customers despite excess generation capacity, expanding corruption, and unsafe infrastructure make it imperative to find solutions for these grave problems.

Figure II.1. Macroeconomic indicators



CPI = Consumer Price Index. Data from http://TheGlobalEconomy.com.

The current environment is hostile to reaching Liberia's energy goals. However, donor investments in generation, T&D, and new connections—along with the GoL's explicit goal of increasing access to electricity to foster economic development—accelerates the need for sector reform and modernization to bring it in line with technical, economic, and quality standards.

2. Current policy reform activities

Since the 1990s, strategies to reform the energy sector in developing countries have included establishing regulatory agencies, enacting laws, encouraging private participation, and privatizing utilities. Regulatory agencies should establish the environment needed to improve sector performance; achieve standards for safety and quality; unbundle utilities into separate entities for generation, transmission, distribution, and retail; and invite private-sector participation to stimulate competition (Eberhard et al. 2016). With implementation varying by country, the results of policy reform have been mixed (Gulen et al. n.d.; Stern and Cubbin 2005; Eberhard et al. 2016). In some countries, reforms have reduced electricity access for poor customers by increasing tariffs and enforcing collections (Scott and Seth 2013). Researchers have also documented situations in which regulators lacked decision making authority or were resistant to sector reform (Brown et al. 2006; Stern and Cubbin 2005).

A more promising recent study of 47 Sub-Saharan countries by Imam, Jamasb, and Llorca found that industry performance and efficiency improved, and sector corruption reduced with the introduction of independent regulatory agencies and private participation. Moreover, regulatory agencies have been successful when they have independent decision-making authority and focus on principles such as accountability, transparency, and public participation (Brown et al. 2006). These findings are relevant to Liberia, where the utility's technical efficiency is poor, and corruption is spreading. In fact, vertically unbundling generation, transmission, distribution, and retail may be the only way to improve efficiency and performance and reduce losses. Further, horizontal unbundling of generation and distribution would enable independent power producers to enter the energy market and increase access to electricity country wide. Given that LEC is unable to fulfill electricity needs throughout Greater Monrovia, partners are needed. Additionally, regulations on the quality, price, and technical standards would improve safety, reduce electrical hazards, and help the country move toward affordable pricing.

C. Utility reform

Countries throughout Sub-Saharan Africa have poorly performing, state-owned utility companies that are unable to provide access to affordable and reliable electricity to swaths of the population (Eberhard et al. 2011). Further, utility companies often fail to adequately manage operations and finances, maintain and invest in new infrastructure, limit technical losses, and collect tariffs that cover operational costs (Kojima and Trimble 2016). Moreover, utilities are particularly vulnerable to corruption, which "can seriously jeopardize the best-intentioned reforms" (Adejumobi 2015; Rimsaite 2019). In countries with high unemployment and few economic opportunities, utility companies are steady income generators and have become large employers and part of the broader system of patronage (McCulloch, Sindou, Ward 2017, 2018). The situation is exacerbated by the fact that the anti-corruption infrastructure needed to control and reduce these activities often does not exist, and electricity sectors across Africa have consequently become sources of corruption and cronyism (Imam et al. 2019, Rose-Ackerman

1996). Indeed, Liberia presents the exact context in which corruption can proliferate: weak governance, poverty, poor utility management, high energy demand, and high tariffs. Further, according to Imam, "in weak institutional settings, major undertakings such as the construction of large hydroelectric dams, government intervention, monopolistic characteristics of the sector, absence of competition and substantial revenues from the sales of electricity make the sector vulnerable to corruption."

In response, African countries—driven by donor requirements—have implemented reforms to strengthen utilities' performance. For example, West African countries such as Cameroon, Gabon, and Cote d'Ivoire have signed concession contracts with private firms, whereas the Gambia, Guinea-Bissau, and Togo have signed MSCs. Evidence shows that MSCs may be unsustainable or have long-term negative effects or exacerbate policy and sector deficiencies (Eberhard et al. 2011). Researchers warn that management contracts are not always successful and can be complex and contentious, but they can also yield benefits, such as improving revenue and reducing loss (Imam et al.). Further, MSCs have the freedom to make staffing and collection reforms that utility companies could not make without facing a public backlash. Not surprisingly, governments often view MSCs as undesirable but compulsory for donor investment (McCulloch et al. 2017). These findings should be considered when designing contracts because of the sensitive political nature of MSCs and the likelihood they will fail.

To increase the chances of successful utility turnaround, experts in corruption urge utility companies and their partners not to assume that reform activities or technical fixes will successfully mitigate corruption without culture change (U4 2012). Instead, utility managers should design anti-corruption plans with clear objectives and theories of change and appoint a senior officer to oversee activities. Stakeholders should map the drivers of corruption, the corrupt activities, and anti-corruption controls to ensure that all causes and sources of illegal activities are identified, solutions are designed, and mechanisms established to detect, adjudicate, and penalize these acts. Further, anti-corruption plans should contain compliance standards, codes, and procedures along with a plan for organizational adherence to include communication of standards, training, monitoring, and enforcement activities (Rimsaite 2019).

Finally, researchers warn that standard donor-funded reform in the power sector has often failed because donors did not adequately take into account the circumstances of the country, they focused on the end scenario (in this case a functional and competitive power market) without focusing on the steps to get there, and they failed to account for the "underlying political constraints facing decision makers" (McCulloch et al. 2017). McCulloch et al. also argue that reforms in the power sector are politically sensitive in all countries, because electricity is part of the country's economic development agenda. Based on lessons learned from their analysis, they recommend the following to increase the likelihood of successful power reform: Donors should (1) conduct and be certain to use political and economic assessments in the reform strategy so that activities are based on analyses, even if it requires a slower, more thoughtful disbursement of funds; (2) donors should be flexible and opportunistic such that if there are shifts in government, personnel, or circumstances, funding should shift from less effective to more effective activities; (3) donors should operate as a donor collaborative if leverage is needed to make change; and (4) successful reform requires "dialogue, trust, and personal relationships with key decision makers" which form over time through repeated interactions.

D. Grid-level outcomes

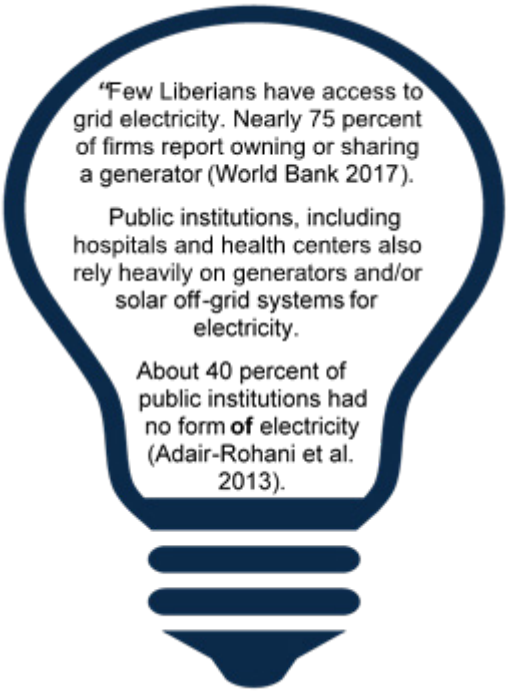
There are few studies that measure the contributions of investments in generation and sector reform activities to increased electricity reliability, reduced outages, and improved voltage stability. In Rwanda, a $44 million World Bank-funded project increased generation capacity from 41 MW to 75 MW in six years through construction of a new thermal power plant (World Bank IEG 2012; World Bank 2010). The intervention successfully reduced load shedding (planned outages) by 50 percent during peak hours at the start of the project to zero load shedding at its end. In Mali, the World Bank successfully increased generation capacity at the Manantali dam and reportedly eliminated all load shedding in the affected region (World Bank 2006). However, in Uganda, the installation of additional generation capacity at Lake Victoria was only partially completed due to low water levels, and the installed capacity remained underutilized at the time of the evaluation (World Bank 2008).

There have been successful generation projects from Rwanda, Mali, Senegal, Mauritania, and Uganda, but none of these countries began implementation with levels of connectivity as low as they are in Liberia. Even in these more developed countries, a World Bank study revealed that many of these projects encountered implementation challenges including cost overruns, project delays, and not enough human resource capacity to build and repair the infrastructure (World Bank 2006; World Bank 2008).

We did not find literature on lessons learned from investments in generation and T&D in an urban setting in a post-conflict country with exceedingly low rates of connectivity. Nor did we find studies that assessed donor partner collaborations to implement T&D projects in Sub-Saharan Africa, yet there is a need for evidence that guides implementation and maximizes investment dollars and expected outcomes.

E. End-user outcomes

Next we review the literature on key end-user outcomes: customer connections, barriers to connecting, impacts of electricity connections, and improvements in the quality of electricity on residences (or households?) and businesses. Outcomes include time allocation, education, labor market participation and productivity, and spillover effects.



1. End user connections

a. Barriers to connecting

Liberia ranks behind most of the world (175th of 187 countries) in the World Bank's Getting Electricity index, which measures the ease, time, and cost of connecting; reliability of supply; and transparency of the tariff (World Bank 2019). The per-kilowatt cost of energy from generators is about 10 times higher than the tariff for grid electricity, at $3.96/kWh (World

Bank 2011) Although there are extensive donor-funded plans to extend LEC's grid infrastructure (see Section VI.A.3.f) customers must have access to electricity poles and wires and the resources to connect; apply for a connection, and hire an electrician to wire their home or office to the pole. As LEC and donors work to extend electricity lines throughout Greater Monrovia, demand for and consumption of electricity are expected to increase. However, households, businesses, and public institutions face barriers to connecting to electricity, such as long wait times, high connection costs, limited capacity of the energy utility, and insufficient information on connecting.

b. Connection wait times and administrative processes

The World Bank (WB) estimates that it takes 482 days for a new business in Liberia to obtain an electricity connection, about four times the regional average of 115 days (World Bank 2017b). LEC's inability to process applications and connect new customers is a consequence of shortages in meters, parts, and utility trucks, as well as the fact that the T&D infrastructure is overloaded. LEC maintains a backlog of applications from customers who have paid the connection fee yet are still waiting to be connected (Miller et al. 2018). This results in widespread frustration with the utility and is a driver of power theft (Wesee and Parley, 2020). Potential customers may also delay electrification because they do not understand application, billing, or procedures. In Ethiopia, 41 percent of households cited administrative issues as the primary reason for not connecting to the grid (Bernard and Torero 2009). In Tanzania, Miller et al. (2015) found that households did not understood the connection process or timeline and had not made plans to pay for wiring or connection fees.

c. Connection rates and fees

Customer connection rates vary across Africa, with several studies finding rapid connections in the first years following electrification and a gradual slowing over time (Barron and Torero 2016; World Bank 2008; Lenz et al. 2017). In rural Kenya, only 10 percent of eligible households connected five years after a community installed a transformer, which study authors attribute to a high connection fee (Lee et al. 2016). Findings from Tanzania reveal similarly low connection rates (Chaplin et al. 2017; Winther 2007). In rural villages in Ghana, Peters et al. (2011) found that only 34 percent of small-scale manufacturing businesses had grid connections seven years after village electrification, whereas more than 80 percent of service sector businesses had connected. Connection fees can be prohibitively expensive, even though monthly electricity costs are lower than the price of fuel and maintenance of generators (World Bank 2011). Households pay connection fees ranging from $30 (in Ghana) to about $150 (in Benin, Cote d'Ivoire, and Uganda) to $300 or higher (in Kenya and Tanzania) (Golumbeanu and Barnes 2013). Much of this evidence focuses on rural areas, but urban households in Liberia could have different barriers and facilitators to connecting, particularly given that LEC abolished connection fees in 2017 (Front Page Africa 2017). In fact, households face significant upfront costs to wire their dwellings, which can impose a substantial burden on poor households when compared with the low cost of batteries, candles, and kerosene that can be purchased on an as-needed basis (Phelps and Crabtree 2013). Additionally, informal bribes or requests for payments from utility workers can slow connection rates for customers who cannot afford the additional charge.

d. Electricity consumption

In low-income countries, average annual electricity consumption among electrified households is 317 kWh per capita per year, indicating that electricity is used for limited purposes. Rural households use electricity primarily for lighting (World Bank 2008; Energy Sector Management Assistance Program 2002; Bernard and Torero 2009; Lenz et al. 2017). Households may also purchase televisions, but in the short term, they rarely rely on electricity for cooking or productive uses (Barron and Torero 2016; Bernard 2012; Bernard and Torero 2009; Lenz et al. 2017; Chaplin et al. 2017). Urban households are more likely to own electric appliances than their rural counterparts are, and they rely less heavily on biofuels, but they still have relatively low levels of electricity consumption (International Energy Agency (IEA) 2014).

2. Household impacts

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

There is not a clear consensus on how electricity impacts adults' use of their time. Bernard and Torero (2015) report no impacts on time allocation for women in rural Ethiopia and El Salvador, whereas men shifted work time from farms to other work. However, multiple studies found that electricity can lead to increased employment for women, but not for men (Khandker et al. 2012b; Grogan and Sadanand 2013; Dinkelman 2011). Two studies showed that adults with electricity spent less time collecting fuel (Grogran and Sadanand 2013; Khandker et al. 2012b; Chaplin et al. 2017), and several others found that adults in connected households were no more likely to have income-generating activities than unserved households were (Bernard and Torero 2009; Wamukonya and Davis 2001; Lenz et al. 2017). A study in India revealed that electrification increased household per capita income and expenditures, with greater impacts among the wealthier households. Other studies have similarly found statistically significant impacts of grid electricity on income and expenditures (Chakravorty et al. 2014; Khandker et al. 2012a; Khandker et al. 2013).

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

a. Impacts on businesses

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

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

Impacts on newly connected businesses. A study conducted in Rwanda suggested that businesses might benefit from access to electricity because there would be (1) customers attracted by more entertainment options; (2) longer business hours and improved safety from electric lighting; (3) higher quality and newer products and financial savings from electrical equipment; and (4) time savings from improved lighting, equipment, and communication. Qualitative findings indicated that electrification impacts were greater where there was a strong business environment, and that some sectors were more likely to connect and benefit than others (Lenz et al. 2017).

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

b. Impacts on public institutions

Descriptive and qualitative studies provide valuable, nuanced information about how public institutions can benefit from electrification. First, electricity enabled schools and health centers in Kenya and Tanzania and schools in Rwanda to stay open longer (World Bank 2008; Miller et al. 2015; Lenz et al. 2017). Electricity also enables institutions to use modern equipment. In Rwanda, a survey of rural health centers found that 100 percent of connected centers used electricity for lighting, 79 percent used it for medical machinery, and 43 percent used it for administrative purposes (Lenz et al. 2017). However, findings from a statistical analysis revealed no differences in appliance ownership based on health center connectivity, suggesting that unconnected centers may be operating equipment with alternative energy sources. Headmasters in Rwanda reported that electricity improved the overall functioning of the school by facilitating computer usage, and improved instruction by powering computer labs (Lenz et al. 2017). Other benefits include enhanced ability to recruit skilled staff, lower energy expenditures, and better safety and security (Miller 2015; Lenz et al. 2017).

c. Spillover effects

Household electrification can have spillover effects in the surrounding community. Several studies in Africa have shown that household electrification improved perceptions of safety

(Chaplin et al. 2017; Bensch et al. 2013; Miller et al. 2015). In Rwanda, Lenz et al. (2017) found that households in connected communities reduced their use of traditional lighting sources and their spending on batteries and kerosene. In India, there were economic spillovers from electrification such that the rate of growth in annual consumption by unconnected households increased by 0.8 percentage points because of residing in an electrified village (Van de Walle et al. 2015). In Rwanda, unconnected households benefitted from their neighbors' electricity through reduced expenditures on mobile phone charging (Lenz et al. 2017).

F. Evidence gaps that the current evaluation fills

Given the thin literature base on energy sector investments and reforms in African and post-conflict countries, the forthcoming evaluations will help fill evidence gaps on interventions in countries that start with extremely limited infrastructure, intense energy poverty and minimal connectivity, poor technical capacity, and a nascent regulatory framework. The evaluations begin to answer questions about priority implementation, performance, and impact at the levels of the energy sector, the utility, the grid, and the end user, particularly in poor, postwar urban and peri-urban locations. Combined, the evaluations will generate valuable evidence and information that are not available through any other source.

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III. EVALUATION DESIGN AND DATA SOURCES

A. Compact activities and evaluation questions

The evaluation designs aimed to examine MCC's and MCA-L's priority evaluation questions on investments in the MCHPP and Activity 2: Capacity Building and Sector Reform. The Compact activities are presented in Table III.1.

Table III.1. Compact activities and evaluation questions by level of outcomes

Activity 1	Activity 2
MCHPP and supporting infrastructure for generation, transmission, distribution, and connections • Rehabilitation of Mt. Coffee Hydropower Plant (MCHPP; MCC's investment) • Repair of substations, transformers, and other transmission and distribution infrastructure (limited support from MCC, additional investments from other donors)	Capacity building and sector reform • Build capacity of Liberia Electricity Company (LEC) through the Management Services Contract (MSC) Electricity Supply Board International • Establishment of Liberia Electricity Regulatory Commission (LERC) • *Limited c*apacity strengthening of Ministry of Mines and Energy (MME)

B. Evaluation studies

We designed evaluation studies with mixed methods approaches (listed in Table III.2) to examine the evaluation questions and provide nuanced information at each outcome level. The comprehensive study designs use rigorous approaches to sampling, data collection, and analysis. In this report, we provide a status update on implementation, energy sector, utility, and grid outcomes. For end user outcomes, we present a retrospective review of outcomes that occurred before data collection, establish a baseline before new outcomes unfold, and follow outcomes and processes in the future. As we examined each evaluation question, we analyzed all data and validated findings across outcome levels so findings could be supported by multiple data sources. The quantitative data sources captured outcomes at the level of communities, households, and businesses, and utility and grid-level outcomes. The qualitative data sources allowed us to examine processes and perceptions from a range of stakeholders and vantage points and to understand the mechanisms underpinning changes influenced by electricity access and energy sector investments. We implemented a collaborative approach to tool development, systematic data collection, and quality control throughout. Namely, we sought input and feedback from MCC and MCA-L throughout the process of designing the study and developing the tools. Then, with local partners, we collected and analyzed data, implementing extensive quality assurance procedures along the way. Table III.3 summarizes data sources, outcomes, methods of collection and analysis, and exposure period estimates for each study approach.

Table III.2. Compact activities and evaluation questions by level of outcomes

Outcome level	Evaluation questions	Evaluation approach
Overarching implementation	1. Were the program logic and Compact designed appropriately for the Liberian context? Were the underlying assumptions appropriate for the context (given the political economy and macroeconomic context)? 2. Were the contract vehicles designed to achieve Compact goals? 3. Were contracts implemented as planned, and what was the quality of implementation? 4. What lessons can be drawn from implementation of the activities? 5. 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? ^	• Performance evaluation: Implementation evaluation with longitudinal analysis of administrative data, document review, qualitative interviews, and site visits • Economic rate of return (ERR): Recomputation using administrative data and a document review
Energy sector	1. 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? 2. 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 independent power producers' operations? [a, ^] 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? (moved from grid level) ^	• Performance evaluation with longitudinal analysis of administrative data, document review, quantitative surveys of end users, qualitative interviews, and site visits
Utility outcomes	1. How has the electricity tariff changed since MCHPP was rehabilitated? To what extent does it cover the costs of generating electricity and other operating costs? 2. To what extent has LEC's management improved since the new management contract became effective? What progress has the Government of Liberia made toward establishing a longer-term management arrangement for LEC? 3. How sustainable is LEC as a utility? What are the biggest barriers to its sustainability?	• Performance evaluation with longitudinal analysis of administrative data, document review, quantitative surveys of end users, qualitative interviews, and site visits
Grid outcomes	1. To what extent have MCHPP rehabilitation and Capacity Building and Sector Reform (MCC's investments) affected Liberia's electricity generation, T&D, and in turn, reliability of the electricity supply, planned and unplanned outages, and voltage stability?	• Performance evaluation with longitudinal analysis of administrative data, document review, quantitative surveys of end users, qualitative interviews, and site visits

Outcome level	Evaluation questions	Evaluation approach
End user outcomes	1. 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? 2. How do LEC customers change behavior such as investing in appliances and use of time? 3. What are the other effects of electricity on connected end users, and what are the spillover effects on non-electrified households? 4. 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? 5. How have MCC's investments affected connected and unconnected households' perceptions of the quality of electricity? 6. How do the above outcomes vary by differences in gender, socioeconomic status, and other demographic characteristics?	• Performance evaluation with longitudinal analysis of administrative data, document review, qualitative interviews, and site visits • Performance evaluation using quantitative pre-post surveys with five samples: - Connected households in Monrovia - Connected small businesses in Monrovia - Unconnected households along the Kakata Corridor - Unconnected small businesses along the Kakata Corridor - Medium and large end users

[a] Throughout the report, the figure of 88MW of MCHPP generation capacity refers to the design specification rather than the maximum instantaneous generation capacity.

^ indicates that this question will be answered in subsequent reports.

C. Study timeline

We present the study timeline in Table III.3. The design and the timeline for data collection—along with ongoing document and administrative data reviews, monitoring the Liberia energy sector, and conducting key informant interviews (KIIs) and site visits as required—allow us to answer each of the study's evaluation questions. We still propose three rounds of data collection—at baseline in 2018–2019, interim in 2020–2021, and endline in 2023–2024—to form a panel that will enable us to collect information on households, small businesses, and medium and large end users, and to measure changes in a broad range of outcomes such as energy demand and consumption, time use, and economic well-being. We will also conduct repeated rounds of qualitative data collection on the same schedule.

The baseline survey data collection in connected communities and among medium and large end users provides retrospective data from 2016 and more current data in 2018. The survey data in unconnected communities provide a clean baseline in 2018, before end users accessed LEC electricity, and two subsequent data points to measure changes over time.

The interim and endline data collection—in which we return to the same respondents, businesses, and organizations—provides the best opportunity to answer the evaluation questions about end user outcomes and the processes by which change occurs. We expect the Capacity Building and Sector Reform Activity to affect connections, reliability and quality, customer satisfaction, and end users' productivity, economic situation, health and safety, and quality of life. We will have more confidence and better insight into endline results by following the patterns that emerge at midline. We also plan to obtain administrative data from LEC and will validate findings across data sets. The interim round will give us the best chance of following

households over time as we return to communities and contact respondents. Given the Liberian context, we are concerned about only returning to respondents in 2023 without tracking the changing context, in- and out-migration, and likely increased concentration of the population in this urban setting. (See Appendix C for notes on administrative data, the document review, quantitative and qualitative sampling, instrument development, data collection and analysis, plans for future data collection, and risks to internal and external validity.)

Table III.3. Study timeline

Name of round	Data collection	Data cleaning & analysis	First draft report expected	Final draft report expected
Baseline quantitative and qualitative	December 2018–September 2019	March 2019–January 2020	January 2020	March 2020
Interim	November 2020–June 2021	January–July 2021	August 2021	October 2021
Endline	November 2023–June 2024	January–July 2024	August 2024	January 2025

Note: The timeline is designed to maximize observation of outcomes for the largest number of end users. Note that end users are connected on a rolling basis. The exposure time for outcomes may range from months to years.

D. Structure and organization of report

In the upcoming chapters, we present the study findings for each level of inquiry: implementation, energy sector, utility, grid, and end user. For each level, we present the guiding evaluation questions, the concepts and outcomes we assessed, and the data sources we used, as summarized in Table III.4. We present interim findings for activities that have been underway for several years and for households and businesses that have been connected to electricity for years. We also present baseline findings for a study of households of businesses that have not yet connected to the grid.

Table III.4. Data sources, outcomes investigated, and exposure period estimates

Data sources; notes on collection and analysis	Outcomes investigated	Exposure period estimates at each outcome level
Administrative data (monthly data from LEC and MCHPP); We began tracking utility outcomes in 2018, with retrospective data as available for 2015–2017. We will continue assessing these data post-Compact.	• **Implementation:** Whether functional data systems were built and utilized by LEC and MCHPP staff to track electricity generation, T&D, collections, service quality, tariffs, and operations • **Energy sector:** Installed generation capacity; percentage of households covered by LEC; unserved demand; tariffs across user types; number, size, and type of IPPs • **Utility:** Indicators of LEC management and operations, including losses; billing and collection efficiency; generation costs; operating expenses (OPEX) per kWh; electricity supply—sold and peak demand; demand by customer type; total electricity sold by customer type, USD and MWh; typical load factor adequacy of supply with available power • **Grid:** Installed generation capacity (by source); power plant availability; MCHPP capacity factor; transmission substation capacity; kilometers of T&D lines upgraded or built; voltage stability and reliability (SAIDI, SAIFI); planned and unplanned outages • **End user:** Number of connections by customer type; number of households in LEC service area connected; customer satisfaction; unserved demand	• **Implementation**: Varies by entity; MCHPP generates electricity following construction completion; MSC make require years for measurable changes in operations; LERC may require five to ten years and greater energy production to influence changes in the market structure • **Energy sector**: LERC: 24 months to draft laws, policies, and regulations: 36 to 80 months for effects on market structure (from LERC and greater energy production); note that new generation (including CLSG line) and T&D construction will increase urgency of sector modernization • **Utility outcomes**: Given state of LEC, make take 3 to 5 years (or more) for MSC to begin to turn utility company around and affect key performance indicators. • **Grid outcomes**: Given donor delays, infrastructure overload and LEC's lack of resources, may take 36 to 60 months from infrastructure investment for sustained improvements in reliability and quality. Changes may emerge continuously given ongoing investments.

Data sources; notes on collection and analysis	Outcomes investigated	Exposure period estimates at each outcome level
Document review: We regularly collected relevant documentation from stakeholders and agencies, including PIU, LEC, the MSC, CMC, MME, LERC, MCHPP, and donor partners • Work plans, timelines, and schedules • Progress, quarterly, annual, and M&E reports Contracts and commissioned studies • Legal, economic, and technical regulations, laws, and policies • News and media on Liberian energy sector The review began in 2017 and will continue post Compact.	• **Implementation:** Context and background to assess quality of design, implementation, successes and challenges, progress and delays, budgets • **Energy sector:** Documentation of new or revised laws, policies, regulations; LERC activities; identification of modernization processes affecting market structure, sector governance, and performance • **Utility:** Documentation of the MSC's efforts to strengthen LEC's capacity; LEC functionality; CMC's documentation of LEC's strengths, weaknesses, opportunities, and threats; LEC's ability to manage all assets, make new connections • **Grid:** Documentation of grid and infrastructure rehabilitation, installation, maintenance, functionality, and future plans.	
Qualitative KII and IDI interviews • MCHPP and PIU • MME and LERC • LEC, MSC, and CMC • MCA, EIB, EU, KfW, NORAD, USAID, and the World Bank • Energy industry and IPPs • Small businesses and public sector • Local government **Focus group discussions (FGDs)**	• **Implementation:** Perceptions of compact design and execution for each activity; whether MCHPP, LEC, LERC, and MME have established systems to carry out core functions; and perceptions of donor coordination and multiple donor model • **Energy sector outcomes:** Perceptions of LERC's independence and accountability; how energy policies, laws, and regulations affect energy sector functionality; energy sector progress and constraints; IPP's perception of sector and how changes in electricity availability and LERC activities have affected sales; perceptions of sectors' greatest threats and challenges • **Utility outcomes:** Perceptions of LEC's functionality, capacity, sustainability, management, and operations; perceptions of	• **End-user outcomes:** From when customers are connected: 12 to 36 months for energy consumption changes; 12 to 36 months for energy behavior changes; 24–48 months for income changes; 24–60 months for appliance purchases or usage changes 12–24 months for community-level changes in markets, safety, the number of households, or household migration; 12–48 months for changes in production, sales, operating hours, the number of employees, and other outcomes for small, medium, or large businesses

Data sources; notes on collection and analysis	Outcomes investigated	Exposure period estimates at each outcome level
• Households (n = 10 FGDs (4 male, 4 female, 2 mixed (8–10 participants per FGD) **Site visits** • MCHPP and substations • LEC and LERC, T&D infrastructure	LEC's management of assets, finances, human resources, and data; perceptions of MSC as best approach to stabilize and grow LEC • **Grid outcomes:** Perceptions of how increased generation and sector reform contributed (facilitated or inhibited) grid reliability and voltage stability for a reduction in outages (SAIDI, SAIFI); perceptions of grid performance, T&D; contribution and SWOT analysis of capacity and sector reform activities • **End-user outcomes (all):** Energy use, connection decisions, costs, process; electricity quality, reliability, and affordability; time use; spillover effects • **Households:** Barriers to connection; energy theft; changes in energy consumption; appliance purchases; impacts on health, safety, and education • **Small businesses:** Changes in business or services; purchase of equipment; revenue, profits, staff size	
Quantitative surveys • **Connected**: pre-post design with community profile, households and small businesses • **Unconnected**: pre-post design with community profile, households and small businesses • **Pre-post design with medium and large end users** Collected retrospective and prospective data	• **End-user outcomes (all):** Background characteristics; sources and amount of energy used; energy expenditures; connection experience, perceptions of LEC • **Communities:** Community composition; energy use; electricity access • **Households:** energy theft; adults' and children's time use; education; health and safety; income, employment • **Small, medium, and large businesses and agencies:** number of employees; electricity and other energy costs; spending on generators and surge protectors; revenue; service provision	

CLSG = Cote d'Ivoire, Liberia, Sierra Leone, and Guinea; EIB = European Investment Bank; CMC = contract monitoring consultant; IDI = in-depth interview; IPP = independent power producer; LEC = Liberia Electricity Corporation: LERC = Liberia Electricity Regulation Commission MCA-Liberia = Millennium Challenge Account; MCC = Millennium Challenge Corporation; MCHPP = Mt. Coffee Hydropower Plant; NORAD = Norwegian Development Corporation; PIU = Project Implementation Unit; T&D = transmission and distribution; SAIDI = system average interruption duration index; SAIFI = system average interruption frequency index

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IV. ANALYSIS OF IMPLEMENTATION

We begin this section by describing MCHPP Rehabilitation (Activity 1) and Capacity Building and Sector Reform (Activity 2) to provide context for the investment and set the stage for implementation findings. First, we present timelines to illustrate the situation prior to MCC investments and then provide some of the implementation outcomes set in the appropriate context (Figures IV.1, IV.2, and IV.3). We introduce the organizations and agencies involved in implementing the main components of these activities. Next, we analyze MCC's project logic model as it relates to investments in MCHPP, LEC, LERC, and MME. We first assess the explicit model assumptions, noting each assumption's current status. Then we identify and list implicit macro-assumptions that underpin the theory of change, along with a description of the current status of the matters that were assumed. Next, we explore the Compact design for the energy investments (given the Liberian context), whether the contract vehicles were designed to achieve the goals of the Compact, and whether contracts were fully implemented.[4] Finally, we describe implementation quality and draw lessons from the baseline period. A main finding in this section is that extreme challenges in the Liberian context—which were not adequately accounted for in the program logic, Compact, and contracts—present obstacles to implementation.

A. Evaluation questions and background

This baseline and interim report answers the following evaluation questions:[5]

- Were the program logic and Compact designed appropriately for the Liberian context? Were the underlying assumptions appropriate for the context (given the political economy and macroeconomic context)?
- Were the contract vehicles designed to achieve Compact goals?
- Were Contracts implemented as planned, and what was the quality of implementation?
- What lessons can be drawn from implementation of the activities?

[4] MCC asked us to assess the appropriateness of the Compact given the Liberian context, determine whether the contract vehicles were designed to achieve Compact goals, and analyze whether Contracts were fully implemented.

[5] We will address the following question in the interim and endline report: To what extent, if any, does comparing the assumptions made in the forecasted economic model with actual program implementation and evaluation findings generate lessons that can be applied to future economic models?

Figure IV.1. MCHPP timeline of events

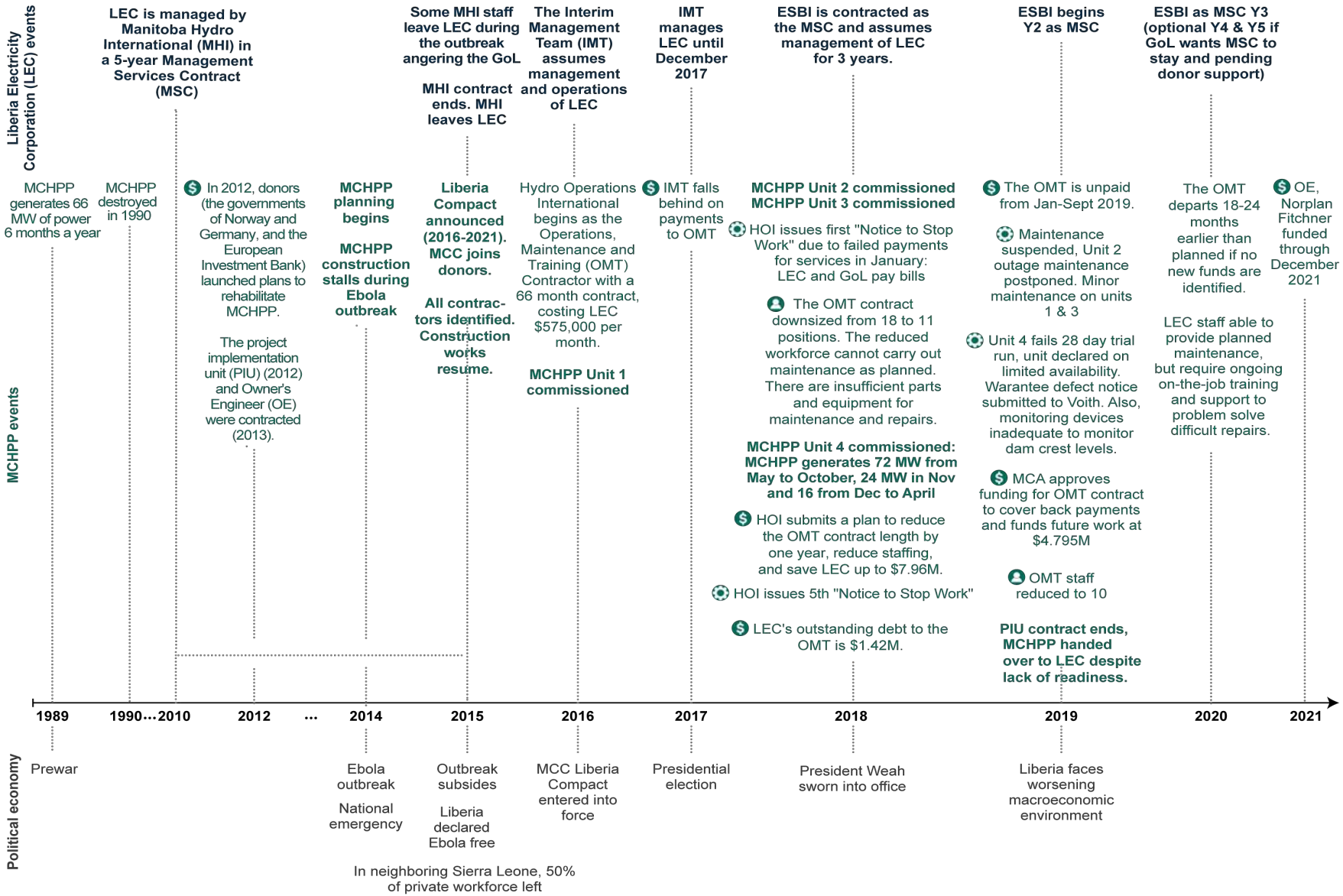


Figure IV.2. LEC timeline of events

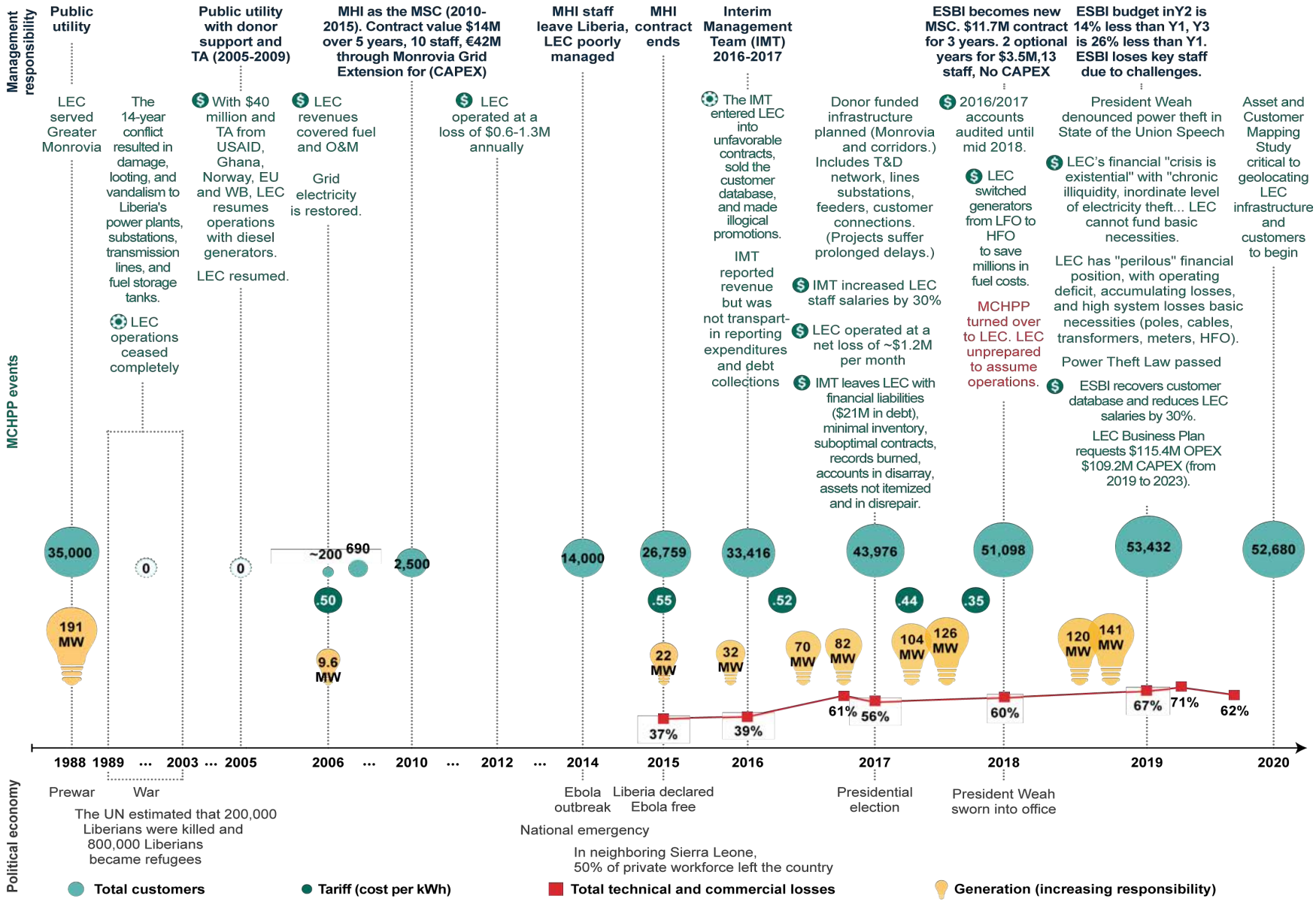
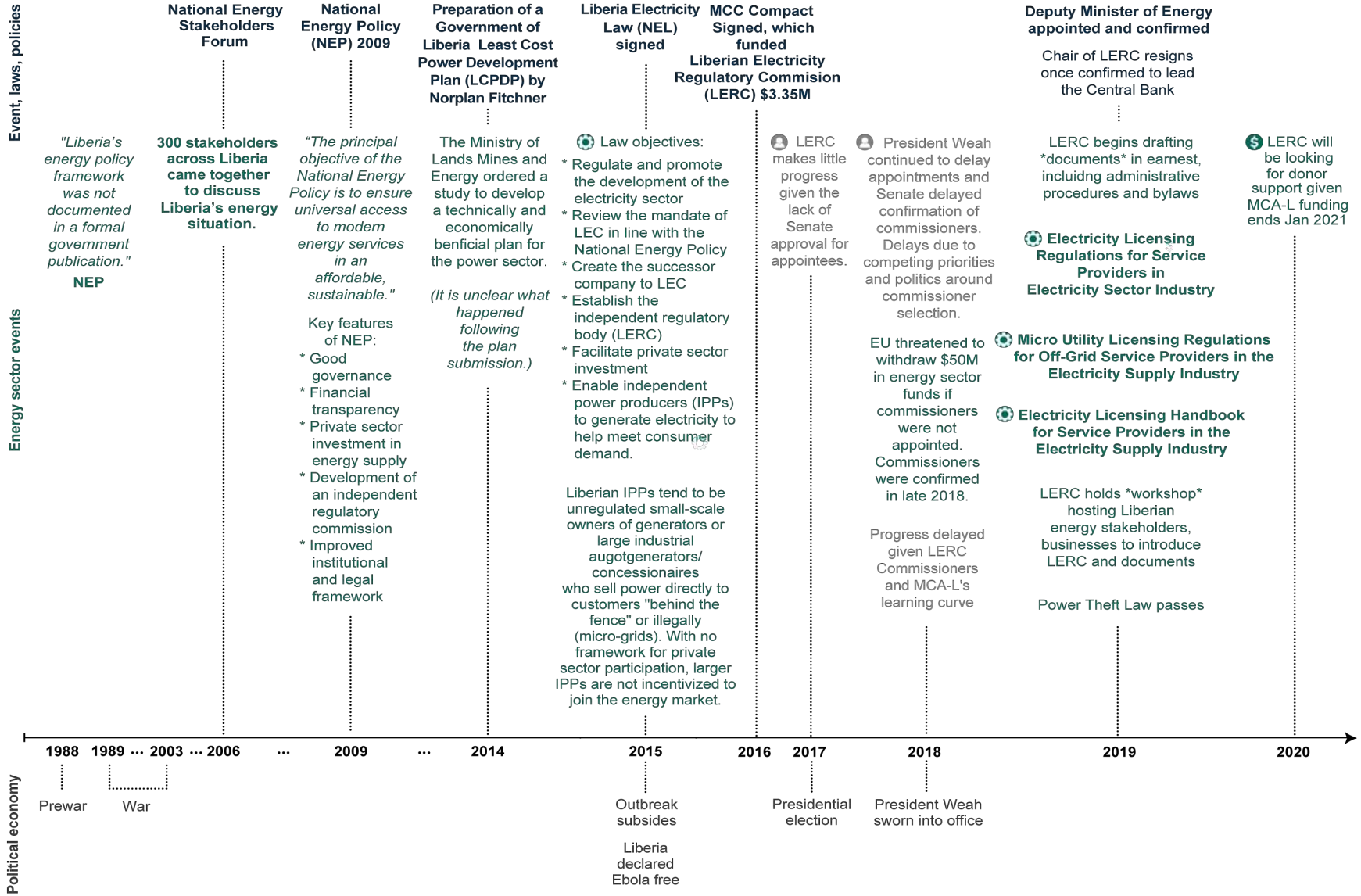
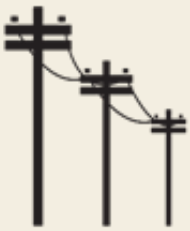


Figure IV.3. Energy sector timeline of events





Data sources for the implementation analysis

- Document review to provide context and assess design, implementation, and progress of activities
- Administrative data, including indicators demonstrating the status of implementation progress, quality, and outcomes
- Qualitative data, including interviews with key actors from MCC, MCA, the contract monitoring consultant, Electricity Supply Board International, LEC board and staff, MCHPP, LERC, and MME; and site visits to MCHPP, LEC at Waterside, Bushrod Power Plant, and all LEC substations
- Household and business survey data, interviews, and focus groups to assess connectivity, LEC service, and customer perceptions of implementation

B. Status of implementation

1. Background on activities

For Activity 1, we describe the process, important events, and the major stakeholders involved with MCHPP rehabilitation. Within Activity 2, for the subtask on strengthening capacity at LEC, we describe the utility company's recent management, the current management services contractor (Electricity Supply Board International, or ESBI) and the contract monitoring consultant (CMC) (Azorom) which oversees the management services contractor. For the LERC subtask, we first situate the regulatory agency within the Liberian energy sector laws and policies, and then describe the reasons for extensive delays in launching LERC. Finally, we describe the status of the Liberian Ministry of Energy and Mines and why there have been minimal ministry-level investments to date.

2. Activity 1: Rehabilitation of MCHPP

The MCHPP rehabilitation project began in 2011, well before the Compact, with financial commitments from NORAD, EIB, KfW, and the GoL. The estimated cost for the three-year (fast-tracked) project was $218.5 million. Implementation began in 2012 when Manitoba Hydro International (MHI) was contracted as the project implementation unit (PIU) and tasked with managing MCHPP rehabilitation on behalf of the GoL and donor partners. The PIU had responsibility for ensuring the project was technically sound and completed on time and within budget, for managing all administrative, financial, legal and environmental matters, and for overseeing all contractors and suppliers (PIU contract with MHI, 2015).

MCHPP rehabilitation was chronically over budget and behind schedule due to uncertainty about hydrology, unforeseen construction challenges, ongoing project optimization as new information became available, procurement delays caused by vendor proposals with

Implementing the Liberia Compact

Grave challenges

Throughout Greater Monrovia, connecting end users to reliable electricity proved to be a more formidable task than stakeholders envisioned. Many factors were responsible for this.

Reforming LEC—Liberia's utility company—has been hindered by Liberia's post-conflict, post-Ebola culture; the loss of a generation of energy sector skills and experience; a worsening financial crisis and unfavorable macroeconomic outlook; a newly elected government with limited expertise; unforeseen and growing utility sector debt; widespread corruption throughout LEC; and the poorly maintained T&D infrastructure that requires costly materials and equipment and skilled staff.

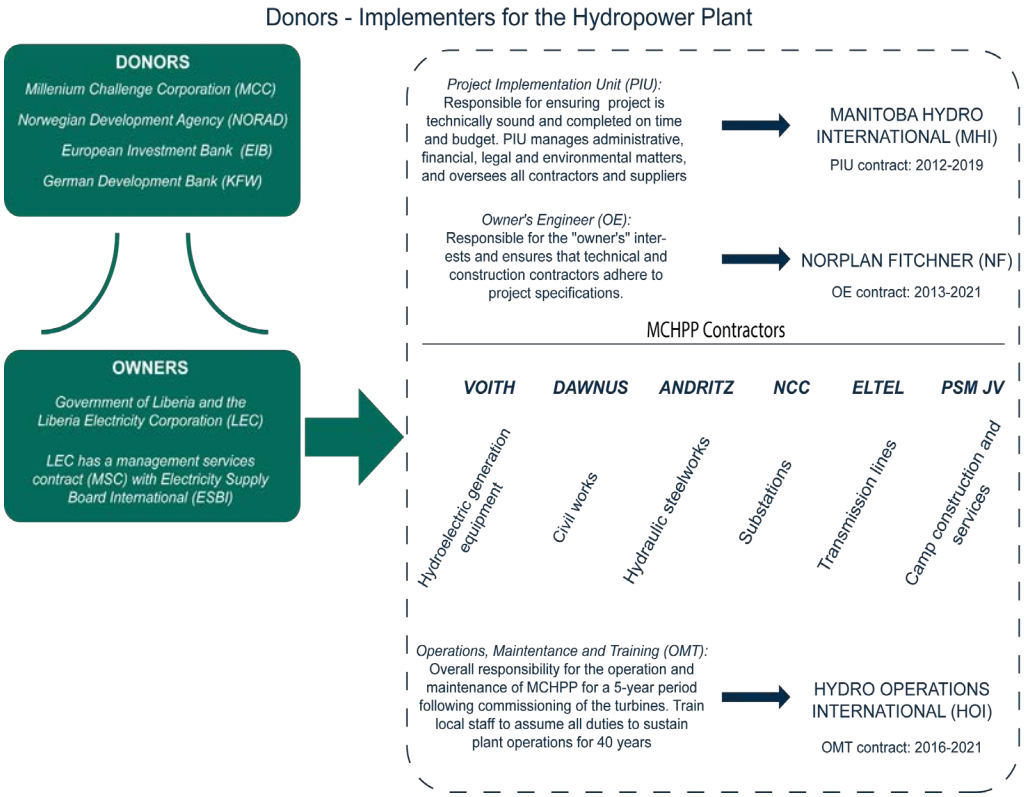
Further, extensive delays have undermined efforts to rehabilitate T&D assets and construct new poles and lines to bring on new customers. The utility struggles to manage the existing customer base and reduce the widespread and growing energy theft that is partly facilitated by utility employees.

Yet, there are clear indications of progress within LEC, LERC, and the energy sector.

overpriced parts, poor roads, resettlement activities, and exchange rate fluctuations. (The reasons for budget shortfalls are documented in PIU monthly reports dating back to 2014.) Progress halted when, in mid-2014, the EVD crisis emerged. On-site work at MCHPP was suspended, and non-essential contractors left Liberia (HOI, MCHPP quarterly reports, 2014). Once the Ebola outbreak was contained by May 2015, the overall cost of doing business had increased, with higher import costs and a persistent post-EBV stigma and a perception among contractors that working in Liberia carried elevated health risks.

MCC—responding to pressure to invest quickly in Liberia and recognizing the GoL's inability to cover budget shortfalls—joined a crowded field of donors to finish rehabilitating MCHPP. MCC began pooling funds with NORAD, KfW, and EIB and committed US$146 million to MCHPP to meet the full cost of rehabilitation ($357 million). Given that the project plans were fully prepared and contractors already identified, construction resumed in April 2015 with all eight contractors (the Owner's Engineer and separate contractors for hydroelectric equipment, civil works, hydraulics, substations, transmission lines, camp construction and catering, and the emergency spillway) mobilized by September 2015.[6] Once the plant was rehabilitated, the first turbine was commissioned (or handed over for operation) in November 2016, and the fourth and final turbine was commissioned and fully functional in September 2018.

In August 2016, Hydro Operations International (HOI) was engaged as the operations maintenance and training (OMT) contractor and tasked with overall responsibility for the operation and maintenance of MCHPP for a five-year period following commissioning of the turbines. With only a couple of years of hydropower operations in the past two decades, there is virtually no technical expertise and knowledge being passed between Liberian workers. Therefore, the OMT contractor is considered critical to ensuring overall plant operations and sustainability.



[6] The Owner's Engineer ensures that technical and construction contractors adhere to project specifications.

In Section B.3., we document lessons learned from the MCHPP activity and related contracts and note threats to MCHPP's functionality and sustainability as the PIU has ended, and LEC takes responsibility for management of MCHPP, Liberia's most valuable electricity asset.

3. Activity 2 sub-task: LEC and Electricity Supply Board International

In 2016, GoL conducted a study to identify the best management option for LEC as a condition of the Compact, Liberia's utility company, and decided a second management services contractor (MSC) was needed, with a concession being the long-term goal of the government. Subsequently, with MCC funding, LEC contracted with Electricity Supply Board International (ESBI) in January 2018 and ESBI assumed all responsibility for LEC's operations (GoL 2017). ESBI—an Ireland-based firm—initially partnered with MHI (the PIU and the previous management services contractor at LEC from 2010 to 2015) to bid on the project given MHI's familiarity with and experience at LEC. However, the GoL refused to contract with MHI because of its dissatisfaction with MHI's performance as the management services contractor, particularly during the Ebola crisis when staff reportedly left Liberia.

Ultimately, ESBI, without a partner, was selected from a competitive pool with three bidders, each of which met the technical specifications. The three-year contract between GoL/LEC and ESBI, with support from MCC, commenced January 8, 2018. The contract has an additional two-year option period (2021–2022) should the GoL want to extend and should it be able to secure resources to cover the costs. As the management services contractor, ESBI assumed all LEC's business and operations with the goal of transforming the utility. The MSC was built with performance targets and payments, including bonuses and penalties developed to incentivize achieving the following objectives:

- Turning LEC into an operationally efficient and financially viable utility
- Increasing staff capabilities
- Improving electricity quality and reliability and customer service
- Increasing the customer base

MCC determined that a contract monitoring consultant (CMC) was needed to assist the LEC board to carry out its oversight responsibilities. The CMC assists both the LEC board and MCA-L in compact oversight. Azorom, another Ireland-based firm, was contracted by MCA-L in August of 2017 to fill this role. The CMC is responsible for evaluating ESBI's performance, reviewing all deliverables, assessing LEC's progress toward addressing concerns, and advising MCA-L on all matters.

In Section B.3, we describe how key informants from across MCC, MCA, the CMC, the donor community, and ESBI reported that they underestimated LEC's operations and functionality, which proved to be extremely limited, and did not fully appreciate how LEC, as a failed utility, would be recalcitrant to reform. Overall, respondents reported that inadequate knowledge of the true situation of LEC—including its dire financial state, the culture of corruption, and the decrepit, poorly maintained, and overloaded infrastructure and assets—meant that the MSC was not structured with adequate resources to cover operating and capital expenditures or equipped

with anticorruption mechanisms or tools to overcome these grave challenges in the first two years of implementation. For example, one respondent explained:

> We didn't anticipate that LEC wouldn't have resources to connect even if generation was fixed. Simple things were missing: wires, transformers, poles, etc. There was no operational capital. Revenue was far below expenses. MCC had to come in to provide these resources and management support. The Compact provided the flexibility for MCC to do this. Other donors also didn't anticipate this issue. The plan at Mt. Coffee was that for every kWh of electricity produced, an escrow account of 6 cents would be created to pay for the MSC. But with 60 percent losses, this couldn't work.

Further, although donors coordinated well to rehabilitate MCHPP, there has been limited coordination to facilitate the political will needed for utility reform.

4. Activity 2 sub-task: The Energy Sector and the Liberia Electricity Regulatory Commission (LERC)

The National Energy Policy of 2009 stipulated a restructuring of the MME and elevated the Deputy Minister of Energy (DME) and Department of Energy (DoE) in recognition that "Energy is an essential service that impacts all aspects of life." The policy articulates the priority goals:

> The principal objective of the National Energy Policy is to ensure universal access to modern energy services in an affordable, sustainable, and environmentally friendly manner in order to foster the economic, political, and social development of Liberia.

The DoE has responsibility for developing and reviewing energy policies, quality standards, and master plans; convening the National Energy Committee; and liaising with the (to-be-established) Energy Regulatory Board.

In 2015, the Liberia Energy Law established the legal framework for the energy regulator. In the Liberia Compact, establishing the independent regulatory board (LERC) builds on previous European Union (EU) efforts to develop the MME's sector capacity. LERC's objective is to create and maintain a stable regulatory environment that accelerates investment and helps achieve universal access to adequate, reliable and efficient electricity. As Liberia modernizes, the new LERC aims to develop the standards, codes, tariffs, licensing, and compliance needed to manage the competing interests of policymakers, the utility company, independent power providers, and consumers (Draft LERC Bylaws 2019). LERC's core functions include (Overview of LERC and Electricity 2019):

- Licensing operators in the sub-sector
- Approving tariffs and charges for the services provided
- Approving sector plans and operators' investments
- Establishment and monitoring of technical standards and codes
- Resolving service- (consumer) or license- (network and licensee) related disputes.

Progress on the LERC activity has been slow and beset by delays. First, MCA-L spent most of 2016 staffing its team, focusing on MCHPP rehabilitation tasks, and developing manuals and

administrative and human resource procedures. In fact, the director of energy at MCA-L was hired in December 2016, at the end of the first year of the Compact. Second, only a presidentially appointed board of three commissioners has regulatory approval and oversight authority. Confirmation of LERC board commissioners was delayed because of Liberia's 2017 presidential election. Previous President Sirleaf appointed commissioners who were not confirmed by the Senate given the imminent change of administration. Subsequently, newly elected President Weah delayed appointing—and the Senate delayed confirming—commissioners, partly due to competing priorities and politics around commissioner selection. Ultimately, following threats by the EU to withdraw $50 million in energy sector funds if commissioners were not appointed, President Weah finally appointed commissioners, who were confirmed in late 2018 (Sieh 2018). Third, LERC progress was delayed because both MCA-L and LERC commissioners admitted to a strong learning curve in establishing the commission. MCA-L staff came to the project without experience in establishing a regulatory board, and both MCA-L staff and commissioners described missteps along the way. Altogether, project set-up delays in 2016, appointment delays in 2017 and 2018, and a learning curve meant that the LERC earnestly began making progress in drafting documents only in 2019.

In Section B.3. we describe LERC's recent progress in setting up the regulatory commission and in the board's capacity to implement its core functions despite the many delays and roadblocks along the way.

5. Activity 2 sub-task: Ministry of Mines and Energy (MME) (*previously Ministry of Land, Mines, and Energy*)

Over the past three decades, Liberia's energy sector has lacked a strategy, policies, data, and information to guide decision making, and it also lacks modern skills and technical capacity (Liberia Energy Policy 2009). Although absent from the program logic model, the MCC Program Implementation Agreement between the MCC and the Ministry of Finance and Development Planning states that there will be modest investments in capacity strengthening within the MME. MCA-L aimed to bolster MME's ability to implement the National Energy Policy by strengthening capacity. MCA-L planned to cover training costs for DoE staff to conduct gender and social assessments to inform MME's social, gender, and environment planning and monitoring. However, the deputy minister position had remained vacant until November 2019, and consequently the DoE, without leadership and key staff, was inactive. As a result, there has been minimal progress in this effort.

In Section B.3. we briefly describe the limitations, including human resources and financial constraints, within the MME.

C. Findings: Were the project logic, Compact design, and contract vehicle appropriate, and what was the quality of implementation?

The Liberia Compact is MCC's first energy compact in a post-conflict country and includes sub-activities new to MCC's portfolio. As such, the Liberia Compact presented unprecedented

challenges. Therefore, the implementation analysis includes a comprehensive assessment of (1) the program logic and underpinning assumptions, (2) the poor macroeconomic context that the Compact must operate within, (3) the Compact design given the context, (4) whether the contracts were adequately designed to achieve Compact goals, and finally (5) the implementation quality and lessons learned.

1. **Were the program logic and Compact design appropriate for the Liberian context? Were the underlying assumptions appropriate for the context? Were the political economy and macroeconomic context adequately considered?**

We critically examined MCC's revised project logic (Appendix A) to assess whether the Compact was adequately designed given the realities of Liberia. This analysis highlighted weaknesses in the Compact design. First, we list the specific assumptions articulated in the program logic by outcome (see superscripts in each outcome in the logic model) and describe the current status of each outcome (Table IV.1). We aim to highlight areas where the causal mechanisms might not lead from inputs to the desired outcomes due to unforeseen circumstances or flaws in the causal chain.

Next, we articulated macro-level assumptions that were not articulated in the model yet underpin the project logic (Table IV.2). We include these assumptions because they are critical to understand when designing and implementing large-scale projects in a post-conflict, economically and politically fragile country. Here too, we describe the current status of the situation.

Table IV.1. Underlying assumptions identified in MCC's revised logic model

Assumptions (A1-15)	Assumption underlying the outcome	Status of outcome at baseline (2019)
A1: Increased lower cost generation	Bringing Mt. Coffee online will lower LEC's operating costs.	Generation increased, especially during rainy season, and the cost per kilowatt of MCHPP power is less than it is with thermal generation. However, LEC's operating costs have increased with additional staff, new connections to maintain, assets to manage (including MCHPP, CLSG is pending) and additional T&D infrastructure, requiring maintenance and repairs.
A2: Regulatory framework adopted	Planned technical support from other donor(s) will complement MCA-L's intervention. Studies funded under the Compact will inform the implementation of the regulatory framework, including tariff-setting and licensing operators.	Other donor activities, such as EU support to LERC, complement MCA-L's intervention. However, the EU consultant was not engaged due to delays in establishing LERC. Once established, LERC produced draft bylaws and licensing guidelines. However, without financial support post Compact, LERC's future sustainability is uncertain. LEC lacks resources to pay for LERC's "premium" staff. LERC is seeking donor support.
A3: Reduced tariffs, Decreased user costs	Cost savings from lower-cost generation will be passed on to consumers; tariffs will recover the utility's costs, which is critical for running a sustainable utility.	It has been infeasible for cost savings from cheaper generation to cover utility costs or reduce tariffs. Since 2012, LEC has chronically operated at a loss, with worsening financial indicators, and has not covered operating costs. During the interim management, tariffs dropped from $0.52 per kw in February 2017 to $0.43 in April 2017 and to $0.39 (with tax) in October 2017. As tariffs do not cover costs, most stakeholders warn against lowering tariffs without reducing theft, improving billability, and increasing the number of paying customers.
A4: Cost-reflective tariffs	The tariff-setting process will adhere to LERC's regulations as stipulated in Section 13.3 of the 2015 Electricity Law and will be insulated from political interference.	The tariffs are not cost-reflective given LEC's poor financial state. With inadequate collections and limited connections, current revenue cannot sustain LEC. A reduced tariff to $0.30 would cost $77 million over five years. The tariff must increase to cover costs, but it is politically infeasible.
A5: Sector operators licensed	LERC has the ability and resources to ensure compliance.	At baseline, draft licensing regulations have been shared with energy stakeholders. Licensing has not yet commenced. LERC's ongoing authority and resources remain unclear.
A4, A5: Improved quality and reliability	MCHPP will improve electricity quality and reliability.	MCHPP rehabilitation has led to improvements in electricity quality and reliability, but gains are modest due to major T&D failures.

Assumptions (A1-15)	Assumption underlying the outcome	Status of outcome at baseline (2019)
A6, A12, A18: Improved LEC operations	LEC has the capacity and resources to manage operations effectively and efficiently, including reducing losses, increasing collections, and performing routine maintenance; LERC standards are effective. Project outputs will result in improvement in customer services practices; LEC is willing and able to address customer complaints. Customer willingness to pay increases. The MSC effects long-term change in LEC operations, and stakeholders with interest and influence support these changes.	LEC (ESBI) has had severely constrained resources and limited operational improvements. Losses have increased, maintenance is ongoing but less than adequate, and it is slow due to shortages of equipment, materials, vehicles, parts, and because of the enormity of the needs across assets; Some improvements in customer service practices and responding to complaints. Willingness to pay is limited among large users. Modest improvements have been realized in communications; a new IMS data management system was built, but utilization is not yet optimal. Stakeholders support all positive improvements at LEC, but actual operations are far below expectations.
LEC training system	ESBI will have the capacity to implement training. Training of trainers' system is effective.	This activity has been delayed and reduced. Construction of a center was canceled. Senior Resource Pool training was delayed but is in progress.
A7, A17: Increased LEC capacity and productivity	There is sufficient staff capacity and continuity to accomplish MSC capacity-building objectives. Increased capacity is sustained after MSC ends.	Limited gains in LEC staff productivity. Mix of staff is questionable (CMC 2018). Cartels responsible for theft have flourished, and there are excessive non-technical losses.
A8, A9, A16: Increased electricity consumption	LEC increases ability to make customer connections. New customers can afford to pay for electricity; LEC can accommodate increased energy demand during dry season. Increased generation capacity and the planned T&D investments able to increase electricity quality and reliability. Customers pay for the electricity they consume.	LEC's ability to make connections is minimal despite excess generation capacity. T&D failures undermine new connections, quality, and reliability. Residential customers are willing to pay, though theft increased. LEC cannot cover fuel costs for thermal generation, so cannot accommodate increased demand during the dry season. Since MCHPP rehabilitation, there are modest increases in paying customers, but large increases in theft (commercial losses more than doubled, from 4.7 million MWh in May 2017 to 10.7 MWh in May 2019.)
A8, A10: Increased customer base	LEC has enough manpower, skill, materials, and operational capacity to respond to user requests for connections.	There has been an extremely modest increase in customers because LEC lacks capacity and resources for connections. LEC lacks meters and other materials. Donor connection projects have been delayed due to failed procurements, infrastructure limitations, and resettlement plans; Also, LEC's has still not reconciled the customer database.
A11: Increased private sector investment	A clear regulatory framework is a critical requirement for private-sector investment.	Regulatory framework is being developed. At baseline, private generation investments have not changed.
A12: Improved customer satisfaction	Better quality electricity would improve customer satisfaction.	There have been modest improvements in customer satisfaction.

Assumptions (A1-15)	Assumption underlying the outcome	Status of outcome at baseline (2019)
A13, A14: Improved plant facility	MSC works to attract donor funding. External actors will extend the transmission and distribution networks as planned. These extensions are critical to expanding LEC's consumer base. LEC will invest in lifecycle maintenance and capital investment.	In late 2019, the MSC began efforts to attract donor funding in a coordinated way. Prior requests had been piecemeal, without an overarching strategy; and some requests were repeated across donors. Donors intend to extend T&D lines, but without adequate master planning that recognizes infrastructure needs and weaknesses. LEC is currently unable to invest in lifecycle maintenance and capital.
A15: Potential outcomes increased investment, and improved health, education, safety outcomes	Electricity is used productively. Cost savings are invested, and other constraints such as access to finance or lack of political stability do not inhibit additional investments.	Qualitative data reveal some positive outcomes, including business development, income generating activities IGAs, and improved health and safety.
LEC has increased revenue and financial sustainability		LEC has not yet achieved these goals. Financial indicators have worsened.

See Appendix A. for the logic model

Table IV.2. Macro-assumptions underlying the Liberia Compact for the energy sector

Assumptions	Actual situation at baseline in 2019
Political and macro-economy	
The GoL would continue to improve performance indicators in MCC's scorecard, such as those in the areas of economic freedom, ruling justly, and investing in people.	Liberia did not pass half the indicators in the FY2020 scorecard, receiving failing scores in fiscal policy, regulatory quality, government effectiveness, and other indicators. Liberia's poor revenue mobilization and budget management; low competence of civil servants, and the extent to which policies and budgets are linked, monitored, and goals achieved are of concern (MCC 2019).
Government would have cash to pay basic utility bills.	Liberia's falling GDP, increasing inflation, and exchange rate depreciation mean the GoL lacks cash to pay bills (IMF 2019).
A five-year Compact would be adequate to finalize MCHHP rehabilitation, connect thousands of customers, reform the utility, and launch the regulatory agency	Liberia's low-capacity context makes completion of all planned activities within a five-year Compact period impossible. "The structure of a five-year compact is not the wisest. An adequate due diligence period of about two years is needed. By the time the clock starts ticking, all the project plans, etc. should be in place. And the technical recommendations from MCC should be contextually appropriate." KII respondent
LERC	
The regulatory commission could be set up in a timely manner.	Project set-up delays at MCA-L in 2016, commissioner appointment delays in 2017 and 2018, and a steep learning curve meant that the LERC only progressed in drafting documents in 2019. LERC has MCC funding until Compact closure in January 2021. Ultimately LERC would be funded by collecting fees from IPPs. LEC described concerns about covering the cost of LERC staff and operations without additional revenue sources, so LERC is currently searching for donor funding.
MME	
The DME would be appointed, and the DoE adequately staffed to provide overall strategy and oversight to the energy sector, conduct social and gender assessments, and use data and information for strategy-setting.	MME has not participated in most sector activities without DoE leadership and has been effectively dormant, lacking key staff and technical capacity. The deputy minister of energy was confirmed in November 2019; however, the DoE does not have any budgetary allocation for director-level and other staff, computers, office supplies, vehicles, or data collection. Without the deputy in place, an EU-supported consultant tasked with building sector capacity had been suspended, finally joining the MME in 2019.
Overall power generation	
Increased power generation at MCHPP would lead to connections, consumption, and payment. Models suggested that tens of thousands of consumers would access electricity in 2018 and 2019.	The extent of LEC's T&D infrastructure problems and the time and resources needed to repair or replace assets were underestimated; The resources needed to manage many large complex donor projects occurring simultaneously were also underestimated, and it was not anticipated that donor-funded T&D projects would suffer long delays, with failed procurements and some failed contracts.

Assumptions	Actual situation at baseline in 2019
MCHPP would solve most energy supply needs. The CLSG line would provide power to LEC customers during the dry season. LEC could maintain thermal plants and afford light and heavy fuel oil for generators (LFO and HFO), repairs, and other costs necessary to keep thermal plants operating.	MCHPP only operates at capacity for six months of the year, so thermal plants and the CLSG line are essential. Thermal plants were donated by different agencies, have different parts and manuals, and require sophisticated skills to maintain and repair. In addition to these costs, LEC must purchase expensive LFO and HFO to run the plants. LEC was in debt for past fuel purchases and had no resources for 2018 and 2019 fuel costs. The CLSG Power Purchasing Agreement is a "take or pay" plan that requires an upfront payment of US$12 million for a security deposit and three months of fees. The MSC aims to renegotiate terms.
The private sector will engage once there is a regulated market. Energy demand is great, so the market may be lucrative.	The T&D network cannot handle additional load, so IPPs could not necessarily sell electricity to LEC; LERC has not improved the regulatory environment yet.
LEC	
LEC board positions would be filled with competent members and provide adequate oversight.	LEC only had a full board in May 2018, with the first meeting held June 2018. Key informants indicate that most members lack energy sector expertise and provide minimal support to LEC. A new board chair was appointed and rejected, so no chair is in place.
Once the MSC was on board, LEC would stabilize and be able to move from putting out fires to planning within six months to a year.	The reality is that the MSC stepped into a bankrupt utility, with deficiencies beyond every stakeholders' understanding. LEC board not yet able to provide adequate oversight and guidance; MSC/LEC lack strong government support; political will for utility turnaround has been minimal; donors have taken a wait-and-see approach.
T&D infrastructure would be adequate to take on thousands of new customers connected through donor T&D projects.	Stakeholders learned (over time) that infrastructure could not handle increased load. Increased theft further overwhelmed the T&D network
There would be a less sophisticated system of theft, and power theft could be reduced by the MSC.	The LEC cartel appears to be "a sophisticated operation" that supports wide-scale theft from large end users. Loss reduction requires intensive political will, new equipment, and materials. Qualitative IDIs and FGDs revealed extreme levels of pent-up energy demand across Monrovia.
Donor projects	
The timing of T&D repairs, LEC turnaround, and new donor connections would coincide with MCHPP's rehabilitation.	Pervasive delays have prevented T&D repairs, the installation of new distribution infrastructure, and final customer connections. Donor informants report that failed procurements, poor quality contractors, and LEC's inability to manage all projects have led to delays. Also, resettlement activities have been delayed given that the GoL is required to pay for them.

CLSG = Cote d'Ivoire, Liberia, Sierra Leone, and Guinea.

2. Were the contract vehicles designed to achieve Compact goals?

We assessed the contracts between MCA-L and various organizations for Activities 1 and 2 to determine their suitability as a vehicle to achieve Compact goals. The contracts define the scope of work and key performance indicators, structure implementation and timing, guide overall task implementation, set out a payment structure with bonuses and penalties, articulate expectations for coordination and communication, and establish overall expectations for performance. These are important to assess to determine areas of strength and weakness and lessons learned. In this analysis, we found that although most key informants thought the contract vehicles were well designed, they also recognized that they did not consider the extreme challenges in Liberia. Contracts did not account for Liberia's political economy, the reality of insufficient political will to support reform, declining macroeconomic indicators, and a cash-poor national budget.

MCHPP. The GoL, through LEC and MME, signed the contract with the PIU (MHI) to assume overall responsibility for rehabilitating MCHPP and all related contracts. Overall, stakeholders reported that the contract was adequate, but there were two challenges related to payment mechanisms and the PIU's contract length. First, funds for MCHPP rehabilitation came from multiple donors with different financial and banking processes. MCC was reported to have the most onerous payment process, which required increasing validation and documentation prior to the release of funds. The processes led to frustrated contractors who threatened the PIU and suspended construction when payments were past due. Respondents suggested that if a multiple donor model is used, donors should systematize financial processes and ensure timely payments.

Second, MHI reported that the PIU contract was not funded until the end of the rehabilitation project. For example, according to the Owner's Engineer (Norplan Fitchner), their contract is funded throughout the defect notification period but MHI exhausted funds by October of 2019. An outstanding problem is that contractors have been late in submitting final documentation (for example, Voith, responsible for hydroelectric generation equipment, and National Contracting Company (NCC), responsible for substation works). MHI should review, validate, and then incorporate the narrative of the final contractor reports into the final PIU project report. MHI reportedly found NCC's performance challenging throughout its contract and does not expect final documentation from the agency without the resources to follow up. MHI said they must be willing to work for free to finish the report, and in the absence of final documentation must submit an incomplete report in January 2020. MCC clarified that MHI would not be expected to work for free.

Additionally, according to HOI, the OMT contract—which started in August 2016—should have coincided with the construction contracts. The OMT contract was delayed due to procurement problems and only began operations when the first unit was commissioned. At that point, the focus was on finalizing construction, and there was minimal planning for maintenance. Space for an operations workshop, equipment storage, and a camp for maintenance employees was not included in the MCHPP complex's design. According to a contractor from the OMT:

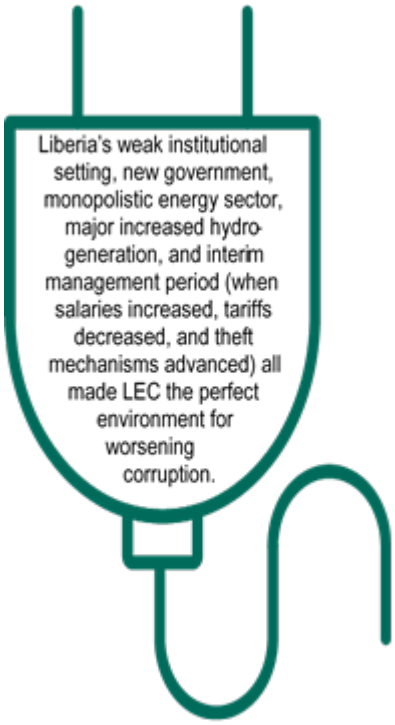
> The idea that [MCHPP] has to be operational at some point should have been a priority since the donors knew that LEC wouldn't be able to do it. The owner must consider that the useful life of the

> project begins after the completion of the construction. MCC/MCA came in halfway through the project. Most things were already signed and underway prior to their involvement, so I'm not sure who could have corrected that.

The late start to the OMT contract meant that it could not contribute to ensuring project quality, according to an MCHPP contractor:

> I was disappointed by the level of supervision and quality of the constructions and equipment. When you look at the equipment, most are very good quality. But the other stuff that is needed to make it work, maintenance and troubleshooting equipment wasn't good. The usual QA steps known to the industry weren't being followed. We complained about it after the fact but enforcing the quality in a very complex facility is challenging. LEC doesn't really have the ability to do this on their own.

MSC. The literature on management services contracts and energy sector corruption in Sub-Saharan Africa demonstrates that (1) MSCs often fail to achieve key goals for political reasons, and (2) there are known factors that increase the likelihood of energy sector corruption. Liberia's weak institutional setting, new government, monopolistic energy sector, greatly increased hydro-generation, and interim management period (when salaries increased, tariffs decreased, and theft mechanisms probably advanced) all made LEC the perfect environment for worsening corruption (Imam 2019). Given all this, resistance to the MSC management should likely have been better anticipated and planned for. Further, given the likelihood of MSC failure and the possibility of expanding corruption, the contract would have benefited from a utility- or country-level political economy analysis to inform a structure and mechanisms that could increase the likelihood of success. Without such an analysis, stakeholders lacked an updated and realistic picture of LEC's poor operational and financial realities and did not anticipate the surge in utility level corruption. As such, the MSC contract was written without explicitly applying lessons learned from the sector and adequate anti-corruption mechanisms and contingencies to deal with insufficient GoL political will and an ineffective board. Further, the contract was written with the same key performance indicators as the previous MSC implemented from 2011 to 2016, when LEC had fewer assets, customers, and responsibilities.



One possible mechanism that may have strengthened the contract is requiring detailed reporting to a donor block, including AfDB, JICA, KfW, MCC, MCA-L, NORAD, USAID, and the WB. Key informants from the donor community supported this suggestion particularly because they felt they did not receive reports from LEC; however, at least one MCC stakeholder did not endorse the suggestion. Clear requirements for regular, coordinated communication with all donors, instead of just MCA-L—through the CMC—would increase donors' understanding of LEC and leverage with the government, rather than the situation in which there was irregular communication with the donor community about LEC's needs, operations, and challenges. According to one key informant from the donor community:

> But the contract wasn't put in place the right way. This is their (MCC's) contract management issue. ESBI should have been more forthcoming on the reasons that they are not able to perform. They should be able to manage this. I don't understand why MCC wasn't sterner about getting them to meet their performance indicators.

Other stakeholders also believed that ESBI could have had a more successful two years had there been donor-wide coordination from the onset. Moreover, a well-informed donor block is important because the MSC contract is only funded through MCC for three years and requires donor buy-in for the two optional years. Operating as a donor block could have, and still can, better inform donors and enable them to act as a united front, increasing their power and control over the GoL's actions to support utility reform. This is especially important throughout 2020 because MCC has already allocated the majority of its Liberia investment to MCHPP and there are limited resources remaining to adequately incentivize or leverage the government's political will to reform LEC. The GoL has not been responsive throughout the Compact, however it has responded to other donors when they threatened investment losses reaching US $40-$50 million (*for example passage of the Power Theft Law and LERC board appointments*). One respondent explained that withdrawing resources from the MSC would only allow the GoL to operate LEC "as a source of personal gain."

Key informants also explained that ESBI's contract funding was insufficient given the expectations and compared to the previous MSC.

> MHI (as the MSC) was provided capex [capital expenditures] of 42 million euros through the Monrovia Grid Expansion project. ESBI was given nothing and were given a company that had more assets (including MCHPP) requiring far more expenses. ESBI has a three-year contract with two option years. After one year of running LEC, they say they are under-resourced even after bringing in resources not in [the] contract. Another two years with funding as is won't work. Tetra Tech highlighted that ESBI's level of effort was unusually low. And this was because they (ESBI) assumed that they would come in with MHI.

CMC. The contract establishes that the CMC serves and reports to MCA-L (creating two layers between ESBI and MCC). The CMC evaluates LEC's performance with ESBI as the MSC and advises MCA-L. The CMC assesses whether key performance indicators (KPIs) are met and why targets were not met. KPIs measure technical, operational, and financial performance using measures of operational efficiency, network performance, new connections, and reduced losses. These indicators are central inputs when evaluating LEC's functionality and the MSC's contribution to improving LEC's operations.

Several weaknesses in the CMC contract and structure have emerged. First, the CMC contract lacks broad reporting requirements that could be strengthened to include LEC, the LEC board, the MME, and the full donor community so that all actors have a shared understanding of performance. Second, given that the CMC reports to MCA-L, MCC lacks a direct mechanism to make the reports more useful. MCC stakeholders reported that the CMC reports were "helpful to a certain extent" but overall lacked sufficient "options and guidance" to inform an adequate response to performance issues. Finally, Azorom (as the CMC) is not required to independently

validate LEC at the source so the accuracy of data cannot be confirmed. For example, LEC sends the CMC data on customer complaints without independent validation from source materials.

3. Were contacts implemented as planned, and what was the implementation quality?

Not surprisingly, actual implementation of activities—within MCHPP, LEC and ESBI, LERC, and MME—has deviated from plans and perceptions of the quality of implementation has varied by agency and contract. We systematically describe how implementation deviated from plans and the quality (and perceptions of quality) in Tables IV.3 through IV.5 (HOI, 2017).

Table IV.3. MCHPP implementation findings

MCHPP	Were the activities implemented as planned?	Perceptions of the quality of implementation	Factors affecting implementation and quotes describing current status
Plant rehabilitation	Rehabilitation was implemented generally as planned, albeit with delays and cost overruns.	• Overall, plant rehabilitation was rated as high quality based on documentation, KII reports, and plant functionality. • However, the OMT reported there was inadequate supervision over some construction, resulting in suboptimal quality and requiring additional maintenance.	• Payment and contractor delays • PIU oversight ended before the project was finished. • Contractors often do not assign high caliber workers to Liberia. • One contractor (Dawnus) went bankrupt before it finished civil works projects.
Electricity production	MCHPP generates 72 MW from May to October, 24 MW in November, and 16 MW from December to April, assuming a load factor of 70 percent (LEC Business Plan 2019).	• Although it is "not perfect," the PIU's overall implementation and management of contracts was effective and MCHPP rehabilitation was high quality. • MCHPP electricity production meets expectations.	• LEC lacked capacity to oversee implementation • Donors coordinated but the number of donors created challenges given different processes and requirements. • According to the OMT: "In terms of what could have been done better, we expected more from the two top-tier engineering companies that were involved in this project. [However] MCC was able to catch problems early on." • Without additional works, MCHPP's generation capacity is seasonal, which means additional energy sources are required to have continuous electricity throughout the year.

MCHPP	Were the activities implemented as planned?	Perceptions of the quality of implementation	Factors affecting implementation and quotes describing current status
Maintenance and repair of infrastructure and equipment	• Not as originally envisioned given LEC's financial situation. LEC fell behind in payments under the IMT in 2017. Only 11 of 18 positions were filled until LEC (with ESBI) reduced the contract. The reduced workforce means that maintenance is not carried out as planned. Further, the extent of parts and equipment needed for regular maintenance and repairs was underestimated. • Other implementation deviations include that MCHPP contractors have not yet provided all warranty parts. • Maintenance and troubleshooting equipment are insufficient.	• Overall quality of OMT implementation is suboptimal, but the contract has not been fully funded so HOI has provided services in line with payments. • Performance of equipment at MCHPP has been reduced because contractors are not providing all warranty parts and there is not enough troubleshooting equipment. • Inadequate maintenance of MCHPP increases the risk of turbine failure.	• LEC's poor financial standing resulted in failure to pay the OMT. • Suboptimal quality on some works left LEC and the OMT with unanticipated technical challenges. For example, the NCC contract had more than 200 defects within the 66kV substation. Most, but not all, defects were resolved, and NCC has not completed final reports, probably because of these issues.

MCHPP	Were the activities implemented as planned?	Perceptions of the quality of implementation	Factors affecting implementation and quotes describing current status
Overall MCHPP operations	Implementation not as originally planned given the reduced staff in the OMT contract and low quality equipment, which hindered operations. Respondents also described inadequate planning for operations: • "Nobody was prepared for us [OMT contractor] The idea that this has to be operational at some point should have been a priority since the donors knew that LEC wouldn't be able to do it. The owner must consider that the useful life of the project is after the completion of the construction." • "Sometimes we've had issues when the equipment was brought here. I think we should tell the contractor to go back to the drawing room and debug it before bringing it here."	MCHPP is generating low cost electricity, however, according to respondents at HOI, current operations and implementation is of suboptimal quality due to OMT staffing and resource shortages and the lack of planning: • "It's a partial success. We've been heavily criticized. It's very difficult but learning by doing is the way to go. After almost three years, we see results under supervision. And given the circumstances in which we operate, this is good. They're already able to do many things now. As long as you're in autopilot mode, things will be easy. But when things go wrong, that's when you have to step up …. With supervision, Liberians are doing pretty well. It's not clear how they will do without this supervision. [Repairs are] a lot harder. Controls and electricals have become so sophisticated that you do need a great deal of knowledge and expertise to be able to troubleshoot these things."	Large donor-funded infrastructure problems that require resources and technical capacity are always at risk of failure post contract. Respondents described common scenarios in Africa: • "Most of the things we're experiencing now is outside the warranty period. It bothers me that LEC is not able to sustain itself. Yes, we need external support." • "And when ESBI gets out, the situation becomes worse. They put some sense into the organization, keeping them away from some terrible decisions. I expect that like many African countries, things will run for a while, but it will fall into decay over time." • "This is actually common in Africa. Construction takes place and then the location is handed over to the beneficiary but the facilities decay because there has been no thought given to how it should be operated and maintained." Respondents also described how CLSG will increase the need for technical capacity at MCHPP: • "As soon as CLSG comes into play, then a number of procedures will have to be revamped. We don't know exactly what this would entail."
Sustainability of MCHPP facilities	The sustainability of MCHPP is at risk due to under investment in the OMT. The OMT contract lacks adequate funds for staffing, equipment, parts, and materials. LEC staff can manage preventive maintenance but are not fully trained to problem solve. This could result in increased outages, reduced revenue, plant failure, increased rehabilitation costs, and at worse, loss of property and life (Canale et al. 2017).	Quality of OMT performance in preparing LEC to sustain MCHPP has not met expectations, but this suboptimal performance is not surprising given the reduction in the contract (of $7.9 million) and persisting unpaid bills. MCC paid for the OMT for half of 2019 given LEC's failure to pay. The OMT has repeatedly submitted notice of stop work orders. "The lack of funds to carry out repairs is a critical issue."	• "If there's no ESBI and HOI, MCHPP will break down soon. In 6-12 months, things will go bad. It's not just the machinery, it's about taking care of the entire site." • "Plant is forgiving, robust in the first year. In 2 years, if no maintenance then problem, none of units will be operational. They will cannibalize a unit [when a part is needed]. Capacity will go from 4 units to 3 units. This is exactly what happened at Bushrod from 16 MW (had these 1 MW generators) and then down to 1; it is the same issue as other thermal plants. JICA is doing a major refurbishment."

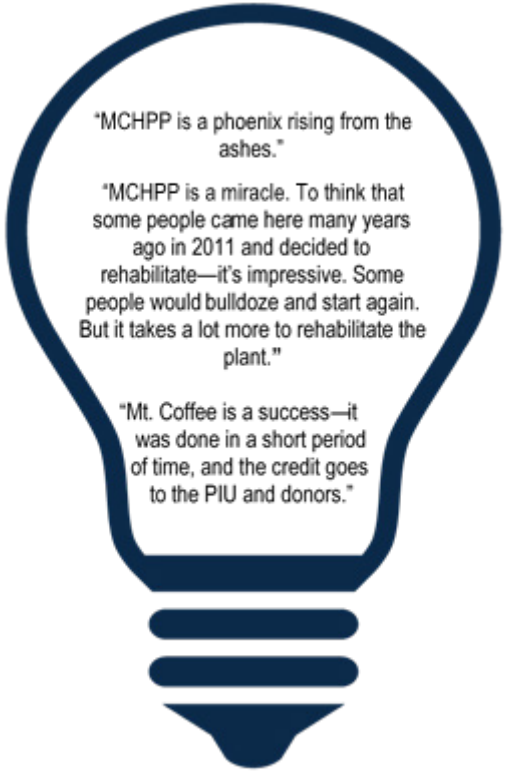

"MCHPP is a phoenix rising from the ashes."
"MCHPP is a miracle. To think that some people came here many years ago in 2011 and decided to rehabilitate—it's impressive. Some people would bulldoze and start again. But it takes a lot more to rehabilitate the plant."
"Mt. Coffee is a success—it was done in a short period of time, and the credit goes to the PIU and donors."

Table IV.4. LEC and ESBI implementation findings

LEC/ESBI	Were activities (to establish systems to conduct these functions) implemented as planned?	Quality of implementation	Factors affecting implementation and quotes describing situation
Utility oversight, understanding problems, strategic planning	ESBI has been unable to quickly turn around LEC. • ESBI came into a chaotic, bankrupt utility, and was immediately faced with overwhelming challenges. • ESBI had not done adequate due diligence, and donors did not fully understand the situation. • The turnaround plan lacked resources to pay debts and operating and capital expenditures, as well as an adequate anticorruption plan. • ESBI's key staff, including the CEO, CFO, and other personnel, resigned in late 2018 and 2019. ESBI paid contractual payments, and the posts were filled.	• Two years into ESBI's leadership, LEC's financial situation has worsened. LEC has increased generation, losses, debt, and responsibilities in early 2020 over what they were to 2018. • ESBI drafted a business plan in mid-2019, which was approved by the board, and continues to work to gain donor and GoL support to continue with the MSC for two option years (2021 and 2022). Some MCC respondents thought the quality of the plan was inadequate given LEC's financial situation. "This isn't a turnaround strategy—it's an expansion for theft strategy." The plan does not describe a comprehensive approach to reduce corruption and dismantle the "LEC cartel." • The plan calls for $115.4 million from 2019 to 2023 for operating expenditures and $109.2 million for capital expenditures. • Although ESBI has not achieved goals, and the quality of planning, communication, and oversight does not meet expectations, most donors agree that LEC is better with ESBI and would "collapse" without an MSC.	• Liberia's poor macroeconomic situation means that the GoL has minimal cash. Fluctuations in the exchange rate (from US$1 to LRD 92 in 2015 to US$1 to LRD 190 in January 2020) • Insufficient political will to support LEC as a GoL asset. The GoL "owns the utility but they are not acting as a shareholder. The government is not in the business of maximizing the value of their asset, and this is enormously frustrating." • LEC's board has been weak and ineffectual, and MCC has limited leverage to push on the board's functionality: "They should have a utility board that is capable of managing a contract of this nature or hiring someone to advise them." [MCC using leverage] "presumes that the board could function if they wanted to, but they don't have the right skills to manage the contracts or to even be the board of the utility. We suggested that they seek out private-sector members and appoint someone who has the requisite experience, but the board hasn't done that." • Increasing, unobstructed theft at LEC: "Highly organized LEC Cartel, connecting unconnected where there is power and grid expansion and large commercial corruption." • LEC cannot pay high HFO and LFO fuel costs (approximately $10 million per dry season) • Many donor projects have poor quality contractors working on LEC's grid. Liberia lacks regulations for technical quality. • Staff rotation at ESBI (due to illness and burnout) has delayed progress. • Oversight from MCA and MCC may have been insufficient given the enormity of the challenges.

LEC/ESBI	Were activities (to establish systems to conduct these functions) implemented as planned?	Quality of implementation	Factors affecting implementation and quotes describing situation
Asset management (maintenance and repair of infrastructure and equipment)	Overall asset management has been difficult due to the following: • A lack of information on LEC's inventory of assets • Inoperable assets that carry debt • Suboptimal quality throughout LEC's low voltage network, feeders, and transformers, which require extensive maintenance, repair, and replacement • Thermal generators require extensive maintenance and repair	• ESBI's T&D maintenance plan for 2018 aimed to use situational knowledge to tackle immediate issues and update standards and procedures. • However, implementation quality of the plan has been low. Resource and staffing shortages have only enabled ESBI to focus on "putting out fires." • Maintenance and repairs have been implemented as problems surface, without an overarching strategy. This response is due to the frequency of problems and insufficient resources to resolve them. • ESBI has not prioritized managing MCHHP, LEC's greatest asset, and has lacked resources to maintain and rehabilitate thermal generators.	• The asset and customer mapping study, which would list and tag all assets, has been delayed since 2018. It is currently planned for the first and second quarters of 2020. • The IMT left LEC with unpaid debts, little inventory, and no information on assets, which lengthened the time it has taken for ESBI to fully assess asset repair and maintenance needs • Thermal generators were out of warranty and had not been adequately maintained over time given the cost, lack of parts, and lack of technical capacity. • Substations have faulty transformers, switch operating mechanisms and handles, malfunctioning and inoperable earthing systems, damaged control and protection wiring; battery bank not up to standard; and a lack of spare fuses, rectifiers, and other parts. Essentially, assets have exceptional maintenance and repair needs.
Financial management and cost recovery	LEC's finances continue to worsen despite plans to improve the situation. (See section VI.A.3.c) • ESBI inherited LEC's bad financial position from the IMT period. Audits revealed larger problems than the IMT wanted to reveal. • According to ESBI staff, the IMT "had burned all LEC documents" ahead of its departure, leaving ESBI without a paper trail for all operations. • ESBI's plans for turning around LEC were inadequate given the dire finances and ongoing theft.	• Most stakeholders have not been satisfied with the quality of ESBI's performance. However, respondents agree that ESBI, over time, has come to understand the extent of LEC's debts and the level and source of loss, and to move from a focus on petty to organized power theft (see Section VI.A.1 for data on LEC's financial situation). • ESBI has lobbied the GoL and worked with the LEC Board to get the Power Theft Law ratified.	• Attempts to normalize customers and reduce power theft have been undermined by material shortages and normalization costs ($267 per prepaid and $2,139 per commercial customer), as well as insufficient political will to deal with "LECs sophisticated cartel" and reduce theft. • Donor projects have focused on new connections, which adds to LEC's responsibilities, rather than supporting operating or capital expenditures to repair or improve the T&D network.

LEC/ESBI	Were activities (to establish systems to conduct these functions) implemented as planned?	Quality of implementation	Factors affecting implementation and quotes describing situation
Human resource management (staff training retention, technical capacity, and productivity)	Implementation has deviated from plans given the extreme challenges: • ESBI's initial situational assessment indicated that LEC's organizational structure is insufficient. Of LEC's 636 employees, 12 percent are in generation, 28% in T&D, 6 percent in commercial, 7 percent in planning, and 47 percent in administration. • ESBI indicated that the IMT made "illogical appointments and demotions" causing dissent and excessive management time. • The IMT made salary increases and new appointments increasing total remuneration costs by 54 percent. • The IMT made costly concessions to the trade unions that could not be reversed. These were not implemented resulting in historical debt to employees. • ESBI submitted a plan for the Tandem Management Program and training plan in August 2018. ESBI planned to select and appoint 16 Liberians to the Succession Management Resource Pool (SMRP) at a cost of $569,315. The plan included training for non-executive staff and the MCA-L Training Center. Although the plans were articulated, ESBI did not make much implementation progress in 2018 and began efforts in 2019.	Not surprising given the range of challenges, the quality of ESBI's HR implementation has varied. • Progress in restructuring LEC has been slow. • In November 2019, LEC deferred salaries by 30 percent (Koinyeneh 2019) until LEC's finances improve • Implementation quality for training has been insufficient due to delays, despite LEC's exceptional need for technical and management capacity strengthening. The SMRP model was only implemented in March 2019. However, as of the second quarter in 2019: - 55 people were participated in training on the IMS database, meters, EPA, contract management, and biometric systems. - The LEC Training Policy was finalized and approved - 78 personnel were trained and certified in WAPP-National Power Training Institute of Nigeria (NAPTIN) - Second- and third-wave operator training at was MCHPP completed. • Whether these trainings were of adequate quality, met skill gaps, and built capacity is unclear.	• The magnitude of challenges at LEC—in many cases due to IMT management—overwhelmed ESBI's ability to focus on human resource management and training. This was exacerbated by ESBI's management turnover in 2018 and 2019. • LEC staff have low morale given LEC's poor performance, poor reputation, high rates of theft, the political economy, and lack of GoL support. • LEC staff also have exceptional training needs given the lack of generational knowledge with LEC for operating a utility. • The culture of LEC has been harmfully affected by Liberia's history. The consequence of not having a modern human resource culture, policies, structures, and systems is inadequate professionalism throughout the utility. In addition, impunity in the face of power theft has incentivized further stealing and exacerbated utility-wide corruption. • LEC has also had an "external appointment of personnel by senior political figures, which is affecting its HR, procurement, and inventory control activities, and has resulted in critical internal control procedures being compromised." A key informant said, "The ringleader for theft in LEC came out of the oil company and then moved over to LEC." While LEC was advised to document issues in 2018, the situation has gone unresolved through 2019 (CMC 2019).

LEC/ESBI	Were activities (to establish systems to conduct these functions) implemented as planned?	Quality of implementation	Factors affecting implementation and quotes describing situation
Data management Use of data and IMS to improve operations	First, LEC has not had a monitoring and evaluation (M&E) position to oversee all data management and analyses efforts. This oversight has undermined ESBI's ability to quickly understand LEC's finances, operations, losses, assets, and other key indicators. In 2018, LEC lacked any functional information management system and staff capacity to collect, manage, analyze, and utilize data. The need for a donor funded IMS system was quickly understood. It was procured (with Indra as the contractor) and designed in 2018 to go launch in 2019. Core modules include: • Commercial Management System (InCMS) • Outage Management System (OMS) • Energy Control & Losses (ECL) • Integrated Graphical Enterprise (IGEA) • Enterprise resource planning) • Reporting (Pentaho) • Prepayment metering	Despite the lack of an M&E position, ESBI did not actively work to fill this gap. The IMS went live in March 2019. Although there is still suboptimal quality of implementation for data management tasks by the end of 2019, there is a dramatic improvement from the IMT period. • Utilization of the system is still low because although they have been trained, few staff have the data skills. • LEC staff report that on-site support from Indra is lacking. • Data (such as for this evaluation report) are difficult to obtain. • The process to validate the customer relations model and prepaid customers is ongoing.	• LEC staff have limited technical capacity to utilize data. • ESBI and LEC have had limited capacity to oversee the Indra contract. • The IMS system only recently came online, so defects are still being fixed. • The CMC, MCA, and MCC receive various Excel data files but not the full complement of data from the IMS dashboard. The CMC receives data in LEC reports. CMC reports are reviewed by MCA-L and shared with MCC.

LEC/ESBI	Were activities (to establish systems to conduct these functions) implemented as planned?	Quality of implementation	Factors affecting implementation and quotes describing situation
Donor coordination	There was no explicit donor coordination plan. As a result, this was a persisting issue at the end of 2019. Although ESBI did not have a plan to coordinate donors, these agencies also mostly took a "wait and see" approach. • "We don't have a clear picture because we also stopped following up on them. We wanted to take a back seat in order to let them perform and deal with all the issues."	• LEC has presented to the Energy Sector Working Group and High Level Stakeholders group. The data-rich presentations are a marked improvement over the IMT's vague presentations. Meetings are infrequent. Though, and donors leave without a clear sense of how to move forward. • Implementation quality for donor coordination has been inadequate despite LEC's donor reliance. As "more of a technical firm" ESBI was not adequately equipped to manage the range of donor projects, each with different sets of plans, goals, contracting requirements, contractors, procedures, payment processes, and resettlement requirements. • However, information sharing has improved since MHI was the MSC, when "reports were not detailed, generation and customer numbers were low." The IMT shared more information, but ESBI believes it was flawed. Now stakeholders report receiving regular status updates.	• Liberia's energy sector lacks an overall strategy and Liberian ownership. • Donors do not regularly operate as a block unless there are extreme factors, such as war or a failed government. Given Liberia's status as a fragile democracy with a poor economy, and the level of donor reliance and interest, coordination is essential. • Key informants agreed that there has been insufficient donor coordination across agencies: - "There is usually an assessment made before the project. But in this case, preparedness of the donors, including MCA, is questionable." • Donors led with the assumption that each agency could fill in generation, T&D, management, data, policy, and regulatory gaps independently without understanding the interconnectedness of the sector and energy infrastructure. - [Donors] "pushed generation, did not push transmission and new connections were delayed … investment in transmission was late. Assumptions were late. Generation came before transmission … system upgrades did not coincide. There [were] expanding corridors … the start date for all these [T&D] delayed because of contracts, environmental issues and resettlement." - "The infrastructure is not new. Donors are not taking into this account. Donors rely too much on implementing agencies, without understanding their capabilities. If all donor connections come online, it would overwhelm the system. Management has become aware of that, and they are working to out how to accommodate all the projects".

LEC/ESBI	Were activities (to establish systems to conduct these functions) implemented as planned?	Quality of implementation	Factors affecting implementation and quotes describing situation
Overall LEC operations	ESBI's overall implementation of LEC has not proceeded as planned given the overwhelming challenges.	LEC's data indicate low quality implementation, but respondents describe ESBI's challenges in implementation: • "The operating environment is impossible, and that's frustrating. ESBI underbid and underestimated how challenging the work would be. ESBI's staff got burned out in Liberia. It was an impossible environment to work in, and there's been high staff turnover. It's not a failure in the contract, but rather the operating conditions were much harder than what was laid out originally. However, ESBI may not be sending in their A-team." • "ESBI should have been more forthcoming on the reasons that they are not able to perform. If the cartel holds them back, then why don't they explain? We got a foreign firm to manage them so that they are free of the cartel. They should be able to manage this."	Donors expressed a commitment to Liberia's energy sector and agree that further investment is essential. However, most respondents were unsure of the path forward: • "Liberia is a very difficult country. This is the last opportunity to fix LEC. After next year, if we continue to have these losses, then it's difficult to justify an MSC." • "Individually, ESBI team members are working hard. But leadership has been lacking. We also understand the effects of the interim management team. We know that we can't turn over the utility to LEC totally." • Regarding a second Compact: "Preconditions could be used to advantage; MCC should have a more hands-on approach. MCA-L may not be able to do [that]. For more leverage, MCC may have to do it themselves. In terms or reprogramming, MCC needs to have more control."

Note: In ESBI's 2019 business plan, the budget calls for $115,425,000 from 2019–2023.
LEC's operations and finances are presented in detail in Chapter VI: Utility-level outcomes

Table IV.5. LERC implementation findings

LERC	Were activities (and processes to set up the committee and empower it to conduct these functions) implemented as planned?	Quality of implementation	Factors affecting implementation and quotes describing situation
Progress towards modernizing the energy sector and developing legal, economic, and technical regulations	Following prolonged delays (as described in Sections IV.B.4. and V. B.1) LERC is now functional, but progress is behind schedule, so it is not proceeding as planned. The prolonged delays mean the future sustainability is questionable given that Compact funding ends in January 2021.	The quality of LERC's implementation is strong, as evidenced by LERC's timely production of bylaws, operating procedures, and draft regulatory guidelines and the successful workshop which brought together stakeholders to review licensing regulations.	• LERC's performance is challenged by the GoL's suboptimal performance and weak governance and institutions • LEC and the GoL have inadequate funds for LERC's ongoing operations. • LERC is one of the first regulatory agencies in Liberia, so the culture of technical, licensing, and quality regulations is new.
Capacity and functionality as a board; ability to implement the business plan	Although LERC commissioner appointments and confirmation were delayed, meaning implementation did not proceed as planned, in 2019 LERC had a cohesive board with an active, knowledgeable managing director. LERC has many open positions, and the chairman of the board was recently given another presidential appointment.	The LERC commissioners and staff have functioned cohesively and have the capacity needed for high quality implementation of the LERC's responsibilities.	Overall GoL stability is necessary for LERC's ongoing quality implementation. LERC must secure additional donor funds for 2021 and beyond if it is to keep operating.

Figure IV.4. MCHPP aerial view

SCADA = supervisory control and data acquisition.

D. Findings: What implementation lessons can be learned?

We present an overall assessment of implementation lessons learned, highlight successes, and challenges, opportunities, and threats, and recommend areas for improvement (Tables IV.6. and Table IV.7). The suggestions were generated by synthesizing all findings, including from key informants, administrative data, and sector literature.

Table IV.6. MCHPP and LEC/ESBI implementation lessons

	MCHPP	LEC / ESBI
Successes	• MCHPP is a fully rehabilitated and operational hydropower plant. • MCHPP "is a miracle," "like a phoenix rising from the ashes." KII respondent • MCHPP has both emotional and economic value. To Liberians, it is as symbol of rebirth, modernization, and hope for the future. • MCHPP generates high quality, inexpensive electricity. • MCHPP stimulated a high level of donor coordination.	• Without ESBI in place at LEC: - There would likely be fewer connections, lower quality electricity, and more theft. - Stakeholders would lack accurate data and information on operations, and there would even less coordination of donor investments in generation and T&D projects. • Although ESBI's performance has not met stakeholders' expectations, a careful review of data, procedures, systems, and management over time indicates that ESBI has been successful in taking over LEC, and in diagnosing and beginning to solve critical problems.
Challenges (most salient)	• The length of the PIU contract was inadequate to complete the project with oversight of all contractors. • More MCC/MCA-L oversight and easier financial processes were needed to anticipate and solve problems. • There are insufficient resources for ongoing operations and maintenance. MCHPP is at risk of performance losses and other consequences without adequate investment.	• MCC did not conduct a political economic analysis before establishing the MSC, and ESBI did not conduct adequate due diligence. No one knew the extent of LEC's financial and infrastructure problems. However, one informant explained: LEC deteriorated while the MSC was being procured. MCC recommended extending MHI's contract, which Norway would have financed, however the GOL did not agree. • ESBI has insufficient operating and capital expenses and lacks LEC Board and GoL support. • ESBI's contract is structured to fund fewer staff over time so while challenges persist, staffing is reduced. - "Now there are less staff, and some of the key staff have been swapped with people who are less qualified. Many are getting burnt out. Some have faced health complications that made them leave Liberia. [We/they] underestimated how difficult the job is." • There has been no comprehensive analysis of the sources and drivers of corruption and loss. The utility lacks a senior management position focused solely on theft reduction. • The donor community has not been adequately coordinated in working with LEC.

	MCHPP	LEC / ESBI
Opportunities	MCHPP is Liberia's greatest human-made asset. Organizations are interested in operations contracts or concessions. There are opportunities to ensure MCHPP's sustainability by renegotiating HOI's contract to maximize value of the OMT's presence; identifying additional funding to maintain MCHHP until LEC can cover costs; or unbundling and concessioning MCHPP to a private firm.	• There are opportunities to use all new data and learning, in coordination with donors, to address issues raised. This is the time to optimize interest particularly the African Development and World Bank, to fund the MSC beyond January 2021. • ESBI to use the donor meetings to communicate priorities and obtain operating and capital resources. • Stakeholders may seize opportunity to advocate for composition needed on LEC board to improve governance and oversight. Board to conduct full and subcommittee meetings focused on problem solving. • Build on current understanding of losses and identify all drivers and sources of corruption at LEC. Develop theory- and evidence-based approaches, both technical and behavioral, to reduce theft and losses. Involve all stakeholders, LEC board, donors, and GoL • Add a contracts manager to ESBI to oversee all T&D plans. This could accelerate new connections.
Threats	• If LEC staff are unable to problem-solve or do not have the parts needed to maintain and repair MCHPP, the turbines will go offline one by one as parts are pillaged. • Without PIU or OE oversight, the warranty periods for defective parts and service will lapse without resolution, leaving LEC to cover the cost of repairs. This would lead to the plant falling into disrepair.	• Indecision or inaction on the part of the GoL to continue the MSC is a key threat. The donor community should work together and foster closer relationships with GoL decision makers to gain support for extending the MSC. • Further threats include the fact that the GOL appears to continue to condone theft, demonstrate poor oversight of LEC management, provide inadequate technical expertise on the LEC board, and lacks fiduciary commitment to LEC. Trying to reduce losses without a thorough analysis of all sources of corruption and theft may miss key sources and drivers. • Continuing to assume that ESBI can reach KPIs without adequate operating and capital resources. • If the CLSG line becomes operational without an effective loss prevention program in place, power theft will increase at a high cost to LEC.

	MCHPP	LEC / ESBI
Lessons learned	• Donor collaboration on infrastructure rehabilitation can be successful. The structure of the consortium should be better. • Ensure that contracts are for the full length of the project. • Establish clear lines of authority for each agency (donor/contractor/LEC) regarding who should manage different issues. - "Right now, everyone is pointing to everyone else, and there's no accountability." • Plan as systematically for the operation period as the rehabilitation works. • Estimate the cost of completion if a contingency plan is needed because of a catastrophic event. Build a budget assuming a catastrophic event to give the program a better chance to succeed.	• Conduct a utility-level PEA and country-level PEA prior to investing to understand the context. • Build Compact and contracts to account for context and high likelihood of corruption. In a complex context such as Liberia, do not structure contracts so that level of effort decreases in just a few years. • Assume an MSC will face immense challenges; apply all lessons from the literature when designing Compact and contracts. • Build in preconditions and identify leverage to ensure an adequate board and government accountability. • Operate as a donor block in extremely poor, post-conflict countries.

Table IV.7. Implementation lessons from LERC, MME, and the donor community

	LERC	MME	Donor community
Successes	Establishing the Commission, building support for the Commission, and launching licensing documents	• There were limited successes given the open positions, but a deputy minister was appointed in November 2019. • The Power Theft Act of 2019	• MCHPP and other T&D accomplishments • Passing the Power Theft Law and getting commissioners appointed to the LERC
Challenges	• Delays in starting up • Funding for sustainability • Changing the Liberia's energy sector culture, now characterized by - The lack of technical and quality regulations - LEC's monopoly on public electricity supply - Maverick entrepreneurs who perpetuate electricity theft and operate without standards and with impunity	The lack of leadership at MME has prevented progress.	• Overcoming culture of limited cooperation • Finishing existing T&D plans without LEC having a contracts manager
Opportunities	There is donor interest in supporting LERC, and the Commission has an opportunity in 2020 to prove its value and generate financial support.	The new deputy is eager to work with all donors and stakeholders and welcomes collaborations.	Donors can fill in important gaps that the MCC Compact closure will leave, including funding ESBI at LEC, LERC, the OMT at MCHPP and building capacity at MME. The IMF recently approved a loan for $213.6 million to Liberia which provides an opportunity for the government to pay bills to LEC (New Dawn Liberia 2019).
Threats	If there is interference from GoL or other high-level actors, LERC can be used to perpetuate corruption through licensing and standards.	Politically appointed positions could change at any time.	Further macroeconomic decline could destabilize Liberia if salaries are unpaid and services decline even further.
Lessons learned	Expect that establishing a regulatory agency make take 5 to 10 years, and plan for financial stability throughout that time period to avoid government interference.	MCC might want to add government appointments to key positions as a condition in the PIA.	Donor coordination to strategize, pool funds, or use leverage helps accomplish goals in a context like Liberia.

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V. ANALYSIS OF ENERGY SECTOR OUTCOMES

Liberia's overall governance, institutional capacity, and public sector management were decimated by the prolonged civil war and diaspora. The energy sector was a clear casualty, severely incapacitated and purposeless given the lack of energy generation, assets, and investments. Since 2015, even though Liberia has increased generation (from 22 MW to 141MW of hydro and thermal power) and increased the number of connected households and businesses (about 30,000 to 55,000) progress in energy sector reform—including building the Department of Energy (DoE), developing a sector-wide strategy, and regulating the sector—has lagged. However, well-designed reforms, such as establishing an independent regulatory agency and enabling privatization, have been shown to boost energy sector performance and increase access to power (Imam et al. 2019). These energy sector reforms may be critical given Liberians' extreme pent-up (and unserved) demand for power. Liberians agree: "Electricity is life."

"Electricity is life"

"The challenges involved are immense and should not be underestimated. The Government inherited a situation where there was no public electricity infrastructure or functioning utility, the petroleum company was looted and destroyed, petroleum exploration was at a standstill, and there was no coordinated energy policy and strategy.

Nevertheless, it is imperative to be systematic and disciplined about energy policy and strategy implementation if the energy sector's potential …[is] to be realized."

National Energy Policy 2009

A. Evaluation questions and background

In this section, we investigated the following evaluation questions on the energy sector. We focus on the first evaluation question in this baseline and interim report given the limited progress made in energy sector reform over the course of the Compact.

1. 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?

2. 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?

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? (Moved from grid level because focused on energy sector level)

B. Findings: Current status

LERC's activities

The 2015 National Energy Law legislates the establishment of "the legal and regulatory framework for the generation, transmission, and distribution and sale of electricity within … Liberia for exports." According to best practices in the regulatory sector, agencies should strive to meet regulatory governance, substance, and outcome standards. Regulatory governance means that the agency is legally mandated, has clearly defined roles and objectives, is independent, accountable, transparent, predictable, provides open access to information, and encourage participations (AfDB 2018). Substantive best practices require agencies to develop a licensing framework and economic, technical, and commercial quality regulations. For optimal performance and best outcomes, the agency should track access, financial and technical performance, and commercial quality outcomes.

LERC became operational when commissioners were confirmed at the end of 2018. Over the course of a year, LERC has progressed in defining the purpose and role of the commission and developing a vision. These are both best practices in regulatory governance. LERC's defining documents are listed in Table V.1. LERC materials depict the relationships between MME, LERC, LERC and private operators in Liberia's electricity supply industry (Figure V.1), and the LERC organizational structure is shown in Figure V.2.

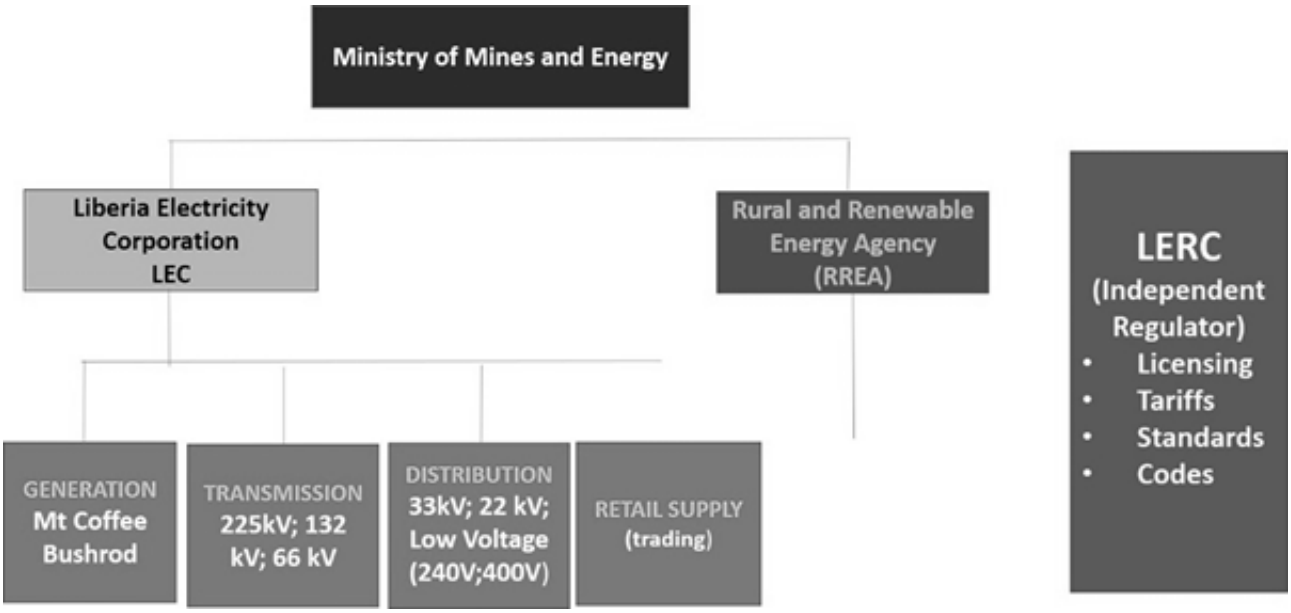
Data sources for the energy sector analysis

- Document review to assess laws, policies, and regulations, including progress, implementation and enforcement
- Qualitative data: KIIs with MCC, MCA, MME, LEC, LERC, donors

Table V.1. LERC defining documents

LERC draft document	Purpose of document (from document text)
Administrative Procedure Regulations, *Draft* September 2019	The purpose of these Regulations is to ensure that: (a) The Commission will operate in an open, transparent and impartial manner, including the use of a formal docketing system for tracking matters pending before it; (b) Parties are granted a fair hearing in all matters before the Commission both adjudicatory and non-adjudicatory; (c) All affected parties can participate in the processes of the Commission; and (d) The Commission can keep the general public fully informed about Commission actions as contemplated by the Law.
LERC By Laws, *Draft* May 2019	1.2 Bylaws are the framework for regulating the internal procedures of LERC and are guided by the Law, principles of transparency and accountability which are designed for ensuring good governance and regulatory effectiveness.

Figure V.1. Liberia's electricity supply industry



Source:(LERC, October 2019)

As Table V.2 illustrates, LEC currently has a monopoly in the sector. LERC has communicated its vision of the current and future status of Liberia's energy industry. The vision is to transform Liberia's monopolistic regime, in which LEC is the sole operator of an outdated sector with limited capacity and poor policy implementation, into a well-regulated, competitive market with private-sector participation and regional integration. LEC would be vertically unbundled with separate operations for generation, T&D, and sales. Generation would be horizontally unbundled so that independent power producers would enter the market in addition to LEC. Ultimately, customers benefit from increased access, quality and affordability.

Table V.2. LERC's status assessment and future vision for the electricity industry

Current status of the electricity industry	Future vision for the industry
• Monopolistic regime: LEC is the sole operator engaged in generation, T&D, retail/sale • Self-regulatory regime with ministerial oversight; • Poor policy implementation and lack of strategy; • Outdated technology • Limited technical capacity	• Liberalized and regulated electricity market • Private sector participation • Increased access, improved quality and affordability • Regional integration • Competitive market

In the substantive standard, LERC has drafted several licensing documents (Table V.3) which articulate a framework to service providers for registering and licensing.

Table V.3. LERC draft document and purpose of document

LERC draft document	Purpose of document (from document text)
Electricity Licensing Regulations for Service Providers in Electricity Sector Industry, *Draft* September 2019	These Regulations provide a framework for the licensing and registration of persons engaged in activities within the electricity industry which require a license or registration under the Law.
Micro Utility Licensing Regulations for Off-Grid Service Providers in the Electricity Supply Industry, *Draft* September 2019	These Regulations provide a framework for the registration and licensing of persons engaged in or intending to engage in the provision of Micro Utility services under the Law.
Electricity Licensing Handbook for Service Providers in the Electricity Supply Industry, *Draft* September 2019	This Handbook provides guidance to applicants in the registration and licensing process.

In October 2019, LERC hosted a stakeholder validation workshop on draft regulatory instruments and procedures in Monrovia, which brought together government officials, donor partner countries and agencies, and business owners. All the draft documents were shared for validation. From all stakeholder accounts, the workshop was well received, and the energy stakeholders are eager to see how LERC can improve sector performance. According to one LERC commissioner:

> People are able to understand our role in the system. They are welcoming us because they recognize a problem in the sector, and they think we can help. LEC is not financially viable and there are issues with power supply, so they think we can make a difference. We can make good policies, but the key is implementation. The market is very fragile and unstable.

However, the commissioner does not underestimate the challenges that LERC's faces:

> We aren't just proposing technical changes, we are also going against the existing system and utility culture.… Going forward, there will be a lot of progress, and people are supportive of us.

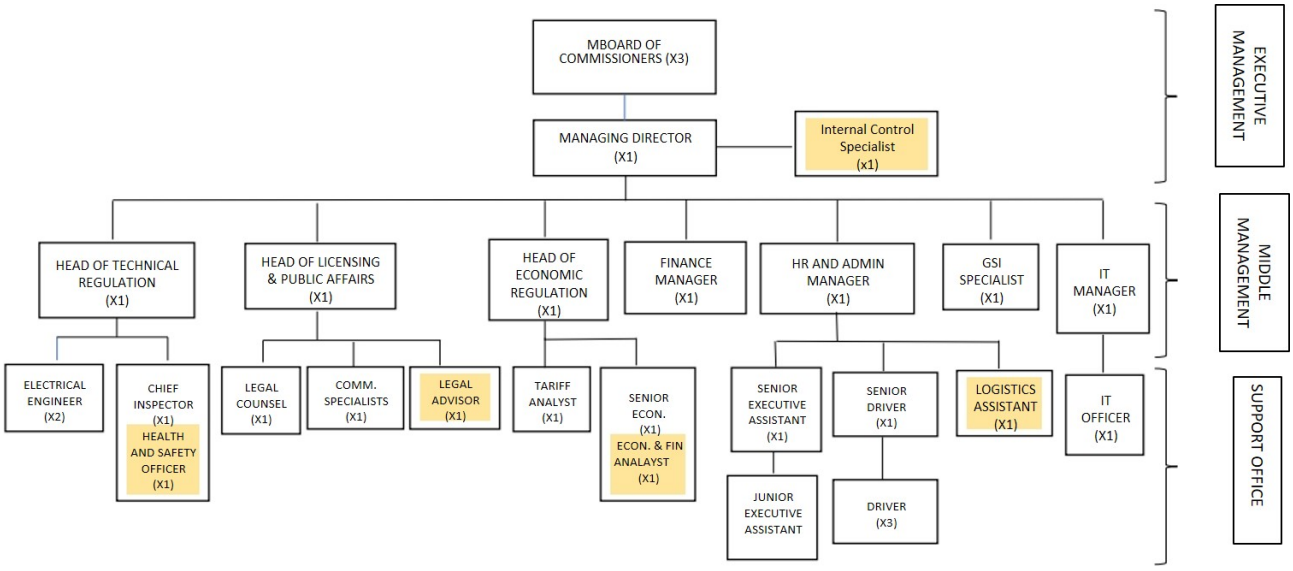
Although LERC has more documents to draft to articulate economic, technical, and commercial quality regulations, the agency has made important progress over the course of 2019. Moving forward, two important challenges exist. First, the LERC Chairman, Jolue Aloysius Tarlue was confirmed by the Senate as the Executive Governor of the Central Bank of Liberia, thus leaving

his LERC post. The LERC chairmanship position has not been filled and it is unclear what this means for LERC's progress.

Second, LERC is funded through MCA-L until Compact closing in January 2021. The annual operating costs of LERC are not yet clear, but as the organogram illustrates, fully staffed, LERC would have 30 positions, five at the executive level, seven in middle management, and 12 support staff (V.2). In theory, LEC would cover LERC's costs through regulatory fees, however as a bankrupt utility, this is unlikely in the foreseeable future. It is unlikely the GoL will cover costs given that salaries of current civil servants are often delayed, inflation is high, and the government is cash poor. Recognizing these realities, the managing director and commissioners are working on securing resources with a business plan and donor mapping activities, however they only have the remainder of 2020 to identify resources. Their belief is that donor funding is the best option to ensure that LERC is an independent agency, particularly in the early years:

> Certainly, if we don't have donor support, there will be folks in the government who will have leverage. It may not come from the President, but there are others who will try to use their leverage over us. Until we get the market going and can generate our own revenue, it's better for us to be donor funded. This might even be 7–10 years for us to be a solid regulator. We don't want a quid pro quo situation.

Figure V.2. LERC organogram (LERC, October 2019)



If LERC can identify donor funding, the agency envisions moving from the current scenario in Figure V.3, where LEC remains the only supplier and main T&D provider, to a well-regulated energy market in which generation and T&D are unbundled, and the private sector helps achieve Liberia's goals for energy access, affordability, and quality (Figure V.4.).

Figure V.3. Where Are We Now? LERC's regulatory architecture of evolving electricity industry under the Liberia Electricity Law of 2015

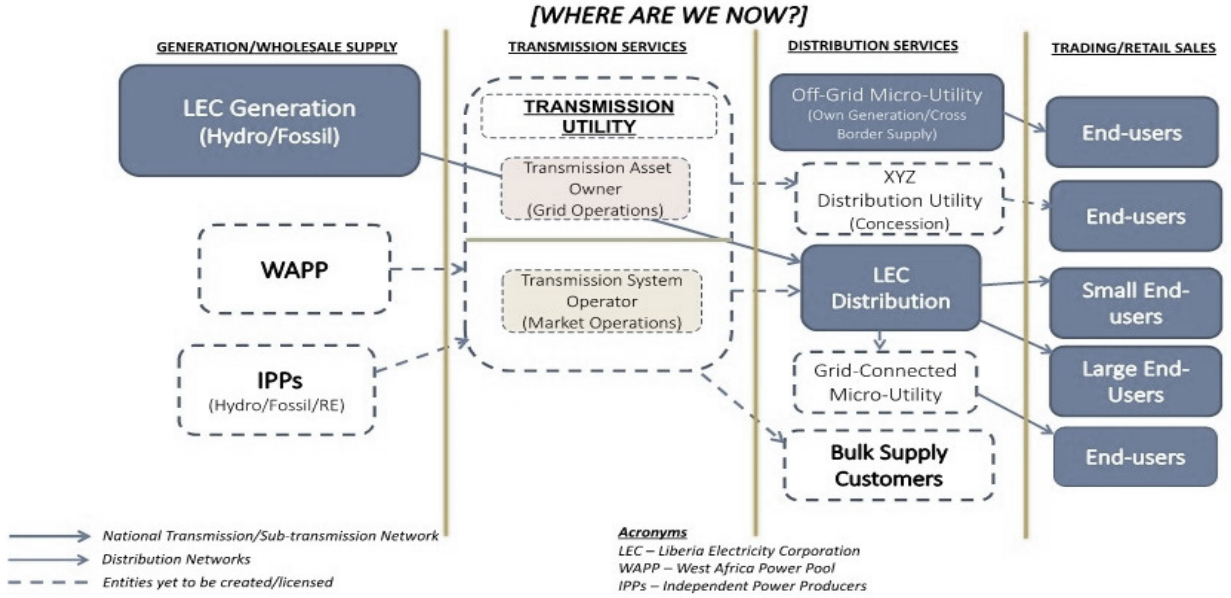
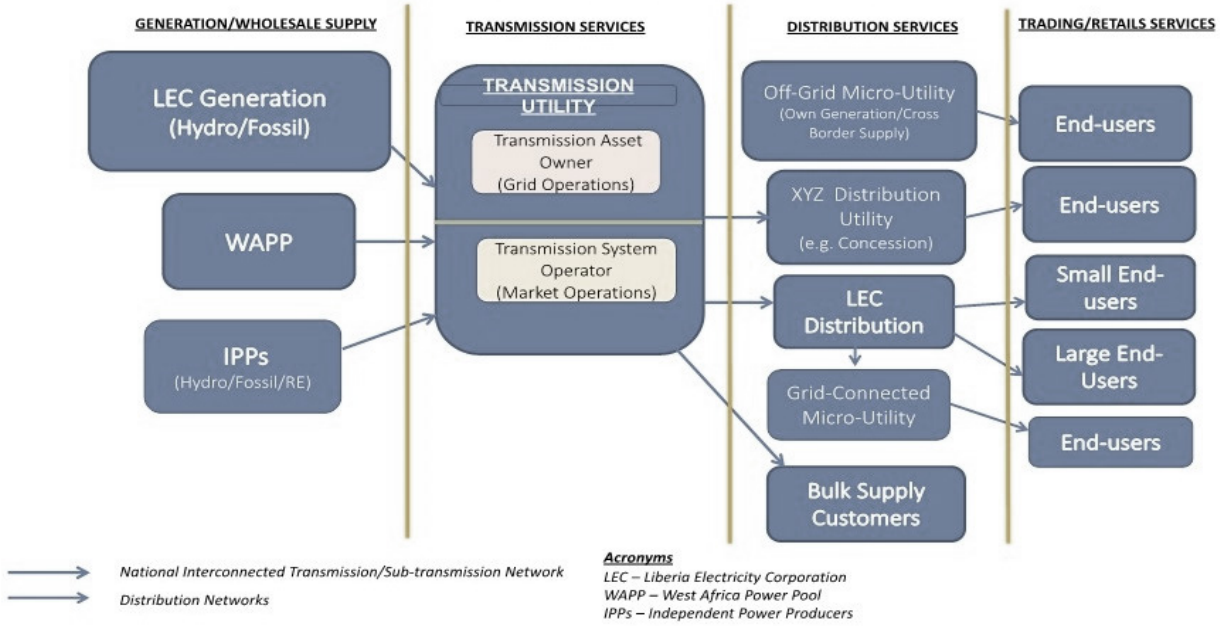


Figure V.4. Where Are We Going? LERC's regulatory architecture of evolving electricity industry under Liberia Electricity Law of 2015

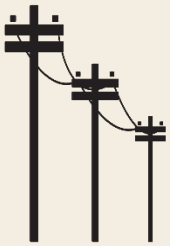


VI. ANALYSIS OF UTILITY-LEVEL OUTCOMES

In this section, we assess LEC's management with ESBI as the MSC, LEC's current ability to cover costs, progress towards a longer-term arrangement, and the sustainability of LEC.

A. Utility-level evaluation 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?
2. To what extent, if any, has LEC's management improved since the new management contract became effective?
3. What progress has the 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?



Data sources for the utility-level analysis

- Document review including CMC reports, LEC reports, MCA schedules; sector and implementation updates
- Administrative data including key IMS indicators such as operating costs, collection rates, technical and non-technical losses, staffing information
- Qualitative data including key informant interviews with key actors that have specific knowledge of utility operations (LEC board, LEC, ESBI, CMC, Tetra Tech, MCC, MCA, MME, LERC, donors, and other stakeholders that interact with LEC; site visits

B. Findings: Current status

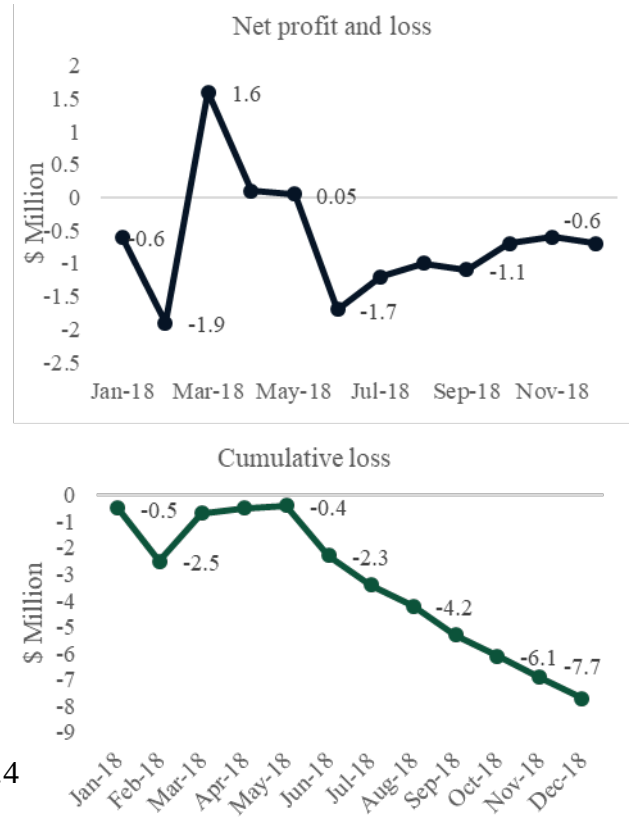
1. What was LEC's situational and financial status when ESBI assumed responsibility?

As described previously, when ESBI assumed the operations of LEC in January 2018, the utility was in an extremely poor financial situation, with excessive debt, a negative operating and profit margin, and low liquidity (see Figure IV.1). In ESBI's assessment, LEC's 22 kV network lacked capacity for new connections; the low voltage (LV) network was of "limited standard"; and LEC had a shortage of materials, equipment, and tools. According to ESBI: "LEC can only carry out basic emergency maintenance of its system … and is dependent on international donor agencies." Without an increase in operational or capital expenditures, LEC would soon gain responsibility for additional assets, including MCHPP, 66 and 22 kV lines, substations (Kataka), 230 V distribution lines, and customer connections, as well as the OMT contract for MCHPP (See Appendix B for LEC infrastructure). According to ESBI's Initial Situation Report:

> The utility faces large financial liabilities, with substantial payments due for the MCHPP O&M contractor, the EIB loan (for MCHPP), Côte d'Ivoire cross-border power (which had been consumed but for which the tariffs were uncollected), West African Power Pool subscriptions, purchase of heavy fuel oil (HFO) for the dry season thermal generation, and tax due to the Liberian Revenue Authority.

ESBI's initial assessment of finances in early 2018 also identified the following problems:

Figure VI.1. LEC financial indicators

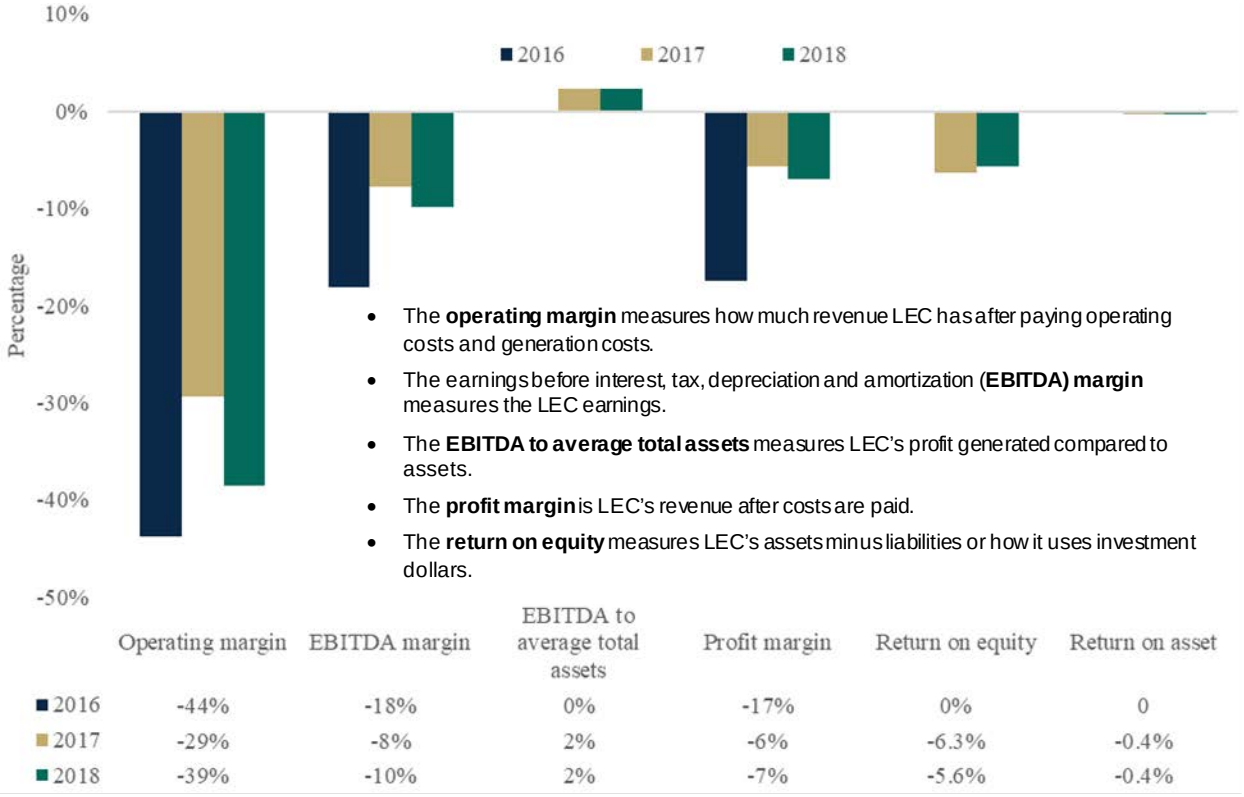


- LEC was named in lawsuits by the petroleum industry for US$9.3 million in unpaid debt for HFO and LFO used in 2017. Without any provision for fuel for the 2018 dry season, ESBI—brand new to Liberia—wanted to avoid widespread outages, and so overpaid for LFO.
- Escrow accounts for the EIB loan interest and the OMT contractor required $575,000 per month. The IMT had set aside only $50,000 and $177,000 respectively, in these accounts, which had immediate impacts on the OMT's staffing and performance at MCHPP.
- LEC had outstanding debts for $1.4 million in nonoperational assets, including trucks, IT equipment, and building renovations.
- As of December 2017, unpaid government debt to LEC included the following:
  - Street lighting and autonomous agencies: $5.4 million
  - Liberia Water and Sewage: $1.1 million
  - Post-paid customers: $5 million
- The IMT had entered LEC into suboptimal contracts without due diligence and competitive processes for the prepayment metering vendor, purchase of streetlights, renovation projects, and generation materials. The meter vendor contract proved extremely problematic when ESBI tried to reconcile LEC's customer list.
- The IMT had increased staff salaries and added new positions so that payroll rose from US$ 3.94 million per month in January 2017 to US$ 6.224 million by December 2017, an increase of 54 percent that accounted for 23 percent of operating expenditures.

ESBI leaders further explained that, "The interim management burned every file that was here. It took a year to get through all the accounts."

Figures VI.2–VI.4 illustrate LEC's poor financial standing. By all indicators, LEC's finances worsened from 2016 to 2019. (The IMT operated LEC from 2016 to end of 2017; ESBI became the MSC in January 2018.) VI.4 illustrates LEC's declining opening and closing cash balance in 2018, and despite increases in generation, relatively flat net inflows from sales. Given this financial context, we address the first evaluation question about electricity tariffs.

Figure VI.2. Indicators of LEC's profitability 2016–2018



	Operating margin	EBITDA margin	EBITDA to average total assets	Profit margin	Return on equity	Return on asset
2016	-44%	-18%	0%	-17%	0%	0
2017	-29%	-8%	2%	-6%	-6.3%	-0.4%
2018	-39%	-10%	2%	-7%	-5.6%	-0.4%

Figure VI.3. LEC's liquidity ratio 2016–2018

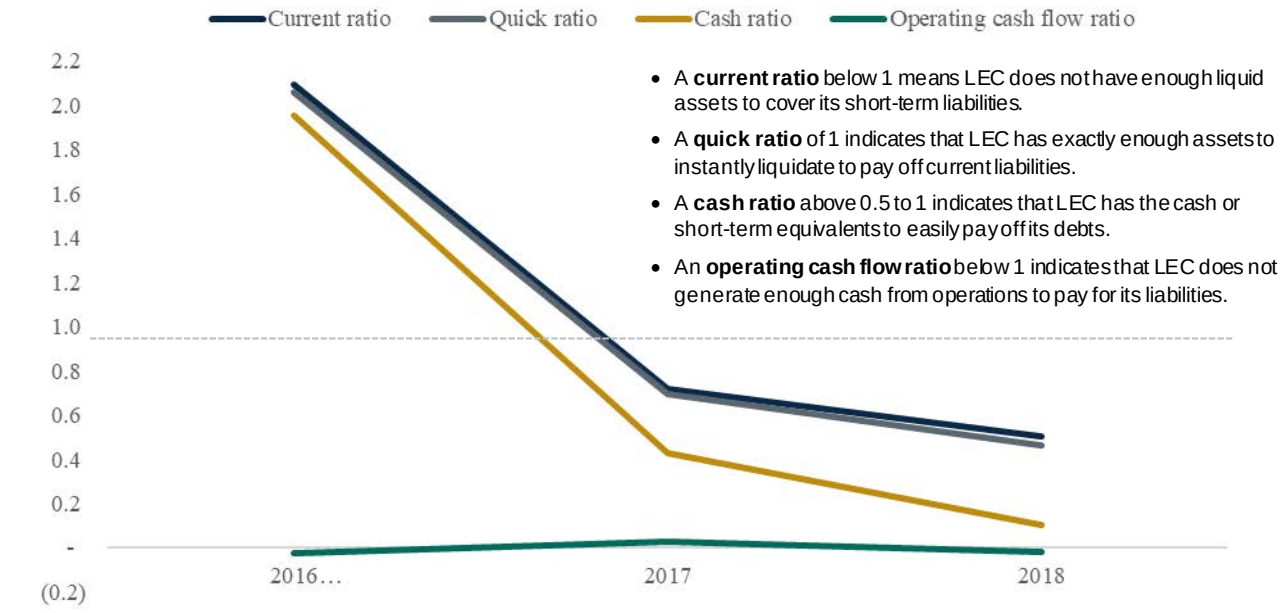
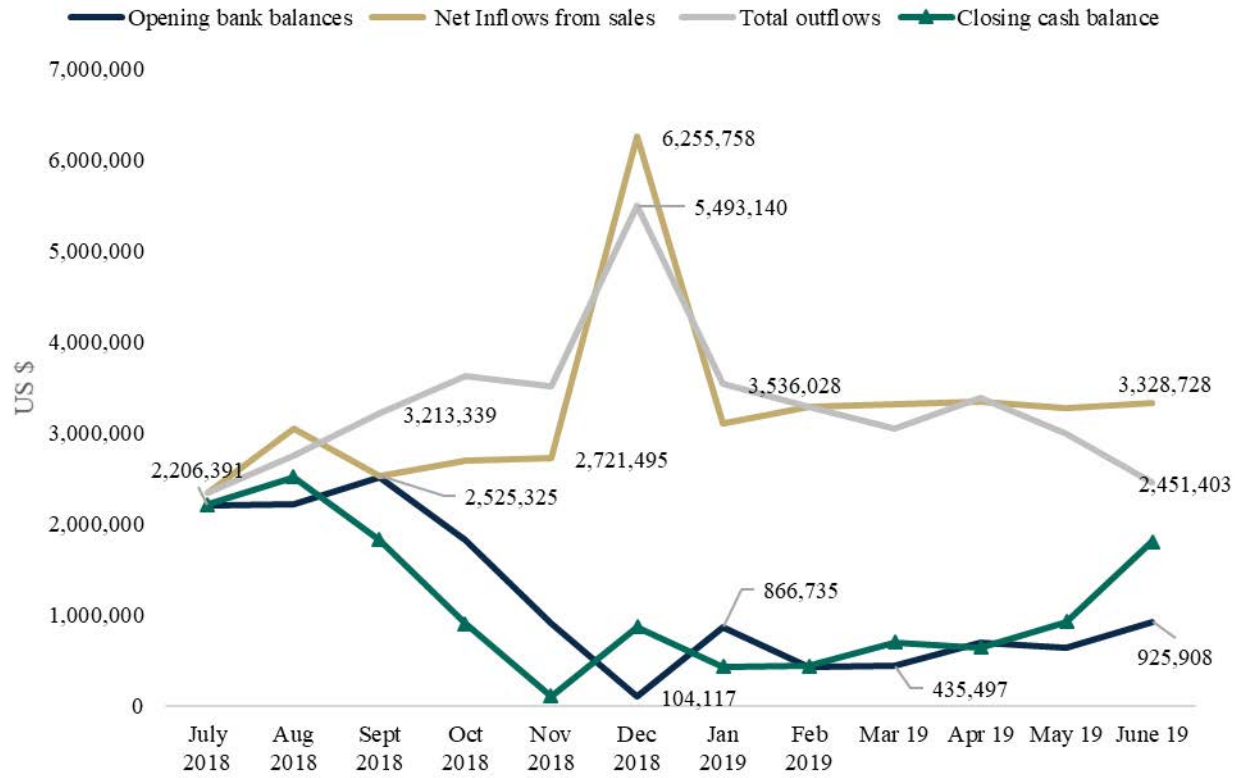


Figure VI.4. LEC's financial situation, July 2018–June 2019



2. What is the status of the LEC Board and governance of the utility company?

Liberia's Public Authorities Law of 1973 (Chapter 8.45) establishes that the LEC "shall be vested in a Board of Directors consisting of the Chairman of the Public Utilities Authority, the Minister of Finance, the Minister of Justice, the Minister of Planning and Economic Affairs and five other members who shall be chosen from the private sector of the economy and appointed by the President of Liberia." The Liberian National Energy Policy of 2009 further establishes that public utilities are managed by boards and executive officers appointed by the president, with the advice and consent of the Senate. Consequently, the current president appointed LEC's board of directors. LEC's board is responsible for strong oversight of all LEC's operations, management decisions, and strategy setting. The MSC contract states that LEC's CEO (from ESBI) and the LEC board have the following roles and responsibilities:

- The CEO shall be fully accountable to LEC's board of directors for the achievement of the contract objectives. The CEO is responsible for keeping the executive management team and the board fully informed of activities and matters of importance to LEC. The board must be properly informed with information to make appropriate decisions and hold the operator (ESBI) accountable for all operations.
- LEC is responsible for developing all reports and deliverables, with LEC board guidance, for ultimate submission and approval by the LEC Board. ESBI was responsible for developing plans, models, and standards in consultations with the board, MME, and donors to meet objectives of the contract.

- Once the plan is approved, the board is responsible for work with LEC/ESBI, GoL, and donors to arrange funds for the identified projects in the Electrical Master Plan.

The CMC's 2018 annual report reported the following:

> LEC has continually struggled for survival since Liberian state institutions and agencies were re-launched after the restoration of democratic institutions in Liberia following the end of hostilities. In these circumstances it is not surprising to find that LEC had virtually no effective corporate governance in place when the ESBI management team assumed executive control on January 8, 2018. LEC did not have a fully constituted Board of Directors until May 2018. Its first meeting was held on June 6, 2018. Lack of a fully constituted Board of Directors for LEC was a serious breach of good corporate governance and posed significant risks in respect of both LEC's general business and its contract with MCA-L.

By the end of 2019, most stakeholders agreed that the LEC board—operational for just over one year—had not provided the oversight, support, and accountability required at LEC. The board has been ineffective at approving procurements and budgets and planning or monitoring and controlling treasury activities. The board had not identified and helped LEC manage risks, such as underfunding the OMT contract at MCHPP. As a key informant from MCC explained:

> [ESBI as the LEC operators] should have a utility board that is capable of managing a contract of this nature or hiring someone to advise them. We talked to them about doing that and there isn't one. This [is] partly due to the general lack of capacity in Liberia to implement an MCC program.

Respondents described how poor corporate governance can "derail operations." The LEC board was described as a "highly dysfunctional board" and too deferential to influence external to the board. Board members have lacked the time, knowledge, and capacity to oversee the utility. According to one board member:

> ESBI is not listening to the board. There's not a lot of private members; most are statutory members who are busy. [The] board needs subcommittees that can recommend decisions to LEC. The board meetings last for four hours. Some issues keep getting pushed and decisions don't get made.

Another board member explained as follows:

> I can't say that the board hasn't supported ESBI since they [ESBI] don't even bring things to the board. They have a lot of freedom.

Another MCA-L respondent stated the following:

> The board is not effective. Most government-owned entities have the same statutory entities sitting on the board. The problem is that these guys are on so many other boards. They are busy. They send a proxy who can vote, and proxies don't update them. More private sector and civil society members should be on the board instead of government people. [The] government wants representatives on the

> board since they are [a] 100 percent shareholder. But not too many understand the utility. There should be more board meetings. ESBI doesn't want to go to the board. They should get rid of one-third of the staff to make [the] — [the] board doesn't approve, then you can at least say you had a plan that wasn't approved.

MCC respondents explained that they observed situations in which they wanted ESBI to take action to solve a problem, but if the board was too busy to meet or it was not a board priority, the problem remained unresolved. For example, despite LEC entering the dry season with no financing to cover HFO for thermal generation, there was no LEC board meeting to strategize or discuss a potential plan and then advocate for that plan with the government. Respondents thought that adequate board performance ultimately "requires the government to understand that the utility is an asset that they own and that they are responsible for its proper functionality," so it should make the appropriate appointments and set expectations for the performance of each board member. A board member explained the GoL's challenges from his point of view:

> Government talks a lot, but they don't have the money to do anything. The president has a good heart, but he doesn't have the money to do anything. The finance minister is a good guy. They just don't have the money. LEC needs to stop thinking about debt and think about increasing revenue (especially given the budgetary constraints of the government). Right now, LEC is like a boxer with … hands tied behind their backs.

Board members anticipated that the compact closure would be problematic, given the loss of MCA-L participation on the board. "It's a big loss. If we lose MCC, then we lose our biggest funding source. Donor fatigue is increasing, but there's a small window where we can still get support for LEC." He offered the following suggestions to improve board performance and oversight (Table VI.1). The main point of the suggestions is to improve functionality and to break into smaller sub-committees to focus on these main goals.

In October 2019, a new chair of the LEC board was announced, with Senate approval expected in January 2020. Most respondents were concerned whether the new chair would be prepared for the role. Without the chair, preparations and implementation of the donor conference—in which ESBI advocates for the future business plan—may be on hold, given the lack of board oversight.

Table VI.1. Suggested reforms to the LEC board from a current board member

Suggested reforms			
1. The board, through its chairman, should form subcommittees to follow up on major issues at LEC. The key responsibility of these subcommittees is to ensure that issues discussed in board meetings are worked on and resolved speedily, as well as provide more information to the board. Below are the suggested subcommittees and targeted issues.			
LEC losses: • Loss of generated power (technical & non-technical) • Property lost • Work time lost	**Increase access to electricity:** • Increase customer base • Increase revenue	**Human resource & capacity building:** • Staff capacity building (training) to achieve long-term sustainability • Increase pace of turning over management operations to Liberians • Increase productivity and improve work ethics	**Project implementation & donor funding:** • Donor funding is forthcoming and, where possible, increased • Future and ongoing projects are successful (time, quality, & budget) • Donor matching funds • Single project with multiple donors; project stakeholder coordination
2. These subcommittees should report to the chairman and his board. The intent is not to perform management services, but rather foster the decisions of the board, as well as provide the board with more information for decision making. It is also intended to provide support to the management of LEC while targeting a profitable LEC in the near future.			
3. The management of LEC should provide the board with monthly updates. This will eliminate the rush to review a lot of paperwork before each meeting; it also will keep the board constantly informed for proper decision making.			
4. Management should provide the means for out-of-country board members to participate in board meetings via Skype or other means.			
5. Management should provide the means for the board to tour LEC facilities annually or biannually.			

C. Findings: How has Liberia's electricity tariff changed, and how much of the operating cost does it cover?

Liberia's current electricity tariff, at $0.35 per kWh, plus 10 a percent goods and services tax ($0.385 per kWh) for residential, commercial, and public corporation customers, is among the highest in the world. Figure VI.5 illustrates the tariff level for each customer class from January 2015 until October 2019 and Figure VI.6 shows the tariff for residential, commercial, and public corporations customers over this period. The average tariff was reduced in 2017, when the IMT led LEC and as MCHPP began generating hydropower at a lower cost than the thermal plants (Table VI.2). Note that even at the cost of $0.385 per kWh, LEC's high tariff is preferable to thermal generation for most customers. The WB estimates that the cost of operating a generator is nearly eight times greater than the price of grid electricity, at about $4 per kWh (National Millennium Compact Development Project and Government of Liberia 2013).

Still, the GoL and other stakeholders have pressured LEC to lower tariffs, given that affordable electricity is fundamental to economic and human development. Further, MCHPP does in fact reduce generation costs, from a high of $0.25 for thermal generation to $0.10 per kWh for hydropower. The Cote d'Ivoire, Liberia, Sierra Leone, and Guinea (CLSG) power would cost $0.17 per kWh. Note that, as Table VI.2 shows, costs may decrease over time, particularly for hydropower. One risk with CLSG power is that if theft is not curtailed, access to this power could result in increased debt for LEC, given that there "will be more electricity to steal."

Figure VI.5. Average tariff charge, by customer type (USD/kWh)

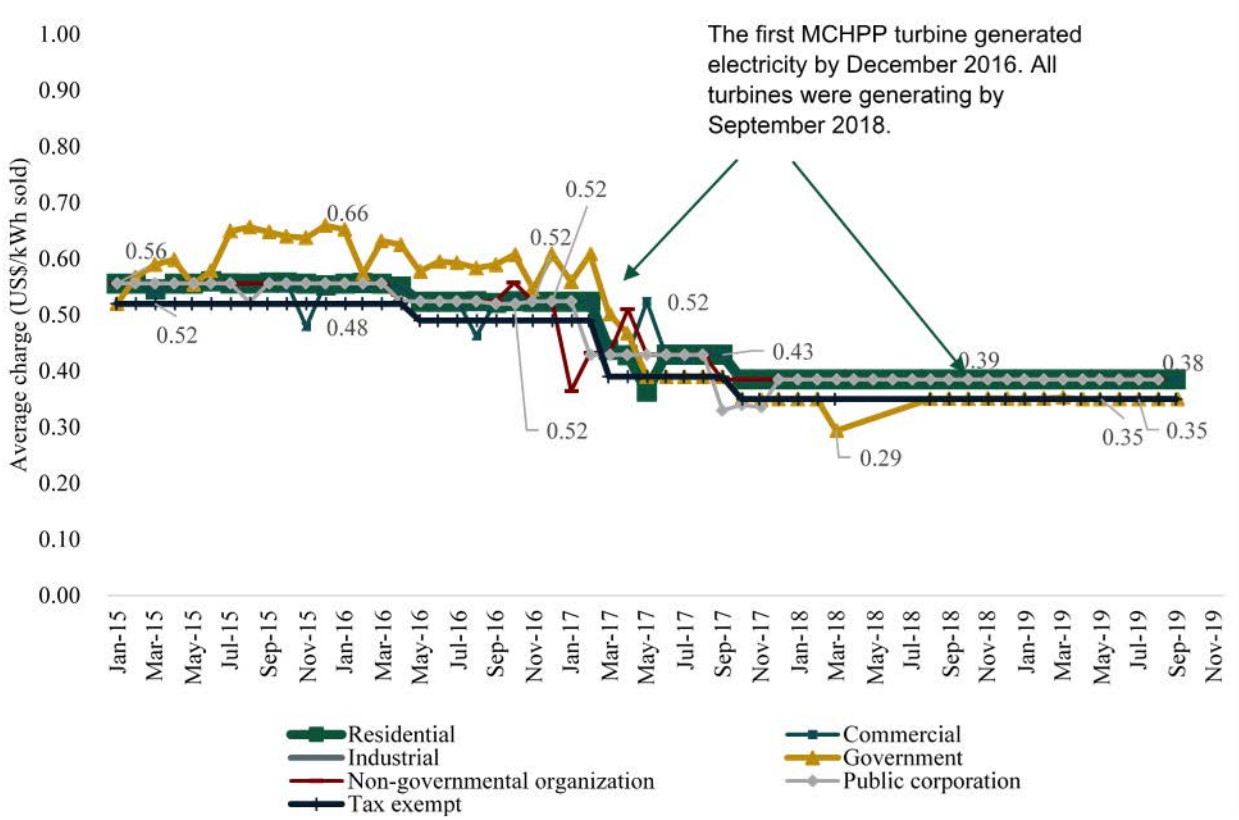
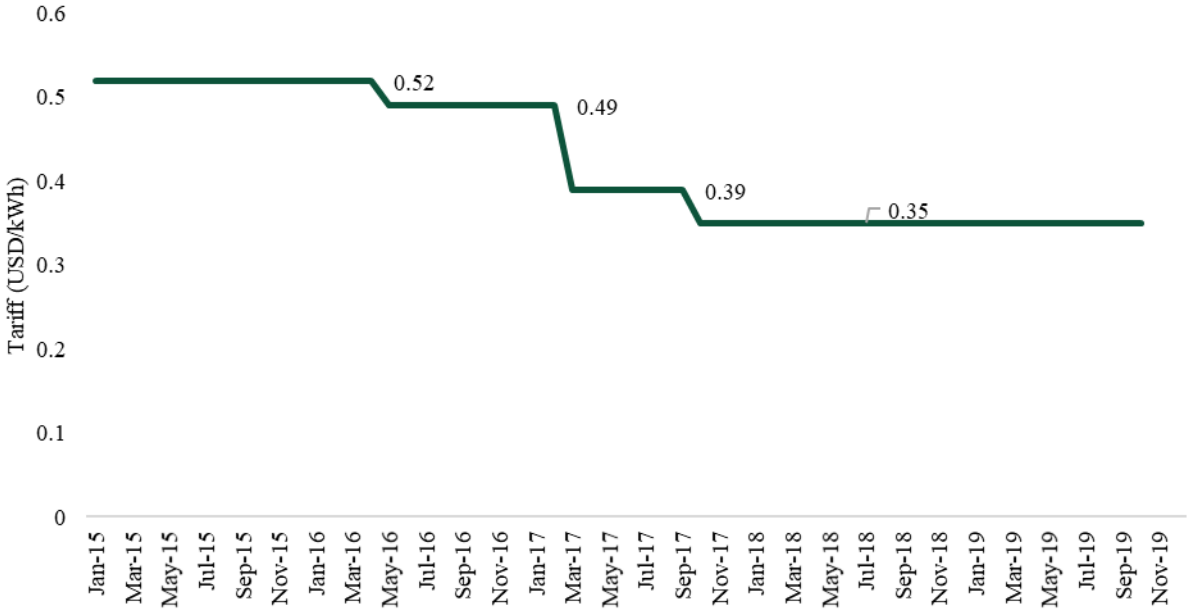


Figure VI.6. Average tariff (pre-tax) 2015–2019



In response to pressure from the GoL to reduce the tariff, ESBI has modeled a reduced tariff of $0.30 per kWh for the first 20 units of electricity consumed by all residential customers. A $0.30 per kWh tariff for all customers would require "additional funding of US$77 million" over five years (Table VI.3, Figure VI.7) (Macro Consulting 2018). The report states, "Due to the magnitude of such impacts and the prevailing financial circumstances, LEC does not recommend any tariff reductions during the period." Note that the 2018 Liberia Electricity Corporation Cost of Service Study funded by the WB suggested a structure in which residential customers pay a flat charge of $0.316 per kWh, with a fixed charge of $4.80 per month. For those households consuming less than 50 kWh per month, the report suggested a charge of $0.219 per kWh. Nonresidential customers would pay $24.50 per month and $0.20 per kWh. However, the study's models were based on outdated data and the authors recognize the impact the tariff would have on LEC.

Table VI.2. Generating unit cost projections, US$ per kWh

	2019	2020	2021	2022	2023
Thermal $	0.25	0.24	0.24	0.24	0.24
Hydro $	0.10	0.06	0.06	0.05	0.05
CLSG $	0.17	0.17	0.17	0.17	0.17
Total costs per kWh billed	0.69	0.36	0.29	0.28	0.28

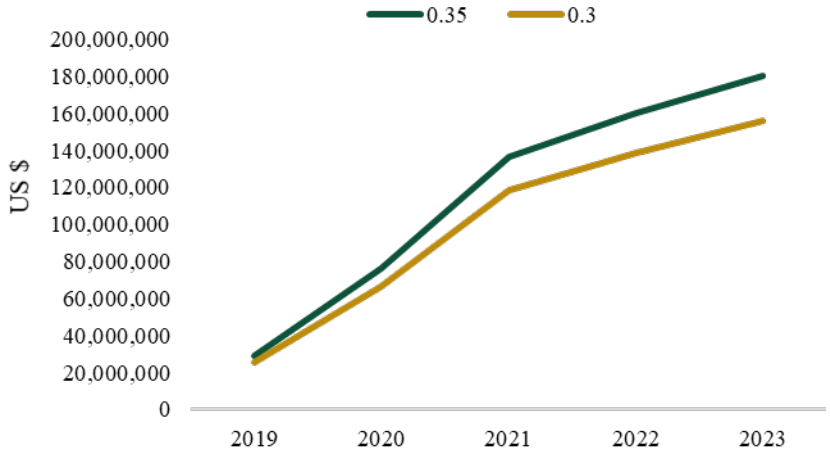
Source:LEC Business Plan 2019

Table VI.3. Projected revenue based on current and reduced tariff

USD	Tariff	2019	2020	2021	2022	2023	Total
Revenue at normal tariff	0.35	29,091,981	76,341,505	136,462,642	159,931,408	180,088,346	581,915,882
Revenue at reduced tariff	0.30	25,324,749	66,530,313	118,442,707	138,730,262	156,179,108	505,207,139
Reduction in revenue		3,767,232	9,811,192	18,019,935	21,201,146	23,909,239	76,708,743

Source: LEC Business Plan 2019

Figure VI.7. Reduction in revenue with a tariff reduced from $0.35 to $0.30



A US$0.05 reduction in the tariff would reduce revenue by $3.7 to $23.9 million per year, or an estimated $76.7 million over five years. At the same time, LEC's operational expenses would increase to cover the cost of additional customer connections and care and T&D maintenance and repair. Note this assumes customer connections increase over time.

Among focus group (FGD) respondents (from households in connected and unconnected communities) the Liberian perspective on the cost of tariffs fell into two main categories: Liberians who are economically better off and regularly use different energy sources, and Liberians who are economically worse off and struggle to afford even basic energy sources, such as candles and batteries. The first group finds the cost of LEC acceptable and an improvement over generator costs. Their concerns are about electricity quality and outages. The second group cannot afford LEC. One respondent explained as follows:

> If LEC wants us in the interior to enjoy the current, I want them to drop the USD. Let them leave the USD. We are Liberians, let them be charging us in Liberian dollars. If they come up with the charges in Liberian dollars, everybody can be able to afford it. But this USD is what [is] creating the problem … We that are in the bush, we are not working … not working in government or any company … If they want us to enjoy it, let them put it in Liberty. If they put it in Liberty, then I can pay it. If they talk about US$10, I don't have money to buy food for my children; we will be sleeping in the darkness.

This respondent demonstrates that for low-income Liberians, the reduced tariff of $0.05 per kWh still would not enable them to access LEC. Admittedly, a reduced tariff would allow customers to spend their savings on other necessities; however, the reduced price of hydropower compared to thermal power may be the only reduction achievable at this time. Given LEC's extremely tenuous financial situation, which went from bad in 2016 to worse in 2019, a tariff reduction is financially irresponsible, with LEC's high operating costs relative to electricity sales, low customer connectivity, and exceedingly high commercial and technical loss rates. Still, ESBI is considering the reduced tariff to bolster GoL support for the utility.

D. Findings: Has LEC's management improved with ESBI as the MSC?

Next, we examine changes in LEC management and the extent to which it has improved with ESBI as the MSC. In this section, we aim to narrowly focus on ESBI's management and utility outcomes to answer the utility-level evaluation questions. Note the following:

- Section IV.B.1.b. provides background on the MSC contract.
- Section IV.B.2.b describes the contract vehicle.
- Section IV.B.2.c presents an assessment of whether contracts were implemented as planned, implementation quality, and external factors affecting implementation.
- Section IV.B.3 presents a summary of implementation successes, challenges, and lessons.
- Grid-level outcomes, such as generation and electricity quality and reliability, are presented in Section VII.

Next, we assess ESBI's management and outcomes such as electricity supply, commercial operations, customer service, operational costs, and donor project coordination.

1. How has ESBI's management affected electricity operations, including supply, sales, and losses?

We next provide an overview of LEC's electricity and commercial operations, with a focus on presenting trend data on critical electricity outcomes for the past five years. Again, each turbine at MCHPP became operational from November 2016 through September 2018, generating up to 88 MW for six months of the year. Also, ESBI assumed management of LEC in January 2018.

ESBI's four priority key performance targets (KPIs) are as follows: **aggregate technical and commercial losses** (AT&C), **operating cost per kilowatt billed** (see Section VI.D.3), **network performance** (see Section VII.B.2), and **number of new connections** (Section VIII.B.1). We examine each of these KPIs in subsequent sections, using monthly administrative data from 2015 through 2019 primarily sourced from the Tetra Tech LEC data workbook and the LEC IMS. Note that final fourth quarter 2019 data were not received before report submission.

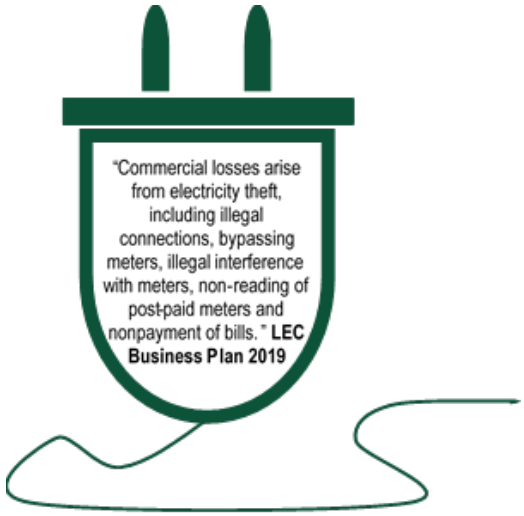


Figure VI.8. Results of a 2016 meter inspection

LEC periodically conducts meter inspections and documents the status of meters. In a 2016 audit of 5,347 meters, LEC documented that 38 percent of meters were faulty, 13 percent were providing free power, 17 percent had been tampered with, and less than a third were functioning properly (Tetra Tech 2016).

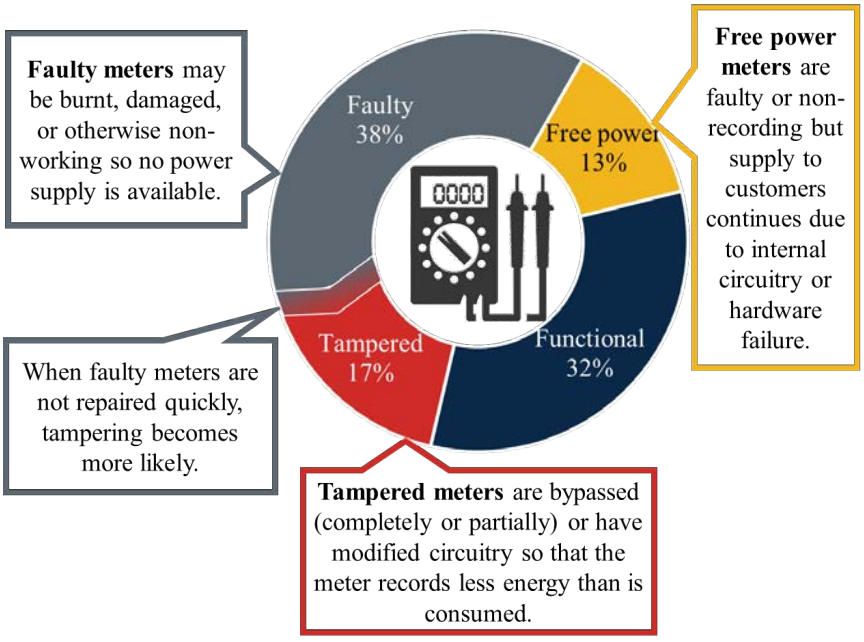


Figure VI.9 (page 80) illustrates the almost fourfold increase in total electricity supply (in MWh per month) from 2015 to 2019 compared to total electricity sold, which has only doubled. Peak demand increased from 10.2 MW in January 2015 to a high of 36.3 MW in March 2019, and 30 MW in October 2019 (despite 88 MW of generation capacity). The modest sales compared to supply is due to LEC's inadequate T&D infrastructure, limited capacity to connect new customers, and delays in donor-funded customer connection projects. If all customers who wanted to connect could do so, we would expect to see a much higher peak demand.

Next, Figure VI.10 plots total electricity supply in MWh, with the technical and commercial losses for comparison. Technical losses increased almost fourfold, from approximately 500,000 MWh in January 2015 to 1.9 million MWh in September 2019. More strikingly, commercial losses increased from about 1 million MWh in January 2015 to 10.8 million MWh in January 2019, dipping modestly to 9.3 MWh in September. Commercial losses are the primary source of LEC's major financial losses. Figure VI.11 plots technical and commercial losses as a percentage of supply that is lost. Since 2018, commercial losses have steadily risen and stabilized around 58 percent, for a total loss rate of about 70 percent. Figure VI.12 is slightly different from the previous figures; it shows—in one image—total electricity supply, sold, and lost. Of course, the goal is for supply and sales to converge and losses to decline. ESBI has only recently begun to make modest reductions in commercial losses. In interviews with ESBI staff, they explained how their understanding of the problem has changed over time:

> In the absence of metering, we were unable to measure with certainty …. We realized around Q4 of 2018 that we needed to shift focus from residences to large businesses. We identified large numbers of businesses that were connected with a tampered meter. More highly qualified staff were involved in this tampering. This was a challenge initially, especially due to the lack of a legal framework to deal with this. We need to have zero tolerance. These guys are skilled. We also had the issue of the deputy managing director—[the] president's appointee—who was causing issues.
>
> We put in systems, including IMS, which was crucial, as well as procedures to tighten various operations. It took a while, but we also got an HR person. We worked with the government, the Ministers of Mines and Energy, Justice, and Police. We were able to create a taskforce to influence the top of the administration. You need a framework to talk to the president. So this is a success, passing the Power Theft Act [August 2019], and we influenced the president to focus on power theft in his State of the Union speech. The outgoing LEC board chairman also pushed this. The Minister of Justice helped draft the law. It helped having donor support.

In 2018, ESBI understood commercial losses to be driven by residential customers (ESBI presentation to HLSG 2018) and created a strategy to reduce power theft in communities. For example, in 2019, LEC replaced faulty meters, including 2,838 single-phase prepaid meters, in the first quarter (Q1), 2,712 single and 124 three-phase (pre- and postpaid) meters in Q2, and 4,823 single and 109 three-phase meters in Q3 (CMC 2018, 2019). Additionally, LEC made meter inspections and audits, implemented a community engagement strategy in which it made 142 community visits, and held a workshop with 40 community leaders by the end of Q3 to talk to business associations and leaders about theft.

However, by 2019, LEC realized that 60 percent of losses were from large commercial customers (CMC 2019). Given ESBI's revised understanding of the multiple drivers of commercial losses, it has formulated a commercial loss reduction strategy in the LEC Business Plan 2019:

> Reduction of commercial losses requires a rigorous campaign of meter inspections, installation of new secure meters and replacement of damaged meters, enforcement of strict meter reading and billing procedures and public information, coupled with the enactment and rigorous enforcement of legal remedies to deter electricity theft. The following steps need to be carried out:
>
> - The greatest contribution to revenue is from secure large/post-paid customers and donor-funded customers. Install high-security, tamper-resistant metering systems for commercial customers, both new and those currently connected.
> - Ensure a prepaid metering normalization process. Institute tamper-proof meter and service connection replacement for all new and prepaid customers at an installation rate of 1,000–2,000 to December 2023. Ensure meter installation on residential premises (which residents can monitor), not the pole (where tampering is easily done at night).
> - Persuade donors to consider close to 100 percent saturation on electrification of new areas to reduce the occurrence of theft among the unconnected.

ESBI has a sound, yet resource-intensive strategy, requiring meters and materials, adequate staff, and the political will to ensure that LEC's activities are not reversed and penalties enforced if energy theft persists. Many stakeholders expressed measured optimism that ESBI would be able to reduce losses and acknowledged positive developments, including the Senate's unanimous passing and president's signing of the Power Theft Act and revised approach. Respondents also agree that without the MSC, LEC would not have performed better than ESBI. ESBI continued to request $1.2 million from donors for additional meters to increase the rate of replacement. ESBI staff explained as follows:

> It's very easy for stakeholders to say that we need to take care of theft. But we tried to explain that it's not just LEC that was failing.
>
> Every time we expand the network, we are also risking theft. So, we have to shift focus from just building lines to customer additions. *(See for example Chapter VIII which maps illegal connections in donor project areas.)*

2. How has ESBI's management affected commercial operations, including billing, collections, and aggregate losses?

LEC's billing efficiency (or the amount of kWh billed to customers divided by the amount generated) has decreased over time, from about 76 percent in 2015 to a range of 34 to 43 percent in 2019 (Figure VI.13). This inadequate billing undermines LEC's financial performance. LEC's collections efficiency (or the amount of money collected from customers divided by the amount billed) has fluctuated wildly, from 21 percent to 376 percent. This large range is generally due to the GoL not paying and then finally settling outstanding bills.

The next illustrates LEC's aggregate technical and commercial losses (AT&C), a KPI of ESBI's contract (Figure VI.14). AT&C is a measure of the overall efficiency of the distribution business, or the difference between energy input in kWh units and the number of units paid for in kWh. Although the global average for AT&C losses is under 9 percent, few countries have rates above 30 percent (World Bank 2018). However, Liberia's rate ranged from 62 to 71 percent throughout 2019. The AT&C highlights the extent of LEC's disappointing inability to improve billing and

collections, albeit with modest reductions from May to August 2019. Again, ESBI's strategy is to regularize large customers with tamper-resistant meters, grow the large customer base, leverage donors to saturate communities with connections, and convert illegal to legal connections. Further, ESBI aims to implement a behavior change strategy that makes it easy for customers to transition to a regularized status even if there has been substantial theft in the past.

LEC's electricty sales for each customer class in MWh and U.S. dollars are shown in Figures VI.15 and VI.16. Residential customers account for the largest share of MWh sold and dollars collected (Figure VI.17). Government and commerical customers are the next largest classes of customers, measured in MWh. ESBI's collections have been hampered by lack of ownership of the prepaid vending process, the GoL's failure to pay bills, and widespread commercial theft and meter tampering. Other customers from industry and nongovernmental and tax-exempt agencies do not account for enough sales to substantially improve LEC's cash flow.

Figure VI.9. Total electricity supply, electricity sold, and peak demand

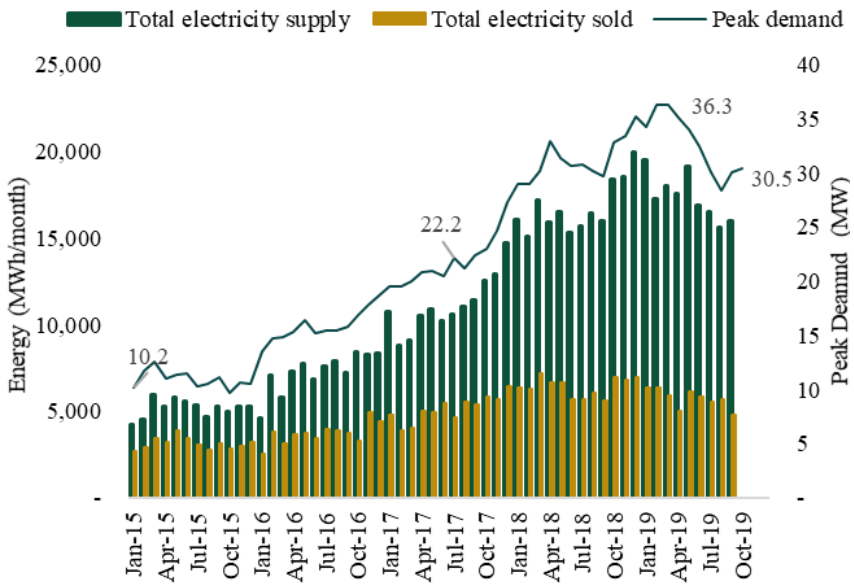


Figure VI.10. Total electricity supply and losses in MWh

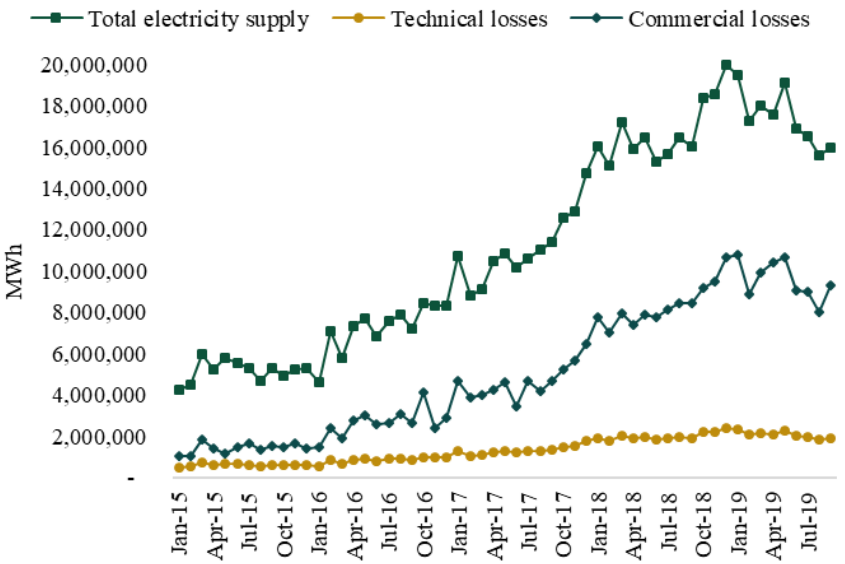


Figure VI.11. Technical and commercial losses

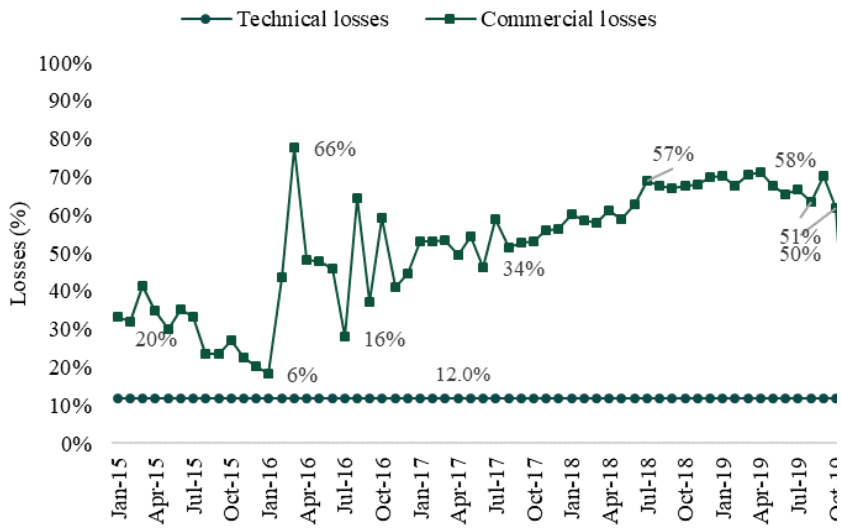


Figure VI.12. Total supply, electricity sold and total losses

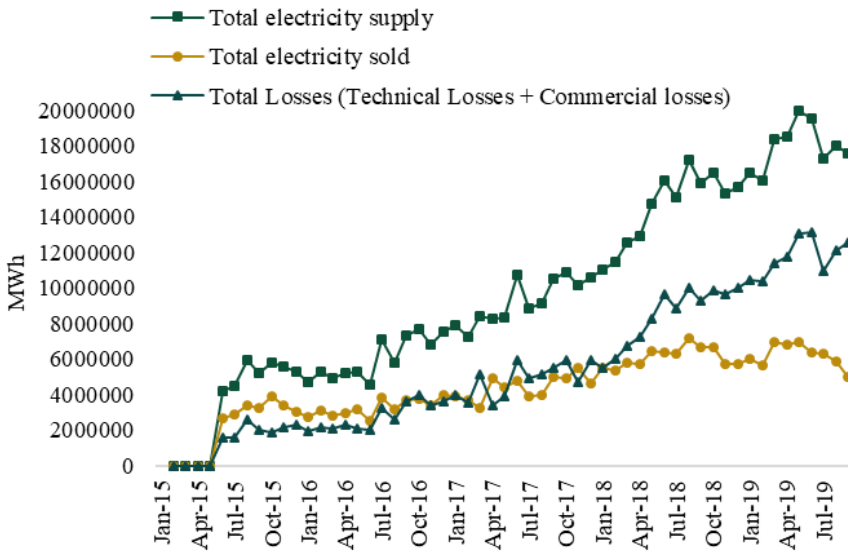


Figure VI.13. Billing and collection efficiency

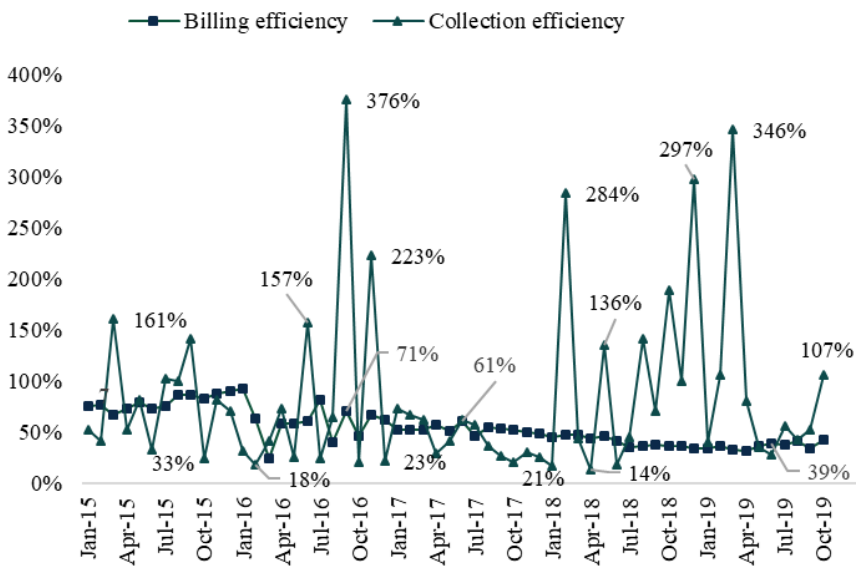


Figure VI.14. Aggregate technical and commercial losses (AT&C)

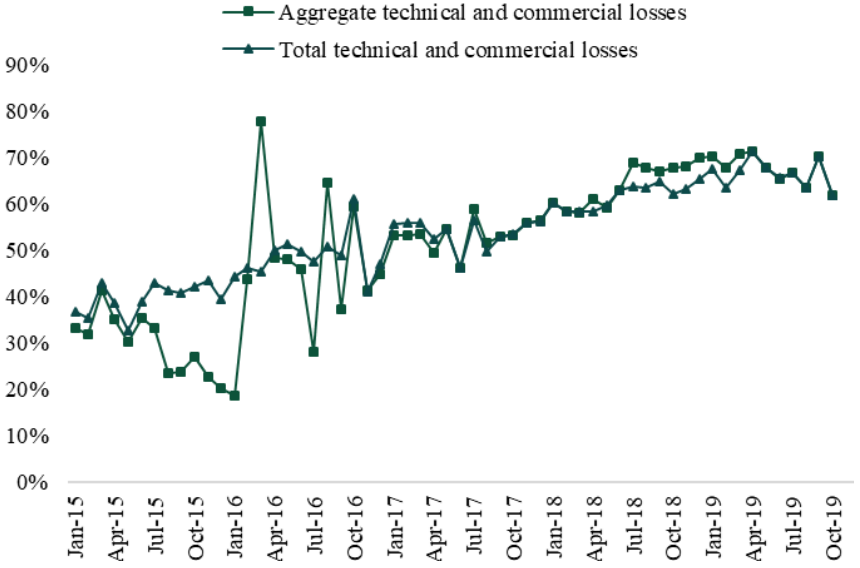


Figure VI.15. Total electricity sold in megawatt hours (MWh)

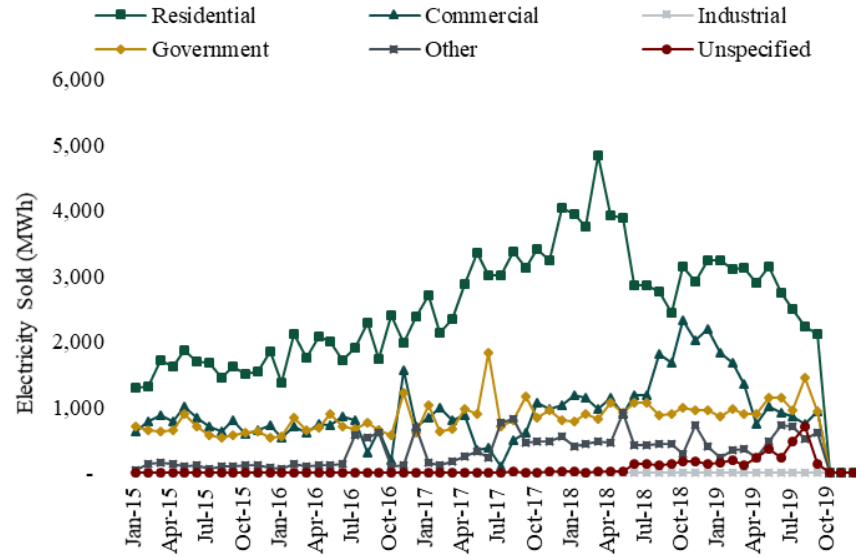


Figure VI.16. Total electricity sold in US$

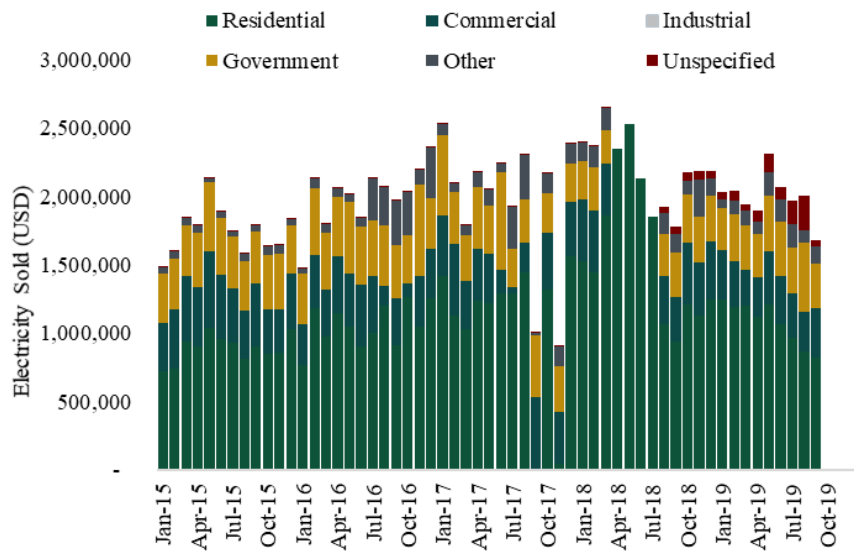


Figure VI.17. Customers as a share of total consumption

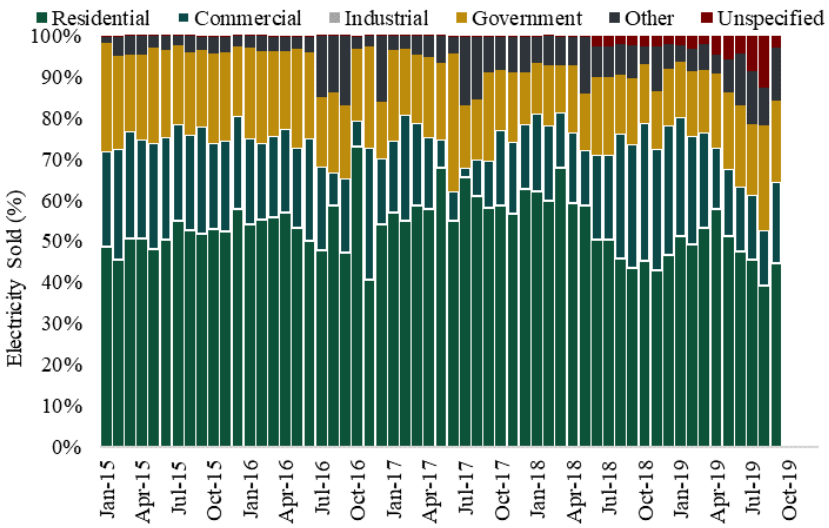


Figure VI.18. Operating costs per kWh sold

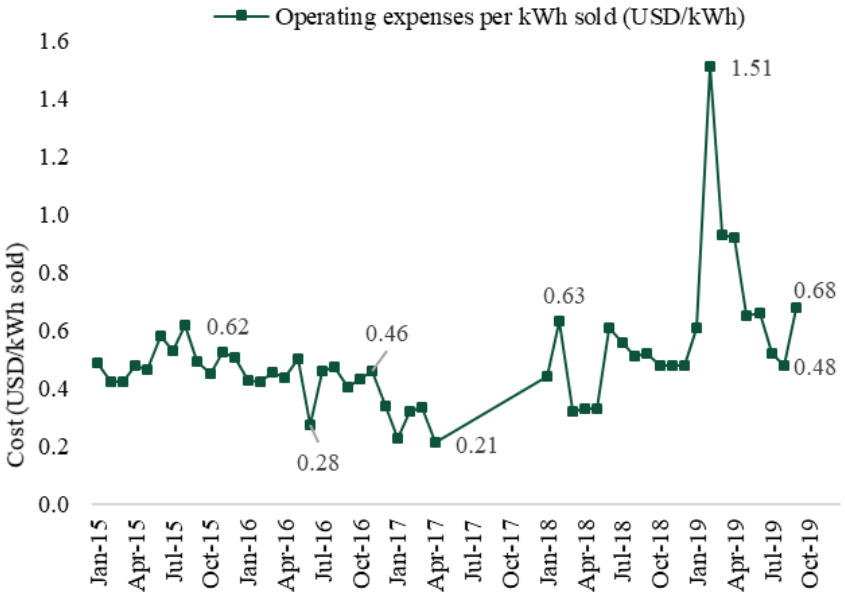
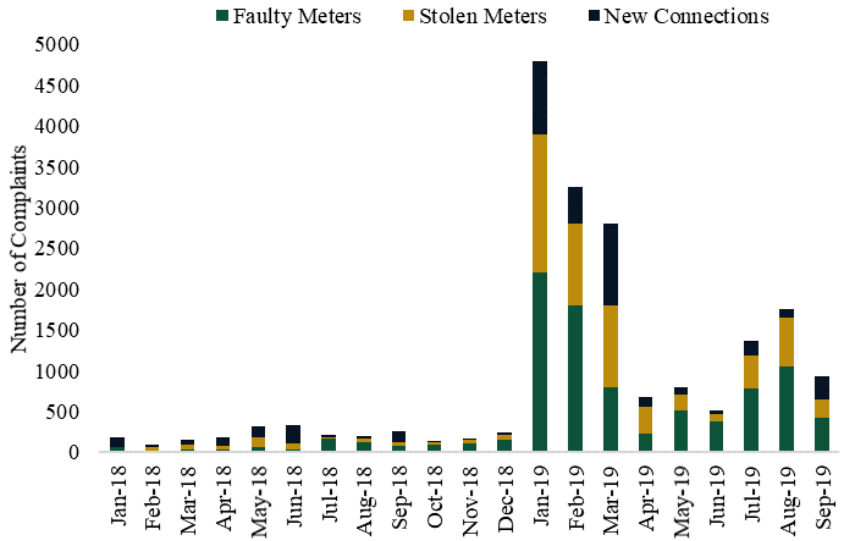


Figure VI.19. Customer complaints



3. How has ESBI managed operational costs?

LEC's operating costs per kWh sold is a KPI in the MSC contract, with the baseline agreed value of $0.64 per kWh and a target of $0.45 for 2018. Figure VI.18 illustrates that operating costs were high during the previous MSC, decreased during the IMT, and increased in spikes with ESBI. Note that data were missing for May to January 2017; however, the IMT's action to increase LEC salaries undoubtedly raised operating costs, as this expense accounts for 50 percent of operating costs during the dry season. The average operating cost for 2018 was $0.47—just above the value that would trigger a bonus for the MSC. The dry season spikes in operating costs are due to fuel costs. ESBI can reduce operating costs as a percentage of revenues by connecting more customers (which requires completion of donor projects and resources for meter installation), reduce salaries or the mix of staff (which it has done), and secure lower-cost fuel for the dry season (which it has not done successfully for 2020).

4. How has ESBI's management affected customer relations, the customer database, and service?

LEC has a poor reputation for customer service and has even lacked critical customer information. Customer complaint data are shown in Figure VI.19. (Note that complaints jumped in January 2019 because there was a place for customers to complain.) When ESBI took over LEC management in January 2018, the utility lacked ownership of a customer database. The IMT had transferred operation of a vending system to a local Liberian company (Libango) to manage prepaid customer sales for a commission, and ESBI inherited a 10-year contract. LEC had limited access to the system, despite the critical importance of a utlity company having access to customer information, and Libango refused to provide a copy for LEC to use for analysis. By Q3 of 2018, LEC had realized that the Libango system lacked capabilities to update customer or connection fee information, and customer entries lacked meter and residential locations. When LEC notified Libango of its intent to replace the system, Libango threatened legal action. Following negotiations, ESBI was able to sever the contract without legal action and acquire the database in Q1 2019. With the new Indra IMS, LEC began the process of transferring, cleaning, and validating all customer data into the Commerical Management System (CMS) module of the IMS. ESBI intends to continue to reconcile, validate, and update the CMS, and will acquire all customer data with the Asset and Customer Mapping Study to be implemented in 2020.

Before the MSC, LEC had one small customer service center with no systems, one telephone line, no facilities for 16 agents, no facilties for walk-in customers, and no ability to follow up on customer complaints. In 2018, LEC installed and advertised a new customer phone system, which was equipped with a dedicated line for whistleblowing and customer service complaints. In Q1 2019, ESBI appointed a customer service manager to develop a strategy, including refurbishment of a service center at LEC Headquarters at Waterside. By Q2, a web portal for customers and the general public was launched, offering self-service for new connections, information requests, and complaints (Figure VI.20). In Q3, LEC implemented a 24-hour call center and began focusing on monitoring and reporting customer service KPIs and agreeing with LERC on quality-of-service benchmarks, including reporting on response times for processing

new connections, meter replacements and complaints, and outage management. The dramatic increase in complaints from 2018 to 2019 is apparent. The majority of complaints were due to faulty and stolen meters. Although complaint resolution data are still outstanding, the new systems that ESBI aims to implement should help fill this gap. Importantly, LEC requires the operating and capital resources needed for meters, tools, and other equipment necessary to resolve the complaints. The LEC Business Plan 2019 estimates the cost of meter upgrades and new connections at $26.7 million for 2019–2023.

Figure VI.20. LEC customer portal: https://portal.lecliberia.com

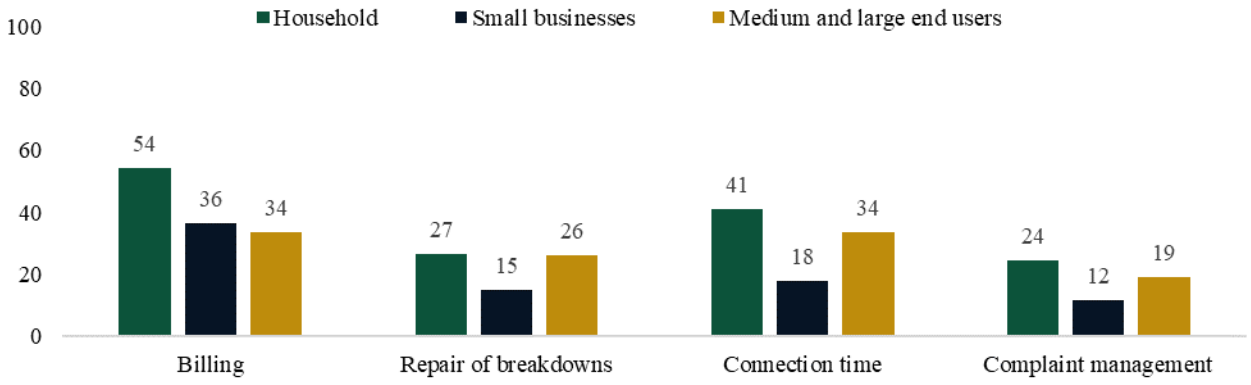
5. How has ESBI's management affected customer satisfaction?

Respondents from household, small business, and medium and large organizations in connected communities across Monrovia rated satisfaction with LEC's customer service in different areas (Figure VI.21). Overall, household customers had the highest rates of satisfaction with LEC in billing, repair of breakdowns, connection times, and complaint management, whereas small businesses had the lowest levels of satisfaction, except for billing; in this area, medium and large end users had the lowest satisfaction. We will follow these measures at the interim and endline data collection periods to measure changes based on LEC's reform agenda.

Next, we asked survey respondents what they thought were the main disadvantages of LEC electricity (Figure VI.22). All respondent types reported that unreliable service was the main disadvantage (48 percent of households, 65 percent of small businesses, and 79 percent of large businesses). Forty percent of small business owners said that paying bribes for connectivity was a main disadvantage. This figure stands out because it appears small businesses are targeted for bribes more so than households (16 percent), potentially because small businesses may have

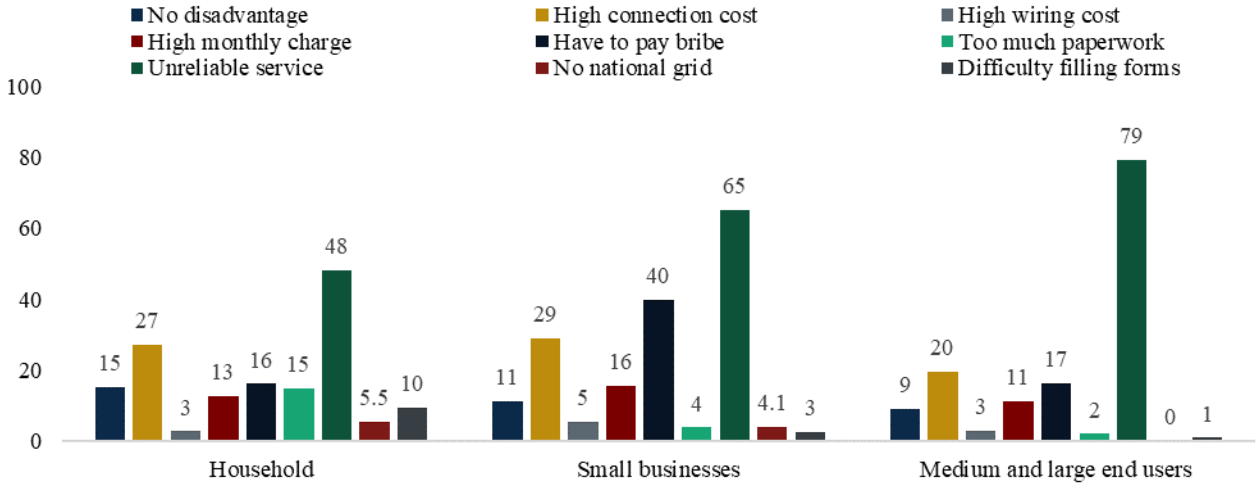
more resources than households. High connection costs were a disadvantage cited by 27 percent of household, 29 percent of small business, and 20 percent of medium and large end users.

Figure VI.21. Percentage of customers somewhat or very satisfied with LEC's service



Sample size: Households (n = 1,174), small businesses (n = 311), large organizations (n = 97).

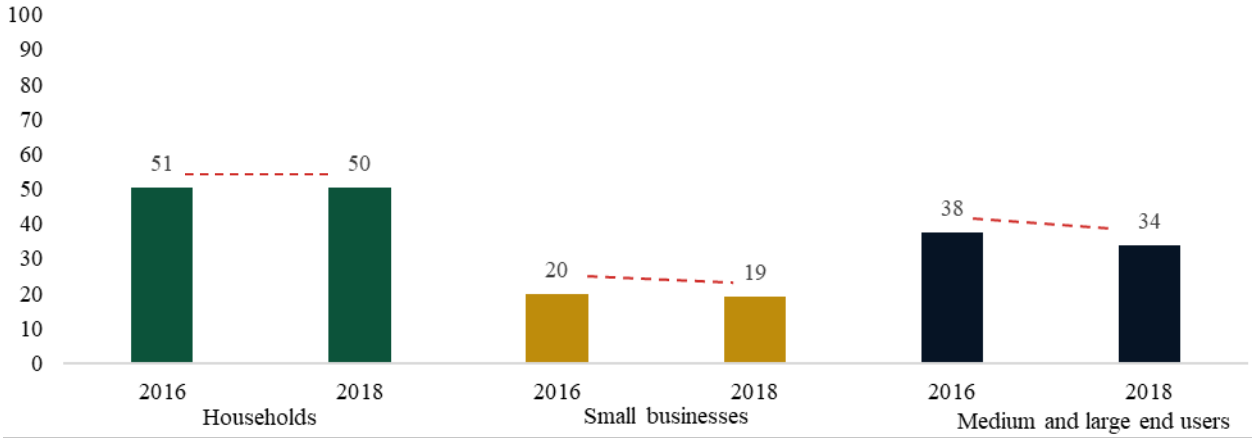
Figure VI.22. Customer reports of the main disadvantages of LEC electricity



Sample size: Households (n = 1,174), small businesses (n = 311), large organizations (n = 97).

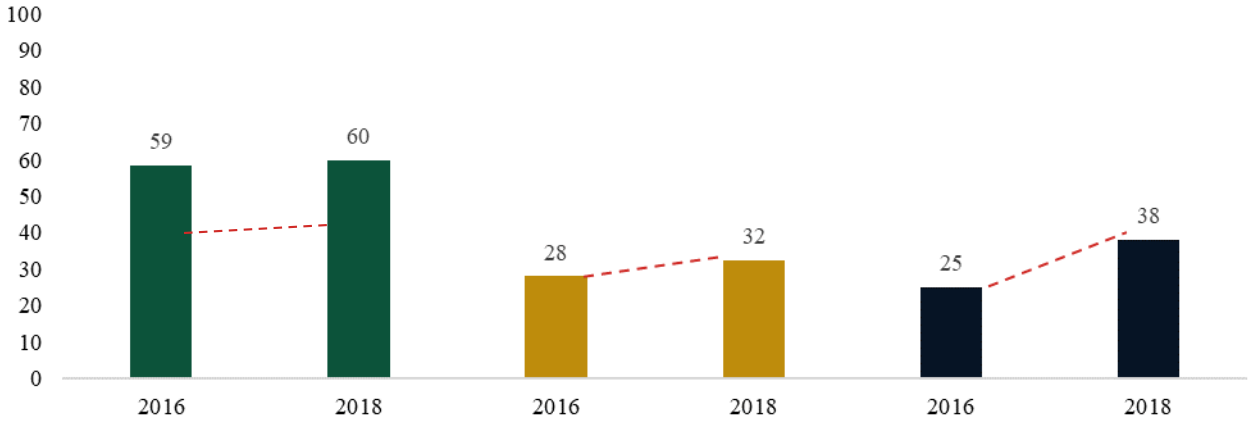
The next question we asked end users was about their satisfaction with LEC's customer service and the quality of electricity in 2016 and 2018. They were asked to retrospectively report on satisfaction from 2016 (Figure VI.23). Overall, household and small business respondents reported no change in their level of satisfaction with customer service, whereas medium and large customers reported somewhat less satisfaction during that period (38 percent in 2016 versus 34 percent in 2018). Customers reported improved satisfaction with electricity from 2016 to 2018, particularly small business owners (28 percent satisfied in 2016 compared to 32 percent and 25 percent, respectively, in 2016, and 38 percent satisfied in 2018) (Figure VI.24). We provide additional insights into customers' perceptions of LEC in Chapter VIII. Again, we will follow these outcomes over time at interim and endline to measure changes in satisfaction based on LEC's reforms.

Figure VI.23. Customers who are somewhat or very satisfied with LEC customer service



Sample size: Households (n = 795 in 2016, 1,162 in 2018), small businesses (n = 73 in 2016 and 301 in 2018), large organizations (n = 32 in 2016 and 70 in 2018).

Figure VI.24. Customers who are somewhat or very satisfied with LEC electricity

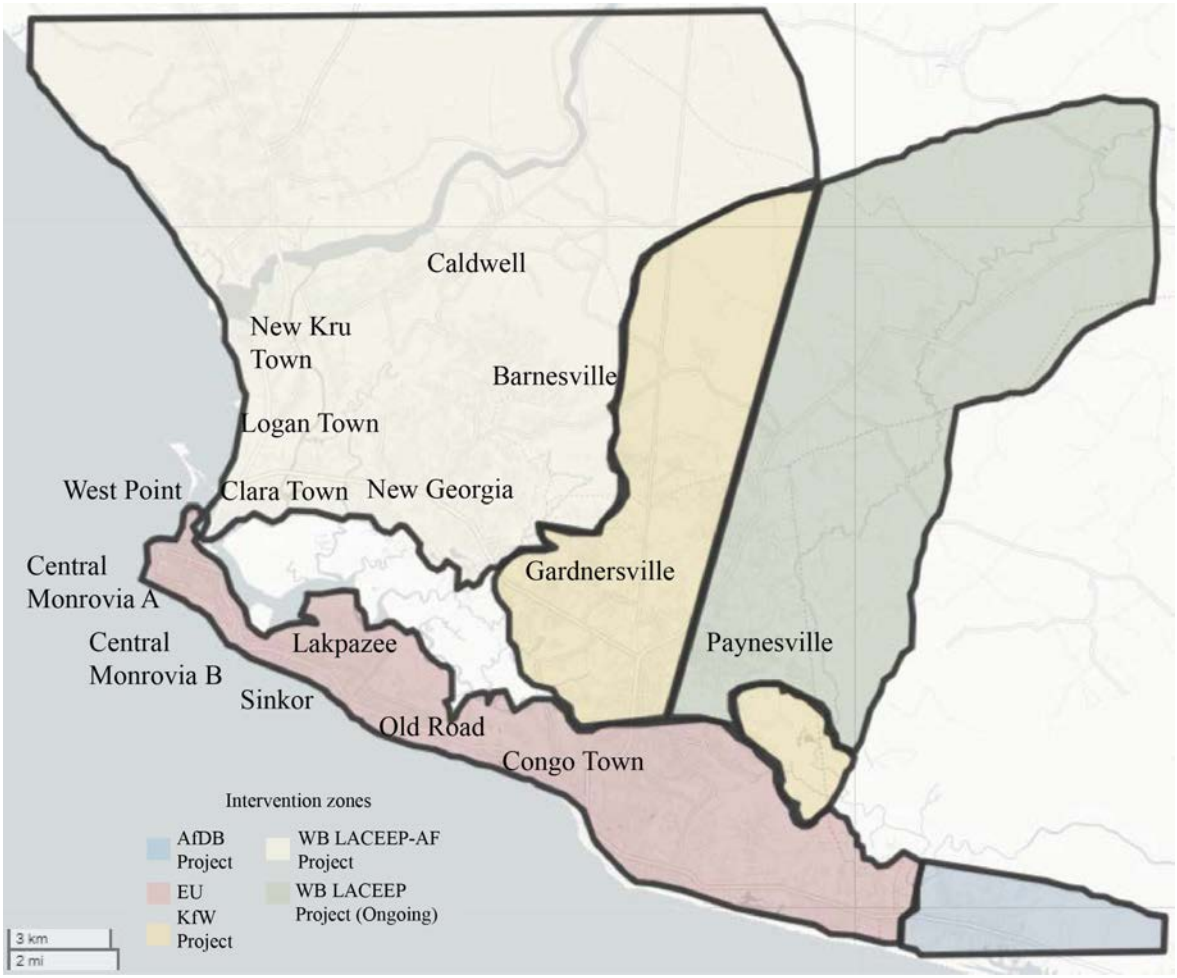


Sample size: Households (n = 800 in 2016, 1,169 in 2018), small businesses (n = 73 in 2016 and 303 in 2018), and large organizations (n = 32 in 2016 and 71 in 2018).

6. How has ESBI's management affected managing donor-funded projects?

As the MSC, ESBI also assumed the role of overseeing and liaising with all the large donor-funded T&D projects – given LEC is the official owner of these projects – worth about $200 million (excluding MCHPP). Donors (AfDB, EU, KfW, MCC, NORAD, USAID, and WB) each worked with different goals, plans, procedures, interested stakeholders, contractors, and funding. They aimed to coordinate across the crowded energy sector to avoid replicating any investments; however, each agency made decisions based on the goals of their own organizations. The MME was unable to devise a sector strategy, and neither the IMT nor MSC could provide direction, so donors divided Monrovia and the surrounding areas into zones and focused on customer connections (Figure VI.25). Although a practical approach in theory, in practice, plans were made before the MSC completed a network analysis to identify system capacity and weaknesses across the T&D infrastructure.

Figure VI.25. Donor-funded project zones (LEC)



The donor-funded projects across Monrovia and their current status are shown in Table VI.4. Each of these projects has been delayed by several years due to challenges with procuring contractors; failed contracts; problems with design plans; resettlement challenges; and LEC's limited ability to make new customer connections, given that transformers, feeders, and circuit breakers have been overloaded. ESBI was transparent about its lack of ability to manage all these projects.

> From our perspective, we need a contracts manager. We are fundamentally comfortable with problem solving at the utility. We knew things were radically different from the expectations. It was genuinely not our space. We really needed contract support. But this might not be productive, so we needed a broader vision for what we want to do. It took 12 months to understand the problem.
>
> Donors haven't realized the gaps in the system, and the absence of an overarching managing system is a big challenge. This should have been the role of the LEC, but that was not the case. Every donor came in with good intentions but wants to do flashy things, not the things that aren't flashy but could be very helpful. We are having problems with the touchpoints between donor projects [and the] government. There is no provision for growth in the scope of work for these plans. In the decision making, they [donors] must think about where Monrovia is going to be in the future. People are migrating to this city daily.

> There was a minimal feasibility assessment conducted by donors. They just assumed that [the] existing network will work well. Donors assumed there are functional communities where LEC will collect revenue. Power theft is huge. And LEC is not able to collect revenue to fund capital expenses. The donors/government should recapitalize LEC. They should make sure that all people in [a] community should get access to LEC BEFORE moving to new areas, otherwise, we are motivating power theft. You must invest in transmission lines [and] transformers, and fund other capital expenses. They should invest in training.
>
> We should have written comprehensive standards and specifications that donor projects should have followed. USAID equipment doesn't comply with any standard used in West Africa or Europe—completely American design.

Respondents from the donor agencies reflected that, given years of delays with the T&D projects, funds may have been used differently if they had had a better understanding of the network deficiencies and LEC's needs. In hindsight, stakeholders agreed that priority should have gone to repairing the low-voltage network before trying to connect thousands of customers. Additionally, both donors and LEC relied on project contractors to design the distribution and connection plans. Neither the donor agencies nor LEC could provide exact information on where new connections would occur. Ultimately, project designers decided to construct poles and lines such that only a portion of communities would be connected, rather than saturating the communities. By implementing this approach, energy theft increased because connected customers shared power with neighbors. If the communities had been saturated, there likely would not have been as much of an increase in residential power theft in newly connected communities.

Table VI.4. List of T&D investment locations, expected number of connections, and implementation status

Location of T&D investment	Components	Expected number of connections	Status of project Status as of November 12, 2019
World Bank: Liberian Accelerated Electricity Expansion Project (LACEEP)			
Paynesville-Kakata corridor ($35 million concessional loan)	Transmission lines Paynesville and Kakata substations	17,000	• Supply and Installation of 66kV Paynesville-Kakata transmission line (TL) (Lot 1) - Work is progressing on the Kakata TL, adequate resources being deployed, contract completion expected April 2020 - Substation is awaiting commissioning and handover to LEC • 33kV Distribution network and customer connection in Kakata (Lot 2) - Pole erection completed, stringing ongoing in Kakata and Weala - Some WB connections are ready boards rather than full wiring of the house or business
	Distribution network		• 22kV Distribution network and customer connection in the community of Paynesville (Lot 3) - Pole erection completed, stringing ongoing - Customer connections ongoing in Soul Clinic, additional connections after December 2019
Bomi corridor ($60 million concessional loan)	Transmission lines Stockton Creek, Kle, Virginia, and Gardnesville substations	20,000 to 30,000	• Monrovia-Bomi corridor (transmission lines and substations) - Construction ongoing at all but one substation (Stockton Creek) - RAP compensation ongoing from Paynesville substation to Virginia substation • Monrovia-Bomi corridor (Distribution Lot 1) - Works are ongoing, customer connections expected December 2019 in Caldwell and other communities • Monrovia-Bomi Corridor (Distribution Lot 2) - Bid evaluation completed, contract was expected to be awarded in November 2019
Monrovia	Distribution network		Construction of 22kV network and low voltage connections in 18 communities

Location of T&D investment	Components	Expected number of connections	Status of project Status as of November 12, 2019
African Development Bank (AfDB): Liberian Energy Efficiency and Access Program (LAEEP)			
Roberts International Airport (RIA) corridor ($21 million concessional loan)	Construction of two substations and T&D lines	25,000 to 40,000	• Update - All three works contracts are effective, contractors mobilized (initial contractor disqualified) - Supervision engineer contract effective, consultant mobilized - Design and procurement activities ongoing - Construction expected to begin by March 2020, - Project is expected to be completed February 2021 • Challenges - Resettlement payment for RIA corridor; ($5.4 million for roads, electricity to be determined) - Installation of streetlights along the RIA corridor vis-à-vis the conceived road expansion project by Ministry of Public Works • Actions - LEC to engage MPW on possible solution for streetlights - LEC to engage GoL through MME for resettlement compensation
CLSG	Construction of feeder and distribution lines	150 communities along lines	• Update - Bid/proposal evaluation completed - Pre-contract negotiations ongoing for works and supervision contracts - Works and supervision contracts expected to be signed by November 30, 2019. • Challenges - Road accessibility/difficult terrains • Actions - Request sent to AfDB for extension of closing date - Speedily conclude works and supervision contracts
German Development Bank (KfW): Monrovia Electrification			
Monrovia ($18 million grant)	Construction of feeder and distribution lines	17,500	• Pre-qualification for engineering procurement contractor launched, closes November 2019 • EPC contract expected to be signed by April 2020 • Environmental and social impact report completed by the consultant, awaiting KfW comments

Location of T&D investment	Components	Expected number of connections	Status of project Status as of November 12, 2019
European Union (EU): Monrovia Consolidation Project			
Monrovia ($46.5 million grant)	Construction of substations and T&D lines	38,000	• Update - Civil works have begun at Paynesville, Bushrod, and Congo Town substations - TL construction to begin in March 2020 - Purchase order for 100 percent of bill of quantities items in Lot 1 placed - Final designs are being completed - Project expected to be completed by December 2020 • Challenges - Complete final distribution design - RAP compensation • Action - Conclude final resettlement action plan (RAP) study and request compensation from GoL - LEC and engineer to complete distribution design

Source: LEC Presentation to the Energy Sector Working Group 2019.

7. Overall assessment of LEC's management

Next, based on the preceding evidence, we present an assessment of LEC's management to assess whether it has improved with ESBI (Table VI.5). Note that, although most key informants believed that LEC had not fully met expectations, all of them determined that LEC was in a better position with ESBI's oversight.

Table VI.5. Overall assessment of LEC's management

LEC/ESBI	Has LEC's management improved with ESBI as the MSC (current status)?
Overall management	Although LEC's underperformance persists, ESBI has made significant progress in diagnosing its problems, normalizing customer lists, developing human resource policies, (re)creating financial systems, revising contracts, improving utility data and records, and launching the Senior Resource Pool training. According to KIIs: • "[ESBI is] doing the right things, but Liberia is not a normal set up; [The previous CEO] worked tough assignments; [LEC is] by far the toughest assignment ever done." • "Individually, ESBI team members are working hard. But leadership has been lacking." • "We were hoping to get an A+ when we initially brought them in, and that hasn't happened. I'd give them a grade of 75 percent. The utility is better because they are there. It's a good effort. They're dealing with challenges—internal staffing problems, external political interference, theft, etc. They're constantly putting out fires."
Operations: electricity supply, sales, losses, billing, and collections	Though operations are better with ESBI, there are still critical flaws in the management of supply, sales, losses, and collection. LEC does not have a reasonable plan to take over MCHHP and is not paying the OMT contractor (~$300k per month), thus risking MCHPP's long-term sustainability. ESBI has repaired thermal generators but lacks fuel for the dry season. ESBI is renegotiating the CLSG power purchasing agreement, but it is not clear that LEC can prevent losses and manage new connections once the line is operational. The asset and customer management study, loss prevention strategies, and IMS should help with reducing losses and improving sales, billing, and collections.
Commercial operations and cost recovery	This area is the MSC's most serious challenge. Although it is impossible to know for certain, respondents (including LEC staff, donor agencies, and contractors) believe that LEC's finances would be worse if the MSC was not in place. Given the extensive problems the IMT left behind, it is extremely unlikely that the IMT could perform better than ESBI. Though ESBI's leadership is suboptimal, the MSC is collecting and using data and information to identify and solve problems. Moving forward, the LEC board should form a subcommittee and LEC should form a taskforce focused on cost recovery.
Customer coverage and service	Customer coverage is lower than anticipated and does not meet expectations; however, it is unlikely that LEC would operate at a higher caliber without ESBI (see Section VIII.B.1 for customer coverage data and maps).

LEC/ESBI	Has LEC's management improved with ESBI as the MSC (current status)?
Technical capacity and staff development, retention, and productivity	ESBI brings strong technical expertise. Stakeholders mentioned the Directors of Generation, T&D, and Commercial and Regulatory as having strong technical skills and working closely to mentor LEC counterparts. In 2018, there was minimal staff development, but in 2019 ESBI began involving LEC department heads in weekly meetings and brought on a director of HR. ESBI's performance in staff development has not yet met expectations; however, LEC without the MSC would be unable to develop and execute a suitable training plan or improve human resource manuals, policies, procedures, and systems. ESBI staff made the following comments: • Training is high on ESBI's priorities. At the upper levels, they need specialized training in which they should go to other utilities. We have senior management team meetings where we review the division performance. But we also need training at lower levels for around 60–65 people, including linesmen. We get expats to do this. But for specialists, we send them outside Liberia to get trained at utilities. It's very dangerous how the stations are operating in Liberia. There aren't any safety procedures. We can't wait for formal training, so we have taken it on ourselves. We train them and give them certificates to operate certain lines.
Use of data and IMS to improve operations	The WB-funded IMS was developed under ESBI's leadership. The IMS includes the CMS, distribution management system (DMS), and enterprise resource planning (ERP). Each of the modules are live, there is a dedicated server, and LEC staff are being trained. One ESBI respondent explained as follows: • We also access [the] DMS, and we use it regularly. When customers call, the complaints are recorded, and customers are given a ticket number. The dispatchers manage that complaint, send a crew if necessary, [and] raise it with another department as needed. The repair team gets the info over radio. And they will provide feedback, too. [The] CMS has not established itself fully. They produce a daily report. We are not yet there with data quality. Some people are not competent with computers, and they write it manually and wait for younger folks who are good with computers. The system came online in April, but fully became operational since July. It's definitely helpful since it provides a history of records. Our network is weak and there are a few areas that are pretty fragile. For these areas, this new system is helpful.
T&D, electricity quality, maintenance, and repairs	T&D and electricity quality have unquestionably improved from the IMT period, and there are improvements in both electricity quality and reliability (see Section VII.B.2 for SAIDI and SAIFI). Measures of overall grid performance would improve if ESBI/LEC could overcome the challenges outlined by ESBI respondents: • "There's no redundancy, so substations can't reroute power. Some lines become overloaded. The Paynesville line is overloaded, so even if customers want to connect, they can't. In the smaller transformer stations, the transformers keep blowing up. Transformers keep tripping. We did an audit and saw that 150 transformers blew up. We waited for new ones. 90 [were] bought by LEC, 10 donated by China, and 47 [were] expected by MCA. Almost 70 have been replaced with the LEC, and 7 from China [have] has been replaced. We go through a rigorous system, where we send a designer to scope an area before we deploy. We tell the communities that if they overload by hooking into [a] line that they won't get a new transformer for another year. Manpower issue: we lack the necessary skill even if we have the numbers."

LEC/ESBI	Has LEC's management improved with ESBI as the MSC (current status)?
Donor project management	ESBI's management of donor projects has been weak. ESBI readily admits it has not been staffed to manage the donor contracts and needs a contract manager. The lack of communication means that donors have invested in connection projects that are misaligned with LEC's needs, exceed the grid's capacity, and in some cases have caused problems. Stakeholders explained the following: • "Donors are not [getting] new tools, equipment, etc. to deal with more coverage. Most of their projects are way behind schedule. The transformers can't always handle new customers. The contractors are responsible for the transformers now." • "Donor projects where they connect some and leave behind others causes power theft." • "Projects are dependent on each other."
Communication with MCC, MCA, and other donors	ESBI's materials for the HLSG and ESWG are detailed and clear about progress, challenges, and needs, and represent a clear improvement over IMT materials. In addition, LEC's Chief Operating Operator (COO) was key to the elaboration of the LEC Business Plan and Recovery Strategy and development of the Financial Model to quantify the financial implications of the recovery strategy. The COO was instrumental in supporting MCC's position that the Business Plan and Financial Model are key tools to enhance the credibility of LEC's plans and its ability to eventually to attract donor funding. However, ESBI has not yet established communication effective enough for donor agencies to feel they understand ESBI's efforts and needs and can adequately support them. Here are some comments. • "We've been disappointed in their inability to articulate what their challenges are in a compelling way. They should have someone working on strategic issues, how to find funding for the work, how to interact with donors and the board, etc. This might seem frivolous but it's an important part of their job. They brought in a COO who should be responsible for this, but he's also been overcome by fighting fires." • "We won't be too harsh on their performance, but they could have done better in communicating their work and challenges."

8. What is the progress toward a longer-term management arrangement, and what is the sustainability of LEC?

The purpose of the MSC was to stabilize LEC's operations with enhanced management and oversight so the utility was better able to deliver low-cost electricity to an increased number of customers, reduce aggregate total losses and operating expenditures per kWh, and improve electricity quality and reliability. Beyond stabilization, the MSC would prepare the utility for growth and profitability, so the private sector would see LEC as an attractive partner. Given the limitations of the public utility, public-private partnerships are necessary for Liberia to realize the goal of connecting 35 percent of the country by 2030. With LEC reformed, the power market could be vertically and horizontally unbundled to improve overall performance. Vertical unbundling would entail separating generation, transmission, and distribution into different markets and entities owned and managed by the public and private sectors. For example, a concessionaire

could assume operations of MCHPP while LEC managed the transmission network and private sector partners managed energy distribution. Generation would be horizontally unbundled, so that both public and private power producers could generate the energy needed to connect all Liberians over the next few decades. Proponents of unbundling argue that this structure would increase competition, efficiency, and overall performance.

LEC's sustainability and longer-term management arrangement can be described as having several phases (Table VI.6): In Phase 1, ESBI's three-year contract ends in January of 2021. In Phase 2, the MSC contract can be extended for two option years (for either ESBI or another MSC), lasting through January of 2023 should the GoL wish to extend it and resources can be allocated. If the GoL does not want an MSC, LEC will revert to Liberian management in 2021. Phase 3 will begin after the MSC contract is completed in 2023, or sooner if the GoL decides not to extend the MSC. We describe these phases and options in VI.6.

Table VI.6. LEC's sustainability and future options

LEC sustainability: Present to January 2021

MSC: ESBI

Current status as of January 2020:

- ESBI has a strategy in place to reduce loss, improve collections, implement the training plan, and otherwise achieve key goals. Pending major disruptions or loss of staff, plans should be implemented.
- ESBI was in the process of requesting additional resources from donor organizations for operating and capital expenditures to carry out key tasks.
- ESBI was planning a donor conference to discuss extending the MSC for the two option years.
- ESBI expressed concerns about threats from Liberians, given LEC's poor performance and fear of Liberian retaliation if the lights go out during the dry season. ESBI may "pull staff if they are under siege" (New Dawn Liberia 2020)

LEC sustainability: Options for January 2021–January 2023

MSC: ESBI | Public with new MSC | Public with local Liberian management

- LEC's post-compact sustainability is unclear. Even with the MSC in place, ESBI leadership expressed concern about operations after 2021 as the MCC Compact closes. Without MCC and MCA, performance may deteriorate, as suggested by this comment:

  > "MCA and (name) are very powerful, she was willing to knock on ministers' doors. Once MCA is gone, it will be very tough for ESBI to do many things that will be out of their control. None of the other donors really fill this role. [Most donors] don't go toe to toe with [the] government."

- Liberians across LEC and respondents from each of the donor organizations argued that LEC still needs the MSC in place to avoid the "collapse" of LEC.
- One MCC respondent felt that "LEC has already collapsed" and went on to explain:

  > "What's the worst that can happen if ESBI leaves? There's no money. There's more theft, corruption, and fewer connections over time. LEC starts to crumble and maybe they are forced to start addressing issues for their own survival."

- Other donors expressed commitment to LEC:
  - "We know that we can't turn over the utility to LEC totally. We understand the effects of the interim management team. This is the last opportunity to fix LEC. After next year, if we continue to have these losses, then it's difficult to justify an MSC."
  - "We will participate in the donor conference. We want to fill gaps when MCC leaves, and we want to know what we can do."

- "AfDB has supported MSCs in other countries, but we can't say for sure if we'll support ESBI. The end goal is a viable energy sector; we just want to avoid duplication. Nothing is off the table."

LEC sustainability: options for January 2023 and beyond

Public with new MSC	Public with local Liberian management	Public with O&M agreement	Public with concession	Privately owned

- Given stakeholders' focus on the immediate challenges—LEC's overall performance and challenges, and whether to extend the MSC for the two option years—there is minimal serious planning going on for 2023, particularly given that MME has lacked leadership, MCC/MCA-L exits Liberia, and ESBI is a time limited contractor. LERC—along with the MME and donor organizations, which have so far taken a hands-off approach—must engage in discussions and planning. Respondents from the donor community, the LEC board, LERC, ESBI, the OMT, and the PIU all talked about the possibilities of unbundling. However, to be attractive to the private sector or a concessionaire, LEC would need to increase the customer base and usage of available capacity, improve collections, reduce losses, obtain capital financing, and reduce fuel purchase prices (Tetra Tech 2018). LERC also would need to establish a regulatory framework. Further, MCHPP must be adequately maintained to protect the asset or it will quickly lose value.
- LERC commissioners made the following observations:
  - We have already started working with LEC on this. Normally people have a problem with change. LEC was a law unto themselves, was doing regulations, services, and operations. They know that we have to unbundle generation, transmission, and distribution. That is just the law. The unbundling process is natural, and it will help the utility. It's hard to do it now in this market. But the micro-utilities can be consolidated as a small group.
  - At the end of the day, we need to be sustainable. These investments in power are absolutely essential for Liberia's development. We hope that everybody puts their hands together to move this further.
- Following the donor conference in early 2020, the donor community should begin advocating for regular working group discussions to plan for 2023 and beyond. Each option requires one to two years of planning before developing bids, conducting a bidding process, and transferring management. For a detailed description of possible options, see Tetra Tech (2018).

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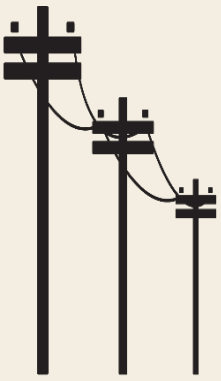
VII. ANALYSIS OF GRID-LEVEL OUTCOMES

In this section, we present analysis to answer questions on the grid-level outcomes. First, we use LEC administrative data to describe the current status of LEC electricity generation and T&D infrastructure. Then, we report perceptions of how key activities affected these quantitative outcomes.

A. Grid-level evaluation questions

To what extent have MCHPP rehabilitation and Capacity Strengthening and Sector Reform (MCC's investments) affected Liberia's electricity generation, T&D, and in turn, reliability of the electricity supply, planned and unplanned outages, and voltage stability?



Data sources for the utility-level analysis

- Document review, including LEC materials, CMC and other reports to describe grid functionality
- Administrative data including key IMS indicators to assess grid functionality
- Qualitative data, including key informant interviews and focus groups with key actors that have specific knowledge of grid level outcomes (LEC board, LEC, ESBI, CMC, Tetra Tech, MCC, MCA, donors, and other stakeholders that interact with LEC; Site visits
- Survey data from household, small business, medium and large end users; assessed measures of electricity quality and reliability; use of other energy sources

Summary of findings

Liberia's grid has many weaknesses.

Donors have tried to extend the grid, but "*without improving the backbone… these plans are likely to fail.*"

B. Findings: Liberia's electrical grid: Generation, T&D

The Liberia electricity infrastructure is concentrated in Monrovia and surrounding communities. Assets consist of thermal generators and the Mt. Coffee Hydropower Plant, with 66 kV and 22 kV transmission and a low voltage distribution system. As ESBI articulated in its Initial Situation Report, Turnaround Plan, and subsequent LEC and CMC quarterly and annual reports, Liberia's generation and T&D rehabilitation needs were far more extensive and expensive than anticipated (See Appendix B for a simplified line diagram of LEC's system). Liberia's thermal generators and T&D infrastructure suffer from frequent mechanical failures. Generators have largely been donated, and T&D infrastructure has been rebuilt piecemeal through donor contributions following the civil war. The system is fragmented and fraught with mechanical and commercial challenges.

1. How have MCC's investments affected electricity generation?

As noted in the LEC Business Plan, "LEC's system demand has grown on average by 50 percent year-on-year since 2016." This growth trend is expected to continue placing increasing demand on LEC given that the utility already faced serious operational and financial challenges. Increasing demand intensifies LEC's funding gaps in generator operations and maintenance and dry season fuel costs.

MCHPP provides cheaper renewable hydropower, while LEC's thermal generators require expensive heavy fuel oil (HFO), light fuel oil (LFO), and diesel fuel (see photos of the Bushrod Power Plant in Figure VII.1). LEC's power plant availability (the percentage of hours a plant produces electricity out of the total hours in the time period) from 2015 through 2019, is shown in Figure VII.3. (Note that several months of data from 2016 were unavailable.) The data illustrates the low level of use and reliability of the thermal plants and diesel generator, particularly for the thermal plants at the end of MHI's tenure as the MSC and the diesel generator during the IMT period. MCHPP coming online significantly reduced the need for these electricity sources. In December 2018, Unit 1 had a planned outage for a routine inspection and otherwise the plant operated at capacity. In contrast ESBI quickly realized the thermal assets required extensive maintenance and repair. Table VII.1 lists LEC's thermal plants and their respective status in February of 2018.

Figure VII.I. Bushrod Power Plant

Throughout 2018 and 2019, LEC managed to convert plants from LFO to cheaper HFO, saving the utility millions of dollars in dry season fuel costs. The fuel oil usage in MWh and kWh per gallon of HFO is show in Table VII.5. The more efficient the plants are, the less fuel needed. Although there have been noted improvements in efficiency, resulting in increased generation capacity, ongoing rehabilitation and maintenance must continue. Note however, that planned outages of plants continue given the need for additional works.

Table VII.1. LEC's thermal power plants

Thermal plant		MW	Status	Notes
Bushrod Plant 1-2	1	MW	2 units operational	All units commissioned to run on Light Fuel Oil (LFO)
Bushrod Plant 3-8	1	MW	5 units out of service	No units able to run on cheaper heavy fuel oil as of February 2018
Bushrod Plant 9-10	1	MW	3 units have been decommissioned	The difference in fuel costs is approximately $26,000 per day
World Bank Plant 1	2.5	MW	1 unit out of service	
World Bank Plant 2-4	2.5	MW	3 units operational	
GOL Power Plant 1-2	9	MW	2 units operational	Out of warranty, no on-site support
JICA Power Plant 3-4	5	MW	2 units operational	Out of warranty, no on-site support

The adequacy of LEC's supply, a measure of generation capacity from all plants divided by average peak demand, is shown in Figure VII.4 along with generation in MW and peak demand. Again, with MCHPP's generational capacity and limited connections, Liberia is generating on average about three times as much energy as is being consumed.

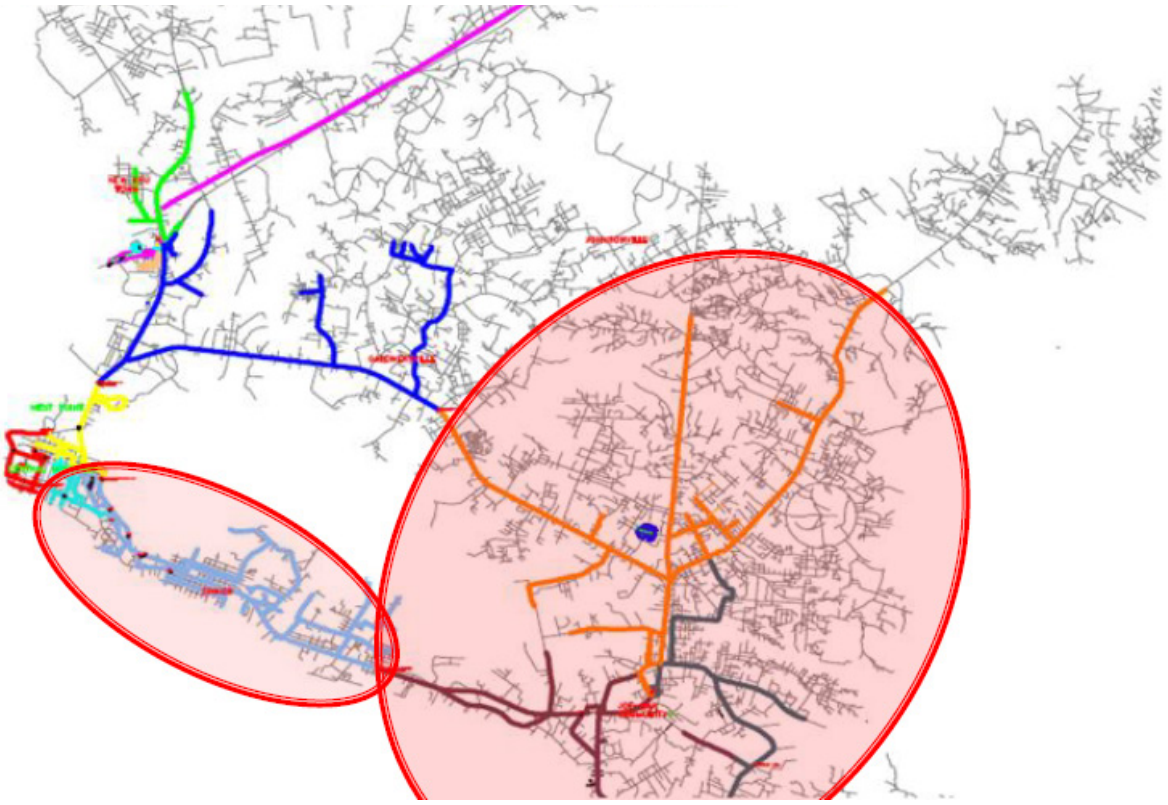
New generation from the Cote D'Ivoire, Liberia, Sierra Leone and Guinea (CLSG) line is expected to become available in June 2020 or later, following several years of delays, including a recent delay due to the covid-19 pandemic. According to the Transmission Service Agreement (TSA) with TRANSCO and the power purchasing agreement with CI-ENERGIES (Ivory Coast), LEC must pay $10.3 million for a security fee. Given that neither LEC nor the GoL have the resources and donors are not willing to pay the fee, ESBI plans to renegotiate terms with TRANSCO and CI-ENGERIES. ESBI also plans to negotiate other key terms including transmission charges, firm and extra energy price, and the flexibility of supply based on LEC's needs.

For each of the generation achievements and activities, key informants describe the challenges that ESBI and LEC have faced. Respondents were confident that LEC, without an MSC, would not be able to manage the increased generation capacity, extensive maintenance and repairs to generation assets, and managing negotiations for the CLSG line.

2. How have MCC's investments affected LEC's transmission and distribution?

LEC's T&D infrastructure, which only sprawls across Monrovia and Greater Monrovia is wrought with challenges. ESBI's initial assessment was that the high voltage system was of good standard, however there were large numbers of outages on the 22kV and 66kV networks. The low voltage network had serious constraints requiring extensive replacement of transformers and circuits, while LEC lacked materials, equipment, tools, and funding to fix the problems. Throughout 2018, LEC constantly dealt with transformer overloads and subsequent failures due to overloaded feeders and extreme weather. Growth in customer connections was limited by these deficiencies given that the feeders and transformers lacked capacity to handle additional load. ESBI managed to arrange the use of World Bank project materials, repaired transformers locally, procured two 500 kilovolt amp transformers, and repurposed existing transformers to increase quality and reduce outages. By the end of 2018, LEC had no remaining stock of poles, transformers, conductors, LV circuit breakers, earthing materials, or meters to continue needed repairs. The network constraints as of 2019 are illustrated in Figure VII.2.

Figure VII.2. Network constraints on the LEC grid (ESWG presentation April 2019) (Circled)



In Q1 of 2019, LEC had more than 70 faulty transformers off the system and managed to install 50 replacement transformers. LEC continued to lack resources and materials and so focused efforts on vegetation control, organizing the Bushrod facility, and recovering unused or stolen poles and transformers. During Q2 of 2019, LEC had even more transformers (124) off the system and replaced only six new units. ESBI continued to request donor support and financing for extensive works including for substations, feeders, 22 kV cables, loops overhead lines, transformers, low voltage circuit breakers, network patrollers to identify and quantify remedial works, test equipment for calibrating and testing protection relays, T&D materials, equipment for line crews, and critical line hardware to address the connection backlog. By Q3, the transformer situation began to turn around, with 100 newly replaced and commissioned transformer units. With newly donated materials, LEC implemented additional critical network repairs.

The LEC Business Plan requests $13.7 million for the necessary upgrades and refurbishment needed to improve the T&D system.

3. How have MCC's investments affected electricity reliability, outages, and stability?

LEC's outages or the system average interruption frequency index (SAIFI) and system average interruption duration index (SAIDI) are also KPIs in the MSC contract. Figure VII.7 shows LEC's progress, despite grave challenges and resource constraints, in reducing outages and improving electricity reliability. Although LEC's SAIDI and SAIFI measures are high compared to other utility companies across Africa and the world, the baseline level was 500 hours, so

LEC's result of 183 hours per customer in 2018 demonstrates a marked improvement. Note that the peak in outages in 2019 occurred during the dry season because of fuel shortages. LEC's load factor from 2015 through 2019 is shown in Figure VII.8. The load factor measures how much energy was used versus how much would have been used if power had been on during peak demand. Generally, a load factor above 0.75 is considered adequate, yielding a lower generation cost aper unit (kWh). In LEC's system, hydropower produces a higher load factor and lower generation cost than thermal power.

Figure VII.3. Power plant availability

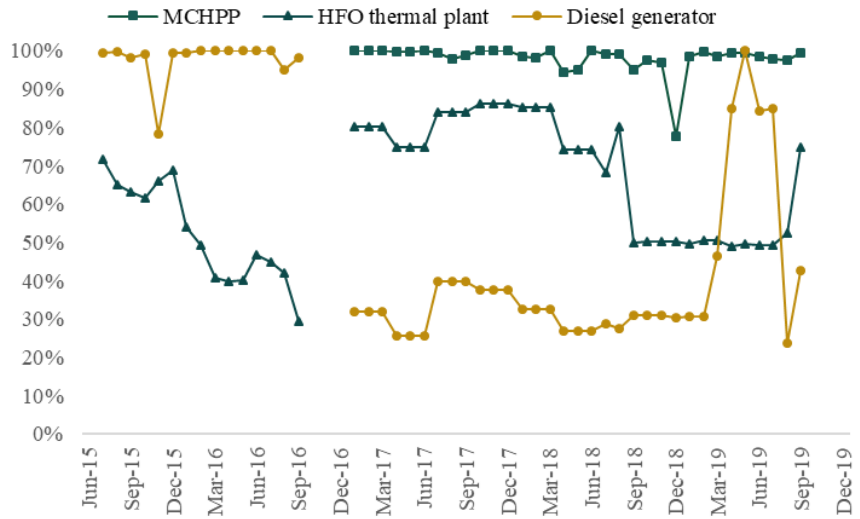


Figure VII.4. LEC generation 2015-2019

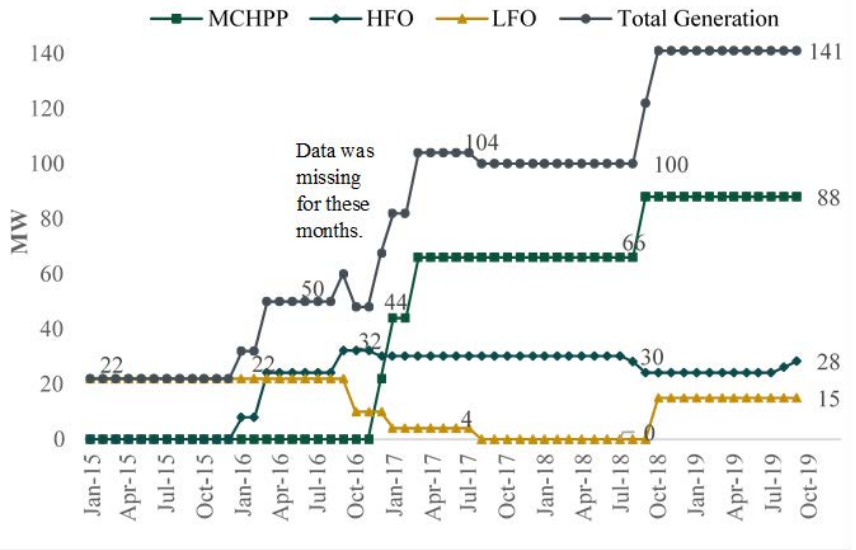


Figure VII.5. Fuel oil usage (US gallons/MWh)

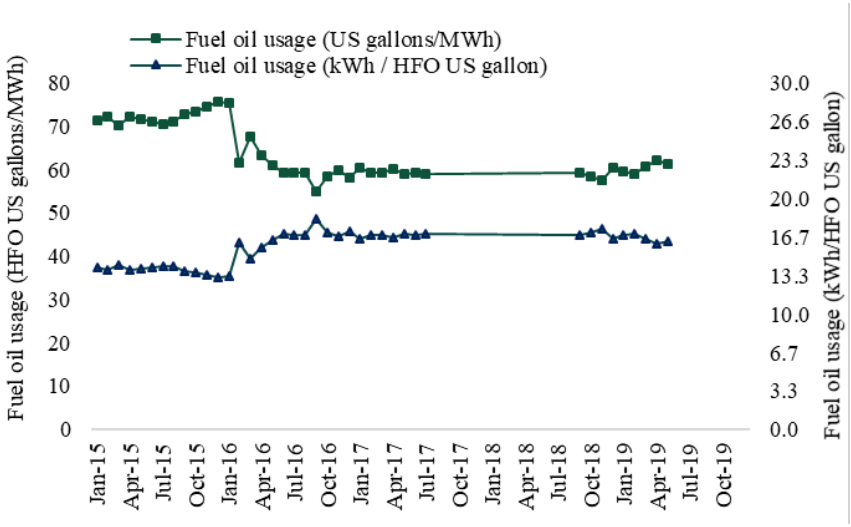


Figure VII.6. Adequacy of supply, available power, and peak demand

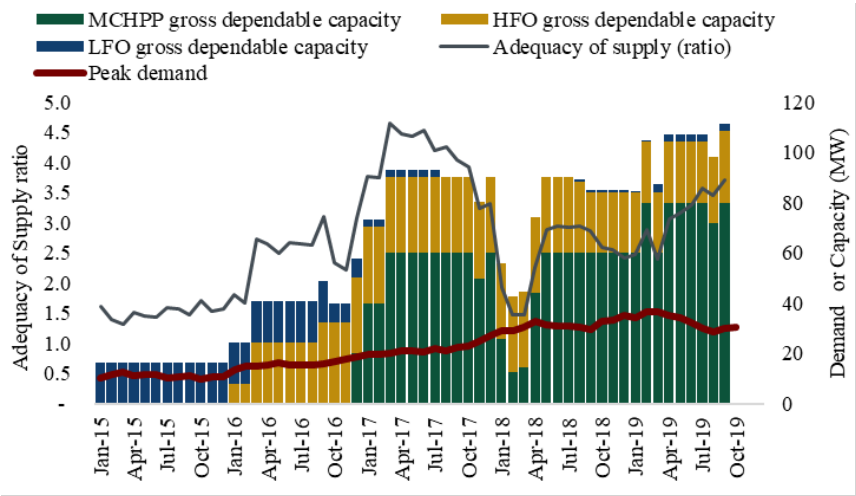


Figure VII.7. System average interruption frequency

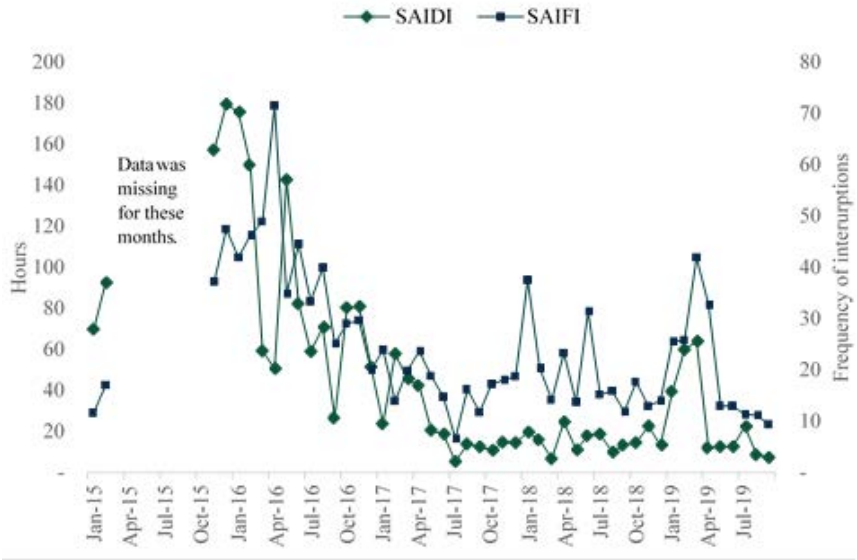
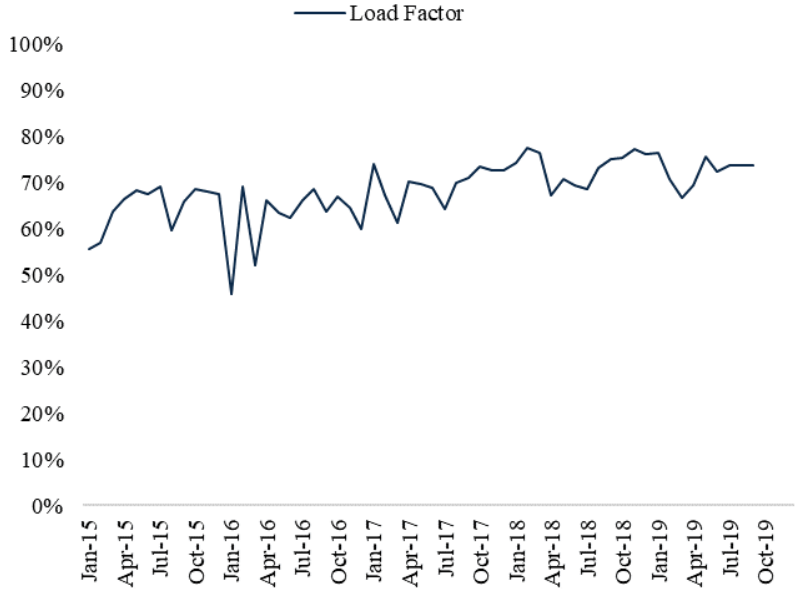


Figure VII.8. Load factor and duration index (SAIDI and SAIFI)



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VIII. ANALYSIS OF END-USER OUTCOMES

In this section, we present the baseline analysis of the outcomes for end users. Note that high-level characteristics of the study sample are in presented in this chapter. Appendix D contains additional tables which describe the samples. We begin with the evaluation questions and proceed to the data that contributed to answering each question. The baseline results are presented by outcome and data type.

A. Evaluation questions

1. 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?
2. How do LEC customers change their behavior, such as investing in appliances and use of time?
3. What are the other effects of electricity on connected end users, and what are the spillover effects on non-electrified households?
4. How do customers decide to connect, and why have other potential end users not connected? What barriers do potential customers face when they try to connect to the grid?
5. How have MCC's investments affected connected and unconnected households' perceptions of the quality of electricity?
6. How do the above outcomes vary by differences in gender, socioeconomic status, and other demographic characteristics?

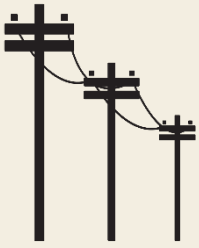
Summary of end user findings

New end user connections were far less than anticipated however, illegal connections proliferated across donor project areas.

Liberians place high value on electricity and have high demand for electricity.

Once connected, many respondents report improved quality of life, increased asset ownership, changes in time use, and improved safety.

Respondents also warn that electricity presents safety risks and communities require education on electricity safety.



Data sources for the end-user–level analysis

- Document review, including LEC materials, CMC reports, and other reports to assess connectivity, outages, and customer satisfaction
- Administrative data, including key IMS indicators to assess connectivity
- Qualitative data including in-depth interviews and focus groups with household members, small business owners, and medium and large end users
- Survey data from households, small businesses, and medium and large end users in both connected and unconnected communities

B. Findings: What are the effects of MCHPP and Sector Reform on the number of users and electricity demand?

1. What is the number of end users and effects of investments on electricity demand?

Number of customers. The expectation had been that once MCHPP was rehabilitated and donor projects were underway, LEC would connect 2,000–4,000 new customers per month (MCC 2017). However, given the severity of network constraints with overloaded transformers and feeders, and insufficient resources, parts and materials, along with implementation delays in donor-funded projects, the rate of new (legal) connections has been far lower than anticipated.

Figure VIII.1 shows the total number of households in Liberia, the total number of households in the LEC service area, and LEC's customer numbers, from 2015 through 2019. This shows the gap between actual connections and the number of households in LEC's service area and countrywide. It also shows the slow rate of growth in new (legal) connections. (Note that LEC is still reconciling data to determine the number of actual customers.)

The composition of LEC's customer base is shown in Figure VIII.2. Residential customers comprise about 95 percent of the base. Although there is growth over time, it remains unclear how many customers are purchasing electricity monthly, or at least quarterly. The anomalies, such as in September 2017, are likely inaccurate data points. In addition, not all residential customers purchase electricity every month, so a resident may be a customer but only purchase units every other month. In fact, in our field sample of connected end users, 59 percent of households, 51 percent of small businesses, and 76 percent of medium and large end users had purchased electricity in the previous month.

Electricity demand. The average consumption in kilowatt hours for all customers and for residential customers from January 2015 through September 2019 is in Figure VIII.3. The trend lines indicate slight overall growth in average consumption, although the monthly variations are difficult to interpret. Given that average consumption per customer requires accurate values for the number of customers, it may be more useful to focus on trends than actual monthly values until the reconciliation of customers in the CMS database is complete.

Unserved demand is the amount of electricity in megawatt hours that LEC customers want but cannot be supplied due to generation or T&D failures (Figure VIII.4). We caution that, at baseline, the unserved demand indicator is flawed because of the customer data. However, the spike in unserved demand in 2019 is due to dry season fuel shortages and planned outages.

In qualitative focus groups (FGDs) and in-depth interviews (IDIs) respondents described their intense demand for connections (if unconnected) and more consistent electricity in detail:

> This is 21st century, and you can't live without current. There will be nobody unwilling to get LEC.

Unconnected respondents explained their long wait for connections:

> It shouldn't just be like what happened to Kakata where the poles were installed more then 2-3 years ago. At the end of the day people's expectations die because they didn't see any sign of current in the line. We want LEC to the speed up the process so that we can have affordable electricity now.

Figure VIII.1. Trend data on annual number of customers

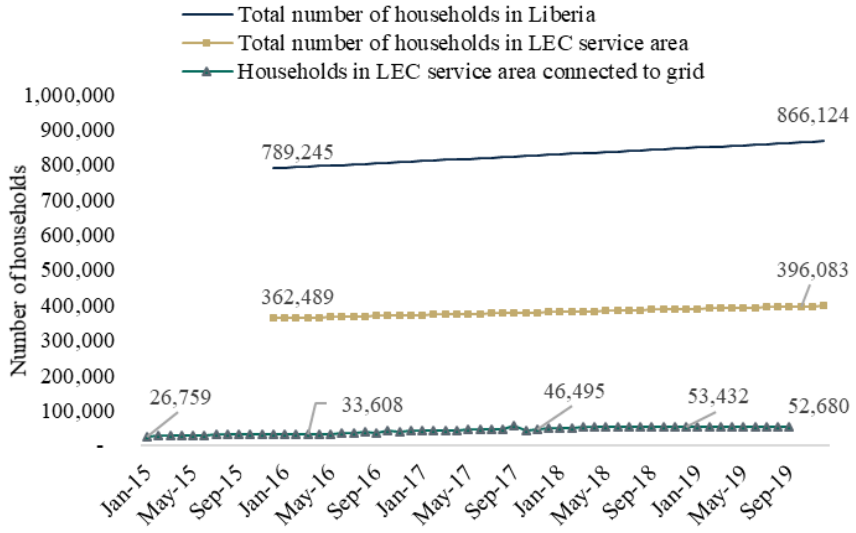


Figure VIII.2. Percentage of customers by customer class

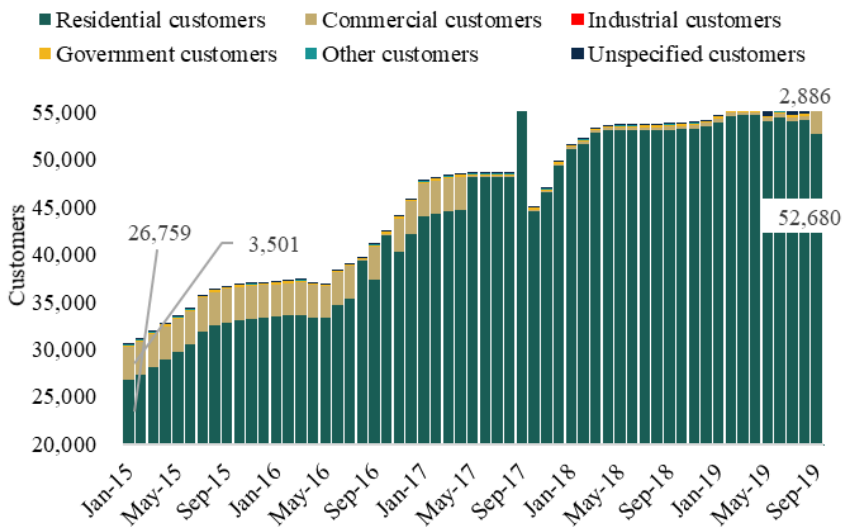


Figure VIII.3. Average customer consumption (kWh)

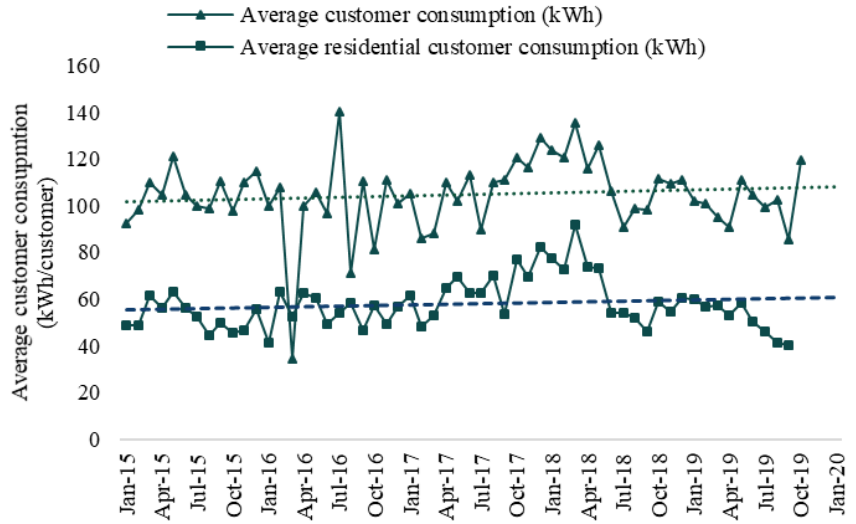
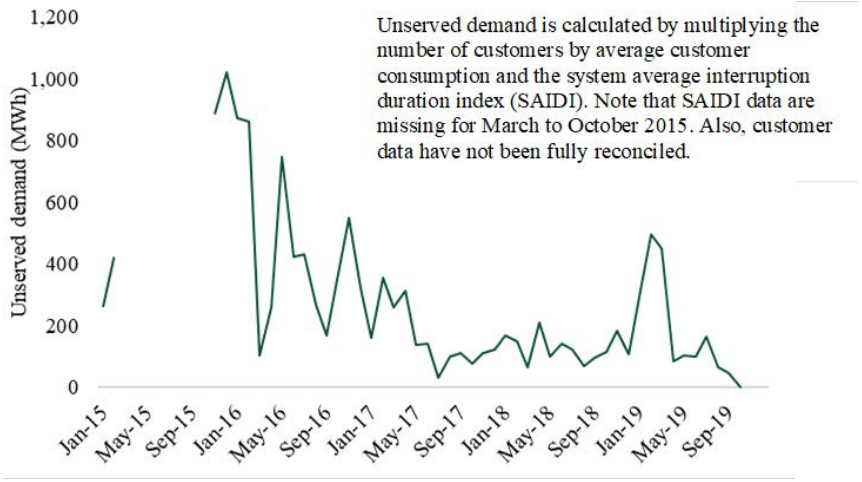


Figure VIII.4. Unserved demand

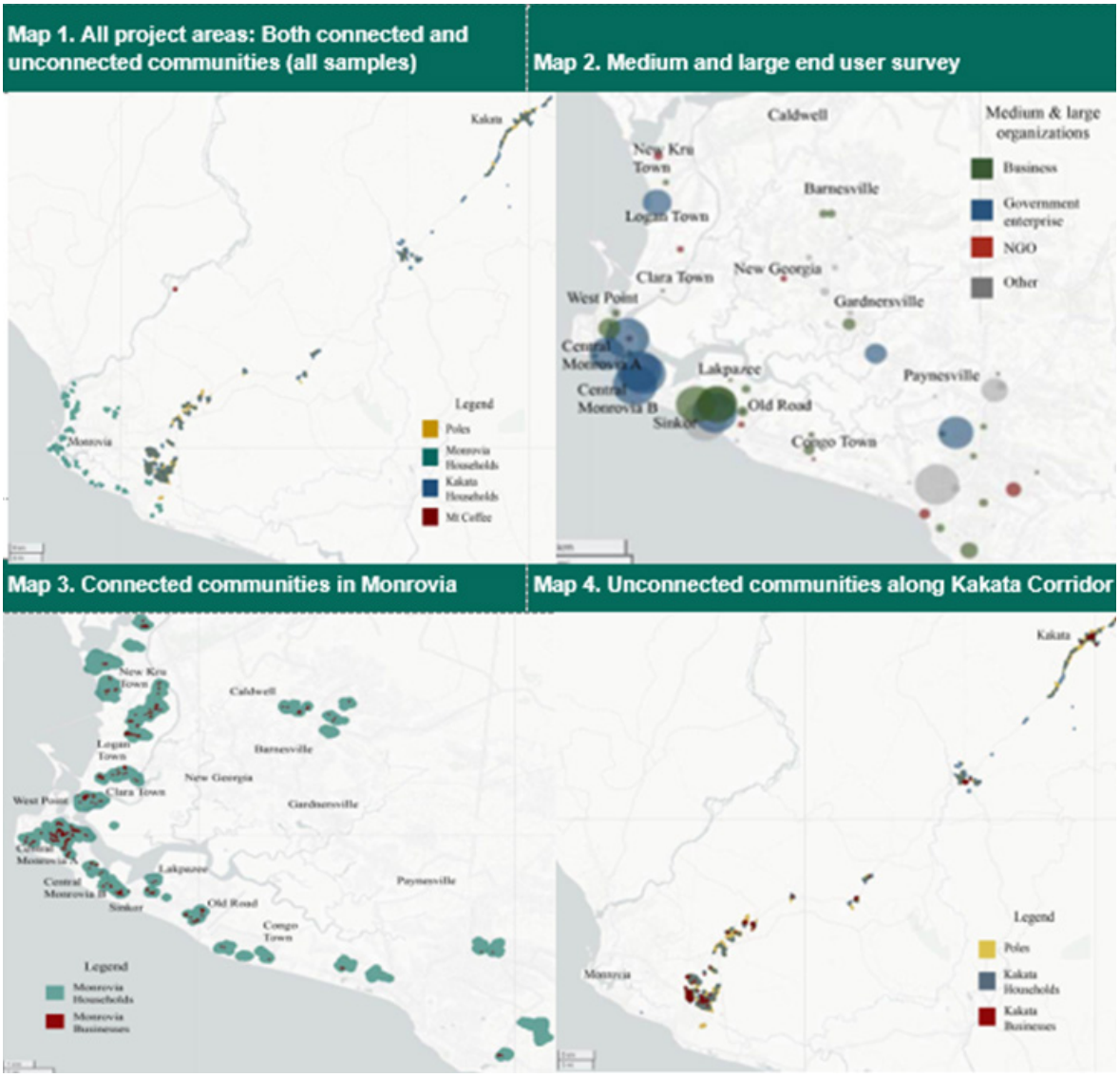


2. Study samples: Location, demographics, end-user characteristics, and year of connection

Next we briefly describe the study samples, including the location of communities where we conducted the studies, household demographics, characteristics of small businesses and medium and large end users, and the year of connection among respondents with LEC electricity.

Location. First, Figure VIII.5 shows four maps. Map 1 shows the communities where we randomly selected a sample of connected households and small businesses in Monrovia and communities we selected for the study of unconnected households and small businesses along the Kakata Corridor. Map 2 plots the location of medium and large end users throughout Monrovia. The different colors indicate the type of end user. The icon size indicates the number of employees at the organization. Maps 3 and 4 provide a closer view of the communities plotted in Map 1. These maps highlight where electricity infrastructure is concentrated.

Figure VIII.5. Location of survey samples



Demographics. In both the connected and unconnected samples, the average age of the head of household was 43 years (Figures VIII.6 and VIII.7). In connected households, more than two-thirds of respondents had completed secondary school or more education compared to only 47 percent in unconnected households. Average annual income was higher in connected households in Monrovia compared to unconnected households along the Kakata Corridor. This suggests that end users in Monrovia may have more resources to spend on electricity and electrical appliances and equipment than end users along the Kakata Corridor. Note that, although we compare the samples for descriptive purposes and will follow trends over time in both samples, these are not comparable groups for evaluation purposes. That is, the Kakata Corridor sample does not serve as a control group to the Monrovia sample, given the demographic differences. We expect—once connections are made along the Kakata Corridor—to be able to compare connected and unconnected households and small businesses within this sample.

Figure VIII.6. Connected households households

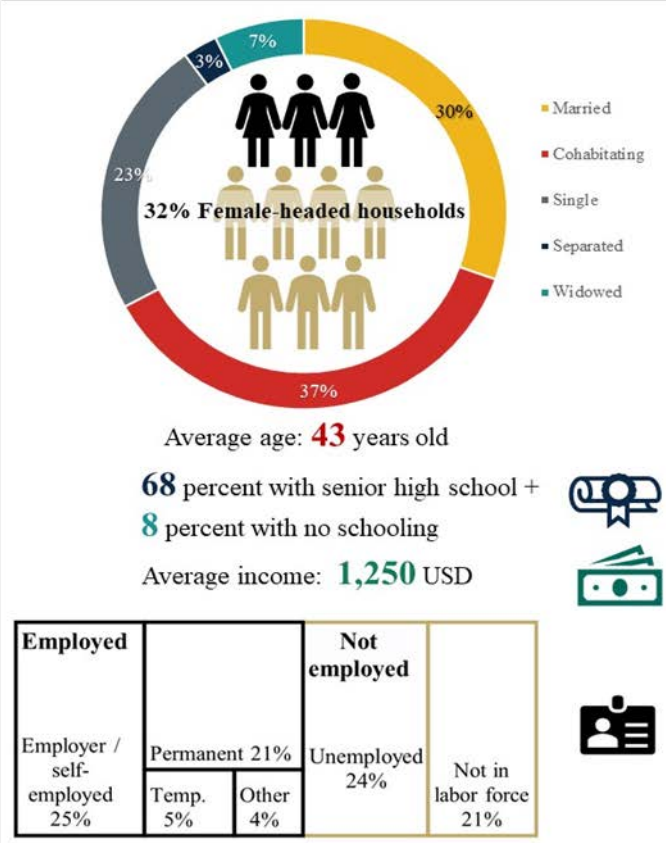
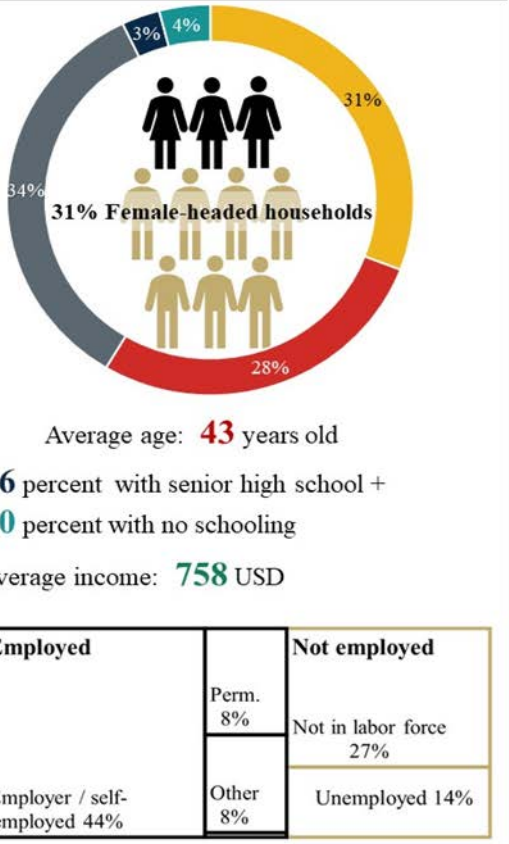


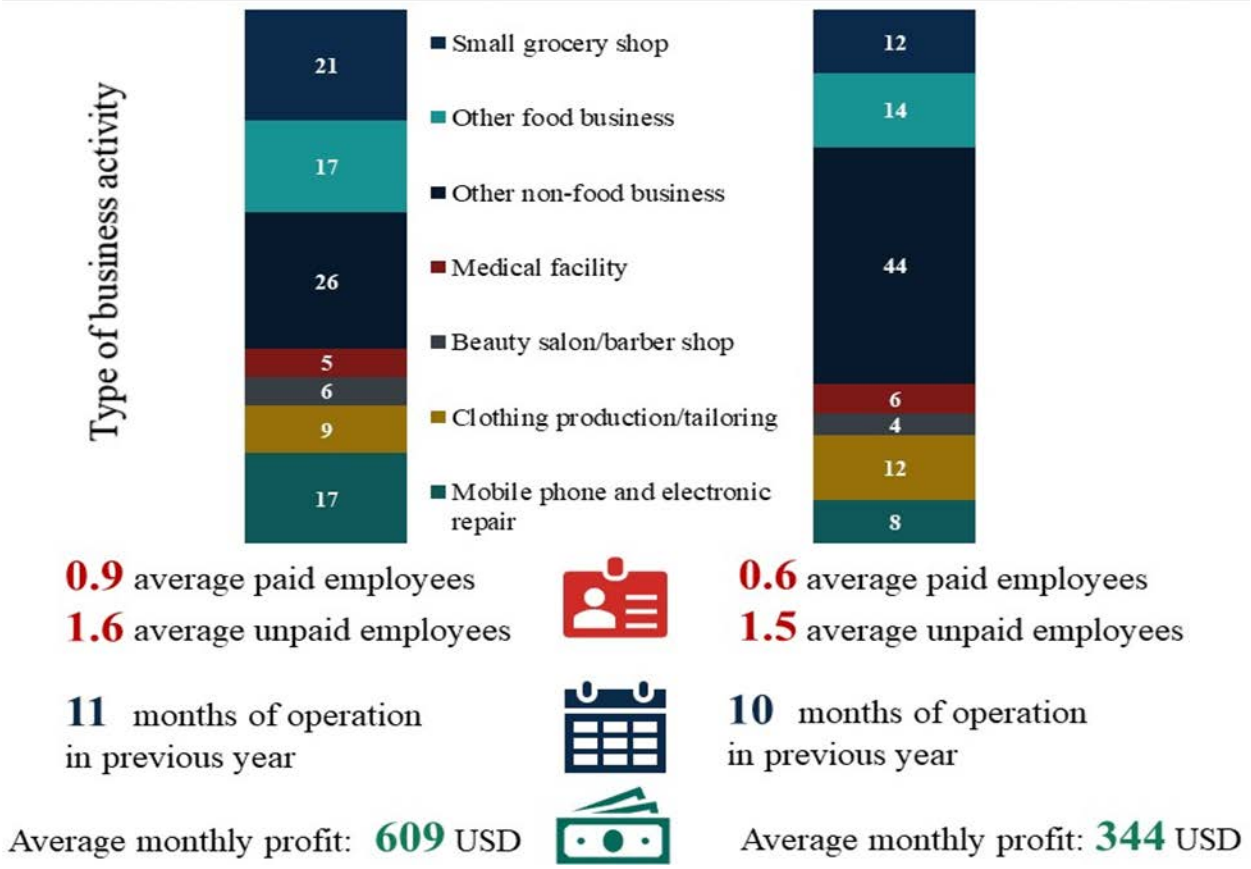
Figure VIII.7. Unconnected



Characteristics of small businesses. The small business sample across Monrovia and the Kakata Corridor is composed of groceries and other food businesses, nonfood businesses, health centers and pharmacies, salons, clothing and tailor shops, and mobile phone and electronic repair shops (Figures VIII.8 and VIII.9). On average, small businesses have fewer unpaid than paid employees and operate 10 to 11 months of the year. Connected business owners estimate an average annual profit of US $609 compared to $344 among unconnected small business owners.

Figure VIII.8. Connected small businesses

Figure VIII.9. Unconnected small businesses



Characteristics of medium and large organizations. The medium and large end-user sample was comprised of government offices and state-owned enterprises, nongovernmental organizations (NGOs), medium and large business, and other private organizations. Figure VIII.10 shows the distribution of end users and types of organizations within each category. We believe this sample is representative of medium and large end users who have legal connections (if they have LEC electricity) and are likely to pay taxes. Based on the high refusal rate among medium and large end users, these organizations may not be typical of LEC's larger customers, many of whom refused participation because they did not want to report on sensitive financial information or electricity usage. Nevertheless, even though this sample may be unique, it still provides a valuable snapshot of larger current and potential customers, their energy-related behaviors, and how they change over time with electricity access. Figure VIII.11 illustrates the organizations' operations, including the hours of operation per day, days of operation per week, and months of operation per year. Over time, with increased access to quality electricity, we might see end users extend their operations per day, week, and or year. Figure VIII.12 shows end users' reports of their finances, including cost of operations, revenue, and profit. We will follow these indicators over time to measure the efffects of electricity on end users' finances.

Figure VIII.10. Medium and large end-users: numbers and characteristics

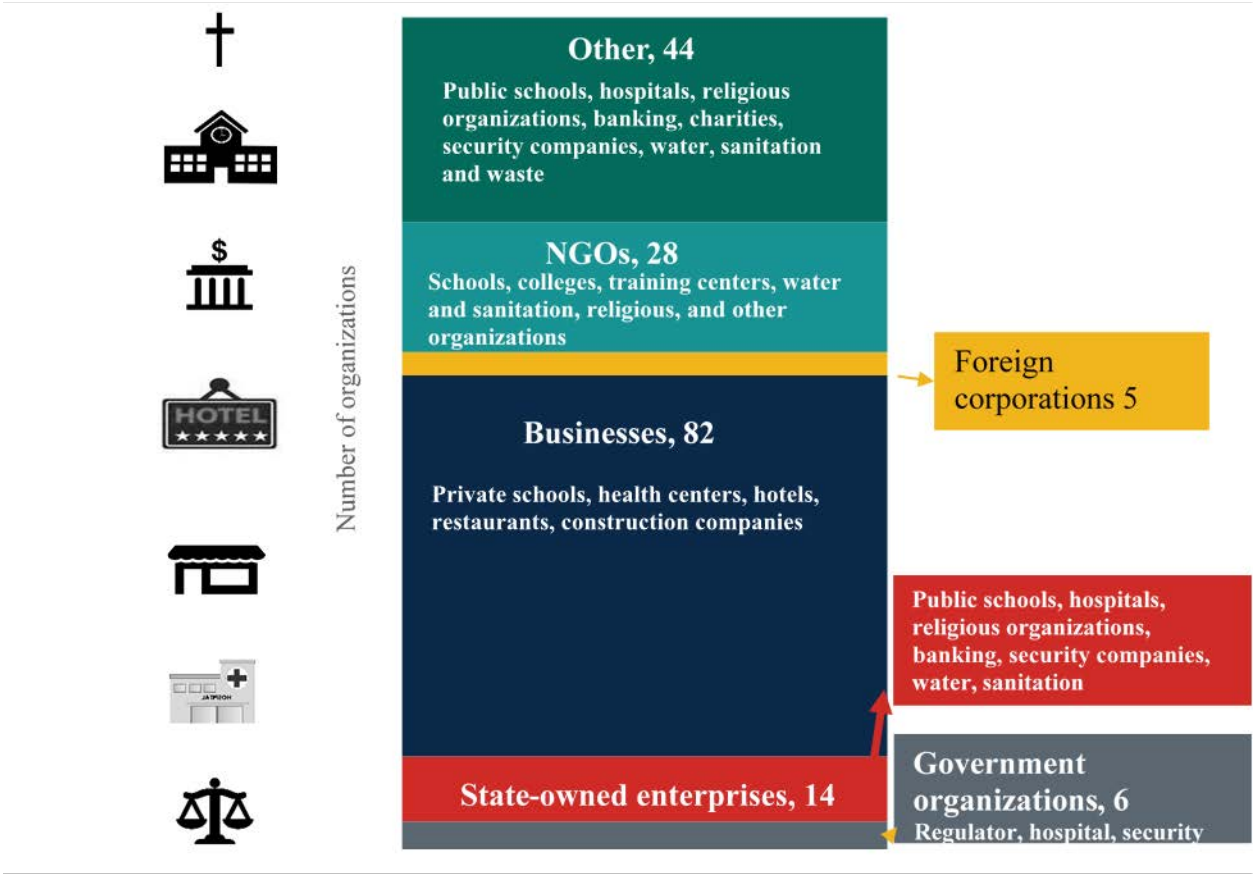


Figure VIII.11. Medium and large end-user operations

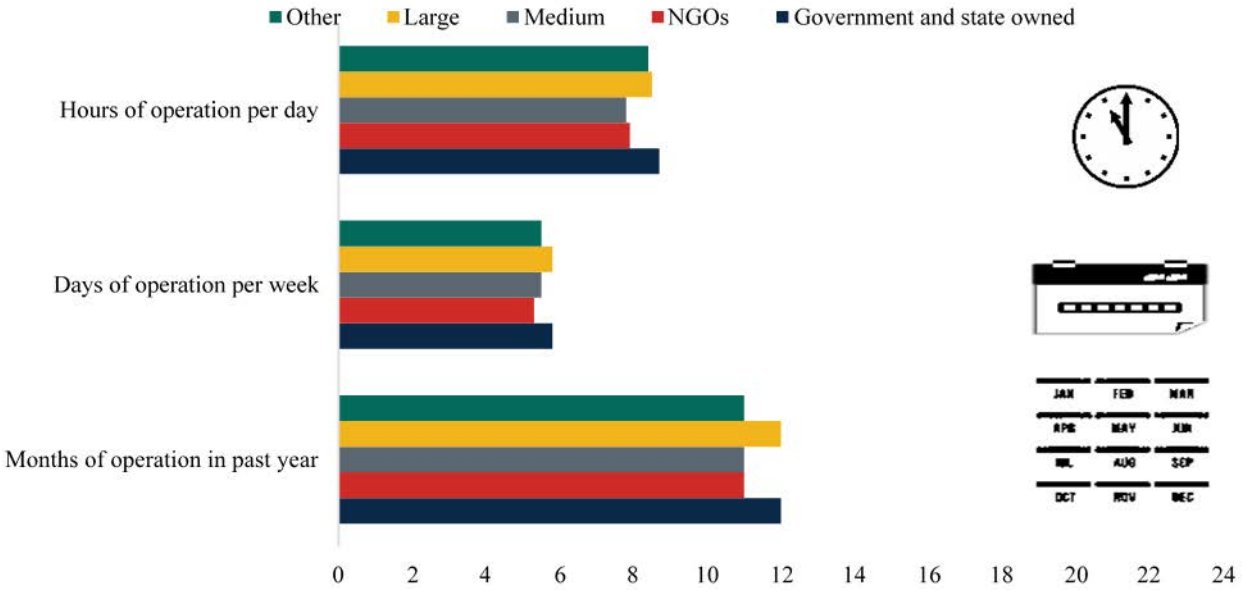
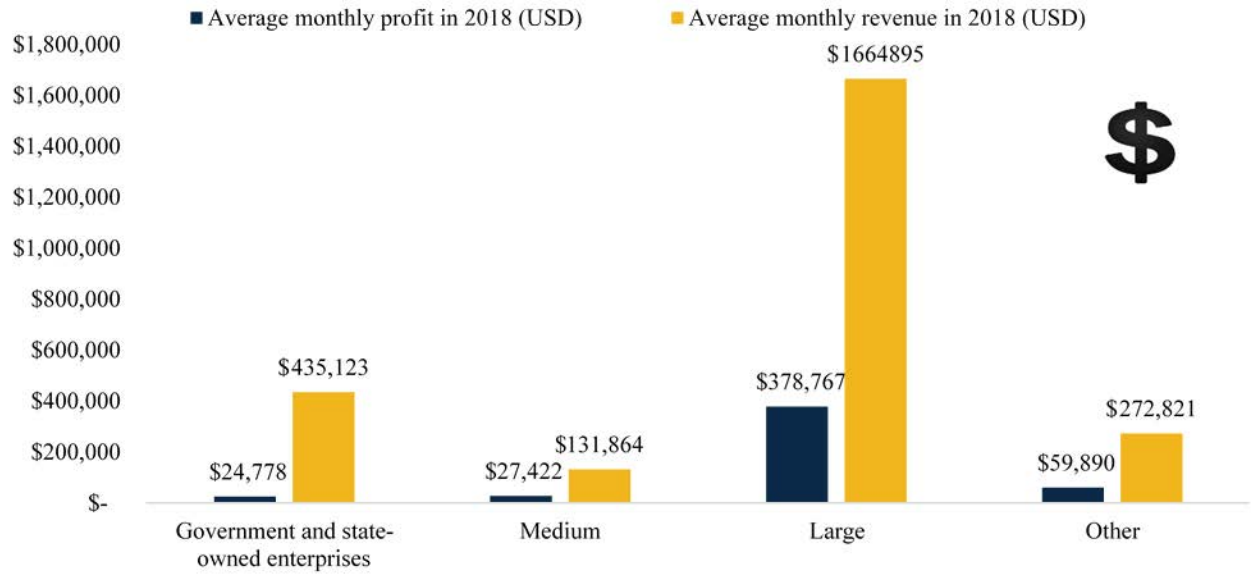


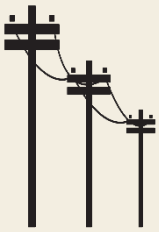
Figure VIII.12. Medium and large end-user financials



Year of connection. The years that household, small business, and medium and large customers connected to LEC electricity are displayed in Figures VIII.13 and 14. The first connections occurred in 1988, although notably there were only three total collections prior to 2003. Even by 2012, there were fewer than 35 connections. Among the households and small businesses, 18 percent had connected before 2014, 33 percent in 2015 or 2016, and 48 percent after 2017. Most medium and large end-user connections occurred after 2015.

3. What is the distribution of direct (legal) and indirect (illegal) connections among connected households, small businesses, and medium and large end users in our sample?

We asked respondents from households, small businesses, and medium and large organizations whether they had direct (legal) or indirect (illegal) electricity connections. In Figure VIII.15, we first plotted the respondents who reported legal LEC connections by using black dots; then, we plotted illegal connections in red (superimposed on the legal connections). We also color-coded Monrovia to show where the various donor organizations are working to improve T&D infrastructure and connect end users. Illegal connections have emerged in all areas where donors have made end-user connections. ESBI and other stakeholders have emphasized that when donors invest in customer connection projects that do not saturate communities and connect all customers who want electricity, the rate of illegal connections will increase as users find ways to access the grid illegally.



Electricity theft can take different forms:

- Users—with the help of rogue LEC staff or local electricians—illegally tap the grid by connecting wires from homes or businesses directly to tension wires.
- Legally or illegally connected customers connect additional third-party users, who access the power without paying the utility.
- Customers collude with LEC staff to tamper with meters and pay for less than they consume.
- Thieves steal meters (to make connections or to sell).

Figure VIII.13. Year of connection for connected households and small businesses

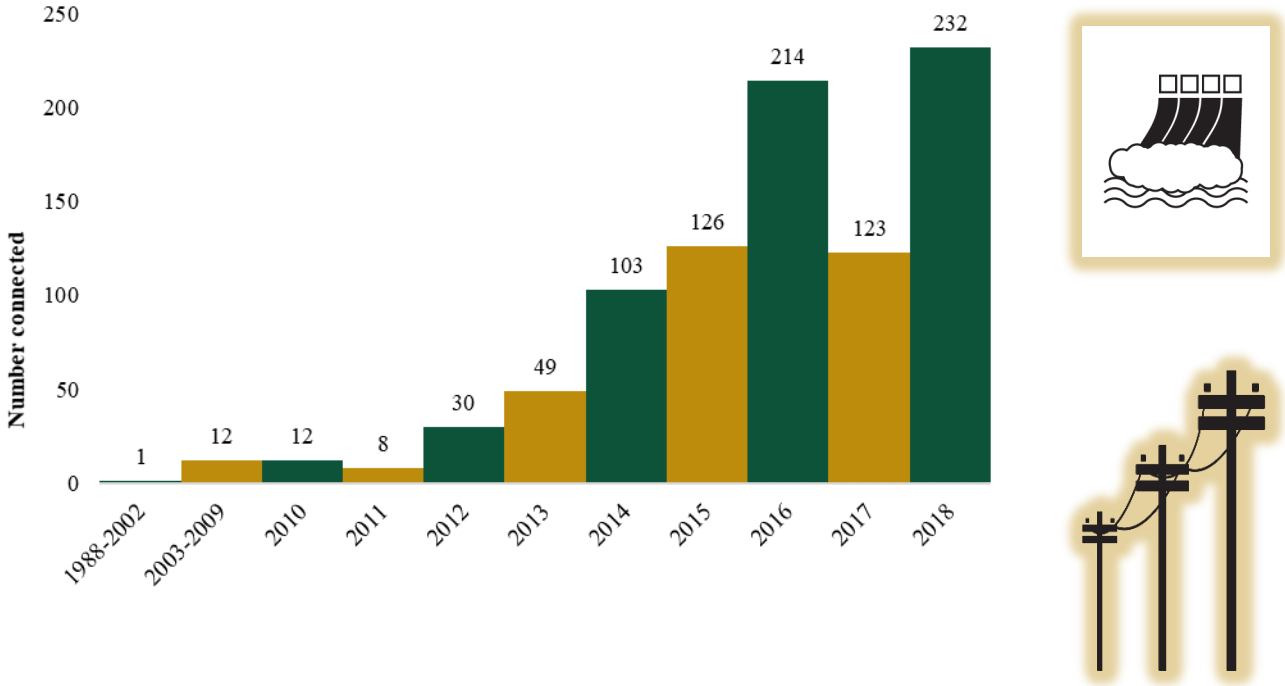
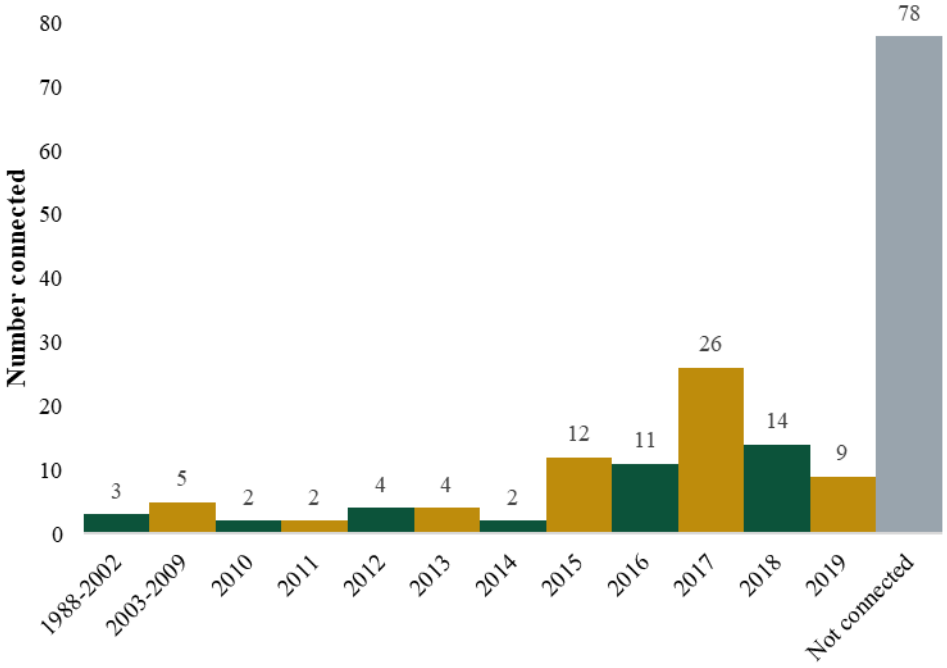
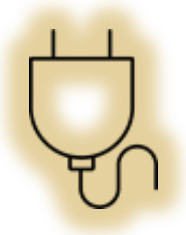


Figure VIII.14. Year of connection among connected medium and large end users

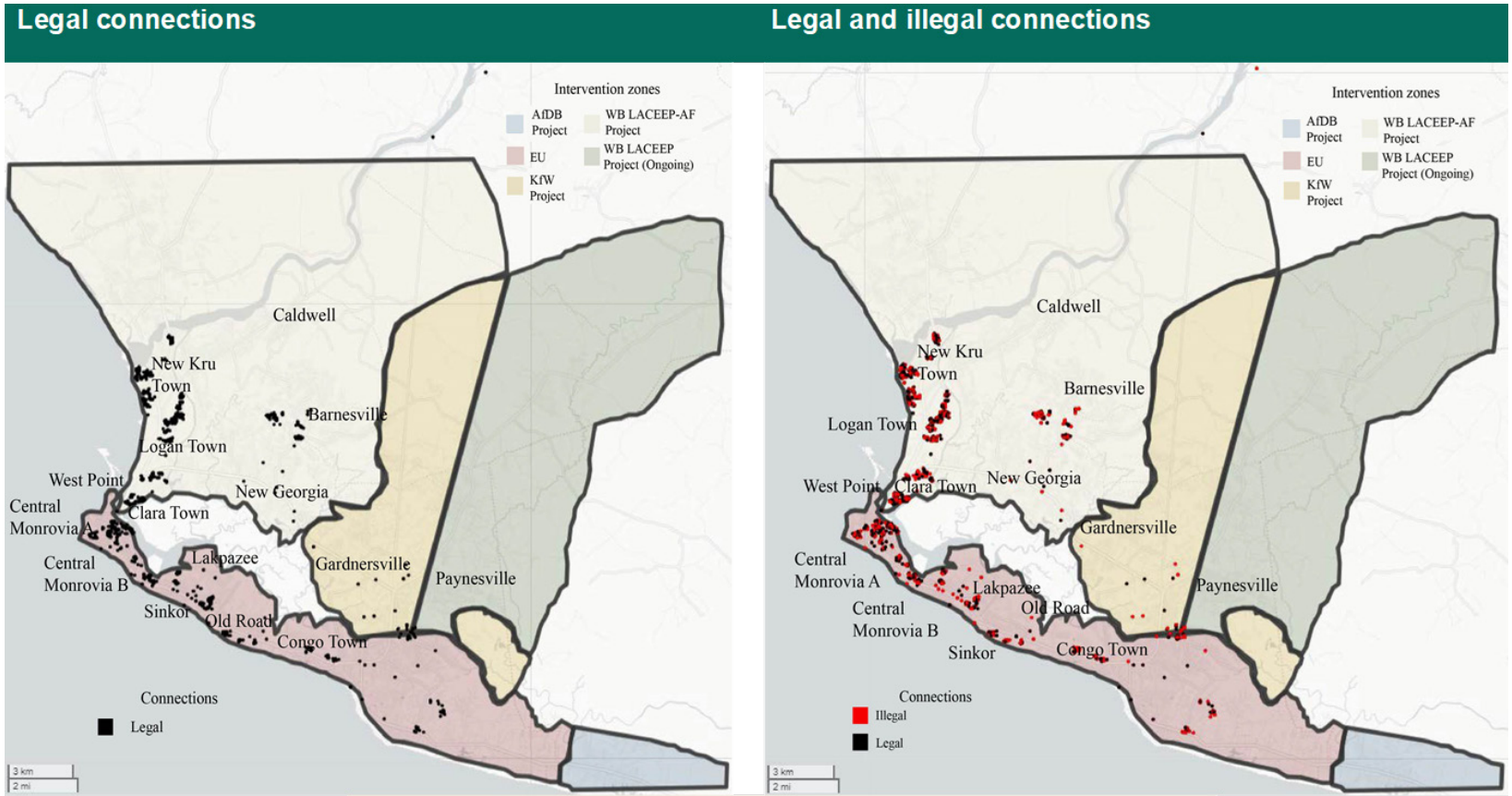




Regarding the illegal connections pictured in Figure VIII.15, FGD respondents explained that they connect illegally because of frustration with waiting for LEC to supply power legally:

> Because LEC is refusing to help me with current I will help myself, I make attempts 3 to 4 times and if LEC doesn't come I will go to a man that LEC trained and deserted to connect me and I will pay him.
>
> Only because LEC doesn't give current, the people steal. And to be frank, I say, power theft, that's LEC's problem. LEC is benefiting from the power theft more because their big, big people…
>
> It was difficult in the sense that people don't believe that LEC will bring current. You don't blame the people, you blame LEC. You cannot take people's information, they wait for 2-3 years without power
>
> Sometimes you finish your registration process. They tell you "within 3 days". After 3 days you call them. They tell you 'we will be there' but they will not come. Sometimes the time extends to years.
>
> The only thing I know if that persons want that current they will get the current at all cost.

Figure VIII.15. Connected households, small businesses, and medium and large end users across Monrovia



Meter sharing
- 37% of households
- 27% of small businesses share a meter
- Those sharing meters include family, friends, neighbors, and businesses

Average number of users per meter
- 4.2 among households
- 2 users among small businesses

4. What are community leaders' perceptions of electricity access?

During community surveys, we asked respondents to estimate the percentage of households that used different energy sources in their communities in 2016 and 2018 (Figures VIII.16 and 17). These indicators provide community leaders' perceptions rather than a systematic count of change; however, it is interesting to see which sources are increasingly and decreasingly used. Community respondents also estimated which services were connected to LEC in 2016 and 2018 (2018 only in unconnected communities). Respondents overwhelming prefer LEC to community current or minigrids, which provide low quality power and generators, which are expensive to fuel and maintain and emit smoke.

Figure VIII.16. Community-level access to LEC and other sources of electricity

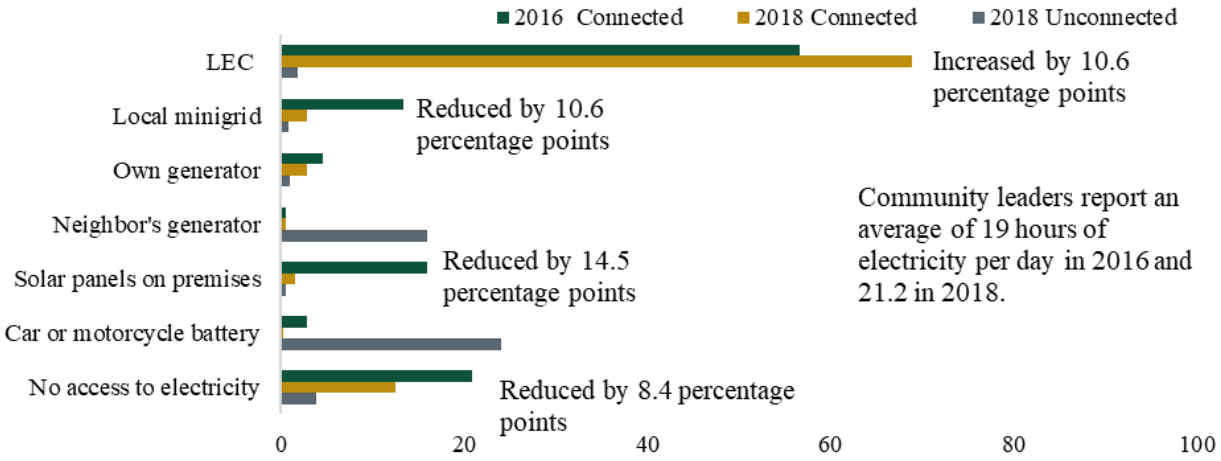
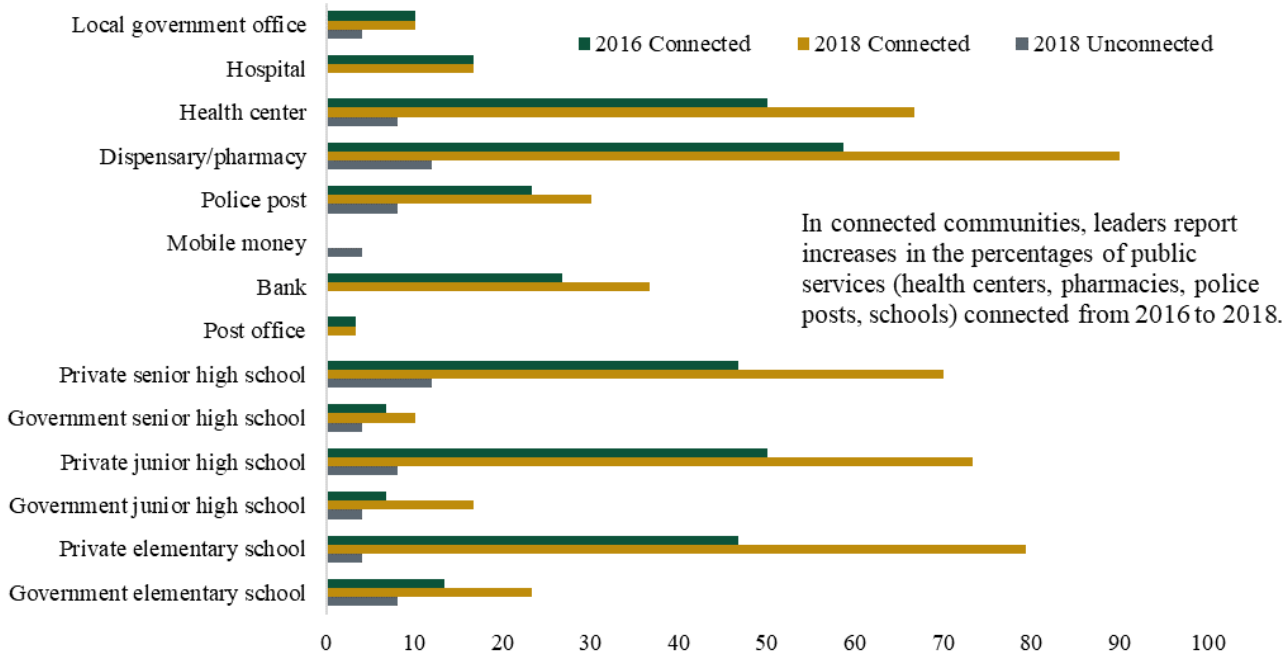


Figure VIII.17. Estimates of connectivity for public services



5. What are the main sources of electricity for households, small business, and medium and large end users?

We asked all respondents to report their main source of electricity (Figures VIII.18 and 19). Respondents from households and small businesses in connected communities and medium and large end users reported their main source of electricity in 2016 and 2018. LEC electricity was the main source for households and small businesses in connected communities. Although there was a slight increase in direct, legal connections from 56 percent to 60 percent in households and 49 percent to 50 percent in small businesses, there were sizeable, statistically significant increases in indirect or illegal connections for households, from 26.5 percent in 2016 to 39 percent in 2018 (12.5 percentage points), and for small businesses, from 15 percent to 30 percent (15 percentage points). The increase in illegal connections is partially responsible for LEC's high rate of commercial losses; however, it represents a smaller percentage of lost revenue than power theft from large customers.

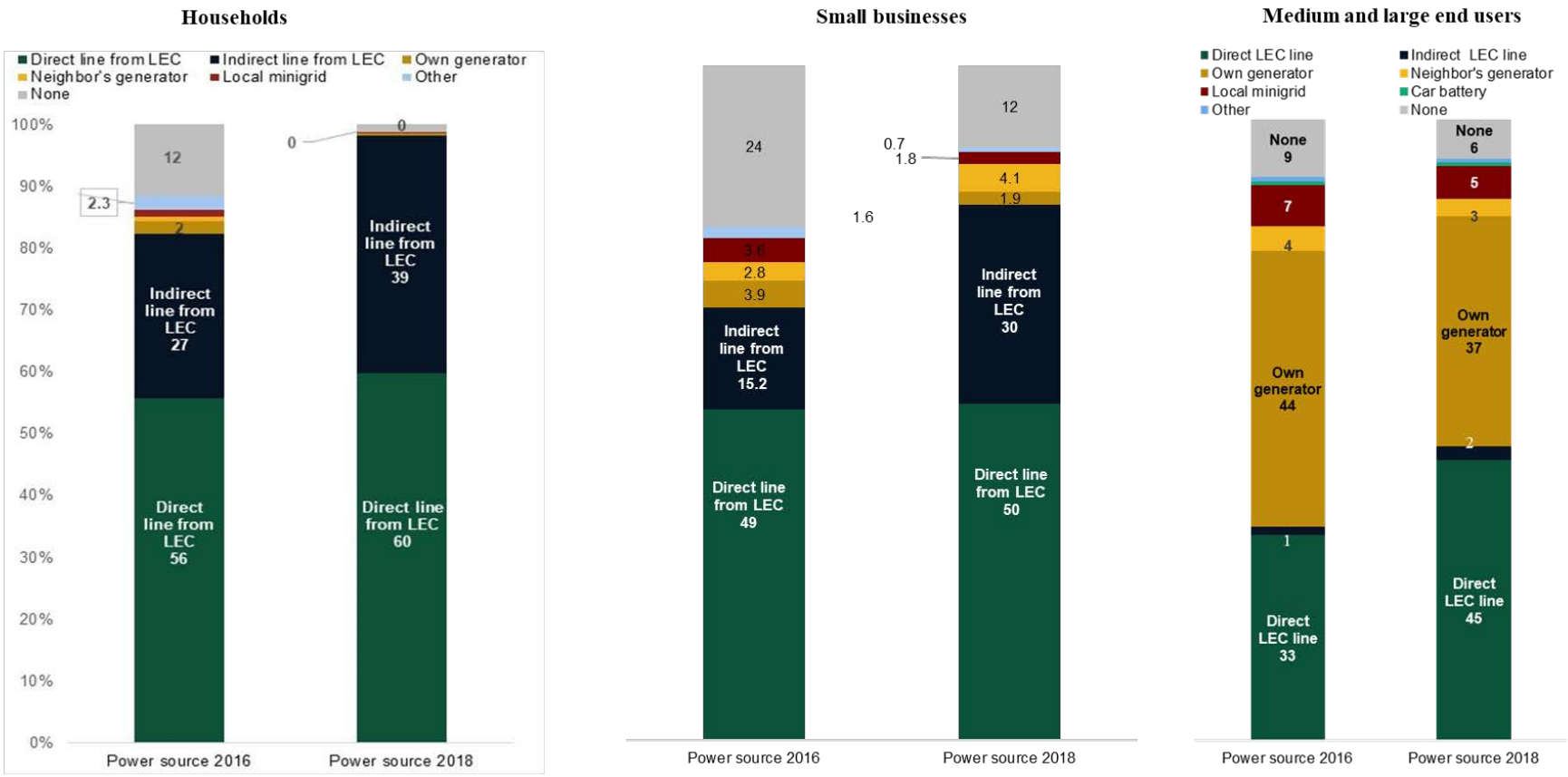
For medium and large end users, 33 percent had a direct connection in 2016 and 45 percent had a connection in 2018 (a 12-percentage point increase), while 6 percent still had no source of electricity in 2018. In 2016, 1 percent had an indirect line, which rose to 2 percent by 2018. The percentage of medium and large end users relying on generators decreased from 44 percent in 2016 to 37 percent in 2018.

The differences between the connected and unconnected samples are stark at baseline. Nearly 82 percent of households and 57 percent of small businesses had no source of electricity in unconnected communities, compared to 1 percent of households and 12 percent of small businesses in connected communities.

Among the still unconnected households and small businesses along the Kakata Corridor, the vast majority (82 percent of households and 57 percent of small businesses) have no electricity source (Figure VIII.19). Among those with electricity, 9 percent of households and 13 percent of small businesses have their own generators, while 7 percent of households and 26 percent of small businesses use a local minigrid. We expect to see changes in these households and small businesses once the T&D construction is finished and LEC offers electricity access to these end users. However, noting that this population is lower income than Monrovia, there may only be modest changes. Poor households and businesses are less likely to benefit from electricity than wealthier end users, who can make larger investments in appliances, equipment, and other energy-intensive items.

Spending on electricity. We asked respondents from connected and unconnected households and small businesses and medium and large end users to estimate the amount of money they spend annually on LEC; generators; and other energy sources, including charcoal and batteries (Figure VIII.20). These calculations do not show the cost per kilowatt hour, so these data cannot be used to compare prices across sources. Still, comparing across each sample, respondents spend more on LEC than other sources, if they have access. Note that cost per kWh of LEC is less than other sources. Comparing connected and unconnected study samples, it is evident that the Monrovia sample is a wealthier sample that is using more energy than the Kakata Corridor sample. Given differences in the cost of LEC compared to generators, the connected samples could spend less on electricity if they were connected to LEC.

Figure VIII.18. Main electricity source 2016-2018 among connected end users



Percentage point change in main source of electricity from 2016 to 2018

Households
- Direct LEC line: +4**
- Indirect LEC line: +12***
- No electricity: -10***

Small businesses
- Direct LEC line: +1
- Indirect LEC line: +15***
- No electricity: -12***

Medium and large end users
- Direct LEC line: +12**
- Indirect LEC line: +1
- Generator: -7
- No electricity: -2/9

*/**/*** Indicates statistical significance at the .05/.01/.001 level with a two-tailed test.

Figure VIII.19. Main electricity source in unconnected households and small businesses

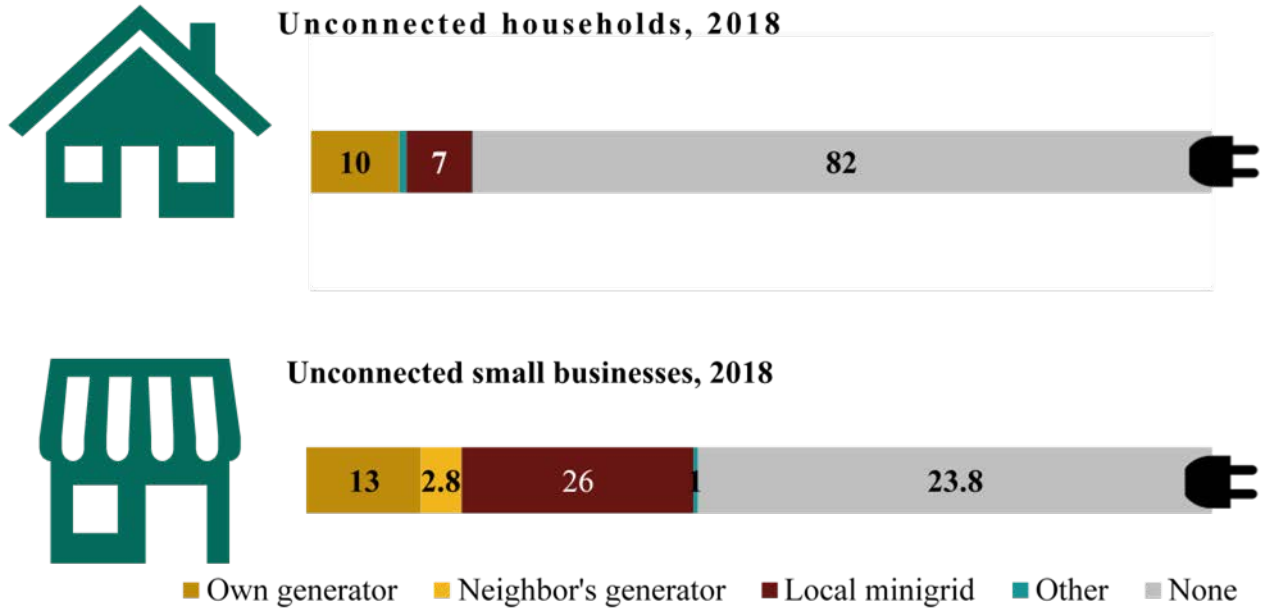
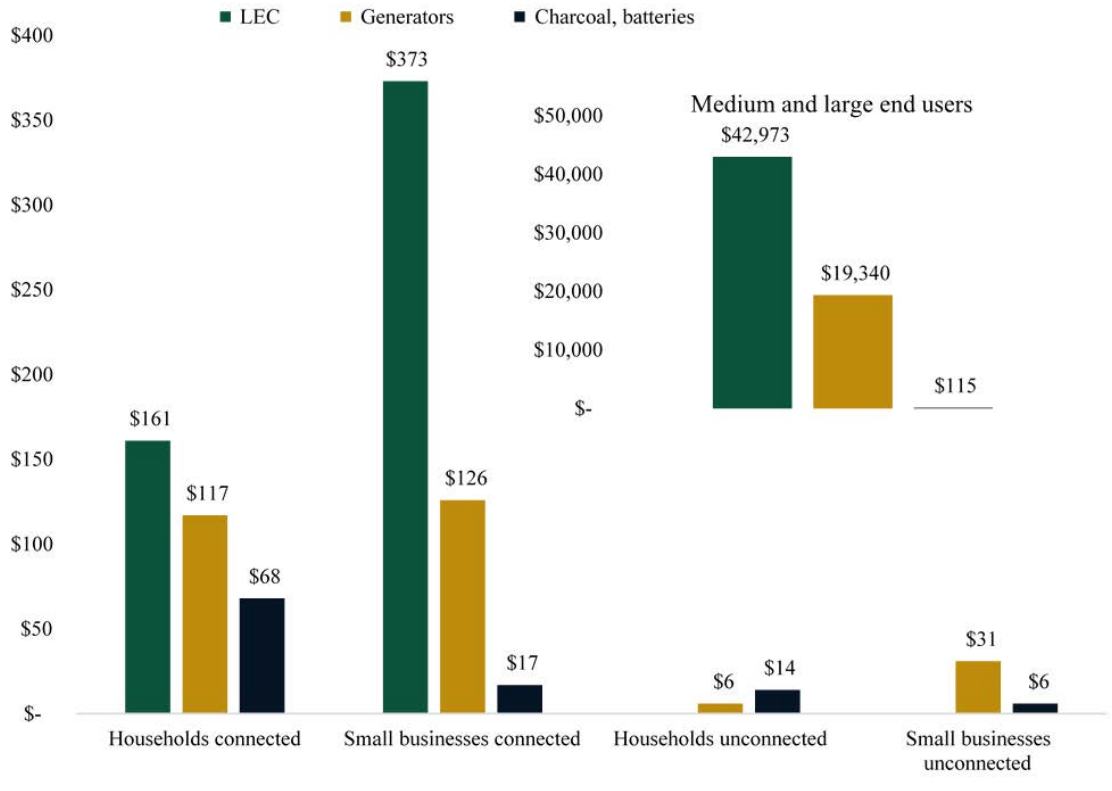


Figure VIII.20. Annual spending on LEC and other electricity sources



6. What do end users spend on electricity and other energy sources?

We asked connected respondents to estimate whether they spent more, the same, or less on LEC in 2018 compared to 2016 (Figure VIII.21a). About 8 percent to 25 percent of end users spent more on LEC in 2016 compared to 2018. Respondents may be capturing the fact that tariffs were reduced from an average of $0.52 per kilowatt hour in 2016 to $0.38 per kilowatt hour in 2018. Thirty-three percent of households and small businesses and 63 percent of medium and large end users reported spending less in 2016 compared to 2018. These end users may be using more electricity for more time or more energy-intensive appliances in 2018, which would account for the increased spending. In fact, household respondents in connected households reported the number of hours they used each appliance in 2016 and 2018. Respondents reported increasing their use of lighting from 11.5 to 12.3 hours per day, use of fans from 4.5 to 4.8 hours per day, use of television from 3 to 3.1 hours per day, and use of refrigerators from 1.6 to 1.7 hours per day.

We also present respondents' reports of LEC expenditures by decile based on whether they have a direct, legal, or indirect, illegal connection (Figure VIII.21a). This illustrates the monthly cost of electricity for households and small businesses. Customers with legal connections report paying more per month than those with illegal connections across the distribution.

Other energy sources. We asked connected respondents to name the energy sources they used in 2016 and all respondents to list the energy sources they used in 2018 (Figure VIII.22). There were only small differences from 2016 to 2018. Within connected and unconnected households, charcoal and double-A batteries were the most commonly used sources. Connected and unconnected small businesses were most likely to report not using any energy source. Depending upon the business type, these end users may benefit the most from access to low cost quality electricity. In addition, medium and large end users relied on petrol and diesel for energy. Given high fuel costs, these users too would benefit from greater access to low cost electricity.

Figure VIII.21a. Spending on LEC

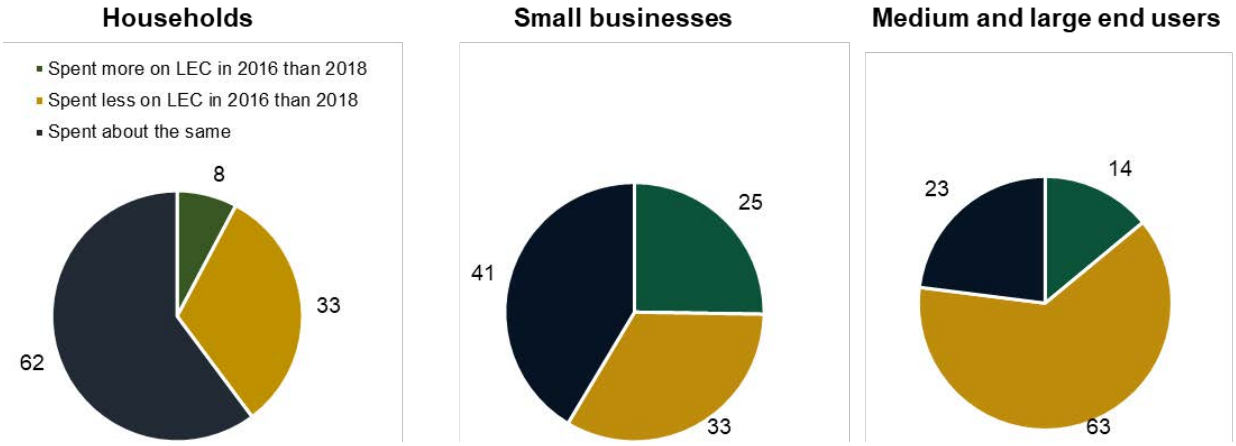


Figure VIII.21b. Monthly spending on LEC for legal and illegal connections, households and small businesses

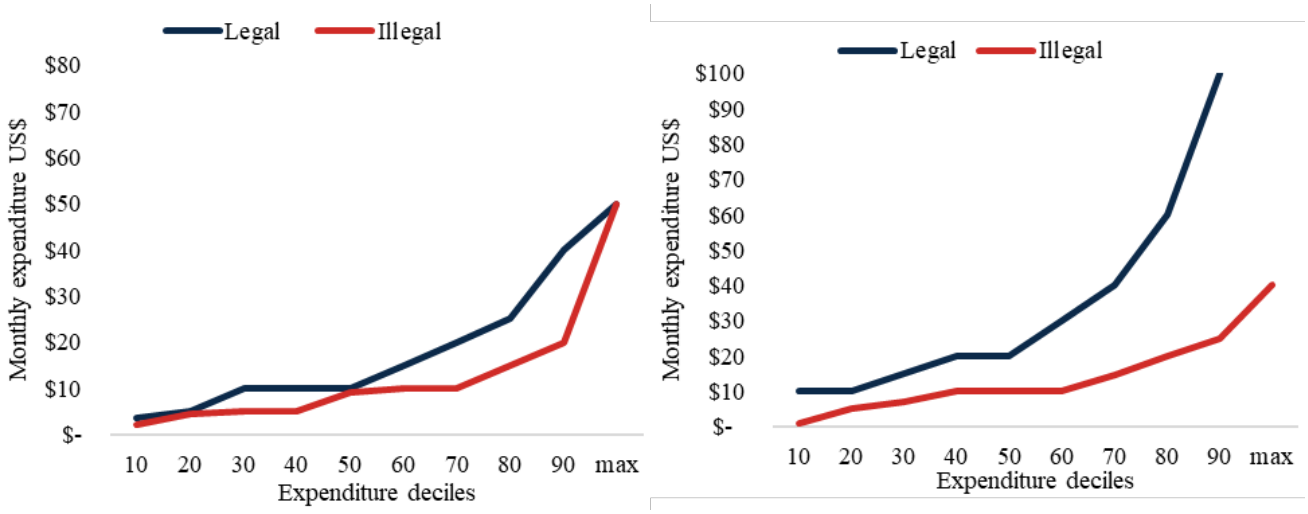
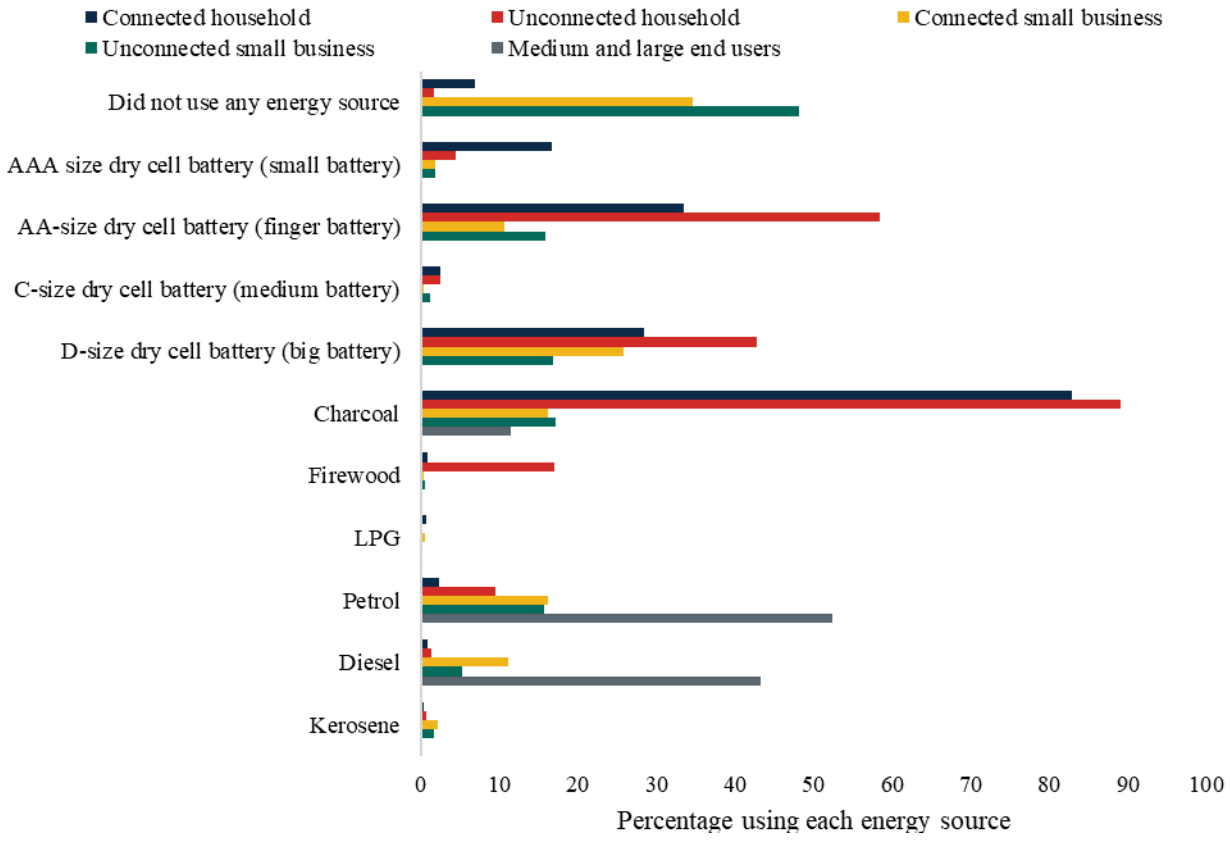


Figure VIII.22. Other energy sources



Some respondents explained that they sacrifice other purchases, even food, to be able to pay for electricity. FGD participants explained:

> For me, I can save money in a small little cup. The man that sells me current loves to collect his money on time. Because I love current, I don't joke about it. I pay.
>
> If I have 100 LD to for breakfast, I will cut it down to 75LD and keep the 25LD as part of my bill because I know current is life.
>
> Eating soon (early) morning is very hard, because I have to save each day for electricity. Sometimes I don't eat in the morning until 1Pm or 2Pm, especially when customers are not buying. We will not eat until in the evening.

C. Findings: How do LEC customers change their behavior, such as investing in appliances and time use?

1. What are the main uses of electricity?

Most respondents reported that their main use of electricity was lighting (Figures VIII.23 and 24.) This was true for households, small businesses, and medium and large end users across connected and unconnected communities. However, from 2016 to 2018, households, small businesses, and medium and large end users reported a shift away from lighting as the main use of electricity towards electronics, appliances, and technology. In households, there was a 9.9 percentage point increase in electronics and appliances as the main use and 3.5 percentage point increase in the use of fans. Among small businesses, respondents shifted toward using freezers (4.4 percentage point increase). Medium and large end users shifted toward technology (6.7 percentage point increase) and machinery (4.5 percentage point increase.)

2. Do customers invest in energy-intensive appliances or equipment?

Access to LEC encourages investments in energy-intensive appliances and planning for purchases. Appliance ownership for all samples (connected and unconnected households, connected and unconnected small businesses, and medium and large end users) is shown in Figures VIII.25 to 29. Connected households and small businesses reported whether they owned appliances and equipment retrospectively for 2016 and in 2018, when the survey was conducted. Among households, the only statistically significant difference was in light bulb ownership (from 88 percent in 2016 to 98 percent in 2018). Small businesses reported increased ownership of light bulbs (from 55 percent to 82 percent), standing fans (from 35 percent to 43 percent), and ceiling fans (from 7 percent to 8 percent). Television, radio, and refrigerator ownership increased, but the change was not statistically significant. Still, one FGD participant explained:

> I have bought lot of new equipment since I got connected to LEC. I had my generator but there was equipment I couldn't turn on. With LEC, I can turn them on so I bought more equipment and I even want to get more as long as LEC is available.

Figures VIII.27 and 28 show appliance ownership within unconnected households and small businesses only for 2018. Overall, the unconnected samples own fewer items than the connected samples. Radios, light bulbs, and fans are the most commonly owned items by unconnected respondents. Among medium and large end users, computers and accessories were the most commonly owned items. Respondents expressed strong interest in using energy-intensive

appliances once connected. Businesses and individuals operating IGAs purchased or intended to purchase freezers and fridges. Some respondents owned these appliances, but generators or community current could not support them. One respondent explained:

> Once there is a current, you buy more electric appliances, but with the community current, the suppliers regulate the usage of the current. If you have 2 amps, it's not possible to put a fridge on.

Businesses and entrepreneurs described plans to purchase equipment to make customers comfortable. However, unstable electricity is a disincentive to making purchases.

Figure VIII.23. Main use of electricity in connected and unconnected households

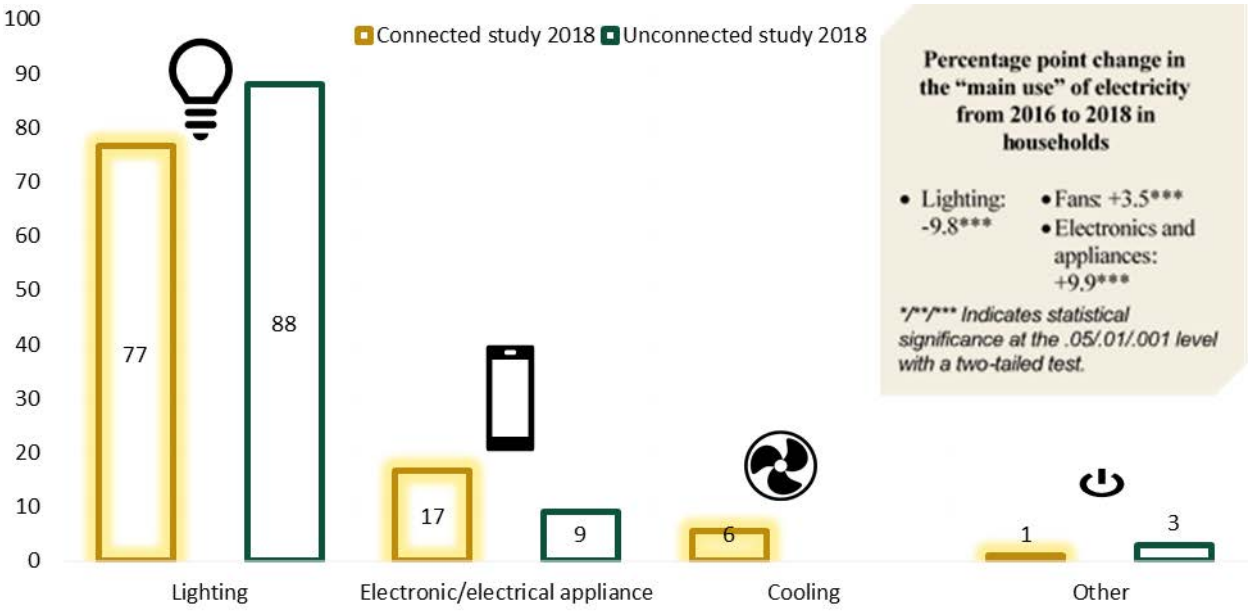


Figure VIII.24. Main use of electricity for connected and unconnected small businesses and medium and large end users (2018)

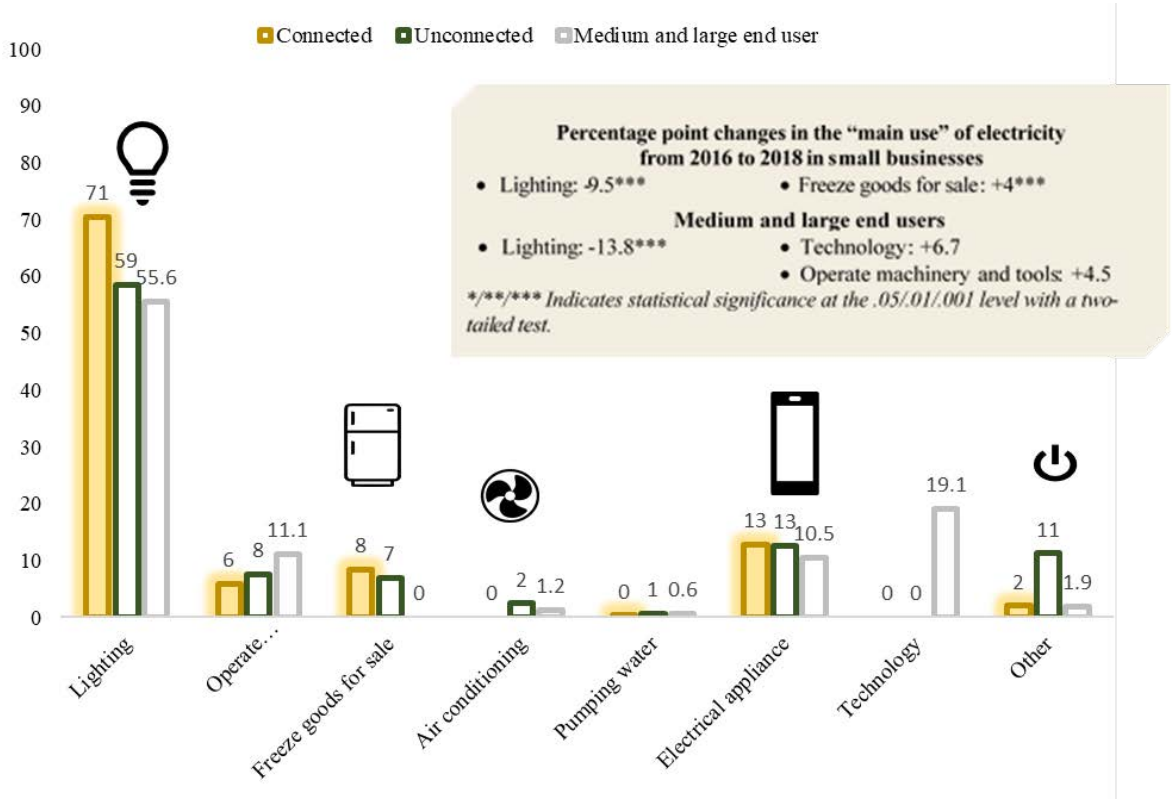
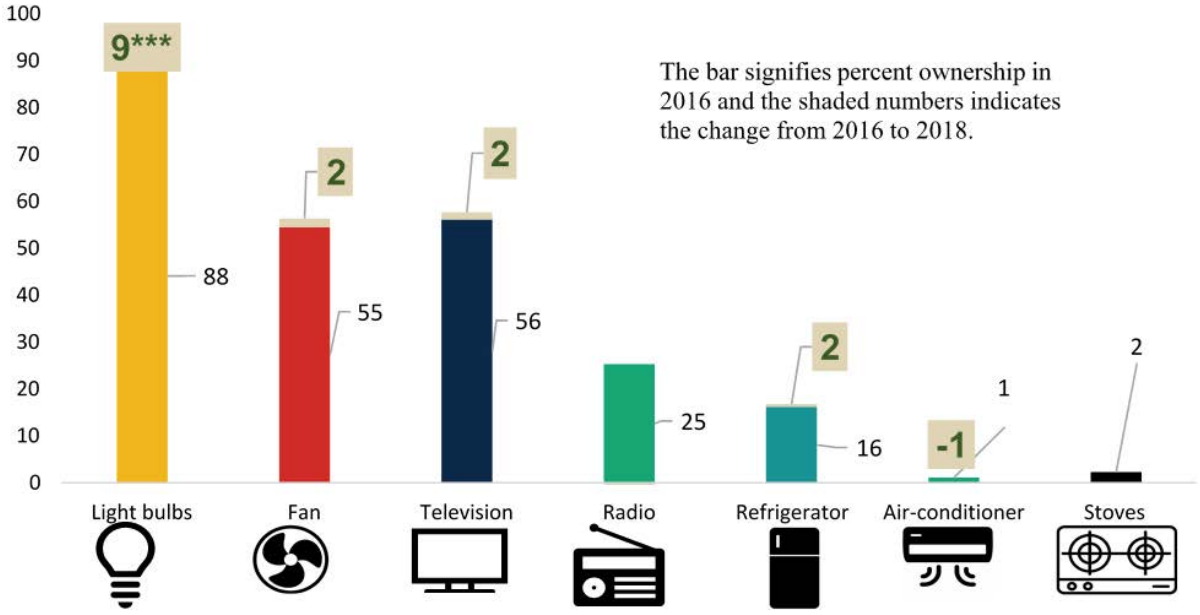


Figure VIII.25. Ownership and usage of energy-intensive appliances or equipment over time in connected households



Note: Percentage point change in ownership from 2016 to 2018 is bolded and shaded.
*/**/*** Indicates statistical significance at the .05/.01/.001 level with a two-tailed test.

Figure VIII.26. Ownership and usage of energy-intensive appliances or equipment among unconnected households in 2018

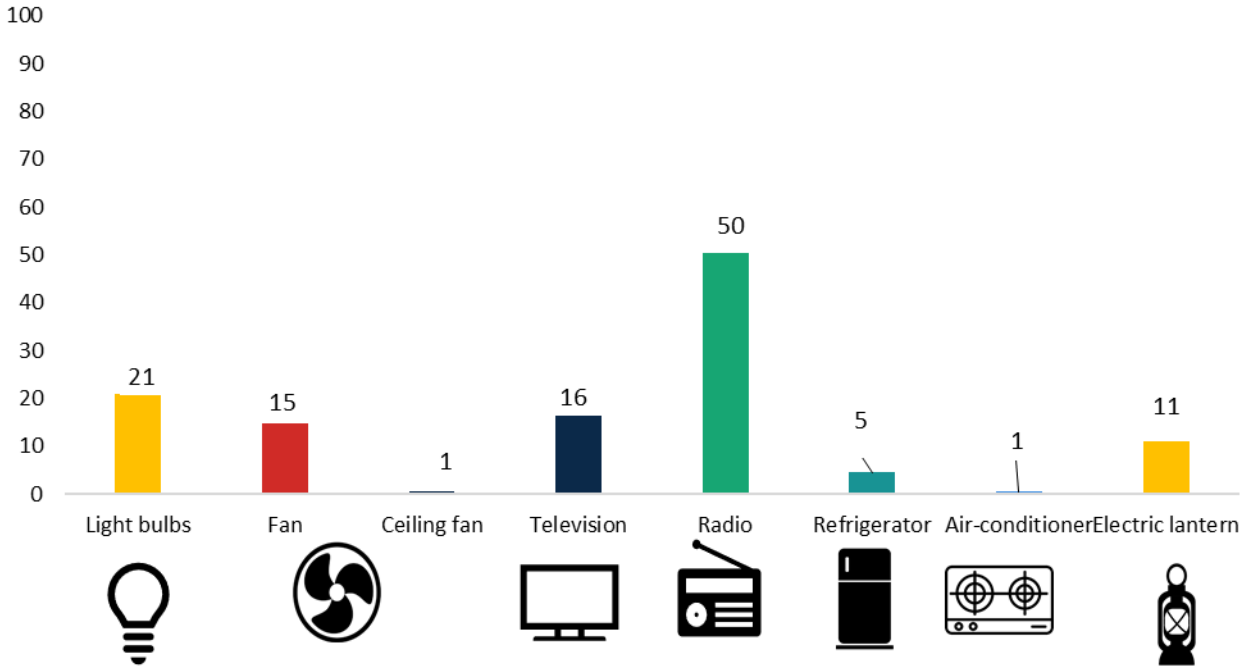
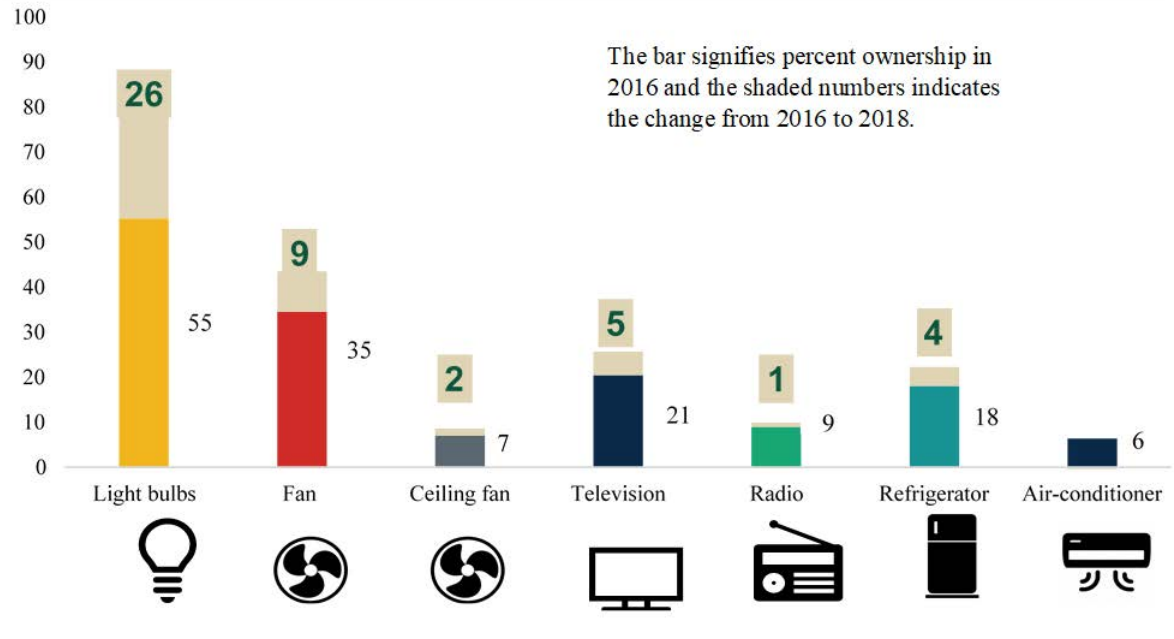


Figure VIII.27. Ownership and usage of energy-intensive appliances or equipment over time in connected small businesses



Note: Percentage point change in ownership from 2016 to 2018 is bolded and shaded.
*/**/*** Indicates statistical significance at the .05/.01/.001 level with a two-tailed test.

Figure VIII.28. Ownership and usage of energy-intensive appliances or equipment among unconnected small businesses in 2018

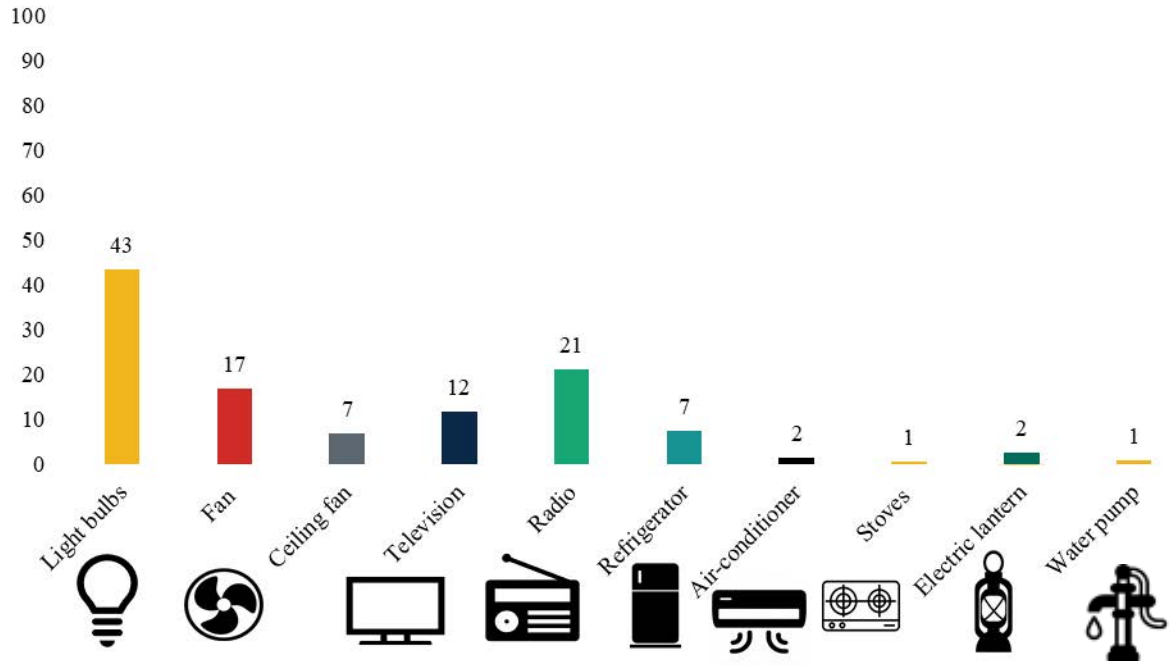
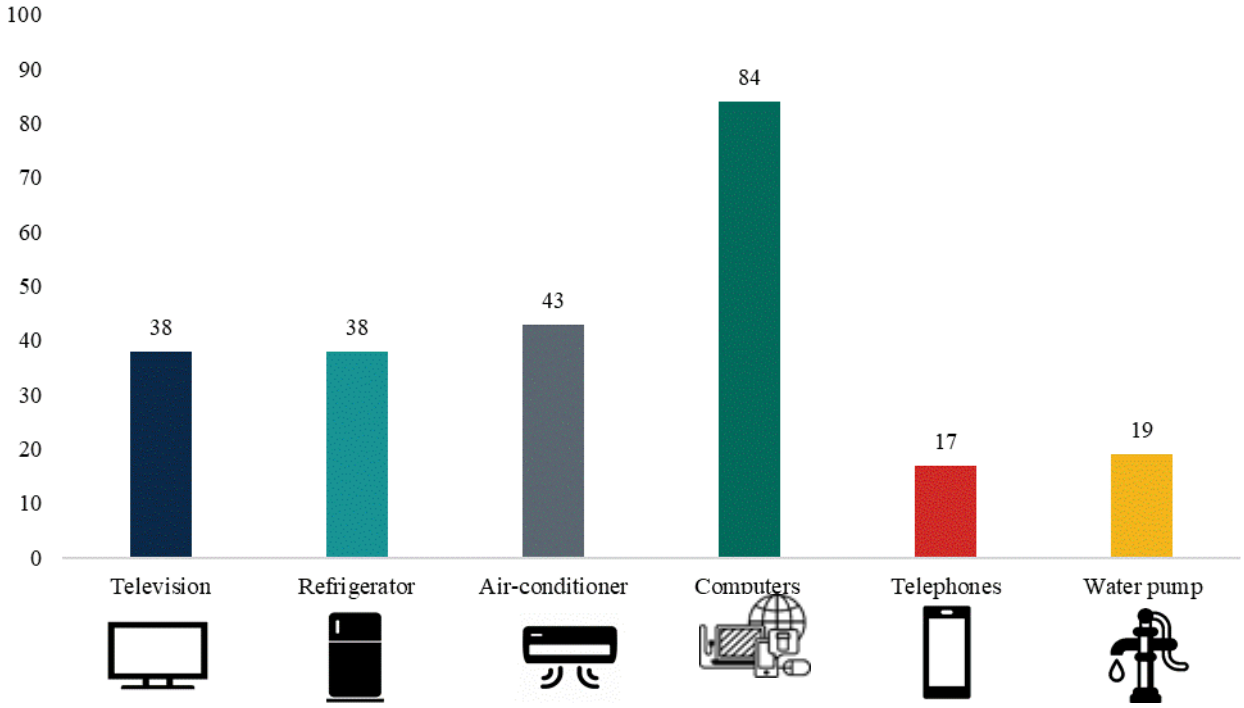


Figure VIII.29. Ownership and usage of energy-intensive appliances or equipment among medium and large end users in 2018



In addition, headmasters reported wanting to buy printers for test printing and health facility respondents wanted to purchase wanted to purchase x-ray machines, CBC machines, and microscopes. These respondents indicated that LEC is necessary for equipment purchase, but they still must raise the funds to pay for them.

3. What are the effects of electricity on time use?

In connected households, women spent the most amount of time watching TV (3 hours per day), followed by doing household chores (2.2 hours per day) and cooking (1.7 hours per day) (Figure VIII.30. Men reported listening to the radio (2.6 hours per day), watching TV (2 hours per day), and participating in leisure activities (1.4 hours per day). In unconnected households, there were somewhat similar patterns; however, women and men watched less than 30 minutes of TV (Figure VIII.31). Women in unconnected households spent the most time on wage labor (2.6 hours per day), followed by household chores (2.2 hours per day), while men reported the most amount of hours listening to the radio (3.3 hours per day), followed by performing wage labor (2.6 hours per day). When asked about changes in time use, about 3 percent of women in connected households reported spending more time on wage labor, 11 percent spent more time on cooking, and 16 percent spent more time on leisure from 2016 to 2018 (Figure VIII.32). For men in connected households, 27 percent reported spending more time listening to the radio and 25 percent reported spending more time on leisure activities.

In FGDs, participants reported that electricity is time saving compared to other energy sources, helping shorten the time it takes to complete domestic tasks such as ironing and cooking. Respondents described how electric appliances reduce cooking time and eliminate the need to spend time gathering firewood or acquiring charcoal. For women, this may mean more time for other work or leisure, and for children, more study time. Domestic tasks are not only faster but also easier, allowing families to multitask in ways that were impossible when using labor-intensive cooking techniques.

> When our mothers or sisters are using the microwave or electric cook stove, they spend less than 30 minutes in cooking but when they are using the charcoal stove, they spend one to two hours to cook.

Electric lighting also contributes to changes in time use. Respondents report shifting bedtimes when they have lights as family members can talk, watch TV, do chores, or study into the evening. Students' lengthen study time when they are not limited to daylight hours, candlelight, or battery-powered 'Chinese lights.' Respondents report that family members, especially women and children, spend more time watching TV. They also listen to the radio or stereo more. Respondents' reports of time spent at home. For some respondents, electricity in the community makes it easier and safer to stay out later. At the same time, other respondents report spending more time at home, with electric fans that make the home comfortable.

Figure VIII.30. Adult time use in connected households

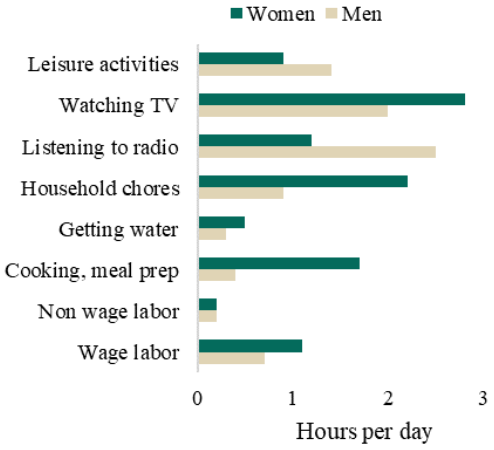


Figure VIII.31. Adult time use in unconnected households

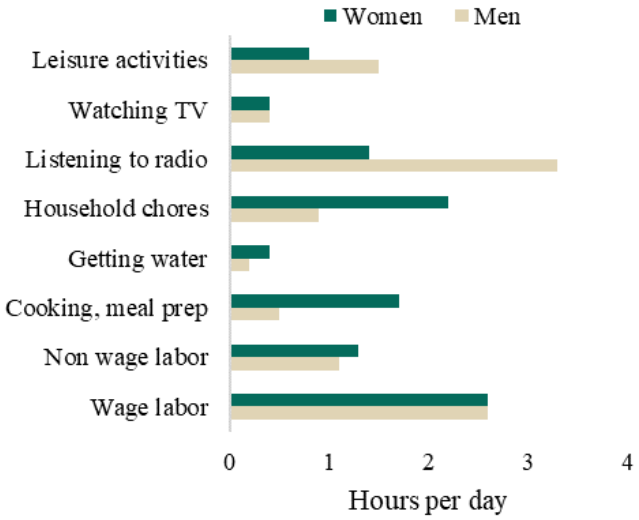
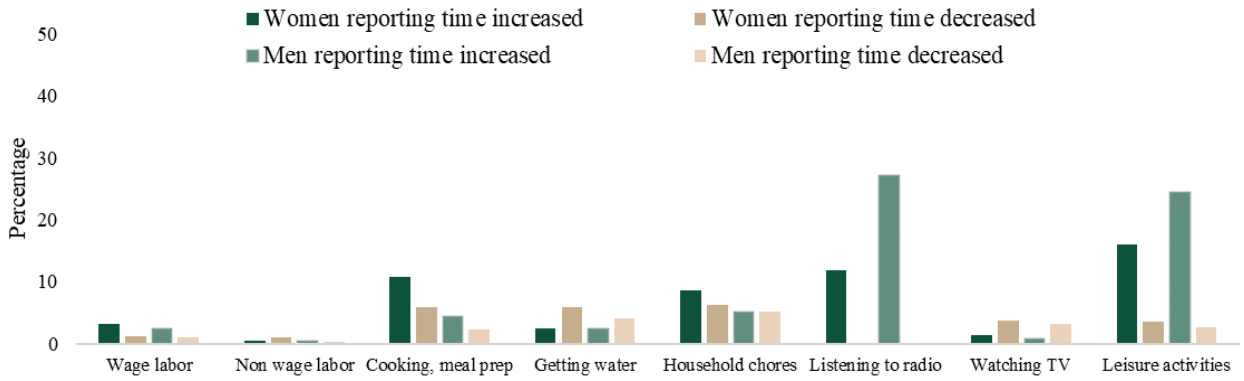


Figure VIII.32. Changes in time use



We asked respondents to estimate the time that children spent on various tasks. Boys and girls in all households spent most of their time sleeping, about 8.3 hours per day in connected households and 9.5 hours per day in unconnected households (Figures VIII.33 and VIII.34). It is not surprising that children in homes without electricity sleep longer than other children. Children in connected households spend less time outside playing than children in unconnected households (1.2 hours per day versus 2.5 hours per day for girls and 1.8 hours per day versus 3 hours per day for boys). Children in connected households also spend more time watching TV, listening to the radio, doing chores, performing wage labor, and studying compared to children in unconnected households. These differences may be due to different lifestyles in Monrovia versus more rural areas or due to having electricity or not.

Figure VIII.33. Child time use in connected households

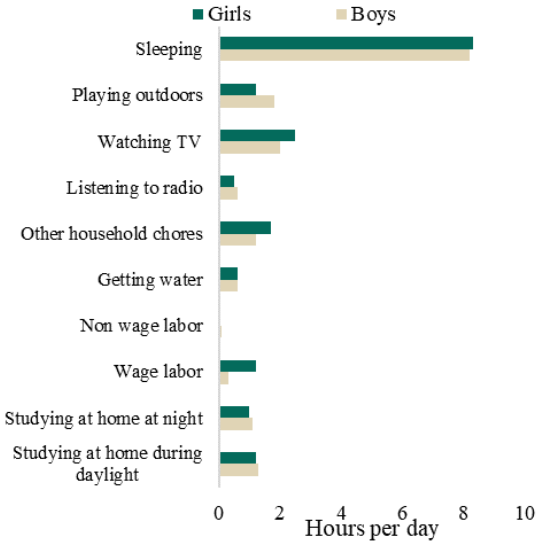


Figure VIII.34. Child time use in unconnected households

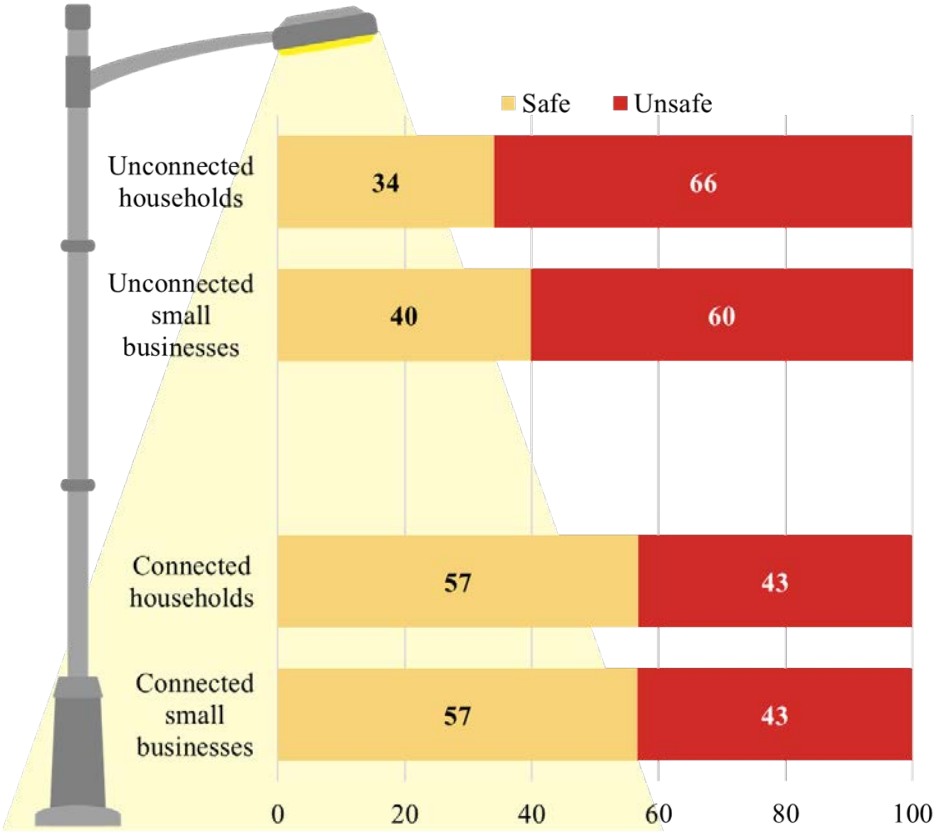
D. Findings: What are other effects of electricity?

1. What are the other effects on end users?

Safety and security. In both connected and unconnected communities, respondents reported at least some streetlights in most areas. Seventy-two percent of respondents in connected households and 78 percent of respondents in unconnected households thought that streetlights provided some protection against crime and animals. Figure VIII.35 shows respondents' perception of safety in their communities based on having streetlights. Respondents in better lit communities are more likely to report feeling safe compared to those in unlit communities. Respondents described how LEC improves safety:

> It is beneficial because when you have LEC current you can sleep sound. But if you have to put the generator on, you will have to wake up at night thinking the gas has finished or the smoke will strangle you. LEC is very much beneficial to us. If you are using generator, it is a risk.
>
> I'm alone in my house, my children and I, so the light helps prevent criminals from coming around, so I sleep very sound and peacefully. It's a benefit for me.

Figure VIII.35. Reported feeling safe when walking in community at night



Dangers of electricity. Injuries and fatalities from electrocution and electrical fires are commonly reported in Liberia's press. Among respondents in connected communities, 1 percent of household respondents and 3 percent of small business respondents reported that they knew of someone who had been severely injured or killed by LEC electrical lines. In addition, 6 percent of household respondents had experienced a fire because of LEC electricity. Community leaders and FGD participants discussed the danger of LEC and made pleas for educational programs to teach Liberians about the dangers of electrical wires.

> The current is good and the current is dangerous.
>
> We recommend again that there should be lot of training and advertisements for the users of LEC current so that we don't encounter lots of problems. Electricity is a new thing to this community especially for this new generation. It is not like community current. We know that this LEC current has hard voltage, so we recommend LEC does some education and puts signs around so that people know the dangers. Many people get hurt.

We present photos from field work which illustrate how power lines are draped across homes. In some case, people hang laundry to dry across electricity lines.

Photos from field work

2. What are some spillover effects?

Respondents also reported spillover benefits for safety, education, income opportunities, and quality of life for non-electrified households in connected communities. One of the more consequential effects is access to better quality healthcare in connected communities. Many respondents had stories of not getting adequate care at hospitals without electricity and care improving with electricity. For example:

> I know a lady that carried her daughter. The hospital had no current. They have a generator but no fuel. They asked that woman to buy 15 gallons of fuel before they could do the operation on that girl. They asked her to provide that fuel. That lady left the pregnant woman in the care, ran to Weala to get money to buy fuel and put in the generator. So if she could not provide that money, it means the lady could die. If at all we see premature deaths at government hospital because they don't have the cash to provide the fuel money. If there is electricity that is stable.

As noted, streetlights in a community can improve safety. Residents feel more comfortable leaving their homes at night, which allows businesses to operate later. Respondents also noted that access to neighbors' current creates new income-generating opportunities:

> You tie cold water in the big mineral bag and ask your friend 'let me use your freezer to store my water' or buy the mineral sack water and ask your friend to store your water. There you bring it out put it in the cooler and your children sell or yourself sell, then your children will have something to do for you to send your children to school.

Several respondents reported that children often go to the homes of connected neighbors to study or they study under streetlights.

> Electricity helps a lot in the education of kids. If majority of us have current, our kids will do better academically.

Electricity in a community also facilitates tasks like charging phones and laptops and providing entertainment.

E. Findings: Connection decisions, reasons for not connecting, barriers to connections

1. Decisions to connect made by HH, small business, and large organization surveys:

Liberians in our study overwhelming feel that electricity is important to daily life. They report interest in connecting to LEC and that they will connect if LEC provides access. FGD participants explained:

> Current is life and it provides comfort.
>
> Everybody is happy when current comes, even the children.
>
> LEC current makes the community lively. Normally you won't want to be in darkness, that's why we always need light. Once there is current, you are free to move at any time, so the LEC current provides security for the community. The LEC current makes people to live in a good atmosphere

> I don't think Liberians want to be in darkness. People what to enjoy current (electricity), watch videos, charge our laptops, and entertain ourselves. People don't want to always find themselves in difficult times.

2. Barriers to connecting to LEC electricity

Respondents from households and small businesses listed the various barriers to connecting to LEC electricity. The most common barrier was that the power lines were too far from the respondents' home or business. This suggests that once distribution lines are built near homes, potential customers will connect. Among large organizations, 19 percent of respondents reported that they had submitted an application and were waiting for connection, 18 percent said that LEC had refused to connect the building (likely due to a meter shortage or overloaded transformers), and 19 percent said the application procedures were too complicated.

While few survey respondents reported that connecting was too expensive, we asked FGD and IDI respondents how much they paid for LEC connections and received a range of replies (all US $):

> I paid the fee for the form which was $55 dollars.
>
> We paid two hundred fifty $250. We went to Waterside (LEC HQ), paid the money and got the registration and invoice documents.
>
> I tried the normal process during the Ebola time. I paid cash to the bank, just to find out that my meter was being used by someone else. Because I didn't want to spend cash foolishly again, so I waited to be connected before I paid them the $100.
>
> They charge me $150 because my house is a bit distance away from the pole, but I bargain for $100 and they accepted.
>
> They called and asked if I had the cash $100 that we agreed on. They came and connected my household and I gave them the cash. I preferred to pay the cash and get connected rather than buy 2.5 KVA generators for $200 to $300 and keep buying gasoline, which is more expensive.
>
> Everybody was paying $50. That was straight flat rate for everybody that wanted to use the LEC current, so we paid ours.

FGD and IDI respondents reported different views of whether Liberians would migrate to access LEC. Here, two respondents insisted people are moving while a community leader disagreed:

> Definitely, most people have migrated because of lack of LEC current. Some people have built houses in places like Caldwell and other places because of the lack of electricity. For example, my uncle said he cannot go to his house because of the lack of current. People moved to Logan town, Doe Community, Clara Town, New Kru Town, West Point and you just name them. People move to communities not because they love the community, it's because of the service. This is the twenty-first century. People don't want to live without current.
>
> Yes, 100% people move for current. People were pouring in the community in search of rooms, all because of the current. Current serves as security.
>
> Nobody has moved. As far as I'm concerned people bought their land here, we sitting here and waiting

Population growth in Monrovia suggests that Liberians may be moving to access power.

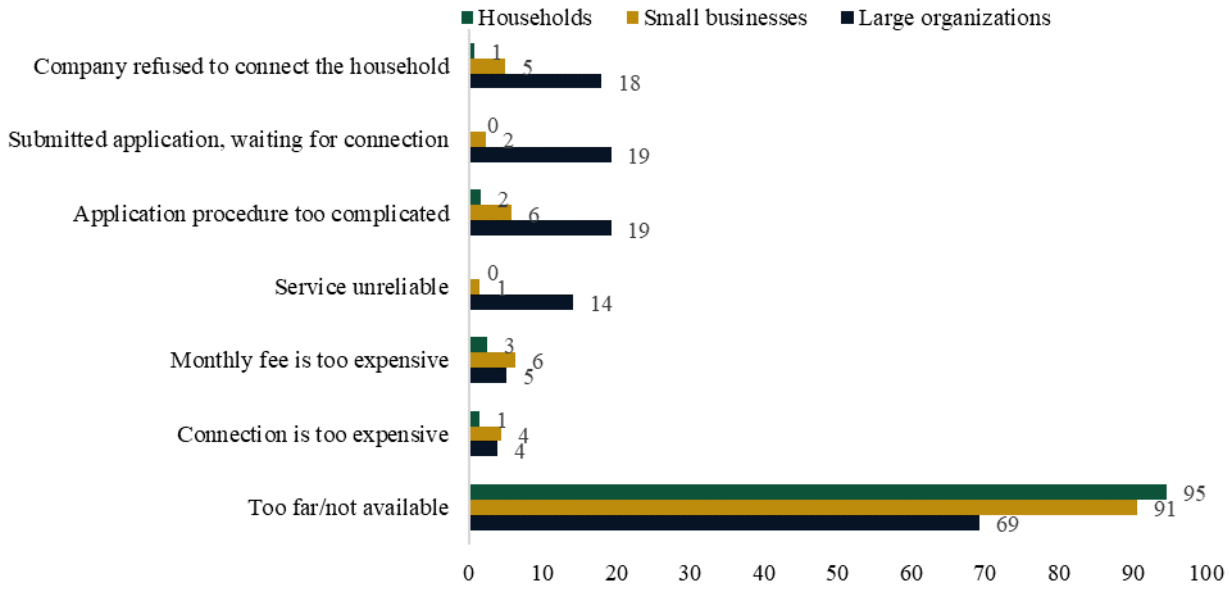
F. How have (MCC's investments) affected end users' perceptions of electricity quality?

In surveys and qualitative activities, we asked respondents about their perceptions of the quality of electricity, experiences with outages and negative effects of outages, and LEC's service when problems occur (Figure VIII.36). One respondent summed up most reports:

> Outages make me feel miserable, especially when I have to transact business.

Household customers appear to have the highest quality of electricity with fewest outages compared to small businesses and medium and large end users. On average, households report approximately 19 hours of electricity per day, compared to an average of approximately 15 hours of electricity per day for small businesses, and 14 hours of electricity for medium and large end users. Households also reported 5.5 to 6.7 hours of outages per week compared to small businesses with 8 to 11.7 hours of outages, medium and large end users with 13.7 to 15.5 hours of outages depending on the season.

Figure VIII.36. Barriers to connecting to LEC electricity in 2018



Respondents also reported seasonal variations in electricity quality (Figure VIII.37). Both the rainy and the dry season pose challenges. Power fluctuates and outages are more frequent in the dry season. In the rainy season, respondents report that they "usually experience good electricity when it's raining." However, power may also fluctuate during heavy downpours.

> Most of the time current goes and comes, especially when rain is falling.

Households, small businesses, and medium and large organizations differed in their reporting of when outages were most likely to occur (Figure VIII.38). Customers reported deep frustration and hopelessness with LEC's service when electricity problems occur. FGD participants explained:

> Could you imagine you purchase your credit and on your way home the transformer blows up. And when you go to them they will tell you "go come, go come, go come" and we are still going, coming, going coming but there is no solution.
>
> It will be better you buy cup of rice for you and your children to eat instead of giving it to LEC because it will yield no understanding.
>
> Without money to give in bribes your minor problems will never be solved. Everything about LEC is problem, even common things.

FGD participants also noted that LEC employees lack adequate training and there is an unmet need for community education about how to connect to and use current safely.

Figure VIII.37. Quality of electricity (connected households and orgs)

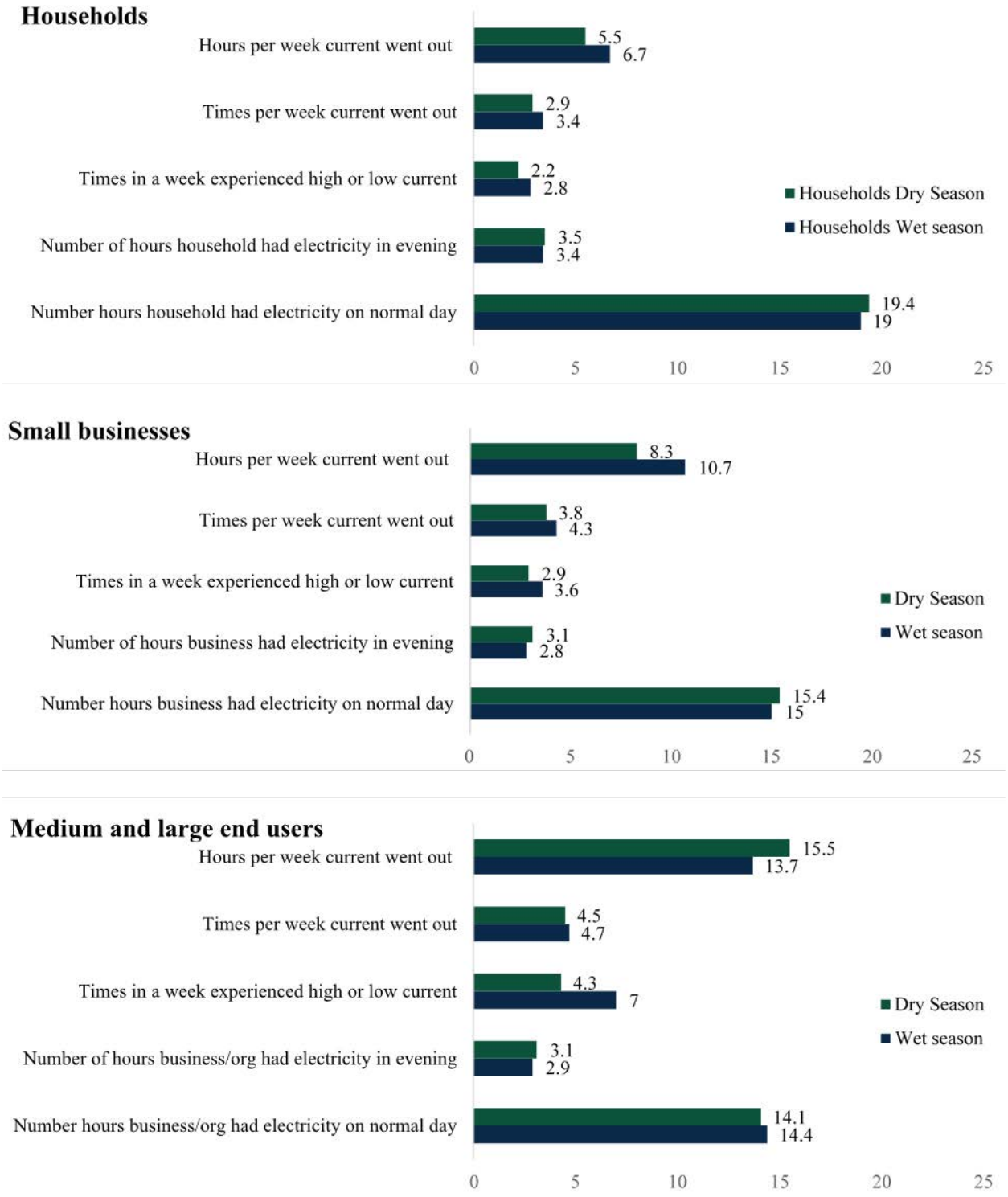
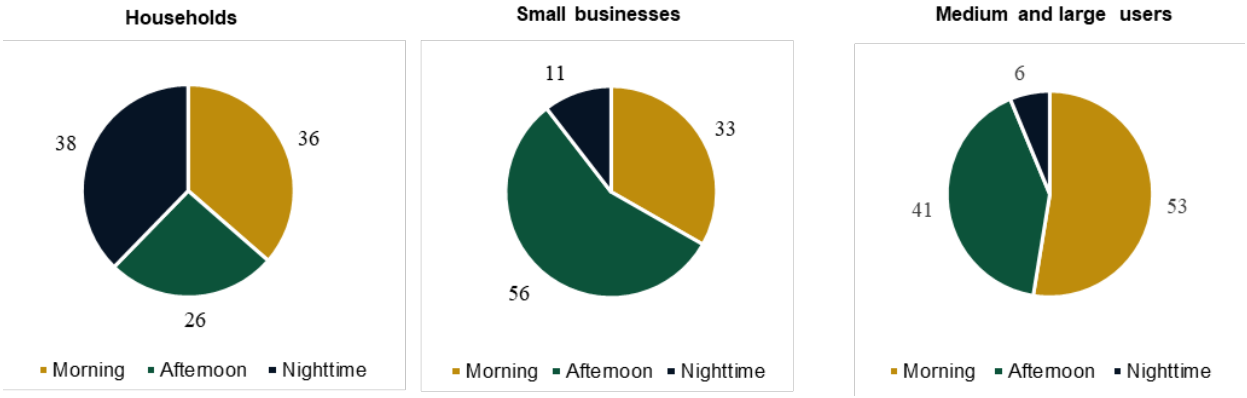


Figure VIII.38. Electricity outages



We asked respondents if they were notified of outages and 99 percent of household and 97 percent of small, medium, and large businesses and organizations said that LEC never informs them in advance of outages. Of 17 household respondents who reported being notified, the majority said they heard notification on the radio (75 percent), and 12 percent said they saw a notice on social media. Nine small businesses and three large organizations heard notification on the radio or by SMS.

Next survey respondents from each study group reported the negative effects of outages within households and businesses (Figure VIII.39 and Figure VIII.40).

Figure VIII.39. Negative effects of power outages in households

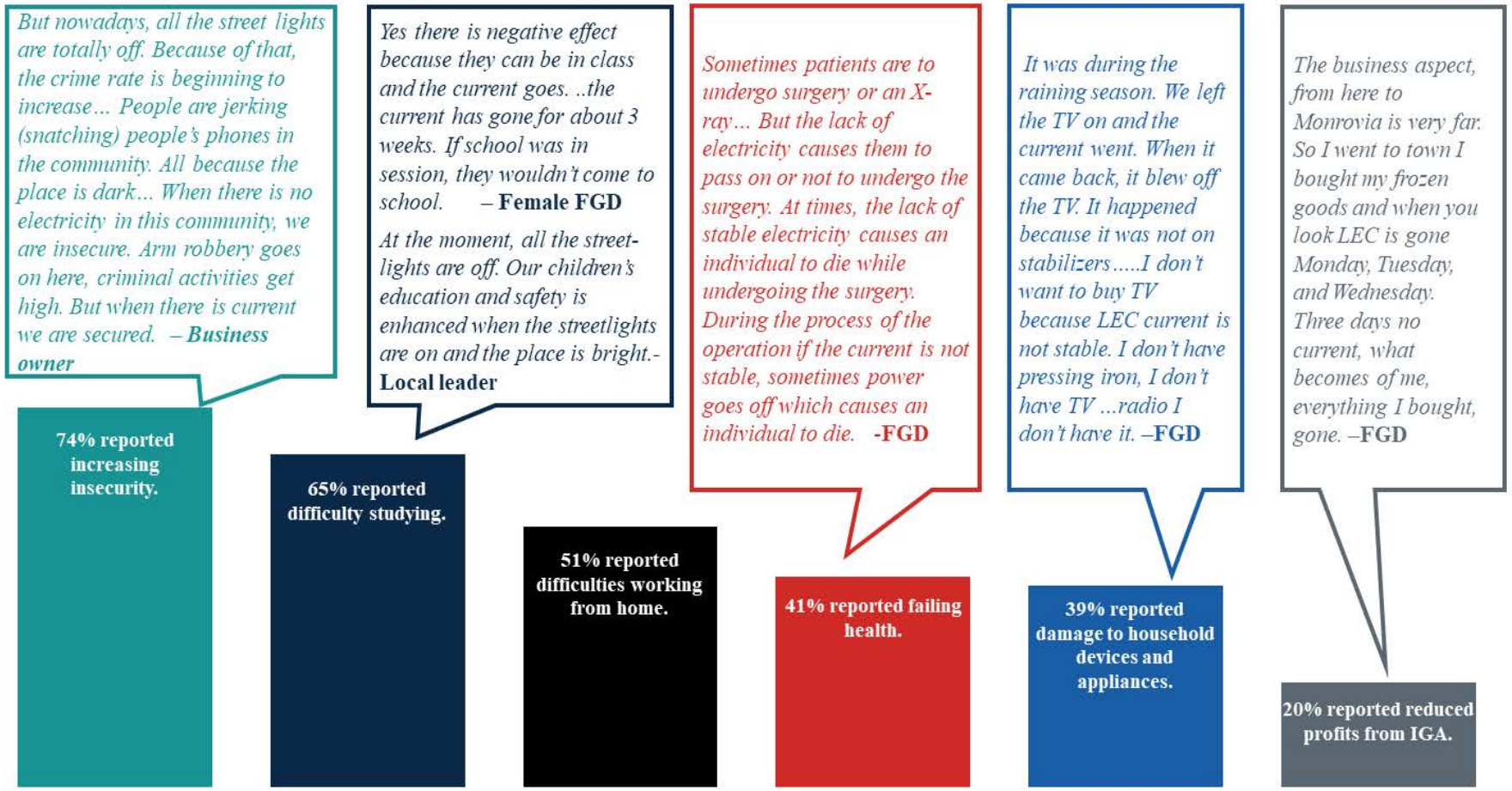
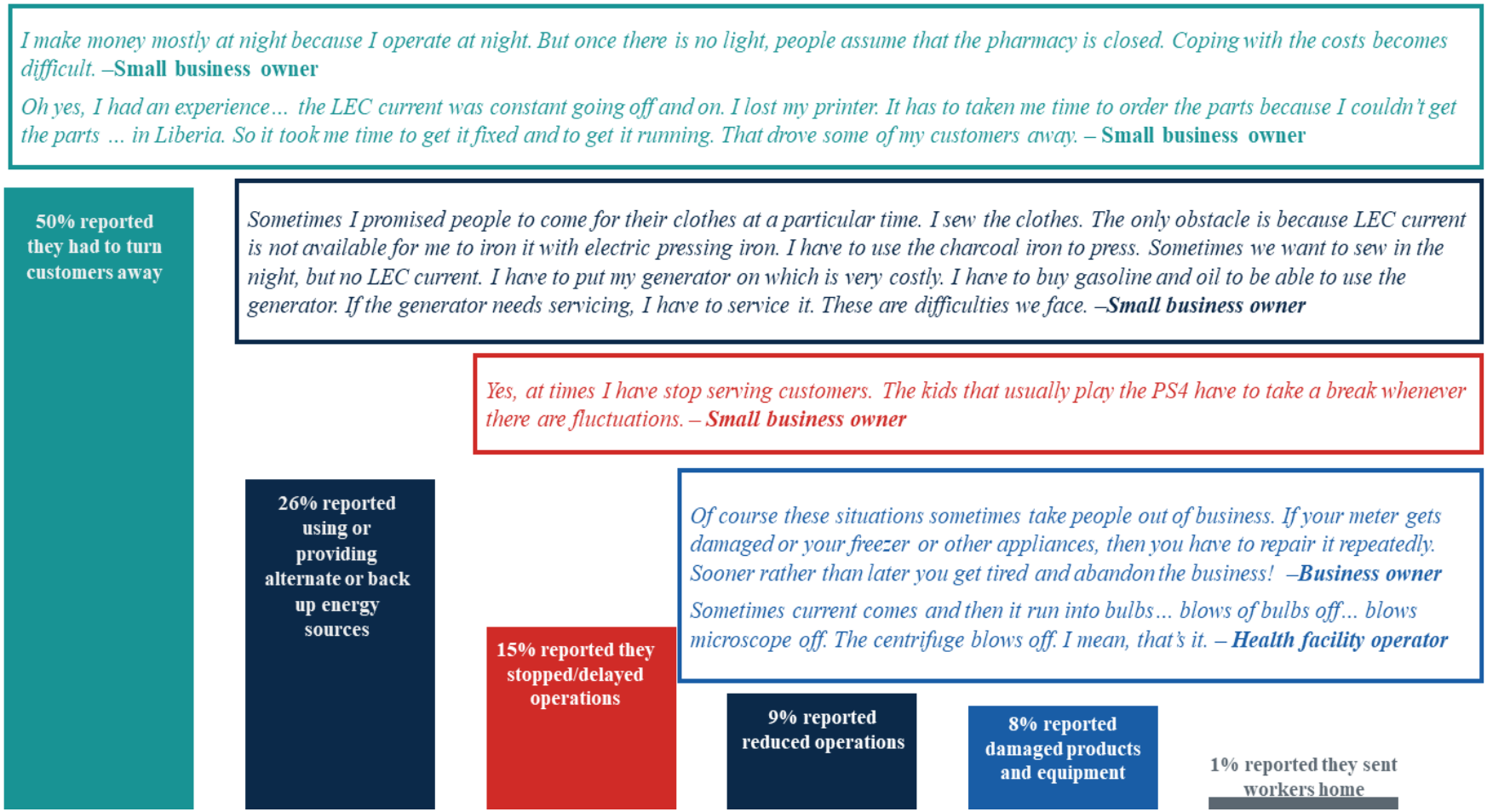


Figure VIII.40. Negative effects of power outages in small businesses



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IX. CONCLUSION

Next steps

We look forward to sharing the draft report with MCC, MCA-Liberia, and all energy sector stakeholders for review and discussion. We aim to present findings to the Liberia Energy Team in Washington, to MCC and MCA-Liberia in Liberia, and to stakeholders in Liberia, including donor partners, policymakers, ESBI, and LEC. We will seek feedback, revise the report in response to stakeholder comments, and finalize it. We will conduct additional analyses or draft materials from the report findings as requested and as funding permits.

Then, we plan to continue with program monitoring activities, including conducting an ongoing document review, key informant interviews, and site visits as needed. We also plan to begin the interim data collection toward the end of 2020 and produce an interim report in August of 2021.

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REFERENCES

Adair-Rohani, Heather, Karen Zukor, Sophie Bonjour, Susan Wilburn, Annette C. Kuesel, Ryan Hebert, and Elaine R Fletcher. "Limited Electricity Access in Health Facilities of Sub-Saharan Africa: A Systematic Review of Data on Electricity Access, Sources, and Reliability." *Global Health: Science and Practice*, vol. 1, no. 2, August 2013, pp. 249–261. Available at https://doi.org/10.9745/GHSP-D-13-00037.

Adejumobi, S. *Democratic Renewal in Africa: Trends and Discourses*. New York: Springer, 2015.

Adenikinju, Adeola F. "Electric Infrastructure Failures in Nigeria: A Survey-Based Analysis of the Costs and Adjustment Responses." *Energy Policy*, vol. 31, November 2003, pp. 1519–1530. Available at https://doi.org/10.1016/S0301-4215(02)00208-2.

African Development Bank Group. "The High Cost of Electricity Generation in Africa." February 18, 2013. Available at https://blogs.afdb.org/blogs/afdb-championing-inclusive-growth-across-africa/post/the-high-cost-of-electricity-generation-in-africa-11496. Accessed December 12, 2017.

Akpan, Uduak S., Maurice A. Essien, and Salisu R. Isihak. "Impact of Rural Electrification on Rural Micro-Enterprises in Niger Delta, Nigeria." *Energy for Sustainable Development*, vol. 17, October 2013, pp. 504–509. Available at https://doi.org/10.1016/j.esd.2013.06.004.

Arnold, Jens Matthias, Aaditya Matoo, and Gaia Narciso. "Services Inputs and Firm Productivity in Sub-Saharan Africa: Evidence from Firm-Level Data." *Journal of African Economies*, vol. 17, no. 4, February 2, 2008, pp. 578–599. Available at https://doi.org/10.1093/jae/ejm042.

Azorom. Contract Monitoring Consultant (CMC) for Management Services (MSC) Contract for Liberia Electricity Corporation (LEC). Monthly Reports, January to December – 2018. Millennium Challenge Corporation Liberia (MCA-L). Dublin.

Azorom. Contract Monitoring Consultant (CMC) for Management Services (MSC) Contract for Liberia Electricity Corporation (LEC). Quarterly Report, January to December – 2019. Millennium Challenge Corporation Liberia (MCA-L). Dublin.

Azorom. Contract Monitoring Consultant (CMC) for Management Services (MSC) Contract for Liberia Electricity Corporation (LEC). Quarterly Reports, Quarters 1, 2, 3, and 4 – 2018. Millennium Challenge Corporation Liberia (MCA-L). Dublin.

Azorom. Contract Monitoring Consultant (CMC) for Management Services (MSC) Contract for Liberia Electricity Corporation (LEC). Quarterly Report, Quarters 1, 2, 3, and 4 – 2019. Millennium Challenge Corporation Liberia (MCA-L). Dublin.

Azorom. Contract Monitoring Consultant (CMC) for Management Services (MSC) Contract for Liberia Electricity Corporation (LEC). Quarterly Report, Quarter 2 – 2019. Millennium Challenge Corporation Liberia (MCA-L). Dublin.

Azorom. Contract Monitoring Consultant (CMC) for Management Services (MSC) Contract for Liberia Electricity Corporation (LEC). Annual Report, 2018. Millennium Challenge Corporation Liberia (MCA-L). Dublin.

Ballh, Zeze. "Weah's Gov't Hit by Massive Resignations Over Salary Delays, Other Grievances." *Bush Chicken*, November 26, 2019. Available at https://bushchicken.com/weahs-govt-hit-by-massive-resignations-over-salary-delays-other-grievances/. Accessed January 31, 2020.

Barron, Manuel, and Maximo Torero. "Household Electrification and Indoor Air Pollution." *Journal of Environmental Economics and Management*, Vol. 86, November, pp. 81-92. 2017. Available at https://www.ocf.berkeley.edu/~manuelb/research.html. Accessed May 12, 2016.

Bensch, Gunther, Jorg Peters, and Maximiliane Sievert. "Fear of the Dark? How Access to Electric Lighting Affects Security Attitudes and Nighttime Activities in Rural Senegal." *Journal of Rural and Community Development*, vol. 8, no. 1, 2013, pp. 1–19. Available at http://dx.doi.org/10.2139/ssrn.2159712.

Bernard, Tanguy, and Maximo Torero. "Social Interaction Effects and Connection to Electricity: Experimental Evidence from Rural Ethiopia." *Economic Development and Cultural Change*, vol. 63, no. 3, April 2015, pp. 459–484. Available at https://doi.org/10.1086/679746.

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

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

Canale, L., N. Sans, P. Lorillou, and F. Ciampitti. "Securing Long-Term Commercial Operation Through Adequate O&M in Sub-Saharan Africa." *International Journal on Hydropower and Dams*, vol. 24, no. 4, 2017, pp. 50–57. Available at https://www.hydropower-dams.com/articles/securing-long-term-commercial-operation-through-adequate-om-in-sub-saharan-africa/.

Chakravorty, Ujjayant, Martino Pelli, and Beyza Ural Marchand. "Does the Quality of Electricity Matter? Evidence from Rural India." *Journal of Economic Behavior and Organization*, vol. 107, part A, November 2014, pp. 228–247. Available at https://doi.org/10.1016/j.jebo.2014.04.011.

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

Cooper, Helene. "Living in Darkness, but Holding onto Hope in Liberia." *New York Times*, Tuesday, February 14, 2017.

Dinkelman, Taryn. "The Effects of Rural Electrification on Employment: New Evidence from South Africa." *American Economic Review*, vol. 101, no. 7, December 2011, pp. 3078–3108. Available at https://www.jstor.org/stable/41408731.

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

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

Electricity Supply Board International. "Presentation to the Energy Sector Working Group." Monrovia, Liberia: ESBI, November 12, 2019.

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

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

Goanue, Augustus V. "Overview of LERC and the Electricity Market of Liberia PowerPoint Presentation." Monrovia, Liberia: Liberia Energy Regulation Committee, presented October 2019.

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

Government of Liberia. "Program Implementation Agreement Between The United States of America." Monrovia, Liberia: Government of Liberia, 2017.

Government of Liberia. "Republic of Liberia Statutory Rules and Orders: Liberia Electricity Regulatory Commission (LERC) Bylaws, Internal Operating Procedures." Monrovia, Liberia: Government of Liberia, May 2019.

Grimm, Michael, Renate Hartwig, and Jann Lay. "Electricity Access and the Performance of Micro and Small Enterprises: Evidence from West Africa." *European Journal of Development Research*, vol. 25, no. 5, December 2013, pp. 815–829. Available at https://doi.org/10.1057/ejdr.2013.16.

Grogan, Louise, and Asha Sadanand. "Rural Electrification and Employment in Poor Countries: Evidence from Nicaragua." *World Development*, vol. 43, March 2013, pp. 252–265. Available at https://doi.org/10.1016/j.worlddev.2012.09.002.

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

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

Hettinger, Patrick. "Ebola Hits Liberia's Economy Hard." International Growth Centre. Blog post, August 15, 2014. Available at https://www.theigc.org/blog/ebola-hits-liberias-economy-hard/. Accessed January 31, 2020.

Imam, Mahmud I., Tooraj Jamasb, and Manuel Llorca. "Sector Reforms and Institutional Corruption: Evidence from Electricity Industry in Sub-Saharan Africa." *Energy Policy*, vol. 129, June 2019, pp. 532–545. Available at https://doi.org/10.1016/j.enpol.2019.02.043.

International Energy Agency. "Africa Energy Outlook: A Focus on Energy Prospects in Sub-Saharan Africa." Paris, France: IEA, 2014.

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

Johnson, Obediah. "Liberia: Electricity Meter Theft on the Rise, Several Households, Communities Left in Darkness." *FrontPageAfrica,* November 26, 2019. Available at https://frontpageafricaonline.com/news/liberia-electricity-meter-theft-on-the-rise-several-households-communities-left-in-darkness/. Accessed January 31, 2020.

Khandker, Shahidur R., Douglas F. Barnes, and Hussain A. Samad. "The Welfare Impacts of Rural Electrification in Bangladesh." *Energy Journal*, vol. 33, no. 1, 2012, pp. 187–206. Available at https://www.jstor.org/stable/41323350.

Khandker, Shahidur R., Douglas F. Barnes, and Hussain Samad. "Welfare Impacts of Rural Electrification: A Panel Data Analysis from Vietnam." *Economic Development and Cultural Change*, vol. 61, no. 3, April 2013, pp. 659–692. Available at https://doi.org/10.1086/669262.

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

Koinyeneh, Gerald C. "Liberia Electricity Corporation Workers' Salary Slashed by 30 Percent." *FrontPageAfrica*, November 26, 2019. Accessed January 31, 2020. Available at https://frontpageafricaonline.com/news/liberia-electricity-corporation-workers-salary-slashed-by-30-percent/.

Koinyeneh, Gerald C. "Liberia: President Weah Warns of Govt Losing US$40M If Legislature Fails to Pass Executive-Backed Bills." *FrontPageAfrica,* August 27, 2019. Accessed January 31, 2020. Available at https://frontpageafricaonline.com/news/liberia-president-weah-warns-of-govt-losing-us40m-if-legislature-fails-to-pass-executive-backed-bills/.

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

Lee, Alan David, and Zainab Usman. "Taking Stock of the Political Economy of Power Sector Reforms in Developing Countries: A Literature Review." Policy research working paper no. WPS 8518; Rethinking Power Sector Reform. Washington, DC: World Bank Group, 2018. Available at http://documents.worldbank.org/curated/en/431981531320704737/Taking-stock-of-the-political-economy-of-power-sector-reforms-in-developing-countries-a-literature-review. Accessed January 31, 2020.

Lee, Kenneth, Eric Brewer, Carson Christiano, Francis Meyo, Edward Miguel, Matthew Podolsky, Javier Rosa, and Catherine Wolfram. "Electrification for 'Under Grid' Households in Rural Kenya." *Development Engineering*, vol. 1, June 2016, pp. 26–35. Available at https://doi.org/10.1016/j.deveng.2015.12.001.

Lenz, Luciane, Anicet Munyehirwe, Jorg Peters, and Maximiliane Sievert. "Does Large-Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda's Electricity Access Roll-Out Program." *World Development*, vol. 89, January 2017, pp. 88-110. Available at https://doi.org/10.1016/j.worlddev.2016.08.003.

Liberia Electricity Corporation. "Presentation to High Level Steering Group (HLSG)." PowerPoint presentation. Monrovia, Liberia: LEC, 2018.

Liberia Energy Regulations Commission. "Organogram Overview of LERC & Electricity Market of Liberia." Monrovia, Liberia: LERC, October 2019.

Liberia Ministry of Foreign Affairs. "An Act to Amend Chapters 85 of the 1973 Public Authority Law Creating the Liberia Electricity Corporation and Amendment Thereto, to Establish the 2015 Electricity Law of Liberia." Monrovia, Liberia: Ministry of Foreign Affairs, October 23, 2015.

Liberia Ministry of Lands, Mines and Energy. "Republic of Liberia National Energy Policy: An Agenda for Action and Economic and Social Development." Monrovia, Liberia: Ministry of Lands, Mines and Energy, January 2009.

Macro Consulting. "Liberia Electricity Corporation Cost of Service Study." Final consolidated report. Washington, DC: World Bank, August 20, 2018.

Manitoba Hydro International. "Mt. Coffee Project Implementation Unit (PIU) Mount Coffee Hydropower Rehabilitation Project: Quarterly Progress Reports #1 January 2014 - through #16 December 2017." Liberia Electricity Corporation. Monrovia.

Manitoba Hydro International. "Mt. Coffee Project Implementation Unit (PIU) Mount Coffee Hydropower Rehabilitation Project: Monthly Progress Reports January 2018 - through August 2019." Liberia Electricity Corporation. Monrovia.

McCulloch, Allison, and Joanne McEvoy. "'Bumps in the Road Ahead': How External Actors Defuse Power-Sharing Crises." *Journal of Intervention and Statebuilding*, vol. 13, no. 2, March 2019, pp. 216–235. Available at https://doi.org/10.1080/17502977.2018.1526994.

McCulloch, N., Esméralda Sindou, and John Ward. "The Political Economy of Aid for Power Sector Reform." *Institute of Development Studies*, vol. 48, nos. 5-6, November 2017. Available at https://doi.org/10.19088/1968-2017.168

McCulloch, Neil, Esméralda Sindou, and John Ward. "Aid and the Design and Implementation of Power Sector Reform Projects in Sub-Saharan Africa." *Oxford Institute for Energy Studies*, Issue 115, September 2018. Available at https://www.oxfordenergy.org/wpcms/wp-content/uploads/2018/09/OEF-115.pdf.

Miller, Candace, John Schurrer, Nicholas Redel, Arif Mamun, and Duncan Chaplin. "Millennium Challenge Corporation's Electricity Transmission and Distribution Line-Extension Activity in Tanzania: Qualitative Evaluation." Report submitted to the Millennium Challenge Corporation. Washington, DC: Mathematica Policy Research, July 22, 2015.

Miller, Candace, Kristine Bos, Ali Protik, Randall Blair, Paolo Abarcar, and Matthew Ribar. "Evaluation Design Report for the Liberia Energy Project Activities 1 and 2." Report submitted to the Millennium Challenge Corporation. Cambridge, MA: Mathematica Policy Research, August 2019.

Miller, Candace, Kristine Bos, and Ali Protik. "Evaluability Assessment for the Liberia Energy Project." Report submitted to the Millennium Challenge Corporation. Washington, DC: Mathematica Policy Research, December 2018.

New Dawn Liberia. "IMF Approves US213.6 Million for Liberia," December 13, 2019. Available at https://thenewdawnliberia.com/imf-approves-us213-6-million-for-liberia/. Accessed January 31, 2020.

Norplan Fichtner. "Mount Coffee Inception Report." For Liberia Electricity Corporation. September 2013.

Peters, J., C. Vance, and M. Harsdorff. "Grid Extension in Rural Benin: Micro-Manufacturers and the Electrification Trap." *World Development*, vol. 39, no. 5, pp. 773–783, May 2011. Available at https://doi.org/10.1016/j.worlddev.2010.09.015.

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

Rimšaitė, Laura. "Corruption Risk Mitigation in Energy Sector: Issues and Challenges." *Energy Policy*, vol. 125, February 2019, pp. 260–266. Available at https://doi.org/10.1016/j.enpol.2018.10.066.

Rose-Ackerman, S. "The political economy of corruption—causes and consequences." Public policy for the private sector. Note No. 74. Washington DC: World Bank. 1996. Available at https://openknowledge.worldbank.org/handle/10986/11629, January 31, 2020.

Rose-Ackerman, Susan. *The Political Economy of Corruption: Causes and Consequences*. Washington, DC: World Bank Group, 1996.

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

Sieh, Rodney D. "Liberia: Weah Administration Poised to Lose Euro 42 Million for Rural South-East Electrification." FrontPageAfrica, September 3, 2018. Available at https://frontpageafricaonline.com/politics/liberia-weah-administration-poised-to-lose-euro-42-million-for-rural-south-east-electrification/. Accessed January 31, 2020.

Simone, Tagliapietra, and Morgan Bazilian. "The Role of International Institutions in Fostering Sub-Saharan Africa's Electrification." *Electricity Journal* 32, vol. 32, no. 2, March 2019, pp. 13–20. Available at https://doi.org/10.1016/j.tej.2019.01.016.

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

Tetra Tech. "Legal Issues in Management Services Contracts – Liberia utility private sector partnership options." Presentation to MCC, Washington D.C. September 2018.

Tetra Tech. "Liberia Utility Options." Presentation to MCC, Washington D.C. September 2018.

Tetra Tech. LEC M&E Indicators Calculations for the Liberia Energy Evaluation. Monrovia. September 2018.

United States Agency for International Development. "Loss Reduction Program for the Liberia Electricity Corporation: Power Africa Transactions and Reforms Program (PATRP)." Washington, DC: USAID, August 26, 2016.

United States Agency for International Development. "Power Africa in Liberia." Washington, DC: USAID, May 2016. Available at https://www.usaid.gov/powerafrica/liberia. Accessed February 15, 2018.

Van de Walle, Dominique, Martin Ravallion, Vibhuti Mendiratta, and Gayatri Koolwal. "Long-Term Impacts of Household Electrification in Rural India." *World Bank Economic Review*. Advance online publication. doi:10.1093/wber/lhv057. Washington, DC: World Bank, 2015.

Wamukonya, Njeri, and Mark Davis. "Socio-Economic Impacts of Rural Electrification in Namibia: Comparisons Between Grid, Solar, and Unelectrified Households." *Energy for Sustainable Development*, vol. 5, no. 3, September 2001, pp. 5–13. Available at https://doi.org/10.1016/S0973-0826(08)60272-0.

Wesee, Ben P., and Winston W. Parley. "Liberia: LEC Under Pressure." allAfrica.com, January 15, 2020. Available at https://allafrica.com/stories/202001150085.html.

Winther, Tanja. "Rising Electricity Consumption: Driving Forces and Consequences. The Case of Rural Zanzibar." Oslo, Norway: ECEEE Summer Study 2007, pp. 1835–1845.

World Bank Independent Evaluation Group. "ICR Review. Rwanda – Urgent Electricity Rehabilitation." Washington, DC: World Bank, March 22, 2012. Available at http://ieg.worldbankgroup.org/ieg-search-icrr?search_api_fulltext=&field_country%5B0%5D=214&sort_by=field_official_date&sort_order=DESC&0=214&page=1#. Accessed April 12, 2017.

World Bank. "Doing Business: Getting Electricity." Washington, DC: World Bank, 2017b. Available at http://www.doingbusiness.org/data/exploretopics/getting-electricity. Accessed February 14, 2018.

World Bank. "Enterprise Surveys: Liberia (2017)." Washington, DC: World Bank, 2017c. Available at http://www.enterprisesurveys.org/data/exploreeconomies/2017/Liberia. Accessed February 14, 2018.

World Bank. "Getting Electricity Index (Doing Business - World Bank Group.)" Available at https://www.doingbusiness.org/en/data/exploretopics/getting-electricity/score. Accessed January 30, 2020.

World Bank. "Options for the Development of Liberia's Energy Sector." Energy Sector Policy Note Series. Washington, DC: World Bank, Africa Energy Unit, 2011. Available at https://web.worldbank.org/archive/website01378/WEB/IMAGES/LIBERIA_.PDF. Accessed February 14, 2018.

World Bank. "Overview of Regional Energy Projects and Project Performance Assessment Report for the Mali, Mauritania, and Senegal Regional Hydropower Development Project." Washington, DC: World Bank, December 17, 2006. Available at http://documents.worldbank.org/curated/en/942181468051004677/Mali-Mauritania-Senegal-Regional-Hydropower-Development-Project. Accessed April 12, 2017.

World Bank. "Project Performance Assessment Report: Uganda Third Power Project and Supplemental to Third Power Project Credit." Washington, DC: World Bank, June 26, 2008. Available at http://documents.worldbank.org/curated/en/500171468318019768/Uganda-Third-Power-Project-and-Supplemental-Credit. Accessed April 12, 2017.

World Bank. "Rwanda: Projet de réhabilitation d'urgence du réseau électrique." Washington, DC: World Bank, September 20, 2010. Available at: http://ieg.worldbankgroup.org/ieg-search-icrr?search_api_fulltext=&field_country%5B0%5D=214&sort_by=field_official_date&sort_order=DESC&0=214&page=1#. Accessed April 12, 2017.

World Bank. Sustainable Energy for All database from the SE4ALL Global Tracking Framework.. *Online at https://data.worldbank.org. Accessed January 30, 2020.*

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