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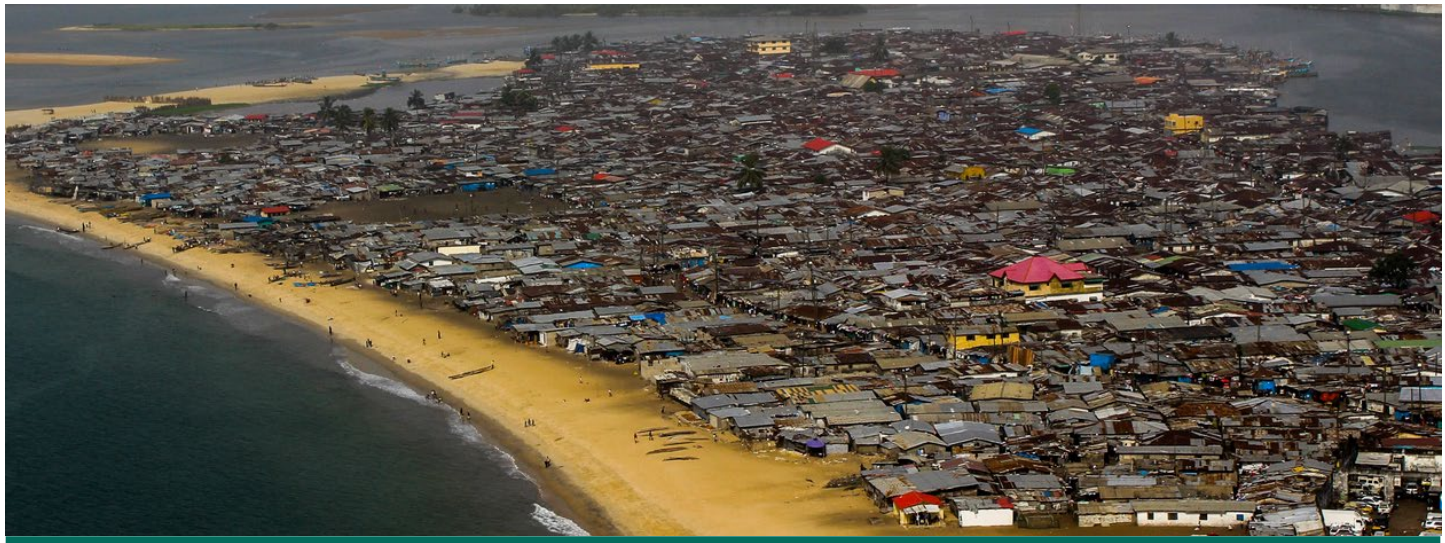

Evaluation of the Liberia Compact's Mt. Coffee Hydropower Plant Rehabilitation and Capacity Building and Sector Reform: Findings from the Final Round

Final Report

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Acronyms

AT&C	Aggregate technical and commercial loss
AfDB	African Development Bank
ACMS	Asset and Customer Mapping Study
BoD	Board of Directors
CAPEX	capital expenses
CBA	cost-benefit analysis
CIE	Cote d'Ivoire Energy
CLSG	Cote d'Ivoire, Liberia, Sierra Leone, and Guinea Transmission Project
CMC	contract monitoring consultant
CMS	Commerical Management System
COSS	cost of service study
CPI	consumer price index
DME	Deputy Minister of Energy
DMS	distribution management system
DOE	Department of Energy
EBITDA	earnings before interest, taxes, depreciation, and amortization
EIB	European Investment Bank
ELL	Electricity Law of Liberia
ERI	Electricity Regulatory Index
ERR	economic rate of return
ESWG	Energy Sector Working Group
ERP	enterprise resource planning
ESBI	Electricity Supply Board International
EU	European Union
EVD	Ebola Virus Disease
FBMU	feeder-based management units
FGD	focus group discussion
GDP	gross domestic product
GoL	Government of Liberia
GoN	Government of Norway
GSI	Gender and Social Inclusion
HFO	heavy fuel oil
HH	household
HLSG	High Level Stakeholder Group

HOI	Hydro Operations International
HR	human resource
HV	high-voltage
IDI	in-depth interview
IGA	income-generating activity
IMS	information management system
IMT	Interim Management Team
IPP	independent power producer
IRB	Institutional Review Board
JEP	Jungle Energy Power
JICA	Japanese International Cooperation Agency
KII	key informant interview
KfW	German Development Bank
KPI	key performance indicators
kV	kilovolt
kWh	kilowatt hour
LACEEP	Liberian Accelerated Electricity Expansion Project
LAEEP	Liberian Energy Efficiency and Access Program
LEC	Liberia Electricity Corporation
LERC	Liberia Electricity Regulatory Commission
LESSAP	Liberia Electricity Sector Strengthening and Access Project
LFO	Light fuel oil
LISGIS	Liberian Institute for Statistics and Geo-Information Systems
LV	low-voltage
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
MV	medium-voltage
MW	megawatt
MWh	megawatt hour
NCC	National Contracting Company

NGO	non-governmental organization
NORAD	Norwegian Development Agency
OMT	Operations, management, and training
OPEX	operating expenses
PEA	political-economy analysis
PIA	program implementation agreement
PIU	program implementation unit
PPA	power purchasing agreement
REOI	request for expression of interest
RGI	Regulatory Governance Index
RIA	Roberts International Airport
ROI	Regulatory Outcome Index
RSI	Regulatory Substance Index
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index
SCADA	supervisory control and data acquisition
SIDA	Swedish International Development Cooperation Agency
SWOT	strengths, weaknesses, opportunities, and threats
T&D	transmission and distribution
TRANSCO	Transmission Company Cote d'Ivoire, Liberia, Sierra Leone, and Guinea
TSA	transmission services agreement
USAID	United States Agency for International Development
WB	World Bank
WTP	willingness to pay

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Executive Summary

A. Compact overview and interventions evaluated

MCC's $257 million Liberia Compact[1] (2016–2021) aimed to encourage economic growth and reduce poverty. The Project Objectives were to "provide access to more 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, Rehabilitation of the Mt. Coffee Hydro Power Plant (MCHPP) ($147 million), and Activity 2, Capacity Strengthening and Sector Reform, 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 MCHHP investments should increase production and distribution of lower-cost electricity, reduce tariffs and user costs, and increase consumption of quality electricity by more customers. Energy sector investments were intended to establish an independent authority that would create a regulatory environment that accelerates investment and incentivizes independent power producers to help increase generation and meet the energy demands of Liberians. Investments in the MSC were intended to reform LEC so it becomes an operationally efficient and financially viable utility that can increase customer connections and maintain the electricity infrastructure. These investments and their expected short-term and intermediate outcomes aim to foster positive social and economic outcomes in the long term.

[1] Signed value $257 million. Disbursed value $238 million.

B. Evaluator description and contribution

As part of an overall evaluation of the Energy Project, MCC contracted Mathematica to conduct an independent evaluation. This report presents final evaluation findings for Activities 1 and 2. Two additional reports contain findings from the evaluations of the LEC Training Activity (Bos et al. 2022) and the White Plains Pipeline Sub-Activity (Ravindranath et al. 2022).

The evaluation documents important lessons for MCC and other donors investing in major rehabilitation works and utility reform in Liberia and other post-conflict countries. The evaluation team had the luxury of time and resources to focus on learning. We were able to collect, triangulate, and validate a broad array of data from diverse sources and return to key actors and organizations numerous times to ask about and compare perspectives and track changes over time. We synthesized years of data from many sources and actors, as well as the sector literature, to distill important insights and lessons learned. Our task was much easier than that of implementers who—in the middle of challenging circumstances—had to make complex decisions quickly, without adequate data or perspective on the full scope of the situation over time and across activities. Many actors provided reflections in hindsight, which provides a better vantage point for seeing missteps. With data and reflections, we were able to identify patterns and relationships, and based on the past, predict future implications of current circumstances. We frame lessons learned from the past as recommendations for the future, which we offer to inform US government and other stakeholders' future work in Liberia and other similar contexts.

C. Implementation summary, evaluation questions, and key findings

EQ. A1-A2. Were the activities implemented as planned? What was the quality?

Department of Energy and Liberia Electricity Regulatory Commission (LERC)

MCC Compact designers recognized the need for extensive capacity strengthening, entering a post-conflict country recovering from decades of sector-wide inactivity. However, activities were delayed due to the change in presidential administration, longstanding vacancies, and delayed appointments. The Compact made small investments in capacity strengthening among Department of Energy (DOE) staff at the Ministry of Mines and Energy (MME), however implementation was limited to several short trainings as DOE officials were only confirmed in late 2019 leaving little time and resources for capacity strengthening.

Although delayed, the Compact also established LERC to create a modern regulatory framework for the generation, T&D, and sale of electricity. The regulatory agency became operational when LERC commissioners were confirmed in September 2018, nearly three years into the MCC Compact period, leaving 30 months to operate before Compact closure. Aligned with best practices, with objectives to accelerate investment towards achieving universal access to low-cost reliable electricity, LERC defined its purpose and developed a vision to transform Liberia's monopolistic utility into a well-regulated, competitive market with private-sector participation and regional integration. Implementation quality—or MCC/MCA-L's efforts to

establish the regulatory agency—was strong, as evidenced by LERC's timely production of bylaws, operating procedures, and regulatory guidelines.

While LERC has developed strong regulatory governance and substance, improved sector outcomes will take years to realize. The 2022 tariff reduction, which is not cost-reflective, is an example of how LERC has made progress on governance and substance; however, outcomes remain problematic. The tariff reduction does not cover LEC's operating costs for the energy mix, so it threatens the utility's financial solvency. While regulations have been developed and an Operator Census conducted, Liberia has informal operators that are not yet eligible for licensing. As a result, LERC cannot yet collect regulatory fees, finance monitoring activities, and enforce fines. LERC's financial model relies on revenue from regulator fees and levies on sales; however LEC is insolvent, with unlicensed operators. The literature on regulatory agencies shows that commissions usually take 10 years to become financially independent. LERC's long-term independence and sustainability are threatened by lack of funding and reported interference from the Government of Liberia (GoL).

Mount Coffee Hydro Power Plant

In 2016, MCC, joined with global donors, to rehabilitate the Mt. Coffee Hydro Power Plant. Implementation diverged from plans due to construction challenges and contractor issues. Constructed in the 1960s and located on the St. Paul River northeast of Monrovia, MCHPP had peak generation of 64 MW of renewable hydropower before the civil war. Early in the war, which lasted from 1989 to 2003, the dam was breached, the plant was destroyed, and all electrical equipment was pillaged. Post-war in 2011, a group of donors, the Norwegian Development Agency (NORAD), European Investment Bank (EIB), and German Development Agency (KfW) began rehabilitating the MCHPP with the GoL. Construction was chronically over budget and behind schedule when the 2014 Ebola Crisis further delayed progress. After the Ebola crisis, MCC committed to pool funds with NORAD, KfW, and EIB to meet the full cost of rehabilitation ($357 million).

The MCHPP was successfully rehabilitated with 88 megawatts (MW) of installed capacity, and provides approximately 76 megawatts (MW) of low-cost renewable hydropower for six months from May to October at a generation cost of approximately $0.06 per kWh compared to $0.25 for thermal generation.[2] Stakeholders agree that despite delays, the overall construction quality was high, but note a fundamental design flaw in the location of MCHPP: "*The islanded operation [suffered from] flow management downstream, leading to instability in operation and reduced total station output"* so despite the historical significance of MCHPP, stakeholders believe it should have been rebuilt upstream to deliver 125 MW of hydropower.

Planning for and financing the Operations, Maintenance and Training Contractor (OMT) was inadequate and MCHPP's long-term sustainability has been jeopardized by inadequate operations and maintenance. Inadequate O&M increases the risk of performance losses, extended outages, turbine or plant failure, expensive rehabilitation costs and potential

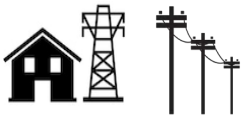
[2] Note that generation costs do not include the utility's full operating costs, such as all the expenses related to electricity transmission, distribution, and sales.

emergency situations such as the loss of life or property (Canale et al. 2017). The OMT contractor, Hydro Operations International (HOI), was only engaged late in August 2016 for five years despite the risks to MCHPP. The contract started late, the length and scope were inadequate for the complexity of the work. Implementation quality suffered due to payment problems. Initially, MCC planned to cover OMT contract costs while LEC set aside $575,000 per month in escrow to cover subsequent years. By 2017, LEC under the Interim Management Team (IMT), had set aside only $177,000 in the MCHPP escrow account. The IMT chronically underpaid and HOI repeatedly submitted "notice of stop works orders," reducing its staff count from 18 to 11. In 2019, stakeholders predicted catastrophic failure at MCHPP without greater investment in the OMT and better stewardship by LEC (Miller et al. 2020). Additionally, HOI's contract required LEC (which was insolvent) to fund spares and materials. This was unrealistic and weakened HOI's performance.

Design and construction choices may have led to the catastrophic failure of Unit 1 at MCHPP in January 2021. The OMT and design contractors attributed the unit failure to design choices, manufacturing processes, operating conditions, and climatic conditions during testing and installation. Repair costs were estimated at $4 million, lost revenue may exceed $5 million (unit 1 is inoperable from 2021—2023), and additional units may require a similar repair.

MCHPP generation is seasonal and can fall by 75 percent or more during lower-than-average rainfall, requiring Liberia to rely on alternative sources. While a part of Liberia's electricity generation, MCHPP's seasonal supply requires additional sources to provide year-round access to more reliable and affordable electricity. The long-anticipated Cote d'Ivoire, Sierra Leone, Liberia, Guinea (CLSG) transmission project, would provide natural gas at a generated cost of $0.115 per kWh and reduce dry season reliance on fuel-operated thermal generators. However, note that the CLSG Power Purchasing Agreement (PPA) and Transmission Service Agreement (TSA) (approved in late 2022) contain what stakeholders have called "exploitative" contract terms which are problematic for Liberia and LEC's financial solvency.

Management Services Contract (MSC) at LEC



MCC invested in the three-year management services contract between GoL, LEC, and ESBI to support utility reform and capacity strengthening. However, implementation diverged from plans and quality was undermined by the fact that stakeholders did not fully understand the situation of LEC when the contract was signed. In 1990, with the T&D network across Monrovia destroyed, poles and wires looted, and main streets in darkness, the state-run utility ceased operating and remained closed for 15 years. Consequently, LEC lost human resource capacity, technical and management skills. Post war, in 2005, with a new government and $40 million in donor investments for temporary diesel generators, LEC resumed operations with Manitoba Hydro International as the first MSC. LEC's grid, customer base, debts, and losses grew during the MSC, while the tariff was slightly reduced. This is important historical context, specifically that the GoL had deemed the first MSC as unsuccessful, while the MSC documented that the GoL was not committed to reform.

> *"The operator [MHI] was perceived as a threat from the earliest days, and LEC was seen by some government officials as a cash cow that could be coerced into financing nontransparent procurements to handpicked contractors. Serious trust issues emerged immediately upon start of the contract, which undermined the relationship between operator and government and worsened after one of the primary government representatives involved was promoted to a leadership role in the Ministry of Energy, permitting him more direct oversight of the operator and more leeway to frustrate the operator's potential for success." USAID (2018)*

Following MHI's management, the Liberian Interim Management Team (IMT) managed LEC from 2016 through 2017, effectively pillaging the failed utility. When the IMT handed over operations to ESBI (the MCC-funded MSC), LEC operated at a loss, with staffing misaligned to needs, debt exceeding $21 million, lawsuits for unpaid fuel, loans for inoperable equipment, suboptimal contracts, no asset listing, burnt records with no digital or paper trail, no customer database, and a low-quality low voltage network requiring extensive repair. Outages were at 500 hours per year and power theft was estimated at 60 percent.

Despite these insurmountable challenges, the management services (MSC) contract, Electricity Supply Board International (ESBI) was able to increase connections, reduce operating costs and outages, restructure LEC, transition to a digital data system, and develop key performance indicators for all positions. The $11.7 million contract with ESBI supported eleven staff for three years and 1.5 years with World Bank (WB) funding. While confronting a financial crisis, low quality infrastructure, increasing responsibilities with new assets, insufficient Board of Directors support, political interference, and expanding corruption, the MSC lacked operating (OPEX) and capital expenditures (CAPEX), and adequate staffing and sector allies. ESBI's pre-contract assumptions were not met, for example that donor-funded transmission and distribution (T&D) works would be completed in early 2019, a supervisory control and data acquisition (SCADA) system would provide network level data, the CSLG transmission line would be operable in 2020, and tariffs would remain stable. LEC administrative data and interviews show that revenue continuously declined due to expanding maintenance and repair needs, new and normalized customers (paid for by LEC), unchecked political interference, intractable power theft, reduced tariffs, and increased fuel prices. For a utility to be financially solvent, it requires OPEX and CAPEX, a systematic response to theft and corruption, and political and donor support to implement the reform needed to sustain the utility.

Several key factors explain why the quality of implementation was not as anticipated. First, MCC respondents said they did not conduct a political economy analysis (PEA), which they believed would have helped them better understand and prepare for the context and design mechanisms to reduce political interference in LEC. Second, the contract length, components, and value proved to be insufficient given the scale of the challenges facing LEC. For example, the contract contained no operating (OPEX), nor capital expenditures (CAPEX) and the lack of OPEX and CAPEX in the face of major resource-intensive challenges was insurmountable. Additionally, the contract budget and staffing declined each year, assuming the workload would diminish over time. Respondents felt that ESBI did not succeed in developing a successor

management team. Third, ESBI's implementation quality was weakened by LEC's ineffective Board of Directors. Finally, weak donor coordination undermined LEC but has strengthened after the Compact. Donor projects that focused on new T&D infrastructure, overwhelmed LEC capacity, while resources were needed for existing grid maintenance and repair.

D. Energy sector evaluation questions and outcomes

EQ. B1. What new energy policies, laws, and legal, economic, and technical regulations have been enacted or adopted, given the LERC's activities and support from the donor community? How have these contributed to modernizing the energy sector and making the sector financially viable?

LERC has progressed in creating a regulatory environment with clear and transparent regulations, including Electricity Licensing Regulations, Micro Utility Licensing Regulations, Electricity Licensing Handbook, Customer Service and Quality of Supply Regulations, Electricity Tariff Regulations for Service Providers, Multi-Year Tariff Methodology. These new policies, laws, and regulations, align with international standards, are benchmarked against other African countries, and help modernize the energy sector. Note that standards are somewhat aspirational given that LERC has inadequate resources to monitor and enforce some regulations. Also prosecuting electricity operators for failing to meet standards is a new phenomenon in Liberia and LERC has not yet been through the process. For example, LERC was called a "paper tiger" lacking teeth to enforce fines against LEC. As a government utility in financial crisis, LEC lacks the resources to pay the fine, yet wants to maintain a positive relationship with LERC, particularly given their regulatory power.

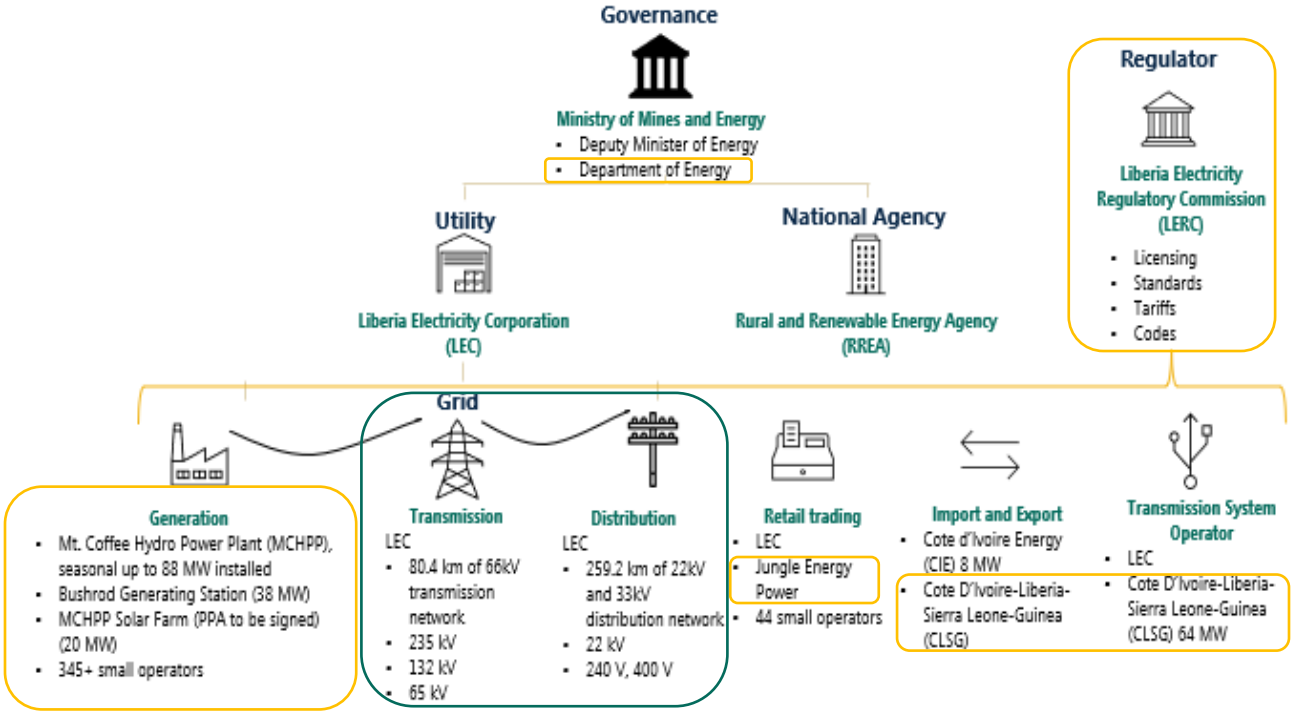
EQ. B2. Have LERC activities (regulating the legal, economic, and technical environment or changes in the availability and reliability of electricity) had any effect on independent power producers (IPPs') operations?

LERC licensed Jungle Energy Power (JEP) as a large micro-utility in Nimba County and the Totota Electric Cooperative, a micro-utility in the Lower Bong County, but has otherwise made little progress registering and licensing operators. The Operator Census identified informal operators that do not currently meet licensing eligibility and who are using rather than selling power. Figure ES.1. illustrates Liberia's Energy Sector in 2022, including additions since 2016.

EQ. B3. To what extent, if any, have energy sector reform activities contributed to improvements in electricity regulation, policy formulation, and monitoring? How sustainable are these improvements?

Establishing LERC has contributed to improvements in Liberia's electricity regulation and policy formulation; however, monitoring IPP operations has not yet occurred because of resource shortages. Post-Compact, LERC has struggled to secure donor resources while it works to license operators and ultimately collect levies and regulatory fees. Without this income, LERC must secure additional funds to operate independently. Additionally, private investors and franchisees remain elusive given the challenging energy sector environment.

Figure ES.1. Liberia's energy sector, 2022



Note: Entities with a gold box were established or rehabilitated during the Compact 2016-2021. The green box indicates major extensions and increased capacity.

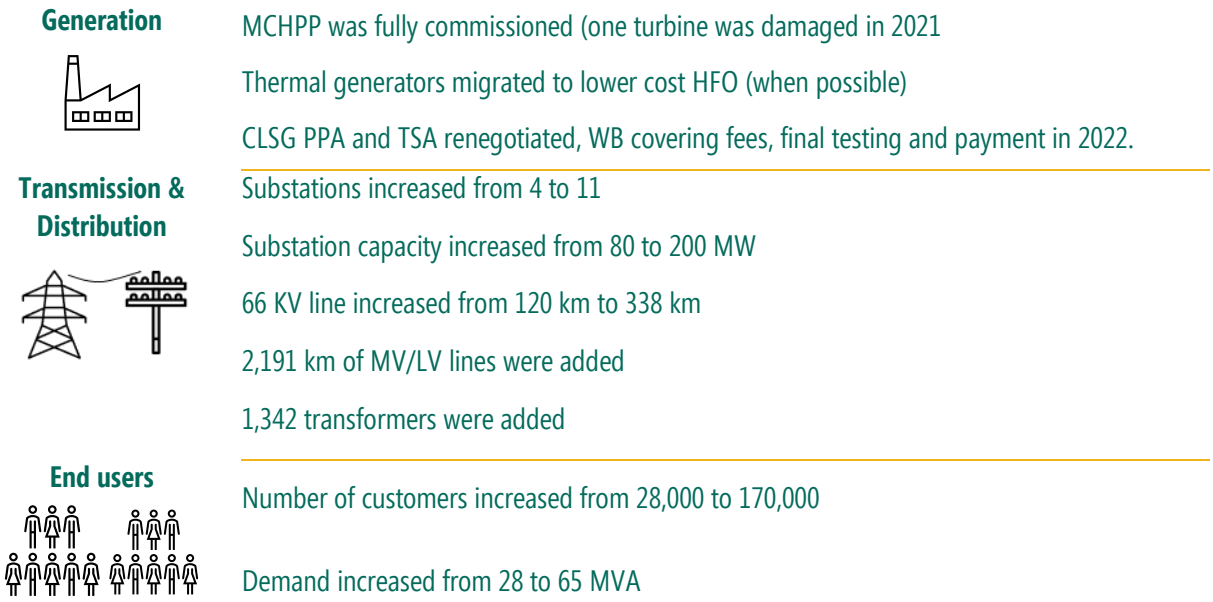
E. Utility and grid evaluation questions and outcomes

EQ. C1. How have MCC's investments affected electricity generation, T&D, reliability?

MCC's investments—with complementary donor investments—were instrumental to MCHPP rehabilitation, thermal plant management, improving T&D infrastructure, conducting the Asset and Customer Mapping Survey (ACMS), and improving electricity quality. MCHPP enabled LEC's system demand to grow from 10 MW in 2015 to 52 MW by late 2021. MCHPP generates low-cost renewable hydropower (at a cost of approximately $0.06 per kWh compared to $0.25 for thermal generation). The MSC has mostly kept LEC's thermal generators operational, despite major and frequent mechanical failures. The MSC improved the functionality of the T&D infrastructure, despite the ongoing need for significant investments in the low voltage network (Figure ES.2.)

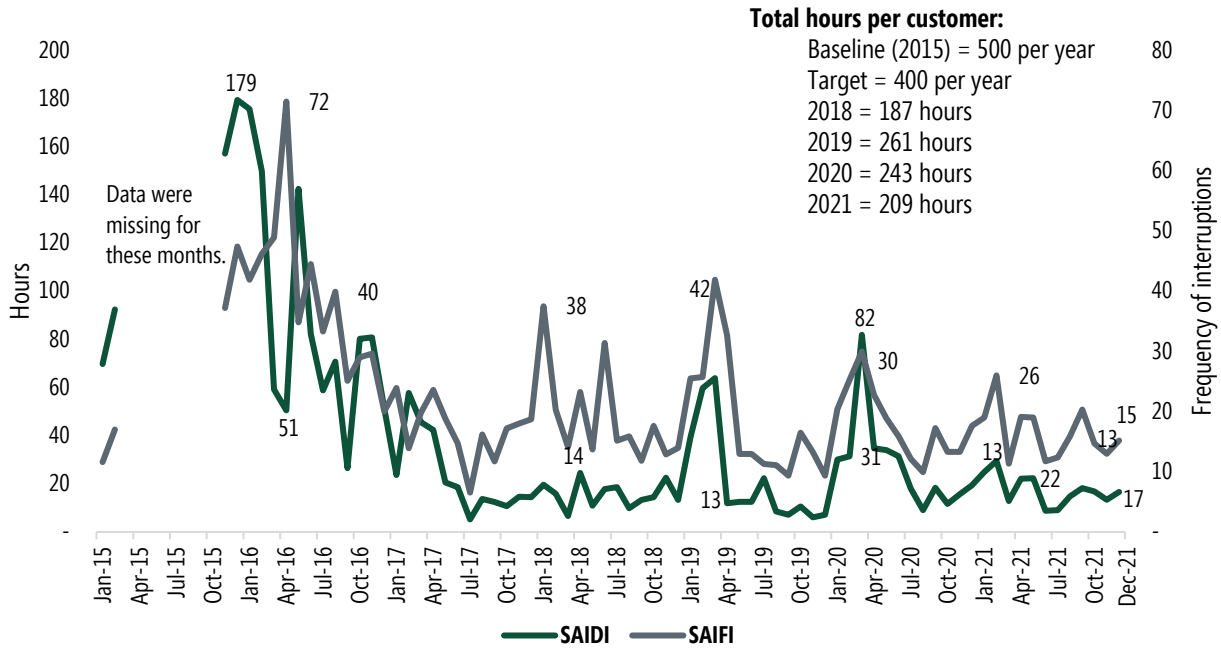
LEC's T&D network has grown dramatically since 2016 and the MSC has reduced outages from 500 hours at baseline to 204 hours per year in 2021. The MSC has made significant improvements in Liberia's patchwork of mismatched, poorly maintained, and aging assets. The number of substations (4 to 11) and capacity (80 to 200 megavolt amps) has grown, as well as length of lines, and the number of transformers. Customer numbers (28,000 to 170,000 actively vending customers) and demand has also increased (28 to 65 MW). Network outages also decreased (Figure ES.3.)

Figure ES.2. ESBI's accomplishments during tenure as LEC's MSC (January 2018 – July 2022)



As shown in Figure ES.3, LEC's system outages have trended downwards, indicating that MCHPP and the MSC helped improve electricity quality and reliability. Still, dry-season fuel costs, power theft, and overburdened infrastructure result in many monthly outages, exceeding SSA averages of 9 outages lasting 5 hours per month (108 outages per year, lasting 60 hours in total).

Figure ES.3. System average interruption frequency and duration index (SAIDI and SAIFI)



Source: LEC administrative data

Notes: SAIDI is defined as the sum of durations, in customer-hours, of all customer interruptions in a quarter / Total number of customers connected to network in the same quarter. SAIFI is defined as the sum of customer-interruptions in a quarter / Total number of customers connected to network in the same quarter.

EQ. C2. How has the electricity tariff changed since MCHPP was rehabilitated? To what extent does it cover the costs of electricity generation and other operating costs?

LEC's tariff was reduced several times since MCHPP was rehabilitated. Figure ES.4. shows how LEC's power sales have increased since 2018 however annual revenue declined in 2019 and has not kept pace with sales given the tariff was not cost reflective. LEC implemented reductions for very low consuming customers (less than 20 kWh), and incentives for large customers. While hydropower is Liberia's lowest cost electricity (full cost with T&D and overhead at approximately $0.14 per kWh in 2021, compared to $0.33 for thermal generation or more depending on fuel prices), and $0.24 per kWh for CLSG power. The mix of power matters to the average rate charged. Ideally cheaper hydropower is heavily used rather than higher cost thermal generation and CLSG gas, especially given that 97 percent of customers pay $0.15 per kWh.

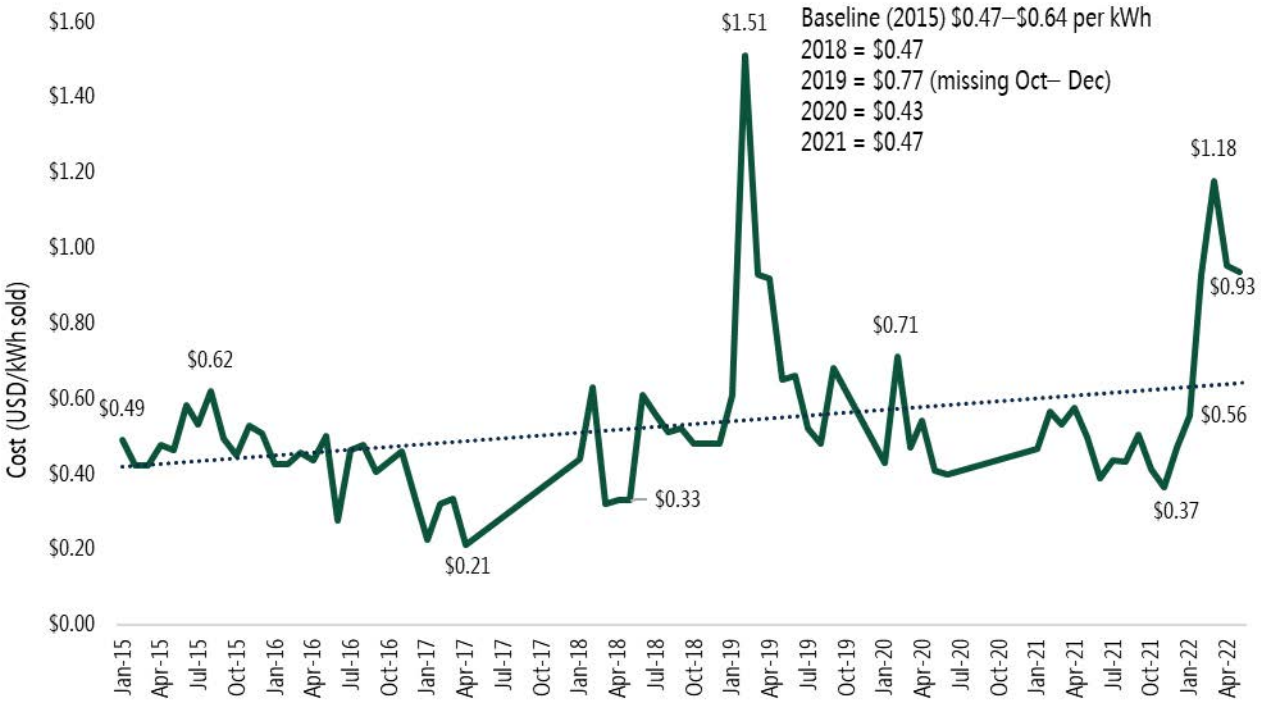
Figure ES.4. Change in tariff, sales, and revenue over time

Source: LEC administrative data

Notes: From 2020 to 2021, LEC introduced a life-line tariff (US$0.22 for 20kWh), a large HSM customer incentive (US$0.27), and the LWSC tariff.

Despite LEC's financial situation, outdated or flawed assumptions in the tariff model, and Liberians' documented willingness to pay more for better quality, LERC approved a significant, non-cost reflective tariff reduction in January 2022 (Tetra Tech 2021). LEC's grave financial situation, coupled with growing demand across an increasing customer base with low average consumption, reduced revenue with the low tariff, will cause a further downward spiral at LEC (without government or donor intervention). The tariff cannot cover operating costs (Figure ES.5), cost of thermal generation, or CLSG 'take or pay' contract terms. Not surprisingly, LEC was unable to meet targets for operating costs per kWh, which were driven by high dry season fuel costs and worsened by inflated payroll costs due to political interference as ESBI was required to hire hundreds of unneeded staff. LEC has been in a grave situation with all financial measures worsening and cumulative losses growing.

Figure ES.5. Operating costs per kWh sold

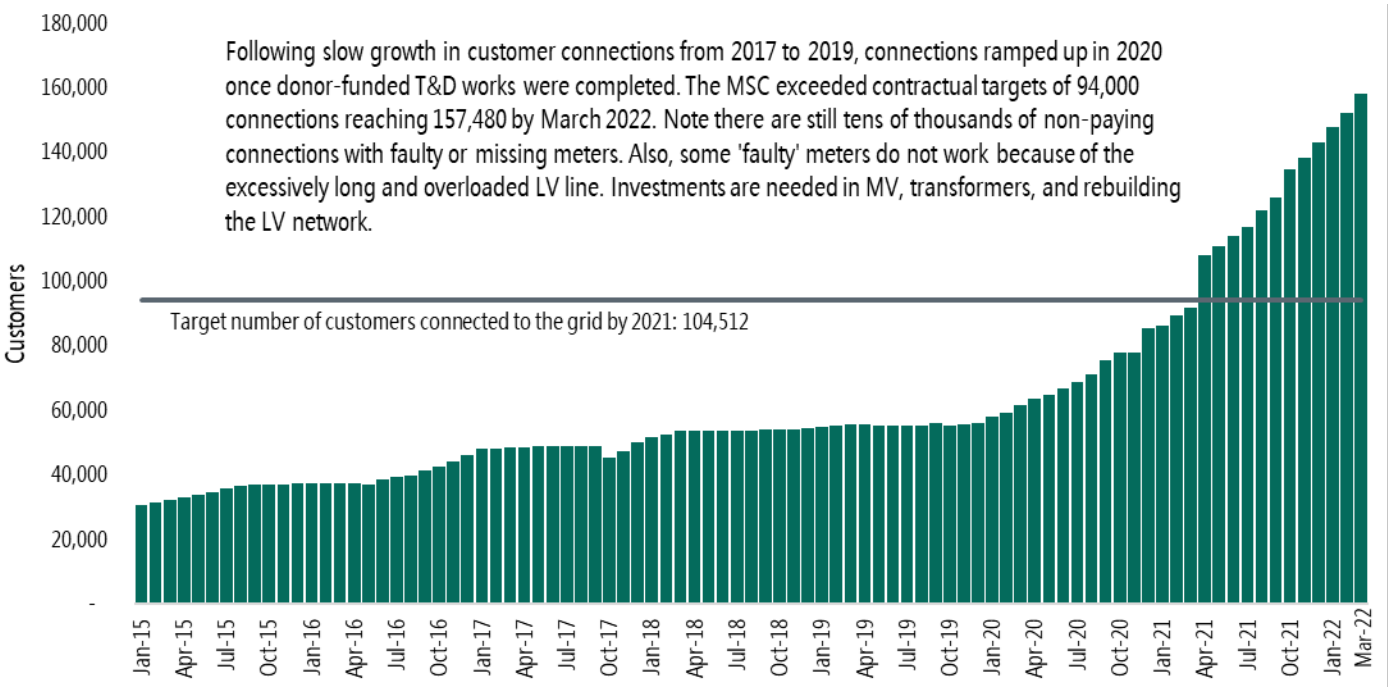


Source: LEC adminstrative data

EQ. C3. To what extent have the MCHPP Rehabilitation and Capacity Building and Sector Reform Activities affected the number of users connecting to the grid and the demand for electricity?

MCC's investments in MCHPP Rehabilitation and Capacity Building Sector Reform activities increased new customer connections and exceeded the MSC's contractual targets. LEC estimated there were 35,000 customers vending at baseline with a contract target of 94,000. Connections grew to 157,000 by March 2022 (Figure ES.6). While the number of connections has increased, average customer consumption has declined over time. By April 2022, 97 percent of connections were residential and average consumption was less than 50 kWh per month (ranging from 22 to 40 kWh) (Figure ES.7). The 2022 tariff reduction approved by LERC means that LEC will only earn $0.15 per kWh for electricity sold to most customers, despite operating costs hovering around $0.47 per kWh in 2021 (prior to the sharp escalation in fuel prices).

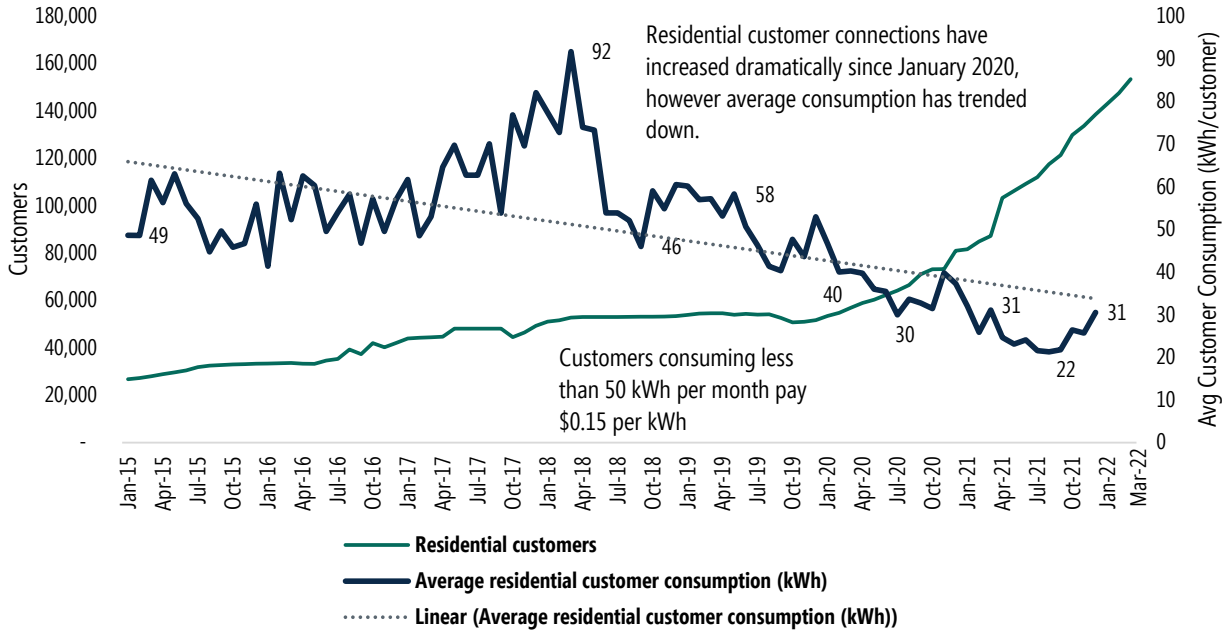
Figure ES.6. Customers connected to the grid, by customer class



Source: LEC adminstrative data

Notes: The vast majority of customers are pre-paid residential customers.

Figure ES.7. Residential customers and average residential consumption



Source: LEC adminstrative data

EQ. C4. To what extent, if any, has LEC's management improved since the MSC became effective?

The MSC improved LEC management on multiple measures since assuming operations of the failed utility in 2018, achieving several KPIs including reduced operating costs, new connections, and improved network performance. The MSC has improved maintenance, assumed ownership of more than $200 million in new T&D infrastructure, migrated from paper to digital data management utilizing the Information Management System (IMS) database, established a Training and Development Department, opened a new Customer Service Center, and instituted improved service practices.

However, utility reform and organizational transformation have been hampered by excessive resource shortages, political interference in staffing and operations, human resource constraints, insufficient workforce development and training activities, a culture of corruption throughout LEC, and other complications. The MSC's management of commercial operations has been fraught with insurmountable barriers to improving LEC's commercial performance. While LEC's electricity supply has increased almost six-fold from 2015 to the end of 2021, sales have not quite doubled over the same period. Disappointing sales result from power theft, as well as inadequate billing and collections. Sales for all customer types have trended upwards —albeit modestly—since 2015.

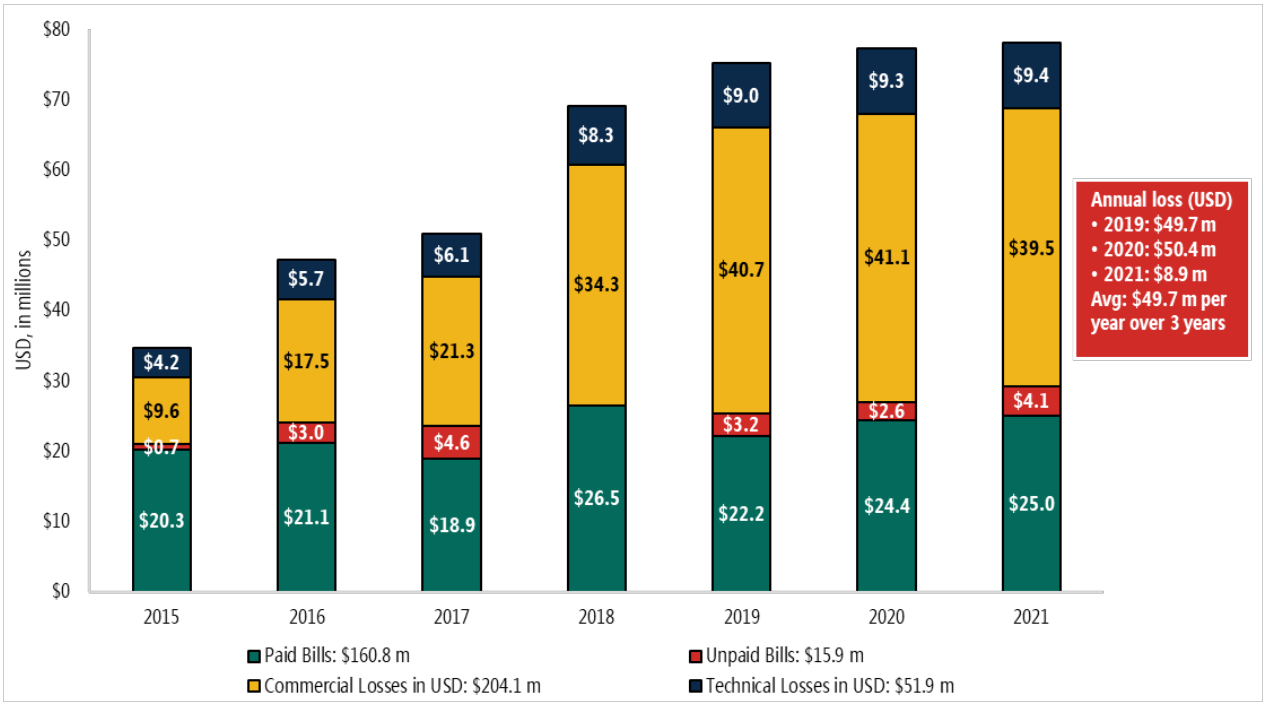
LEC has not been able to achieve meaningful reductions in power theft in the absence of major investments and the political will to prosecute theft and prioritize LEC's solvency. Technical losses are not directly measured given the lack of feeder meters but an older analysis, when the load was lower, estimated losses at 12 percent. Given growing demand that is overloading the low-quality grid, technical losses are likely 20 percent or higher. Still at 12 percent, LEC lost about 500,000 MWh in technical losses in 2015 and an estimated 1.9 million MWh by 2020 (totaling $51.9 million from 2015 through 2021). Commercial losses were 48 percent of supply in 2018, peaked at 58 percent in September 2019, and reduced to 44 percent in December 2021, totaling $204.1 million from 2015 to 2021. Combined, technical and commercial losses were 56 percent of supply at the end of 2021.

The MSC's Revenue Protection and Loss Reduction Unit has continuously worked to reduce losses, albeit with limited success. Most recently, the MSC established feeder-based business or management units (FBBU or FBMU) in February 2021 to build accountability and improve T&D operations. Still, the MSC had limited success removing corrupt staff, reducing political interference, and getting theft prosecuted. Despite efforts, aggregate technical and commercial losses (AT&C), a key performance indicator (KPI), have trended upwards from 2015 to 2021 and staff suspected of theft remain in their jobs.

LEC has lost $271.9 million from 2015 to 2021 including $15.9 million in unpaid bills, $204.1 million in commercial losses, and $51.9 million in technical losses. We estimate losses of $49.7 per year in the last three years. Note this exceeds the value of MCC's $257 million Compact (signed value) (Figure ES.8). The MSC has improved human resource department and practices, however LEC's workforce composition is problematic given political

interference. The MSC improved safety practices and reduced environmental waste, however staff report that LEC's lack of safety equipment prevents them from implementing safety procedures. The MSC's donor coordination and management of T&D construction was inadequate.

Figure ES.8. Paid, unpaid bills, technical and commercial losses by year



Source: Authors' calculation from LEC administrative data from 2015 to 2021

Notes: Technical losses are assumed to be 12% of total electricity supplied. Commercial losses are the difference in electricity supplied and billed, after accounting for technical losses. Losses were monetized by applying LEC's tariff for electricity sold. *The figure excludes $2,315,000 in excess payments for bills in a previous period. GOL made large payments to their arrears.*

EQ. C5. What progress has GoL made toward establishing a longer-term management arrangement for LEC? How sustainable is LEC as a utility? What are the biggest barriers to its sustainability?

After MCC's Compact closure, the WB funded the MSC through July 2022, and will continue to provide support to LEC through the Liberia Electricity Sector Strengthening Access Project (LESSAP).[3] The GoL did not make progress towards establishing a longer-term management solution. Currently LEC is an unsustainable utility which could collapse at any time. Additionally, MCHPP is at further risk of catastrophic failure without adequate OMT support. Respondents also described how CLSG will increase the need for technical capacity at MCHPP and that its sustainability will be precarious. The biggest barriers to LEC's sustainability include

[3] https://projects.worldbank.org/en/projects-operations/project-detail/P173416

the cartel or syndicates growing sophistication, political interference in LEC operations, the Ministry of Justice's failure to prosecute power theft, LEC's culture of corruption, insufficient OPEX and CAPEX, the historically weak and ineffectual LEC Board of Directors (BoD), inadequate donor coordination, high dry season fuel costs without adequate revenue to cover, insufficient commercial connections, and unpaid bills.

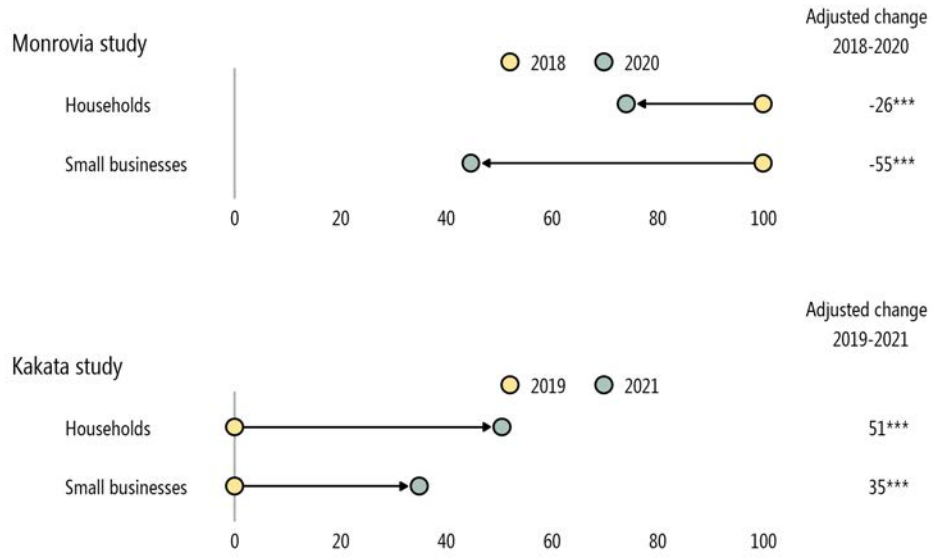
F. End user outcomes

MCC expected Compact investments to affect end users by increasing access to low-cost renewable power, reducing user costs, and increasing connections and electricity consumption. Compact activities were expected to improve the customer experience through improved reliability and quality of electricity and customer service. The realization of these medium-term outcomes should, in turn, lead to greater incomes for households (through increased investment and improved education, health, and safety) and businesses (through increased productivity and expanded operations, employment, and employability).

EQ. C3. D1. 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? 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?

The end-user surveys show a reduction in connections in Monrovia (where LEC implemented meter normalization activities and disconnected indirect customers) and a dramatic increase in connections in Kakata where WB-funded T&D was completed (Figure ES.9). Among end users in Monrovia who lost their connection, there was strong desire to be connected again to LEC, but LEC's meter shortage and slow response to complaints about equipment issues and connection requests was a major challenge for these potential customers. In Kakata, unconnected households and businesses indicated a strong interest in connecting to LEC if their community receives access to electricity.

Figure ES.9. Connection status over time among household and small business end users in survey samples in Monrovia, Kakata



In Monrovia, LEC efforts to normalize customers (and potentially end users not wanting LEC) resulted in 26 percent of households and 55 percent of small businesses losing connections from 2018 to 2020.

In Kakata, more than half of households and 35 percent of sampled businesses were connected by 2021, within one year of completion of T&D construction.

Source: 2018 and 2020 Monrovia household and small business surveys; 2019 and 2021 Kakata household and small business surveys

Notes: Yellow circles indicate baseline data; green circles indicate endline data collection

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

EQ. D2. How have MCC's investments affected connected and unconnected households' perceptions of the quality of electricity?

Households and businesses confirmed a reduction in the duration of outages, but there were minimal changes in the number of outages per week during the survey period, likely due to network weaknesses and inadequate technology to monitor the network. Businesses experienced damaged goods and equipment from outages and had to modify or interrupt operations. Hence, while LEC has improved the reliability of electricity, end users require more hours of reliable power with fewer interruptions to improve business productivity and operations, as set out in MCC's program logic.

EQs. D3. D5. To what extent do customers invest in energy intensive appliances or equipment? What is the effect of energy on time use (household production, leisure, school, work, and employment)? How do impacts vary by gender, socioeconomic status, and other demographic characteristics?

Since baseline, more end users—households, small businesses, and medium and large end users across Monrovia and Kakata—reported electrical appliances as their most important use of electricity, and fewer reported it to be lighting (Figure ES.10).

Use of electricity: From 2018-2019 to 2020-2021, many end users in Monrovia and Kakata shifted to more productive uses of power by transitioning from lighting to electrical appliances as their main use of energy.

Business activity: We did not find evidence that increased productive use of electricity translated into improved financial outcomes. Business activity and profits decreased among households and businesses since baseline, a period marked by the Covid-19 pandemic, a worsening macroeconomic environment in Liberia, and decreased connection rates among our Monrovia sample.

Time use: Respondents reported that electricity improves everyday life and allows children to study, but we found were no meaningful changes in time use since baseline.

We did not find meaningful differences in outcomes based on demographic characteristics.

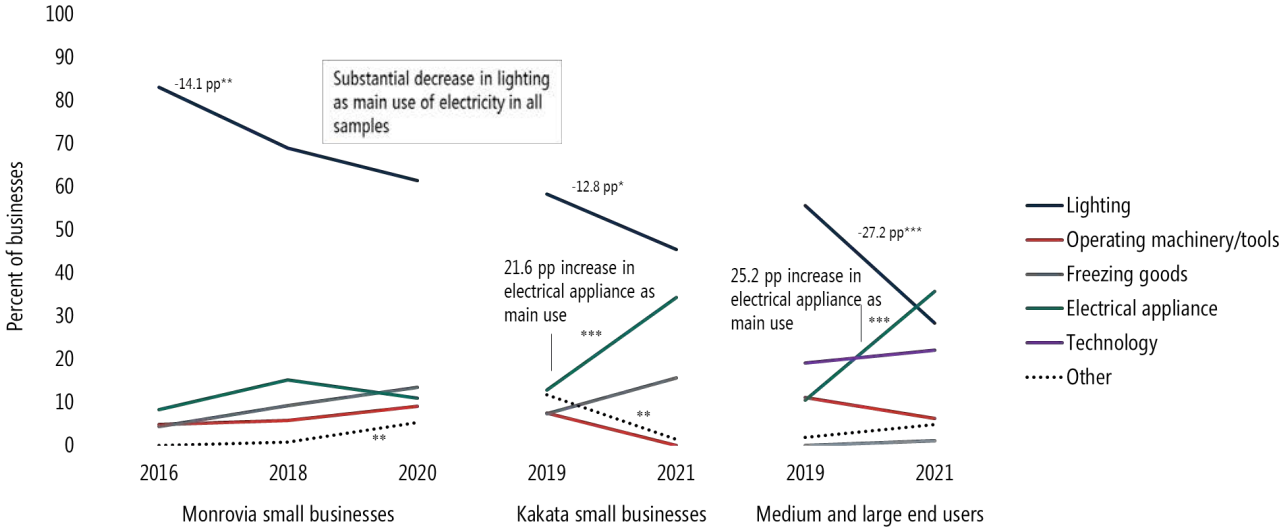
EQs. D4. D5. What, if any, are the spillover effects on non-electrified households? How do impacts vary by gender, socioeconomic status, and other demographic characteristics?

Once connections were made, end users reported some important spillover effects including public services gaining electricity and improved perceptions of public safety.

Public services: We found large increases in the percentage of community services with LEC electricity in Kakata. Access to electricity seems to have improved service delivery, particularly for schools and health clinics.

Safety: Respondents reported that their perceptions of safety and security were tied to electricity access. Connections rates and perceptions of security improved in Kakata but worsened in Monrovia.

Figure ES.10. Main use of electricity (from any source) for small businesses and medium and large end users



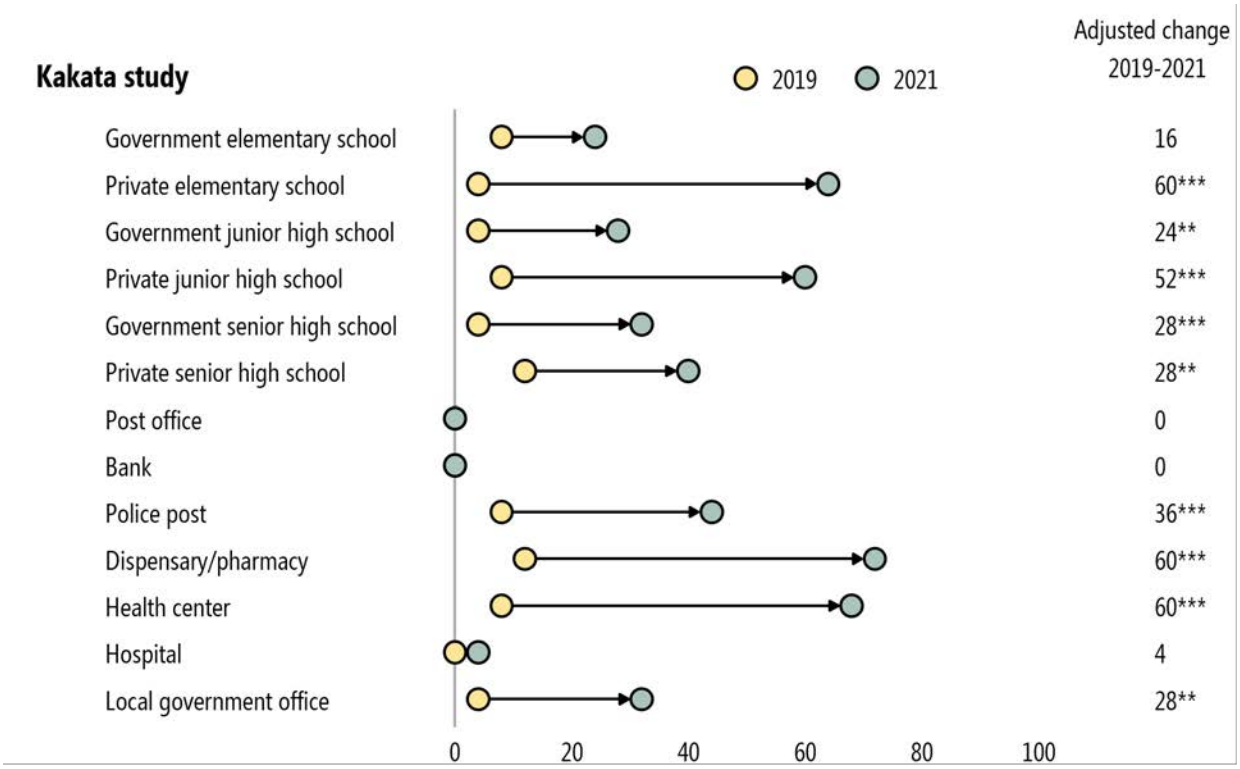
Source: 2016, 2018, and 2020 Monrovia and 2019 and 2021 Kakata household surveys.

Notes: Respondents were asked to identify the main use of electricity in their household; the measure does not reflect kWh consumption. Sample includes businesses and end users who are connected to LEC and those who use other sources of electricity, such as generators or community current. Findings are based on 1,183 households in Monrovia and 875 households in Kakata that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

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

In Kakata, community leaders reported large increases in the proportion of public-service entities that have access to the grid after two years (Figure ES.11.), including public and private schools, health care providers, police, and local government offices. More than 60 percent of community leaders now report having LEC electricity in health facilities, pharmacies, and private primary and secondary schools in survey Kakata communities now have LEC electricity, compared to under 15 percent in 2019 (Figure ES.11).

Figure ES.11. Percent of Kakata communities with LEC-connected services



Source: 2019 and 2021 Kakata community leader surveys.

Notes: Findings are based on 30 community leaders who were interviewed over time.

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

G. Cost Benefit Analysis

EQ A4. To what extent, if any, does comparing the assumptions made in the forecasted economic model, actual program implementation, and evaluation findings generate lessons that can be applied to future economic models?

The Liberia Energy Project sought to address the lack of access to affordable and reliable electricity by increasing the amount of electricity generated, facilitating a decrease in the overall electricity tariff, and helping to increase the reliability and adequacy of electricity. MCC identified households and businesses as the main beneficiaries, including newly connected customers and already connected customers who profit from lower energy costs and more reliable power. It also includes new and existing indirect consumers who benefit from LEC electricity but do not pay LEC for the service. Thus, the cost-benefit analysis incorporates benefit streams directly related to the increased supply and reliability of electricity.

We estimate the project's economic rate of return to be 8.0%, suggesting the project was not cost-effective, falling below MCC's hurdle rate of 10 percent to consider projects worth pursuing. In fact, the net present value of the investment from 2015 to 2035 is estimated to be

negative $51,019,841. We note that, even though the estimated economic rate of return was less than expected the project provides important benefits to end users regardless of whether they fully pay the utility company. Of course, the risk is that the utility company will not be able to maintain assets and continue to provide power without adequate cost recovery.

The model accuracy could be improved with better data on indirect or illegal energy consumption, given the total number of indirect consumers increased over the course of the project and contributes dramatically to the CBA estimates. However, we lack precise data on this diverse population, which is an important caveat to the model and requires us to make assumptions about their willingness to pay and consumption.

H. Conclusions: Liberia Compact Results

MCC's vision with the Liberia Compact was to provide access to more reliable and affordable hydropower through MCHPP rehabilitation, by establishing an independent regulatory agency, and reforming the national utility. Figure ES.13. presents MCC's logic model for the Liberia Compact with colored symbols indicating whether outcomes were fully or partially achieved. Table ES.1 presents a summary of MCC's anticipated outcomes, underlying assumptions, and the status in 2022. In summary:

- MCC successfully achieved output level tasks. Despite success at the output level, the short-, medium-, and long-term outcomes in the program logic were not all achieved.
- Investments were able to increase production of low-cost, renewable hydropower, establish LERC and the regulatory framework, and reduce tariffs and user costs.
- Many energy sector, utility, and grid level outcomes were not achieved given the Compact length, delays in implementation, underinvestment in the operations, maintenance, and training contract (OMT), and LEC's prolonged challenges.
- End user outcomes improved, including energy access and consumption among recently connected users, and improved perceptions of safety. However, delays in donor-funded T&D construction, dry season outages, Liberia's negative macroeconomic situation, and the Covid-19 pandemic may have reduced end users' ability to use electricity productively.

The Liberia Compact was unable to overcome political and macro-economic challenges that undermine Liberia's progress. For instance, indicators measuring Liberia's governance are worsening. In the FY2022 MCC scorecard, Liberia received failing scores on fiscal policy, inflation, regulatory quality, trade policy, government effectiveness, and other indicators.[4] Areas of concern include Liberia's poor revenue mobilization and budget management; low competence of civil servants; and the extent to which policies and budgets are linked and monitored, and goals are achieved. As of July 2022, the GoL was still struggling to make payroll.

[4] For MCC scorecard indicators, see https://www.mcc.gov/who-we-select/indicators

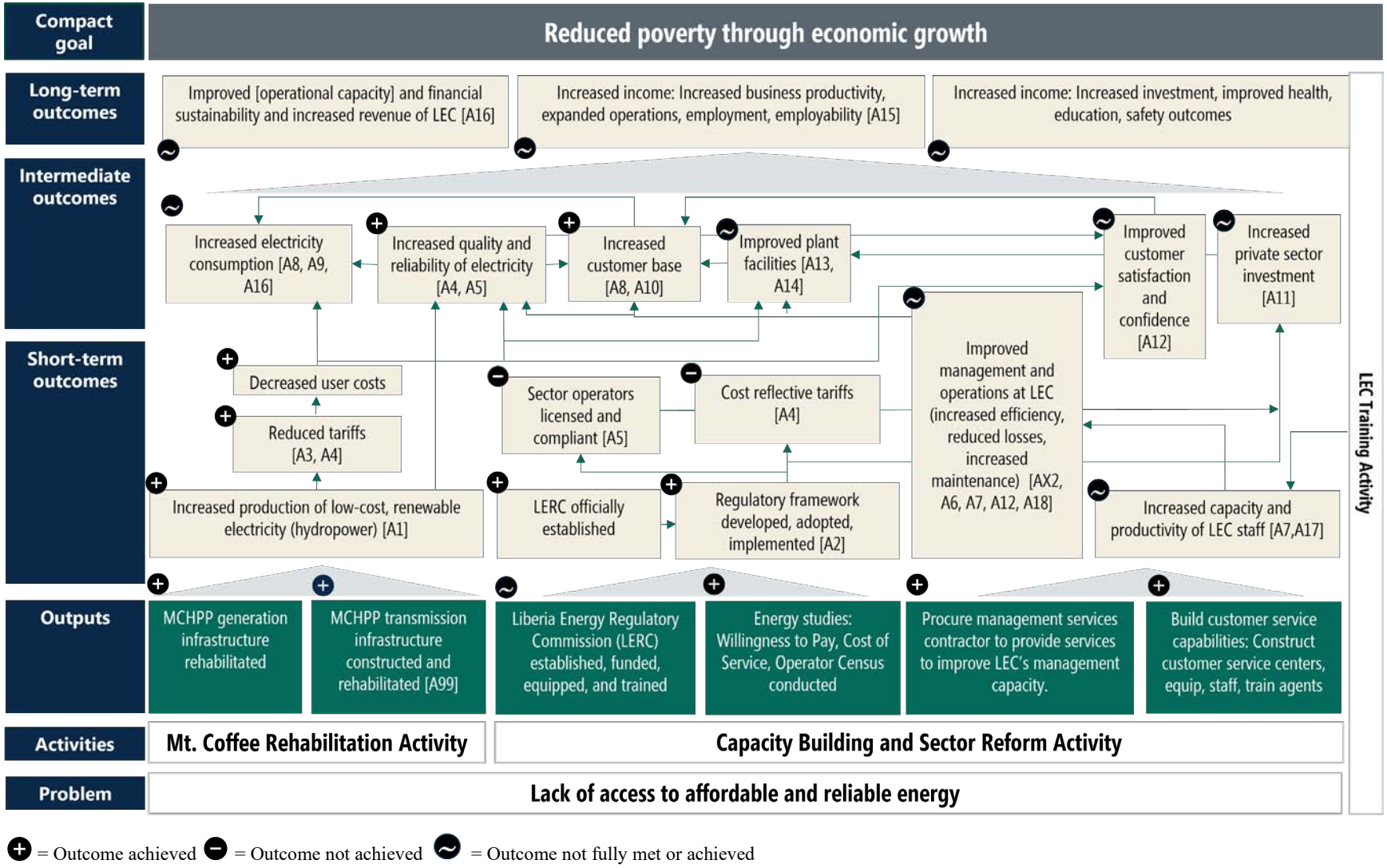
MCC's five-year, $257 million Compact was inadequate to rehabilitate and ensure MCHPP sustainability, fully reform the utility, and ensure regulatory agency proficiency, particularly given Liberia's low-capacity, post-conflict, post-Ebola context and with implementation during a prolonged global pandemic. Although donors have voiced frustration about investing more than $1 billion in the Liberia Energy Sector over the past decade, rebuilding and establishing a solvent sector require significantly more time, coordination, accountability, and resources than have been invested. Future reform will continue to be delayed in the absence of a master strategy that GoL and donors work towards collaboratively and with accountability.

MCC (and other stakeholders) had assumed that MCHPP would solve most energy supply needs during the rainy season, and thermal plants and the CLSG transmission project would meet LEC customer needs during the dry season. However, the situation at MCHPP, the thermal plants, and CLSG have each undermined these assumptions. First, MCHPP has had lower-than-average rainfall and the catastrophic failure of Unit 1. Second, thermal plants have frequently been out of order and expensive to run and maintain. Donated to LEC by different agencies, these plants have incompatible parts and manuals and require sophisticated skills to maintain and repair. Moreover, thermal plants are prohibitively expensive due to the high and increasing costs of light and heavy fuel oil. LEC carries debt for past fuel purchases, plans to rely on $3.9 million in IMF funding for 2023, and lacks a plan to pay for fuel in 2024. Finally, CLSG usage has been undermined by delays and the fact that the Power Purchasing Agreement and Transmission Service Agreement (approved in late 2022) contain problematic contract terms for Liberia and LEC's financial solvency (IMF is covering costs in 2023).

MCC also assumed that, with the MSC on board, LEC would stabilize within six months to a year. The MSC stepped into a bankrupt utility, with deficiencies beyond every stakeholder's understanding. The LEC board was unable to provide adequate oversight and guidance throughout the Compact. MSC/LEC withstood ongoing political interference, political will for utility turnaround was minimal, and donors added new connections, but not resources to maintain new assets. No OPEX or CAPEX meant that the MSC could identify but not solve problems. The assumption was that T&D infrastructure would be adequate to take on tens of thousands of new customers. Stakeholders learned over time that the infrastructure could not handle the increased load. In addition, increased theft further overwhelmed the T&D network. Stakeholders did not anticipate how sophisticated the system of theft had become and thought the MSC could reduce power theft just by disconnecting indirect customers. However, the LEC cartel is "a sophisticated operation" that organizes wide-scale theft and "is bolstered by political cronyism, MoL efforts to protect thieves employed by LEC, and MoJ failure to prosecute". Loss reduction requires intensive political will, significant investment, and consistent effort.

Finally, Liberia's history, politics, challenges, and complexities needed more time, resources, coordination, and strategizing to overcome. Moving forward, accomplishing energy sector progress, improved electricity access, and a sustainable utility requires applying lessons learned to future planning, implementation, and resource allocation.

Figure ES.12. Program logic for Activity 1 and 2



⊕ = Outcome achieved ⊖ = Outcome not achieved ~ = Outcome not fully met or achieved

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

MCC identified outcomes and assumptions in the program logic model (A1-18)		
Outcomes	MCC's assumptions underlying the outcome	Status of outcomes in 2022
⊕ **A1: Increased lower cost generation**	Bringing Mt. Coffee online will lower LEC's operating costs.	Rainy season generation increased and the cost per kilowatt of hydropower ($0.06) is less than thermal generation ($0.25). However, LEC's operating costs have increased with new infrastructure to maintain. MCHPP has had one catastrophic unit failure, which reduced generation by 25 percent.
⊕ **A2: Regulatory framework adopted**	Planned technical support from donor(s) will complement MCA-L's intervention. Compact-funded studies will inform the implementation of the regulatory framework, including tariff-setting and licensing operators (power producers).	Regulatory framework has been adopted. LERC's resource shortages delay full implementation. LERC continues to seek donor support to establish itself as an independent regulator. The EU funded several consultants to support LERC. Energy studies inform the sector but are already outdated. Operator census has not yet led to new licensing of majority of small operators.
⊕ **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.	LERC approved tariff reductions in 2022. Although they decreased user costs, they do not reflect actual utility costs. The COSS, with outdated assumptions, recommended $0.24 per kWh for residential customers. However more than 90% of customers will pay the social tariff at $0.15 per kWh (residential consumption is averaging below 50 kWh per month). Operational costs averaged $0.47 per kWh.
⊖ **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 tariff does not reflect costs. The 2022 reduction occurred when LEC was chronically operating at a loss, MCHPP had reduced generation due to a turbine loss and a long dry season, the CLSG transmission line was not yet operational, and global fuel costs were skyrocketing. LEC was in a financial crisis (losing $100,000 per day during the rainy season) and unable to make payroll.
⊖ **A5: Operators licensed and compliant**	LERC has the ability and resources to ensure compliance.	Among operators in Liberia, LERC has licensed LEC, Jungle Energy Power, and Totota. Liberia has informal small operators that are not yet licensed.
⊕ **A4, A5: Improved quality, reliability**	Increased electricity generation at MCHPP, LERC's regulation of the energy sector, and a tariff-setting process that adheres to LERC's regulations will improve electricity quality and reliability.	MCHPP rehabilitation has led to improved quality and reliability and the MSC met key performance indicators (KPIs); however, outages still occurred frequently (209 per year lasting 204 hours) in 2021.

MCC identified outcomes and assumptions in the program logic model (A1-18)		Status of outcomes in 2022
Outcomes	MCC's assumptions underlying the outcome	
AX2, A6, A7, A12, A18: Improved LEC management and operations	LEC improves use of data for problem solving and decision making and has capacity and resources to manage operations, including reducing losses, increasing collections, and performing routine maintenance; LERC standards are effective. Customer willingness to pay increases. The MSC effects long-term change in LEC operations, and stakeholders support changes. There is sufficient staff capacity and continuity at LEC in order to accomplish MSC capacity building objectives.	LEC has had chronic, severe resource constraints. Delays (T&D, CLSG power, connections, the IMS database, training), the lack of OPEX and CAPEX (US $137 million requested), political interference, and power theft mean the utility loses about US$48 million per year, with 62% of generated electricity unpaid. Maintenance is ongoing but inadequate given equipment, materials, and vehicle shortages. Some improved customer service practices. LEC returned to Liberian management in July 2022.
LEC training system	ESBI will have the capacity to implement training. Training of trainers' system is effective.	The training scope was reduced and delayed. Still, LEC has made notable progress since 2018 including establishing the Training and Development Department, developing a Training Policy and in-house trainings, and partnering to support training. External partner funding is needed.
A7, A17: Increased LEC capacity and productivity	Staff capacity and continuity is sufficient to accomplish MSC capacity-building objectives. Increased capacity is sustained after MSC ends.	In 2018, 80 percent of LEC staff had less than five years of utility experience. LEC's capacity remains below needs, especially given complicated generation, and T&D requirements. Political interference in staffing means many LEC staff were politically installed, rather than hired based on capabilities.
A8, A9, A16: Increased electricity consumption	LEC increases connections. New customers can pay for electricity; LEC can accommodate dry season demand. Increased generation capacity and T&D investments increase electricity quality and reliability. Customers pay for electricity.	LEC has made tens of thousands of new connections (mostly low-consuming and low-paying residential customers). LEC is unable to accommodate dry season demand without the CLSG transmission line, given the high cost of thermal generation. While paying customer numbers have increased, ongoing power theft losses cost LEC about $47 million per year.
A8, A10: Increased customer base	LEC increases ability to make connections. New customers can afford electricity; LEC can accommodate increased dry season demand, with enough staff, skill, materials, and operational capacity to fulfill connection requests.	After lengthy delays in donor T&D projects, connections are quickly increasing, with 90% of end users consuming less than 50 kWh per month. Large customers slow to connect (due to dry season outages) but would yield more revenue for less effort. LEC needs 60,000 meters to make connections and normalize customers. LEC must absorb the $33 connection fee and meter cost ($50).[5]

[5]According to LEC, the real average cost under donor funded projects is about US$800 - US$1000 per connection. Safely connecting 60,000 new customers requires investments in MV network, added transformers, and the LV network.

MCC identified outcomes and assumptions in the program logic model (A1-18)		
Outcomes	**MCC's assumptions underlying the outcome**	**Status of outcomes in 2022**
~ **A11: Increased private sector investment**	A clear regulatory framework is a critical requirement for private-sector investment.	LERC has licensed two operators LEC, Jungle Energy Power, and Totota. The remaining informal small operators are unlicensed. It does not appear that LERC or MCC investments have led to increased private sector investment yet. A recent USAID-funded study identified critical obstacles and risks to private investment.
~ **A12: Improved customer satisfaction**	Better quality electricity would improve customer satisfaction.	There have been modest improvements in customer satisfaction, particularly among businesses.
~ **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.	LEC is currently unable to invest in lifecycle maintenance and capital. Donors intend to extend T&D lines, but without adequate master planning and an overarching strategy that recognizes infrastructure needs and weaknesses.
~ **A15: Improved: outcomes, health, safety, education**	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.	End users have been negatively affected by the COVID-19 pandemic and its sequelae and Liberia's weak economy. However, end users do report some positive outcomes, including business development, income-generating activities, and improved health and safety.
~ **A16: LEC has increased revenue financial sustainability**	Customers pay for the electricity they consume.	LEC was in a financial crisis in 2018 that worsened. T&D failures, slow connections, excessive power theft, poor billing and collections, no OPEX or CAPEX to solve problems, and political interference undermine LEC's financial position.

Notes: + = Outcome achieved − = Outcome not achieved ~ = Outcome not fully met or achieved

I. Lessons learned from implementing the Liberian Compact

EQ. A3. What lessons can be drawn from implementation of the activities?

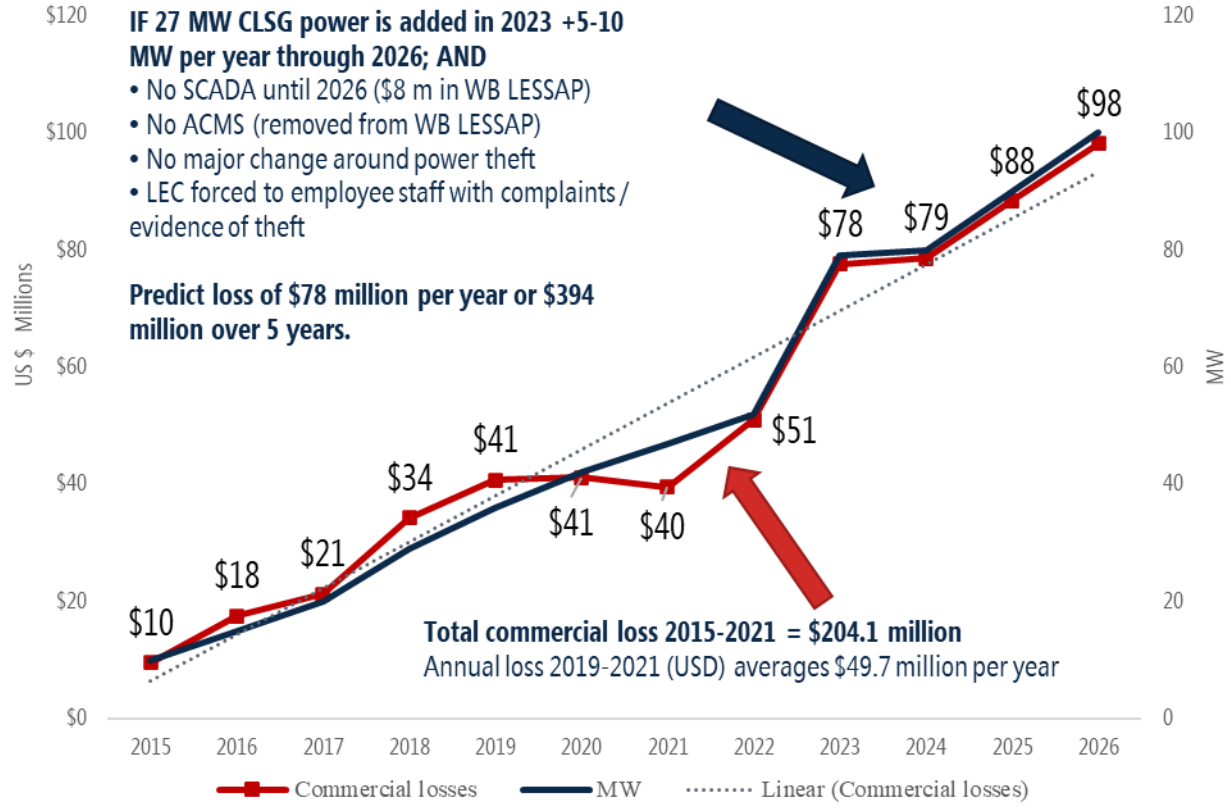
Based on a thorough analysis of all data, we offer the following Compact-wide lessons:

1. Strengthen the due diligence process and a conduct a robust political economy analysis and landscape analysis during Compact development to ensure activities are informed by the historical, political, economic, and social context, and in anticipation of future major political events (such as presidential elections).
2. Plan for the realities of the context, in this case a post-conflict country with weak governance, corruption without adequate tools to identify and reduce it, limited donor coordination, and low human-resource capacity. Identify points of leverage and develop expectations, mechanisms, and penalties to combat unwanted political interference and corrupt actors.
3. Energy is political. Acknowledge, strategize, implement, and communicate with this understanding.
4. Design activities with evidence-based timelines and worst-case risk prevention strategies. In the most challenging contexts, assume that more time, resources, supports, and leverage will be needed to achieve goals. Consider Compact length, then plan for and prioritize sustainability during Compact design and afterwards.
5. Energy projects should be strategic, planning for 20, 30, 40 years in the future and for 24 hour a day, 7 day a week, 365 day per year supply and demand. While MCHPP rehabilitation was collaborative and responsive to the GoL's requests, it was not the most strategic investment in Liberia's long-term energy development. MCHPP's seasonal 78 MW generation means that demand will exceed supply in several years. Constructing a new plant upstream would have costed less, taken less time, and been able to deliver 125 MW of renewable hydropower. Additionally, MCHPP only generates six months a year, leaving half the year without power. The low-quality LV network leads to daily outages.
6. Coordinate across donor agencies. Ensure that financial disbursements include conditions for governments to meet and ensure that donor partners do not undermine conditions.
7. Better support implementation and problem solving with robust and dynamic M&E processes— pushing beyond indicator tracking to problem identification and solution development—to inform real-time collaborative problem solving.
8. Improve MSC implementation and chances of success by designing contracts that better align resources (such as OPEX and CAPEX) and staffing (numbers and capabilities) to specific needs, Compact and Activity goals, desired outcomes, and contextual realities. Require MSC's to prioritize high-quality communications and information sharing, navigate politics, and utilize data systems.

9. Invest in data democratization, such as sharing data through dashboards. All stakeholders, GoL, LEC, and donors should have access to data dashboards that provide all the data sources available in this report. Decisions can be made with historical, contemporary data and analysis on hand so implications can be understood.
10. Finally, in this next post-MSC phase, we believe the Liberian energy sector will face a scenario in which losses could balloon to $78 million per year (or more) and $394 million over five years (Figure ES.13**)**. This is likely as Liberia utilizes CLSG power without 1) a digital SCADA until 2026, 2) complete ACMS data, 3) drastic actions to reduce power theft among large customers, and 4) major efforts to reduce political interference in LEC staffing. *Note the IMF is covering two years of CLSG costs, allowing LEC the ability to earn revenue and invest in the utility. Note that actual loss could be greater given this estimate does not fully capture losses due to the reduced tariff.* To avoid this scenario, we recommend the following:
    - Adjust the tariff to be cost-reflective. Rates for large customers can cross subsidize the rate for low-income customers *if large customers pay* for electricity consumed. Rates must cover the cost of generation, T&D, and overhead.
    - Invest in the (long overdue) T&D SCADA system, at a cost of $8 to $10 million.
    - Complete the ACMS and integrate data into operations for regular updating, at a cost of $1 million per year.
    - Install high security meters (HSM) at the homes and compounds of all political leaders and large businesses with a national media launch. Publicize bills and payment.
    - Implement a more robust approach to power theft. Stakeholders argued that LEC should be resourced to investigate complaints of theft against LEC staff. The Ministries of Labor and Justice should transparently report on benchmarks of progress towards removing and prosecuting staff that engaged in power theft. For LEC staff accused of facilitating large scale theft, procedures should include immediate suspension without pay, followed by an independent external investigation within 7 days. If found guilty, the worker is dismissed, their pension is forfeited, and they are banned from GoL or donor employment, while details of the crime are publicized. There should be mandatory sentencing and no parole.[6]
    - The Ministry of Justice (MoJ) must make progress on benchmarks for timely prosecution of those committing power theft, with transparent reporting to stakeholders.

[6] *We acknowledge improvements in power theft towards the end of 2022 and 2023, but the data is beyond the scope of this study.*

Figure ES.13. Predicted loss over time with CLSG, no SCADA until 2026, and no ACMS



J. Evaluation approach, outcome levels, and data sources

We used a mixed method, longitudinal approach to address evaluation questions on Activity 1 (investments in MCHPP rehabilitation) and Activity 2 (Capacity Building and Sector Reform). MCC's evaluation questions related to implementation, energy sector, utility, grid, and end user outcomes. Our evaluation employed multiple approaches to examine the evaluation questions and provide nuanced information at each outcome level (Table ES.2):

Table ES.2. 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, iterative qualitative interviews, attendance at Energy Sector Working Group Meetings, monthly meetings with the MCC Liberia team, and site visits • Recomputation of economic rate of return using administrative data and a document review

Outcome level	Evaluation approach
Energy sector Utility and grid	• Longitudinal analysis of administrative data to understand trends in key outcomes such as the quantity and quality of LEC electricity • Performance evaluation using a document review to assess LEC operations and the managerial effectiveness of the management contractor, and other key outcomes and processes, quantitative surveys of end users, qualitative analysis of interviews with stakeholders to validate outcome trends and ensure that they are correctly interpreted, 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 to measure changes in household, business, and community outcomes over time.: – Connected households in Monrovia as end users connected to LEC at baseline to estimate changes due to increased electricity supply and reliability – Connected small businesses in Monrovia – Unconnected households along the Kakata Corridor end users unconnected to LEC at baseline to estimate changes due to new connections to electricity and increased supply of electricity – Unconnected small businesses along the Kakata Corridor – Medium and large end users

K. Study timeline and exposure period

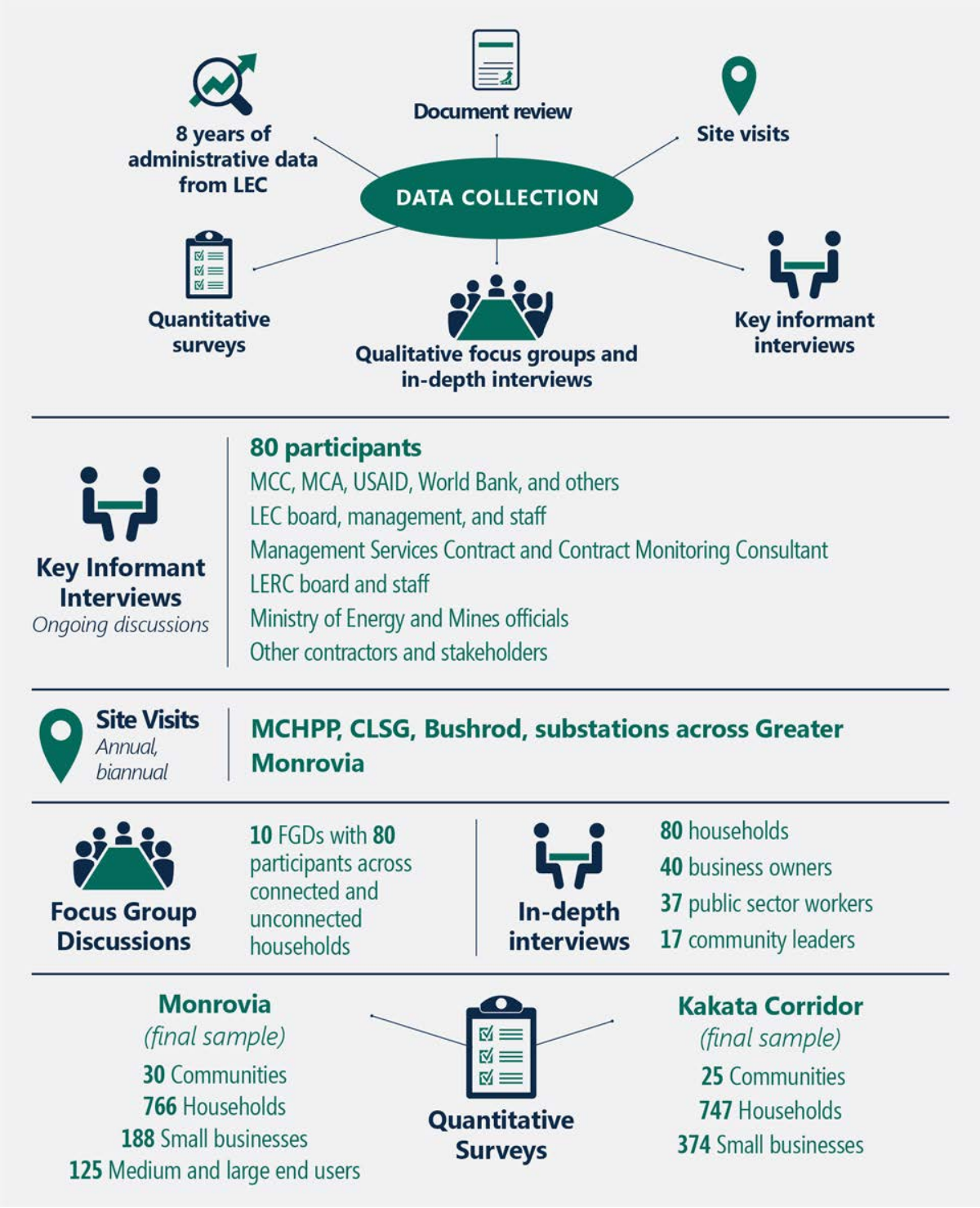
This 2022 report presents the final evaluation results of Activities 1 and 2. MCC originally requested an interim report in 2022 and a final evaluation report in 2024 and later determined that the interim data collection in 2020-2021 and resulting report would be sufficient to fulfill the Compact's accountability and learning objectives. Subsequently, this report is the final evaluation and is referred as the endline.

Endline data collection occurred between November 2020 and December 2021, 11 months after the Compact End Date. This timing means that data were collected approximately three years after completion of the MCHPP rehabilitation, three years after the management services contractor (MSC) Electric Supply Board International (ESBI) was installed at LEC, about two years after the Liberian Electricity Regulatory Commission began functioning, and one to two years after the grid was expanded into some communities in Kakata (Figure ES.14).

Table ES.3. Study timeline

Name of round	Data collection	Data cleaning & analysis	First draft report expected	Final draft report expected
Baseline and interim quantitative and qualitative	December 2018–November 2019	May 2019 January 2020	January 2020	March 2020
Endline	November 2020–December 2021	January–April 2022	August 2022	October 2022

Figure ES.14. Data collection summary: data collected iteratively from 2017-2022



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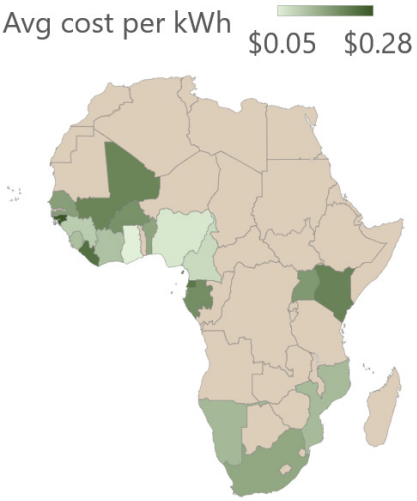
I. Liberia Energy Project

Liberia has had one of the lowest electrification rates and, until recently, one of the highest tariffs in the world. By 2020, 28 percent of Liberians had access to electricity (World Bank 2020a) with the $0.37 per kWh tariff reduced to $0.15-$0.24 in 2022 (Figure I.1; Table I.1). Electricity is often unreliable, with frequent planned and unplanned outages.[7]

Figure I.1. Comparative electricity costs



Before Liberia's 14-year civil war, the Mt. Coffee Hydropower Plant (MCHPP) was Liberia's largest power source, generating 64 megawatts and accounting for 98 percent of the country's total power supply. By the end of the war in 2003, MCHPP and Liberia's entire transmission and distribution (T&D) system had been severely damaged by widespread looting. The Liberia Electricity Corporation (LEC) lost both technical and management capacity when an estimated 800,000 Liberians fled the country and about 200,000 were killed during the wars. The Ebola Virus Disease (EVD) outbreak in 2014 further damaged the fragile economy and human resource capabilities.

To address these energy challenges, the Millennium Challenge Corporation (MCC) partnered with the Government of Liberia (GoL) to fund the $202 million Energy Project under the $257 million Liberia Compact (2016–2021) (signed value). The Energy Project objectives were to "provide access to more reliable and affordable electricity." The Energy Project comprised four activities:

Table I.1. Comparative electricity costs and access in West Africa

Country	Cost per kWh for residential customers US$	Access to electricity % (2020)
Benin	0.16	41
Cote D'Ivoire	0.12	70
Ghana	0.05	86
Guinea	0.10	45
Liberia	0.15 – 0.22	28
Nigeria	0.06	55
Senegal	0.17	70
Sierra Leone	0.12	26

- **Activity 1:** The **Mt. Coffee Rehabilitation Activity** was designed to repair and expand MCHPP, 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,** designed to support a management services contract to operate and strengthen the capacity of the LEC was supported the establishment of an independent

[7] Data are from GlobalPetrolPrices.com, United4Efficiency.org, and the World Bank Global Electrification Database. Tariffs for Liberia based on customer classification.

regulatory agency—the Liberia Electricity Regulatory Commission (LERC)—and strengthened capacity at the Ministry of Mines and Energy (MME).

- **Activity 3:** The **Mt. Coffee Support Activity** was anticipated to address environmental and social risks of the MCHPP rehabilitation and increase productive uses of electricity.
- **Activity 4:** The **LEC Training Center Activity** aimed to improve the capacity of the LEC workforce.

A. Overview of the Mt. Coffee Rehabilitation Activity and the Capacity Building and Sector Reform Activity

The $257 million Liberia Compact, designed to stimulate economic growth and reduce poverty through investments in energy and roads, entered into force in January 2016. The objective of the Liberia Energy Project was to "provide access to more reliable and affordable electricity" and addressing: (1) a weak policy and regulatory environment, (2) insufficient supply and distribution of electricity, and (3) weak capacity across the sector. Below, we describe Activity 1 and 2.

Activity 1: The Mt. Coffee Rehabilitation Activity (Figure I.2) was a $147 million investment to rehabilitate the hydropower plant and contribute to installation of the high voltage system (132 kilovolt (kV) transmission lines, two 66 kV circuits) connecting MCHPP to the Paynesville and Bushrod substations. MCHPP was designed to generate 88 MW of electricity[8], and, according to the economic model, to increase the number of connections from 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 enable electricity distribution throughout Greater Monrovia, increasing access to more reliable and affordable electricity.

Figure I.2. MCHPP before rehabilitation

MCHPP, shown before rehabilitation, is located on the St. Paul River, 27 kilometers northeast of Monrovia. Constructed in the 1960s, MCHPP had a capacity of 64 MW (Norplan Fitchner 2013). In 1990, during the civil war, the dam was breached, and the plant was destroyed. All electrical equipment was destroyed or stolen.

Source: MCC

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

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

Installing a management services contract (MSC) to improve LEC's management capacity. MCC required that GoL select a management plan as a condition of the Compact. As of 2015, LEC had 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). Consequently, GoL selected an MSC to reform management and operations and work to 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, 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 and its strategic and master planning. The studies yielded information on power producers and operators,[9] customer demand, and willingness to pay.

B. Background on Liberia

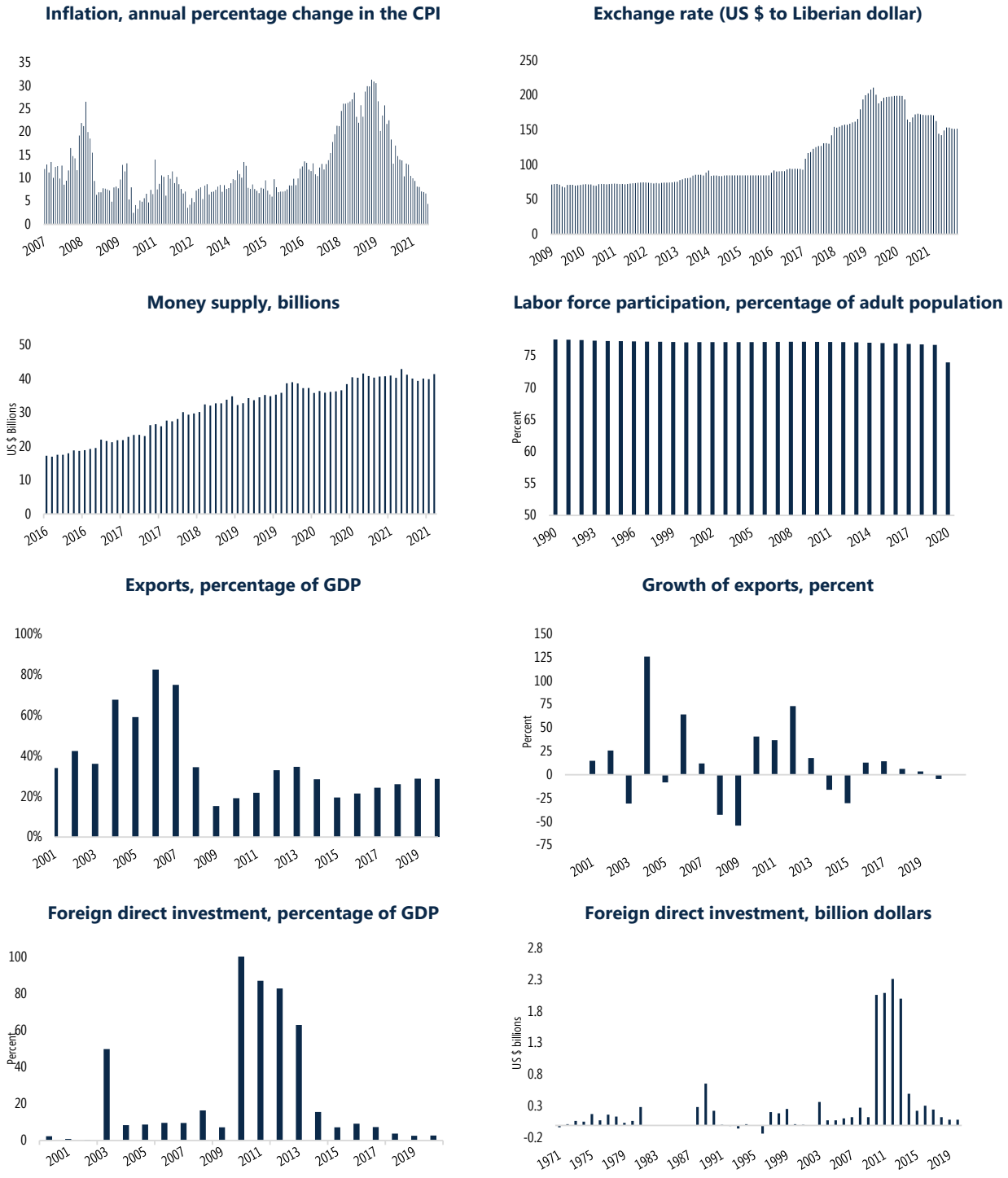
1. Political and economic context

Liberia's devastating 14-year conflict (1989–2003), followed by the Ebola Virus Crisis and macroeconomic decline, have contributed to the nation's fragile political and economic position (Hettinger 2020). Without resources commensurate with the costs of rebuilding and restoring government infrastructure, Liberia has weak ministries; insufficient accountability mechanisms; and inadequate human resource capacity given the large-scale departure of private-sector workers (Liberians and expatriates). Before the Liberia Compact, Liberia steadily improved its performance on MCC's list of policy indicators between 2015 and 2018, passing 10 of the 20 scorecard indicators, a key criterion to assess eligibility for compacts. However, since 2019 Liberia has failed to pass MCC's scorecard and performed poorly on indicators including regulatory quality, government effectiveness, and rule of law, creating a challenging environment for Compact implementation.

Liberia has a fragile economy and has faced deep macroeconomic challenges. After Liberia's economy contracted for two consecutive years, it registered a modest 4 percent growth in 2021 (World Bank 2022). Similarly, after years of rising inflation and depreciating currency, these indicators have improved marginally (Figure I.3). Liberia collects meager tax revenues and has limited foreign direct investment, stagnant growth in money supply, and declining exports.

[9] Operators are entities engaged in electricity generation (mostly diesel generators and some renewable energy), transmission, distribution, and sale, including LEC and hundreds of community operators and self-suppliers.

Figure I.3. Macroeconomic indicators



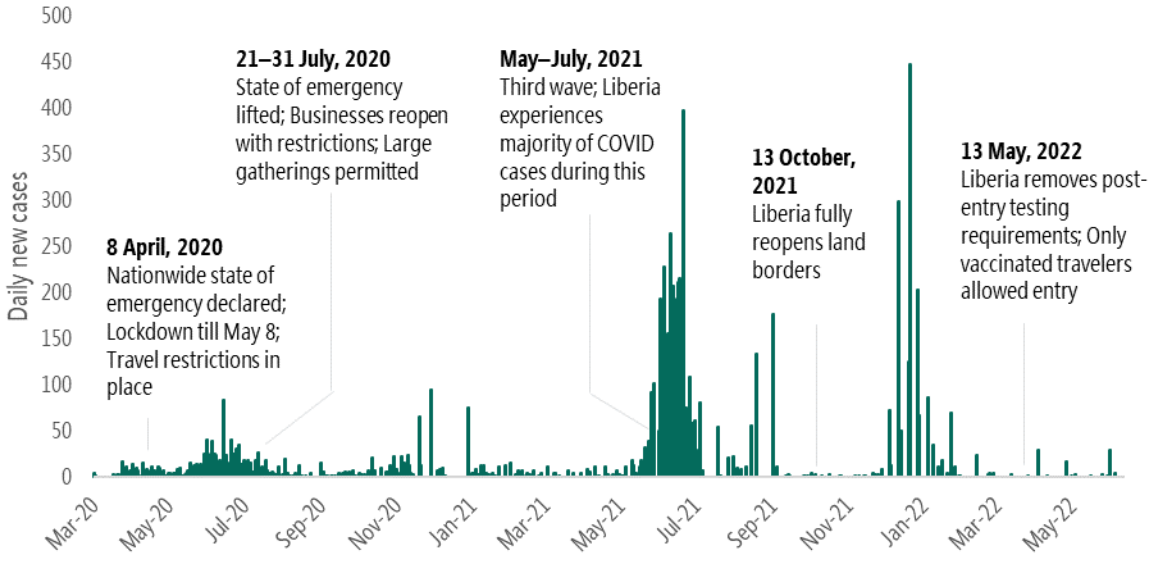
Source: Global Economy and Trading Economics platforms

GoL cannot pay its bills, from the salaries of civil servants to basic materials, equipment, rent, and utility debts (Ballah 2019; APA 2019). Even in July 2022, a GoL check to pay LEC for outstanding energy costs did not clear, and LEC could not make payroll. Across GoL operations, offices have vacant positions and lack supplies. Progress is slow in rebuilding sectors destroyed during the war. Consequently, Liberians have little faith that 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 growth and development (Ackerman 1996). This stark political and economic context is crucial background to interpreting the findings presented in this report.

2. COVID-19

Liberia reported its first case of COVID-19 in March 2020. Since then, the country has reported more than 7,000 confirmed cases and nearly 300 deaths (New York Times 2022). The government of Liberia applied lessons from the Ebola epidemic and responded promptly to COVID-19 with measures such as mandatory lockdowns and social distancing to limit the spread of the disease. Like other countries in Sub-Saharan Africa, Liberia's per capita case count (152 cases per 100,000) and deaths (6 per 100,000) is among the lowest in the world (New York Times 2022). Liberia is currently reporting fewer than a handful of cases per day (Figure I.4). The country began vaccinating its residents in April 2021 and has administered more than 2 million doses, covering almost 20 percent of the population (Reuters 2022).

Figure I.4. Daily covid cases in Liberia (March 2020–June 2021)



Source: Our World in Data and Global Monitoring

Although Liberia's policy response has been successful in curbing the pandemic's spread, the crisis came at a time when Liberia's economic condition was already vulnerable. COVID-related measures contributed to further economic slowdown, trade and supply issues, and food insecurity (Saito 2020). Lockdowns and curfews severely restricted business activity.[10] Many businesses reduced operating hours and therefore generated lower profits or even losses. Some households reported a shortage of goods and widespread financial hardship. Most schools were shut in Liberia, which had a negative effect on children's learning.

C. Program logic

The program logic for Activity 1 and 2 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 (Figure I.5). In theory, investments will lead to increased electricity generation and distribution (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 better access to more reliable and affordable electricity positive economic and social outcomes among customers and enable LEC to be financially viable.

Activity 2 involved two main subtasks. First, Activity 2 was designed to procure a management services contract for LEC to improve LEC's operational and management capacity to oversee electricity generation and distribution in a financially sustainable way. In turn, LEC would build its customer base, accelerating positive social and economic outcomes in the long term. Second, under Activity 2, MCC supported the establishment of the Liberia Electricity Regulatory Commission (LERC) to 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. Further, technical and quality regulations should improve the safety and quality of electricity.

The program logic is dependent on assumptions that must be realized to achieve long-term outcomes and the Compact goal. There are several macroeconomic factors that also underlie the program logic, including assumptions that GoL would have stable governance, be able to pay its bills, that MCHPP would solve most energy supply needs, and that Liberia's T&D infrastructure would be able to accommodate large increases in customers (among others). We list the assumptions in Table I.2, assess outcomes and assumptions in Chapters IV, V, VI, and VII, and summarize them in Chapter VII.

We also note that MCC's program logic does not illustrate the inputs of Liberia's donor community, including the African Development Bank (AfDB), the British High Commissioner, 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). Donors have invested in thermal

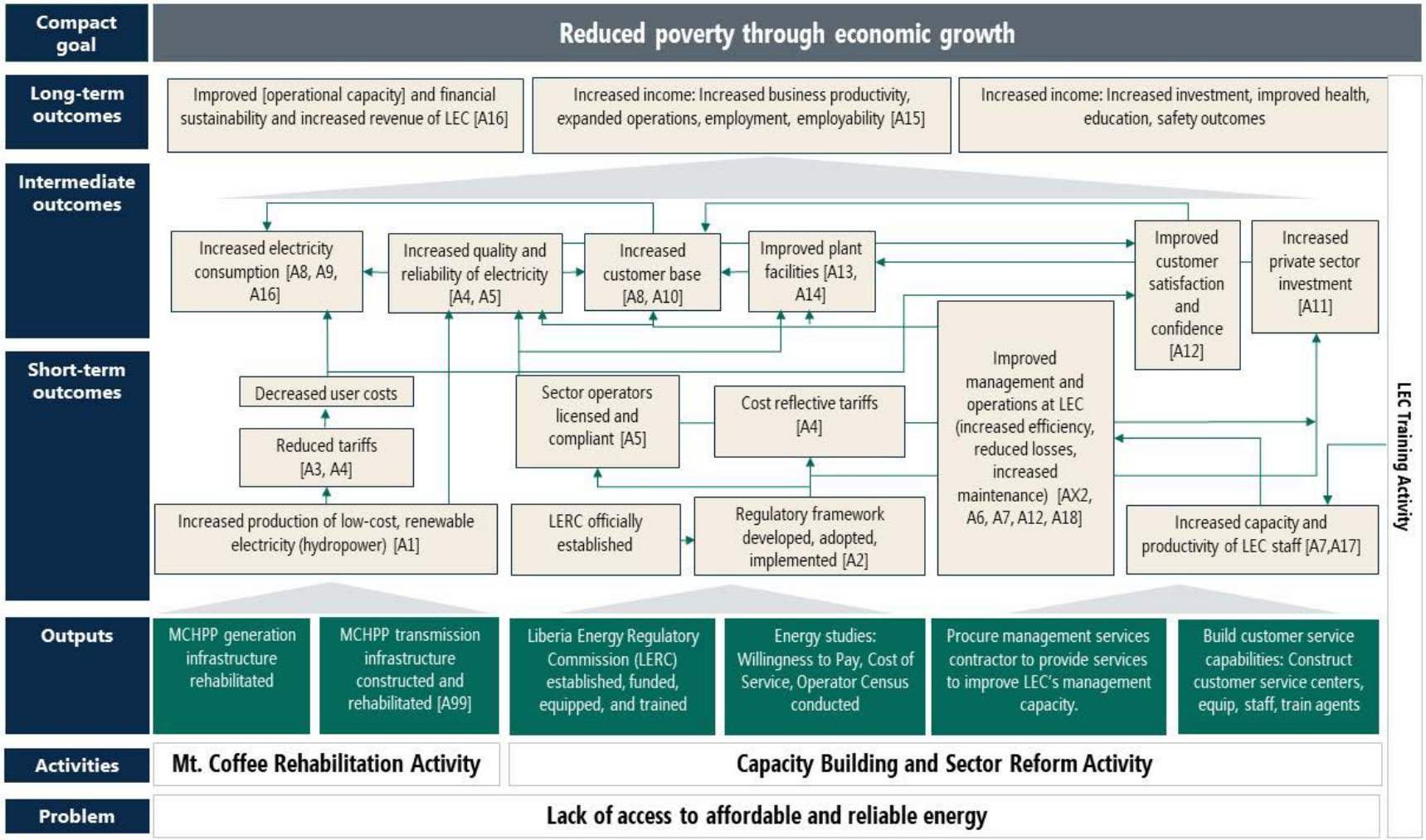
[10] According to interviews with respondents from households, businesses, and public offices conducted in 2020-2021.

generators, grid infrastructure, technical assistance, vehicles, and other items in support of energy sector development. These may complement MCC's investments, helping to achieve the short-, intermediate-, and long-term goals outlined in the program logic.

Table I.2. MCC identified outcomes and assumptions in the program logic model (A1-18)

Outcomes	MCC's assumptions underlying the outcome
A1: Increased lower cost generation	Bringing Mt. Coffee online will lower LEC's operating costs.
A2: Regulatory framework adopted	Planned technical support from donor(s) will complement MCA-L's intervention. Compact-funded studies will inform the regulatory framework, tariff-setting, operator licensing
A3: Reduced tariffs, 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.
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.
A5: Operators licensed	Once the census was complete and LERC in place, operators would be licensed.
A4, A5: Improved quality, reliability	Increased electricity generation at MCHPP, LERC's regulation of the energy sector, and a tariff-setting process that adheres to LERC's regulations, will improve electricity quality and reliability.
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. Customer willingness to pay increases. The MSC effects long-term change in LEC operations, and stakeholders with interest and influence support these changes.
LEC training system	ESBI will have the capacity to implement training. Training of trainers' system is effective.
A7, A17: Increased LEC capacity	There is sufficient staff capacity and continuity to accomplish MSC capacity-building objectives. Increased capacity is sustained after MSC ends.
A8, A9, A16: Increased electricity consumption	LEC increases connections. New customers can pay for electricity; LEC can accommodate dry season demand. Increased generation capacity and T&D investments increase electricity quality and reliability. Customers pay for electricity.
A8, A10: Increased customer base	LEC has enough skill, staffing, materials, and operational capacity to respond make connections.
A11: Increased private investment	A clear regulatory framework is a critical requirement for private-sector investment.
A12: Improved customer satisfaction	Better quality electricity would improve customer satisfaction.
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.
A15: Improved outcomes, health, safety, education	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.
A18: LEC has increased revenue financial sustainability	Increased generation and more end users would yield more revenue and sustainability.

Figure I.5. Program logic for Activity 1 and 2



D. 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 attributed to the increased supply and reliability of electricity from the MCHPP Activity. The first is the benefit accruing to newly connected households and firms from new electricity consumption. The second is the benefit accruing to already-connected households and firms from lower costs and increased consumption with the 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. In Chapter VIII, we present an analysis of the ERR model.

E. Structure and organization of the report

In Chapter II, we describe the Liberian energy context and summarize literature relevant to the Liberia Energy Project investments. In Chapter III, we present the evaluation components, including the study methodology and data sources. In Chapters IV, V, and VI, we reveal findings related to the energy sector, utility and grid, and end user outcomes. In Chapter VII, we present findings from the cost-benefit analysis. Finally, in Chapter VIII, we discuss the policy implications of the evaluation findings and provide recommendations for future energy investments in countries similar to Liberia.

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II. Literature review of the evidence

In this chapter, we describe the Liberian context and review evidence relevant to Compact activities and anticipated outcomes. Figure II.1 summarizes the key findings from this chapter.

Figure II.1. Literature review highlights

Energy sector reform

Independent regulatory agencies can improve industry **performance and efficiency** and reduce sector **corruption**, especially when they have independent decision-making authority and focus on principles such as **accountability**, **transparency**, and **public participation.**

The Electricity Regulatory Index provides a useful set of measures for assessing the Liberia Electricity Regulatory Commission.

Utility reform

Utility performance

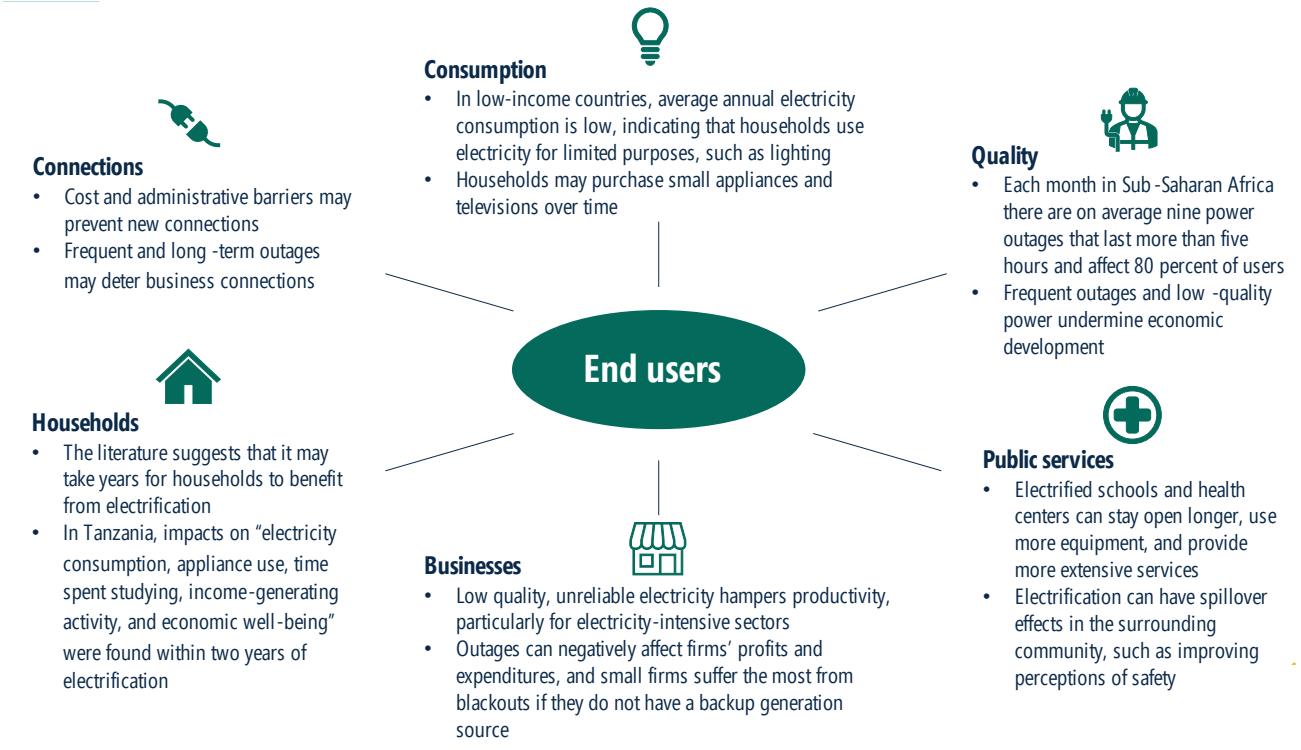
- Utilities in under-resourced countries struggle to manage operations and finances, provide access to high quality, low-cost electricity, limit power outages, reduce losses, and collect cost reflective tariffs.
- Literature suggests that "unequivocal political support" is the most important element of a successful MSC.
- Donor-funded power sector reforms have sometimes failed because they do not adequately account for the political economy.

Corruption and power theft

- Without adequate anti-corruption infrastructure, public utilities—as modest, yet steady income generators—are particularly vulnerable to corruption.
- Utilities can become part of a system of patronage and cronyism, where errors, theft, billing irregularities, and unpaid bills undermine utility finances and operations.

Generation

- Hydropower plants can generate low-cost, high quality renewable electricity but have substantial seasonal variation in production.
- A well-maintained hydropower facility can operate for more than 100 years. However, the strong operations and maintenance practices that are essential to maintaining this longevity are not always implemented effectively, particularly in low-income countries.



A. Energy sector policy and regulatory reform

1. Overview of Liberia's energy sector

The Liberia Electricity Corporation (LEC), the state-run utility, ceased operations in 1990 during the country's civil war when the generation, transmission, and distribution (T&D) infrastructure was destroyed. LEC remained closed for 15 years leaving the country in darkness. Post war, the Liberian energy sector has lacked institutional capacity, strategic and master planning, a regulatory framework, and accountability (Liberia Ministry of Lands, Mines and Energy 2009). LEC reopened in 2005 with a donated one-megawatt (MW) thermal generator and aspirations to restore and grow electricity generation, T&D, and sales in Monrovia before expanding access countrywide.

Donor partners and organizations have collectively invested more than $1 billion in Liberia's generation, T&D, and management contracts since 2010, albeit without a coordinated or long-term strategy. Energy sector reform and modernization is crucial to supporting these investments and GoL's goal of increasing access to electricity to foster economic development.

2. Energy sector reform activities

Since the 1990s, many developing countries have established regulatory agencies to help improve sector performance. These agencies aim to develop standards for safety and quality, create policies to help stimulate private-sector participation and competition, and build an environment suitable for unbundling monopolistic utilities into separate and solvent generation, T&D, and retail entities (Eberhard et al. 2016). A study of 47 Sub-Saharan countries found that independent regulatory agencies and private participation improved industry performance and efficiency and reduced sector corruption (Imam et al. 2019). 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).

To track regulatory activities and development in Africa, the African Development Bank conducts an annual survey of regulatory agencies to calculate the Electricity Regulatory Index (ERI), which is made up of sub-indices of regulatory governance, substance, and outcomes. The 2021 ERI reported scores for 41 countries, noting that high performers (Uganda, Kenya, Tanzania) have mature regulatory frameworks, the capacity and authority for entity and sector oversight, and the ability to achieve measurable outcomes (African Development Bank 2021).

The 2021 ERI report shows that although some African countries have progressed, most still have low Regulatory Outcome Index scores, which suggests that regulatory and policy advances might not quickly result in improved utility performance (African Development Bank 2021). Challenges that reduce the overall ERI score are common across many countries: 93 percent of regulatory agencies reported government influence resulting in low independence, 33 percent reported having no tariff methodology, 40 percent had methodologies that lacked key attributes, and 67 percent did not have a cost-reflective tariff needed for a solvent utility (NARUC 2021). Although the self-reported ERI scores are not a perfect measure of regulatory development, they

provide a useful set of scales for assessing the Liberia Electricity Regulatory Commission, established within Activity 2 of the MCC Compact.

B. Utility reform

1. Management and operations

Underperforming, state-owned utilities are common across Sub-Saharan Africa (Eberhard et al. 2011; Wood 2018). Utility companies—operating in under-resourced countries with capacity constraints—struggle to manage operations and finances, provide access to high quality, low-cost electricity, and maintain aging and piecemeal infrastructure. They also strain to limit power outages, reduce commercial losses, and collect cost reflective tariffs (Kojima and Trimble 2016). Although challenges are manyfold, energy sector and utility reforms are politically sensitive because electricity is fundamental to modern economies and part of every country's development agenda (McCulloch et al. 2017).

2. Management Services Contract

Governments agree to management service contracts (MSCs) when utility performance is poor, and the financial situation repels private investors. For example, Gambia, Guinea-Bissau, and Togo signed MSCs when, owing to poor performance, they could not attract private investors. MSCs can improve revenue and reduce losses (Imam et al. 2019) but often lack the support of country governments who view MSCs as undesirable but compulsory for donor investment (McCulloch et al. 2017). A 2018 USAID review found that MSCs were successful in Georgia and Kenya and moderately so in Tanzania, where each MSC had full government support to disconnect non-paying customers, reduce commercial losses, and make needed staffing changes (Wood 2018). The review attributes unsuccessful MSCs in Haiti and Liberia (Manitoba Hydro International (MHI) in place from 2010 to 2015) to government's lack of support and its interference in operations, emphasizing that "unequivocal political support" is the most important element of a successful MSC.

> *"In many countries, it is common knowledge that public utilities are financial black boxes that finance special—including political—interests. In fact, such practices are frequently at the heart of their dysfunction and poor performance. Using a management services contract is potentially an effective tool to sweep away the individuals, networks, and procedures that propagate such dysfunction, but only if a higher political power recognizes both the nature of utility dysfunction, agrees to root it out, and offers vocal, political support for the operator, who is effectively the government's agent to effectuate these sweeping changes." (Wood 2018)*

Researchers have also noted that donor-funded power sector reforms have failed because reforms did not adequately account for the political economy (that is, the interaction between institutions, laws, political behavior, and the economic system) (McCulloch et al. 2017).

> *"Too many management contracts studied here failed because of the overpowering vested interests of local and national politicians, workers' unions and internal lobbies, and rent seekers dependent on dysfunctional utilities for one reason or another" (Wood 2018).*

Donors may focus on the end scenario (a functional and competitive power market) without understanding the steps to get there, for example, tackling government interference in staffing and obstruction of efforts to reduce theft. McCulloch et al. (2017) recommend that donors conduct and use political and economic assessments in the reform strategy; base activities on analyses, even if it requires a slower, more thoughtful disbursement of funds; shift funding to more effective activities if circumstances change; and operate as a donor collaborative to leverage influence. LEC's MSC from 2010 to 2015 highlights the importance of donor coordination and support for the full scope of necessary reforms:

> *"If the project is supported by multiple donors, there needs to be good donor coordination and donors need to agree on the program and how to achieve its objectives. In the case of LEC management contractor, donors began the project well-coordinated but with the addition of [MCHPP], there was a change in donor priorities and coordination. Donors involved in [MCHPP rehabilitation] were well coordinated … Donors continuing to fund T&D and connections were fragmented and looked after their own ring-fenced projects. Generally, donors had no interest in the LEC electric master plan, the business plan, or the investment plan that were supposed to be the road map for recovery" (Management Hydro International 2016)*

3. Corruption and power theft

Globally, corruption and theft undermine utility performance and development goals. Without adequate anti-corruption infrastructure, public utilities—as modest yet steady income generators—are particularly vulnerable to corruption and cronyism (Adejumobi 2015; Rimsaite 2019; Imam et al. 2019; Rose-Ackerman 1996). Utilities can become larger than necessary employers (hiring politically connected, unskilled staff) in countries with high unemployment and few economic opportunities (McCulloch et al. 2017, McCulloch et al. 2018). In addition, a broad system of patronage may also include fraud, theft, billing irregularities, and unpaid bills. Power theft or commercial losses are the primary indicator of a utility's "financial and operational health" (Carr and Thomson 2022). Further, "major undertakings such as the construction of large hydroelectric dams … absence of competition and substantial revenues from the sales of electricity make the sector vulnerable to corruption" (Imam et al. 2019).

Indeed, Liberia is the exact context in which corruption can proliferate: post conflict, with weak governance, high poverty, limited accountability and capacity, high energy demand, high tariffs, and possession of a new, large, hydropower resource. Since the 2010s, Liberia has had among the highest rates of commercial losses in the world with a thriving cartel responsible for both petty and grand electricity theft. In 2017, the WB had planned to invest about $10 million in a SCADA system which could help identify the location of power theft, however plans were set aside following a failed procurement. In 2021, we quantified the financial losses from power theft and commercial losses, showing that from 2015 to 2020, LEC lost about $220 million in

revenue, averaging $48 million in losses per year in combined technical and commercial losses and unpaid bills. Our analyses also demonstrated how the lack of SCADA systems, meters, measurement tools and processes, and investment have hindered theft reduction in Liberia.

Carr and Thomson (2022) list approaches that utilities have used to combat losses, including installing prepaid and tamper-proof meters, removing connection fees, reducing tariffs, strengthening power theft laws and law enforcement, targeting worst offenders, and engaging local communities. Notably, LEC has invested in each approach while also working to normalize customers, negotiating rates with large customers, and contracting a meter specialist to disconnect non-paying customers. In 2020, Tata Power conducted a study of LEC's losses, recommending a full SCADA system to be able to measure loss at each meter's interface. Other experts urge utility companies and their partners to design anti-corruption plans with clear objectives and theories of change and appoint a senior officer to oversee activities (U4 2012). Of course, to reduce theft, the government must (1) support and not interfere with efforts to stop illegal activities, (2) penalize illegal activity, and (3) prosecute theft.

4. Generation, T&D

Investments in domestic energy generation can increase access to electricity, and with more power, reduce outages and improve voltage stability. Generation investments have reduced or eliminated load shedding (planned outages) in Mali, Rwanda, and Senegal (World Bank IEG 2012; World Bank 2006, 2010). However, in Uganda, a hydropower plant funded by the World Bank underperformed owing to low water levels (World Bank 2008). Although successful generation projects have been implemented across Africa, a World Bank study noted that many projects encountered implementation challenges, including cost overruns, delays, and insufficient human resource capacity to build and repair the infrastructure (World Bank 2006, 2008).[11]

Hydropower is the "world's largest source of renewable energy generation" (World Bank 2020b). Hydropower plants can operate for over 100 years if properly maintained compared to a lifespan of 20 to 30 years for other generation facilities. Good operation and maintenance (O&M) yield a very high return on investment and allows hydropower plants to operate with very little major work required, whereas insufficient O&M allows deterioration of equipment and parts. This leads to lost production and costly rehabilitation and equipment replacement (World Bank 2020b). Canale et al. (2017) warn that possible consequences of insufficient O&M may include performance losses, extended outages, higher rehabilitation costs, and emergency situations such as the loss of life or property. Following completion of the MCHPP rehabilitation, Liberia adopted an outsourced O&M model, with the goal of moving to internal management once staff were adequately trained.

[11] Many donors' contract tender and bid structures prioritize least cost over quality. Note that some European donors are reviewing this practice to protect against low-cost, poor-quality work.

C. End-user outcomes

Next, we review the literature on customer connections, barriers to connecting, and impacts of connections and electricity quality on households and businesses. Outcomes include time allocation, education, labor market participation and productivity, and spillover effects.

1. End user connections: Connecting and barriers to connecting in Liberia

Customer connection rates vary in countries 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, Bos et al. 2018). Over the past decade, although construction has been slow, donor-funded distribution network projects have increased grid access throughout urban Monrovia, and thermal generation and MCHPP have increased installed capacity.

Still, the challenges of connecting to electricity in Liberia are many. 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 tariff transparency (World Bank 2020c). The World Bank estimated that it took 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).

Additional costs and barriers might undermine new connections. Although LEC abolished connection fees in 2017, customers must pay upfront wiring costs, which are substantially higher than the cost of batteries, candles, and kerosene purchased on an as-needed basis (Phelps and Crabtree 2013). In addition, end users have reported that LEC staff sometimes request "informal" payments. Further, Liberians face a cumbersome application procedure and long wait times for connection. LEC's limited capacity, overloaded infrastructure, and shortages in meters, parts, and utility trucks have resulted in a backlog of applicants who have paid yet await connection (Miller et al. 2018). Frequent and long-term outages may slow business connections, particularly among large end users whose operations require reliable power. As a result of LEC's limited generation, most businesses (75 percent) and households with power have relied on private generators, even though the per-kilowatt energy cost of generators (with fuel and maintenance costs) is about 10 times higher than grid electricity tariffs (World Bank 2011).

2. Electricity consumption

In low-income countries, average annual electricity consumption among electrified households is low at 317 kWh per capita per year, which indicates that electricity is used for limited purposes, such as lighting (World Bank 2008; Energy Sector Management Assistance Program 2002; Bernard and Torero 2009; Lenz et al. 2017). Households might purchase small appliances and 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, but they still have relatively low levels of electricity consumption (International

Energy Agency [IEA] 2014). During the baseline study for this evaluation, we found that urban households in Liberia were slowly shifting their main use of electricity from lighting to appliances. However, frequent outages and appliance damage undermine the benefits of electrification.

3. Electricity quality

Each month in Sub-Saharan Africa, there are on average nine power outages that last more than five hours and affect 80 percent of users (Nduhuura et al. 2018; World Bank 2017). Frequent outages and low-quality power have "socioeconomic ramifications" that hinder foreign investment, business operations, and productivity (Andersen and Dalgaard 2013; Mensah 2016; Escribano et al. 2010). In fact, according to the World Bank, power outages are responsible for an estimated 2.1 percent loss of GDP across Sub-Saharan Africa (Eberhard et al. 2011). Andersen and Dalgaard (2013) estimate that a 1 percent increase in outages results in a 2.86 percent reduction in GDP per capita across Africa. In Liberia, LEC has made some progress, but reducing outages remains problematic because of electricity shortages caused by the seasonal nature of hydropower, delays in the Cote d'Ivoire, Liberia, Sierra Leone, Guinea Transmission Project (CLSG) or the cross-border gas line providing power in the dry season, and the high cost of thermal generation during the dry season (which LEC cannot afford). Moreover, LEC's aging network is overwhelmed by extensive illegal connections, and the utility lacks equipment, materials, systems, training, and tools to monitor and repair the network. Still, improving electricity quality and reducing outages in Liberia would yield numerous benefits. Studies from rural India found that households with higher quality electricity reduced kerosene consumption and time spent collecting fuel and that fewer outages led to increased nonagricultural income over a 10-year period (Samad and Zhang 2016).

4. Household impacts

Impacts of improved electricity quality on connected households. Households with existing connections can benefit from improved electricity quality, but the literature is sparse. Two studies using household panel data in rural India investigated this question. One study, using data from 1994 and 2005, found that using better quality grid electricity (measured as fewer outages and more hours of current per day) led to an increase in households' nonagricultural income (Chakravorty et al. 2014). The second study, covering data from 2005 and 2012, found that using grid electricity was associated with less kerosene consumption and time spent collecting biomass fuel, especially for households experiencing fewer outages (Samad and Zhang 2016).

Impacts of new connections on households. A 2018 evidence review by Bos et al. (2018) indicates that it may take years for households to benefit from electrification. In Tanzania, impacts on "electricity consumption, electric appliance use, time spent studying and watching television, access to health information, income-generating activity, and economic well-being" were found within two years of electrification (Chaplin et al. 2017). However, smaller studies elsewhere found impacts only five years post electrification.

Overall, the effects of electricity on child and adult time use, productivity, and income tend to vary by country and study, as described in detail in Bos et al. (2018). Many studies show increased study time for children in electrified households (Khandker et al. 2012a; Khandker et al. 2012b; Chaplin et al. 2017), and there is mixed evidence on whether electrification affects how women and men spend their time (Grogran and Sadanand 2013; Khandker et al. 2012b; Chaplin et al. 2017; Bernard and Torero 2015).

Several studies found that adults in connected households were no more likely to have income-generating activities than unconnected households (Bernard and Torero 2009; Wamukonya and Davis 2001; Lenz et al. 2017). 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). Other studies have found statistically significant impacts of grid electricity on income and expenditures (Chakravorty et al. 2014; Khandker et al. 2012a; Khandker et al. 2013).

5. Impacts on businesses

Impacts of improved quality of electricity on connected businesses. Overall, low quality, unreliable electricity hampers productivity, particularly for 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 if they do not have a backup generation source (Adenikinju 2003). Firms using generators face higher energy costs, as fuel and repairs are 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 can stimulate job creation (International Finance Corporation, Development Impact Department 2012).

Impacts of new connections on businesses. Businesses might benefit from electricity access if they can offer (1) expanded business hours; (2) improved safety from lighting; (3) higher quality or newer products or services; (4) lower costs due to financial savings moving from generators to electricity; and (5) time savings from improved lighting, equipment, and communication (Lenz et al. 2017). However, it may be that the marginal benefit of electricity over generators is too small to have a measurable impact on profit or other outcomes. Also, frequent planned and unplanned outages might undermine positive outcomes.

Despite the potential for cost savings and increased productivity, a few quantitative studies have found no impact on firms' profits or the difference between connected and unconnected micro-manufacturing firms in terms of working hours, labor inputs, or profits (Peters et al. 2011; Peter 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. Qualitative findings from Rwanda 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).

6. 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 enabled institutions to use modern equipment. In Rwanda, 100 percent of connected rural health centers used electricity for lighting, 79 percent used it for medical machinery, and 43 percent used it for administrative purposes (Lenz et al. 2017). Rwandan headmasters reported that electricity improved the overall school functioning by facilitating computer usage and powering computer labs (Lenz et al. 2017). Other benefits include improved recruitment of skilled staff, lower energy expenditures, and better safety and security (Miller 2015; Lenz et al. 2017).

7. 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, unconnected households benefited from their neighbors' electricity through reduced expenditures on mobile phone charging (Lenz et al. 2017). 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).

D. Evidence gaps that the current evaluation fills

Given the thin literature base **on energy sector investments and reforms in African and post-conflict countries**, this evaluation helps 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 evaluation begins 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. Overall, the evaluation will generate valuable evidence and information not available through any other source.

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III. Evaluation design and data sources

A. Compact activities, outcome level, evaluation questions and approach

We used a mixed-method approach to address evaluation questions on Activity 1 (investments in MCHPP rehabilitation) and Activity 2 (Capacity Building and Sector Reform). These two Compact activities are described in Table III.1.

Table III.1. Description of Compact Activities 1 and 2

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 capacity strengthening of Ministry of Mines and Energy (MME)

MCC's evaluation questions relate to implementation, energy sector, utility, grid, and end-user outcomes. Our evaluation employed multiple approaches to examine the evaluation questions and provide nuanced information at each outcome level:

- An *implementation analysis* to answer overarching questions about the implementation timeline, the cause of any deviations from the original design, and implementation successes and challenges.
- A *performance evaluation* to examine questions at all outcome levels, using longitudinal analyses of administrative data to understand trends in key outcomes such as the quantity and quality of LEC electricity; a document review to assess LEC operations and the managerial effectiveness of the management contractor; and a qualitative analysis of interviews with stakeholders to validate outcome trends and ensure that they are correctly interpreted.
- A *pre-post survey analysis* to measure changes in household, business, and community outcomes over time. We collected data from (1) end users connected to LEC at baseline to estimate changes due to increased electricity supply and reliability, and (2) end users unconnected to LEC at baseline to estimate changes due to new connections to electricity and increased supply. We analyzed outcomes related to end-user access, consumption, electricity quality and reliability, safety and security, time use, and economic well-being.

We list the evaluation questions answered in this report and the associated evaluation approaches by outcome level in Table III.2.[12] Further details of our analytic approach—including thematic framing and triangulation between data sources—are provided in the Evaluation Design Report (Miller et al. 2018).

Table III.2. Evaluation questions and approach by outcome level

Outcome level	Evaluation questions	Evaluation approach
Overarching implementation • Chapters IV and V – A1, A2, A3 • Chapter VII – A4	A1. Were the activities implemented as planned? A2. What was the implementation quality? A3. What lessons can be drawn from implementation of the activities? A4. To what extent, if any, does comparing the assumptions made in the forecasted economic model, actual program implementation, and evaluation findings generate lessons that can be applied to future economic models?	• Performance evaluation: Implementation analysis with longitudinal analysis of administrative data, document review, qualitative interviews, and site visits
Energy sector • Chapter IV – B1, B2, B3	B1. What new energy policies, laws, and legal, economic, and technical regulations have been enacted or adopted, given the LERC's activities and support from the donor community? How have these contributed to modernizing the energy sector and making the sector financially viable? B2. Have LERC activities (regulating the legal, economic, and technical environment or changes in the availability and reliability of electricity) had any effect on IPPs' operations? B3. To what extent, if any, have energy sector reform activities contributed to improvements in electricity regulation, policy formulation, and monitoring? How sustainable are these improvements?	• Performance evaluation with longitudinal analysis of administrative data, document review, qualitative interviews, and site visits

[12] The evaluation questions in Table III.2 are organized and worded differently to the questions documented in Liberia Evaluation Design Report. A cross-walk of evaluation questions in the EDR and questions in Table III.2 is presented in Appendix G, Table G.1.

Outcome level	Evaluation questions	Evaluation approach
Utility and grid outcomes • Chapter V – C1, C2, C3[13], C4, C5 • Chapter VI – C3	C1. How have MCC's investments affected electricity generation, T&D, reliability? C2. How has the electricity tariff changed since MCHPP was rehabilitated? To what extent does it cover the costs of electricity generation and other operating costs? C3. To what extent have the MCHPP Rehabilitation and Capacity Building and Sector Reform Activities affected the number of users connecting to the grid and the demand for electricity? C4. To what extent, if any, has LEC's management improved since the new management contract became effective? C5. What progress has GoL made toward establishing a longer-term management arrangement for LEC? How sustainable is LEC as a utility? What are the biggest barriers to its sustainability?	• Performance evaluation with longitudinal analysis of administrative data, document review, quantitative surveys of end users, qualitative interviews, and site visits
End user outcomes • Chapter VI – C3, D1, D2, D3, D4, D5	D1. How do customers decide to connect, and why have other potential end users not connected? What barriers do potential customers face when trying to connect to the grid? D2. How have MCC's investments affected connected and unconnected households' perceptions of the quality of electricity? D3. To what extent do customers invest in energy intensive appliances or equipment? What is the effect of energy on time use (household production, leisure, school, work, and employment)? D4. What, if any, are the spillover effects on non-electrified households? D5. How do impacts vary by differences in gender, socioeconomic status, and other demographic characteristics?	• 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: – (1) Households and (2) small businesses in Monrovia connected at baseline – (3) Households and (4) small businesses along the Kakata Corridor unconnected at baseline - Medium and large end users (businesses, NGOs, and public institutions)

B. Study timeline and exposure period

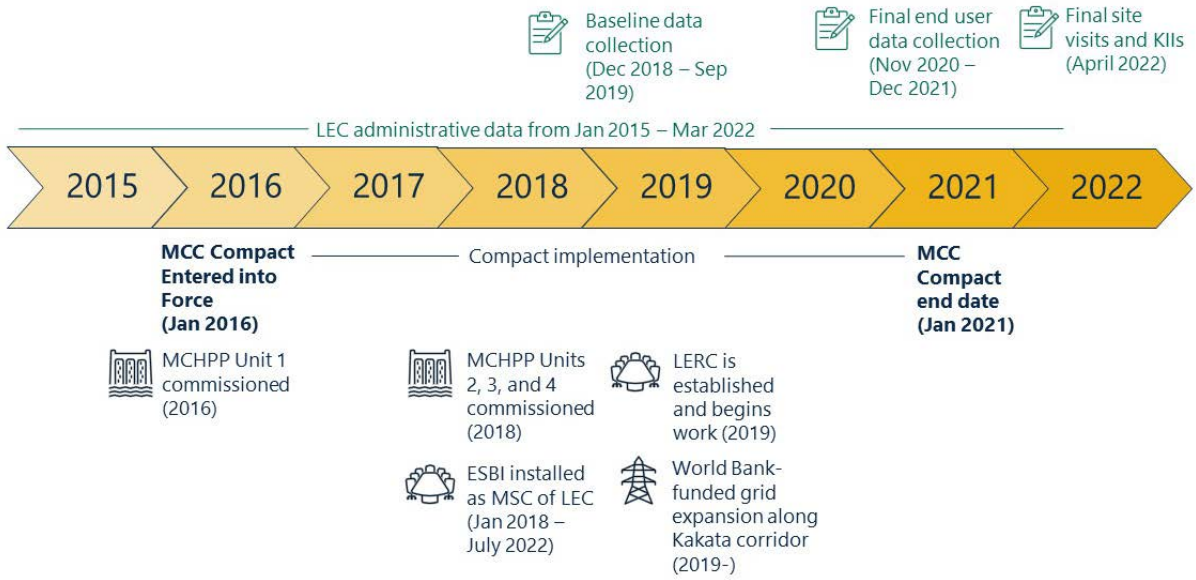
This 2022 report presents the final evaluation results of Activities 1 and 2. MCC originally requested an interim report in 2022 and a final evaluation in 2024, but then later determined that the 2020-2021 data collection and resulting report would be sufficient to fulfill the Compact's learning objectives. This report represents the endline data collection and is referred to as the final round.

As shown in Figure III.1, the final round of data collection commenced in November 2020 and concluded in December 2021, 11 months after the Compact End Date. The timing of the final round means that data were collected about three years after completion of the MCHPP

[13] We present results on overall connection rates using administrative data in Chapter V. The findings from the end user quantitative surveys are presented in Chapter VI.

rehabilitation, three years after ESBI was installed as the MSC of LEC, and two years after LERC began drafting documents. Along the Kakata corridor, we collected data one to two years after the grid was expanded into some communities.

Figure III.1. Data collection timing



Notes: ESBI = Electricity Supply Board International; KII = Key informant interview; LEC = Liberia Electricity Corporation; LERC = Liberia Electricity Regulatory Commission; MCC = Millennium Challenge Corporation; MCHPP = Mt. Coffee Hydropower Plant; MSC = Management Services Contractor.

MCC's ERR calculations assumed that most benefits from increased connections and improved reliability of electricity would accrue to LEC and end users by the Compact End Date in January 2021. The evaluation design estimates how long it would take for measurable effects to materialize at each outcome level, positing that some outcomes might materialize within one year, and others could take five years or longer.

C. Data sources and outcomes

This final report draws on an extensive and continual document review, stakeholder interviews conducted from 2017 through 2022, analysis of LEC administrative data from 2015 to Q1 of 2022, repeated site visits, and quantitative surveys and qualitative focus groups or interviews conducted in 2018-2019 and 2020-2021.[14] We summarize these data sources in Figure III.2. Additional details on sampling, collection procedures, and response rates are in Appendix A.

Through each data source, we collected data on multiple outcomes related to implementation, the energy sector, utility and grid performance, and end-user benefits. We summarize these outcomes in Table III.3

[14] The Khana Group, a data collection firm based in Liberia, conducted surveys and interviews with end users.

Figure III.2. Data collection summary

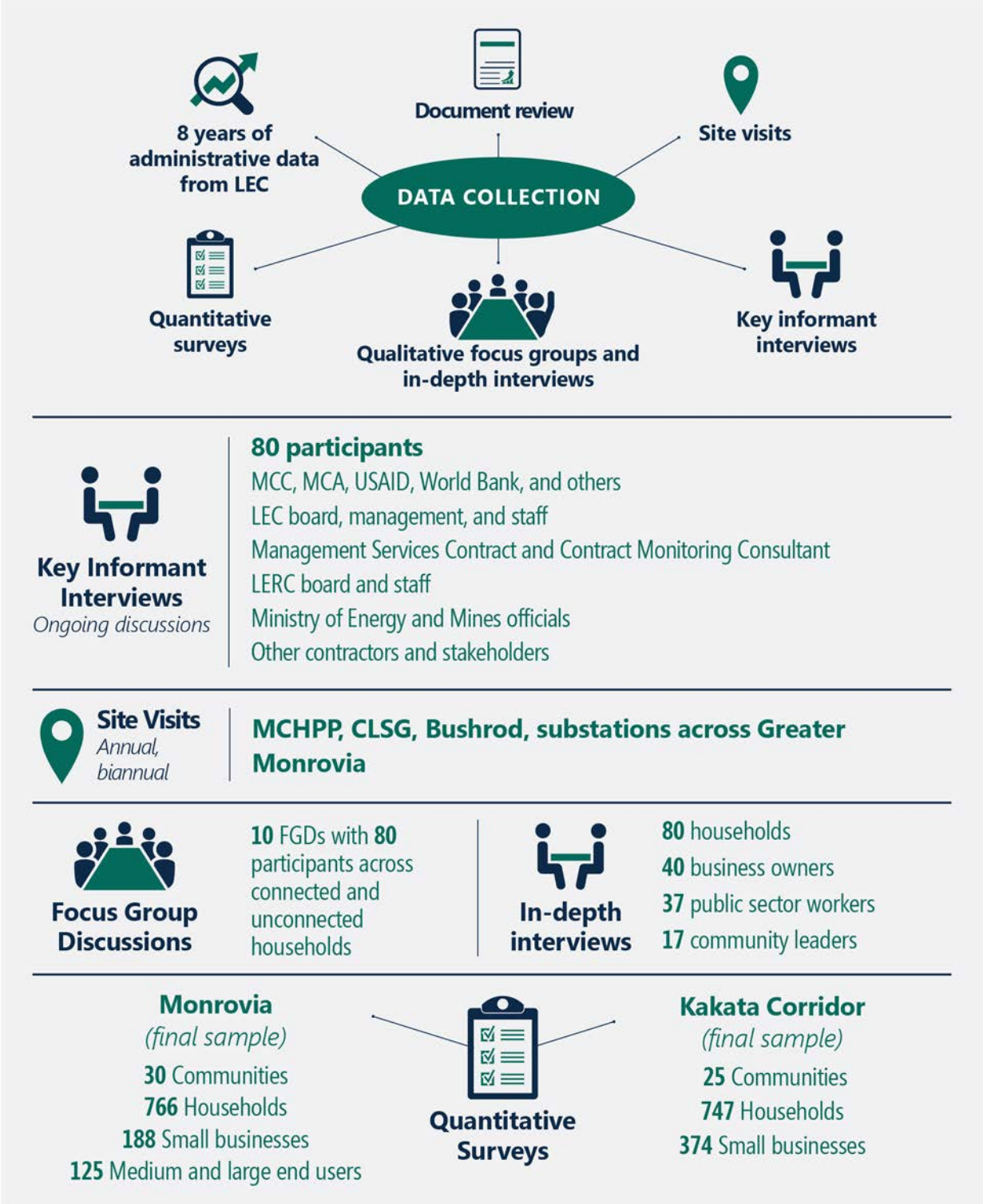


Table III.3. Data sources and outcomes

Implementation	Energy sector	Utility and grid	End user
Administrative data			
LEC operations, functional data systems to track electricity generation, T&D, collections, service quality, tariffs, and other operations	• Installed generation capacity • Percentage of households covered by LEC • Unserved demand • Tariffs across user types • Number, size, and type of IPPs	Indicators of LEC management and operations, including: • Generation (generation costs, electricity sold and peak demand; installed generation capacity (by source); power plant availability; MCHPP capacity factor; typical load factor) • Network infrastructure (transmission substation capacity; kilometers of T&D lines upgraded or built; voltage stability and reliability (SAIDI, SAIFI); planned and unplanned outages) • Customer demand (demand by customer type; total electricity sold by customer type, USD and MWh) • Technical and commercial losses • Billing and collection efficiency • Operating expenses (OPEX) per kWh	• Number of connections by customer type • Number of households in LEC service area connected • Customer satisfaction • Unserved demand
Document review			
Context and background to assess quality of design, implementation, successes and challenges, progress and delays, budgets	• Documentation of new or revised laws, policies, regulations • LERC activities • Identification of modernization processes affecting market structure, sector governance, and performance	• Documentation of the MSC's efforts to strengthen LEC's capacity • Contract Management Consultant's (CMC) documentation of LEC's strengths, weaknesses, opportunities, and threats • LEC's ability to manage all assets, make new connections • Documentation of grid and infrastructure rehabilitation, installation, maintenance, functionality, and future plans.	N/A

Implementation	Energy sector	Utility and grid	End user
Qualitative KIIs, IDIs, and FGDs; Site visits; Attendance at Liberia's Energy Sector Working Group, MCC Liberia Team meetings			
• Perceptions of compact design and execution for each activity • Whether MCHPP, LEC, LERC, and MME have established systems to carry out core functions • Perceptions of donor coordination and multiple donor model	• Perceptions of LERC's independence and accountability • How energy policies, laws, and regulations affect energy sector functionality • Energy sector progress and constraints • Independent Power Producer's (IPP) perception of sector and how changes in electricity availability and LERC activities have affected sales • Perceptions of sectors' greatest threats and challenges	Perceptions of: • LEC's functionality, capacity, sustainability, management, and operations • LEC's management of assets, finances, human resources, and data • MSC as best approach to stabilize and grow LEC • How increased generation and sector reform contributed (facilitated or inhibited) grid reliability and voltage stability for a reduction in outages (SAIDI, SAIFI) • Grid performance, T&D Contribution and SWOT analysis of capacity and sector reform activities	Households, businesses, and public institutions: • Energy use and cost • Connection decisions, costs, process • Electricity quality, reliability, and affordability • Spillover effects • Power theft Households: • Effects on health, safety, and education Small businesses: • Changes in business or services • Purchase of equipment • Revenue, profits, staff size
Quantitative surveys			
N/A	N/A	N/A	• 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; employment • Small, medium, and large businesses and agencies: number of employees; electricity and other energy costs; revenue; service provision

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IV. Analysis of energy sector outcomes

In this section, we assess MCC's investment in building energy sector capacity. The research shows that well-designed reforms, such as establishing an independent regulatory agency, boost energy sector performance and ultimately increase access to quality, affordable power (Imam et al. 2019). MCC assumed that establishing LERC and funding energy studies would yield an independent, data-informed regulator with a developed and implemented regulatory framework, a cost-reflective tariff, and licensed, compliant operators in the short term. In the medium term, the regulator's efforts would increase private-sector investment and electricity quality and reliability and, in the long term, would increase revenue, investments, and LEC's financial sustainability.

Key findings

Overall, LERC was established during the Compact and operated for about 2.5 years before Compact closure. Operational for nearly four years in 2022, LERC has advanced governance and developed substantive regulations, but utility outcomes had not yet improved. LERC will be funded by collecting fees from licensed independent power producers (IPPs) but currently struggles to maintain independence without external funding. It also lacks adequate data for decision making.

- (A2) The new regulatory framework was adopted. Studies, including the Asset and Customer Mapping, Cost of Service, Operator Census, and Willingness to Pay were delayed, yielding important data late in the Compact, but have informed LERC activities. LERC licensed LEC and two micro-utilities: Jungle Energy Power and Totota Cooperative. Hundreds of small, informal operators (thermal generation or T&D) do not yet meet the criteria for licensing.
- (A3, A4) LERC followed a rigorous tariff adjustment model, but data were outdated and had faulty assumptions, worsening LEC's financial crisis. The tariff reduction was not validated with real-time data to optimize decision making.
- (A5) Without external support or consistent regulatory levies yet, LERC is not financially solvent or independent and lacks the resources to monitor regulations or ensure compliance.
- (A11) Although a clear regulatory framework has been established and is necessary, it is not sufficient to attract private-sector investment. Such investment, which faces obstacles and risks, has not occurred in Monrovia.
- (A1) Although MCHPP increased lower-cost generation, new generation was less than expected, the result of a catastrophic turbine failure, low water levels, and delays in the CLSG gas line. LEC has improved electricity quality and reliability, but the aging infrastructure and pervasive power theft result in only modest improvements.
- (A8, A10) LEC has seen increased consumption and an increased customer base. However, unpaid bills and power theft mean that 62% of electricity generated is not paid for. The customer base is 90% residential so LEC is responsible for tens of thousands of customers averaging less than 50 kWh per month at US$0.15 per kWh (or $7.50 on average per customer).

Table IV.1 lists MCC's assumptions, outcomes, and indicators of whether outcomes were achieved.

Table IV.1. Findings on energy sector assumptions and outcomes

Assumptions	Short-term outcomes	Medium-term outcomes	Long-term outcomes
⊕ A2 Regulatory framework adopted; Studies inform regulatory framework, tariff, operator licensing ⊕ A3 Reduced tariffs^* ⊖ A4 Cost reflective tariff ⊖ A5 LERC has the ability and resources to ensure compliance ≈ A11 Regulatory framework is a critical for private-sector investment ≈ A1 Increased lower-cost generation* ≈ A5 Improved quality and reliability* ≈ A8 Increased consumption* ≈ A10 Increased customer base*	⊕ LERC officially established ⊕ Regulatory framework developed, adopted, implemented ⊖ Cost reflective tariff in place* ⊖ Sector operators licensed and compliant	⊖ Increased private-sector investment ≈ Increased quality and reliability of electricity (from various sources, including LEC)* ≈ Improved plant facilities* ≈ Increased customer base and consumption	⊖ Increased revenue, improved financial sustainability of LEC* ⊖ Increased investments by businesses, households

Notes: ⊕ = Assumption met or outcome achieved ⊖ = Assumption not met or outcome not achieved ≈ = At least part of assumption or outcome not met or achieved. ^Outcome assessed in VII. Energy sector and utility, grid-level outcomes.

*Outcome assessed in VI. Utility and grid level outcomes; ~Outcome assessed in VII. End-user outcomes.

A. Evaluation questions

We assessed the following evaluation questions related to energy sector activities and outcomes:

EQ A1. Were the activities implemented as planned?

EQ A2. What was the implementation quality?

EQ B1. What new energy policies; laws; and legal, economic, and technical regulations have been enacted or adopted in light of LERC's activities and support from donors? How have these contributed to modernizing the energy sector and making it financially viable?

EQ B2. Have LERC activities (regulating the legal, economic, and technical environment or changes in the availability and reliability of electricity) had any effect on IPPs' operations?

EQ B3. To what extent, if any, have energy sector reform activities contributed to improvements in electricity regulation, policy formulation, and monitoring? How sustainable are these improvements?

EQ A3. What lessons can be drawn from implementation?

In Section B we introduce major stakeholders in Liberia's energy sector (Figure IV.1). In Section C we describe MCC's energy sector implementation and quality (EQs A1 and A2), and we present energy sector outcomes (EQs B1-B3) and lessons learned (EQ A3).

B. Energy sector background

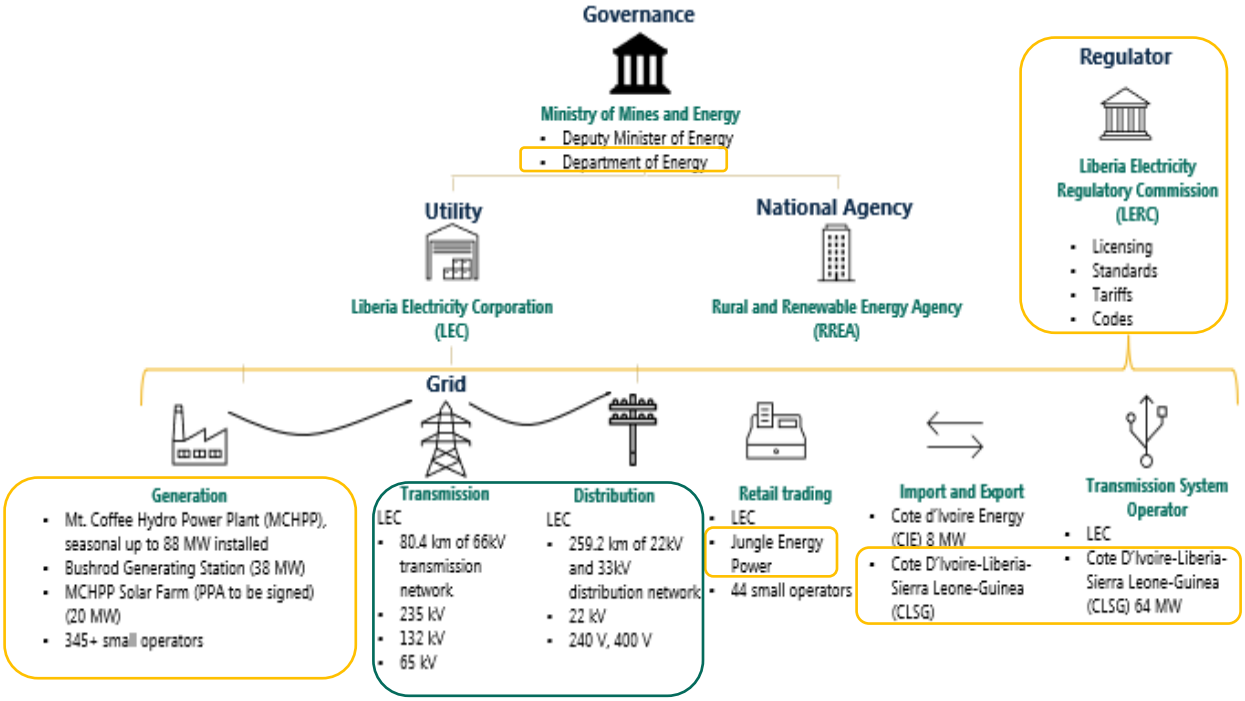
1. Department of Energy (DOE)

When MCC launched efforts in Liberia in 2015, it entered an energy sector in need of a long-term strategy, policies, data, and information to guide decision making, modern skills, and technical capacity. The National Energy Policy of 2009 stipulated restructuring the MME and elevating 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 DoE—as GoL's designated office for managing the sector—is responsible for developing and reviewing energy policies, quality standards, and master plans; convening the National Energy Committee; and liaising with the Regulatory Board. The DOE also must "coordinate stakeholders' actions in the energy sector."

Data sources for the energy sector analysis

- Document review to provide context and assess laws, policies, and regulations, including progress, implementation, and enforcement
- Qualitative data, including interviews with key actors from MCC, MCA, LERC, MME, the contract monitoring consultant, Electricity Supply Board International, LEC board and staff, as well as site visits to LERC, MME, MCHPP, LEC at Waterside, Bushrod, and all LEC substations

Figure IV.1. Liberia's energy sector, 2022



Note: Entities with a gold box were established or rehabilitated during the Compact 2016-2021. The green box indicates major extensions and increased capacity.

2. Liberia Electricity Regulatory Commission (LERC)

Liberia's 2009 National Energy Policy motivates, and the 2015 National Energy Law legislates, the establishment of "the legal and regulatory framework for the generation, transmission, and distribution and sale of electricity" (Figure IV.1). Within this policy and legal framework, MCC funded the establishment of LERC, building upon previous EU efforts. 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.

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 licensing operators, setting tariffs, resolving service and provider disputes, establishing and enforcing technical and safety standards, issuing regulations, approving sector plans and investments, and establishing and monitoring technical standards and codes (Overview of LERC and Electricity 2019).

C. Energy Sector Findings

EQ A1-A2: Were activities implemented as planned? What was the quality?

Components of the Capacity Strengthening and Sector Reform activities were not fully implemented as planned. Sector reform in a post-conflict country, following decades of inactivity and no public power generation for 15 years, is a monumental task. It was made more difficult by the timing of the presidential election. MCA-L was fully operational and staffed at the end of Compact Year 1, but President Ellen Johnson Sirleaf delayed appointments, which resulted in minimal progress in sector reform during Compact Year 2. President George Weah appointed, and the senate confirmed, positions at the end of Compact Year 3 for LERC (2018) and Year 4 for DoE (2019). These late appointments affected implementation progress and quality within the DOE and LERC, as described in the following section.

> "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 had been 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."
>
> "Priority goals are to ensure universal access to modern energy services in an affordable, sustainable, and environmentally friendly manner to foster the economic, political, and social development of Liberia."
>
> National Energy Policy 2009

1. Actual compared to planned implementation: MCC investments within DOE

MCC's actual implementation within DOE was more limited than originally anticipated. Although absent from the program logic model, the "Program Implementation Agreement" between MCC and Ministry of Finance and Development Planning states that MCC, MCA-L would make modest investments in capacity strengthening to bolster the Ministry's ability to implement the National Energy Policy. According to DOE mid-level staff, MCA understood that the DOE lacked Ministry-level positions and basic capacity (energy expertise, policy development, data collection, analysis, and validation) and resources (computers, vehicles, fuel) but assumed that the DOE would be staffed once the Deputy and Assistant Ministers of Energy were appointed after President's Weah took office in 2018. However, the Deputy Minister of Energy and Assistant Minister of Energy positions were vacant until November 2019.

Consequently, the DOE, without leadership and key staff, was inactive until nearly the end of Compact Y4. Without appointed DoE leaders—and despite donors investing millions into the sector—MME did not participate in most sector activities. As a ministry official explained, "*Since 2005, there has been clear chaos*." MCA-L planned to cover costs for DoE staff to conduct gender and social assessment trainings to inform planning and monitoring. Some training occurred, though resources were mostly reprogrammed.

The European Union (EU) funded an energy sector expert (from Ghana) to work with DoE (November 2019 to December 2022).

By 2022, DOE officials explained that their main priority was to develop a clear data-driven energy strategy that incorporates all types of energy sources and draws on country- and sector-

wide stakeholder input. Stakeholders indicated needing resources to accomplish this goal, as they had been given insufficient resources and capacity in the new office. Government officials lamented the lack of strategy given the "*explosive growth in the sector,*" also noting frustration that donors generally do not want to invest in strengthening people and capacity, but rather want to buy "new connections." (Figure IV.4 for Liberia's Energy Sector Timeline)

> *Coordination is an issue; many donors often come with their own ideas of what they want. Ideally, government has a well-coordinated donor policy and then ensures that donors buy in, but it doesn't work that way."*
>
> *"Post-war planning, there must be an institution that does a 10-year, 20-year, 30-year plan. But in the energy sector, there is none.*

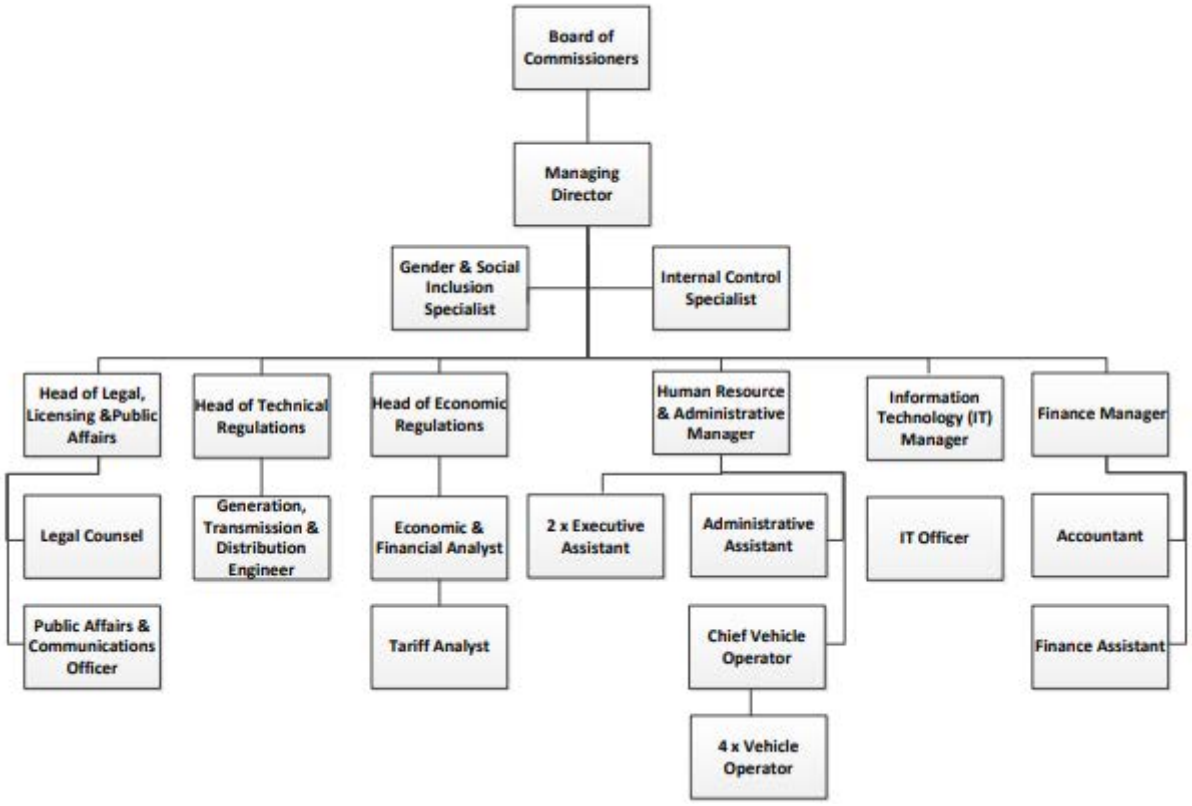
DOE's lack of capacity was widely acknowledged across stakeholders but might have been low priority for MCC. The late confirmation of Ministry officials undermined prioritizing capacity strengthening needs, even though they were fundamental to strategic planning. This is an important omission in view of the Compact goals and the critical role the DOE should play in stakeholder coordination, especially in Liberia, a post-conflict country with well-known for weak governance. MME requires major capacity strengthening to oversee the sector, create a short- and long-term master plan and strategy, and coordinate donors and stakeholders. Currently, the DoE lacks technical capacity and the ministry remains underprepared to lead the energy sector.

2. Actual compared to planned implementation of LERC sub-activity

Establishing the LERC during MCC's 5-year Liberia Compact was slow and beset by delays. The regulatory agency became operational when the Liberian legislator confirmed LERC commissioners in September of 2018, nearly three years into the MCC Compact period. Although MCA-L's Director of Energy—a key position—was hired at the end of year one in 2016, the 2017 presidential election and changing administration delayed appointment of commissioners in Compact year two. By Compact year three (2018), following threats by the EU to withdraw $50 million in energy sector funds, President Weah appointed, and the Senate confirmed, LERC commissioners. During Compact years four and five (2019 and 2020), progress was slow because both MCA-L staff and LERC commissioners admitted to a steep learning curve in establishing a new regulator. As of September of 2022, LERC had been operational for four years, including just over two years with MCC financial support and two years with limited funding from GoL and regulatory levies.

In Figure IV.2, we show the LERC organizational structure, which includes a board of commissioners, a managing director, department heads, and support staff. Fully staffed, LERC has 30 positions: 5 at the executive level, 7 in middle management, and 12 support staff (IV.2). In theory, LEC and other licensees would cover LERC's costs through regulatory fees; LEC's end-user tariffs include a surcharge of US $0.01 per kWh. However, stakeholders doubt that LERC will succeed, as LEC is bankrupt. With few other operators, LERC is unlikely to generate income in the foreseeable future.

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



Aligned with best practices, LERC has defined its purpose and developed a vision (Table IV.2.). LERC aims to transform Liberia's monopolistic utility, with limited capacity and in financial crisis, into a well-regulated, competitive market with private-sector participation and regional integration. Eventually 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 along with LEC. Ultimately, customers would benefit from increased access, quality, and lower costs.

Table IV.2. LERC's status assessment and future vision for the electricity industry, Developed 2021

Baseline 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

3. Energy sector studies

MCC/MCA-L identified the need for high quality studies to inform energy sector decisions and planning and the regulatory framework. Although studies were delayed, in some cases for years, they were eventually completed by the Compact end date in 2021 (Table IV.3).

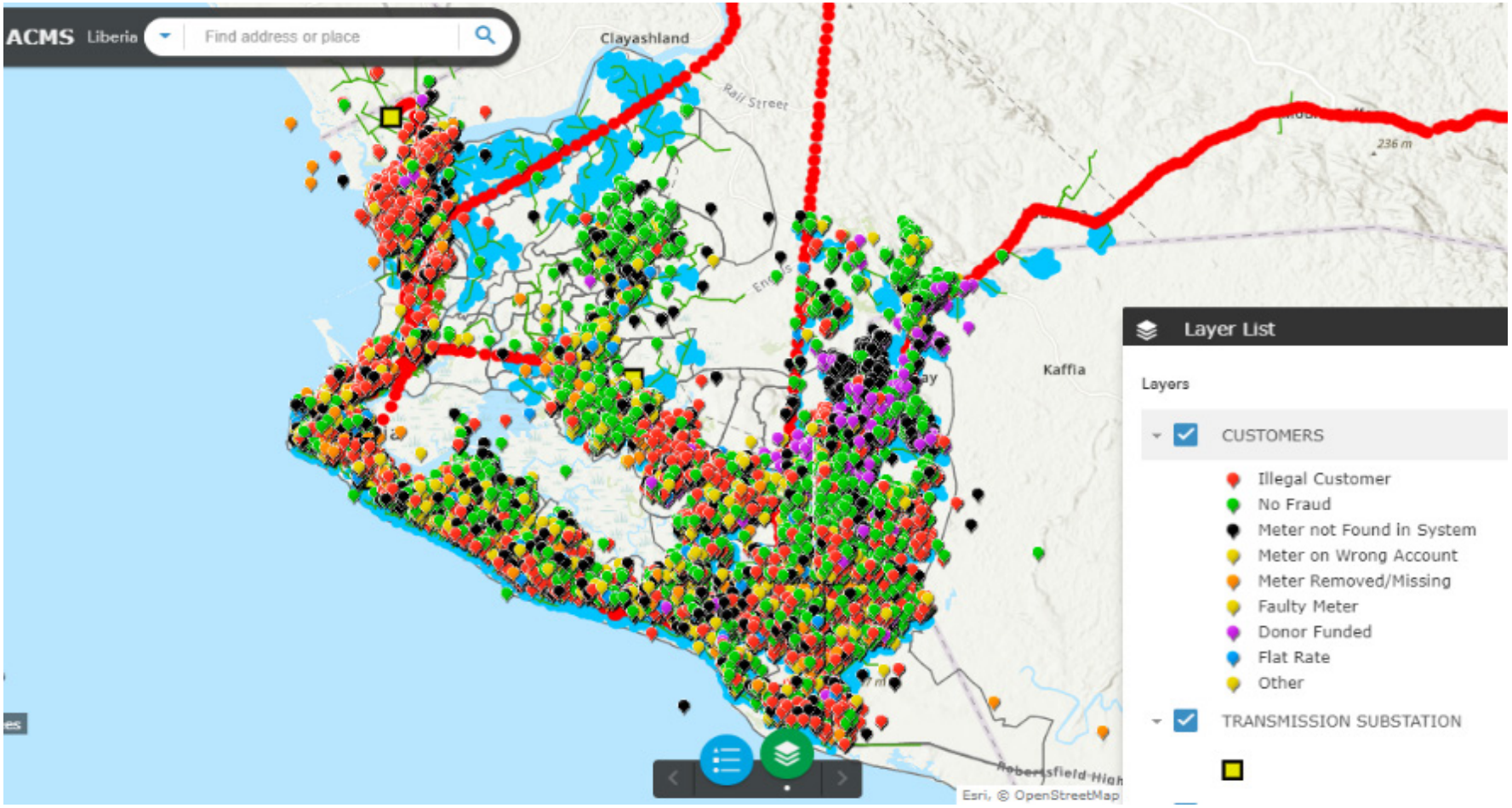
Table IV.3. Energy studies, purpose, highlights, and status

Study and date completed	Purpose	Highlights and status
National Census of Electricity Operators Completed Compact Y4 August 29, 2019	Created an electricity operator database to facilitate the registration and licensing of operators. Recommended threshold for licensing. Also, recommend definitions for T&D based on voltage. Included comparative thresholds and legislation from 10 African countries.	• Informal small operators were enumerated. • Most operators meet 100 kWh threshold, however they operate informally and are not ready for licensing. • Recommends threshold be increased to 500 kWh to incentivize operators to establish businesses. This would require 18% of operators (~62) to register, although it is unclear if they meet all criteria. • LERC published a public notice requiring registration by October 13, 2021. • As of July 2022, JEP and Totota were licensed. • Note that LERC lacks resources for site visits, safety, and other monitoring.
Electrical Cost of Service Study (COSS) and the Development of a Cost-Reflective Electricity-Pricing Model for Liberia Electricity Regulatory Commission (LERC). Also includes willingness-to-pay (WTP) survey Completed Compact Y4 January 2021	• Define and determine the actual and efficient costs associated with the supply of electricity by LEC and other operators. • Develop a model for use by LERC during regulatory review of tariff proposals and tariff determination. • Recommend guidelines based on the Regulatory Accounting System. • Develop a comprehensive strategy and roll-out for a gradual transition to cost-reflective tariffs.	• The study included a power sector structure conduct and performance review; a willingness to pay survey; electrical demand analysis; determination of economic cost of electricity supply, transmission wheeling charges; a consumer characterization and design of cost-reflective electricity-pricing model; a regulatory accounting system; a suggested tariff adjustment strategy and roll-out plan; and training. • Stakeholders agree that the study and tariff model were high quality, but model assumptions did not hold for unforeseen changes (dramatic increase in low-consumption residential customers, global increase in fuel prices, delayed CLSG dry-season power, only modest reductions in power theft). • Further, LERC did not adhere to the COSS recommendations for tariff rates, for example, approving $0.19 per kWh for medium voltage customers rather than $0.242 as suggested.

Study and date completed	Purpose	Highlights and status
Asset and Customer Mapping Study (ACMS) Completed Compact Y5 January 2021 See Figure IV.3 for the ACMS	• Survey, classify, and geocode all LEC customers • Tag and map all low-, medium-, and high-voltage infrastructure and assets • Validate data	• Mapped 70,125 customers, 40,000 low voltage poles, 2,421 transformers, 806 HV towers, 8,503 MV poles (see Figure IV.V). • Allows LEC and stakeholders to visualize grid, power theft, faulty meters. Assets tagged, allowing inventory control. • Data require ongoing validation and updating given new infrastructure, new connections, customer mobility and disconnections. • Data collection was not finished but should be completed given the value of the information.

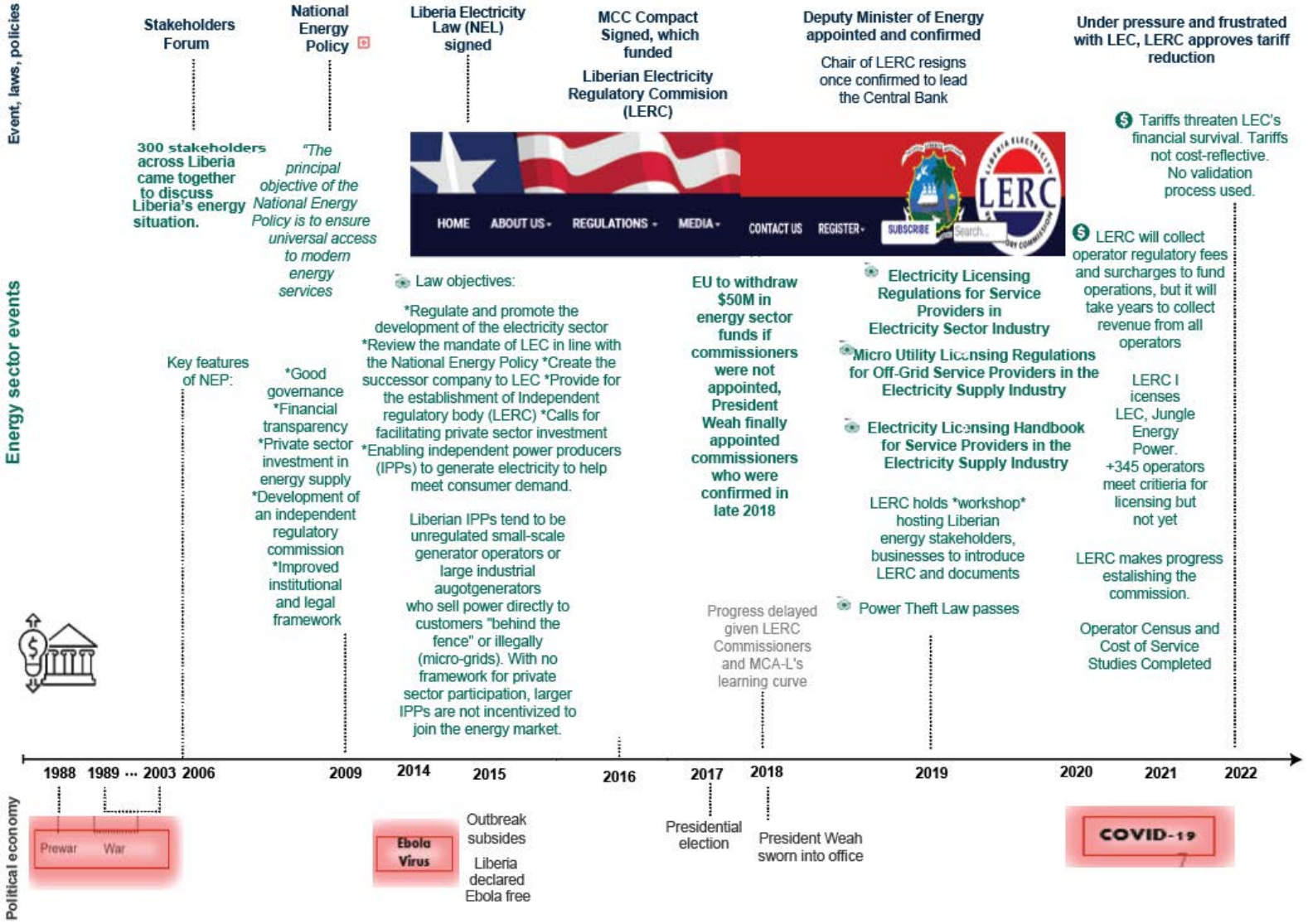
Figure IV.3. ACMS customer and infrastructure data

ACMS visualizes high-, medium-, and low-voltage assets, substations, and LEC customers. It also illustrates power theft. Customer data, including meter serial numbers, were collected. The meter status was classified based on legality and functionality. Although ACMS must be continually updated, it is the only source of geocoded data. Prior to ACMS in 2021, LEC had no listing or mapping of electricity assets and customers.



Source: ACMS data

Figure IV.4. Energy sector timeline of events



In Table IV.4, we highlight key implementation findings, comparing planned and actual implementation, implementation quality, and factors affecting implementation

Table IV.4. MME and LERC implementation findings

Entity	Were activities implemented as planned?	Quality of implementation	Factors affecting implementation and quotes describing situation
MME, DOE Progress towards capacity strengthening to modernize the energy sector.	MCC originally planned capacity strengthening within MME and DOE. With critical positions vacant, resources were diverted. DoE continues to lack essential capacity post-Compact.	MCC/MCA-L interacted with MME and DOE, but there was no serious investment, so quality cannot be assessed.	• Change in presidential administration led to delayed appointments. Based on MCC and MCA-L's deep sector engagement, it is likely they would have worked closely with MME and DOE had staff been in positions earlier. • MCC's focus on rehabilitating MCHPP (at the request of President Sirleaf) and building capacity at LEC meant that MME and DOE were low priority.
	MME stakeholder: "One thing is to know all the issues, and it's a different thing actually to solve it. The donors come in wanting to put money for a particular purpose—and they can't be dissuaded. There is a mismatch between what's needed and what donors are doing. We have to know our needs and be assertive."		
LERC Progress towards modernizing the energy sector and developing legal, economic, and technical regulations; capacity and functionality as a board; ability to implement the business plan.	LERC was established after long delays, which meant that LERC had to work immediately towards financial sustainability, which might undermine the quality of the work, independence, and transparency of decisions. Future sustainability is questionable.	• Implementation quality—or MCC/ MCA-L's efforts to establish the regulatory agency—was strong, as evidenced by LERC's timely production of bylaws, operating procedures, and regulatory guidelines.	• LERC is one of the first regulatory agencies in Liberia, so the culture of technical, licensing, and quality regulations is new but LERC managed, with MCA-L's support, to establish credibility. • Delays in establishing LERC threaten its sustainability and future credibility if it appears to be politically influenced. • MCC, MCA-L were not able to help LERC secure donor resources. Consequently, LERC's performance is challenged by GoL's and DOE's weak governance and institutions. So that there is no interference, GoL's restraint is necessary for LERC's ongoing quality implementation. LERC must secure additional funds if it is to keep operating until it can collect surcharges and fees.

Next, we describe energy sector outcomes and LERC's recent progress despite the many delays and roadblocks.

EQ B1: What new (1) energy policies; (2) laws; and (3) legal, economic, and technical regulations have been enacted or adopted as a result of LERC's activities and support from the donor community? How have these contributed to modernizing the energy sector and making it financially viable?

Since its inception, LERC has produced an impressive collection of regulations, resolutions, documents, and public notices (Table IV.5.) that create the framework, rules, processes, and pricing that govern Liberia's sector. According to the licensing handbook, in 2020, LERC formally licensed LEC as an operator for generation, transmission, distribution, system operation, and import.

Table IV.5. Regulations and decisions

Full Title of Regulation	Date	Full Title of Board Resolution	Date
• Electricity Licensing Regulations	2020	• Approval of Electricity Mini Grid Code	2022
• Micro Utility Licensing Regulations	2020	• Approval of the Electricity Distribution Code	2022
• Electricity Licensing Handbook	2020	• Publication of Electricity Tariffs	2021
• Administrative Procedure Regulation	2020	• Approval of Fine Against LEC Noncompliance	2021
• Customer Service and Quality of Supply Regulations	2021	• Approval of the Jungle Energy Power License	2021
• Electricity Tariff Regulations for Service Providers	2021	• Approval of the Totota Electric Corporative Permit	2021
• Multi-Year Tariff Methodology	2021	• Approval of Electricity Regulations	2021
		• Approval of Proposed LEC Incentive Scheme	2021

Table IV.6. Publications and public notices

Full Title of Publication	Date	Full Title of Public Notice	Date
• Annual Report 2021	2022	• Abridged LEC's Application	2021
• Tariff Review Report	2022	• Notice Pendency Application for Review of Tariffs	2021
• Annual Report 2020	2021	• Public Notice: Registration	2021
• Power Theft Law	2019	• Jungle Energy Power (JEP) Application	2020
• 2015 Electricity Law of Liberia (ELL)	2015	• Notice to Public of Pendency Application Permit	2021
• National Energy Policy	2009	• Public Notice: Registration	2020
• National Census of Electricity Operators	2019	• Request for Expression of Interest (REOI)	2020

To date, new policies, laws, and regulations have helped modernize the energy sector. Regulations align with international standards and are benchmarked against other African countries. The improved regulatory environment has not yet been able to make the sector more financially viable. This is partly because (1) the main operator (LEC) is in crisis, (2) there have been few newly licensed operators, and (3) the revised tariff is not cost reflective.

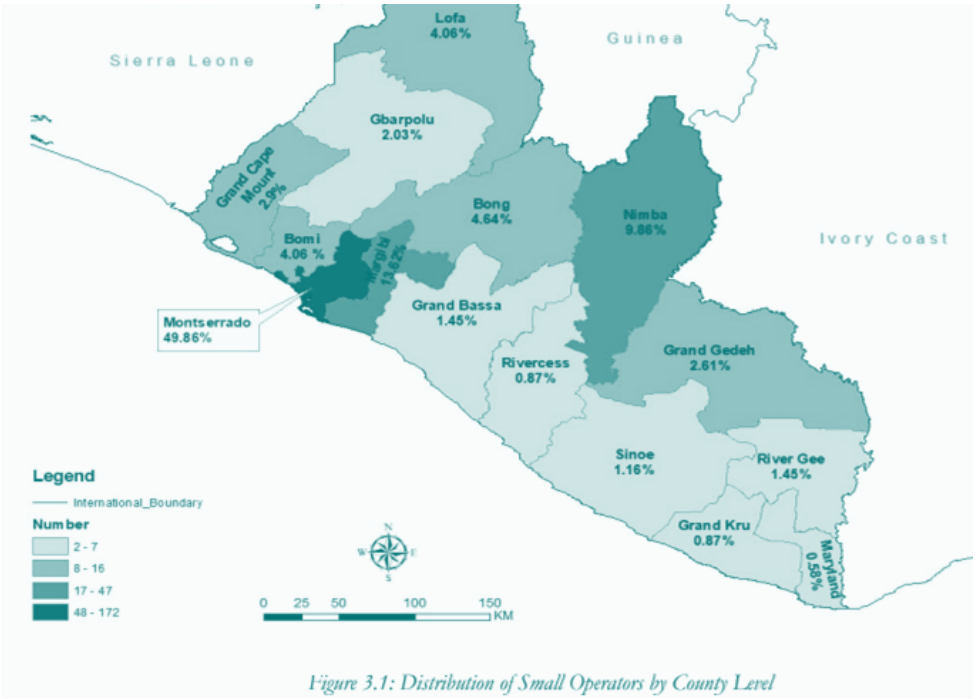
EQ B2. Have LERC activities (regulating the legal, economic, and technical environment or changing the availability and reliability of electricity) had any effect on IPPs' operations?

LERC has progressed in creating a regulatory environment with clear and transparent regulations. However, there has been little progress in registering and licensing operators, monitoring IPP operations, and attracting private investment and franchisees.

"Unbundling the electricity industry will result in transparent costing and pricing of generation, T&D, and retail sale of electricity, allowing the entry of private sector and community developers into segments of the industry where they are competitive in terms of expertise and resources." *National Energy Policy 2009.*

Licensing and operations. The 2021 National Operator Census enumerated informal operators engaged in electricity generation, transmission, distribution, sales, or import/export. In 2021, LERC licensed Jungle Energy Power (JEP) as a large micro-utility in Nimba County and the Totota Electric Cooperative, a micro-utility in the Lower Bong County. *(Note that the Totota Cooperative was licensed by LERC without authorization from LEC, so the license is modified with a temporary status*.) JEP operates about 140 km of 33kV distribution network and has 38 distribution transformers (LERC, 2019). The remaining operators that meet the threshold for licensing have not yet registered or been licensed. Many of these engage in thermal (diesel) generation but report they use, rather than sell power (Figure IV.5).

Figure IV.5. Map of small informal electricity operators in Liberia



Operators that meet the 100 kWh (or the recommended 500 kWh) should be licensed by LERC. Once licensed, LERC would receive licensing fees and collect a surcharge. This income would sustain LERC. Without resources for public relations, travel, inspection, and safety checks, most operators do not yet have licenses despite the LERC's Public Notice of Registering.

Monitoring operations. LERC's fragile financial situation means that the agency is unable to conduct site visits across the country to monitor operations and conduct inspections. LERC stakeholders expressed disappointment that they are unable to do community engagement, public relations, capacity building, or site visits, or to set up an inspection system. They have a hiring freeze but require additional engineers and finance staff.

Private investment. Most stakeholders and an independent assessment agree that "*privatizing is too optimistic"* in Liberia under current circumstances. They explain that LERC and political leaders are not realistic about the prospects of attracting private-sector investment in the foreseeable future:

> *"There is a gap in understanding what kind of situation the investor would come into. They all see LEC as selling a commodity that everyone wants, so what's the problem? Senators are talking about franchising parts of the grid to private corporations. The Senators are [not well informed].*

A USAID-funded assessment of the feasibility of a franchisee model in rural Liberia (also relevant to Monrovia) found that obstacles to a private concession included (1) cartel presence that has "*taken over revenue collection*" and has "*a high level of corruption*"; (2) unrealistic private-sector expectations: government "*may wish that the private sector will solve all the woes…but there are real challenges*" that will repel private investors; (3) projects lack financial incentives, require large investments, and will generate minimal revenue. Ultimately, the assessment finds that corruption, high investment costs, and minimal yield dissuades reputable bidders (Fobben, 2021).

Several other factors undermine IPP participation. First, it is widely accepted that energy solutions require financial tools to overcome costly barriers to market entry. However, the governments of developing countries might lack the financial means to offer stimulus packages. Indeed, Liberia struggles to afford basic costs of electrification, so financing tools that would incentivize private sector participation are out of the question for the foreseeable future. Second, even if a private firm brought private capital for investment, if they were a transmission or distribution operator, they would be reliant on LEC's network, which is well known to have problems. Although new substations represent the state of the art, LEC lacks a SCADA system to monitor feeder-level power input and output, weaknesses in medium voltage lines, and transformers that are frequently overwhelmed. According to one stakeholder:

> *"It will be a long time, with many changes in the administration, before LEC is a stable entity in its own right. Privatizing LEC is not a solution to the problem. A company would be nuts to buy LEC. They [LERC, government stakeholders] don't understand."*

The combination of limited financial tools and incentives, the Covid-19 pandemic, Liberia's fragile macroeconomic context, and the political economy of energy result in an unfavorable environment for the establishment of IPPs and IPP operations.

EQ B3. To what extent, if any, have energy-sector reform activities contributed to improvements in electricity regulation, policy formulation, and monitoring? How sustainable are these improvements?

Establishing LERC has contributed to improvements in Liberia's electricity regulation and policy formulation, however monitoring has not yet been implemented given resource shortages. First, to assess LERC's progress in improving the regulatory and policy environment, we used the Electricity Regulatory Index (ERI) for Africa to assess how Liberia has progressed over time and compares to other countries across sub-indices of regulatory governance, substance, and outcomes (AfDB 2021). According to best practices in the regulatory sector, agencies should strive to meet regulatory governance and substance standards to achieve optimal outcomes.[15]

Table IV.7. Sub-indices of the ERI and underlying main indicators

Regulatory Governance Index (RGI)	Regulatory Substance Index (RSI)	Regulatory Outcome Index (ROI)
Legal Mandate	Economic Regulation	Financial Performance
Clarity of Roles and Objectives	Technical Regulation	Commercial Quality
Independence	Commercial Quality of Electricity	Technical Quality
Accountability	Licensing Framework	Electricity Access
Transparency of Decisions		
Participation		
Predictability		
Open Access to Information		

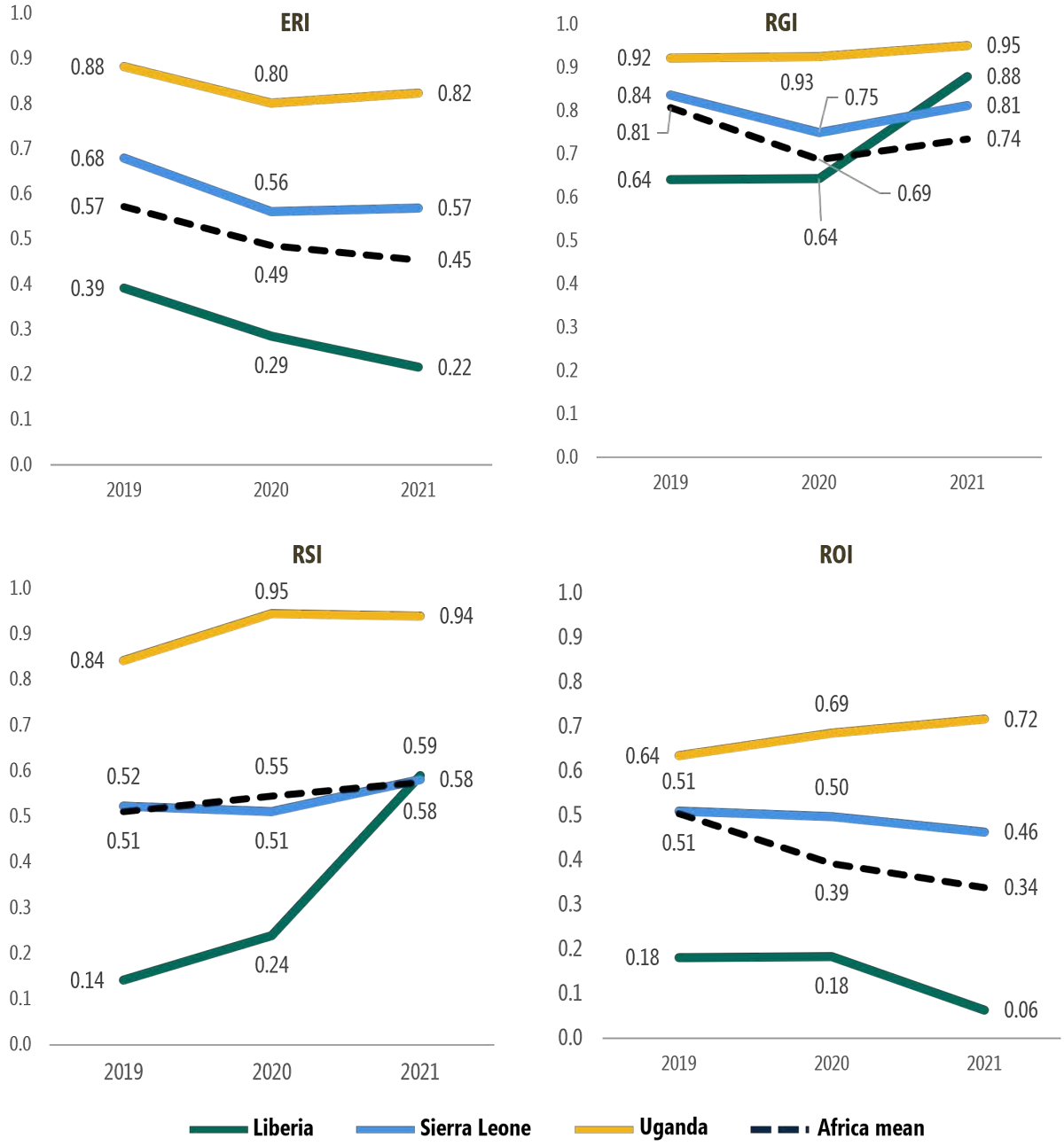
The ERI permits assessing changes within an agency over time and provides country and continent comparisons. Figure IV.5 shows Liberia's performance in the overall ERI and the sub-indices in 2019, 2020, and 2021 (AfDB 2019, AfDB 2020, AfDB 2021). Liberia's overall RGI and RSI scores have climbed from 2019 to 2021 (0.64 to 0.88 for RGI and 0.14 to 0.58 for RSI) (Figure IV.6). However, because the outcome score fell from 0.18 to 0.06, Liberia is ranked about 38 among the 43 countries in this domain. Liberia's overall ERI score fell from 0.39 in 2019 to 0.22 in 2021. As we describe in Chapter V on utility and grid-level outcomes, LEC's fiscal crisis helps explain the poor outcome ratings for financial performance, technical and commercial quality, and access.

Note that the ERI is not a fully objective measure of agency effectiveness, as the regulator self-reports. It is still a useful measure but cannot be used without validating against country level reports and data. For example, LERC's tariff change is an example of how a country can achieve high RGI and RSI scores but still score low on the ROI. Regulatory governance and substance do not ensure favorable outcomes.

[15] As introduced in Chapter II, the Power, Energy, Climate Change and Green Growth Complex of the African Development Bank conducts an annual survey of regulatory agencies to track activities and development.

For example, Liberia is one of only five countries noted for having a documented tariff methodology with a schedule for review, a tariff indexation formula, and a recent Cost of Service and Study (COSS). Liberia has these, but the tariff methodology was problematic. LERC instituted a major tariff reduction in January 2022, which caused a severe cash flow crisis during the rainy season. According to one stakeholder, the tariff methodology was rigorous, but several key assumptions had not been met. For example, the model assumed that CLSG would provide dry season power by 2021, LEC would achieve 10 percent per year reductions in commercial losses, new customer connections would continue to increase gradually, more medium-voltage consumers would connect, and fuel costs would remain somewhat stable.

Figure IV.6. Liberia's Electricity Regulatory Index, Regulatory Governance Index, Regulatory Substance Index, and Regulatory Outcomes Index



LERC based their tariff model on a recent 2021 cost of service study using 2018-2019 billing data, which indicated that only 31.6 percent of LEC customers consumed less than 50 kWh per month, representing 7.7 percent of consumption and billing. The COSS also estimated there would be 79,407 residential customers in 2022. However, by March 2022, there were 153,308 residential customers (accounting for 90 percent of all customers), and average residential consumption had fallen below 50 kWh per month (except for one month) by October 2019 with

rates as low as 21 kWh. The study also estimates technical and commercial losses at 62 percent, falling to 23 percent by 2030, which is exceptionally optimistic. LEC reported that commercial losses did not fall below 50 percent through 2021, and technical losses have been mostly stable. In summary, the model underestimates the number of customers, overestimates their monthly consumption, and underestimates the level of power theft.

Further, according to LEC stakeholders, the new tariff process was not validated, and the reduction came as a surprise to LEC (see Table IV.8 for tariff). Stakeholders from LEC explained the problems with the tariff setting process:

> *"The tariff-setting process is new.. There needs to be a structure to carry out validation. But there was no real validation. LEC is losing $100k/day. We were extremely surprised when lower tariff came into effect. It was the first time there was a tariff change like this. It was a very political decision."*

> *"[The tariff change was] completely out of the blue for us. Expected [tariff] to come down maybe 25 cents. Working towards [lower tariff] with discounts for larger customers. Tetra Tech came up with something, we were heading in that direction. Expecting something like that [from the COSS]. When this came out on the day, there had been no prior discussions with us."*

> *"We thought 25 cents or 27 cents for businesses would be reasonable. It should not be too far below 30 cents."*

> *"The main issue [with tariff] was the timing. They shouldn't have done it in the dry season. Fossil fuel prices have gotten so high, they are killing us financially. We are doing load shedding, turning off lots of feeders. LERC got many assumptions wrong. Donors didn't expect the situation with Mt. Coffee (the catastrophic failure of Unit 1)."*

> *"I am in support of reducing the tariff. The only way LEC can stabilize a revenue base is to attract large customers. Businesses are saying rates are too high, so they use generators instead. So there is a need to bring the tariff down. But this should have started in rainy season and used the lower tariff to get more businesses connected. Now there is zero planning for the next dry season."*

Table IV.8. LERC changed electricity tariffs January 2022

Tariff Category	Tariff	LERC approved tariff	Suggested tariff following cost of service study	
	April 2017 – January 1, 2022	January 1, 2022	Single tariff with social	Differentiated tariff
Social Consumption <=50kWh) Energy Charge	**US$0.35/kWh**	**US$0.15/kWh**	**US$0.10/kWh**	**US$0.189/kWh**
Residential				
Prepaid				
Fixed Charge		US$2.48/Month		US$6.921/Month

Energy Charge		**US$0.24/kWh**	**US$0.242/kWh**	**US$0.189/kWh** **US$0.284/kWh** **US$0.408/kWh**
Postpaid				
Fixed Charge		US$4.47/Month		US$6.921/Month
Energy Charge	**US$0.35/kWh**	**US$0.24/kWh**	**US$0.242/kWh**	**US$0.189/kWh** **US$0.284/kWh** **US$0.408/kWh**
Non-residential				
Prepaid				
Fixed Charge		US$10/Month		US$18.909/Month
Energy Charge	**US$0.35/kWh**	**US$0.22/kWh**	**US$0.242/kWh**	**US$0.233/kWh**
Postpaid				
Fixed Charge		US$12/Month		US$18.909/Month
Energy Charge	**US$0.35/kWh**	**US$0.22/kWh**	**US$0.242/kWh**	**US$0.233/kWh**
Medium Voltage				
Fixed Charge		US$50/Month		
Energy Charge	**US$0.35/kWh**	**US$0.19/kWh**	**US$0.242/kWh**	

LERC's long-term sustainability remains fragile because it lacks resources that are critical to remain independent from government. According to one LERC commissioner, stakeholders understand the importance of the agency's role in developing policies to address LEC's financial sustainability and electricity quality. However, according to LERC stakeholders, although donors tend to focus their resources on grid expansion, "*LERC needs money for survival*."

> *"As a new regulator, the best practice is that it takes no less than seven years or so to be independent, to raise money."*

> *"We need funding. We can't go far without funding. It creates a nightmare, sleepless nights. We have trained educated people in building, but we struggle to find money to meet their payroll. They come from a different environment where they got paid every week. Today's the 11th, and we haven't gotten paid for last month. We don't need consultants. We don't need operating expenses, we need payroll."*

Stakeholders noted the fragile state of LERC, including their limited resources, their inability to enforce fines, and political pressure from government to reform the sector:

> *"They are independent in theory and so should have the power to act, but in reality they are a paper tiger. They fined LEC $10,000 but they can't enforce that fine."*

> *"They are under political pressure to deliver; the Senate questions them."*

According to LERC, GoL will add LERC costs to the budget for 2023; however, the government is cash poor, so whether resources are allocated remains to be seen. LERC stakeholders warn:

"Certainly, if we don't have donor support, there will be folks in the government who will have leverage. … others who will try to use their leverage over us. … might even be 7 to 10 years for us to be a solid regulator. We don't want a quid pro quo situation."

If LERC can identify donor funding, the agency envisions moving 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.

EQ A3. What lessons can be drawn from implementation?

The Liberia Compact provides important lessons for MCC and other donors investing in nascent energy sectors.

1. **Conduct a full political economy and landscape analysis to ensure that the Compact is informed by the historical and current context, and in anticipation of future major political events (such as presidential elections).**

Reflecting on the Compact, MCC staff acknowledge that they did not conduct a political economy analysis beforehand.

"A political economy analysis should have been done before signing the contract. We needed a study of feasibility and capacity of the country to implement might have led us to do less in the compact."

"We didn't do a political economy analysis prior to implementation, and this had repercussions. If the analysis had been done beforehand, it might have provided a clearer view of the challenges and would've been a good check to see if there really was government buy-in."

Stakeholders explained that it is hard to say, *"This is how it should have been done,"* but they also believe that a better understanding of the situation earlier in the development process would have made them identify priorities and thus reduce time-consuming, less-urgent sub-activities so they could focus on major issues.

2. **Plan for the realities of a complex context with weak governance, corruption, limited donor coordination, and low human-resource capacity.**

The challenges to the Liberia Compact cannot be underestimated. MCC staff explained that Liberia was selected around the time of the Ebola epidemic, and they were under pressure to quickly develop and implement the Compact. A sober understanding of the context would have allowed MCC to better align expectations, sub-activity components, and contingency plans to help achieve outcomes.

"It is difficult starting at such a low level in the power sector, it needed regulation, operation, and policy. The amount of change and change management needs to be thought about carefully. How much funding do we really need? Will we be able to spend/manage it?"

Sector reform and capacity strengthening within DOE and LERC require more time, resources, training, technical assistance, and on-the-job support than the Compact provided.

3. **Design activities with evidence-based timelines and worst-case risk prevention strategies. In the most challenging contexts, assume that more time, resources, supports, and leverage will be needed to achieve goals.**

Again, sector reform and capacity strengthening activities should be designed using high quality evidence from similar contexts. LERC staff indicated that establishing a regulatory agency takes 7 to 10 years, but they had only several years of MCC funding. The Compact ended without a plan for financial stability to help LERC avoid government interference. Since current legislation prevents Compacts from extending beyond five years, MCC might want to partner with other donors and formulate a plan for sustainability early on.

4. **Prioritize tight coordination across donor agencies.**

In a context with weak governance or non-cooperative administrations, donor coordination can be maximized to strategize, pool funds, or use leverage to accomplish goals. Although donors tend to operate independently, rehabilitation of MCHPP shows that donor coordination can accomplish a great deal. Regardless of investment size, good will, or effort, independent donor projects might, without adequate coordination, collectively fail in low-capacity countries.

5. **Ensure that financial disbursements include conditions for governments to meet and ensure that donor partners do not undermine conditions.**

MCC might want to add more conditions, including making government appointments to key positions, in the PIA. During implementation, MCC might want to set up warning systems whereby government delays alert donors to withhold payments and use other leverage to ensure that conditions are met.

V. Analysis of utility reform and grid-level outcomes

In this section, we assess MCC's investment in MCHPP and utility reform. MCC's assumptions, in the short term, were that rehabilitating MCHPP, investing in utility reform, and capacity strengthening with 88 MW of low-cost renewable electricity, while funding a management services contract would result in a reformed utility company that could decrease costs and losses, maintain infrastructure, and improve customer service. In the medium term, the Liberia Electricity Corporation (LEC) would increase electricity quality and reliability, the customer base, and customer satisfaction, and consumers would increase consumption. In the long term, LEC would assume financial and operational responsibility for MCHPP and become a financially viable and sustainable utility, and end users would benefit from improved development, productivity, safety, and investments.

Key findings

Many of MCC's assumptions were flawed or overly optimistic given Liberia's lack of energy sector coordination, LEC's low level of functionality, political interference, and limited political will for reform.

(A1) ESBI reduced LEC operating costs. However, operations and maintenance were inadequate. For example, MCHPP and thermal generators require more resources to avoid failure, make essential repairs, and avoid catastrophic failure.

(A2-2) Donor-funded T&D network expansion was necessary to increase the customer base, but grid extension occurred without adequate a strategy or coordination, which led to increased power theft when communities were not saturated with connections. LEC was not given the resources to maintain new infrastructure (training, equipment, parts). Consequently, LEC was overburdened and lacked the OPEX and CAPEX need to support new infrastructure costs. Without a SCADA system (WB had intended to fund), feeder meters, measurement tools, and processes. LEC lacked geocoded asset and infrastructure maps and cannot fully track power theft.

(A3) LERC reduced tariffs, but they are not cost-reflective and threaten the utility's sustainability.

(A6, A14) ESBI made progress in improving LEC operations, though losses remain high. The utility still lacks an essential SCADA system.

(A7, A17) The LEC workforce lacks the skills and capabilities needed to effectively manage the complicated infrastructure and operations.

(A8, A10) LEC connected tens of thousands of new customers but lacks sufficient materials and capacity to meet demand fully, to maintain and repair meters, to reduce power theft, and to optimize billing and collections.

(A8, A9) Power quality and reliability have improved, though high fuel costs and increased demand have caused widespread outages. LEC has never successfully met dry season demand given high fuel costs.

(A12, A16) LEC has improved customer service. Billing, collections, and power theft remain problematic.

(A15) End users report modest gains in using electricity to improve development, but it is hampered by Covid-19 and the macroeconomy.

(A18) ESBI effected essential changes, but LEC remains fragile. Donor coordination and GoL support for reform was never optimal.

Table V.I lists a summary of MCC's assumptions, outcomes, and indicator of whether outcomes were achieved.

Table V.1. Key findings: Summary of assumptions and outcomes

Assumptions	Short-term outcomes	Medium-term outcomes	Long-term outcomes
⊕ A1 MCHPP lowers LEC's operating costs ~ A2-2, A13 Donor support is complementary ⊕ A3 Reduced tariffs, ⊖ A4 cost reflective^* ⊕ A4, A5, LEC improves quality and reliability ~ A6, A14 LEC manages operations effectively: losses, maintenance, data ~ A7, A17 MSC has sufficient staff capacity, Training of trainers is effective ⊕ A8 LEC makes new connections, ⊖ accommodates dry-season demand ~ A10 LEC has operational capacity and materials to make connections ~ A12, A16 Customer service improves; Willingness to pay increases. Customers pay for electricity ~ A15 Electricity used productively. Constraints do not inhibit investments ~ A18 The MSC effects change in LEC operations, stakeholders supportive	⊕ Increased MCHPP generation, power supply ~ LEC management and operations, capacity improved ⊕ Decreased operating costs (KPI) ⊕ Improved stewardship of infrastructure ~ Reduced losses (KPI) ⊕ Reduced tariffs ~ Customer service capabilities improved	⊕ Increased customer base (KPI) and consumption ⊕ Increased quality and reliability of electricity ~ Improved plant facilities* ~ Improved customer satisfaction and confidence	~ Improved operational capacity and financial stability ~ Increased revenue, improved financial sustainability of LEC* ~ End-user household and business productivity, investment, development, improved safety

Notes: ⊕ = Assumption met, outcome achieved ⊖ = Assumption not met, outcome not achieved
~ = Assumption or outcome not fully met or achieved; ~Outcome assessed in Chapter VII.

A. Evaluation questions

We investigated MCC's energy sector evaluation questions focused on implementation, outcomes, and lessons learned.

EQ A1. Were the activities implemented as planned?
EQ A2. What was the implementation quality?
EQ C1. How have MCC's investments affected electricity generation, T&D, reliability?
EQ C2. How has the electricity tariff changed since MCHPP was rehabilitated? To what extent does it cover the costs of electricity generation and other operating costs?
EQ C3. To what extent have the MCHPP Rehabilitation and Capacity Building and Sector Reform Activities affected the number of users connecting to the grid and the demand for electricity?
EQ C4. To what extent, if any, has LEC's management improved since the new management contract became effective?
EQ C5. What progress has GoL made toward establishing a longer-term management arrangement for LEC? How sustainable is LEC as a utility? What are the biggest barriers to its sustainability?
EQ A3. What lessons can be drawn from implementation?

B. Utility background: MCHPP and LEC

In this chapter, we introduce and describe the situation at MCHPP and LEC to provide context for MCC's investments. We present timelines to provide historical and current context at MCHPP and LEC and set the stage for implementation findings (Figure V.1). Then we describe MCC and MCA-L's implementation of MCHPP Rehabilitation (Activity 1) and Capacity Building and Sector Reform (Activity 2). Next, we answer MCC's implementation and quality evaluation questions (EQ A1, A2).

Next, we present utility reform and grid-level outcomes (EQ A3, C1-C3. We evaluated MCHPP's and LEC's performance, including contractual key performance indicators (KPIs) such as the number of customer connections, technical and commercial losses, network performance, and operating costs. We use LEC administrative data to describe the electricity generation and T&D infrastructure and assess indicators of utility management and operations, including financial management. We examine the sustainability of MCHPP and LEC post-Compact and MSC. Finally, we present lessons learned.

C. Background, situation, and implementation

The Liberia Compact is MCC's first energy compact in a post-conflict country and includes sub-activities new to MCC's portfolio. The post-conflict, post-Ebola context and political transition, combined with the Covid-19 pandemic, presented unprecedented challenges.

1. Activity 1: Rehabilitation of MCHPP

MCHPP operations before and immediately following the war. The hydro power plant, constructed in the 1960s and located on the St. Paul River northeast of Monrovia, generated 64 MW of renewable hydropower before the civil war. Early in the war, which lasted from 1989 to 2003, the dam was breached, the plant was destroyed, and all electrical equipment was pillaged. Hydro power generation ceased, leaving Monrovia in darkness from 1990 to 2015. Because MCHPP was not operational for 15 years, Liberians were unable to pass technical knowledge on hydropower operations between workers and across generations, which left the country out of practice and without capacity for operating and maintaining modern equipment.

European donors started MCHPP rehabilitation. The project began in 2011 with financial commitments from NORAD, EIB, KfW, and GoL. Manitoba Hydro International (MHI) was contracted as the project implementation unit (PIU) in 2012 to manage the estimated 3-year, $218.5 million rehabilitation on behalf of GoL and donor partners. GoL, through LEC and MME, signed the contract with MHI to assume overall responsibility for rehabilitating MCHPP and all related contracts. The PIU was tasked with ensuring that the project was technically sound, met deadlines, and stayed within budget. MHI managed all administrative, financial, legal, and environmental matters and oversaw all contractors and suppliers (PIU contract with MHI, 2015). An Owner's Engineer was contracted to represent LEC and GoL.

MCHPP rehabilitation was chronically over budget and behind schedule from 2012 to 2015. This was due to (1) uncertainty about hydrology, (2) unforeseen construction challenges, (3) ongoing project optimization as new information emerged, (4) procurement delays caused by vendor proposals with overpriced parts, (5) poor roads, (5) resettlement activities, and (6) 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. Site work at MCHPP was suspended, and non-essential contractors left Liberia (HOI, MCHPP quarterly reports, 2014). Once the Ebola outbreak was contained (May 2015), the overall cost of doing business had risen. Not only were import costs higher, but there was also a persistent post-EBV stigma and a perception among contractors that working in Liberia carried health risks.

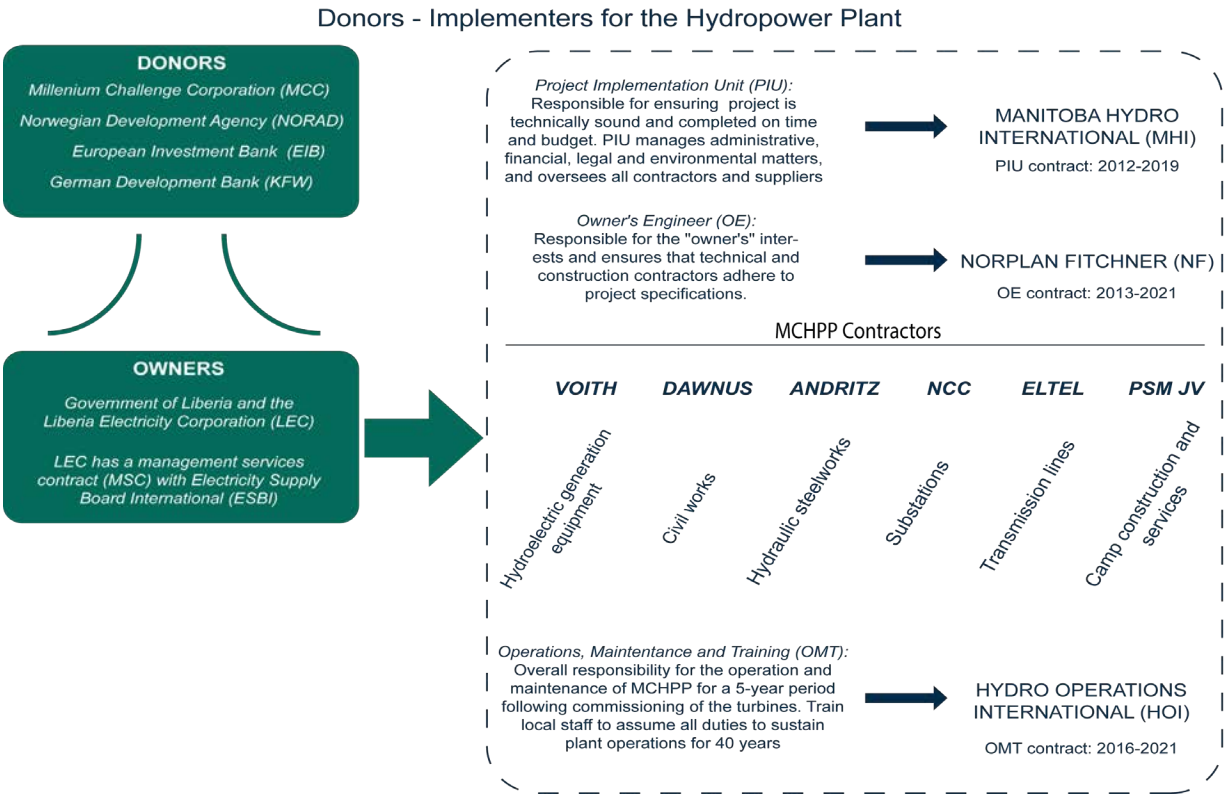
Post-Ebola Crisis, MCC joins the donor field to rehabilitate MCHPP. MCC—responding to pressure to invest quickly in Liberia and recognizing GoL's inability to cover budget shortfalls—joined a crowded field of donors to finish rehabilitating MCHPP. MCC's $147 million Mt. Coffee Rehabilitation Activity aimed to refurbish the hydropower plant and install 132 kilovolt (kV) transmission lines and two 66 kV circuits from MCHPP to the Paynesville and Bushrod substations, enabling 88 MW of electricity to be distributed throughout Greater Monrovia. MCC's investments aimed to increase the supply of high quality and reliable electricity, create the conditions to reduce the tariff, and increase the number of connections from 35,000 to 94,000 to 106,000 (in 2015, 2020, and 2025 respectively).

MCC committed to pooling funds with NORAD, KfW, and EIB to meet the full cost of rehabilitation ($357 million). Because 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.[16] 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 (Figure V.1).

An Operations, Maintenance, and Training Contractor was added to the MCHPP works. Operations and maintenance works are critical to ensuring overall plant operations and sustainability. While the cost of a strong OMT is small compared to the benefits, insufficient OMT operations can lead to expensive, catastrophic failures and reduce the efficiency and longevity of hydro power plants (WB 2020). The OMT contract should have coincided with the construction contracts, but it was delayed as stakeholders focused on finalizing construction, rather than planning for maintenance. Coupled with procurement problems, the OMT contract was initiated only at the time the first unit was commissioned.

Figure V.1. Donors, owners, and contractors for MCHPP



In August 2016, Hydro Operations International (HOI) became the operations maintenance and training (OMT) contractor and assumed overall responsibility for MCHPP for a five-year contract. HOI's scope included training and mentoring local LEC staff to take over all responsibilities, ensuring the sustainability of the power plant after five years of support.

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

Funding operation, maintenance, and training. The plan was for MCC to cover initial costs of the OMT contract while LEC set aside $575,000 per month in escrow to cover MCHPP OMT in subsequent years. By 2017, LEC, under the Interim Management Team (IMT), had set aside only $177,000 in the MCHPP escrow account. HOI was chronically underpaid by LEC's IMT, it repeatedly submitted "notice of stop-work orders," and its staff count was reduced from 18 to 11. In 2019, stakeholders predicted catastrophic failure at MCHPP without greater investment in the OMT and better stewardship by LEC (Miller et al. 2020). Subsequently, MCC diverted $3.3 million from the Activity 3, the Training Activity to cover the OMT contract costs.

2. Activity 2: LEC and Electricity Supply Board International

LEC operations ceased, causing loss of assets and skills. LEC, the state-run utility company, ceased operations during the country's civil war. In addition to MCHPP, the war resulted in the destruction of the transmission and distribution (T&D) network across Monrovia. In 1990, with poles and wires looted and main streets in darkness, LEC operations remained closed for 15 years. Consequently, LEC lost human resource capacity and technical and management skills.

After 15 years, LEC resumes operations, and MHI becomes the first MSC. Post-war, in 2005, with a new government and $40 million in donor investments for temporary diesel generators, LEC resumed operations. The utility serviced 2,500 customers in Monrovia by 2010. As LEC began to rebuild, it faced acute shortages of technical and management capacity. In July 2010, MHI became the first MSC post-war, with a $14 million contract and 10 staff over 5 years. At the time, LEC generated 9.6 megawatts (MW) of electricity, relying solely on donated thermal generators. Tasked with improving technical and commercial performance, MHI had $42 million in capital (CAPEX) to support grid expansion through the Monrovia Grid Extension project.

LEC's grid, customer base, financial problems, and losses grew during the first MSC (MHI), while the tariff was slightly reduced. By 2016, LEC generated 22 MW, served 45,000 customers, and maintained a monthly operating loss of $0.6 to $1.3 million (Figure V.2.). High fuel costs and delays in new generation meant that MHI reduced tariffs by only $0.05, to $0.49 per kWh. LEC perpetually operated at a loss owing to inadequate billing and collections. Total technical and commercial losses averaged about 44 percent per month. While the grid and customer based was growing, LEC lacked adequate funds to repair infrastructure failures. MHI reported that the Liberian workforce required extensive capacity strengthening "*unlike training programs where employees need simply targeted skill building in their area of expertise, training in Liberia required improvement to basic mathematical ability and the fundamentals of science and engineering*." By 2014, the Ebola Crisis led to some MHI staff evacuations. LEC oversight was inadequate with MHI operating remotely.

Figure V.2. LEC Headquarters at Waterside

Liberia was declared Ebola free in May 2015, though the country had suffered damage to its reputation. With the health and safety fears generated by EVD, qualified contractors were even more difficult to attract to Liberia. MHI's contract ended in early 2016.

In Chapter II, we note that the MHI contract was considered unsuccessful, a result of insufficient government support and interference in operations, along with inadequate donor coordination:

> *"There was a lack of government commitment to full reform of LEC. The operator was perceived as a threat from the earliest days, and LEC was seen by some government officials as a cash cow that could be coerced into financing nontransparent procurements to handpicked contractors. Serious trust issues emerged immediately upon start of the contract, which undermined the relationship between operator and government and worsened after one of the primary government representatives involved was promoted to a leadership role in the Ministry of Energy, permitting him more direct oversight of the operator and more leeway to frustrate the operator's potential for success." (USAID 2018)*

> *"Donors were … well-coordinated through the MCHPP PIU and quarterly … meetings. Donors continuing to fund T&D and connections were fragmented and looked after their own ring-fenced projects … donors had no interest in the LEC electric master plan, the business plan, or the investment plan that were supposed to be the road map for recovery. (MHI, 2016)*

The Liberian Interim Management Team (IMT) managed LEC from 2016 through 2017, effectively pillaging the failed utility. During these two years, Liberia's generated power supply grew to 70 MW when unit 1 of MCHPP was commissioned and served 44,000 customers. With increased generation, power theft became rampant, causing combined technical and commercial losses to balloon to 61 percent. LEC operated at a monthly loss of $1.2 million. The IMT increased staffing and salaries by 30 percent and salary costs by 54 percent given "illogical promotions." The IMT made costly, irreversible concessions to the trade unions that were not implemented and resulted in historic debt to employees. When the IMT ceased operations in 2017, LEC had no training department, minimal inventory, burnt records with no digital or paper trail, no customer list or asset inventory, inoperable assets that carried debt, contracts that were not in LEC's best interests,[17] and debt exceeding $21 million.[18] LEC infrastructure was of suboptimal quality: the low voltage network, feeders, and transformers required extensive maintenance, repair, and replacement. Thermal generators were beyond the warranty period and required extensive maintenance and repairs. Substations had (1) faulty transformers, switch operating mechanisms, and handles; (2) malfunctioning and inoperable earthing systems; (3) damaged control and protection wiring; (4) a substandard battery bank; and (5) a lack of spare fuses, rectifiers, and other parts.

[17] For example, the IMT led 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.

[18] LEC was named in a lawsuit for $9.3 million in unpaid debt for dry season fuel. Outstanding debts were for non-operational assets, vehicles, IT equipment, and building renovations.

MCC invests in the second MSC to lead utility reform and capacity strengthening. Recognizing that LEC was a failed utility, with poor performance and a financial crisis, GoL agreed to a second MSC to turn the utility around, but it could not attract private investment. With MCC funding, GoL selected and contracted with Electricity Supply Board International (ESBI) to assume all responsibility for LEC's operations (GoL 2017). The three-year contract between GoL/LEC and ESBI, with support from MCC, commenced January 8, 2018. The $11.7 million contract funded 11 staff for three years and had an additional two-year option period (2021-2022) at $3.5 million per year if GoL or another donor provided funding. The contract contained no operating (OPEX) or capital expenditures (CAPEX). The contract budget and staffing declined each year, assuming the workload would diminish over time. As the MSC, ESBI assumed all LEC's business and operations with the goal of utility turnaround. The contract had performance targets and payments, including bonuses and penalties developed to incentivize achieving these objectives: (1) turning LEC into an operationally efficient and financially viable utility, (2) increasing staff capabilities and the customer base, (3) boosting electricity quality and reliability, and (4) improving customer service.

In August of 2017, because LEC had a weak Board of Directors (BoD) and MCA needed the support of an owner's engineer, MCC engaged a contract management consultant (CMC), Azorom, to assist the LEC board with utility oversight and support MCA-L and MCC with compact oversight. CMC assessed whether key performance indicators (KPIs) were met and why targets were not met. LEC's KPIs measure operational efficiency, network performance, new connections, and reduced losses. These indicators are central to evaluating LEC's functionality and MSC's contribution to improving LEC's operations. CMC also evaluated and documented ESBI's and LEC's overall performance, reviewed deliverables, and advised MCA-L on all matters.

D. Utility reform and grid-level implementation and outcomes

EQ A1-A2: Were activities implemented as planned? What was the quality?

MCHPP planned and actual implementation and quality

Actual implementation of MCHPP rehabilitation was implemented generally as planned. However, when implementation diverged from plans, it was mainly due to payment and contractor delays and cost overruns due to construction challenges, procurement delays, multiple donors, and external circumstances. Donors generally coordinated, however different financial processes and requirements placed a time-consuming burden on contractors.

Overall, most stakeholders rated the quality of implementation as high, though challenges persist. For example, it was suboptimal that the PIU oversight ended before the project was finished because LEC lacked capacity to oversee implementation. Consequently, stakeholders reported inadequate supervision during construction, which resulted in unanticipated technical challenges and additional maintenance. MCC stakeholders felt that implementing agencies over-promised, and there was limited leverage and accountability as project closeout approached. For

example, the National Contracting Company, responsible for substation works, had more than 200 defects within the 66kV substation. Most, but not all, defects were resolved when the contract ended. 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."*

MCHPP generates high quality renewable power (Figure V.3.). 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). However, less rainfall and low water levels resulted in reduced generation, which occurred in both 2021 and 2022. MCHPP's seasonal generation capacity means that additional energy sources are required for continuous electricity throughout the year. While MCHPP electricity production met expectations, stakeholders note that building a new plant would have cost less and taken less time than rehabilitating MCHPP, particularly if a site was selected upstream, where a bigger dam and reservoir capacity would yield more power. Figure V.5. illustrates MCHPP timeline of events.

MCHPP electricity generation is limited by design choices, such as site location and the hydrology of the site, and plant specifications, such as turbine size. While stakeholders had differing opinions, most agree that upgrading to four 22 MW turbines without rebuilding key components, introduced risk. Respondents differed on their view of the design choices for the generators, with at least some indicating that the choice of (cheaper) coil over rubber windings, increased the risk of failure. In January 2021, just prior to the closing of the Compact, the Unit 1 turbine suffered a catastrophic failure when a coil winding failed and burnt machinery. The units could potentially have operated for decades without the flaw, but frequent blackouts and low water levels increased the likelihood of unit failure. HOI stakeholders note that Units 2, 3, and 4 have the same design. MCHPP staff are operating in fear of additional failures. They also note that new connections and substations means that demand is increasing. Loss of a unit—which is expected to take three full years to repair—results in a loss in reliability of supply for all customers and less low-cost hydropower for LEC to sell. While the root cause analysis was inconclusive, the repair estimate for unit 1 is $4 million, and each unit requires the upgrade.

Planning for and financing the OMT was inadequate. Without a clear sense of LEC's capacity and financial situation, stakeholders did not understand how unrealistic it was for LEC to pay for and manage the OMT.

> *"Nobody was prepared for us [OMT contractor]. The idea that this has to be operational at some point should have been a priority, because 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."*

In addition, the complicated nature of ensuring adequate parts and supplies and managing warranties and insurance with manufacturers and companies around the world requires sophistication that the OMT was not fully staffed or funded to provide to the local workforce.

OMT implementation has not been as planned, and quality has suffered owing to payment problems. The OMT contract was not implemented as originally envisioned, as LEC has a poor financial situation and failed to add resources to the OMT escrow account. Because of LEC's persistent unpaid bills, the OMT repeatedly submitted stop-work orders, and the contract was reduced by $7.9 million (from an estimated $575,000 to $350,000 per month) and eight staff. MCC diverted funds from the Training Activity to pay the OMT: *"The lack of funds to carry out repairs is critical."* HOI provided services in line with the reduced contract, but this was less than required to maintain the complicated plant. The reduced workforce and low-quality equipment meant that actual maintenance diverged from planned, state-of-the-art operations. Funding the OMT contract has remained problematic through 2022, and the HOI contract has been further reduced.

Planning for MCHPP's equipment and parts has been suboptimal. First, contractors, MCC, and other stakeholders underestimated the extent of parts and equipment needed for regular maintenance, troubleshooting, and repairs. Second, MCHPP contractors have not yet provided all warranty parts. Third, in the MCHPP SCADA system, stakeholders described flaws that hampered HOI's ability to monitor MCHPP operations.

> *"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."*

Fourth, nearly all MCHPP components and parts are made only in Europe. Consequently, if there is a fault, a system must be off-line until the new part comes from Europe. Staff indicated that this was a major issue and was not easy to handle. In fact, some components must be custom manufactured and cannot be purchased off the shelf. OMT staff noted that they attempted to obtain parts from CLSG (as the substation is located at MCHPP), but all CLSG parts are made in China and are incompatible with the European parts.

Fifth, the OMT led procurement with suppliers and vendors, but without LEC coordinating, this left "*LEC poorly equipped and without key contacts*" once the OMT demobilized.

Finally, reflecting on the OMT training, LEC staff at MCHPP, HOI stakeholders explained:

> *"It's a partial success …. 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."*

In the LEC Training Activity Report, we documented how MCHPP staff felt as though they required additional hands-on training to anticipate, prevent, and repair major or catastrophic failures (Bos et al. 2022).

Figure V.3. MCHPP aerial view

SCADA = supervisory control and data acquisition.

LEC planned and actual implementation and quality

Actual implementation of the MSC at LEC diverged from plans. All stakeholders agree that MCC's actual implementation (or contract management of ESBI) as LEC's management services contract was more complicated than anticipated, a result of LEC's poor functionality and ineffective Board of Directors, Liberia's challenging context, GoL's interference and weak political will for reform, insufficient donor coordination despite major investments (requiring complementary parts and materials and ongoing maintenance and repairs), and inadequate time and resources vis-à-vis the extreme challenges. ESBI entered a chaotic, bankrupt utility, with overwhelming challenges and unprecedented constraints to solving problems. Stakeholders did not understand the true situation of LEC, that finances were dire, corruption was rampant, skills and capacity were exceedingly low, material shortages were extreme, and the poorly maintained

and overloaded infrastructure and assets were wrought with safety risks and system failures. Figure V.5. illustrates LEC's timeline of events.

Implementation was not informed by a PEA. Because MSCs often fail to achieve key goals for political reasons, and GoL's resistance and interference in the first MSC was documented, MCC and MCA-L would have benefited from a country- and utility-level political economy analysis (PEA), including understanding Ministries of Energy, Labor, and Justice and their role in the energy sector. The PEA could have informed the contract structure, forced MCC to find leverage points, institute benchmarks for GoL to meet, and work more closely with donors. 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. Without a PEA, stakeholders lacked an updated and realistic picture of LEC, did not anticipate the surge in utility-level corruption, and were unprepared to support ESBI fully with political and technical solutions.

> *"For us, the frustration was immense. We were never given tools to tackle problems. We know what the problem is and how to solve it but don't have tools. Donors don't give them, or half give them. We needed government support, working capital. Can't do anything without it. Do not come into place like this thinking that you will fix commercial losses and that will fund everything else. Need money to solve those and eventually start funding itself. Don't do it unless you have money. That's a fundamental issue—real mistakes were made."*

> *"Need to allow yourself first year in country to understand what was driving the issues that were there... If look at original scope, we were meant to have a SCADA system, IMS, GIS system. That was to happen before we got here. All the donor projects were meant to be done. We arrive to discover that none of it is done. Need way bigger resource on ground than we thought. Came here … Crews going into field switching network with bamboo. Literally no money. So you need to understand at front end, need scale of problem. Due diligence needs to be here ... Client needs to be supporting you."*

Implementation quality was undermined by insufficient mechanisms to overcome political interference and continued resistance. Effective implementation and overcoming corruption was especially difficult because of Liberia's weak and easily influenced institutions; the new, inexperienced government; the monopolistic utility; a new, high-quality hydro-generation; and the aftermath of the IMT period, in which theft mechanisms advanced into a sophisticated cartel. As noted in Chapter II, corruption can occur if politically connected individuals demand favors, side payments, or contracts; through cronyism and LEC appointments; with patronage to organizations or individuals; when cartels and syndicates operate with impunity; and with grand corruption designed to enrich political leaders. Respondents described examples of forced or coerced contracts, cronyism, patronage, and cartel operations, as well as overt power theft, involving members of the GoL.

MCC and MCA-L became increasingly aware of the challenges. *"[It is] unsustainable to have the government undermine the program in so many ways" but felt that "MCC has only blunt tools."* According to ESBI *"GoL sees LEC as a vehicle for delivering its own agenda."* ESBI stakeholders explained:

> *"We don't have many allies in government at end of day. They think LEC is a cash cow. They say we don't know what you're doing with money. Part of problem is that if you look into utilities, few are really cash cows. [GoL wants to] squeeze assets to the Nth degree until nothing is left. Electric utilities are not cash cows. They are good, solid, low yield, but reliable. Not going to invest in this thing if expecting a windfall at end of the year."*

The CMC continued to document political interference as LEC's syndicate or cartel was expanding and opportunistically using the situation for its gain. Although MCC and MCA-L understood these challenges during the Compact and tried to influence GoL, there was minimal progress, and few solutions were offered to overcome problems. MCC and MCA-L lacked mechanisms to overcome the worsening situation. For example:

> *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." "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).*

It was noted that MCC had limited leverage once the bulk of funds were committed to MCHPP. High quality implementation would have required much more direct oversight, continuous data monitoring, immediate problem solving, and mechanisms and tools to leverage GoL behavior.

Implementation quality was also weakened by LEC's ineffective Board of Directors. The board is responsible for full oversight of all LEC's operations, management decisions, and strategy setting. Throughout the Compact, stakeholders agreed that the presidential appointees provided minimal oversight, support, and accountability and were ineffective at coordinating donors, identifying risks, approving procurements and budgets, planning, monitoring implementation, and influencing treasury activities. According to the CMC:

> *LEC has continually struggled for survival since Liberian state institutions and agencies were re-launched after the restoration of democratic institutions following the end of hostilities. In these circumstances, it is not surprising to find that LEC had virtually no effective corporate governance .... LEC did not have a fully constituted Board of Directors until May 2018. This 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. —CMC Annual Report 2020*

MCC respondents observed situations in which they wanted ESBI to act, but the LEC Board was too busy to meet, so the problem remained unresolved. For example, with each dry season pending and no HFO financing, the LEC Board neither strategized nor advocated for a plan with GoL. Stakeholders explained that board members did not have the skills to manage contracts or provide utility oversight. One stakeholder said, "*We suggested that Board of Directors seek out private-sector members and appoint someone who has the requisite experience*." LEC "*should have a utility board that is capable of managing a contract or hiring someone to advise them*." Stakeholders explained that adequate board performance ultimately "*requires the government to understand the utility is an asset they own, and they are responsible for its proper functioning."*

Throughout the Compact, MCC had limited leverage to push on the board's functionality. However, after Compact closure but prior to MCC leaders leaving Liberia, the outgoing MCA-L CEO was appointed as Chairman of the LEC Board following well-coordinated donor and MSC advocacy. Most stakeholders believe the new LEC Board Chair is well suited for the position, though "*a one man show with a poisoned chalice"* in the absence of GoL reforms.

ESBI's implementation was damaged by inadequate resources, given the scope and scale of responsibilities and unanticipated challenges. 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 2019 LEC Business Plan, ESBI requested $115.4 million from 2019 to 2023 for operating expenditures and $109.2 million for capital expenditures. ESBI assumed the tariff would remain unchanged, large customers would connect and pay, and CLSG would provide additional dry season power, generating significant income by 2020.[19] However, LEC did not receive the requested CAPEX to fund network strengthening, thermal plant remediation, dedicated feeders, an interim SCADA system, and other items such as a fire prevention system for the Bushrod Power Plant, nor OPEX to cover fuel, meter normalization, taxes, and other basic costs. LERC reduced the tariff dramatically for most customers in 2022, large customer connections have been slow while theft has been high, and as of July 2022, CLSG was not yet commissioned in Liberia given the nearly $11 million entry fees to cover security and monthly payments for the power purchasing agreement (PPA), the transmission services agreement (TSA), and cross-border debt.

At the same time, over the course of ESBI's tenure at LEC (between January 2018 and May 2022), the number of customers and substations increased, substation capacity increased, the length of the 66 KV line increased, demand increased, MV/LV lines were added, and transformers were added (Figure V.4). In addition, MCHPP was fully commissioned (one turbine was damaged in 2021), thermal generators require maintenance (several remain offline), and CLSG will generate power pending final testing and payment in 2022 (which will require additional grid maintenance and new connections.)

The lack of OPEX or CAPEX, despite this growth in responsibilities, reduced ESBI's ability to transform the utility. 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 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.*

ESBI stakeholders noted that reducing power theft requires significant financial investments in SCADA systems and meters:

[19] The ESBI CEO presented the above figures at the June 2022 ESWG.

"Other utilities have gone through this, though their losses have eventually gone down. Investors have put a lot of money into loss reduction. For example, it was $60 million in Uganda. We started in 2005, had 44% losses, 20% losses by 2012. Now in Liberia they're expecting loss reduction with no CAPEX."

Figure V.4. ESBI's accomplishments during tenure as LEC's MSC (January 2018 – July 2022)

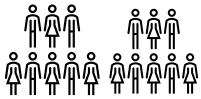
Generation

- MCHPP was fully commissioned (one turbine was damaged in 2021
- Thermal generators migrated to lower cost HFO (when possible)
- CLSG PPA and TSA renegotiated, WB covering fees, final testing and payment in 2022.

Transmission & Distribution

- Substations increased from 4 to 11
- Substation capacity increased from 80 to 200 MW
- 66 KV line increased from 120 km to 338 km
- 2,191 km of MV/LV lines were added
- 1,342 transformers were added

End users



- Number of customers increased from 28,000 to 170,000
- Demand increased from 28 to 65 MVA

The Contract Management Consultant (CMC) was necessary to inform MCC and MCA-L but not sufficient to improve MSC implementation. The CMC contract helped MCA-L and MCC understand LEC operations and ESBI's performance, but the contract and structure had several weaknesses. First, the CMC contract lacked broad reporting requirements that could have been strengthened to include LEC, the LEC board, the MME, and the full donor community so that all actors had a shared understanding of performance. Second, while the monthly, quarterly, and annual reports were valuable, they were not well utilized for building stakeholder support, informing real-time problem solving and decision making, and making mid-course corrections. 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. Problems and risks were documented month after month, but there was minimal monitoring of reports and what they were used for. Finally, Azorom (as the CMC) was not required to validate all data independently at the source to confirm accuracy.

MCC and MCA-L oversight was inadequate given data shortages and the lack of capacity to utilize data. Initially oversight was hampered because LEC lacked a functional information management system (IMS) and staff capacity to collect, manage, analyze, and utilize data. The World Bank procured the IMS with Indra as the contractor. It was designed in 2018 and launched in 2019, but stakeholders reported that training was suboptimal and few staff had

access to the system.[20] MCA-L tried to hire a monitoring and evaluation officer, but were unable to. An IMS-generated dashboard with trend data, key indicators, and reports could have informed stakeholders of LEC operations. In practice, key LEC staff used various modules, while some stakeholders received excel data files. Without analysis, contextualization, and explanation of data, MCC and MCA-L were not able to utilize the range of information to provide more oversight and help solve problems. The system lacks connectivity between modules and some LEC staff indicate it was "too off the shelf" rather than customized for LEC. Despite flaws, the IMS could have enabled MCA-L and MCC to have a more hands-on approach.

Weak donor coordination undermined LEC but has strengthened post-Compact. Most stakeholders believed that ESBI could have been more successful had there been donor-wide coordination from the onset. Although donors coordinated well to rehabilitate MCHPP, MCC and MCA-L were able only to facilitate limited, yet essential, coordination to leverage the political will to support utility reform. A well-informed donor block could operate as a united front, consolidating power to shape GoL's actions to support utility reform. GoL was not responsive throughout the Compact but 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*). During the Compact, donor community stakeholders felt they did not receive reports from LEC or ESBI.[21] However, in 2021, MCC requested an analysis of power theft (using evaluation data), which was presented at the Liberia Energy Sector Working Group (ESWG) to support donor coordination toward reducing power theft. This model of data sharing could have supported reform throughout the Compact.

Donor projects focused on new T&D infrastructure overwhelmed LEC capacity. The range of donor projects added to LEC's responsibilities, rather than supported operating or capital expenditures to strengthen LEC (Table V.2.). Liberia needed T&D infrastructure to increase the customer base, but without the energy sector, LEC, or donor coordination or a coherent strategy to ensure maintenance and sustainability, LEC was overwhelmed. As "more of a technical firm," ESBI was inadequately equipped to manage the range of donor projects, each with different sets of plans, goals, contracting requirements, contractors, procedures, payment processes, and resettlement requirements. ESBI's implementation quality would have improved if MCC or MCA-L had been able to support ESBI with additional staffing or play a more hands-on role. ESBI noted that many donor projects have low quality contractors working on LEC's grid, and without regulations for technical quality, LEC inherits new infrastructure and new problems.

[20] Core IMS modules: Commercial Management System, Outage Management System, Energy Control & Losses, Integrated Graphical Enterprise, Enterprise resource planning, Reporting (Pentaho), and Prepayment metering

[21] ESBI reported submitting monthly reports to MCA-L, however these were not shared with additional stakeholders.

Table V.2. Donor T&D investments

Location of T&D investment	Components	Expected connections
World Bank: Liberian Accelerated Electricity Expansion Project (LACEEP)		
Paynesville-Kakata corridor ($35 million concessional loan)	Transmission lines Paynesville and Kakata substations Distribution network	17,000
Bomi corridor ($60 million concessional loan)	Transmission lines Stockton Creek, Kle, Virginia, and Gardnesville substations	20,000 to 30,000
Monrovia	Distribution network	
CLSG	Generation and feeder and distribution	20 MW
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
German Development Bank (KfW): Monrovia Electrification		
Monrovia ($18 million grant)	Construction of feeder and distribution lines	17,500
European Union (EU): Monrovia Consolidation Project		
Monrovia ($46.5 million grant)	Construction of substations and T&D lines	38,000

Figure V.5. MCHPP timeline of events

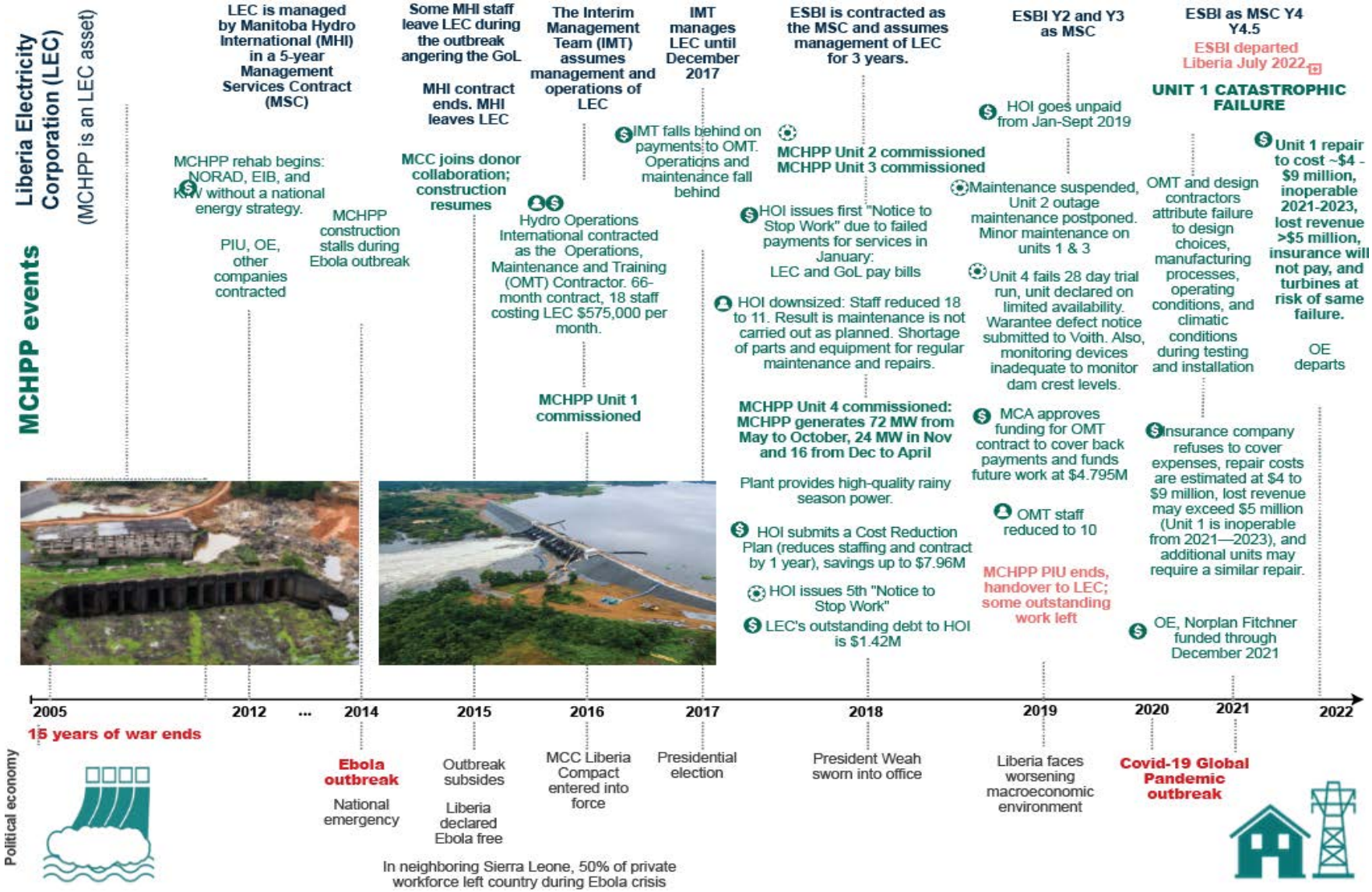
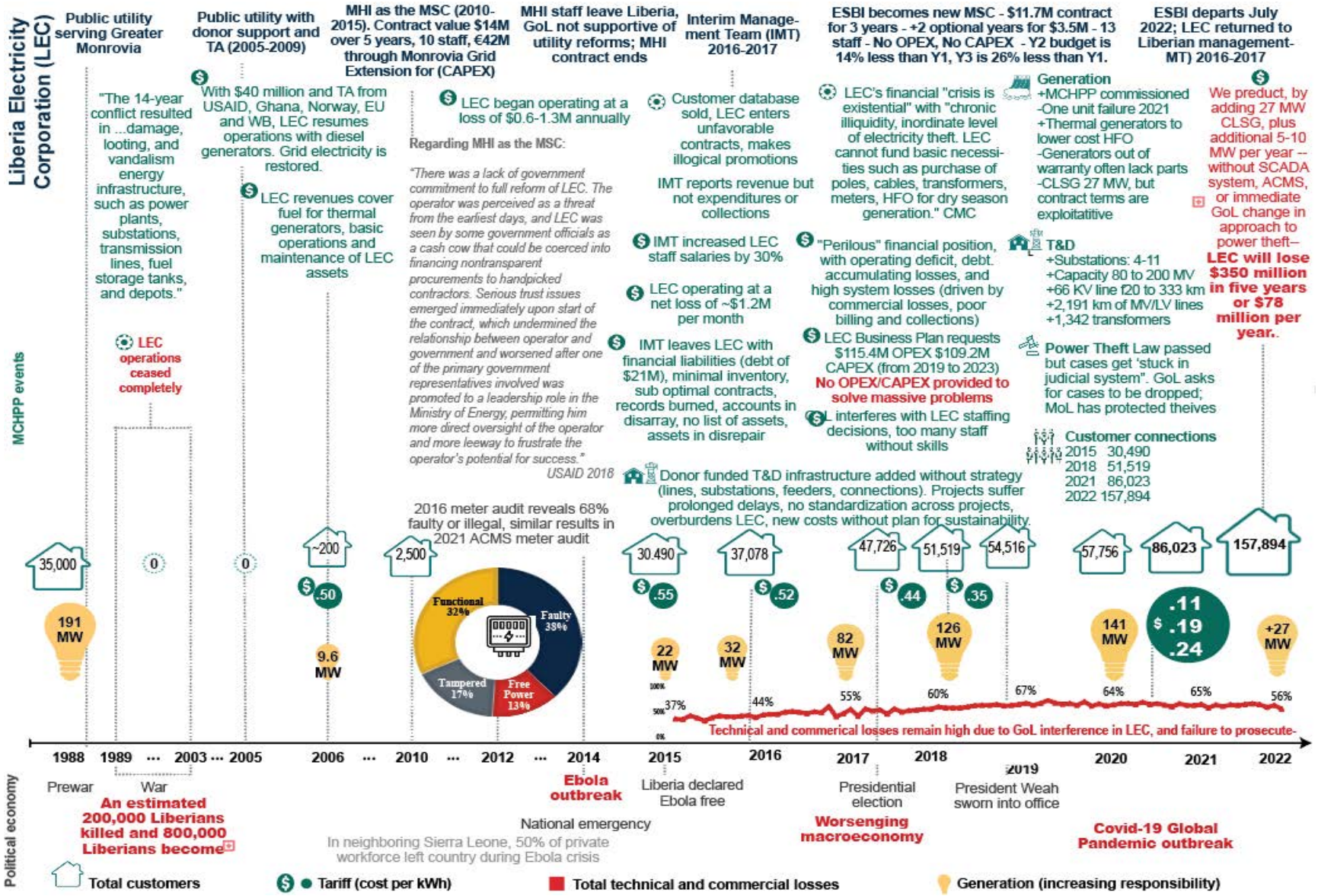


Figure V.6. LEC timeline of events

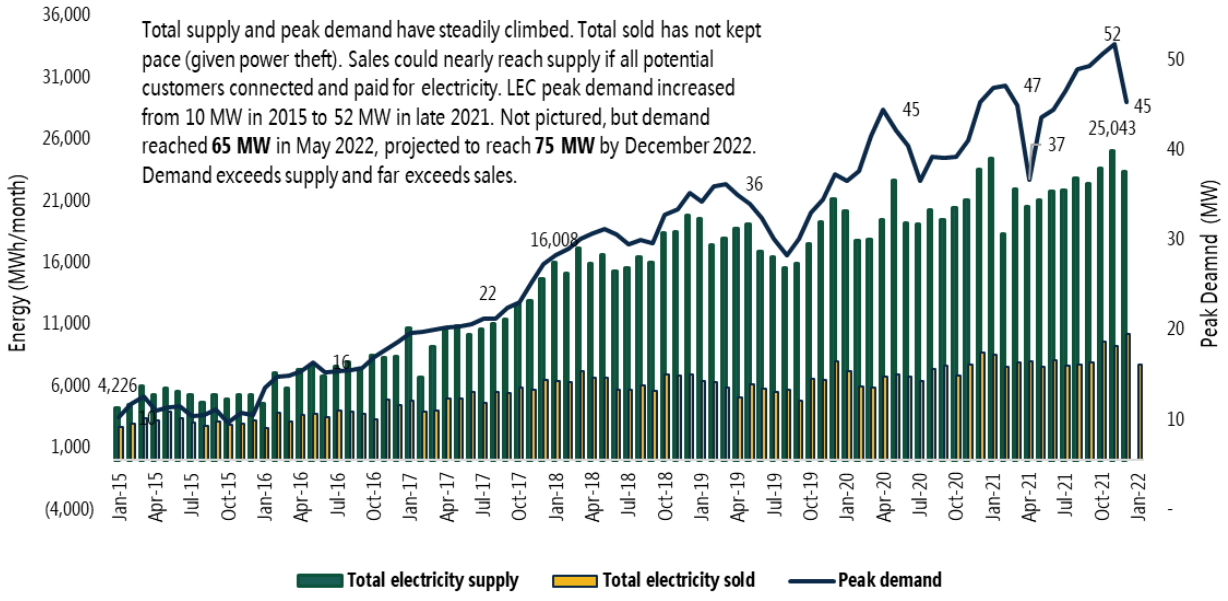


We analyzed many data sources to answer each question, including 7 to 10 years of LEC administrative data, end-user survey data, Asset and Customer Mapping (ACMS) data, and qualitative stakeholder interviews. Next, we answer each evaluation question, providing additional detail in each figure.

EQ C1: How have MCC's investments affected electricity generation, T&D, reliability?

MCC's investments—with complementary donor investments—were instrumental to MCHPP rehabilitation, thermal plant management, improvement of T&D infrastructure, conducting of the ACMS, and improvement in electricity quality. MCHPP enabled LEC's system demand to grow on average by 50 percent year-on-year from 2015 to 2018, reaching 52 MW by late 2021 (Figure V.7 and V.8). MCC's investments were essential to improving power plant availability (Figure V.8. are photos of generators, V.9 is plant availability), LEC operations and understanding of infrastructure, and increasing thermal generation at the Bushrod Power Plant (Figure V.10). Table V.3 shows Bushrod thermal generators. Liberia's adequacy of supply, available power, and peak demand are illustrated in Figure V.11. Note that Peak demand is often less than available power because LEC has been unable to fulfill all customer connection requests. However, during the dry season, demand exceeds supply.

Figure V.7. Total electricity supply, electricity sold, and peak demand (LEC administrative data)



Generation

MCHPP provides low-cost renewable hydropower (about $0.06 per kWh compared to $0.24 for thermal generation). However, MCHPP is seasonal and generates, on average, 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) (Figure V.12.). LEC's load factor has trended upwards since 2015, which is positive indicator that LEC is operating with a lower generation cost per unit (kWh). However, lower-than-average rainfall and the Unit 1 turbine failure have reduced MCHPP's output. Seasonal output and the turbine failure make thermal plants, CLSG (Table V.3), and other generation essential.[22]

Figure V.8. Bushrod Power Plant, thermal generators

Note: T&D and Network performance LEC infrastructure

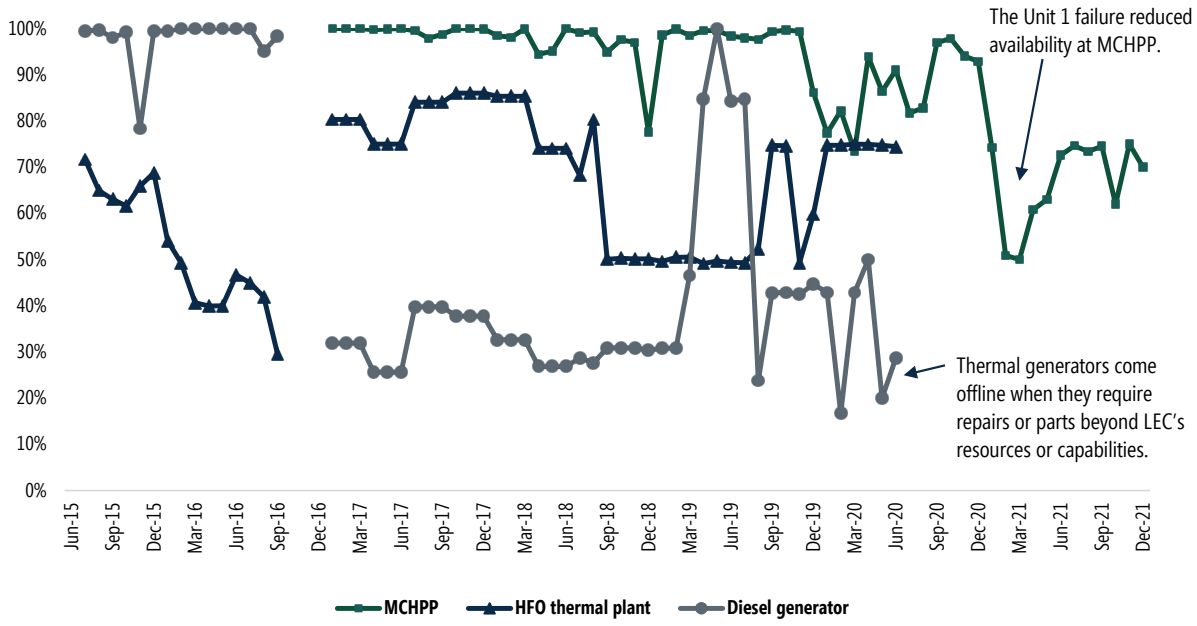
The MSC has kept most of LEC's thermal generators operational, despite major and frequent mechanical failures. Generators have been donated piecemeal to Liberia by various countries, and LEC has relied on additional donor contributions to repair each plant after failures. The thermal system is fragmented, with machinery requiring expensive heavy fuel oil (HFO), light fuel oil (LFO), or diesel (Table V.3). Maintaining the plants is complicated because of the different make, models, parts, and designs of each plant. LEC lacks spare parts and plant instructions, and generators are out of warranty. Nevertheless, ESBI has made ongoing repairs to keep most plants online and operating with the cheapest fuel that the system can use. While there have been improvements, inadequate resources limited LEC's ability to maintain and repair thermal generators. If MCC had provided additional resources, ESBI could have provided better maintenance and improvements to the plants.

[22] MCC did not invest in the CLSG line, but once it is commissioned, it will reduce dry-season fuel costs and reliance on expensive thermal generation. However, LEC must reduce power theft or GoL will be responsible for electricity costs.

Table V.3. Bushrod thermal generators

Thermal plant	Capacity W		Status across 2021
Bushrod Plant 1–2	1	MW	2 units operational
Bushrod Plant 3–8	1	MW	5 units out of service
Bushrod Plant 9–10	1	MW	2 units decommissioned
World Bank Plant 1–2	2.5	MW	2 units out of service
World Bank Plant 3–4	2.5	MW	2 units operational
GOL Power Plant 1	9	MW	1 unit operational
GOL Power Plant 2	9	MW	1 unit out of service
JICA Power Plant 3–4	5	MW	2 units out of service

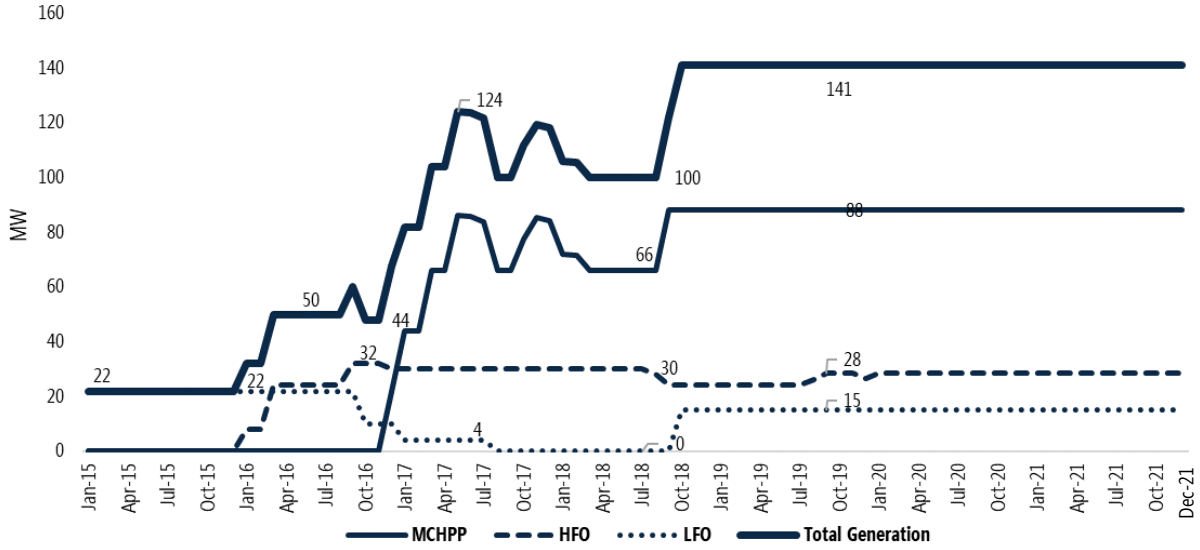
Figure V.9. Power plant availability



Source: LEC administrative data

Notes: Data missing for October-December 2016.

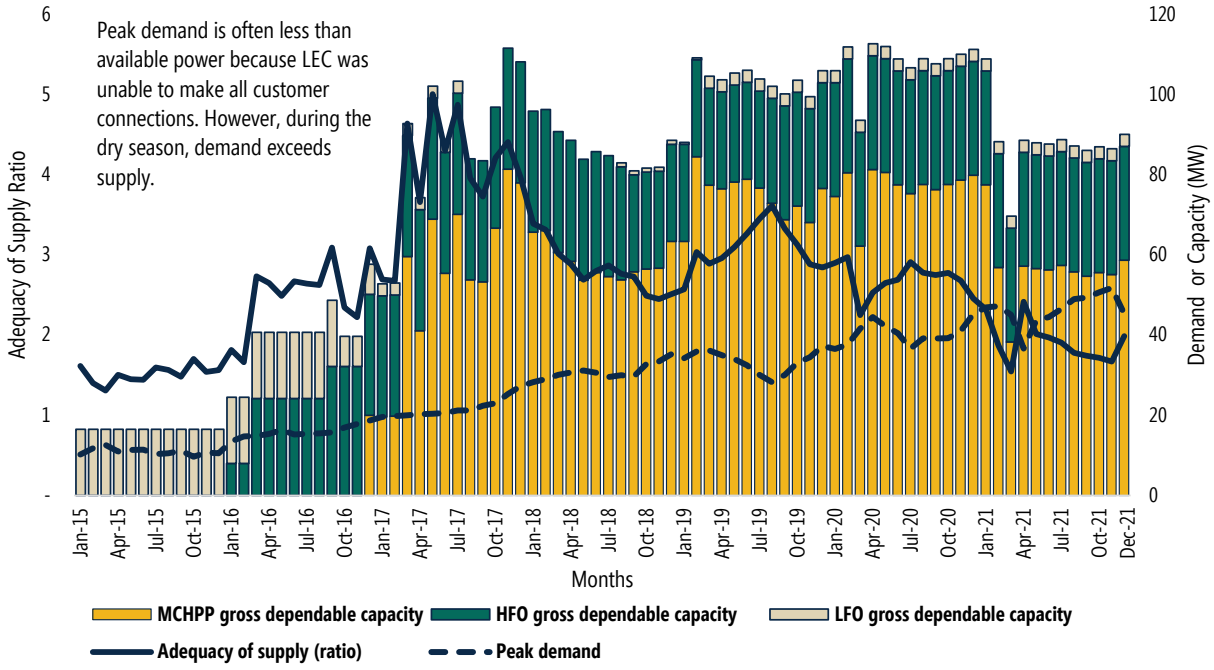
Figure V.10. LEC installed generation capacity, 2015–2021



Source: LEC administrative data

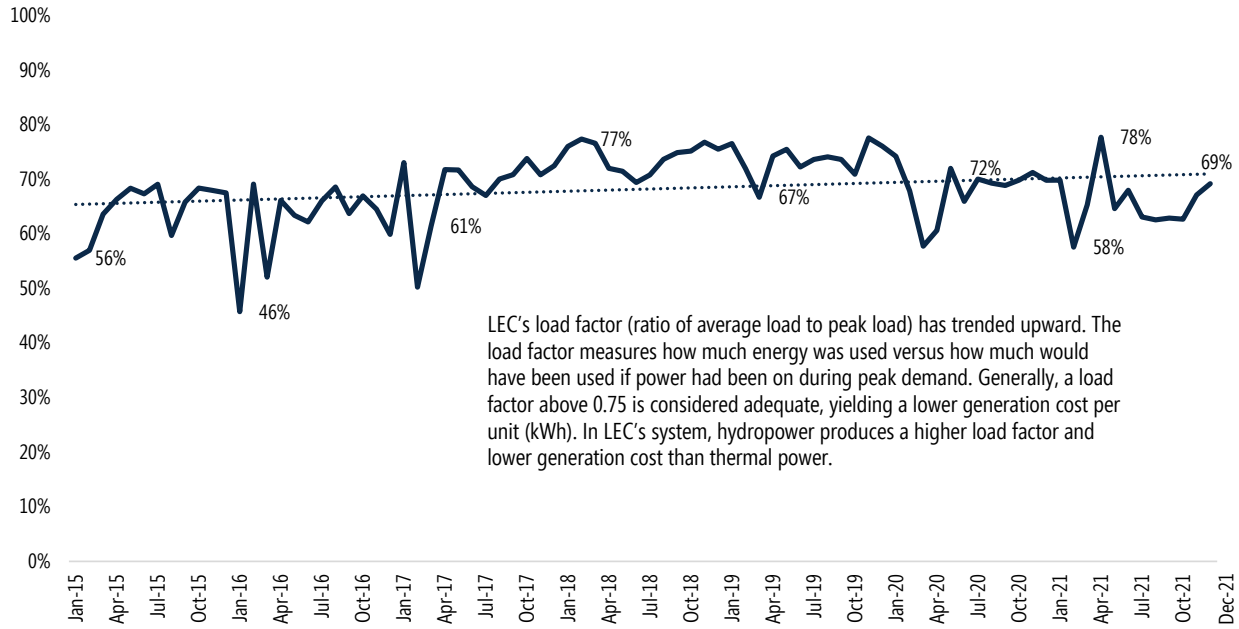
Notes: This figure illustrates installed capacity, not available power. If all plants were producing optimally, LEC could generate this capacity. In 2022, CLSG is expected to add 20-64 MW of gas-powered electricity.

Figure V.11. Adequacy of supply, available power, and peak demand



Source: LEC administrative data

Figure V.12. Load factor



Source: LEC administrative data

Transmission and Distribution

The MSC improved the functionality of LEC's T&D infrastructure, a patchwork of mismatched, poorly maintained, and aging assets. Despite challenges, ESBI worked continually to address network failures, make repairs, and utilize all available resources to improve the T&D network. ESBI's initial assessment was that the 22kV, 66kV, and low-voltage network had serious faults (See Figures V.13-V.16). LEC consistently lacks poles, transformers, conductors, LV circuit breakers, earthing materials, and meters to make needed repairs. ESBI requested, but never received, financing for extensive works for substations, feeders, 22 kV cables, overhead lines, transformers, low-voltage circuit breakers, and network patrollers, as well as tools, test equipment for calibrating and testing protection relays, T&D materials, equipment for line crews, and critical line hardware to address the connection backlog.[23] Further network improvements were possible with additional resources, donor coordination, feeder meters, and a supervisory control and data acquisition (SCADA) system to measure performance.

MCC funded the much-needed ACMS study to map assets, such as substations, towers, medium- and low-voltage poles, and customers. One of LEC's major constraints was lack of a SCADA system and geocoded mapping of infrastructure. A utility cannot diagnose or measure loss or analyze patterns without inventoried, metered, and geolocated assets. MCC's investment in the ACMS, albeit in 2020, finally provided LEC and ESBI with desperately needed data on LEC infrastructure and customers (Figure V.13-V.16.). LEC still does not have a network-wide SCADA system, which is a major oversight, particularly with the CLSG line scheduled to

[23] The LEC Business Plan requested $13.7 million for upgrades and refurbishment needed to improve the T&D system.

generate 20 MW of additional power in 2022 (Figure V.17.).[24] Note that CLSG Power Purchasing Agreement (PPA) and Transmission Service Agreement (TSA) contains "exploitative" contract terms which LEC has been renegotiating. According to the MSC:

> *"The real cost implications of CLSG were either not understood or ignored. The TSA was designed to protect Transco irrespective of what hardship or burden it placed on the shareholders (GoL and utilities). The PPA is not value for money. Liberia shoulders almost 50 percent of the debt with only 25 percent of the equity."*

While the CLSG line increases available power, there are serious concerns about the financial impacts of CLSG on Liberia.

[24] WB has committed to funding the SCADA system through the $64 million Liberia Electricity Sector Strengthening and Access Project (LESSAP), to be completed in 2026.

Figure V.13. ACMS Mapping of infrastructure and assets. Once data is digitized and added to IMS modules, LEC can operate like a modern utility.

ACMS mapping

Transmission elements	Number of mapped
Substation	9
Feeder	23
Tower	807
Distribution	
Primary substation	2
Primary feeder	19
Medium voltage pole	8,749
Switch	1,985
Distribution transformer	2,515
Low voltage pole	23,878

IMS DATABASE *Live 2019 but data, skills, sharing still needed to maximize utility*

Commercial Management System (inCMS)
Processing new connections, meter replacements, meter reading and billing, complaints, management of customer-based field work (service orders

Enterprise Resource Planning (ERP)
Management of corporate accounting, HR Inventory, line processing of payments and automation of payroll

Energy Control & Losses (ECL)
Module allows in-depth control of the energy that flows through the distribution network, supporting the identification of losses and fraud detection, considering data from the distribution meters and the energy bill to customers. Note: LEC requires meters at every interface and to normalize about 20,000 meters to fully

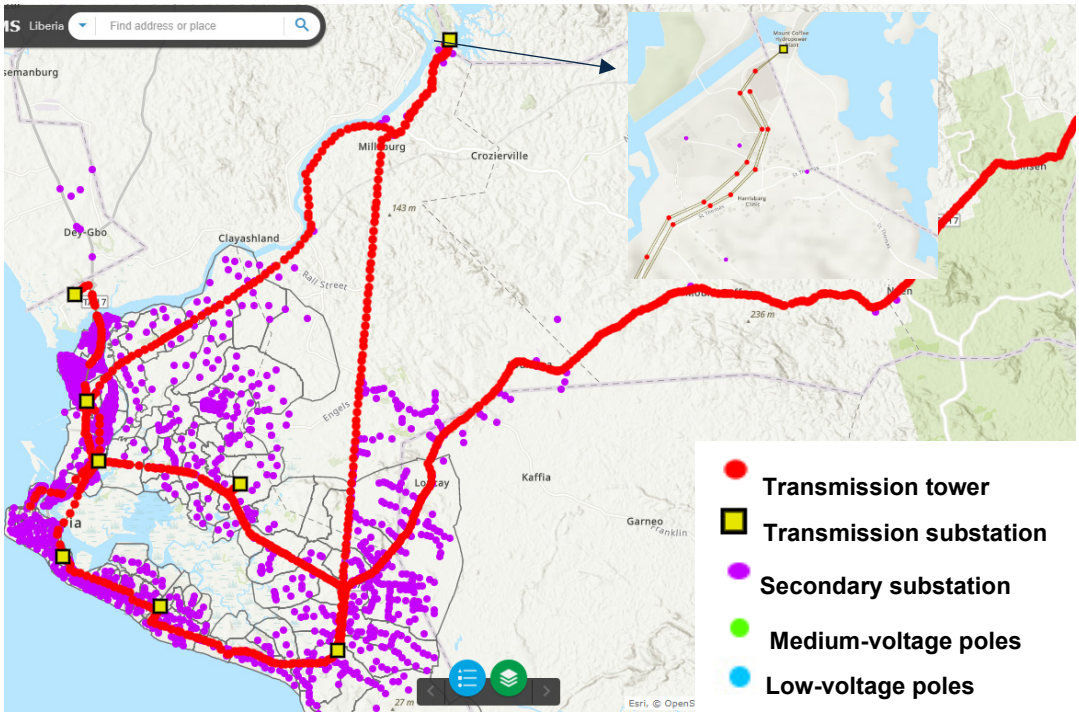
Integrated Graphical Enterprise (IGE)
Facilitates integration of data across databases and workflow.

Outage management System (OMS)
To identify, track, measure, and manage outages. Note: LEC requires meters at every interface to adequately measure outages.

Prepayment Metering
To manage all prepaid customers. Still needs Customer Resource Management Platform (CRM) and mobile phone capabilities

Reporting (Pentaho)
Infrastructure for reporting on all aspects of IMS

Figure V.14. Primary and secondary substations and transmission towers (ACMS)

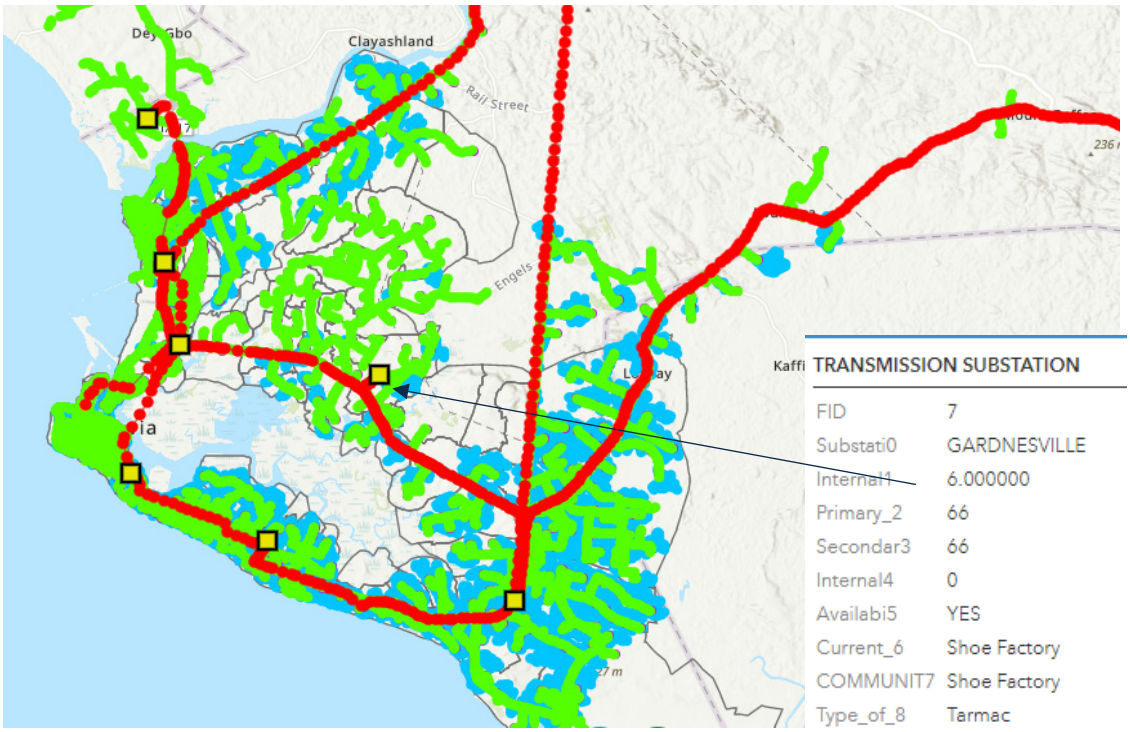


Source: Earthetic ACMS database. 2020

The ACMS was conducted in 2020 to help visualize assets; measure trends, identify patterns, target problem areas, and focus on priorities.

Assets and customers are listed, inventoried, geo-coded, and tagged, and then data are entered into the IMS to use for understanding performance, decision making, budgeting, and planning for repairs.

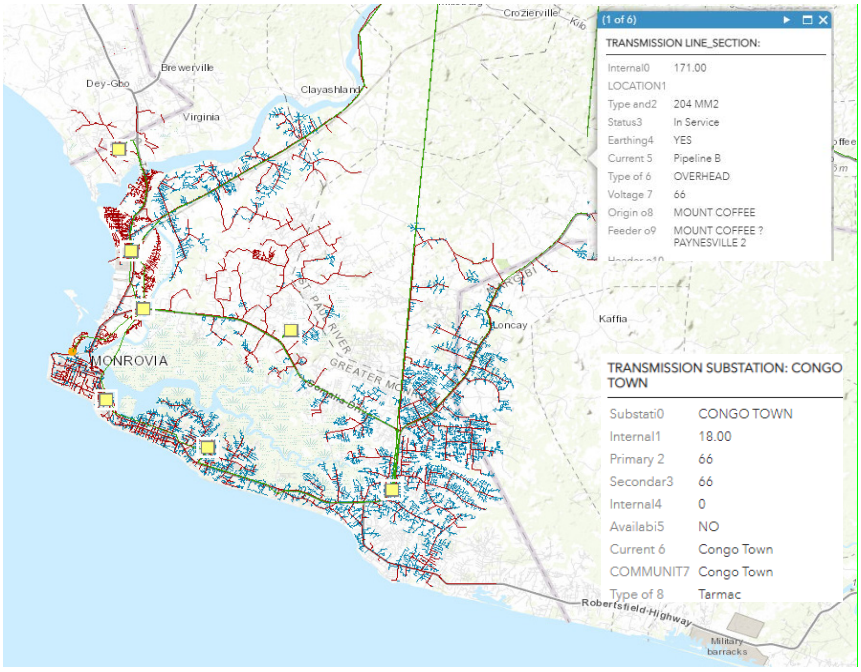
Figure V.15. Medium- and low-voltage poles and transmission towers (ACMS)



Source: Earthetic ACMS database. 2020

Without the ACMS, LEC had no way to visualize assets, infrastructure, and customers or track functionality and payments. LEC's overall asset management was difficult given suboptimal quality throughout LEC's low-voltage network, feeders, and transformers, which require extensive maintenance, repair, and replacement.

Figure V.16. LEC's substations, high-, medium-, low-voltage transmission lines (ACMS)



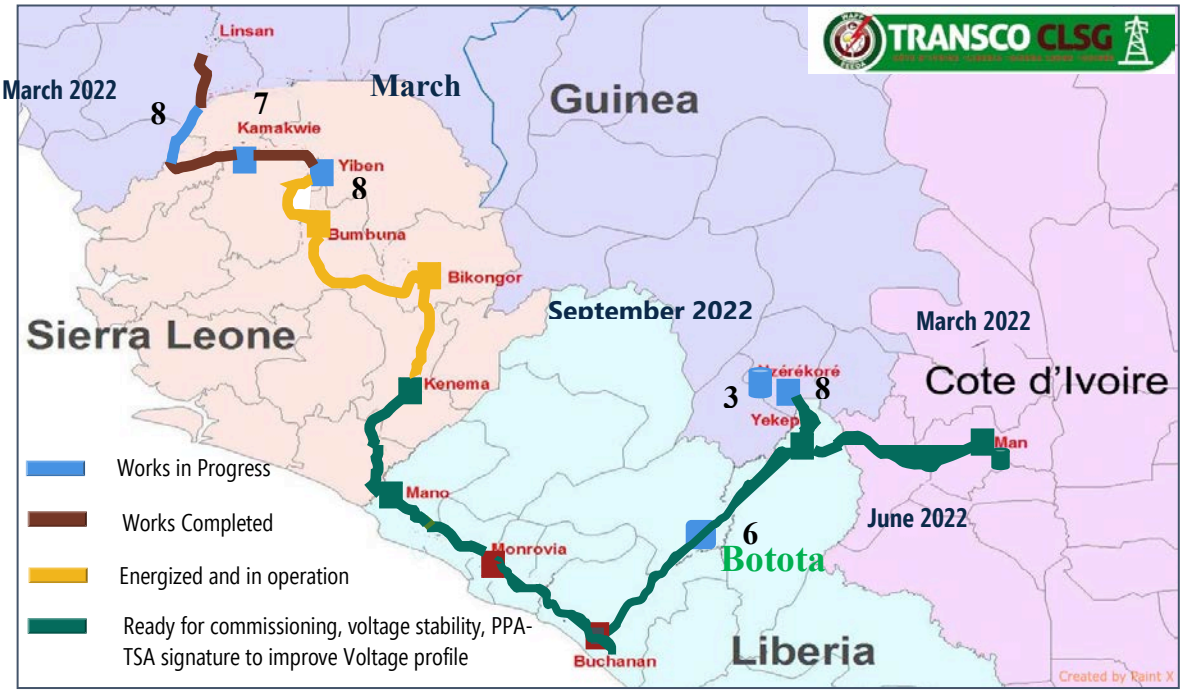
Source: Earthetic ACMS database. 2020

T&D and electricity quality and reliability have unquestionably improved from the IMT period. Measures of overall grid performance would improve further with resources for maintenance, repairs, and feeder meters.

Stakeholders describe challenges faced in improving network performance:

"There's no redundancy, so substations can't reroute power. Some lines become overloaded…so even if customers want to connect, they can't. In the smaller transformer stations, the transformers keep tripping…blowing up. 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 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."

Figure V.17. CLSG Transmission line (Transco) and project details (PPA and TSA)



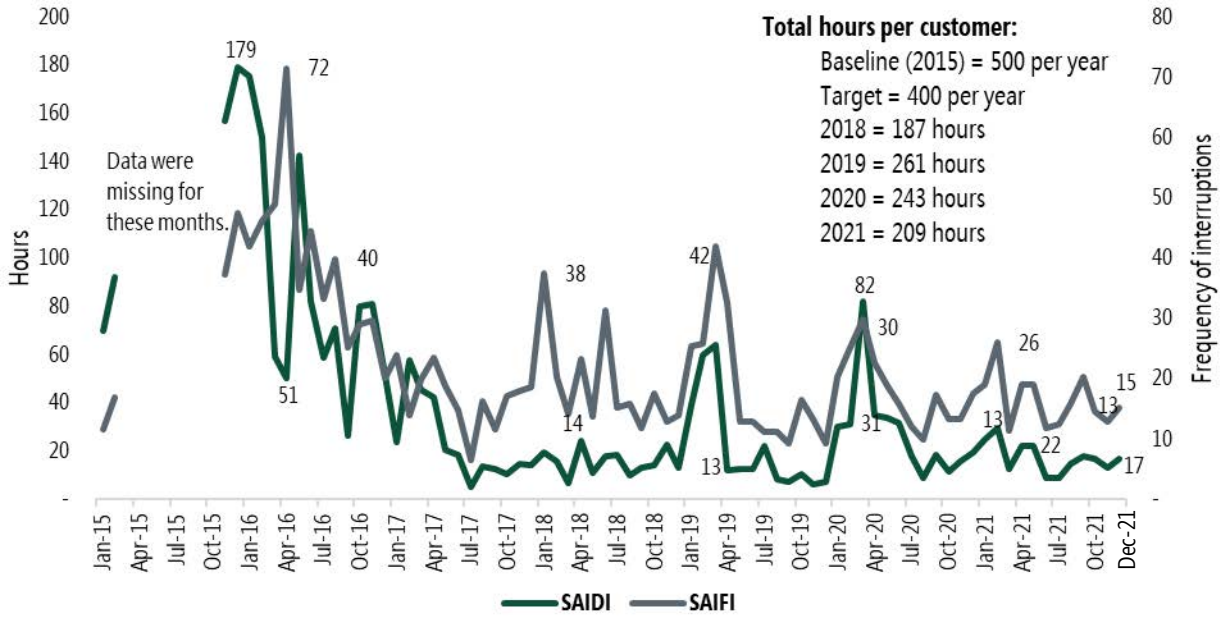
Note: This map shows where the CLSG transmission line will be placed. The substation at MCHPP will allow CLSG to power the grid.

	Power Purchase Agreement	Transmission Service Agreement
Term	3 years, Take or PAY	3 years, Take or PAY
Price	$0.1135 kWh • *LEC negotiating $0.08*	US$166K/MW reserved+ technical losses ~US$4.5m for 27MW, ~US$9m for 54MW ~US$2c/kWh @ 100% LF, ~US$8c/kWh @ 25% LF • *LEC negotiating $0.02 kWh +technical losses*
Liquidated damages *(if fail to perform)*	1.5 x Price • *LEC negotiating 3 x price)*	Uncapped
Payment Guarantee	60 days cash Escrow *$3.7 million • *LEC negotiating 30 days cash escrow, $1.8 m*	60 days, $800,000
Entry into Force	Full payment of Cote d'Ivoire Energy (CIE) cross border debt $9.3 m + $2.6 m • *LEC negotiating $3 m immediately, separation of unrelated issues*	
Volume offtake		Minimum 27 MW • *LEC negotiating Seasonal demand, which is growing*
Technical losses		Uncertain. Expected 5% at initial drawdown. Could increase to 105 as load increases. Losses pad at PPA cost $0.1135 per kWh)

System reliability

Investments led to reduced outages since baseline and improved SAIDI, SAIFI. With extensive infrastructure repairs, LEC was able to reduce outages (Figure V.18). The system average interruption duration index (SAIDI) was reduced from a baseline of 500 cumulative hours in 2015 to 187 cumulative hours in 2018 and 261 in 2019. SAIDI remained relatively high at 243 hours in 2020 and 209 in 2021. MCC initially set the KP target for SAIDI at 400 hours per year, which LEC achieved by 2018. Figure V.18. shows LEC's progress, despite grave challenges and resource constraints, in reducing outages and improving electricity reliability. Still, dry-season fuel costs, power theft, and overburdened infrastructure result in many monthly outages, exceeding SSA averages of 9 outages lasting 5 hours per month (108 outages per year, lasting 60 hours in total)

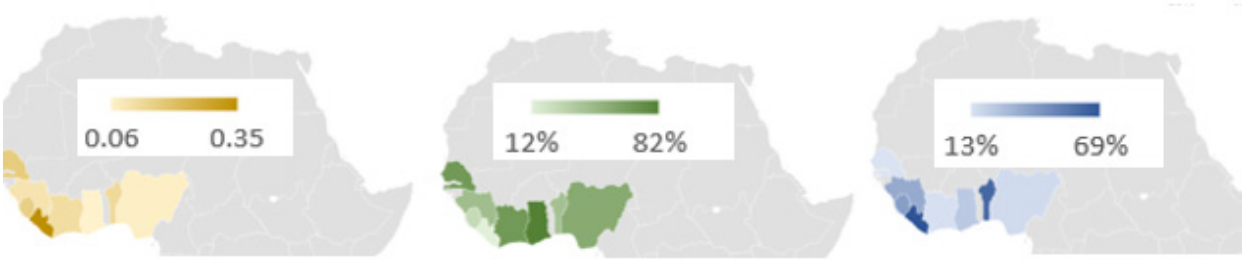
Figure V.18. System average interruption frequency and duration index (SAIDI and SAIFI) (LEC administrative data)



EQ C2: How has the electricity tariff changed since MCHPP was rehabilitated? To what extent does it cover the costs of electricity generation and other operating costs?

LEC's tariff was reduced several times since MCHPP was rehabilitated. While among the highest tariff in West Africa in 2021 (Figure V.19.), even at $0.385 per kWh ($0.35 plus tax), LEC's cost per kWh is preferable to private generators for most customers, which can range from $0.40 to $5 per kWh. Table V.4. illustrates average tariff across customer class. LERC's rates as of January 2022 and Figure V.20 show the tariff charge by customer type from 2015 through 2021). In 2017, the tariff was reduced from $0.49 to $0.39 as MCHPP began generating hydropower and further reduced to $0.35 in 2018. The WB estimates that the cost of operating a generator is often nearly eight times greater than the price of grid electricity (National Millennium Compact Development Project and Government of Liberia 2013).

Figure V.19. Comparison of West African country's costs, access, and losses



	Avg cost per kWh US$	Access to electricity % (2018)	Transmission and distribution (T&D) losses (% of output)
Benin	0.13	42	61
Cote D'Ivoire	0.12	67	14
Ghana	0.06	82	23
Guinea	0.10	44	*35
Liberia	**0.35** Before reduction to $0.15 – 0.24	**12**	**~69**
Nigeria	0.07	56	16
Senegal	0.17	67	13
Sierra Leone	0.16	26	**40
Average		Sub-Saharan = 48 *Note: access may be greater given power theft*	Global avg=9%, Few>30%

Hydropower is Liberia's lowest-cost electricity at about $0.06 per kWh in 2021 (for generation), compared to $0.25 for thermal generation (or more depending on fuel prices), and $0.115 per kWh for CLSG power (Figure V.20.). Note that these generation costs do not cover the full cost to LEC (which are estimated at $0.138 for MCHPP, $0.24 for CLSG, and $0.328 for thermal). Note that LEC's full operating costs have ranged from $0.43 to $0.77 per kWh since 2018 (Figure V.21).

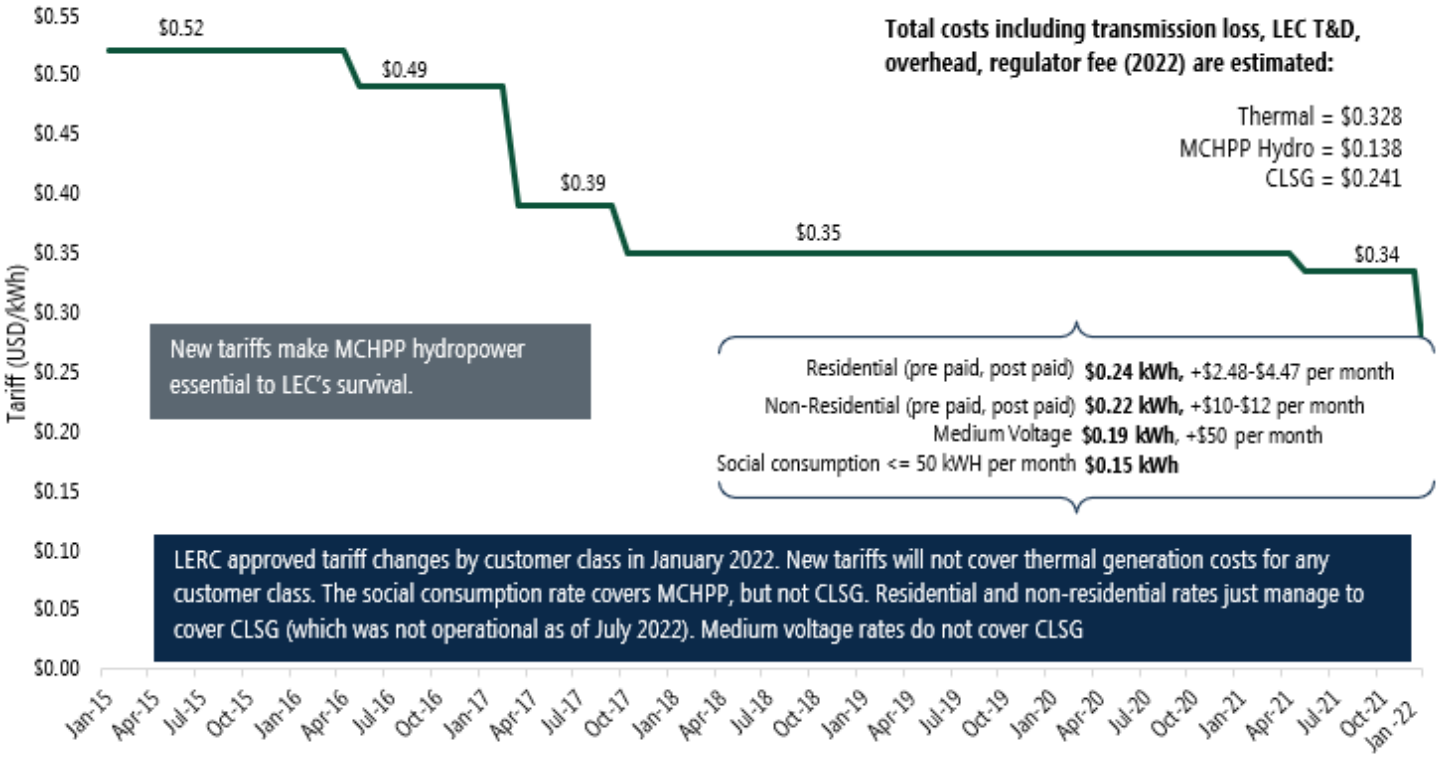
Table V.4. Cost per kWh for generation, US$ per kWh (LEC) not including additional costs of operation

	2019	2020	2021	2022	2023	Total cost per kWh including transmission loss, LEC T&D, overhead, regulator fee (2022)*
Thermal $	0.25	0.24	0.24	0.24	0.24	0.328
Hydro $	0.10	0.06	0.06	0.05	0.05	0.138
CLSG $	0.115	0.115	0.115	0.115	0.115	0.241
Total costs per kWh billed based on LEC's assumed energy mix	0.69	0.36	0.29	0.28	0.28	

Source: LEC Business Plan 2019; Per kWh CLSG was negotiated down from 0.17 per kWh.

Note: *Based on author's calculations from 2022 LEC estimates assuming $0.02 LEC technical losses, $0.02 LEC T&D, $0.02 LEC overhead, $0.01 LERC fee and for CLSG $0.04 TSA charge and $0.008 CGLS technical loss.

Figure V.20. Average LEC tariff over time



Source: LEC administrative data

Several cost-of-service studies have modeled different tariff structures and rates. The rates in each study were higher than the rates that LERC ultimately approved. Because of LEC's extremely tenuous financial situation, the tariff reduction was financially irresponsible, with LEC's high operating costs relative to electricity sales, high fuel costs, and exceedingly high commercial and technical loss rates. The studies made the following recommendations:

- A 2018 WB-funded cost-of-service study suggested a residential rate of **$0.32 per kWh,** with a fixed charge of $4.80 per month and **$0.22 per kWh** for households consuming less than 50 kWh per month. However, the model was based on old data, and the authors acknowledged that the tariff would have a negative impact on LEC. In 2019, LEC estimated total costs billed per kWh at $0.69, which was projected to decline as generation, new customers, and billing increased.
- In 2019, under GoL pressure, ESBI modeled a tariff of **$0.30 per kWh** for the first 20 units of electricity consumed by all residential customers. LEC estimated that even a US$0.05 reduction in the tariff would reduce revenue by $24 million per year and $77 million over five years (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."* While the Covid-19 pandemic negatively affected Liberia's economy from 2019 to 2021, LEC's financial burdens increased as T&D infrastructure expanded and MCHPP OMT costs were due.
- Still, with pressure to reduce the high tariff, and optimism that the lower tariff could reduce power theft, the 2021 MCC funded cost-of-service study suggested a tariff of **$0.24 per kWh for most customer classes** and **$0.10 kWh for social consumption.** These tariffs relied on models with outdated data (for example, underestimating the rate of connections and overestimating average consumption) and incorrect assumptions (for example, that power theft would be reduced by 10 percent per year rather than the actual of 2 to 5 percent). Interestingly, the cost-of-service study willingness to pay analysis confirmed that households with electricity value better service quality. Although reduced revenue impedes LEC's ability to maintain grid infrastructure, the study found that households will pay a higher tariff to have better quality services with fewer weekly outages:

  Using their reported expenditures as benchmark, we find that connected households were willing to pay, on average, 5.3% of their expenditures for an electricity service with 3 weekly outages, … 3.1% for 6 outages."

Despite LEC's financial situation, outdated or flawed assumptions in the tariff model, and Liberians' willingness to pay more for better quality, LERC approved a significant tariff reduction in January 2022 (Figure V.20). Considering LEC's above-average tariff and minimal access to electricity—and the upcoming election season—stakeholders reported that GoL pressured LEC and LERC to lower the tariff, arguing that affordable electricity is fundamental to economic development. Approved rates are $0.15 per kWh for the social tariff for end users with consumption less than 50 kWh per month (97 percent of LEC's customer base). All other rates include a small monthly fee plus $0.24 per kWh for residential, $0.22 per kWh for non-residential, and $0.19 for medium voltage end users. As described in Chapter IV, the reduction—

which was significantly less than the tariff recommended in the COSS study because of the changing customer consumption—stunned ESBI leaders, as it was approved suddenly over the holidays without validation of the methodology and "ignored extensive engagement between LEC and LERC".

The tariff is not cost reflective. LEC's grave financial situation, coupled with growing demand across an increasing customer base with low average consumption and reduced revenue with the low tariff, will cause a downward spiral without any donor or other intervention (Figure V.21, V.22.). According to LEC leadership:

> *"LEC has never been in a worse situation. We are managing on a daily basis to stay afloat. Cash flow is dire. We are $37 million in debt."*

Other LEC stakeholders explained:

> *"The grid expanded massively. We expect to hit 75 MW by Christmas this year [2022]. We have a whole load of customers who wanted to connect to the grid given LEC is 24 cents per kWh vs. $12/gallon for diesel. We have a lot more infrastructure to maintain but no working capital. We are struggling across the board. It's a perfect storm. Everything happening at the same time: increased demand, tariff reduction, revenue collapsing. Our costs going up like crazy. We are losing $100k/day. We won't be able to pay down our $6 million Ecobank loan. Ecobank wouldn't give us a loan unless they did a lean on all assets. If we can't pay, they own Mt. Coffee, all of LEC's assets."*

LEC is not paying its bills:

> *"We're not [paying bills]. We borrowed $6 million from Ecobank to buy fuel. Did same last year. Then we paid off in the rainy season. That is not going to happen this summer. We won't be able to pay off this summer because of tariff."*

LEC's mix of generation (MCHPP, thermal, or CLSG) requires a tariff that covers the weighted average of the overall energy pool. At best, the cost per kWh billed—including LEC and regulator costs—is **$0.138 for hydro**, **$0.328 for thermal** generation, and **0.241 for CLSG** (which is not yet operable). With the current customer base, most users will consume less than 50 kWh per month and pay $0.15, which is untenable given the mix of thermal and potentially CLSG consumption. Rates for residential and non-residential customers ($0.24, $0.22) can almost cover the mix, but not when MCHPP is unavailable. If medium-voltage users, at $0.19 per kWh, maximize consumption during six months of the year when thermal or CLSG is predominant, LEC will lose about $0.14 or $0.05 per kWh respectively.

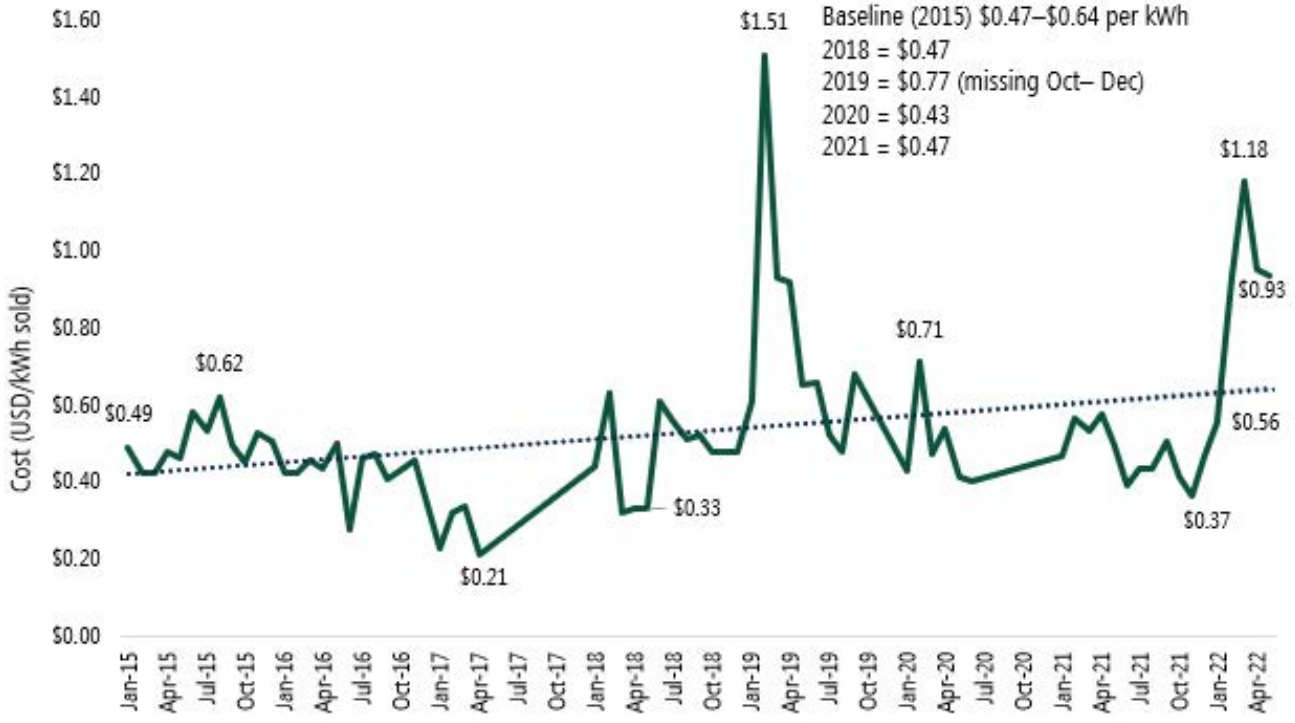
The worst-case scenario occurred in February 2022. At the Energy Sector Working Group (ESWG), ESBI explained that the unprecedented dry season caused MCHPP to operate less than three hours per day, making Bushrod thermal generation the primary provider. With 19 MW available and 12 MW dispatchable, LEC was using, 23,000 US gallons per day at a cost of $70,000, requiring 70 to 80 percent load-shedding (Figures V.24 and V.25). The tariff cannot cover the fuel cost. This scenario could repeat given that CLSG power—most important during the dry season when MCHPP is unavailable—is risky with thousands of kilometers of lines

crossing the rain forest. Repairs will be challenging in remote locations, requiring LEC to serve customers with high-priced thermal generation during outages. The situation underscores how crucial MCHPP is to LEC's solvency as low tariffs cannot recoup high fuel costs.

LEC was unable to meet targets for operating costs per kWh. LEC's financial situation is illustrated in Figures V.21 to V.29. LEC's operating cost per kWh (a contractual KPI) ranged from **$0.47 to $0.64** between 2015 and 2017. MCC set a **target of $0.45 per kWh,** which ESBI achieved only in 2020. By 2021, operating costs were **$0.47** on average—driven up by dry-season fuel costs—but as low as $0.37 per kWh in October 2021. Increased global fuel prices caused operating costs to spike to $1.18 per kWh in 2022, forcing LEC to hold salaries, deplete escrow accounts, and accumulate $5.3 million in Ecobank loans and $2 million loan facility against LEC assets.

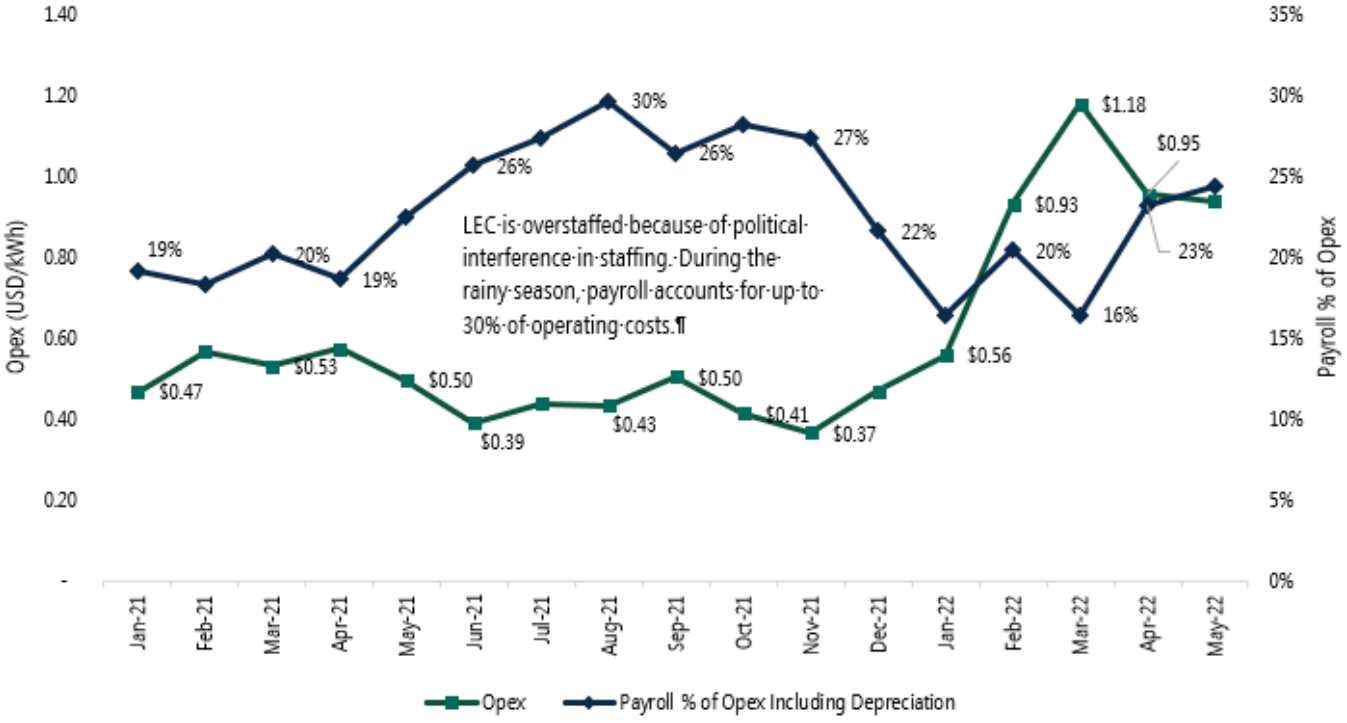
LEC's operating costs are driven by high dry-season fuel costs and worsened by inflated payroll costs, as GoL required that ESBI hire hundreds of unneeded staff. Figures V.23 and 24. illustrate LEC's fuel usage and expenditures, which drive up operating costs in the dry season and lead to increasing debt. LEC's payroll continues to account for a high percentage of operating costs, particularly as LEC has far more staff than necessary (843 employees), yet lacks critical skills and capabilities given. (See EQ C5 for an analysis of LEC staffing) (COSS 2021).

Figure V.21. Operating costs per kWh sold



Source: LEC administrative data

Figure V.22. Operating expenses (Opex) and payroll percentage of opex



Source: LEC administrative data

Figure V.23. Fuel oil usage US gallons/MWh) and kWh per US gallon (LEC administrative data)

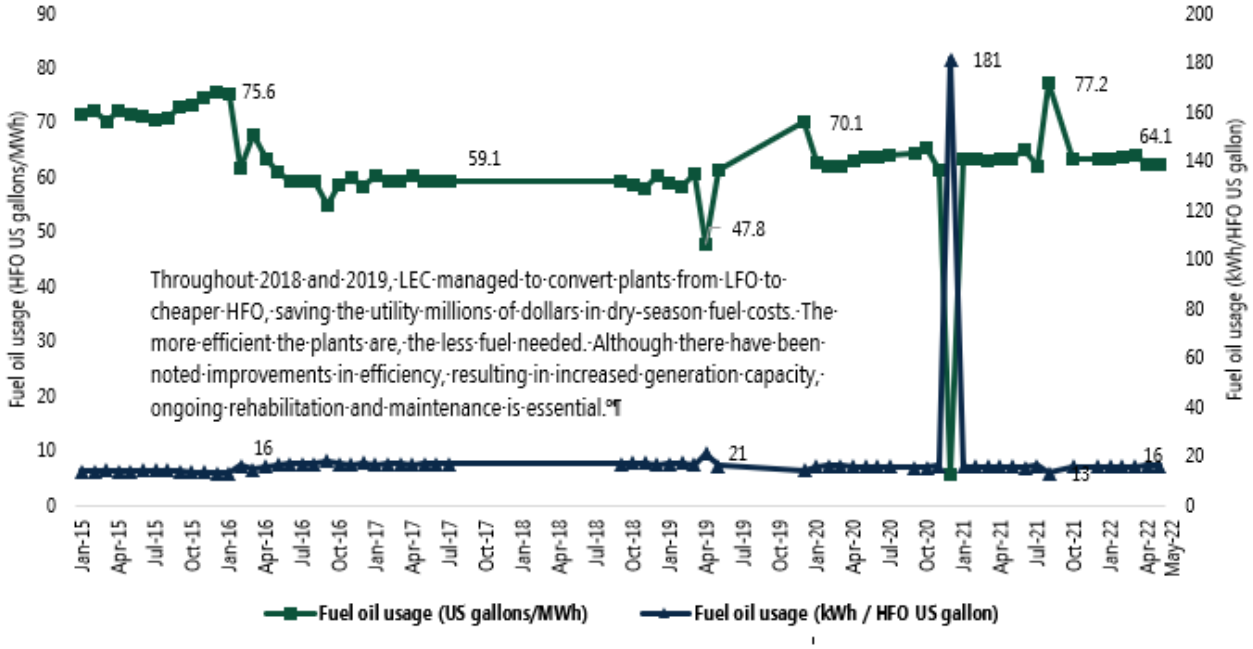
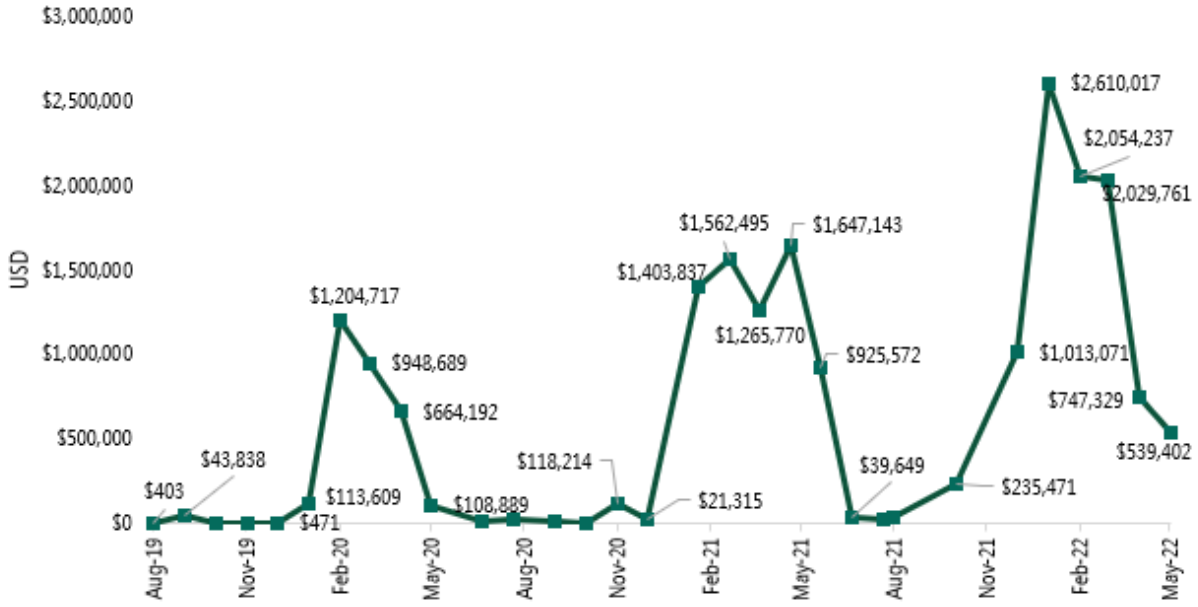


Figure V.24. Total fuel expenditures

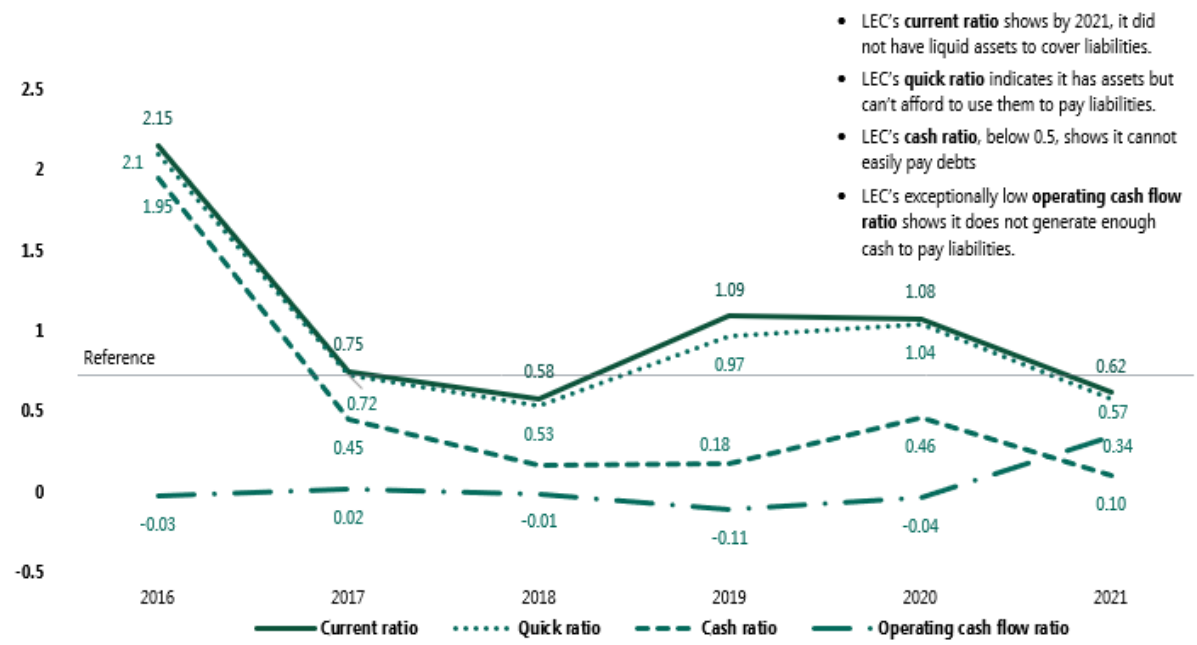


Source: LEC administrative data

Notes: Fuel expenditures increase each dry season when MCHPP is not generating. CLSG was supposed to become operational, reducing dry season fuel spikes, but high entry fees (security deposits and fees) have delayed its commissioning.

LEC has been in a grave situation, with all financial measures worsening and cumulative losses growing. LEC has an unfavorable current ratio, quick ratio, cash ratio and operating cash flow ratio, along with a dismal profit margin and return on equity (Figures V.25., V.26. V.27. V.28). LEC's net profit and losses are shown in Figure V.27. Mounting losses are driven by lack of OPEX and CAPEX, high fuel costs, power theft, and political interference in operations. LEC has lost about 47 million a year to power theft and inadequate billing and collections. LEC also carries debt and liabilities, including payments due for the MCHPP O&M contractor, the European Investment Bank (EIB) loan (for MCHPP), CLSG, Côte d'Ivoire cross-border power (which had been consumed but for which the tariffs were uncollected), West African Power Pool subscriptions, purchase dry season HFO, and tax due to the Liberian Revenue Authority.

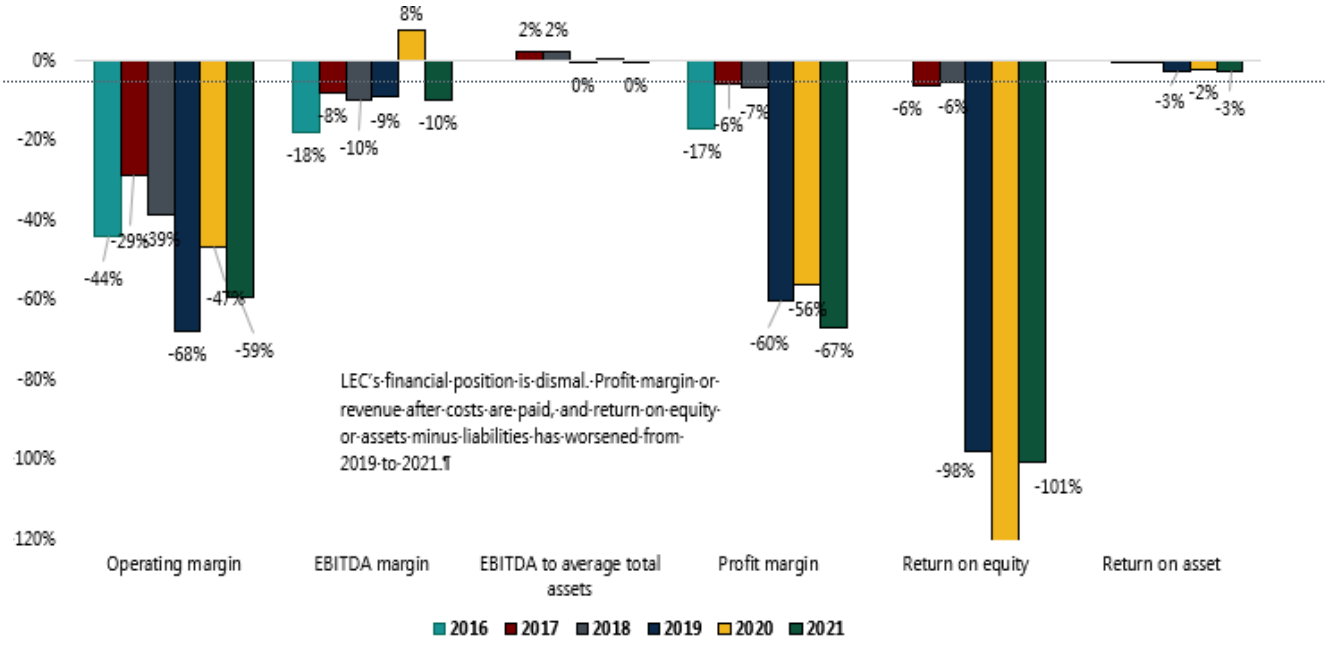
Figure V.25. LEC financial ratios



Source: LEC administrative data

Notes: A **current ratio** below 1 means LEC does not have enough liquid assets to cover short-term liabilities. A **quick ratio** of 1 indicates that LEC has exactly enough assets to instantly liquidate to pay liabilities. A **cash ratio** above 0.5 to 1 indicates that LEC has the cash or equivalents to easily pay off debts. An **operating cash flow ratio** below 1 indicates that LEC does not generate enough cash to pay liabilities.

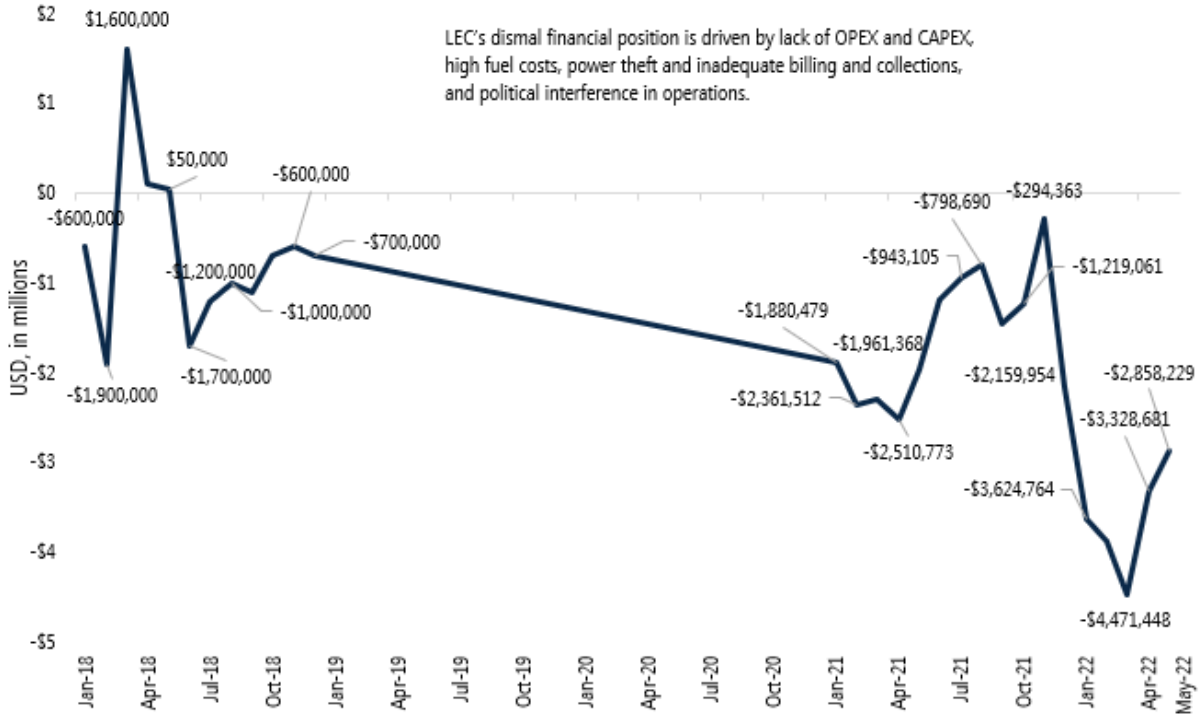
Figure V.26. Operating margin and other financial data



Source: LEC administrative data

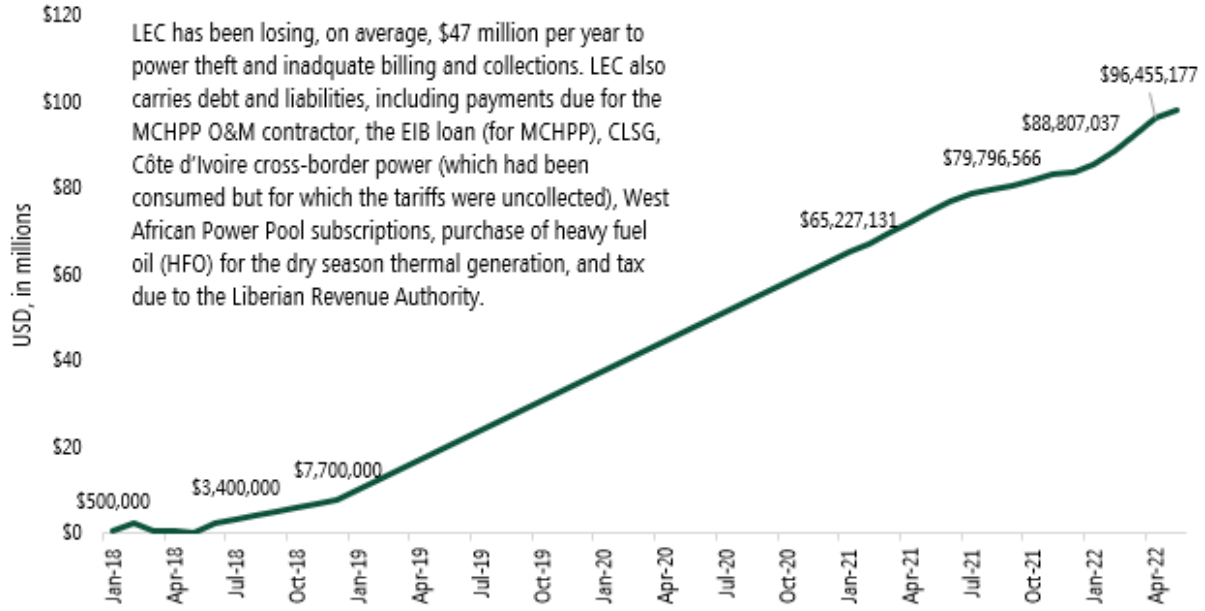
Notes: The **operating margin** measures revenue after paying operating costs and generation costs. **EBITDA margin** measures earnings before interest, tax, depreciation and amortization. The **EBITDA to average total assets** measures LEC's profit generated compared to assets. The **profit margin** is LEC's revenue after costs are paid. The **return on equity** measures LEC's assets minus liabilities or how it uses investment dollars. **Return on asset** measures LEC's profit in relation to resources.

Figure V.27. Net profit and loss



Source: LEC administrative data

Figure V.28. Cumulative losses



Source: LEC administrative data

EQ C3: To what extent have the MCHPP Rehabilitation and Capacity Building and Sector Reform Activities affected the number of users connecting to the grid and the demand for electricity?[25]

MCC's investments in MCHPP Rehabilitation and Capacity Building Sector Reform activities increased new-customer connections and exceeded the MSC's contractual targets. LEC estimated that there were 35,000 customers vending at baseline with a contract target of 94,000 connections. LEC was slow to connect customers, with delays in donor-funded distribution projects and capacity constraints. In 2018 and 2019, LEC had 54,000 vending connections (or 115,000 if illegal ones are counted). Connections grew to 76,263 in 2020, 138,800 in 2021, and 157,000 by March 2022 (Figure V.29). Figure V.30 shows the rise in connections and the decline in average consumption.

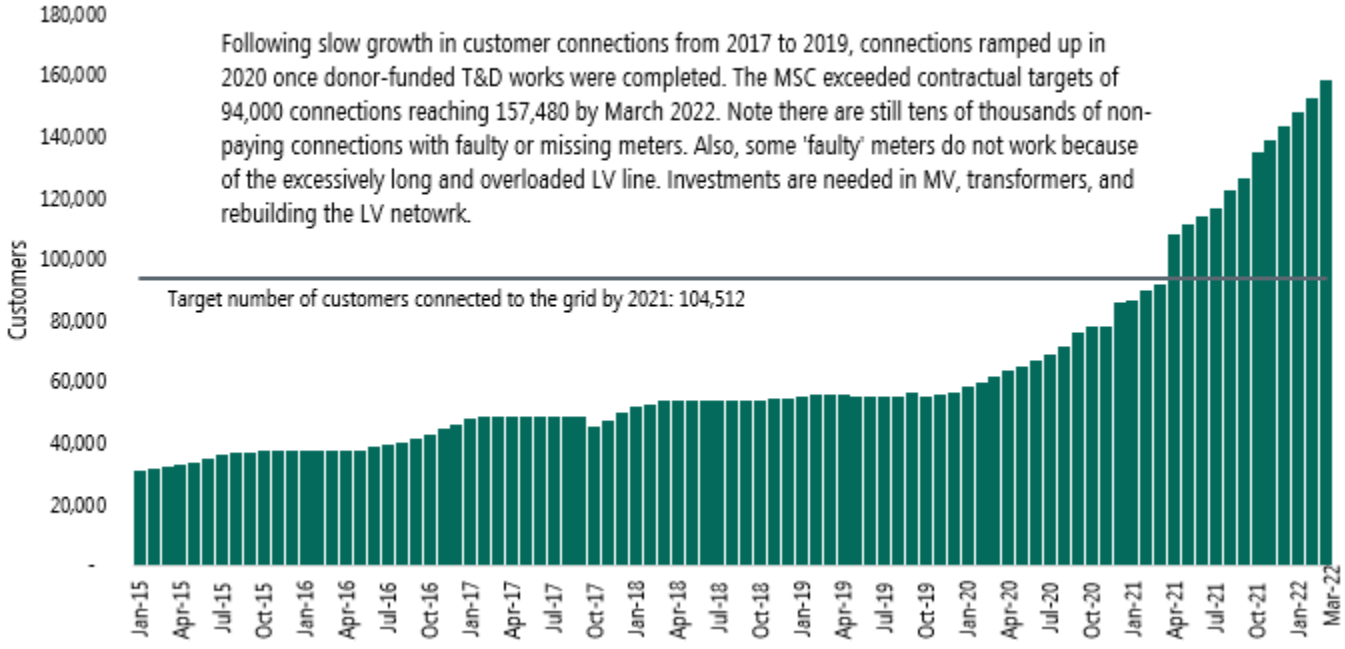
Analysis of night light data shows increased power use from 2010 to 2020. While lights can radiate from LEC, private generators, solar power, or other sources, we show the growth in night lights, likely driven by electrification, from 2010 to 2015 and 2020 in donor project areas (Figure V.31). Liberia has made progress, though it has a long way to go to increase access to low-cost energy country-wide and reach the goal of connecting 35 percent of the population by 2030.

[25] Findings from the end-user quantitative surveys are presented in Chapter VI.

Electricity demand has increased given MCC's investments. Figure V.32. displays peak demand, which measures the highest electrical power that customers demand (on monthly basis). Demand has increased from 13 MW in 2015 to 28 MW in 2018 and 52 MW in late 2021. At the same time, unserved demand, which measures forced load-shedding or user demand that cannot be supplied, has trended downwards but annual rainy season spikes persist when fuel costs require that LEC schedule forced outages. We note that as Figure V.32 displays, increased connections with reduced average consumption suggests that access to electricity is expanding beyond Monrovia's elite, higher-income households and businesses to more users with modest income.

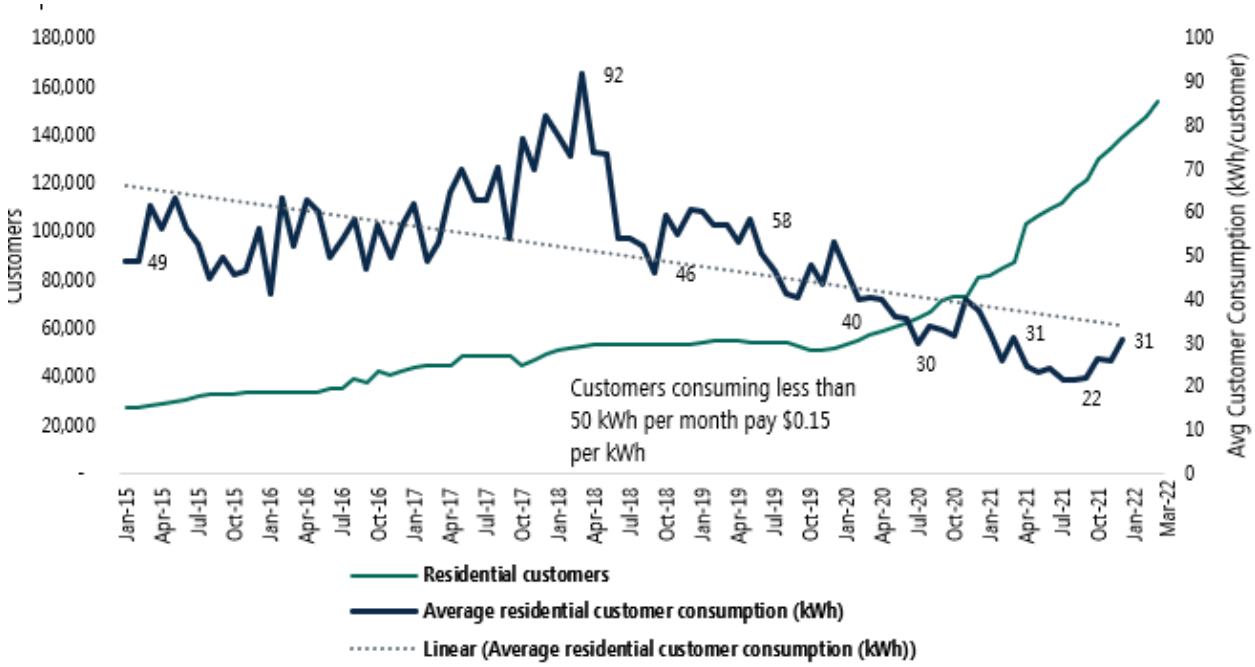
While connections have increased, average customer consumption has declined over time. By April 2022, 97 percent of connections were residential, and average consumption was less than 50 kWh per month (ranging from 22 to 40 kWh) Figure V.33. Figure V.31. shows average total customer and residential customer consumption trending down from 2015 to 2022, which suggests that electricity access is expanding beyond Monrovia's higher-income, higher-consumption households.

Figure V.29. Customers connected to the grid, by customer class



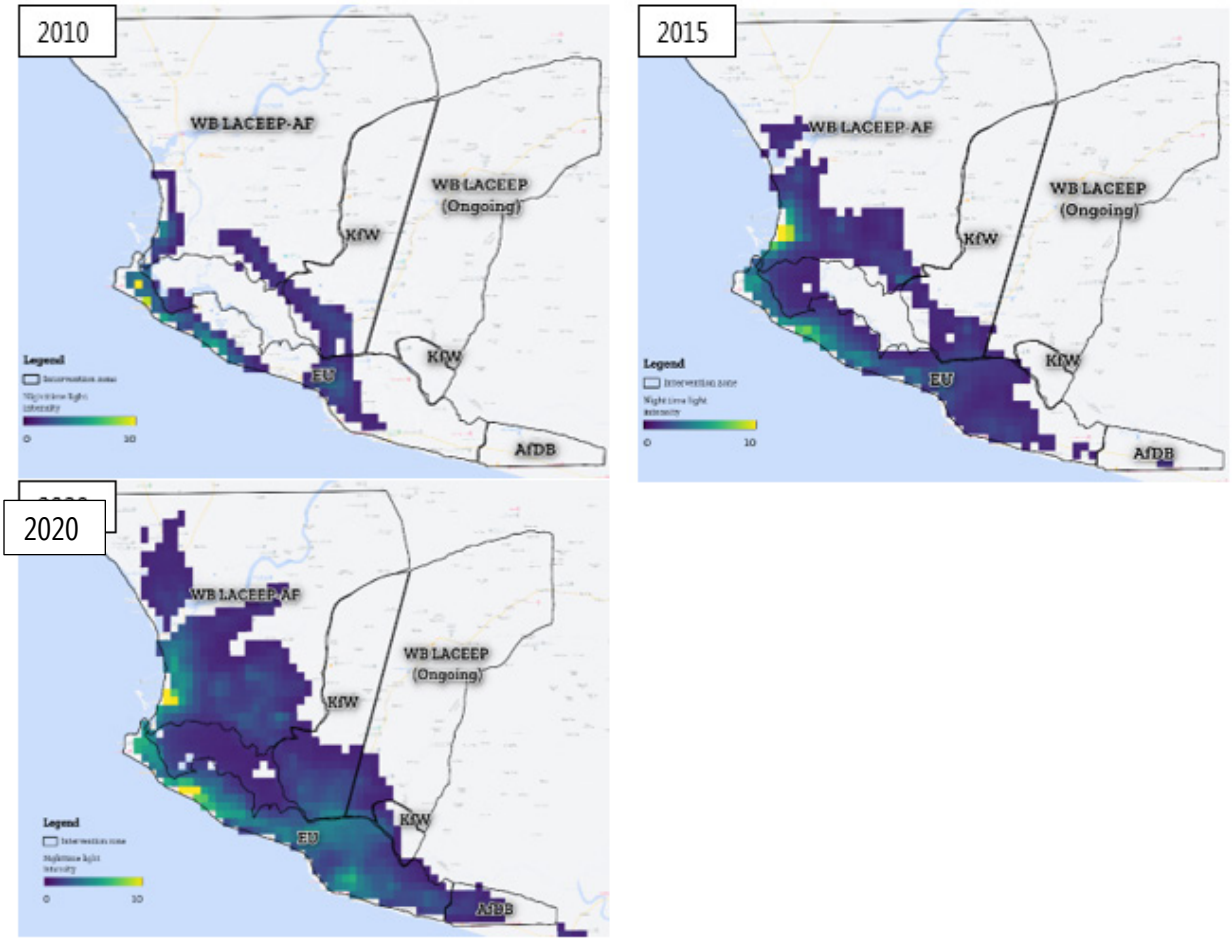
Source: LEC adminstrative data

Figure V.30. Residential customers and average residential consumption



Source: LEC adminstrative data

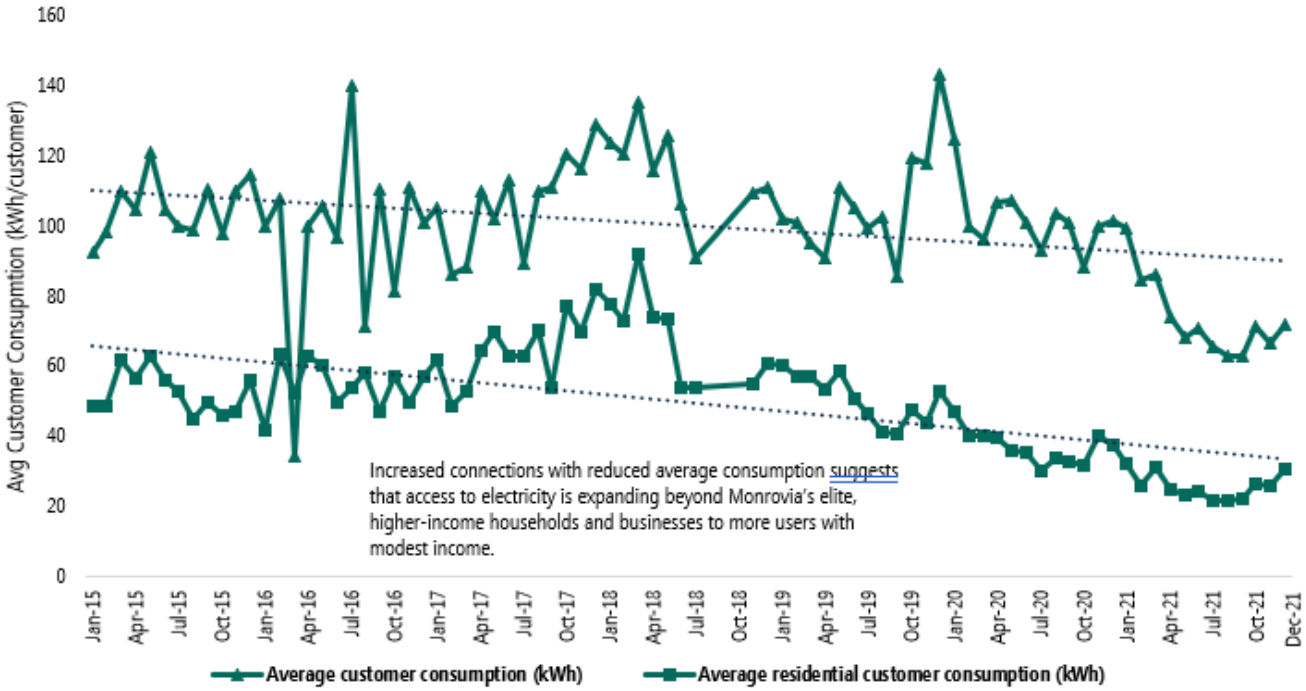
Figure V.31. Average nighttime light intensity 2010, 2015, 2020



Source: Chen et al. 2020.

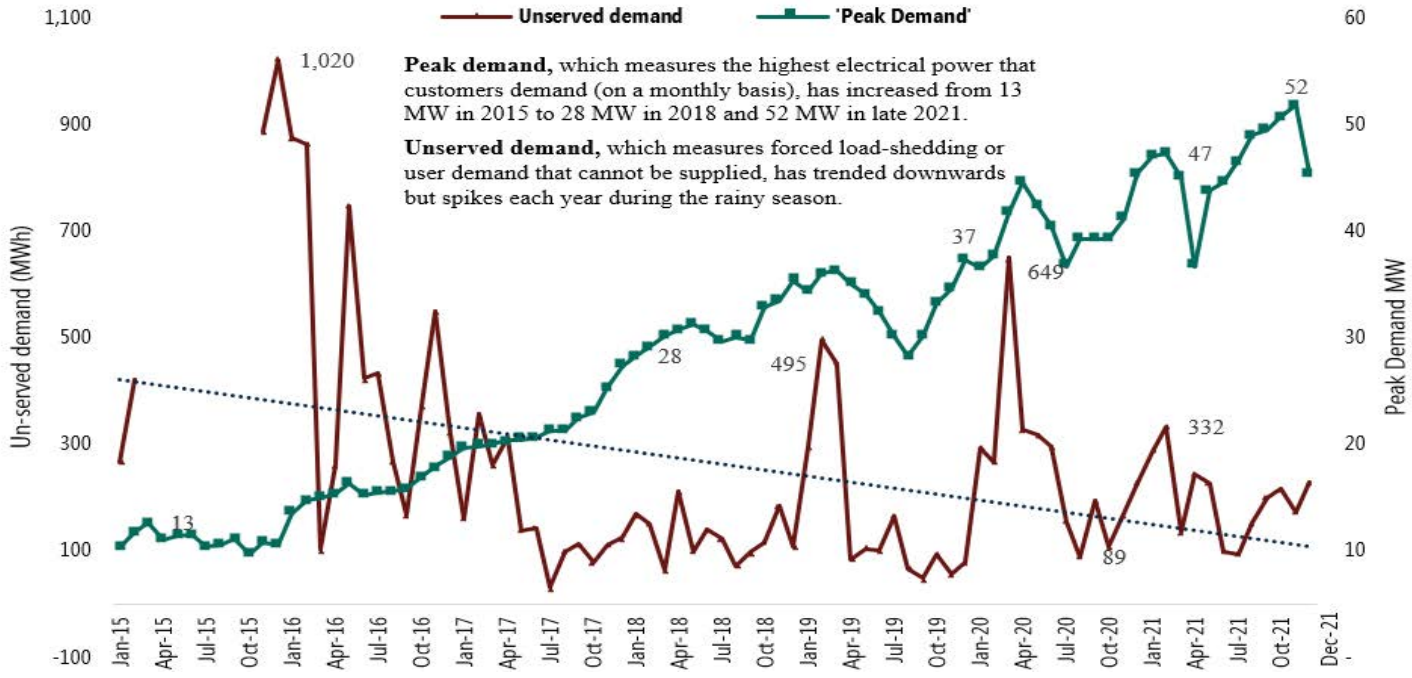
Notes: Night light data over time shows increased electricity use (any source) throughout Monrovia. Project borders are added to show donor areas. Yellow indicates the highest intensity of lights. Non-time-lapse images are taken from annual cross-sensor fusion data, but do not apply a convolution filter (that is, retain raw values after clipping to national borders).

Figure V.32. Customer consumption



Source: LEC administrative data

Figure V.33. Unserved demand



Source: LEC administrative data

EQ C4: To what extent, if any, has LEC's management improved since the MSC became effective?

The MSC improved LEC management on multiple measures since assuming operations of the failed utility in 2018, achieving several KPIs, including reduced operating costs, new connections, and improved network performance. The MSC has improved thermal plant and infrastructure maintenance, assumed ownership of more than $200 million in new T&D infrastructure, ensured the passage of the Power Theft Act, migrated from paper to digital data management utilizing the IMS database built in 2019, established a Training and Development Department, opened a new Customer Service Center, and instituted improved service practices. However, utility reform and organizational transformation have been hampered by excessive shortages of resources, political interference in operations, human resource constraints, insufficient workforce development and training activities, a culture of corruption throughout LEC, and other complications. Plant and T&D maintenance and repairs and commercial operations remain inadequate. Next, we describe the MSC's performance related to commercial operations, including losses, billing, and collections; human resources, staffing, training, safety; customer service; and managing donor projects.

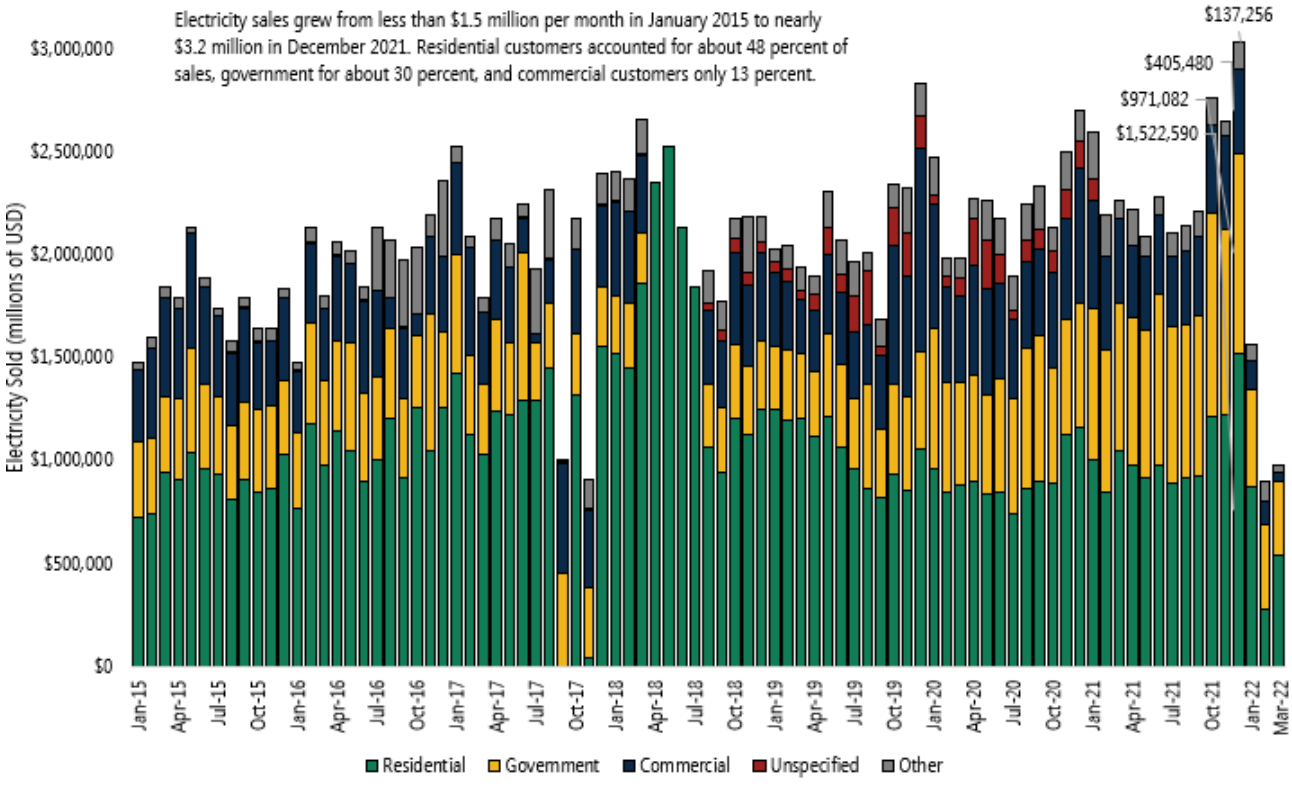
The MSC's management of commercial operations has been fraught with insurmountable barriers to improving LEC's commercial performance. While LEC's electricity supply has increased almost six-fold from 2015 to the end of 2021, sales have not quite doubled over the same period. Supply grew from 4,226 MWh in 2015 to 16,000 in January 2018 and 25,043 MWh at the end of 2021, and sales increased modestly from about $1.45 million in 2015 to $2.3 million in 2018 and $2.9 million at the end of 2021 (Figure V.34). Disappointing sales result from power theft, as well as inadequate billing and collections. Sales for all customer types have trended upwards—albeit modestly—since 2015. Residential customers account for the most MWh sold, followed by GoL (Figure V.35.).

LEC has not been able to achieve effective reductions in power theft without major investments and the political will to prosecute theft and prioritize LEC's solvency. LEC's six-fold increase in electricity supply from 2015 to 2021 meant that technical losses increased from 7.7 million MWh in 2018 to 12.8 million in 2021, and commercial losses increased from 16 million MWh to 25 million. LEC's untenable financial situation; lack of OPEX and CAPEX; absence of a SCADA system; inability to align staffing to LEC's needs and remove problematic personnel; prolonged delays in T&D construction and commissioning CLSG; and political interference in staffing and power theft prosecution means the utility averages a loss of ~US$48 million per year, with 62 percent of generated electricity going unpaid. Without effective loss control measures, political will, skilled staff, meters, and accurate SCADA level data, each of which LEC lacks, more power increases losses. Stakeholders noted challenges from the start:

We arrived in January 2018, identified commercial losses, and our team identified some of the key players. We [arranged] arrests, caught guys red handed. But because government had changed, (we were appointed under old government) and the new government didn't like us. Our appointment meant they lost control of LEC. Everyone we had arrested was released immediately, aided by [a political figure]. If you talk to him…nowadays he would say that was a huge mistake on his part. He was being told we were the devil. [A senior Board official's] task was to get rid of us. There was a hostile board/government. This was our first year in the trenches.

"We've been on an impossible journey of addressing commercial losses but without any money to invest in it. At the time we started, 60k customers were registered in the system, but there were a whole lot of illegal connections. How to tackle something at that scale? We had no GIS system saying where customers are. No billing system. (Libango—a vendor—had it). There was no metering on feeders, transformers. Only way we did it was to send whole guys out into field to cut down connections if not metered. Then people would pay LEC worker $100 in one day to keep their connection. We still don't have feeder metering. Don't have an integrated system. What we would really like to have is automated info on feeders, transformers, customers, revenue."

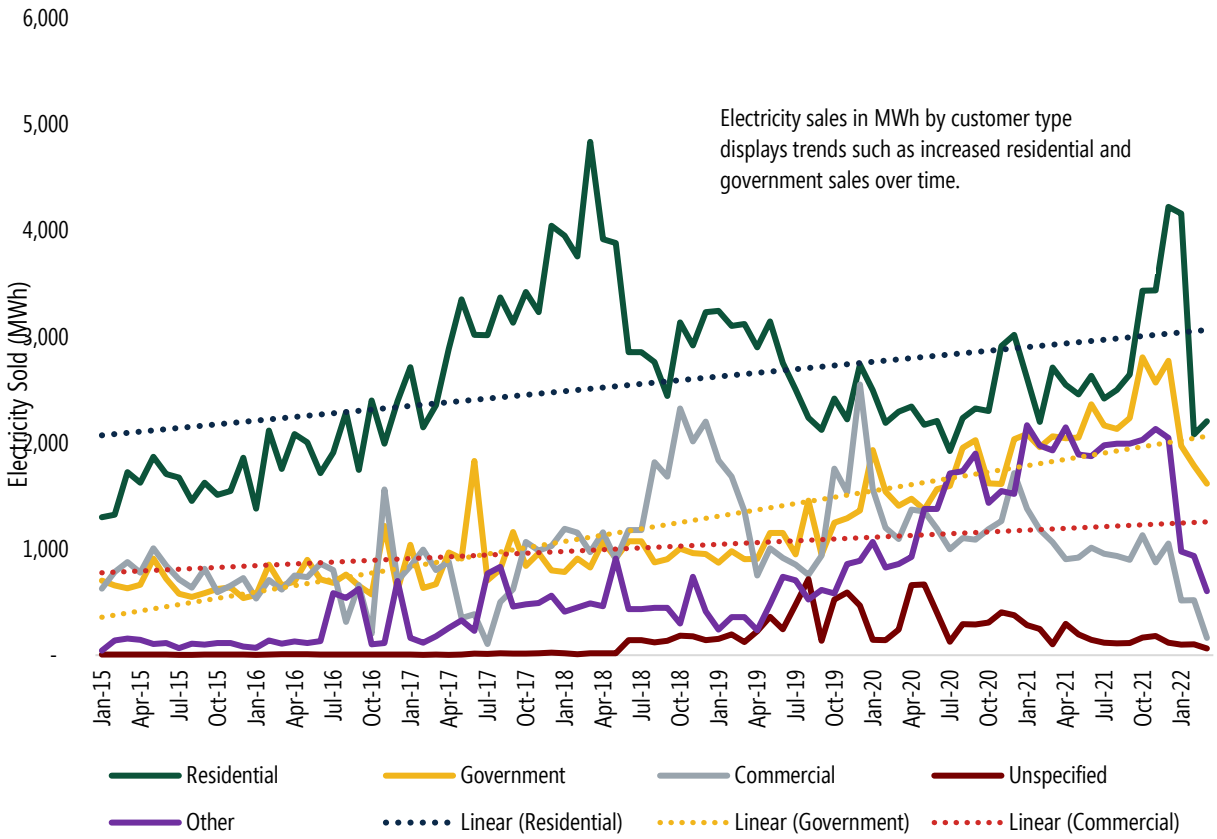
Figure V.34. Total electricity sold in USD, in millions



Source: LEC administrative data

Technical losses have been estimated at 12 percent, though not directly measured, given the lack of feeder meters. LEC lost about 500,000 MWh in technical losses in 2015 and an estimated 1.9 million MWh by 2020 (totaling $51.9 million from 2015 through 2021). Technical losses occur as electricity travels from generators across the T&D network to bulk and retail customers and occurs at connections, across lines, and at transformers. LEC's infrastructure is complicated by the fact that assets come from different donors and manufacturers. They are not standardized according to technical specifications, and LEC has no system-wide diagnostics, to pinpoint major sources of loss, or predictive analytics, to estimate the benefit certain repairs would yield. A utility cannot diagnose or measure loss, nor analyze patterns without inventoried, metered, and geolocated assets, but LEC lacks a full supervisory control and data acquisition (SCADA) system and meters at secondary substations, MV, and distribution feeders to measure load at each asset interface. LEC has relied on single line diagrams and AutoCAD maps, with manual logging of MV feeders, effectively managing losses "in the dark." The Asset and Customer Mapping Study (ACMS)—partially completed in 2021—created an inventory of geo-located assets, with make, model, status; however, the ACMS must be completed and continually updated as change occurs. LEC still requires the full SCADA system.

Figure V.35. Total electricity sold in megawatt hours (MWh), by customer type



Source: LEC administrative data

Commercial losses were 48 percent of supply in 2018, peaked at 58 percent in September 2019, dropped to 44 percent in December 2021, and totaled $204.1 million from 2015 to 2021. Combined, technical, and commercial losses were 56 percent of supply at the end of 2021. Commercial losses are due to errors, theft, fraud, and corruption. Errors may occur during manual processes and with inaccurate meters. Customers and LEC employees might steal or commit fraud by tampering with or damaging meters, directing hooking at busbars or low-voltage lines, deliberate deceiving people, or paying petty bribes charged by staff.

A 2021 Tata Power study documented that LEC's losses are due partly to staff capacity issues and inadequate meter management. First, LEC staff have limited skills in auditing, loss diagnostics, and analysis and have underutilized the IMS customer service and distribution management system modules. LEC has defective, broken, and missing meters; inadequate meter testing, testing kits, and benches. The 2021 ACMS estimated that 65 percent of meters were illegal, faulty, or unfindable. In addition, meter reading is manual and inadequate. In 2021, there was no data validation, regular prepaid meter inspections, or staff rotation for postpaid meter reading to reduce theft. Further, the cost of meters for normalizing customers ranged from $55 to $267 per prepaid and $2,139 per commercial customer. LEC indicated that many high security meter (HSM) installations require network reinforcement or reconstruction at a significantly higher cost. Metering staff capacity is limited with inadequate hands-on, mentored practice solving problems faced daily (Bos et.al. 2022) Tata emphasized that power theft cannot be reduced without resources and advised LEC to ensure that accurate meters are available across the value chain at all interface locations; that LEC develop processes and practices for testing, calibrating, and replacing faulty meters; that LEC improve meter reading processes (including frequency, recording load, voltage, and current frequency in energy audits). LEC noted that in some cases meters may pass testing but the low voltage system is inadequate so meters automatically shut off.

The MSC's Revenue Protection and Loss Reduction Unit has continually worked to reduce losses, albeit with limited success. In 2018, the MSC identified LEC's major constraints and then from 2019 through July 2022, the unit conducted a range of activities including normalizing customers with working meters, repairing transformers, utilizing data systems, conducting community outreach, establishing feeder-based management units, and trying to collect evidence so those who engage in power theft are prosecuted (Table V.5.) However, LEC has not been able to remove staff who are "known to commit theft", which undermines theft reduction.

To improve T&D operations, the MSC established feeder-based business or management units (FBBU or FBMU) in February 2021. The FFBU concept is based on assigning staff to one of five substations (Bushrod, Virginia, Stockton, Paynesville, Gardnesville). The staff (a manager, T&D, and maintenance crews) assigned are held responsible for the area surrounding the substation and must account for the energy. The FBMU team is supposed to learn the machinery and the terrain and randomly inspect connections to identify faulty meters and

indirect connections. FBMU teams are rotated annually to limit collusion with local end users or other actors. An advantage of FBMU is reducing staff time lost in travel and traffic. According to LEC stakeholders: *"The FBMU approach will reduce response time, localize the issues in the area, reduce the losses."*

However, LEC still lacks feeder meters at distribution points to determine where loss is coming from. Also, the FBMUs are not yet fully equipped with the necessary skills, materials, and meters to optimize performance. The five teams do not have the training and expertise needed to complete all tasks, though a working group is focused on assessing and planning to meet needs. Note that stakeholders describe power theft with the T&D Department and that skilled individuals, if not removed from LEC, will be able to continue stealing power despite the FBMU approach.

Table V.5. Loss Reduction Unit Activities

2018: MSC Y1	2019: MSC Y2	2020: MSC Y3	2021 – July 2022: MSC Y4 and Y5 WB 18-month contract
• MSC recognized LEC's "perilous" financials • US $21M in debt • Minimal inventory • Assets in disrepair • Poor meter reading • Inadequate billing • Faulty customer lists • High system losses • "Inordinate theft" • Poor data and processes 1,429 meters replaced 108 transformers replaced	• Normalized customers, converted illegal to legal • Focus on large customer • Saturate communities with new connections • Community meetings, behavior change • Make it hard for cartels • IMS with customer, network modules 5,225 meters replaced 104 transformers replaced 14 cases prosecuted	• Extensive donor T&D • +25,000 connections • Network performance improved • New IMS modules • Community outreach • Customer Service Center 3,562 meters replaced 60 transformers replaced 22 cases presented, stuck in judicial system	• Feeder Based Management Units (FBMU) launched in Feb 2021. • Tariff incentive large end users • Lifeline tariff, $0.22 kWh • Meter experts KfW 3, LEC 1. (Several chased out of country) • Donor efforts ≥100k new connections • CLSG (entry ~$10m) $0.17 kWh: potentially problematic if loss not reduced • 60,000 meters needed to connect and normalize customers, as well as feeder meters, SCADA

The MSC has had limited success trying to remove corrupt staff, reduce political interference, and prosecute theft. ESBI staff who had worked in many other countries over decades-long careers described how theft and corruption was greater in Liberia compared to other African, Eastern European, and Central and South American countries. The MSC was able to lobby GoL and worked with the LEC Board to get the Power Theft Law passed in 2019. The law had limited affect though, with few prosecutions, mostly of low-level offenders. Other cases were stuck in the system. By late 2021, following the May 2021 power theft presentation to the high-level Energy Sector Working Group (ESWG), there was an uptick in arrests and prosecutions (Table V.6).[26]

[26] MCC requested that the evaluation team conduct the analysis, which was created in collaboration with ESBI and presented to the ESWG.

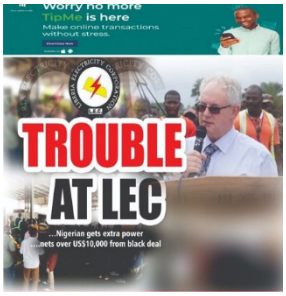
Table V.6. Power theft arrests and prosecutions in 2021

Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Arrests – reported by police and staff	-	1	2	3	2	3	4	15	16	43	25	-
Indictments	-	1	1	3	2	3	3	7	21	37	29	-
S = Sent to court	-	1	1	-	1	-	1	3	10	26	29	-
P = Pending	-	-	-	3	1	3	2	4	11	11	-	-
Resolved	-	-	-	-	-	-	-	8	4	5	-	-

Source: LEC presentation, Energy Sector Working Group February 2022.

LEC stakeholders described ongoing challenges faced in trying to remove corrupt staff, reduce political interference, and prosecute reduce theft:

Power theft is a very difficult thing to manage. It's almost like a pandemic now in Liberia. Even people who can afford it don't want to pay. Even some staff involved in it. The problem is the legal system. Even if we have evidence of staff committing theft, we cannot convict of theft from LEC. It has to be from the court. We can do an internal investigation. We have a disciplinary policy, committee, HR processes, and internal audit department. The committee will do investigation, go in field, do fact finding. … we make a recommendation…can't say we are terminating or suspending because of theft (per law). We have to say there has been a breach or violation of our own policy so we have a sanction.



If we suspect theft, we have to get evidence (which requires resources). We have someone we caught. The community was so angry because he's in security and presented himself as champion against power theft. Allegedly he would collect meters from people and resell them. Sometimes he would just disconnect people and say they have to pay to re-connect. The community was upset and reported him. We tried to keep it as close as possible so he wouldn't know (so we could gather evidence). HR worked with legal and theft team. We did surveillance, but someone tipped him off. We had a court order to go his house. We found meters, transformers, street lights. But even with all that evidence, it has been in two years in court. They reschedule, postpone. When it came time to testify, his lawyer said he should have a jury trial. [he has friends in government]. Even with evidence, pictures, witness, no trial or conviction. He should be sitting in jail.[27]

"Compared to other utilities, there is a higher level of theft/corruption at LEC than anywhere else. The lower level of staff is easier to handle. But the higher level—it's hard to touch them because they have connections with the government, big businesses. If they are caught and put in jail, someone will bail them out. The offenders know that everyone knows about them. We have tried exposing them but it doesn't make them stop. We have tried to use the Minister of Justice as an external support. We revamped the

[27] Daily Observer 8/30/22 "LEC Loses First Power Theft Case, But…" Online at https://www.liberianobserver.com/lec-loses-first-power-theft-case

handbook, set up processes for what to do when stealing. The result is that it slows them down, but it doesn't stop them.

"Before staff join the theft team, we do a reference check and all. It still does not guarantee that person won't be a thief. Communities will call and say, there is a situation with this guy. The problem sometimes is how to prove it. ... Someone filed a complaint against an LEC staff person who requested money from a customer. We investigated but the neighbor who called complaining had to be a witness. They said they couldn't do it. They were afraid they would be targeted. ... It is very common for people to be afraid to be a witness. That's why most cases don't go anywhere… This guy we terminated. We got a call from a minister/deputy minister that we should reinstate him, that we had terminated services unjustly. We had gone through the committee and disciplinary process explained he breached procedures. The minister even wrote to CEO for reinstatement. We said we cannot take him... There is lots of interference."

Despite the MSC's efforts to reduce power theft, aggregate technical and commercial losses (AT&C), a KPI, have trended upwards from 2015 to 2021. (Figure V.36.-V.39.) AT&C measures the overall efficiency of the distribution business, or the difference between energy input in kWh units and units paid in kWh. The global average for AT&C losses is under 9 percent. Few countries have rates above 30 percent (World Bank 2018). Liberia's rate ranged from 62 to 71 percent throughout. The AT&C highlights the extent of LEC's disappointing inability to improve billing and collections.

"Corruption in the energy sector is antipoor… Corrupt utilities are inevitably bankrupt utilities unable to extend service to those without it, usually the poorer segments of society." Laszlo Lovei and Alastair Mckechnie

Figure V.36. Total electricity supply, technical, and commercial losses, MWh millions (LEC data)

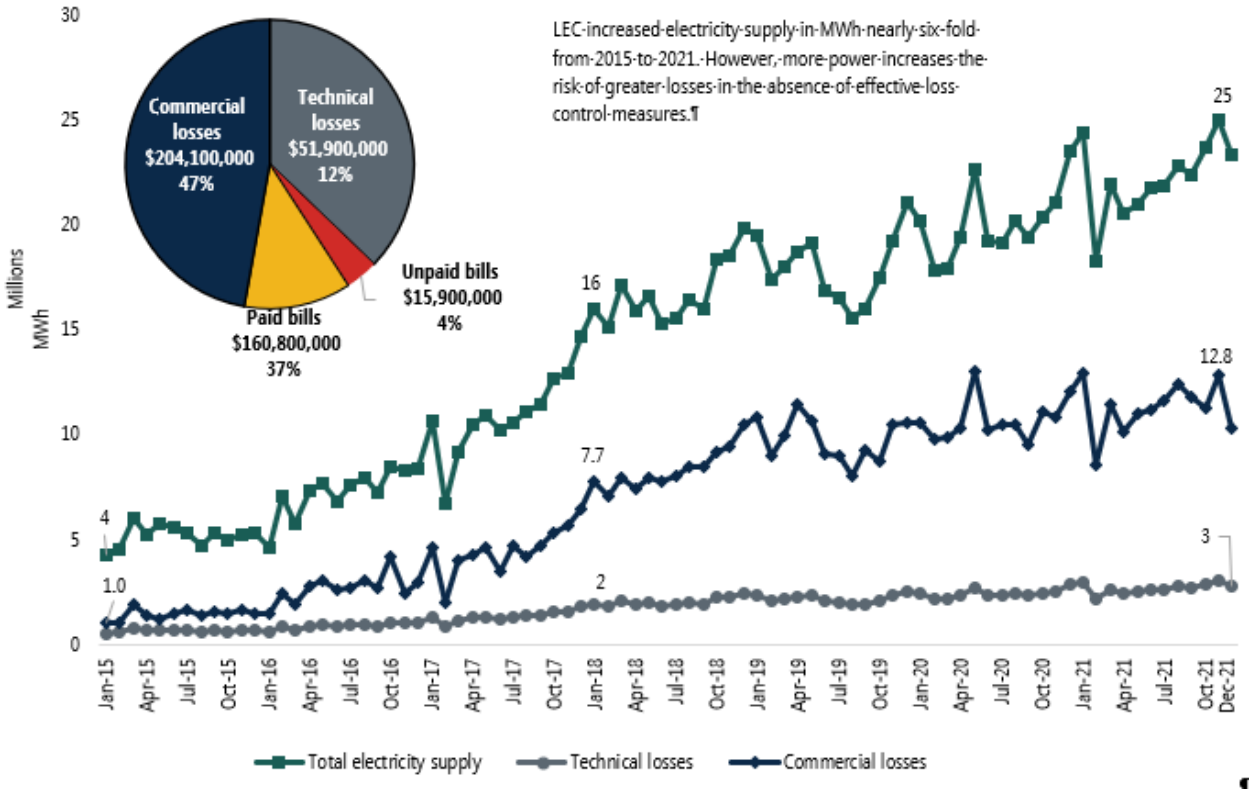
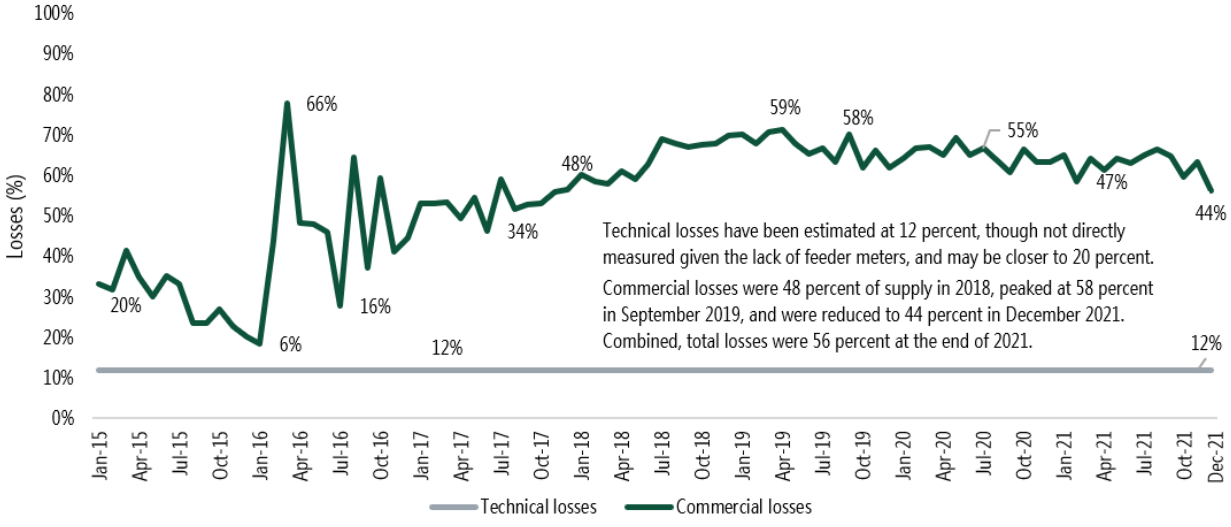
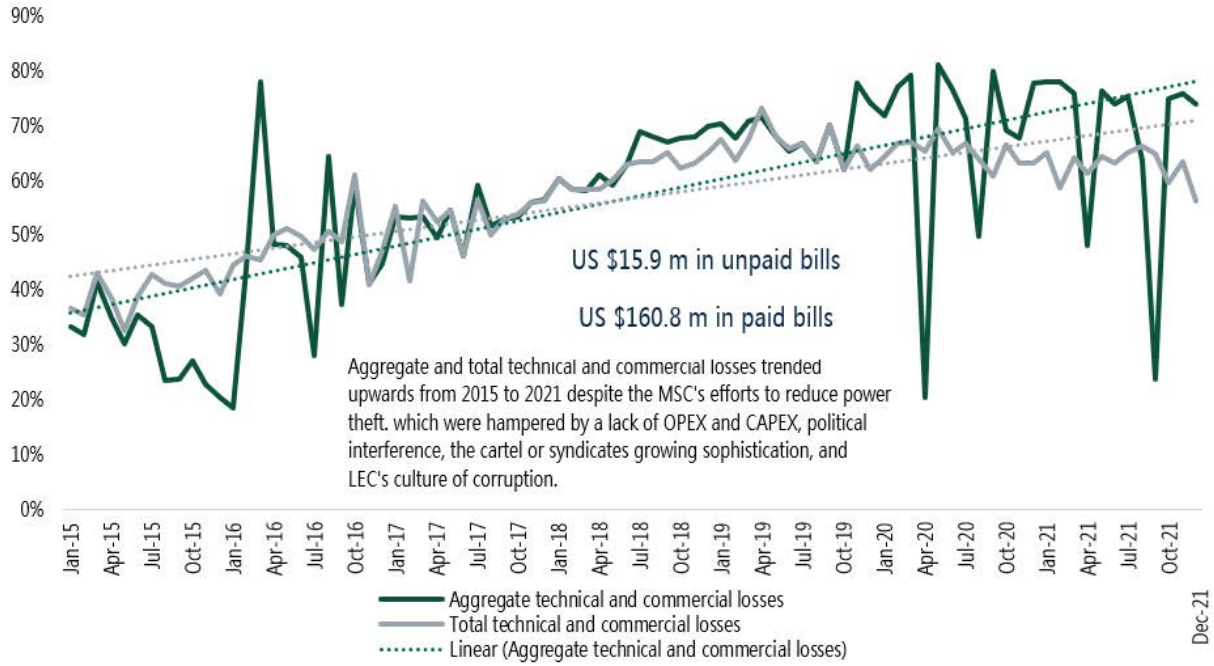


Figure V.37. Technical and commercial losses



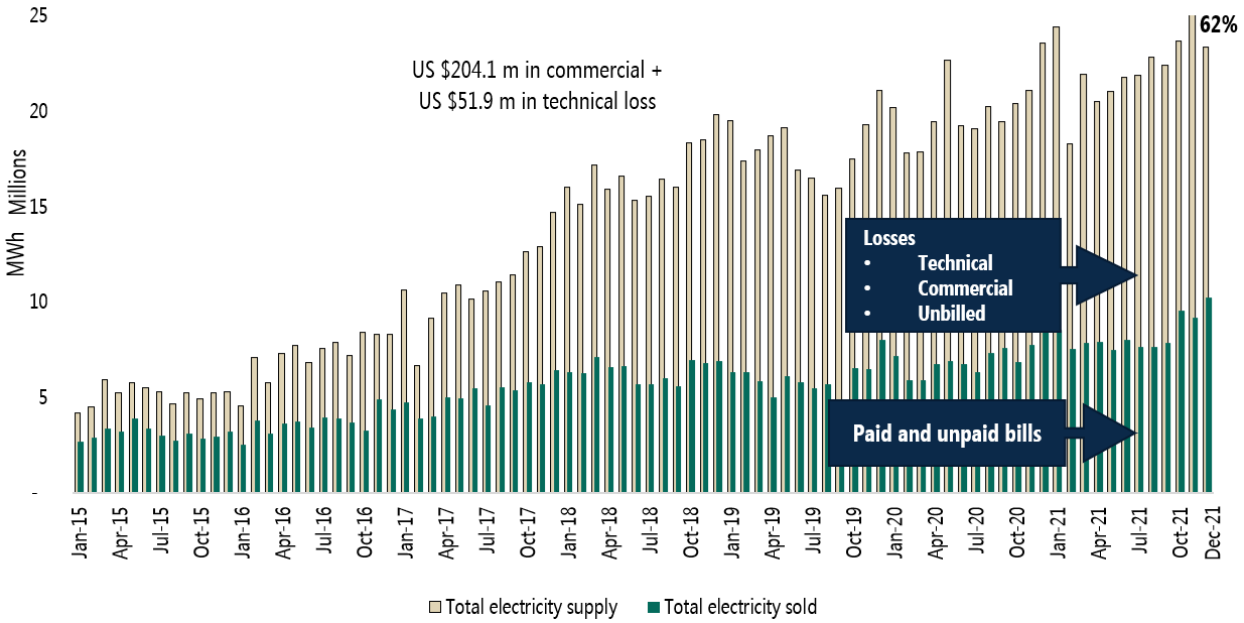
Source: LEC administrative data

Figure V.38. Aggregate technical and commercial losses (AT&C)



Source: LEC administrative data

Figure V.39. Total supply, electricity sold, and total losses (LEC administrative data)

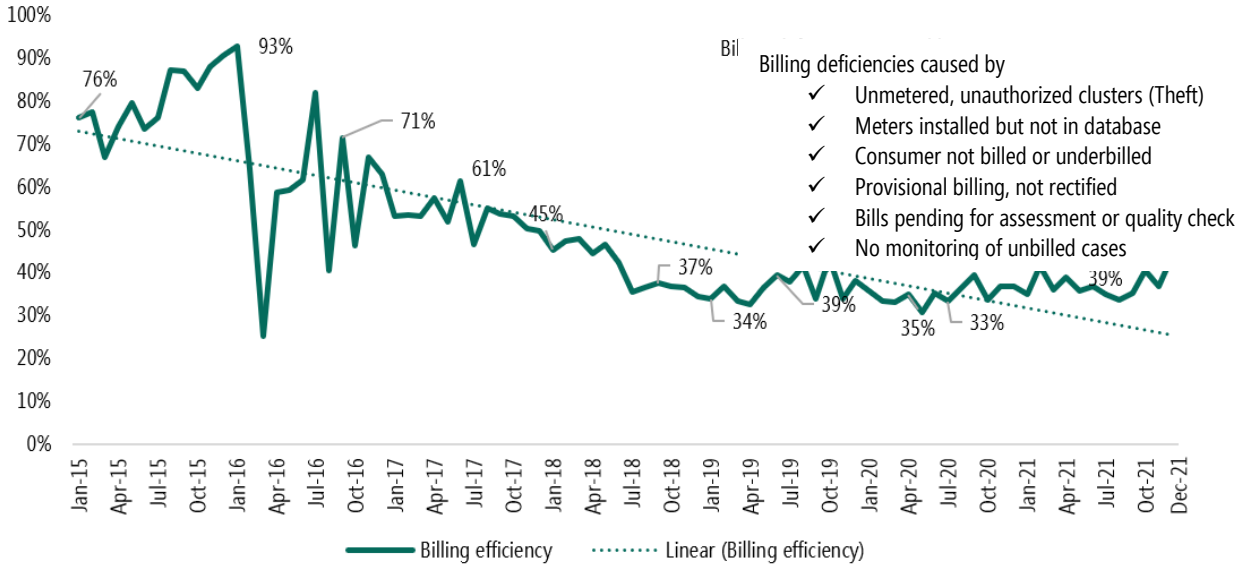


LEC's billing and collections remains insufficient to reduce losses, and chronic failure to pay bills threatens LEC's sustainability. Billing efficiency (or the amount of kWh billed to customers divided by the amount generated) trended downwards from 2015 (76 percent) to 45 percent in 2018, and 44 percent by the end of 2021. Inadequate billing is due to power theft, meters that are not in the LEC Commercial Management System (CMS), consumers being underbilled or not billed and other errors. This inadequate billing undermines LEC's financial performance (Figure V.40.).

Collection efficiency (or the amount of money collected from customers divided by the amount billed) trended upwards from 2015 to 2021, but it remains an area of weakness, requiring more reliable bill payment and collections of arrears (Figure V.41.). LEC's collections efficiency has fluctuated wildly, from 14 percent to 376 percent. This large range is generally due to GoL not paying and then finally settling outstanding bills.

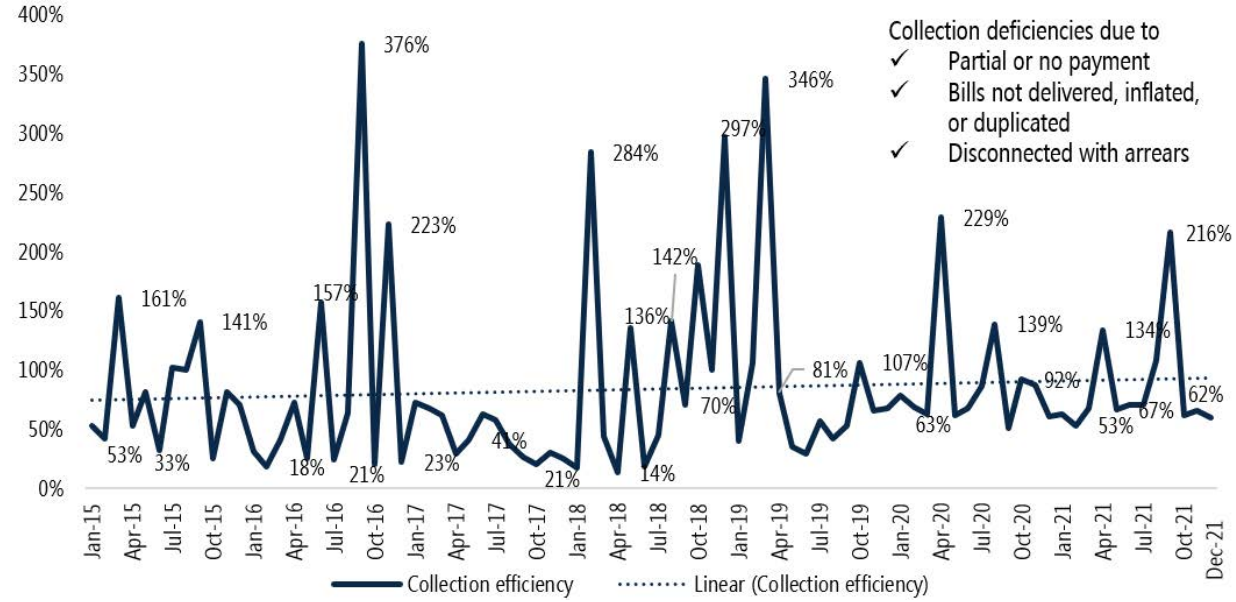
We calculated unpaid bills and collection efficiency by customer type and found that GoL has $7.1 million in unpaid bills, public corporations $5.6 million, and commercial customers $4.28 million (Figure 42). Public corporations with unpaid bills include Liberia Telecommunication Corporation, Liberia Revenue Authority, National Port Authority, Liberian Water and Sewer Corporation, National Oil Company of Liberia, Liberia Petroleum Company and others (Figure V.42.). Next, we estimated the value of paid and unpaid bills, commercial and technical losses from 2015 to 2021. We estimate $160.8 million in paid bills (37 percent of potential revenue) (Figure V.42. V.43). We also estimate that LEC has lost $271.9 million from 2015 to 2021, including $15.9 million in unpaid bills, $204.1 million in commercial losses, and $51.9 million in technical losses. We estimate losses of $49.7 per year in the past three years (Figure V.44).

Figure V.40. Billing efficiency



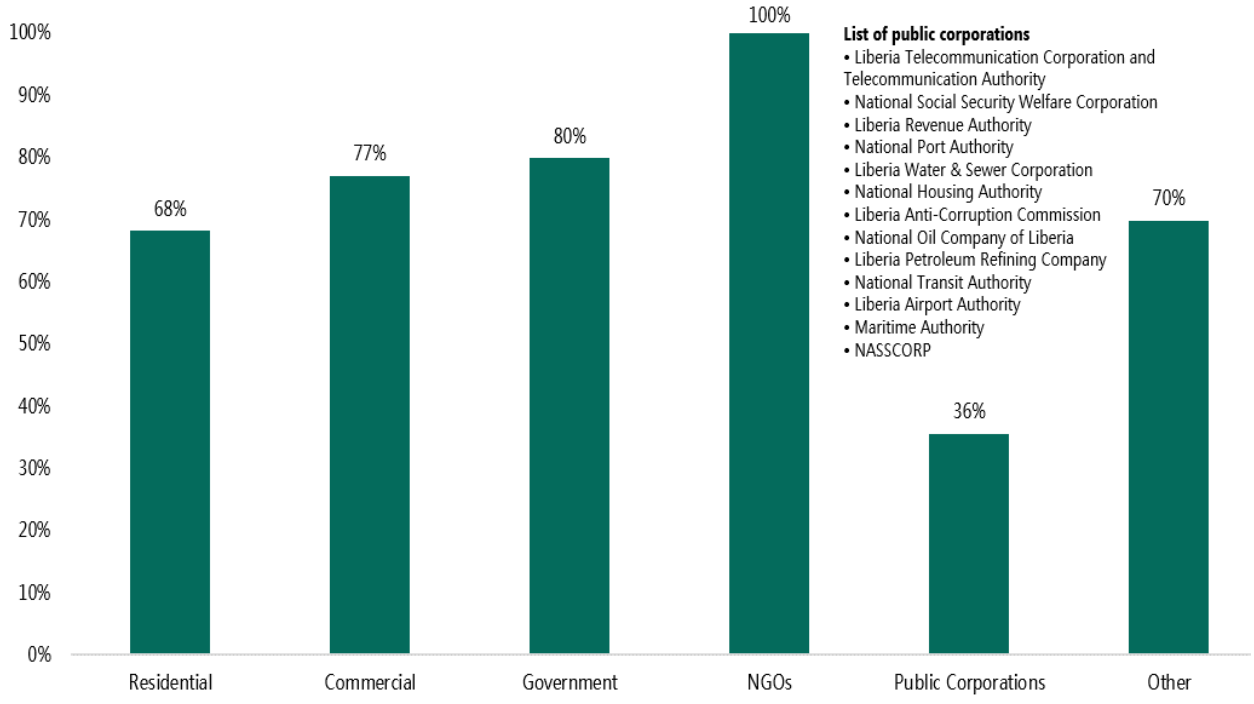
Source: LEC administrative data

Figure V.41. Collection efficiency



Source: LEC administrative data

Figure V.42. LEC collection efficiency by consumer type, 2015-2021

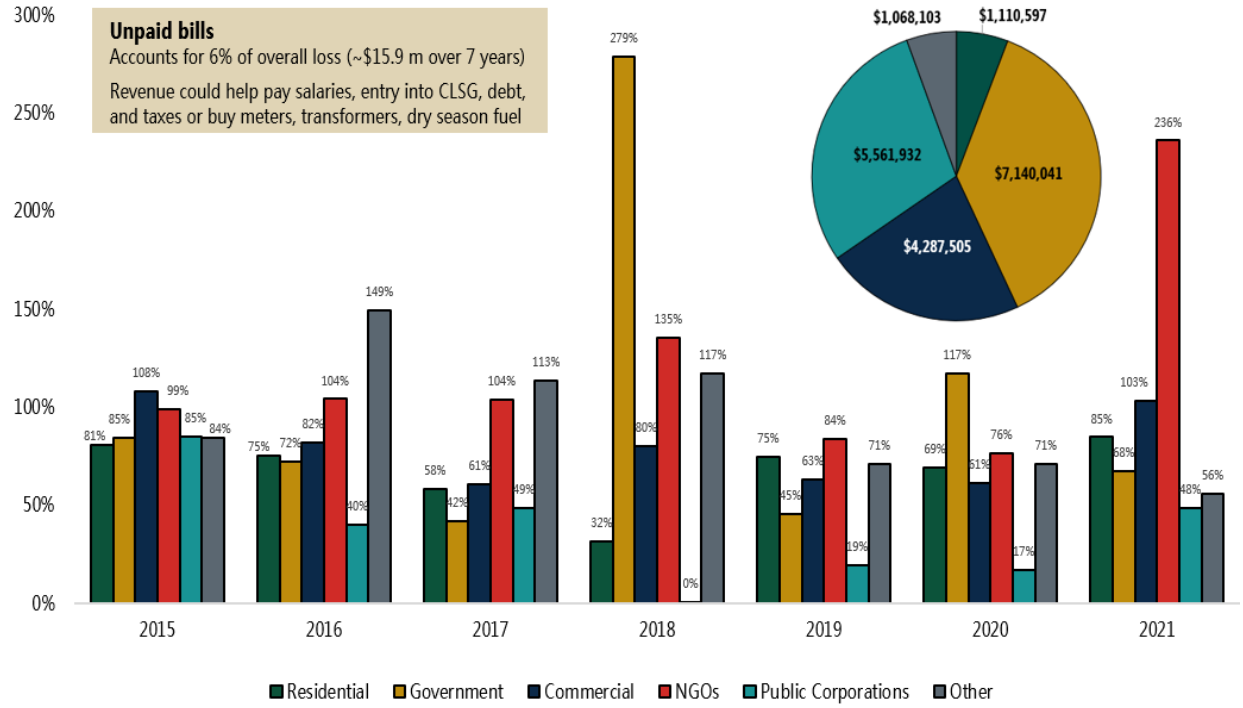


Note: Collection efficiency is the amount of money collected or realized from customers divided by the amount billed.

Source: Authors' calculation from LEC administrative data from 2015 until 2021. Data are missing for 8 months in 2018 and 4 months in 2019.

We present additional analysis on loss prevention activities, including the use of ACMS to understand each customer's connection. (Figure V.45.). Figure V.46 shows meter inspections conducted in 2018 and in 2020 during the ACMS study. Most meters were faulty or illegal in 2016 and in 2020. Attempts to normalize customers have been undermined by material shortages and costs (depending on meter type, $55–$267 per prepaid and $2,139 per commercial customer), as well as insufficient political will to dismantle and prosecute LECs sophisticated cartel and politically connected thieves. To normalize all faulty meters and make new connections, LEC needs about 60,000 meters. According to ESBI, LEC needs to enhance its information management system and install a new customer relationship management (CRM) system linked to its network to respond effectively to customer complaints. However, this requires significant investments, and funds are currently unavailable. Figures V.47.-V.49. show additional views in the ACMS and how the data can be used to identify and reduce losses and theft. Figure V.50. depicts the Feeder Based Management Unit (FBMU) approach designed to reduce losses by assigning staff to areas surrounding substations and increasing responsibility for the energy sales in that area.

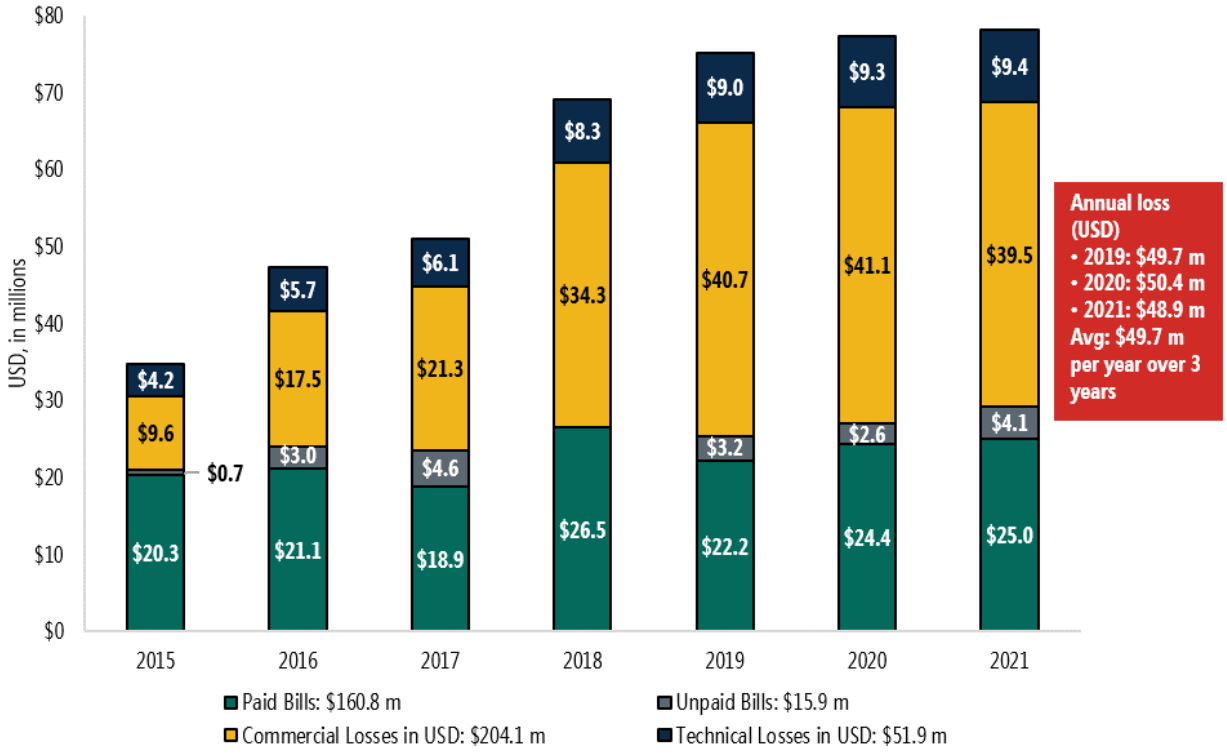
Figure V.43. LEC collection efficiency by customer type and year



Note: Collection efficiency is the amount of money collected or realized from customers divided by the amount billed. Some utilities may have collection efficiency higher than 100 percent, which may indicate that the total collections for the year included payment for bills in the previous period.

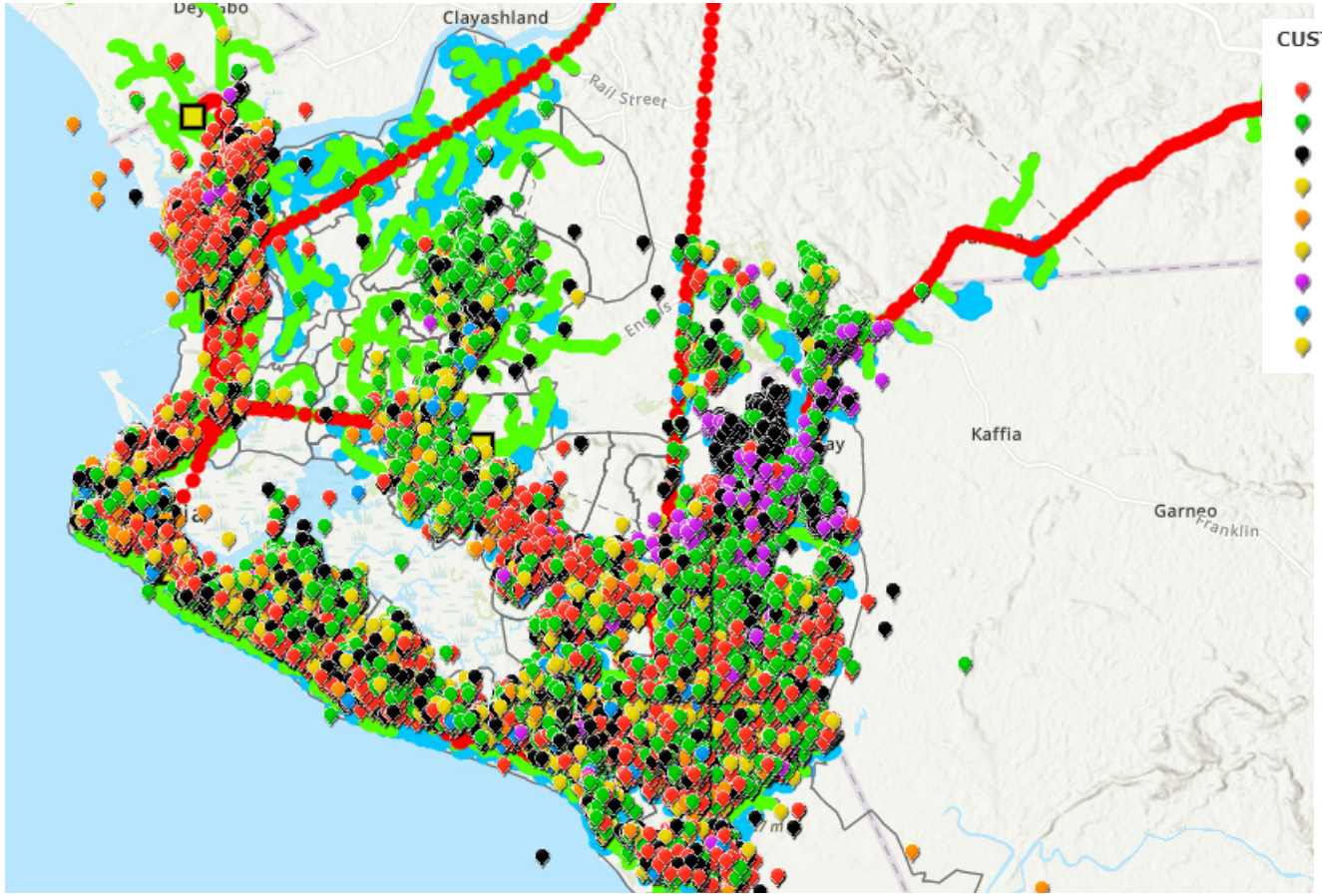
Source: Authors' calculation from LEC administrative data from 2015 until 2021. Data are missing for 8 months in 2018 and 4 months in 2019.

Figure V.44. Paid, unpaid bills, technical and commercial losses by year



Source: LEC administrative data

Figure V.45. Customer connections and LEC infrastructure (ACMS)



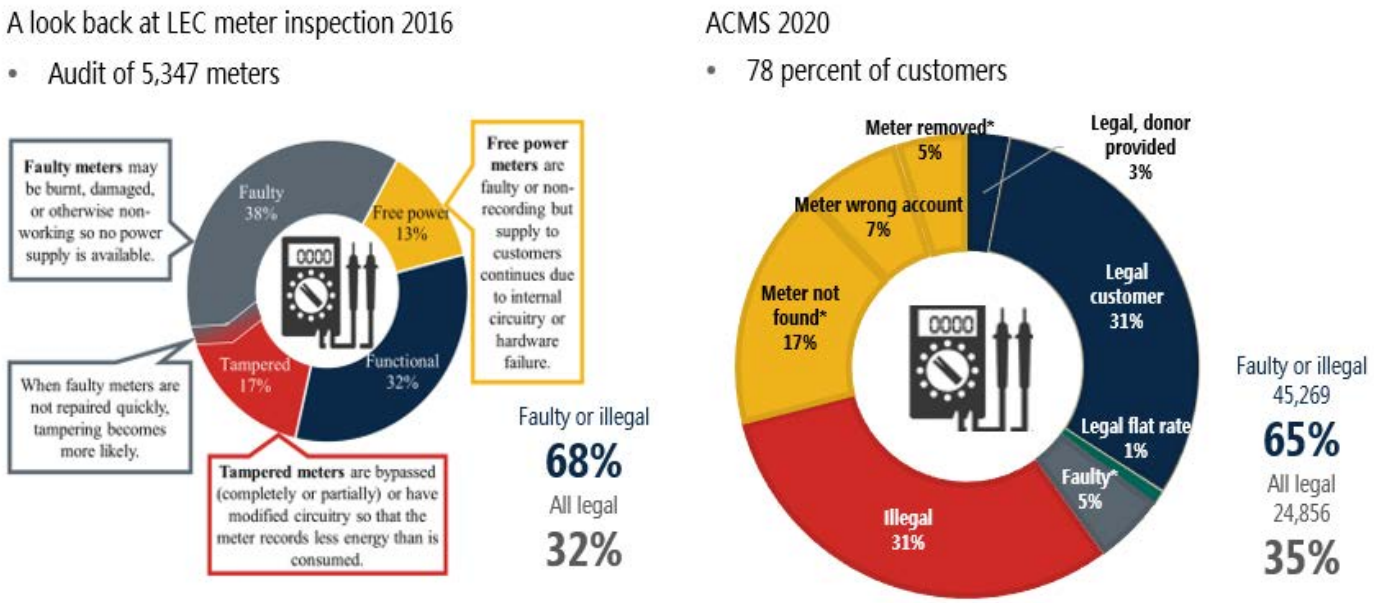
Attempts to normalize customers have been undermined by material shortages and costs ($50-$267 per prepaid and $2,139 per commercial customer), as well as insufficient political will to dismantle and prosecute LECs sophisticated cartel and politically connected thieves.

To normalize all faulty meters and make new connections LEC needs about 60,000 meters

Source: Earthetic ACMS database. 2020.

"Meter management is tricky: it is a combination of functional skills and political will and influence. There is a DMS (Distribution Management System). This can track outages, links to GIS. Setting up a proper system with customer and network itself is important. The finance division is working on gathering data. Staff use tablets to collect customer info that can be linked to the transformer and feeder. ACMS is very useful. Without that, can't fight loss. But we need to enhance the IMS beyond WB-funded modules. We need a CRM and a cell phone system to route calls and follow complaints. CRM cost would be $200k Linking to network module would be another $200k. To reduce loss, need to concentrate on the feeders. Feeder metering is very important. Plan is to install these feeder meters at some point in 2022. It is in the business plan, but there is no funding. KfW, along with MCC, have managed to keep LEC afloat so far. But KfW has no more funds to give. They are done."

Figure V.46. LEC customer meter inspections 2016 and 2020



Source: ACMS database.

Notes: The project aimed to map 90,000 customers and reached 70,215 customers, which is 78 percent of the target. Most meters were faulty or illegal in 2016 and in 2020. Attempts to normalize customers have been undermined by material shortages and costs (depending on meter type, $55–$267 per prepaid and $2,139 per commercial customer), as well as insufficient political will to dismantle and prosecute LECs sophisticated cartel and politically connected thieves. To normalize all faulty meters and make new connections, LEC needs about 60,000 meters.

*Classified as "potential customer" if meter was faulty, not found, or removed.

Figure V.47. LEC customers: new (orange) older (blue)

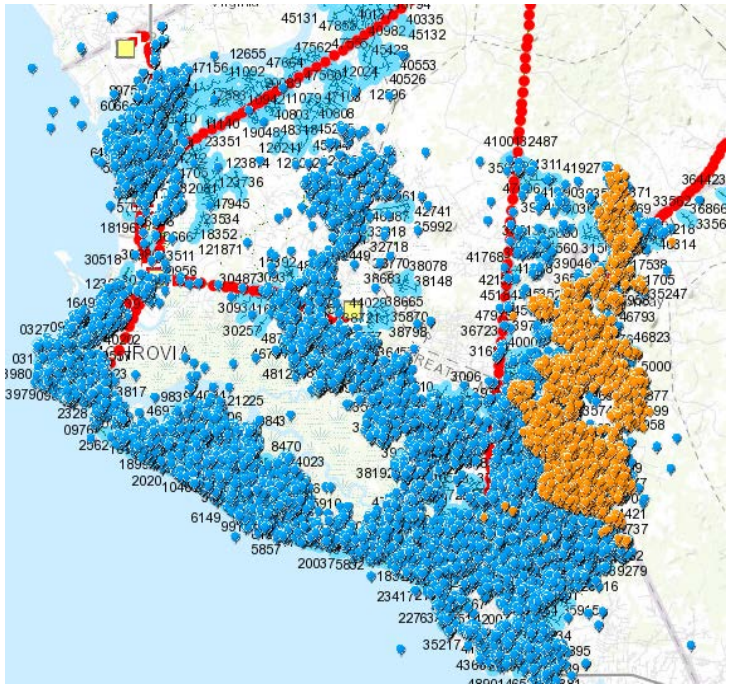
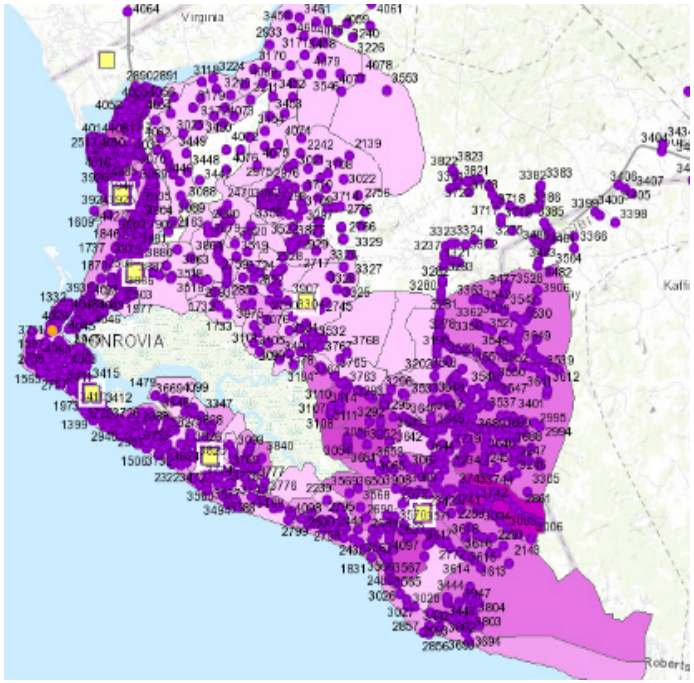


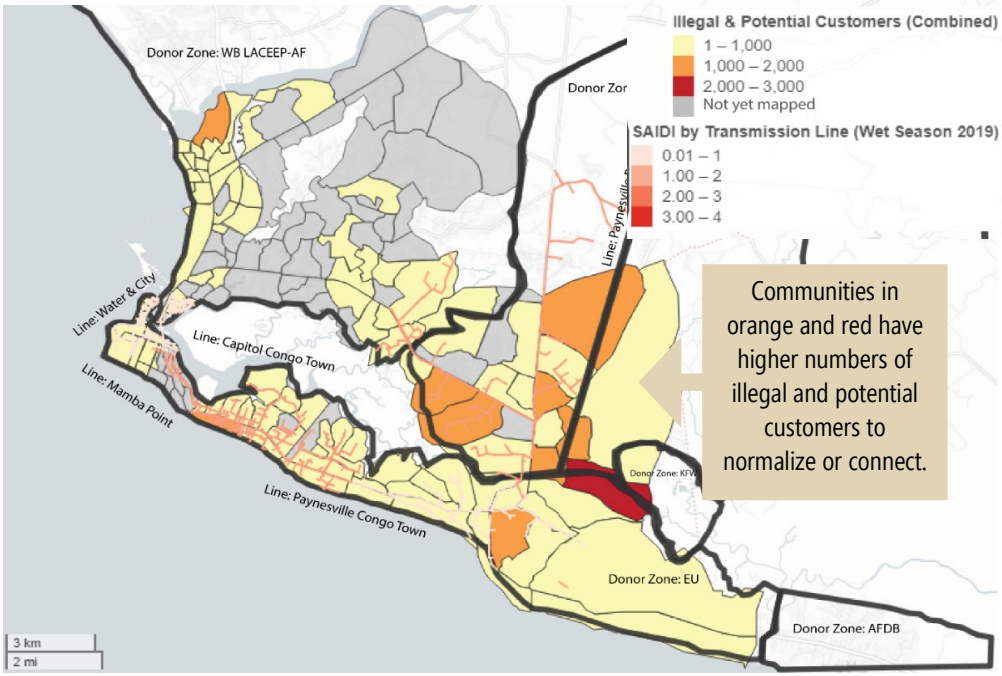
Figure V.48. Secondary substations layered on illegal customers



Source: Earthetic ACMS database. 2020

Notes: The ACMS can produce different views and maps to help understand operations, problem solve, and strategize.

Figure V.49. Mapping of illegal and potential customers by donor catchment and community perceptions of power theft



How it works

End users reported that LEC staff or neighborhood "boys" set up illegal connections. A resident may pay to tap into a neighbor's legal line or run a line directly to the pole.

''If you want current, just go to the boys around here and say that I want current. They will only ask you to buy wire and they connect you quick." Monrovia household

"Like I said, I'm connected to someone who is receiving current and they are supplying me. I'm helping to recharge the meter every month. I pay $20 for current." Kakata small business

"It's a common occurrence, connecting to other lines, and it's based on LEC input. In recent times, they have been diligent in ensuring that persons without a meter are disconnected. As a result, LEC has been there to ensure that persons who were not connected are disconnected, but it's not very common for us because we don't have the sophistication or people who are technically inclined to climb the poles, I believe. So, if you discover that one-house that is not connected to the LEC meter has a current, it must be a LEC man from our community." Kakata HH

Prevalence

During interviews, many end user respondents from our study samples reported theft was uncommon in their community. LEC's crackdown had reduced theft in the last two years. While respondents supported the crackdown, they were frustrated that LEC workers set up illegal connections. Others said that theft would be unnecessary if LEC replaced damaged meters.

"Right now, with the intervention (crackdown on theft) that LEC has done over the past two months, informal connection is less, very less." Monrovia health facility

"As far as I know, in this community, almost everybody has their own meter. Yes, almost everybody have their meter. … yesterday I saw the LEC car going around and discovering those that are illegally connected and they started cutting them off, and make sure that they are doing what is right, but majority of people in this community have their own meter … and pay their token as far as I know." Kakata

Effects on community

End users we interviewed disapproved of illegal connections because they overload and damage circuit breakers, cause community-wide outages, and negatively impact quality and reliability. They said illegal connections deprive LEC of vital revenue needed to run the utility and pose safety risks.

"Informal connections affect the community because the meter that is placed on the pole is supposed to serve several houses. The breaker that is given to a block/community that has the number of houses it supposed to serve, so whenever the number exceeds, either the breaker trip off, and in tripping, the breaker can spoil. So it will have effect on the current." Kakata HH

"There's risk because sometimes it causes damage… the house may catch fire." Monrovia HH

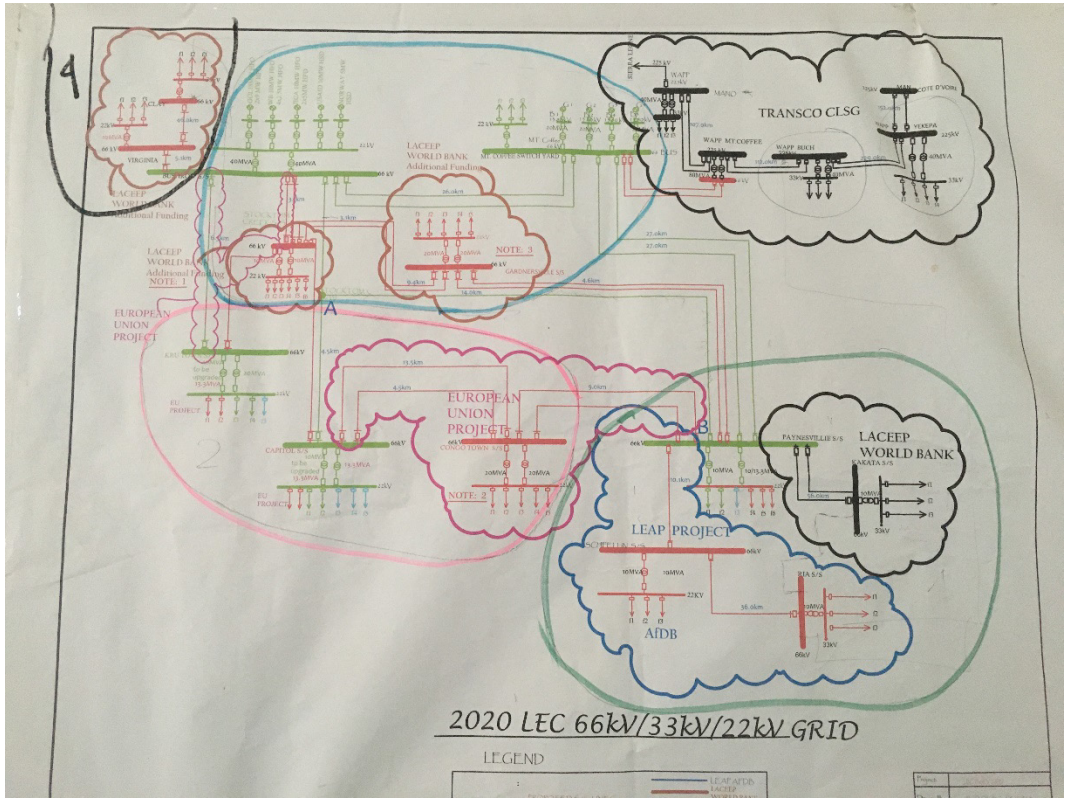
"It (illegal connections) has an impact on the community because when you connect (illegally) when people connect, the transformer cannot withstand the weight and it blows up." Kakata HH

"LEC need to pay their workers, so when you have informal connection … LEC will not be able to generate funds to pay their workers and it causes a serious problem." Kakata HH

Figure V.50. Feeder Based Management Unit approach aims to improve operations, reduce losses, maximize staff time by assigning staff to areas surrounding substations and increasing responsibility for the energy sales in that area.

According to the Director of T&D, assigning staff to outpost at the five substations reduces staff travel time given that the bulk of maintenance and operations staff time is spent in traffic or collecting materials.

"… traffic is tough. Only way to reduce is to post staff at a particular facility. Logistics is a challenge especially with the system expanding."



LEC cannot maximize the FBMU system without feeder meters.

"Right now, we are not capable of pinpointing where improvement has come from until receive additional feeder meters. The WB is paying for 15 feeder meters. We need 2000 to cover all 2,515 distribution stations.

[With feeder meters] we will be able to calculate transmission and distribution losses using digitized module. Hoping that once have feeder meters, we will get a clear-cut link to calculate our real distribution losses. LEC will compare feeder output against feeder sales and definitely see where losses are. Then we can do reporting by units. Answer questions like: How many new connections? How many meter replacements? This data will be reviewed by metering, engineering, T&D, commercial and then have a dashboard to review info real time."

The MSC has improved its human resources department and practices, but LEC's workforce composition is problematic owing to political interference. Human resource (HR) achievements include restructuring to create an HR division with cross-cutting departments, including training, development, gender and social inclusion, and safety. The division introduced a disciplinary policy, established onboarding procedures, created job descriptions with key performance indicators for each position, and has been building a performance management system with timelines, trainings, and staff assessments. LEC has been restructured so that top level includes CEO, CFO, and Directors of planning, T&D, Generation, HR, Commercial and Regulatory, Donor Funded Projects, and General Services (health, safety, environmental quality, and security). In December 2021, HR established a whistle-blowing policy, though no one has yet received a whistle, as many people are afraid to report.

As noted, the number of staff and skill composition does not match LEC's needs. Ongoing political interference prevented ESBI from properly staffing LEC with the right mix of skilled staff. ESBI's initial situational assessment of human resources indicated that LEC's organizational structure was insufficient. Of LEC's 636 employees, 12 percent were in generation, 28 percent in T&D, 6 percent in commercial, 7 percent in planning, and 47 percent in administration. By December 2021—following years of ESBI being told to hire the friends and family of politicians, LEC's staff ballooned to 791 by December 2021. While ESBI wanted to change LEC's staffing to align better with needs, GoL would not allow changes:

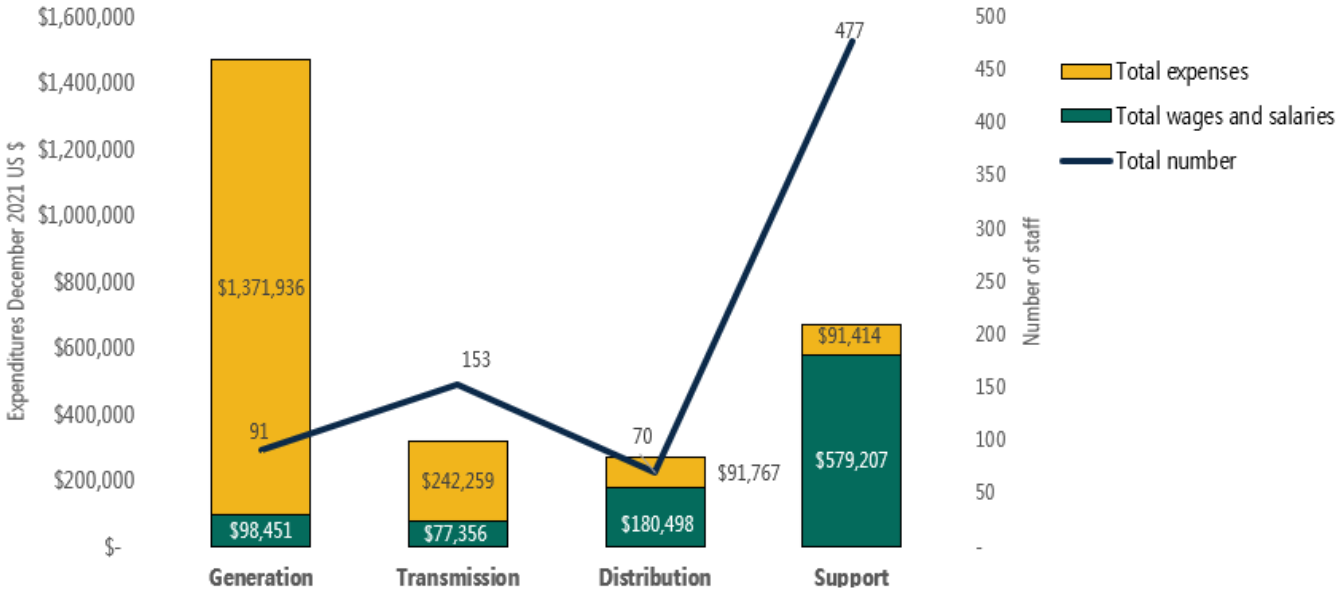
> *"The hard decision would be to get rid of half our staff. We have 800 staff. We could let go 600 unproductive staff, hire 200 useful staff. But we raised it ... Country administration forced us to take on admin type folks, laborers, guys that sweep. Not electricians. Even electricians' qualifications [lack skills]. We haven't been allowed to make necessary changes." [Also] "*..the higher level, it's hard to touch them because they have connections with the government, big businesses*."*

The HR director explained that they are trying to remove unneeded positions and staff by implementing performance evaluations. LEC must abide by employment law and work with the union. These obstacles make it difficult to right-size and skill the workforce:

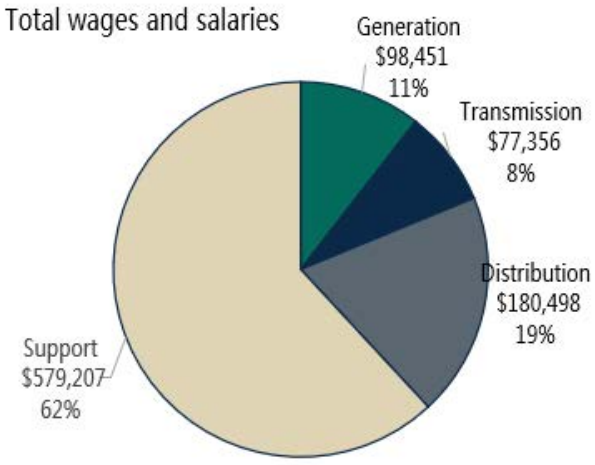
> *"We know there are some people not being properly utilized so we are creating a robust performance mgmt. system. If we see positions not needed or people who don't fit, we try to evaluate them properly. Some might be transferred. Some terminated. Some paid off. Until we do that, we won't know for sure.".*
>
> *"We will be able to let go people once done. The law is such that you cannot just terminate staff without cause. If for any reason employee doesn't fit any more we have to give them a performance improvement plan, but we will be able to let them go if we see that they don't fit. We are going to have a fight from union. The union took us to the Ministry of Labor. We are spending lot of time there. We have 200+ "contractors", but some of them have been here at LEC for 3 or 4 years. According to law, they shouldn't be temporary for long. The union used that part of the law, saying we should not keep renewing one-year contracts. The Supreme Court ruling is that we should hire after six months."*

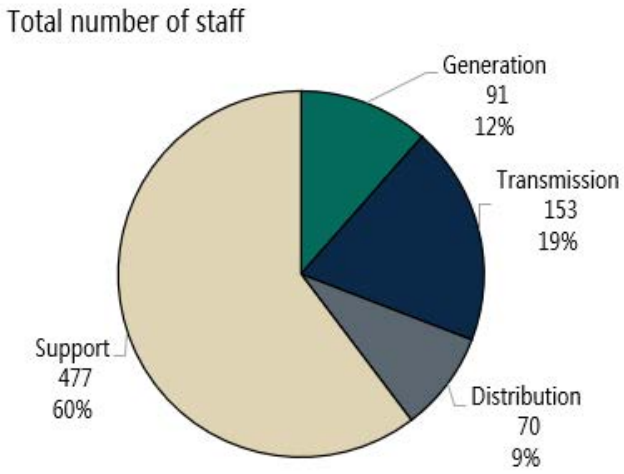
Using LEC's compliance data, staffing numbers, and expenses by functional area, we assessed LEC's expenditures, salaries, and number of staff and average salary by department Figure 51.

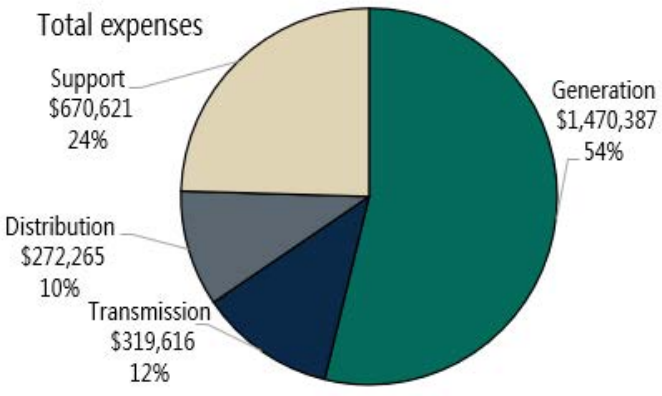
Figure V.51. LEC's expenditures, salaries, and number of staff by department

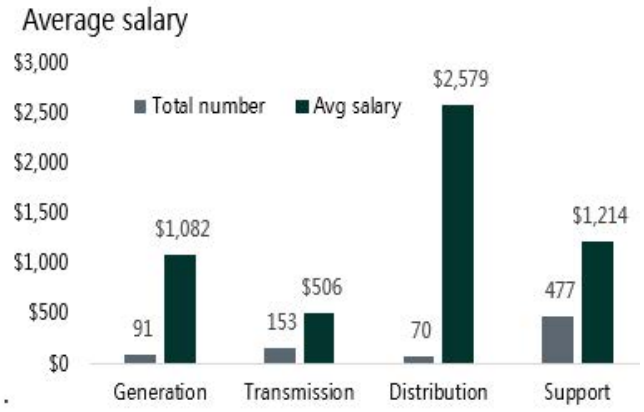


Soure: LEC administrative data









While is unclear what the exact mix should be, it is clear that LEC is off-balance with such a high percent of support staff.

The MSC established the Training and Development Department in August 2018 (LEC 2019). With stakeholder input, the department wrote and LEC adopted a corporate training policy. The department completed a training assessment and gap analysis and began organizing ad hoc trainings, such as the West African Power Pool training and the Association of Power Utilities of Africa. Guided by the draft Master and Strategic Plan, the Training and Development Department builds monthly and annual training calendars and has conducted trainings on topics such as safety, customer relationship management, basics of metering, billing, tariff structure, revenue cycle management, overview of power systems, substation operations and maintenance, and streetlighting. Although there has been progress, the department chronically lacks funding, space, equipment, materials, and prioritization given LEC's ongoing financial crisis. The MSC identified the reduced scope of the MCC-funded training facility as the "*biggest blow to capacity building within LEC and the energy sector at large*."

The MSC improved safety practices and reduced environmental waste, but LEC's lack of safety equipment prevents staff from implementing safety procedures. LEC staff reported that workplace safety training and practices is a critical need across all departments and job functions. They report that LEC does not provide the equipment needed to properly implement safety procedures, though the MSC said safety equipment is available but tightly managed. Numerous T&D and Generation Department staff reported that they lack adequate safety and personal protective equipment including gloves, boots, and masks to comply with best practices. Others reported lacking functioning fire extinguishers and that overall, LEC does not systematically enforce safety protocols. Staff report that LEC leadership is not fully committed to ensuring workplace safety as evidenced by inadequate resources allocated to safety.

The MSC has improved customer management, instituting major improvements and service since 2018. 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. The MSC instituted numerous improvements in 2019. First, the MSC was able to sever a 10-year contract with a low-quality vending system, migrate to an LEC Customer Management System (CMS), and begin the process of transferring, cleaning, and validating all customer data. Second, the MSC appointed a customer service manager to develop a strategy, including refurbishment of a service center. Third, LEC opened a web portal for customers and the general public, offering self-service for new connections, information requests, and complaints. LEC also implemented a 24-hour call center and began focusing on monitoring and reporting customer service key performance indicators (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. Finally in 2020, LEC opened the newly renovated Customer Service Center at LEC Headquarters at Waterside (Figure V.52).

Figure V.52. Customer Service Center at LEC Waterside Headquarters

The MSC's coordination and management of donors and T&D construction was inadequate. The MSC was responsible for overseeing $200 million worth of donor-funded T&D projects—given that LEC is the official owner of these projects. 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—or a comprehensive master plan—so donors divided Monrovia and the surrounding areas into zones and focused on customer connections. 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. Also, simply working in different catchment areas without aligning plans, practices, processes, standards, and materials was overly simplistic given the electrical grid is one system and LEC is one organization. Donor projects were delayed by years because of challenges with procuring contractors; failed contracts; problems with design plans; and resettlement challenges. ESBI was transparent about its lack of ability to manage all these projects and contracts, which fell outside of its contract. They also faced challenges in coordinating donor 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 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. For example, USAID equipment doesn't comply with any standard used in West Africa or Europe—completely American design doesn't align.*

At the start of the compact, ESBI felt that donors did not fully grasp the challenges in the existing network, underestimated the scale of power theft, and assumed that LEC would have adequate revenue to fund complementary investments in the grid and utility. Indeed, 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. In addition, 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 some end users 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, residential power theft in newly connected communities would not have increased so drastically.

EQ C5: What progress has GoL made toward establishing a longer-term management arrangement for LEC? How sustainable is LEC as a utility? What are the biggest barriers to its sustainability?

After Compact closure, the WB funded the MSC through July 2022 and will continue to provide support to LEC, but GoL has not made progress towards establishing a longer-term management solution. A long-term solution would require that GoL prioritize LEC's functionality and financial solvency, engage in long-term and strategic planning, regularly pay bills, cease interfering with staffing and prosecution of power theft. GoL has not done any of these. However, GoL appointed Monie Captan as Chairman of the LEC Board[28] in response to pressure from the U.S. Ambassador and other donors. Stakeholders strongly support Mr. Captan's appointment but worry that he alone cannot turn LEC around. As of July 2022, LEC returned to Liberian management with continued World Bank funding through the Liberia Electricity Sector Strengthening and Access Project (LESSAP) project until 2026.

Currently LEC is an unsustainable utility that could collapse at any time. Further, MCHPP is at risk of catastrophic failures without adequate OMT support. The sustainability of MCHPP is at risk owing to underinvestment 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). 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:

[28] Former Foreign Minister Captan Appointed Board Chairman of Liberia Electricity Corporation

"Most of the things we're experiencing now are outside the warranty period." "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."

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 did happen in 2021]. 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 [because of breakdowns]."

Respondents also described how CLSG will increase the need for technical capacity at MCHPP and that its sustainability will be precarious. LERC's and LEC's decisions dependent on CLSG's future supply and income might be risky given CLSG's placement:

"As soon as CLSG comes into play, procedures will have to be revamped. We don't know exactly what this would entail."

CLSG transmission lines are in a tropical rain forest so there is a major issue of how they will be maintained. When Sierra Leone connected, a tree fell on the line. They did a patch for that section [which took two weeks], but there still needs to be a permanent fix. They also did a single circuit, but the line is designed for a double circuit. TRANSCO maintains the line and they have a O&M contractor—they met their obligations but…. There is a generation deficit, so we have to get CLSG.

Plans are underway for a new solar farm placed at MCHPP, which could also impact the plant in unforeseen ways when it comes online and must integrate into the T&D system.

[There's a planned] PPA with a solar farm at Mt. Coffee. In Phase 1, it will produce 20 MW. It is a high-risk investment. We're not talking a 5-6 cent tariff but more like 10-12 cent. There are a lot of issues to work out.

"Based on experience, we know that while MME and LEC may not be preparing for CLSG and Solar farm power, the cartel is."

The biggest barriers to LEC's sustainability include insufficient OPEX and CAPEX, political interference in LEC operations, the cartel or syndicates growing sophistication, the failure of the Ministry of Justice to prosecute power theft, LEC's culture of corruption, the weak and ineffectual LEC BoD, inadequate donor coordination, high dry-season fuel costs that are not adequately planned for, insufficient commercial connections, and unpaid bills.

EQ A3. What lessons can be drawn from implementation?

The Liberia Compact provides important lessons for MCC and other donors investing in major rehabilitation works and utility reform. The evaluation team had the luxury of time and resources to focus on learning. We were able to collect, triangulate, and validate a broad array of data from many sources and return to key actors and organizations numerous times to ask and compare perspectives and track changes over time. We synthesized years of data from many different sources and actors, as well as the sector literature, to distill important lessons learned. Our task was much easier than the implementers who—in the middle of challenging circumstances—had to make difficult decisions quickly, without adequate data or perspective on the full scope of the situation over time and across activities. Many actors provided reflections in hindsight, which provides a better vantage point for seeing missteps. With data and reflections, we were able to identify patterns and relationships and based on the past, predict future results. We frame lessons learned from the past as recommendations for the future, which we offer to inform US government's and other stakeholders' future work in Liberia and other similar contexts.

E. Lessons learned on implementing an energy Compacts in a complex country for MCC and MCA-L

Compact design and launch

1. **Strengthen the due diligence process and a conduct a robust political economy analysis during Compact development to ensure activities are informed by the historical, political, economic, and social context, and in anticipation of future major political events (such as presidential elections).**

   MCC staff indicated the lack of a political economy analysis prior to Compact signing meant they were unprepared for challenges. Stakeholders explained that unlike other Compacts, Liberia had almost no due diligence and was rushed because of U.S. diplomatic pressure to support Liberia post-Ebola. Prior to the Ebola crisis, three donors were investing in MCHPP rehabilitation with the GoL, but the economic impact of the Ebola crisis left the GoL unable to meet obligations. MCC stepped in with financing to support the recovering country.

   While MCHPP rehabilitation was largely a collaborative success and responsive to the GoL's requests, it was not the most strategic investment. In the energy sector, investments should be strategic for the long-term, thinking ahead 20, 30, or 40 years. Rehabilitating MCHPP to generate 88 MW means that demand will exceed supply in several years. Constructing a new plant upstream would have costed less, taken less time, and been able to deliver "*more seasonably secure'* 125 MW of renewable hydropower.

   The Capacity Strengthening and Sector Reform Activity was developed, once MCHPP works were underway, without a utility level PEA. While a 2015 USAID-funded, McKinsey & Company analysis offered an informative assessment of six management approaches for LEC, the study only captured some of LEC's complexities and did not include a PEA to help anticipate problems, identify solutions, and predict outcomes. Stakeholders agreed that no

one understood LEC's quickly deteriorating situation, which further declined even while the MSC was being procured.

"We didn't anticipate that LEC wouldn't have resources to connect even if generation was fixed. Simple things – wires, transformers, poles were missing. They had no operational capital and revenue was far below expenses."

Vital time for reform was lost to gaining situational awareness. It took ESBI two years to fully understand the extent of LEC's operational, financial, technical, infrastructure, political, and safety challenges and failures. A PEA would have helped understand the previous MSC's experience and uncovered the extent of LEC's financial and infrastructure problems. MCC recognized that the utility was failing and recommended extending MHI's MSC, which Norway would have financed. This would have allowed MCC to invest in vital equipment such as a SCADA system. However, the GOL would not allow MHI to return, which a PEA might have identified as a red flag and key indicator of interference.

2. **Acknowledge, strategize, implement, and communicate with the understanding that energy is political.**

   The Liberia Compact was designed to account for the technical but not the political aspects of energy, in this case, the GOL's legal and illegal self-serving actions and political favors involving MCHPP and LEC. MCC tried to protect MCA-L from being mired down in political conflict. The resident country director, in the worst situations met with ministers to demand action, but otherwise MCC and MCA-L focused on overseeing Compact components, rather than combatting political interference or inaction. Additionally, the MSC avoided politics partially because they often feared for staff safety and retribution. Unfortunately, the collective avoidance of conflict and political engagement allowed political interference to continue and the cartel to thrive. MCC's investments could have been more successful if all actors and contracts acknowledged, understood, and strategized to reduce political interference in energy. In future Compacts, depending on diplomatic and development priorities, MCC and local counterparts should use tools available to reduce interference, cronyism, and corruption. MCC might consider establishing a high-level steering committee focused on identifying, naming (in meetings and reports), monitoring, and eliminating political interference, cronyism, and corruption. The 'politics committee' should establish expectations, "deleterious interference will not be tolerated," with ministries and rules in contracts. The Ministries of Justice, Labor, Finance, and Energy should be sensitized to seriousness of expectations, ongoing monitoring, and reporting.

3. **Particularly in challenging contexts, ensure that resources align with Compact and Activity goals, desired outcomes, and contextual realities.**

   Stakeholders frequently describe donor fatigue with the Liberia energy sector, noting there are always new costs and additional problems. While stakeholders cite investments exceeding $1 billion in Liberia's energy sector, the reality is that no donor organization, government entity, or other stakeholder ever conducted a data driven costing exercise to realistically estimate the true cost and time needed to rebuild the energy sector post-conflict, Ebola, IMT, and during the Covid-19 pandemic. Indeed, the full costs exceeded the budgets

donors initially allocated to Liberia and while donors have made major investments, these still only cover a portion of the true costs of rebuilding a devastated sector. *"Donors may have spent a lot but not what it really costs."*

Moreover, while donor organizations have become frustrated with disappointing results from their investments, both programmatic costs and losses have increased because investments have often not been strategic given the context and challenges. For example, resources were not allocated for adequate due diligence, a SCADA system, ACMS, and feeder meters in the 2010s and insufficient donor coordination further increased costs and losses over time.

MCC's resource allocations did not align with the true expenses of rehabilitating MCHPP and ongoing OMT support and successful implementation by the MSC. Given the value of MCHPP, and LEC's financial position, taking over OMT costs was always impractical. MCC moved resources from the LEC Training Activity to the OMT, but that depleted much need training resources and was only a temporary patch for the OMT. Additionally, the MSC was likely set up for failure attempting to reform LEC without the operating and capital expenditures needed for maintenance, repairs, customer connections and normalization, training, and basic operations. No MSC could reform and rebuild LEC (in a three-to-five-year contract) without resources and with sustained political interference.

4. **Consider Compact length, then plan for and prioritize sustainability during Compact design and afterwards.**

   Particularly in challenging contexts, reality check timelines. Stakeholders explained that a five-year Compact was too short a timeline to achieve intended outcomes. They suggested that if the contract time and resources cannot expand to meet the scope, the scope should reduce to meet the resources. MCC can also identify partners during the design and implementation phases who can partner to lengthen the implementation timeline. In fact, WB took over the MSC contract, however plans were not official until weeks before the Compact closed, which negatively impacted MSC implementation. Alternatively, while outside of current legislation, MCC could consider entering a country with the expectation that a Compact will be renewed, (allowing 10 years of implementation) if government meets requirements to achieve Compact II. Throughout Compact I, Compact II can be leveraged to shape behavior.

   First, with infrastructure investments, develop strong contingency plans to ensure long-term sustainability. Once it was clear that LEC could not afford to consistently allocate funds to the escrow account and fund the OMT, a clear contingency plan was needed, rather than multiple short-term, temporary fixes.

   In Liberia, again, no MSC could reform and rebuild a utility—that had closed for 15 years and reopened to years of cronyism, expanding losses, and disfunction—with a three-year contract plus two option years. Reforming LEC will likely take 10, 15, or 20 years, adequate OPEX and CAPEX, and removal of GoL influence.

5. **Stakeholders suggested that MCC could strengthen overall implementation quality through improved processes.**

   First, PIU stakeholders explained that of all donors involved in MCHPP rehabilitation, MCC had the most cumbersome payment processes which were time intensive and made their work more difficult. While we recognize this suggestion does not align with current legislation, they suggested simplifying payments in a way that ensures accountability and minimizes time.

   MCA-L stakeholders commonly explained how time-consuming and cumbersome processes delayed Compact launch. They wanted the MCA-L office to function immediately after Compact signing, but staff had to "reinvent processes and procedures" that could have been adapted from other Compacts. They wanted the time to implement the Compact, rather than start up the office.

   MCA-L staff also explained that some processes could be streamlined so they do not undermine Compact activities. "*MCC over-engineers – everyone in MCC has to weigh in, and TOR ends up being inflated because of all the requirements."* ESBI staff described how MCC's processes affected MCA and the Training Activity which they felt was essential, but the scope was reduced:

   "MCA was probably hamstrung with their own processes and procedures, working within MCC procurement processes. They wasted a lot of time. Washington goes back saying "spec is too narrow". This added another 4 months to a 4-month process. It took 2 years. Then they cancelled ... Such a loss that we couldn't get LEC Training Center. Really wanted training, it is critical. Cancelled since they believed they couldn't get the training center and the training in place before the Compact closed."

6. **Better support implementation and problem solving with robust and dynamic M&E processes that inform collaborative problem solving.**

   Stakeholders agreed that the Liberia Compact required more on-the-ground data-informed oversight and collaborative problem solving than MCC/MCA-L was able to provide. MCC and MCA-L's processes and ability to obtain data were not as robust and dynamic as the situation demanded. For example, MCA-L was unable to identify a strong M&E manager to help LEC gather and analyze data, present findings to stakeholders, improve the organization-wide ability to use data to track outcomes, help LEC change course (based on data), and communicate the utility's status.

   MCC could enhance implementation quality by prioritizing the use of data driven and learning to improve implementation and change course as needed. While MCC is accustomed to tracking outcomes, data can be better utilized, including informing country teams, partners, and stakeholders about implementation status and what is needed to achieve outcomes. MCC could better utilize the performance management aspect of evaluation contracts for analytical technical assistance that informs real-time changes in implementation as needed (such as when we presented a power theft analysis to the Energy Sector Working Group (ESWG). Prioritizing data driven problem solving around major risks early and often

can yield better outcomes. For example, stakeholders knew LEC could not pay for the OMT and staff were not acquiring skills at MCHPP at the needed pace. This situation required hands-on collaborative and data driven problem solving to develop solutions, which perhaps could have avoided the loss of Unit 1 at MCHPP.

7. **Invest in data democratization, such as sharing data through dashboards.** Throughout the evaluation period (2017-2022), stakeholders consistently described the challenges they faced due to having inadequate information. However, data was being collected and analyzed and could have been made available. Moving forward, all stakeholders, GoL, LEC, and donors should have access to data dashboards that provide all the data sources available in this report, updated on a monthly basis. Decisions can be made with historical, contemporary data and analysis on hand so implications can be understood.
8. **Improve MSC implementation and chances of success by designing contracts that better align staffing to specific needs and require MSC's to prioritize high-quality communications and information sharing, navigate politics, and utilize data systems.**

   Staff according to needs. All necessary roles should be filled, and stakeholders should continuously assess whether the combination and number of positions is adequate and identify any deficits in skills and capabilities. If gaps are identified mid-way, new positions should be created and funded. For example, ESBI could have benefited from a director of government relations, director of loss prevention, M&E manager, and a contracts manager to oversee T&D plans. Comparatively small investments in staff could have tackled government interference, prevented loss, reduced delays, and yielded important impacts. Contracts should not have a diminishing number of staff over time when responsibilities are expanding, and positions should not be eliminated unless there is clear justification they are not needed.

   Optimize communication, shape the narrative, and tackle the politics. Particularly in complex settings, MSCs should be required to conduct regular stakeholder-wide reporting with user-friendly documents. MSCs should ensure reports and materials are reader friendly with technical details and political issues explained. ESBI indicated that messages were lost between the politically appointed client (BoD) and frustrated funder (MCC). ESBI presented at the Liberian High Level Sector Group and Energy Sector Working Group meetings, but these were held inconsistently, and presentations sometimes had technical details that confused participants. CMC reports were useful but not shared with GoL and donor partners. LEC reports, beyond slide decks, were rarely circulated externally. In the absence of clear, understandable information shared to both the BoD and donors, incorrect assumptions and false narratives undermined the MSC and LEC, allowing corrupt actors and the cartel to take advantage of chaos. Some donors felt the MSC was mistrusted because communication was infrequent, too technical, and did not report the full scope of challenges with a "no holds barred" transparent approach, highlighting the political interference and cronyism. Stakeholders argued that the ESBI, LEC CEO should have gone to cabinet meetings and argued strongly for LEC's needs, though the LEC BoD did not want a foreign CEO at the meetings.

Identify and overcome MSC weaknesses. ESBI proved to be a strong technical firm with the vision and strategy to reorganize, build capacity across departments, develop processes, policies, and systems within each department. However, they were weaker in communication and lacked the political savvy to manage political interference and donor coordination, capabilities which were not included in the MSC contract. Implementation of the strategy was slowed and sometimes derailed by interference, major resource shortages, unpaid bills, unforeseen disasters and setbacks, and the Covid-19 pandemic. The MSC was criticized for being risk averse but feared for their safety and did not communicate challenges well enough to gain support. Criticism for misallocating money came from stakeholders who did not understand LEC's finances or were intentionally trying to undermine the MSC by creating false narratives. ESBI could not communicate issues clearly enough to overcome these issues. It is surprising the contractor and key staff remained in country for as long as they did, however they managed to stay because they knew they were slowly making progress and remained optimistic about further progress and hopeful for additional donor investment.

Allocate funds to data systems and processes before scaling up new connections. LEC was in desperate need of investment in a full SCADA system with meters at all interface points, estimated to cost $30 million. While beyond the Compact resources, other donors could likely have been persuaded to fund or contribute to the system to help reduce losses, optimize use and life of assets, and improve electricity quality and reliability. The $30 million price tag is still less than the approximately $47 million in losses per year. The ACMS study was critical but completed at the very end of the Compact. Still, it should be completed, validated, and continuously updated. Ideally these processes would have been funded and integrated into LEC operations while the Compact was still operational, but the Covid-19 pandemic delayed implementation. Finally, LEC processes could be further bolstered through full utilization and integration of the IMS and SCADA, and customer data (with a CRM). LEC should implement monthly energy audits to understand current operations, improve meter and collection processes to reduce losses, and continue on-the-job training of LEC staff across all departments to improve operations.

VI. End-user outcomes

In this chapter, we present the final analysis of end-user outcomes in the context of COVID-19, Liberia's economic situation, and the energy sector, utility, and grid outcomes described in Chapters IV and V. The chapter includes a description of our end user survey sample and findings on changes in end user connection rates, barriers to connectivity, perceptions of electricity quality among end users, and long-term end-user outcomes related to health, education, and productivity.

MCC expected investments in MCHPP, LEC, and the overall energy sector would affect end users in multiple ways (Table VI.1.). LEC's increased energy production and improved operations were expected to lead to reduced tariffs (and therefore user costs), resulting in increased connections and electricity consumption. The activities were also expected to improve the customer experience through improved reliability and quality of electricity and customer service. The realization of these medium-term outcomes should in turn have led to greater incomes for households (through increased investment and improved education, health, and safety) and businesses (through increased productivity and expanded operations, employment, and employability).

Key findings

- Since baseline, many end users in Monrovia and Kakata transitioned from lighting to electrical appliances as their main use of electricity, which suggests a shift to more productive uses of electricity.
- Increased productive use of electricity has not translated into improved financial outcomes. Business activity and profits decreased among households and businesses since baseline, a period marked by the Covid-19 pandemic, a worsening macroeconomic environment in Liberia, and decreased connection rates among our Monrovia sample.
- Respondents reported that electricity improves everyday life and allows children to study, but there were no significant changes in time use since baseline.
- There were large increases in the percentage of community services with LEC electricity in Kakata. Access to electricity seems to have improved service delivery, particularly for schools and health clinics.
- Perceptions of safety and security are closely tied to access to electricity—connection rates and perceptions of security improved in Kakata but worsened in Monrovia.

Table VI.I lists a summary of MCC's assumptions, outcomes, and indicator of whether outcomes were achieved.

Table VI.1. Key findings: Summary of assumptions and outcomes

Assumptions	Short-term outcomes	Medium-term outcomes	Long-term outcomes
~ A8 LEC makes new connections, accommodates dry season demand[V]	+ Decreased user costs[V]	~ Increased customer base and consumption[V]	~ Increased business productivity, expanded operations, employment, and employability
~ A9 LEC improves quality and reliability of electricity[V]		~ Improved customer satisfaction and confidence[V]	~ Increased investment; improved health, education, and safety outcomes
~ A12, A16 Customer service improves; willingness to pay increases. Customers pay for electricity[V]			
~ A15 Electricity used productively. Constraints do not inhibit investments[V]			

Notes: + = Assumption met or outcome Achieved; − = Assumption not met or outcome not achieved;

~ = At least part of assumption or outcome not met or achieved

[V] Outcome/assumption assessed in Chapter V. Utility reform and grid-level outcomes

A. Evaluation questions

We investigated the following evaluation questions related to long-term end-user outcomes:

EQ C3. To what extent have the MCHPP Rehabilitation and Capacity Building and Sector Reform Activities affected the number of users connecting to the grid and the demand for electricity?

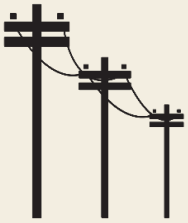
EQ D1. How do customers decide to connect, and why have other potential end users not connected? What barriers do potential customers face when trying to connect to the grid?

EQ D2. How have MCC's investments affected connected and unconnected households' perceptions of the quality of electricity?

EQ D3. To what extent do customers invest in energy-intensive appliances or equipment? What is the effect of energy on time use (household production, leisure, school, work, and employment)?

EQ D4. What, if any, are the spillover effects on non-electrified households?

EQ D5. How do impacts vary by differences in gender, socioeconomic status, and other demographic characteristics?



Data sources for analysis at the end-user level

- Survey data from households, small businesses, and medium and large end users in communities in Monrovia and Kakata
- Qualitative data, including in-depth interviews and focus groups with household members, small-business owners, medium and large end users, public institutions, and local government officials

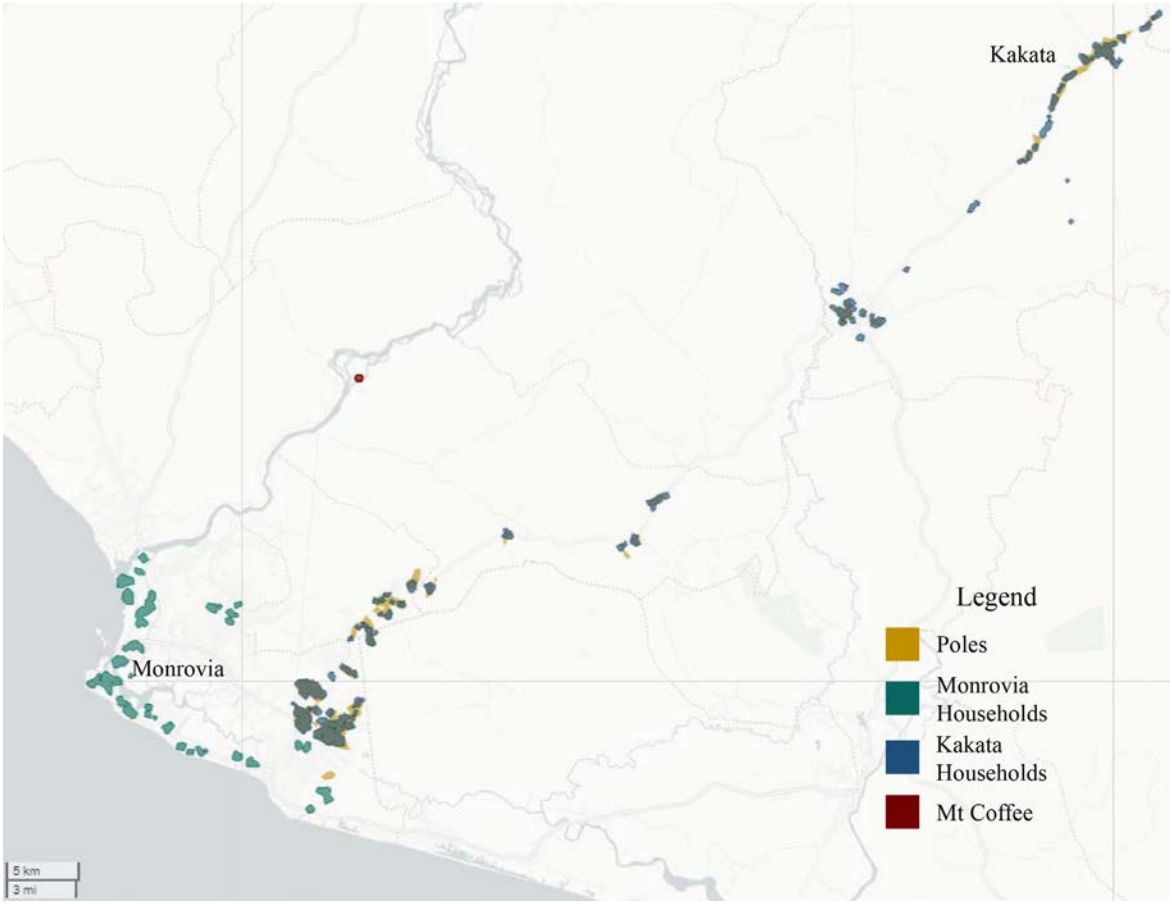
B. End user sample characteristics

We collected quantitative data from community leaders, households, businesses, and medium and large end users in two geographical locations: Monrovia and Kakata. We also conducted key informant interviews with a subset of the full survey sample. In this section, we briefly describe the survey samples, including the location of communities where we conducted the studies, household demographics, characteristics of small businesses and medium and large end users, the year of connection among respondents with LEC electricity, and energy use among respondents. Appendix A contains detailed information on data collection, and Appendix B contains tables of respondent characteristics.

1. Location of study sample

We randomly selected a sample of connected households and small businesses in Monrovia and a sample of unconnected households and small businesses along the Kakata Corridor. We show the location of the household study samples at baseline in Figure VI.1.

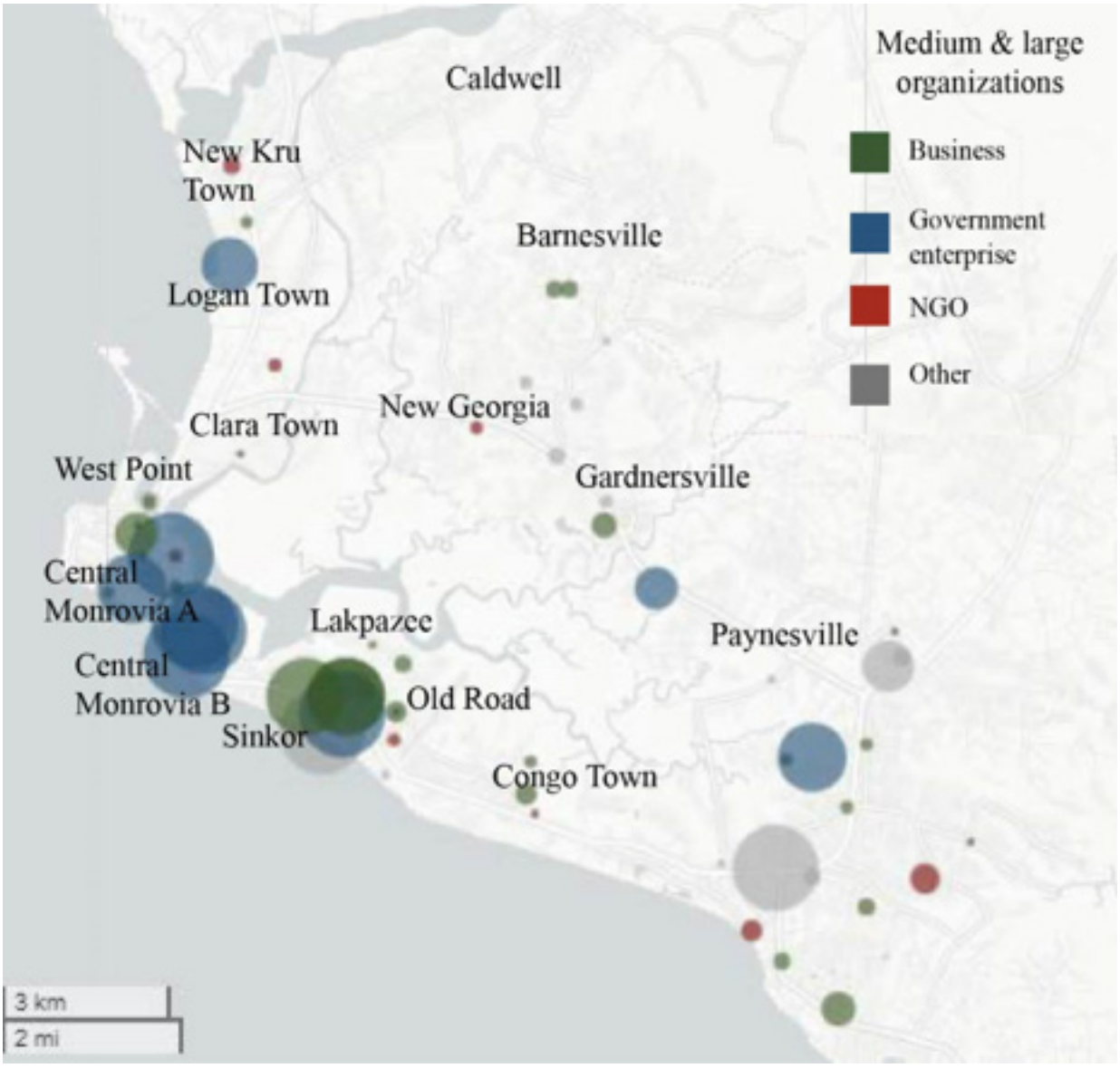
Figure VI.1. Location of Monrovia and Kakata samples



Source: 2018 Monrovia and 2019 Kakata household surveys

We also selected a sample of medium and large end users throughout Monrovia, as shown in Figure VI.2. The various colors indicate the type of end user – business, government enterprise, NGO, or other. The icon size indicates the number of employees at the organization.

Figure VI.2. Location of the medium and large end user sample

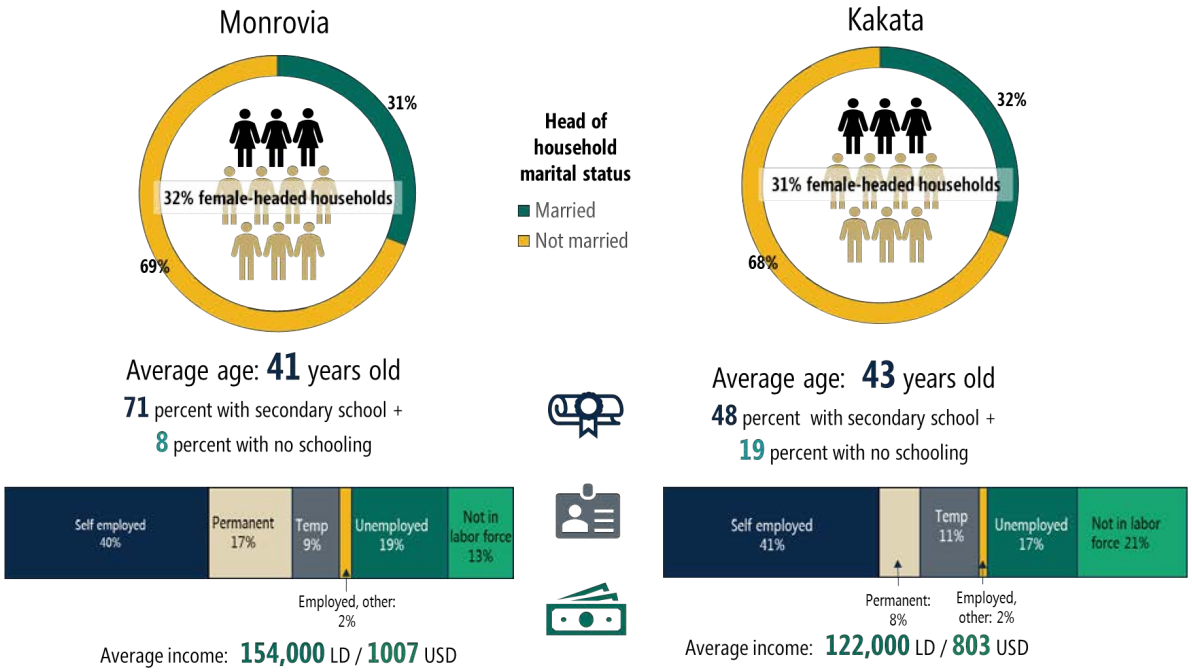


Source: 2019 medium and large end user survey

2. Demographics of the household sample

In both the Monrovia and the Kakata studies, just over 30 percent of households have female heads of household (Figure VI.3). Households in Kakata have lower incomes and lower levels of education than households in Monrovia, on average. These characteristics are similar to those of the baseline sample, as described in Miller et al. 2020. Although we compare the samples for descriptive purposes, these are not comparable groups for evaluation purposes. That is, given the demographic differences, the Kakata sample does not serve as a control group for the Monrovia sample.

Figure VI.3. Characteristics of households in Monrovia and Kakata

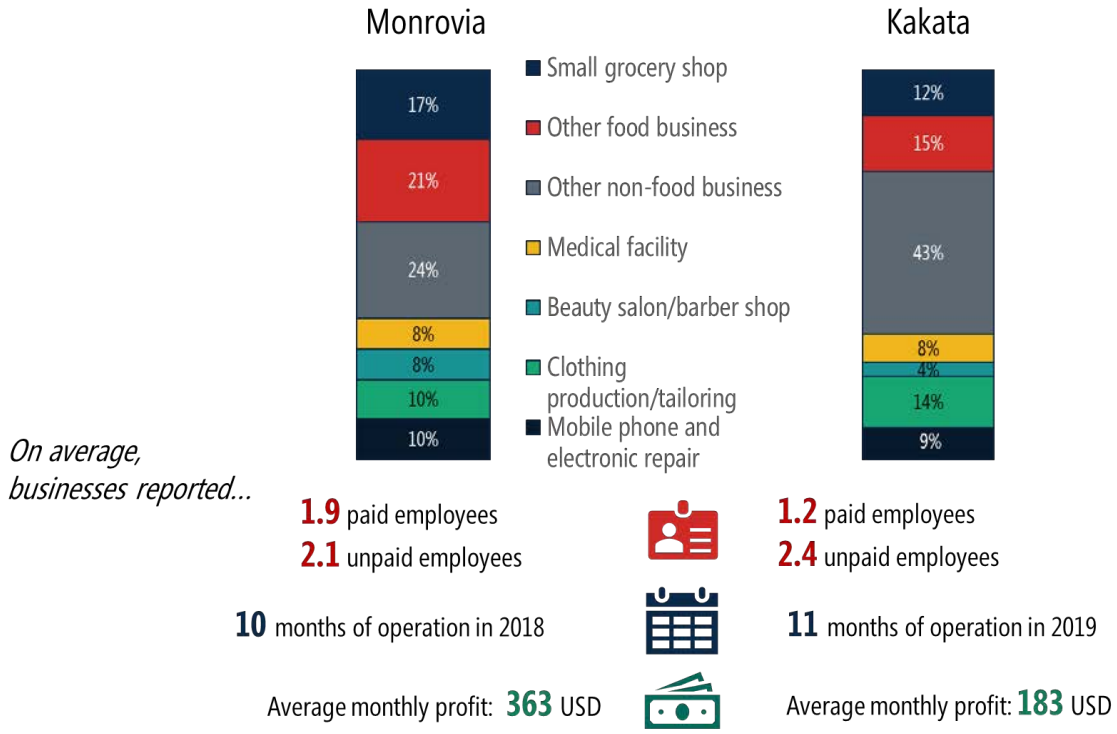


Source: 2020 Monrovia household survey; 2021 Kakata household survey
Notes: N = 766 households in Monrovia; 747 households in Kakata

3. Characteristics of the small-business sample

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 (Figure VI.4). On average, small businesses operated 10 to 11 months of the preceding year. The average monthly profit of small businesses in Monrovia was $363 compared to $183 for businesses in Kakata. Although this difference is consistent with our baseline sample, the monthly profits in both groups are about half what they were at baseline ($609 in Monrovia and $344 in Kakata) (Miller et al. 2020). This likely reflects the challenging economic situation in Liberia during the study period, as described elsewhere in this report.

Figure VI.4. Characteristics of small businesses in Monrovia and Kakata



Source: 2020 Monrovia small business survey; 2021 Kakata small business survey

Notes: N = 188 small businesses in Monrovia; 374 small businesses in Kakata

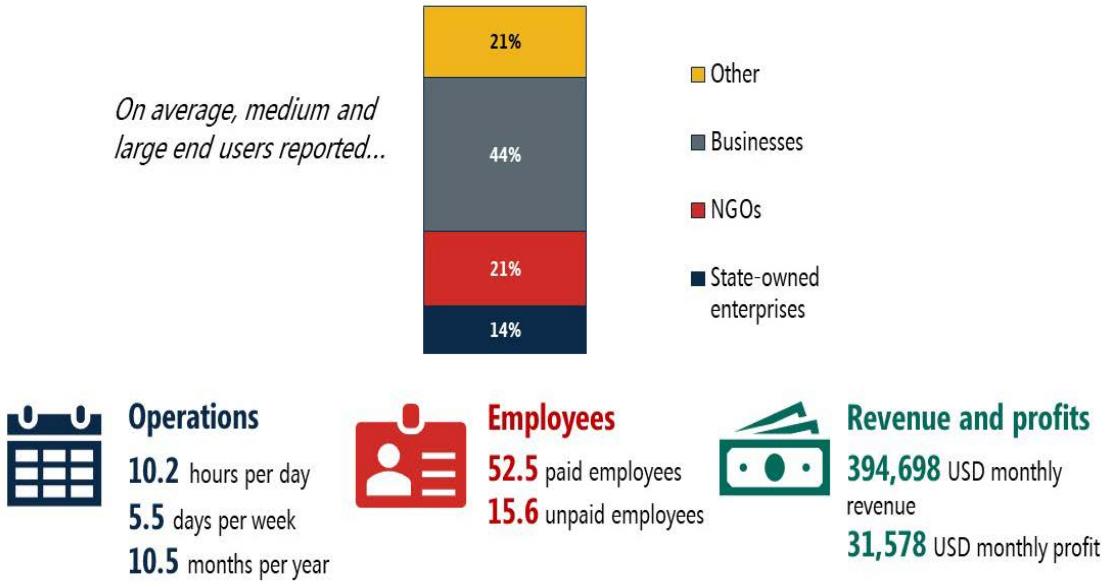
4. Characteristics of the medium and large end-user sample

The medium and large end-user sample was made up of government offices and state-owned enterprises, nongovernmental organizations (NGOs), medium and large businesses, and other private organizations. Figure VI.5 shows the distribution of end users and types of organizations within each category.[29] The medium and large businesses in this sample operated for about 10 hours per day, had about 52 paid employees, and $394,698 in monthly revenue, on average.[30]

[29] At baseline (Miller et al. 2020), we believe the sample was representative of medium and large end users with legal LEC electricity) and are likely to pay taxes. Based on the high refusal rate among medium and large end users at the follow-up round, 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.

[30] Business size varied widely among this sample, from businesses with 20 employees to those with hundreds.

Figure VI.5. Characteristics of medium and large end users



Source: 2021 medium and large end user survey
Notes: N = 125

C. Context

Our study analyzes end-user outcomes for the three study samples described above: (1) the Monrovia sample, made up of households and businesses connected to LEC electricity at baseline (2018); (2) the Kakata sample, made up of households and businesses *not* connected to LEC electricity at baseline (2019); and (3) medium and large end users (businesses, government offices, public services, and NGOs), some connected and some unconnected at baseline (2019). Figure VI.6 shows connection rates across the three study samples.

Figure VI.6. End-user access to electricity

	Monrovia	Kakata	Monrovia	Kakata	Medium and large end users
Baseline	100%	0%	100%	0%	56%
Final	74%	51%	45%	35%	65%

Sources: 2018 and 2020 Monrovia household and small business surveys; 2019 and 2021 Kakata household and small business surveys; 2019 and 2021 medium and large end-user surveys.

Notes: Findings are based on 1,183 households and 330 small-businesses in Monrovia, 875 households and 402 small-businesses in Kakata, and 180 medium and large end users that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

We designed the pre-post evaluation of the Kakata sample to estimate effects of new connections on end-user outcomes. Connection rates in Kakata increased from 0 percent in 2019 to 50 percent for households and 35 percent for small businesses in 2021. By 2021, 84 percent of sampled communities had at least some access to LEC electricity. The Kakata findings presented in this chapter thus capture the effects of increased access to electricity, as intended.

In contrast, we designed the pre-post evaluation of the Monrovia sample to estimate effects of increased supply of electricity from MCHPP and increased quality and reliability of electricity. However, connection rates among sampled households and small businesses decreased from 2018 to 2020, and there was no significant change in perceptions of electricity quality and reliability among end users that remained connected to LEC in 2020. This context is crucial to interpreting the Monrovia findings presented in this chapter.

In addition, our end-user findings are based on data collected in 2018-2019 and again in 2020-2021 and so must be interpreted in the context of the country's macroeconomic environment and the COVID-19 pandemic (as described in Chapter I), as well as the realities faced by LEC during this time (as described in Chapters IV and V). Inflation, which ranged between 9 and 27 percent between 2019 and 2021, was the primary economic concern for Liberian households in our study sample. In interviews, households said the price of essential commodities was unstable and had increased significantly, contributing to financial hardship among Liberians.

These economic challenges were compounded by the Covid-19 pandemic, which constrained most of our study sample. Households reported major learning losses for children, as Liberian schools were shut for most of the pandemic, and few households have internet access. Household income and income-generating activity (IGA) operations were also negatively affected (Figure VI.7).

Figure VI.7. Economic effects of COVID-19 on households

Households

	Monrovia, 2020	Kakata, 2021
Employment status of household member was affected	48%	38%
Decreased income	65%	62%
Stopped IGA operations	50%	51%
Decreased IGA revenue	76%	72%

Source: 2020 Monrovia and 2021 Kakata household surveys

Notes: Findings are based on 1,183 households in Monrovia and 875 households in Kakata that were followed over time. Actual sample sizes vary per outcome because of survey and item non-response.

Most small businesses and many medium and large end users suffered lower profits because of COVID-19 (Figure VI.8). Some businesses reported that they are still struggling to get back to normal after curfews and restrictions on movement limited their business activity and access to goods.

Figure VI.8. Economic effects of COVID-19 on businesses and medium and large end users

	Small businesses		Medium and large end users
	Monrovia, 2020	Kakata, 2021	2021
Stopped operations	60%	67%	61%
Reduced working hours	79%	84%	65%
Reduced profits	84%	83%	50%

Source: 2020 Monrovia and 2021 Kakata small-business surveys; 2021 medium and large end user survey.

Notes: Findings are based on 330 small businesses in Monrovia, 402 small businesses in Kakata, and 180 medium and large end users that were followed over time. Actual sample sizes vary per outcome because of survey and item non-response.

D. End-user findings

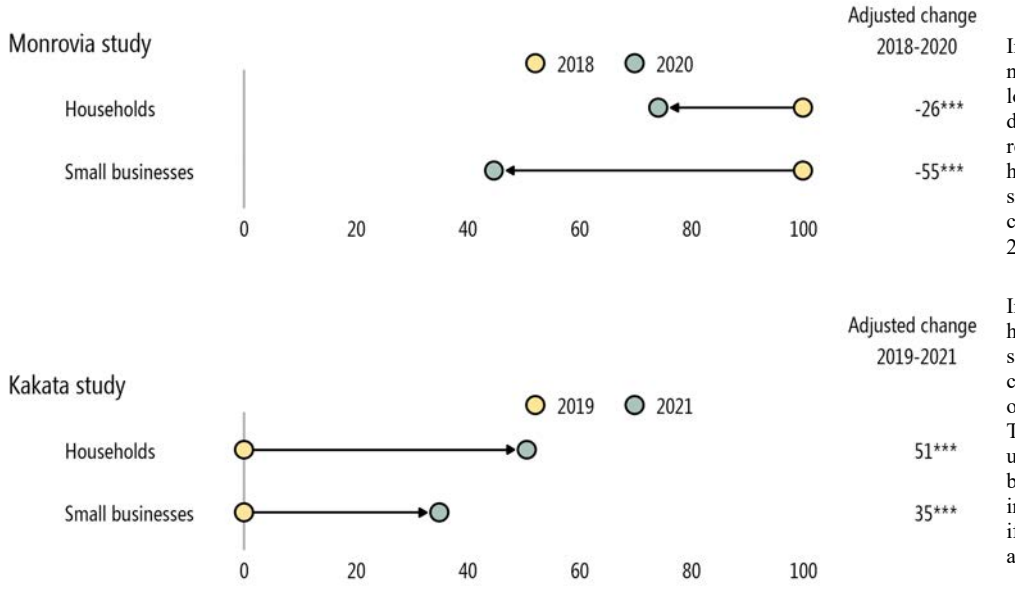
EQ C3. To what extent have the MCHPP Rehabilitation and Capacity Building and Sector Reform Activities affected the number of users connecting to the grid and the demand for electricity?

EQ D1: How do customers decide to connect, and why have other potential end users not connected? What barriers do potential customers face when trying to connect to the grid?

End-user surveys revealed changes in connection status from 2018-2019 to 2020-2021. Among households, small businesses, and medium and large end users in Monrovia and Kakata, changes could result from (1) gaining electricity access after the completion of T&D works; (2) gaining or losing access because of LEC's efforts to normalize connections, such as installing new meters, repairing faulty meters, and disconnecting illegal consumers; or (3) gaining or losing access because of end-user changes in economic status, perhaps as a result of the Covid-19 pandemic and its sequalae, or changes in preferred energy source.

- In Monrovia, there was a 26-percentage-point reduction in household connections and a 55-percentage-point reduction in small business connections from 2018 to 2020 (Figure VI.9.).
- In Kakaka, following completion of WB funded T&D construction, there was a 51-percentage-point increase in household and a 35-percentage-point increase in small business connections from 2019 to 2021. While Kakata has not been saturated with new connections, more than half of sampled households connected within a year of new T&D construction (Figure VI.10.).
- Medium and large end users in Monrovia increased connections from 2019 to 2021. Direct connections increased by 15 percentage points, and there was no change in indirect (illegal) connections (Figure VI.11.).

Figure VI.9. Connection status over time among household and small business end users in Monrovia, Kakata



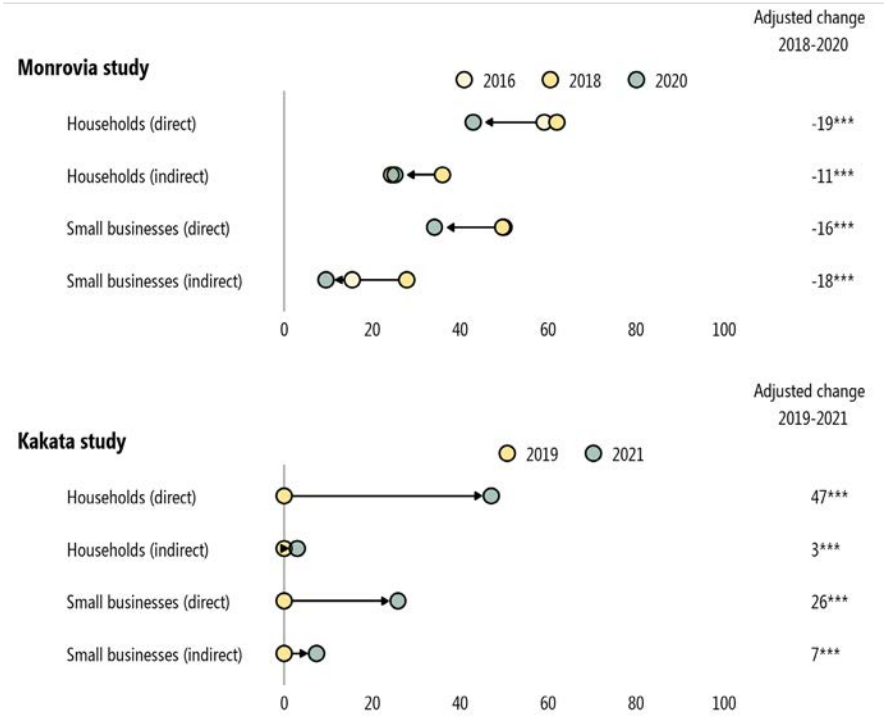
In Monrovia, LEC efforts to normalize customers and a loss in connectivity due to damaged or stolen equipment, resulted in 26 percent of households and 55 percent of small businesses losing connections from 2018 to 2020.

In Kakata, more than half of households and 35 percent of sampled businesses were connected by 2021, within one year of completion of T&D construction. In KIIs, unconnected households and businesses indicate a strong interest in connecting to LEC if their community receives access to electricity.

Sources: 2018 and 2020 Monrovia and 2019 and 2021 Kakata household and small business surveys respectively.

Notes: Based on 1,183 households and 330 small businesses in Monrovia and 875 households and 402 small businesses in Kakata followed over time. Sample sizes may vary because of survey and item non-response.

Figure VI.10. Changes in connection status among households and small businesses in Monrovia, Kakata



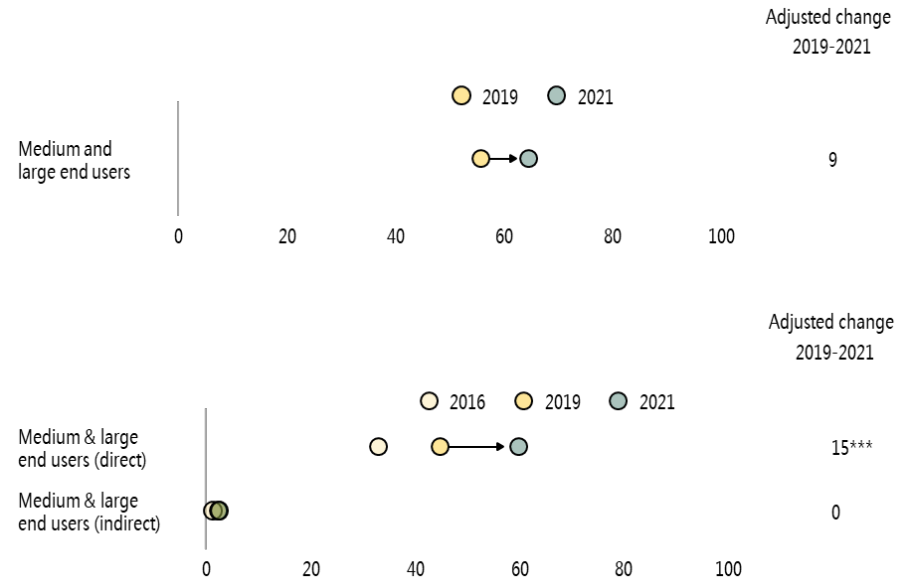
In Monrovia, from 2016 to 2020 direct and indirect connections declined among households and small businesses. The 11- and 18-percentage-point differences in indirect connections among households and businesses respectively likely occurred because of LEC normalization. Declines in direct connections might have occurred because the end user could no longer afford power, LEC's inability to restore connections lost due to equipment issues, or because low satisfaction with electricity quality led to use of other sources.

In Kakata, direct or legal connections increased by 47 and 26 percentage points in households and small businesses respectively compared to 3 and 7 percentage points for indirect connections.

Sources: 2018 and 2020 Monrovia and 2019 and 2021 Kakata household and small business surveys respectively.

Notes: Based on 1,183 households and 330 small businesses in Monrovia and 875 households and 402 small businesses in Kakata followed over time. Sample sizes may vary because of survey and item non-response.

Figure VI.11. Connection status and changes in connection status among medium and large end users



From 2019 to 2021, connections increased by 9 percentage points among medium and large end users (although not significant given the sample size).

We found a 15-percentage point difference in new direct connections and no change in reported indirect connections from 2019 to 2021.

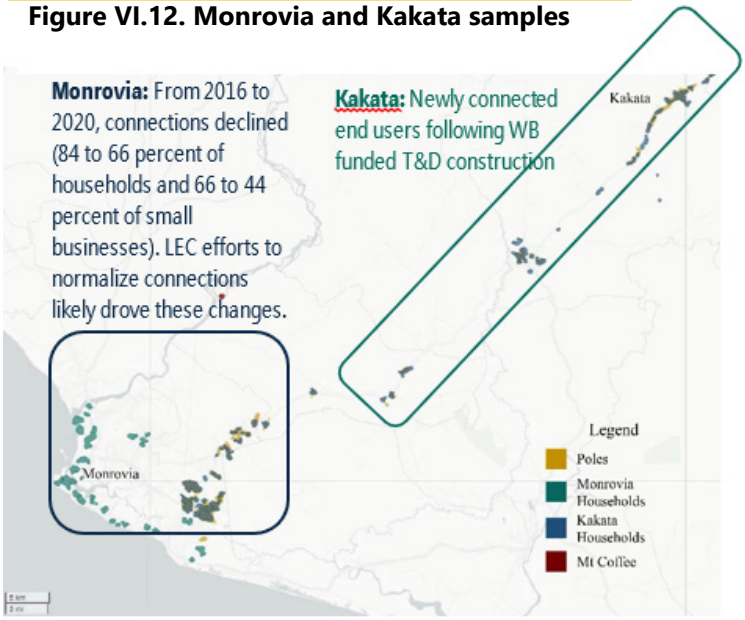
Sources: 2019 and 2021 medium and large end user survey.

Notes: Findings are based on 180 medium and large end users that were followed over time.

Changes in households' and businesses' main source of electricity over time shows how end users respond to gaining or losing electricity access. In Monrovia, households increased illegal connections from 2016 to 2018, then reduced both legal and illegal connections from 2018 to 2020 (Figure VI.13.). Some households and small businesses that lost LEC replaced it with their own or a neighbor's generator or a mini-grid. The 18 percent of households and 17 percent of small businesses that reported no main source of electricity in 2020 used charcoal, batteries, petrol, and kerosene. Among medium and large end users, LEC connections increased and use of a private generator decreased. In Kakata, many fewer households and businesses reported having no main electricity source from 2019 to 2021, when they accessed LEC connections (Figure VI.14.)

In Monrovia, end users faced challenges in restoring connections. Respondents from unconnected households and businesses indicated a strong desire to be connected to LEC. End users who lost their connection report contacting LEC repeatedly to restore their connection or report damaged or stolen equipment, but the utility was often slow to respond or unresponsive. In some instances, it took over two years for connections to be restored. Some end users also report making payments to LEC officials, either individually or through their communities, to get connected, while others have given up on being connected due to LEC's poor response.

Figure VI.12. Monrovia and Kakata samples



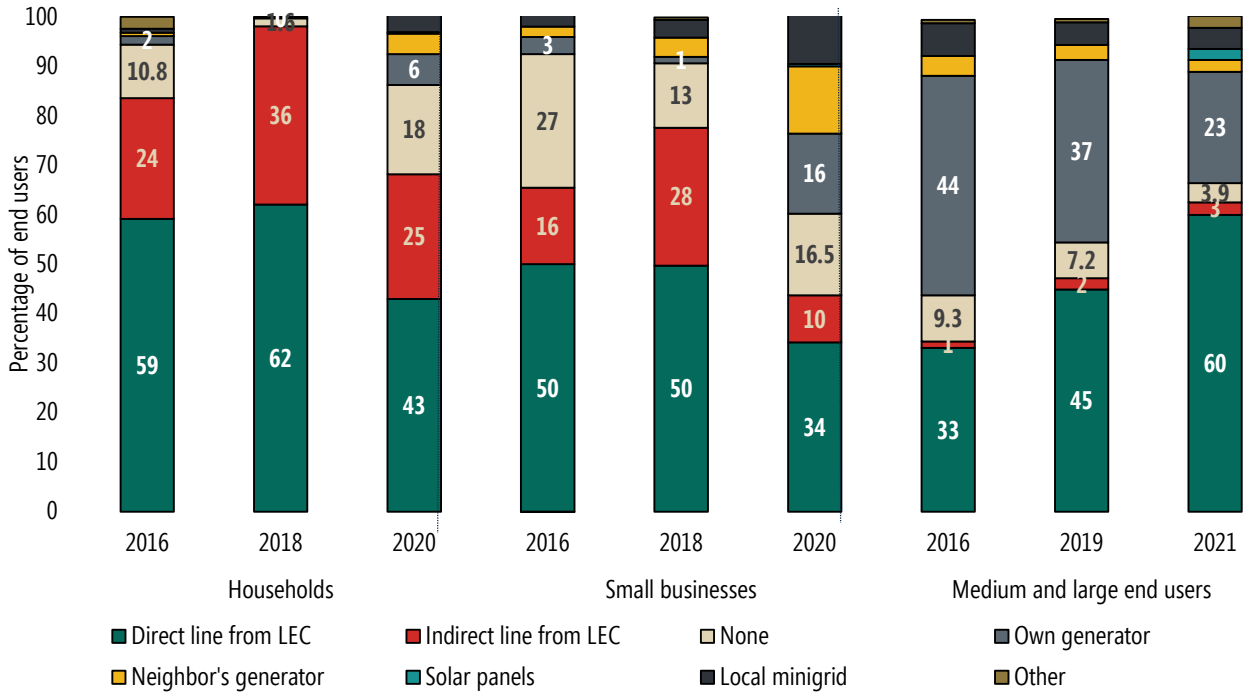
> *"There was a time the transformer blew off and then the community people had to do some level of contribution to get the transformer back on, and so they had to do some sort of reconnection to some other places that had problems and all of that. My business was one of those areas affected so I had to make my contribution."*

End-user spending on LEC electricity and generators decreased from 2018 to 2020-2021, and spending on other low-quality sources increased for most samples. These findings are not surprising, as average consumption decreased over time and the Covid-19 pandemic had negative economic impacts across Liberia and the world. Figure VI.15 displays end users' annual expenditures on LEC, generators and other sources among end users in Monrovia over time. Households, businesses, and medium and large end users decreased spending on LEC. Households increased spending on other sources, such as charcoal and batteries. Medium and large users decreased spending on generators and increased spending on local mini-grids, neighbor's generators, and solar. Small businesses kept similar spending patterns on generators and other sources.

Spending by decile for direct and indirect LEC connections provides additional insight into energy expenditures across income groups. The comparison of spending on legal and illegal connections shows that Liberians are spending very little on electricity at most deciles, which is consistent with consumption of less than 50 kWh per month. Overall, end users report minimal expenditures on LEC even at the 80th percentile ($20 per month, $240 per year among households in Monrovia and Kakata and small businesses in Kakata and $27.50 per month, $330 per year for small businesses in Monrovia). End users in Kakata spent more at each decile than users in Monrovia (Figures VI.16 VI.17 VI.18).

If the end users redirected spending from private generation to LEC, it could significantly increase LEC revenue. These data confirm that LEC should focus on normalizing more affluent households and businesses rather than small consumers.

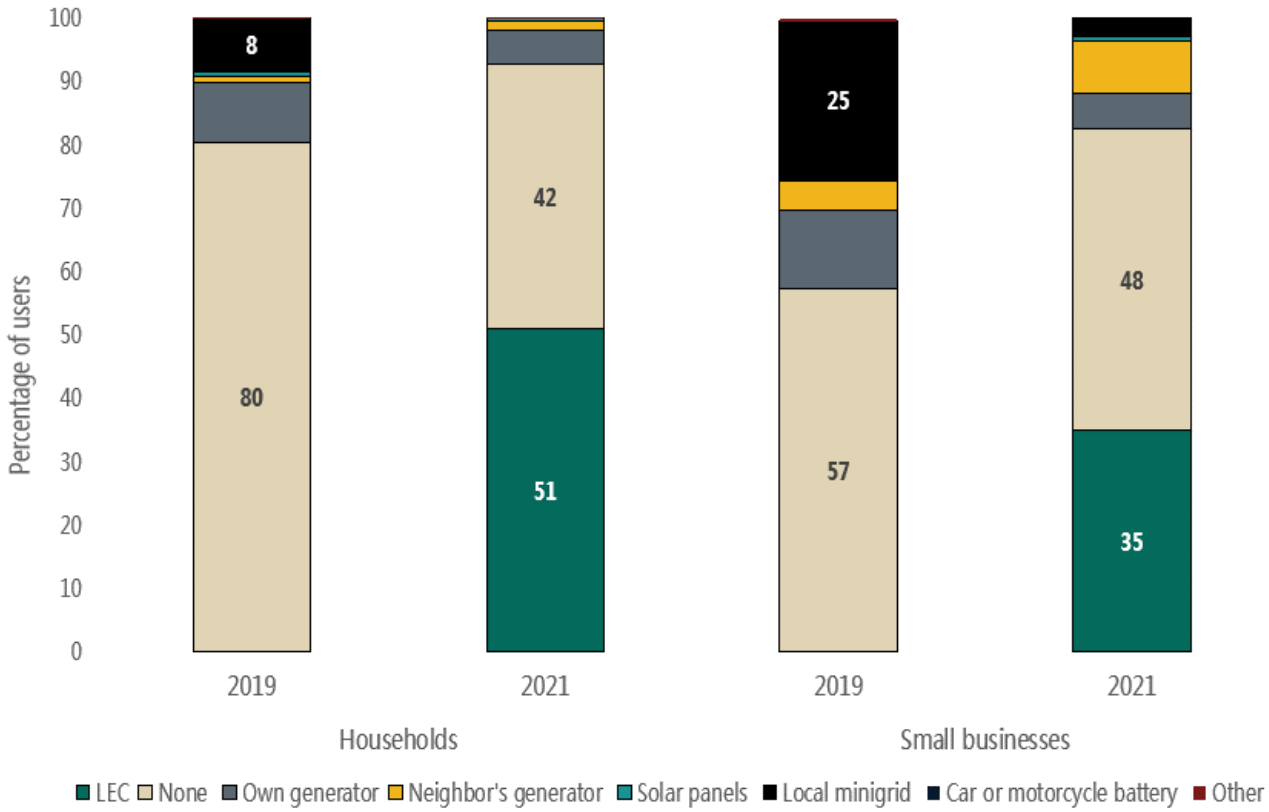
Figure VI.13. Main electricity source from 2016 to 2020, Monrovia end users



Sources: 2018 and 2020 Monrovia household and small-business survey; 2019 and 2021 medium and large end user survey.

Notes: Findings are based on 1,183 households and 330 small businesses in Monrovia and 180 medium and large end users that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

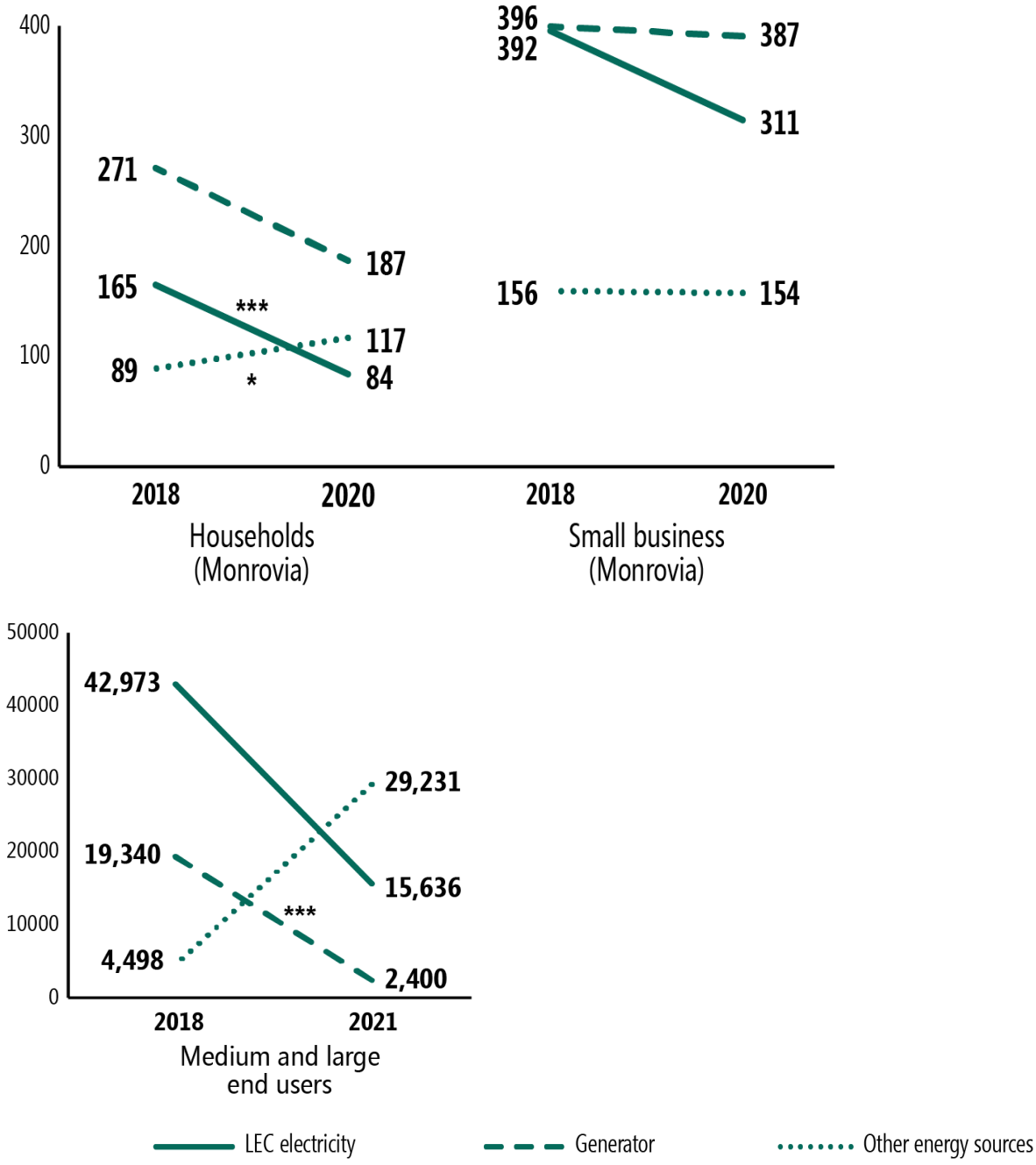
Figure VI.14. Main electricity source from 2019 to 2020, Kakata end users



Sources: 2019 and 2021 Kakata household and small business surveys.

Notes: Findings are based on 875 households and 402 small businesses in Kakata that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

Figure VI.15. Annual expenditure on energy sources (USD), households, small businesses, and medium and large end users in Monrovia.



Sources: 2018 and 2020 Monrovia household and small-business survey; 2019 and 2021 medium and large end user survey.

Notes: Findings are based on 1,183 households and 330 small businesses in Monrovia and 180 medium and large end users that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

Figure VI.16. Monthly spending on LEC for legal and illegal connections, Monrovia households (left) and small businesses (right)

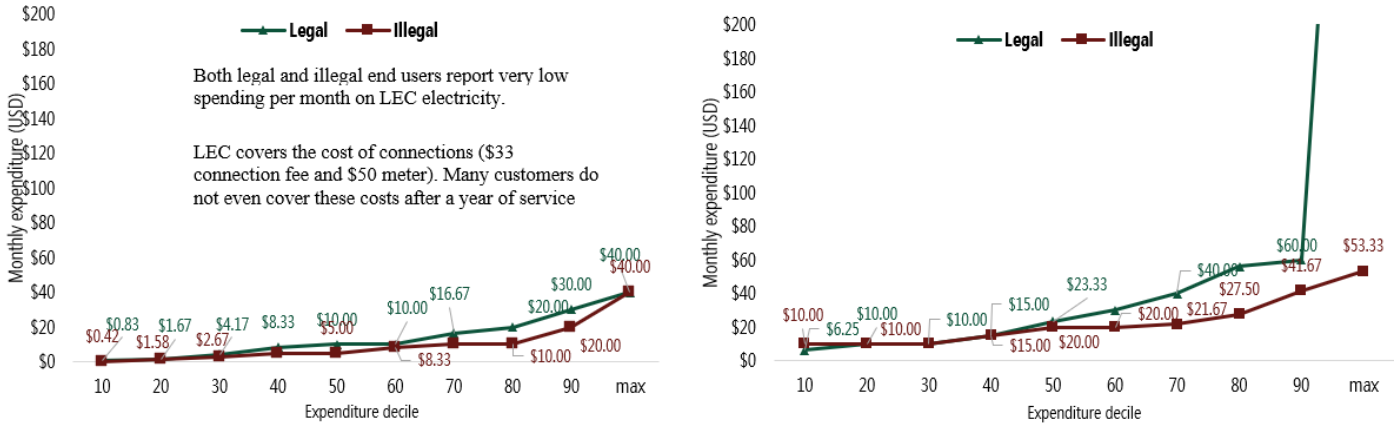
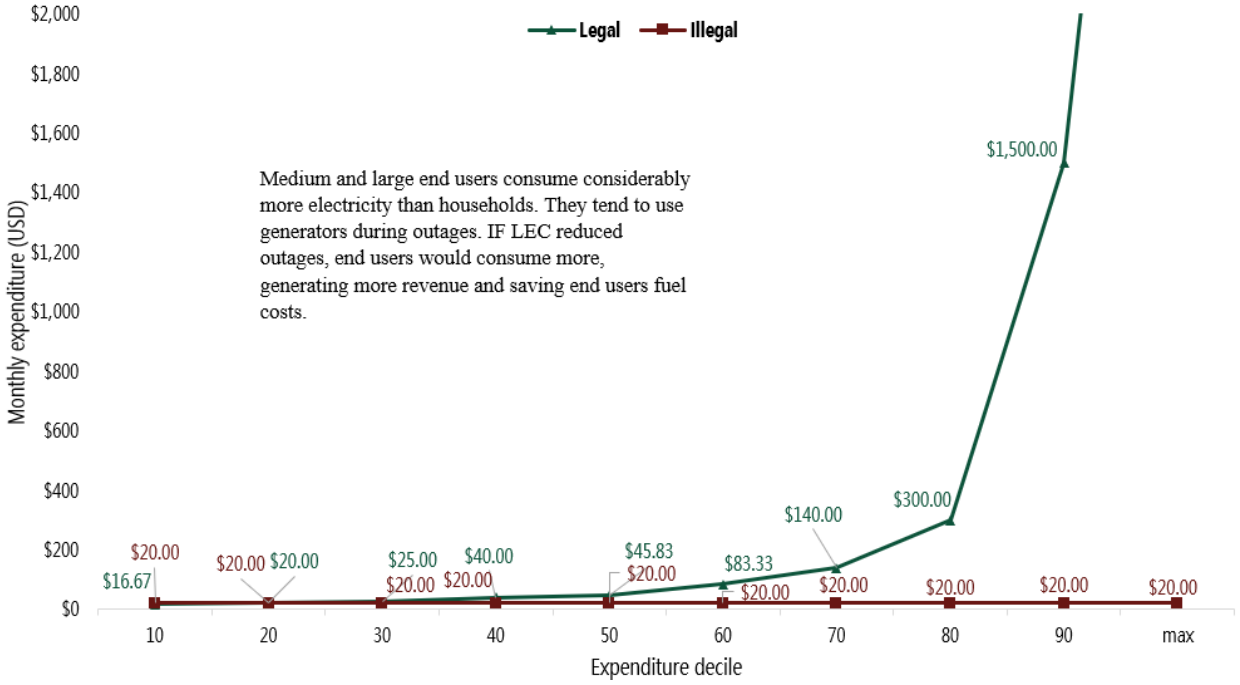


Figure VI.17. Monthly expenditures on LEC for legal connections among Kakata households (left) and small businesses (right)

Figure VI.18. Monthly expenditures on LEC for legal connections among Kakata households and small businesses

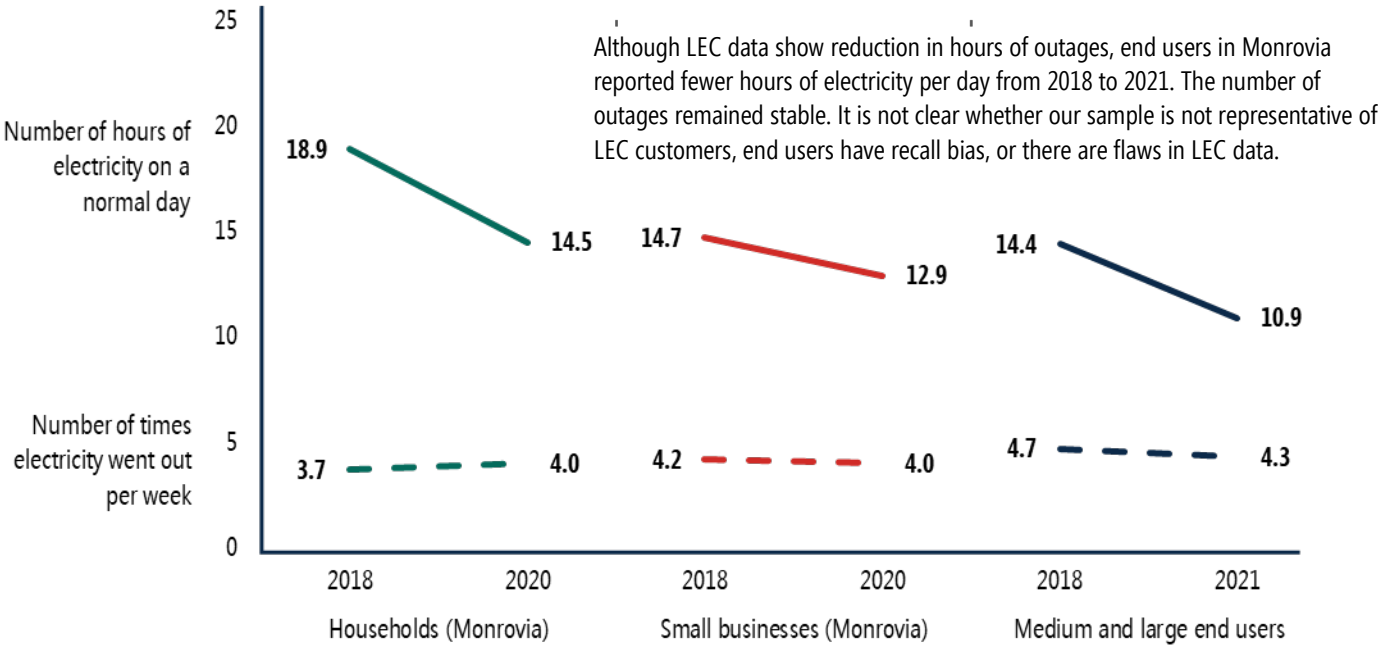


EQ D2. How have MCC's investments affected connected and unconnected households' perceptions of the quality of electricity?

End users from households and businesses confirmed some reductions in outages and described the negative impacts of these power failures. Survey respondents from households, small businesses, and medium and large end users reported a reduction in the number of hours of electricity outages per day from 2018/2019 to 2020/2021, but minimal changes in the number of outages per week (Figure VI.19). This is likely because LEC's reduced outages did not change much during the survey period. Annual outages remained relatively high at 253 hours in 2020 and 204 in 2021. The SSA average is 9 outages per month lasting 5 hours. In December 2021, Liberian end users experienced 15 outages per month lasting 17 hours on average.

According to MCC's program logic, improved electricity reliability and reduced outages would lead to long-term outcomes of increased business productivity and expanded operations. Figure VI.20 illustrates how businesses had to modify or interrupt operations or had damaged goods and equipment from outages. While LEC has made improvements, end users require more hours of reliable power with fewer interruptions to achieve improved productivity and operations.

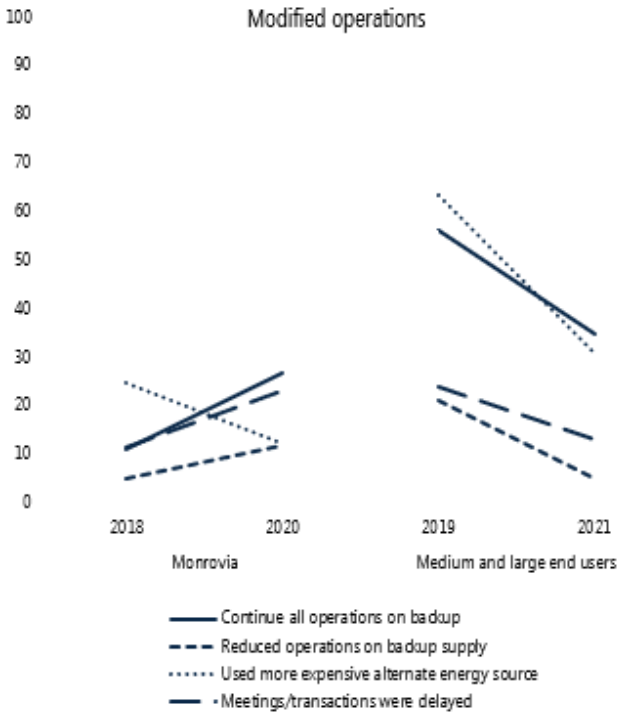
Figure VI.19. End-user reports of outages among connected end users across Monrovia



Sources: 2018 and 2020 Monrovia household and small-business surveys; 2019 and 2021 medium and large end-user surveys.

Notes: Findings are based on 1,183 households and 330 small businesses in Monrovia and 180 medium and large end users that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

Figure VI.20. Negative effects of power outages for businesses

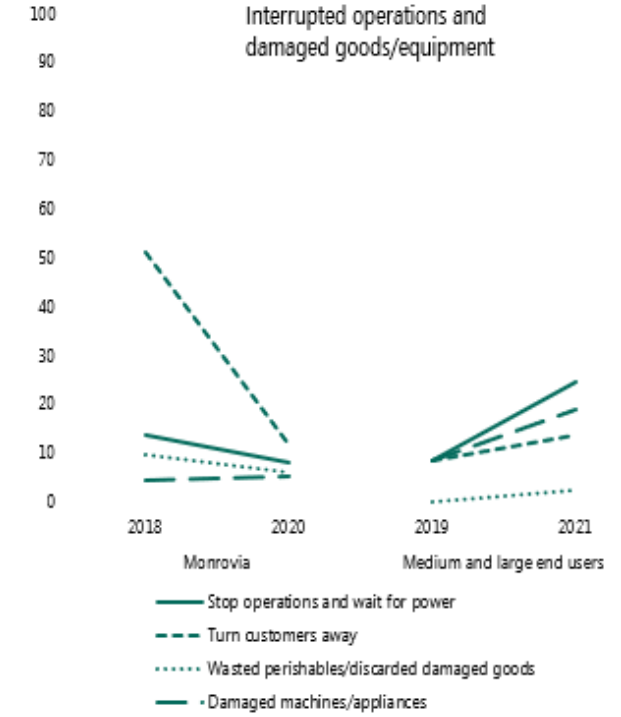


Reliable electricity is important to business operations, and outages require businesses to modify operations.

- Small businesses in Monrovia reported they were more likely to use back-up power, reduce operations, and delay transactions in 2020 compared to 2018.

  "Sometimes I freeze water, I buy water by sack and then I put it in the fridge, so like juices and other things, you know people buy that, so the LEC helps in that direction and it's kind of helpful to the business as well, that's why whenever it goes off, it creates a serious setback to the business."

- They also reported a 15-percentage-point reduction in using more expensive alternative energy from 2018 to 2020, likely because they could not afford to.
- In contrast, medium and large end users were less likely in 2021 than 2019 to modify operations.
- These users had higher satisfaction than small business owners. While the number of hours of electricity per day was reduced in 2021 to 10.9 hours, it may have been adequate, for example for an 8- to 9-hour workday.



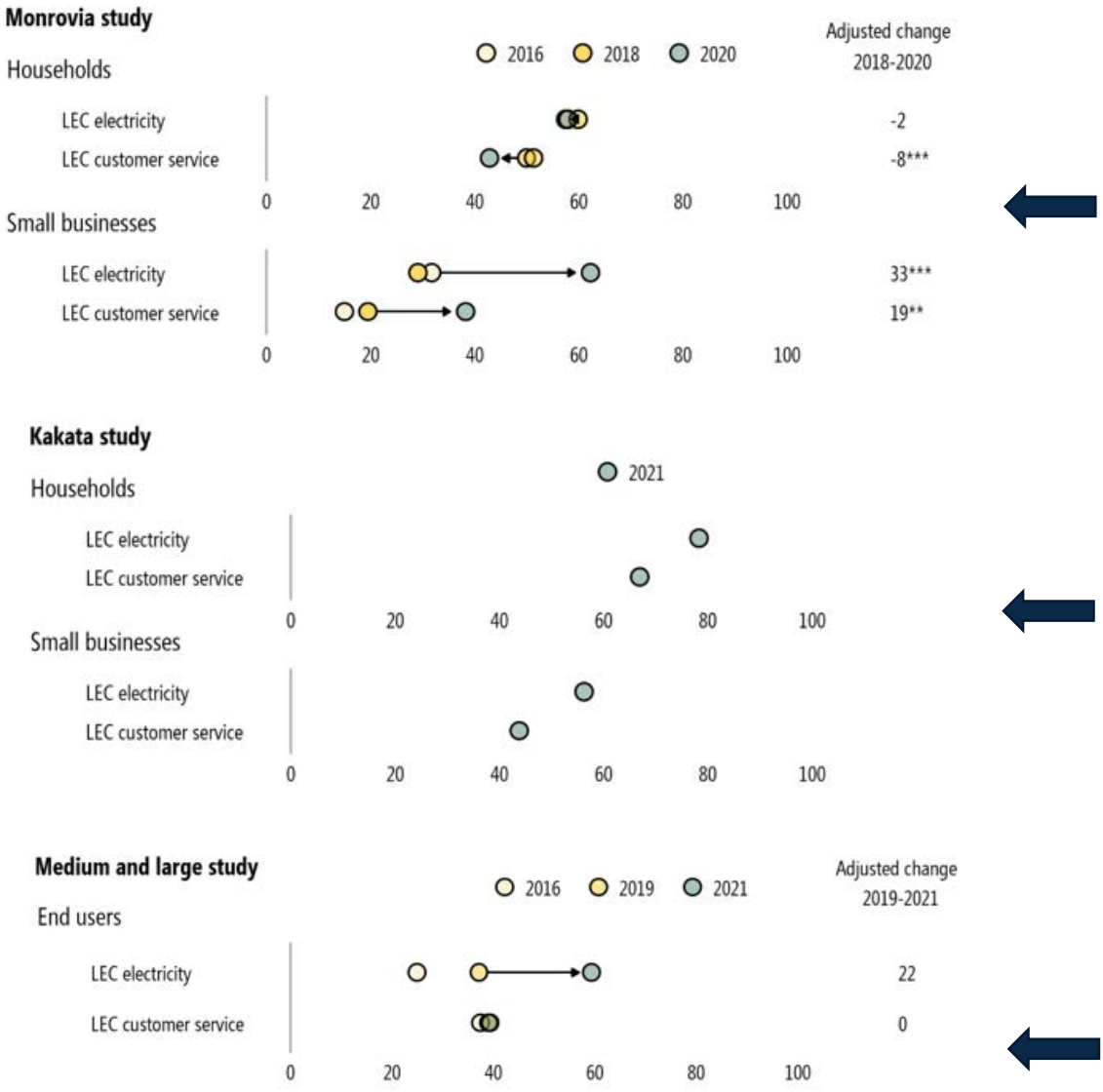
- Small businesses in Monrovia were less likely to turn customers away in 2020 compared to 2018. It is possible that they had fewer customers, as the survey was administered when Covid-19 limited activity.
- Medium and large end users reported differences from 2019 to 2021, including being more likely to stop operations and wait for power.

Sources: 2018 and 2020 Monrovia small-business surveys; 2019 and 2021 medium and large end-user surveys.

Notes: Findings are based on 330 small businesses in Monrovia and 180 medium and large end users that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

End-user satisfaction with LEC electricity and customer service varied by samples and may not reflect the latest improvements. Households in Monrovia reported no change in satisfaction with electricity quality, while lower satisfaction with LEC's customer service (8 percentage points). This may be due to the meter normalizations and disconnections (Figure VI.21). In contrast, small businesses reported improved satisfaction with LEC electricity quality (33 percentage points) and customer service (14 percentage points). In Kakata, 80 percent of households and 58 percent of businesses were satisfied with LEC electricity, and 68 percent of households and 42 percent of small businesses were satisfied with LEC's customer service. Medium and large end users report improved satisfaction with LEC electricity quality from 2016 to 2021 (22-percentage-point difference, but not statistically significant with the small sample size). They reported no change in LEC customer service quality.

Figure VI.21. Percentage of end users reporting they were somewhat or very satisfied with LEC



Households in Monrovia reported no change in satisfaction with electricity quality, but lower satisfaction with LEC's customer service (8 percentage points). This may be due to the meter normalizations and disconnections.

In contrast small businesses reported improved satisfaction in LEC electricity quality (33 percentage points) and customer service (14 percentage points).

Kakata respondents did not report change in satisfaction as they were recently connected.

Overall Kakata households had greater satisfaction with LEC electricity and customer service than businesses and households in Monrovia. About 80 percent of Kakata households, and 58 percent of businesses were satisfied with LEC electricity.

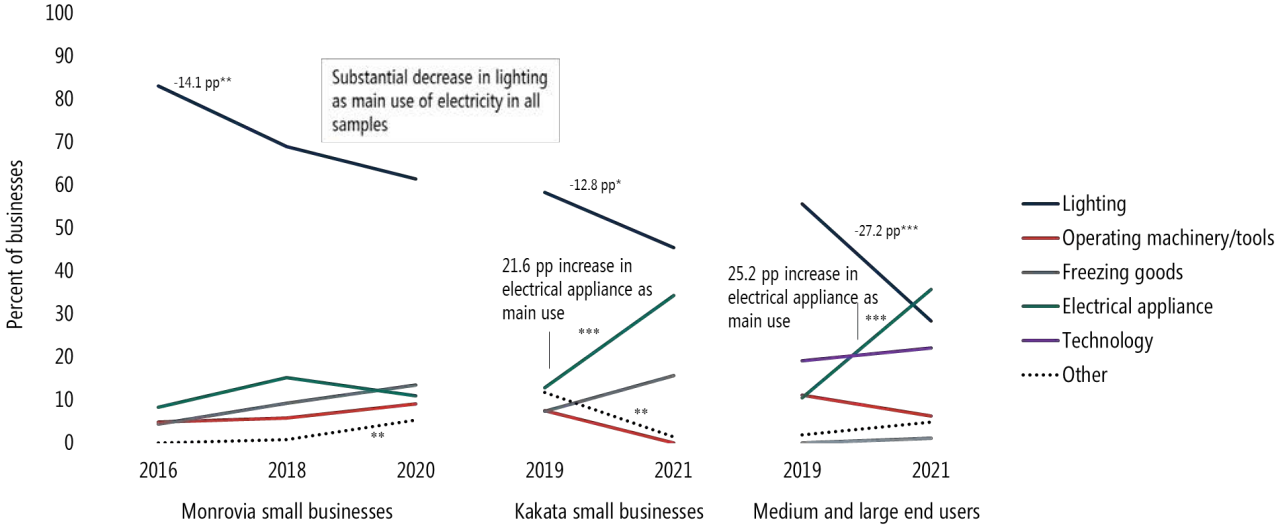
Medium and large end users report improved satisfaction with LEC electricity quality from 2016 to 2021 (22-percentage-point difference although not statistically significant given the small sample size). They reported no change in LEC customer service quality.

EQ D3. To what extent do customers invest in energy-intensive appliances or equipment? What is the effect of energy on time use (household production, leisure, school, work, and employment)?

EQ D5. How do impacts vary by differences in gender, socioeconomic status, and other demographic characteristics?

Main uses of electricity. Since baseline, more end users—households, small businesses, and medium and large end users across Monrovia and Kakata—reported electrical appliances as their most important use of electricity (Figures VI.22 and VI.23). Medium and large end users reported the largest shift, a decrease of 27.2 percentage points in using electricity mainly for lighting and a corresponding increase of 25.2 percentage points in using it mainly for appliances. Kakata small businesses reported a decrease of 13 percentage points in using electricity mainly for lighting and an increase of 22 percentage points in electronics and appliances. The remaining samples had similar shifts, though differences were not always statistically significant. In Kakata, households with income generating activities (IGAs), female-headed households, and households with above-average consumption had larger shifts towards appliance use than households without IGAs, male-headed households, and households with below-average consumption, despite similar connection rates across all subgroups (See Appendix Table D.19 for subgroup analysis).[31]

Figure VI.22. Most important use of electricity for small businesses and medium and large end users (self-reported)

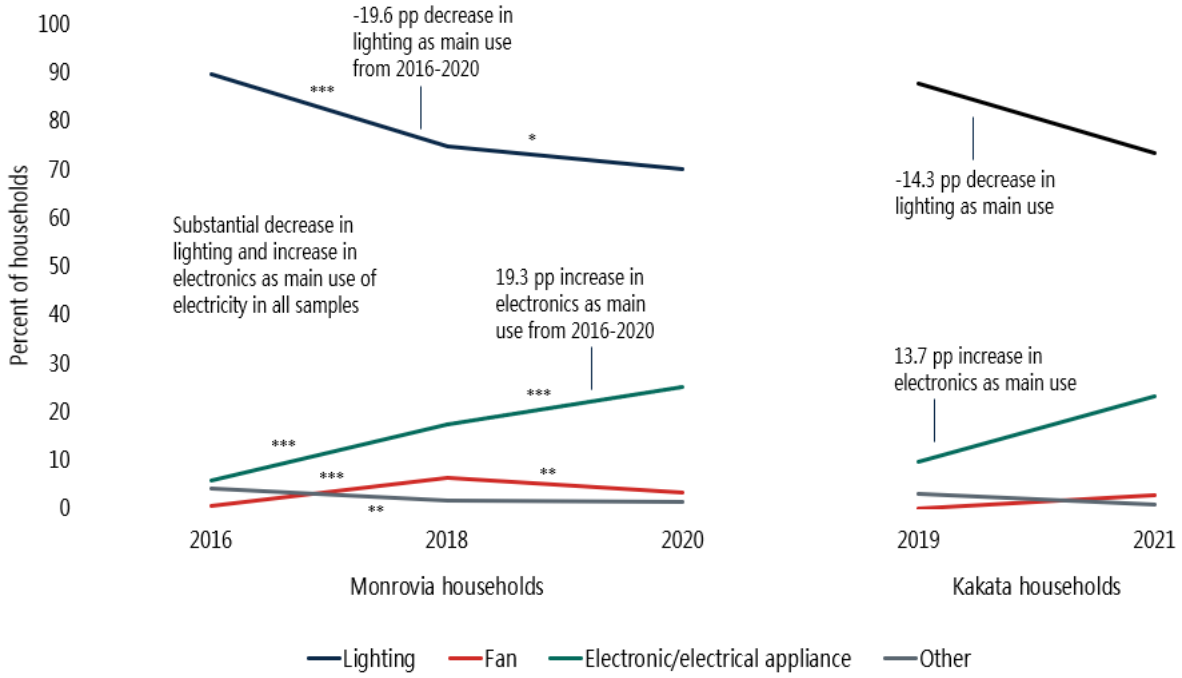


Sources: 2018 and 2020 Monrovia small-business surveys; 2019 and 2021 Kakata small-business surveys; 2019 and 2021 medium and large end-user surveys.

[31] We did not test for statistical significance given small subgroups sizes We report results where there is a consistent trend across multiple outcomes or when the difference is large enough to suggest important variations.

Notes: Respondents were asked to identify the most important use of electricity for their business; the measure does not reflect kWh consumption. Sample includes end users connected to LEC and other sources of electricity, such as generators or community current. Findings are based on 330 small businesses in Monrovia, 402 small businesses in Kakata, and 180 medium and large end users. Sample sizes vary because of survey and item non-response.

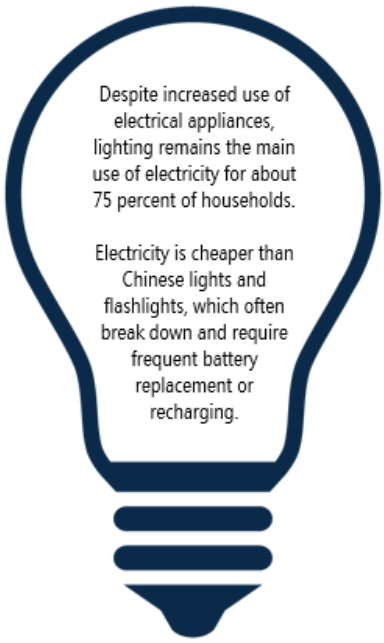
Figure VI.23. Main use of electricity for households (self-reported)



Source: 2016, 2018, and 2020 Monrovia and 2019 and 2021 Kakata household surveys.

Notes: Respondents were asked their main use of electricity; the measure does not reflect kWh consumption. Sample includes businesses and end users connected to LEC and those who use other sources such as generators or community current. Findings are based on 1,183 households in Monrovia and 875 households in Kakata followed over time. Sample sizes vary because of survey and item non-response.

Electrical appliances. In Monrovia and Kakata, interviewed connected households said that they most frequently use televisions and fans to improve quality of life. However, some connected households also used electric stoves and irons for household chores and refrigerators or "ice boxes" to sell cold water, juices, and other perishable food. Selling cold drinks is a common income-generating activity for women in Liberia, and LEC electricity is critical:



> *"When the LEC light goes, it spoils our market…because the goods we sell don't survive in heat." —Household head in Monrovia*

For businesses, schools, health centers, and government offices, use of electrical appliances such as printers, computers, air conditioners, and refrigerators is vital to effective operations. For example, health clinics and pharmacies rely on generators to refrigerate medication and vaccines and ensure adequate lighting during medical procedures.

> *"Yes, we use the LEC to lighten up our environment…in the female ward, in the male ward, in the delivery room….The lab also uses current, so we use the light for the microscope, and we use it to sterilize our equipment." —Connected health facility in Kakata*

Connected schools use LEC mainly for operating fans, computers, printers, and photocopiers during the day, and for lighting in night school. One school in Kakata had invested in new appliances like printers and computers, and another had introduced a computer lab since getting connected to LEC electricity.

> *"Yes, we are making great improvements to our system. We have increased our computers, we have increased our printers, and the enrolment has also increased because we have current. We no longer have to go to…other areas to print our tests; we do our work on campus." —School director in Kakata*

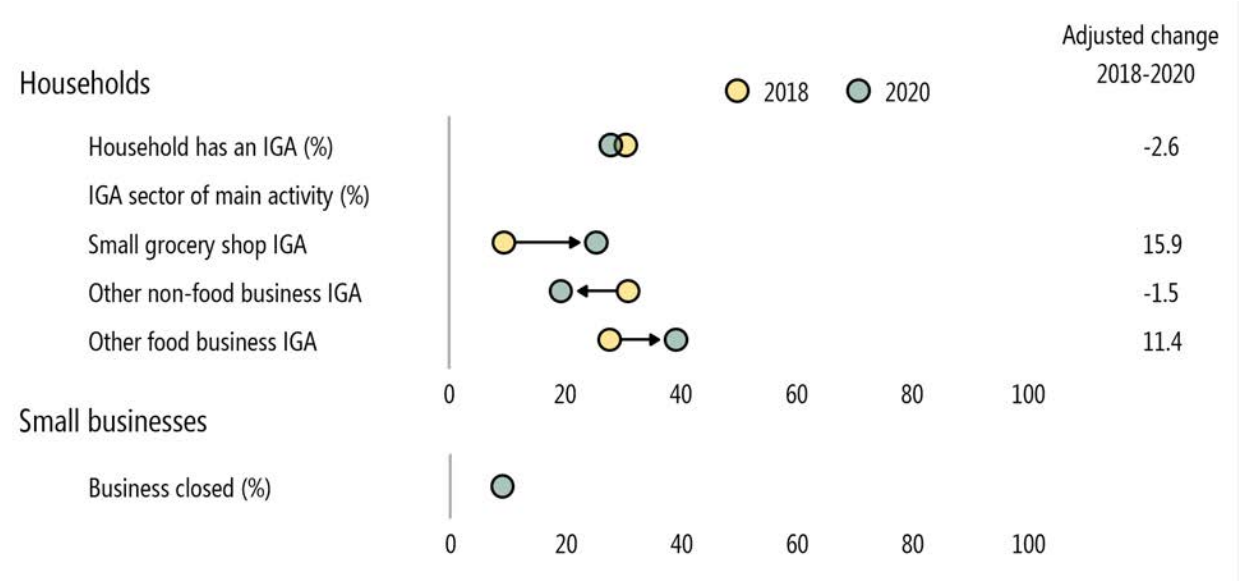
Some unconnected respondents reported using generators to power electrical appliances, but this was uncommon, as the cost of operating generators is high.[32]

Business activity. Our evaluation found that business activity had decreased among households and businesses since baseline, a period marked by the Covid-19 pandemic and a worsening macroeconomic environment in Liberia. The project's theory of change assumed that increased access to electricity would lead to increased business activity. In Monrovia, where connections to LEC among our sample had *decreased* since baseline, that logic holds: the percentage of

[32] Because we had to reduce the length of the phone survey, we did not collect information on appliance use during the interim data collection (2020-2021). We had planned to collect data on appliance use in the final data collection round, but that round was canceled.

households operating at least one IGA fell by 3 percentage points (from 31 to 28 percent), and 9 percent of the original sample of small businesses had closed since 2018 (Figure VI.24).

Figure VI.24. Business activity in Monrovia

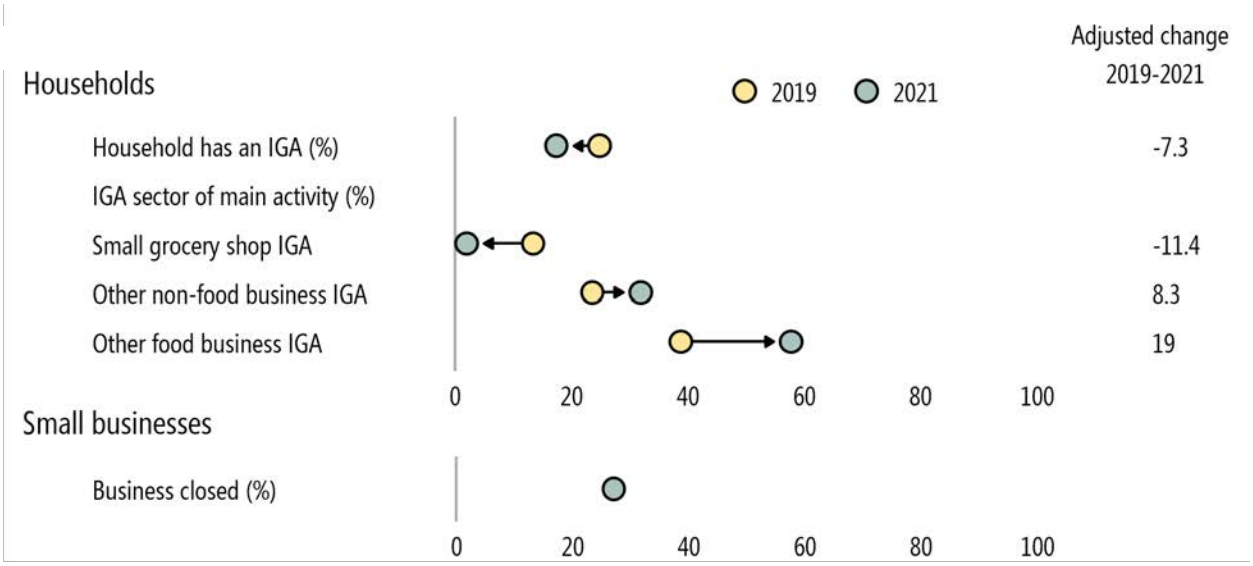


Source: 2018 and 2020 Monrovia household and small-business surveys

Notes: Findings are based on 1,183 households and 330 small businesses in Monrovia that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

However, as LEC connection rates improved along the Kakata corridor, the percentage of households operating an IGA fell by 7 percentage points (from 24 to 17 percent), and 27 percent of the original sample of small businesses had closed since 2019 (Figure VI.25). The findings from Kakata could suggest that access to electricity was insufficient to mitigate the negative effects of the macroeconomic situation and COVID-19, but we cannot say how these businesses would have fared in the absence of any electricity. It could also be that one to two years of access to electricity (the amount of time electricity was available in Kakata communities prior to the final data collection) was not long enough to improve business activity. Finally, we note that the study did not capture the creation of new businesses, as we surveyed only businesses that were already established at baseline.

Figure VI.25. Business activity in Kakata

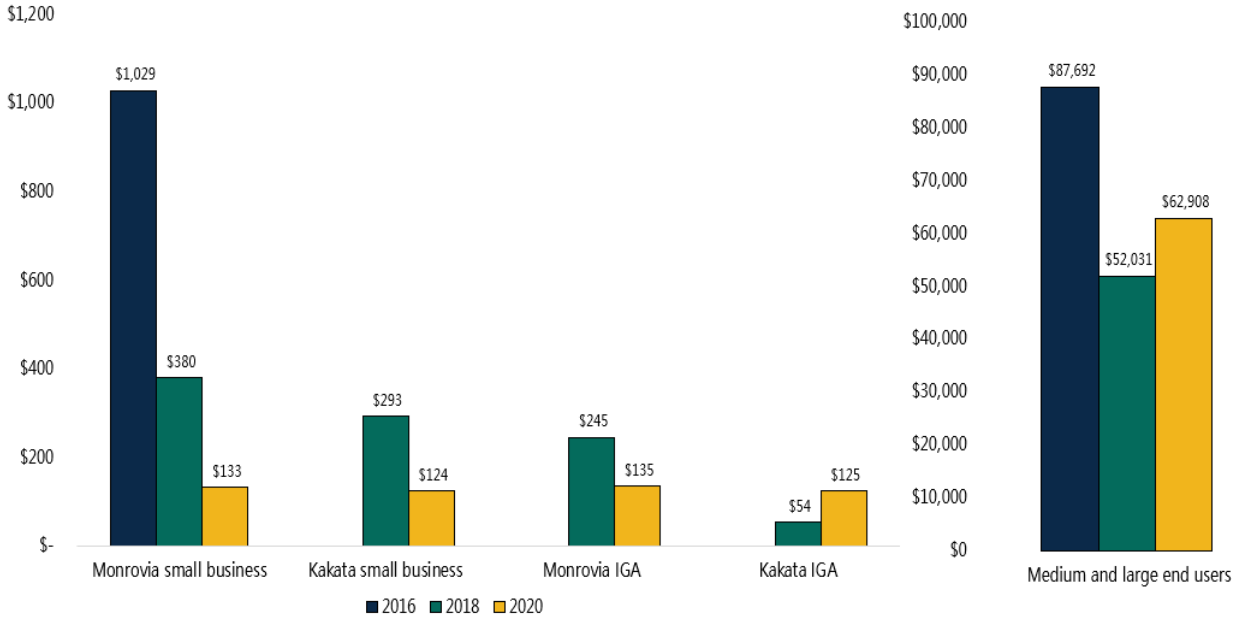


Source: 2019 and 2021 Kakata household and small-business surveys.

Notes: Findings are based on 875 households and 402 small businesses in Kakata that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

Business profits. Business profits also declined across nearly all samples (Figure VI.26). Although the changes are not statistically significant, their magnitude suggests important decreases in the financial performance of businesses. In Monrovia, small-business profits fell by 90 percent between 2016 and 2020, and IGA profits fell by about 40 percent between 2018 and 2020. These decreases could have been caused in part by declining connection rates in our sample between 2018 and 2020. However, there was also a large decrease in business profits between 2016 and 2018, when the Monrovia sample was connected entirely to LEC electricity. This suggests that factors other than access to electricity played a role in reduced profits. In Kakata, small-business profits decreased and IGA profits increased between 2018 and 2020; we cannot say what role increased access to electricity played in these changes. Across both samples, respondents reported that LEC electricity reduces business costs, attracts customers through bright lighting and increased safety, and increases operating hours and sales, all of which lead to higher profits.

Figure VI.26. Business profits



Sources: 2018 and 2020 Monrovia household and small-business surveys; 2019 and 2021 Kakata household and small-business surveys; 2019 and 2021 medium and large end-user surveys.

Notes: Findings are based on 1,183 households and 330 small businesses in Monrovia, 875 households and 402 small businesses in Kakata, and 180 medium and large end users that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

Across both Monrovia and Kakata, IGAs in female-headed households performed worse than in male-headed households. In Monrovia, IGA profits in female-headed households fell by about twice as much (Appendix Tables C.20 and D.20) In Kakata, the share of female-headed households with an IGA fell by more than 13 percentage points, from 31.6 percent to 18 percent, and the share of male-headed households with an IGA fell just 3 percentage points, from 21.6 percent to 18.7 percent. Further, average monthly profits in male-headed households rose by 7 times as much as those in female-headed households. Because connection rates were similar across female- and male-headed households, it seems that external forces such as COVID-19 disproportionately affected female-headed households.

Adult time use. Based on household survey data, we find that increased access to electricity (in Kakata) and decreased access (in Monrovia) did not result in statistically significant changes in how adults allocated their time. However, interviewed respondents in 2019 and 2021 cited many ways in which electricity improves everyday life. Across Monrovia and Kakata, respondents with LEC reported that since getting an LEC connection, they spent less time on chores such as cooking, pressing clothes, and using electrical appliances like electric stoves and irons. Household members also appreciated being able to complete domestic tasks at any time, as they had lighting at night. In addition, interviewed adults say that after getting connected, they spent more time on leisure activities like watching television or listening to music, which resulted in more time spent at home with their families. Respondents said that these quality-of-life

improvements were particularly prominent for female household members, who are more likely to stay home during the day and who perform more household chores than men.

Child time use. In qualitative interviews with households that have LEC connections, respondents reported that children can study at home, where they are safe, because they have lighting at night. Further, their eyes are not strained through use of shoddy Chinese flashlights. Unconnected households noted that their children are unable to use computers or phones for schoolwork. This could mean that as technology evolves and becomes more prevalent in schools, children without electricity will be left even further behind.

Health impacts. Overall, the majority of interviewed households reported no effects on health due to electricity. However, a few households reported using fans to cope with hot weather and drive away mosquitoes, which they stated helped them sleep comfortably and reduced the risk of malaria. This indicates some potential health benefits of access to electricity.

> *"It also helps as it relates to health, in the sense that mosquitoes are around at night, and it's not safe to use the mosquito coil, so if you put the fan on. t will blow away the mosquitoes and that also helps with the health aspect." – Connected household in Monrovia*

> *"When LEC arrives, you turn on the fan so that it can blow and you feel comfortable. But when LEC goes off, the entire room can become hot as fire, and there is no way for a breeze to come in through the window; I even lifted the window curtain, and there is still no breeze." -Connected household in Monrovia*

EQ D2. What, if any, are the spillover effects on non-electrified households?

Community services. When a community connects to the grid, even unconnected end users can benefit from access to better quality services. In Kakata, community leaders reported large increases in the proportion of public-service entities that have access to the grid after two years (Figure VI.27), including public and private schools, health care providers, police, and local government offices. More than 60 percent of health facilities, pharmacies, and private primary and secondary schools in survey Kakata communities now have LEC electricity, compared to under 15 percent in 2019.

Interviewed respondents suggested that these connected facilities have improved service delivery and allowed them to serve more people. For instance, newly connected health facilities in Kakata reported improved medical services as a result of electricity. These health facilities now have adequate lighting to conduct medical procedures at night and use electrical appliances such as air conditioners to keep patients comfortable and refrigerators to store medication and vaccines. In contrast, unconnected facilities struggle to provide high quality care.

> *"[Electricity] helps…when we are giving the patient care. Before, there was no current, but now there is current that we can put on and do our work. We can give our patient injections and IV, and do all the other things. Even in the lab, there was no current before, but we are carrying on the test for our patient. So we don't have to use our*

phone light to do all those things. Now, since current is available, we put the current on…. It really helping us." Connected health facility in Kakata

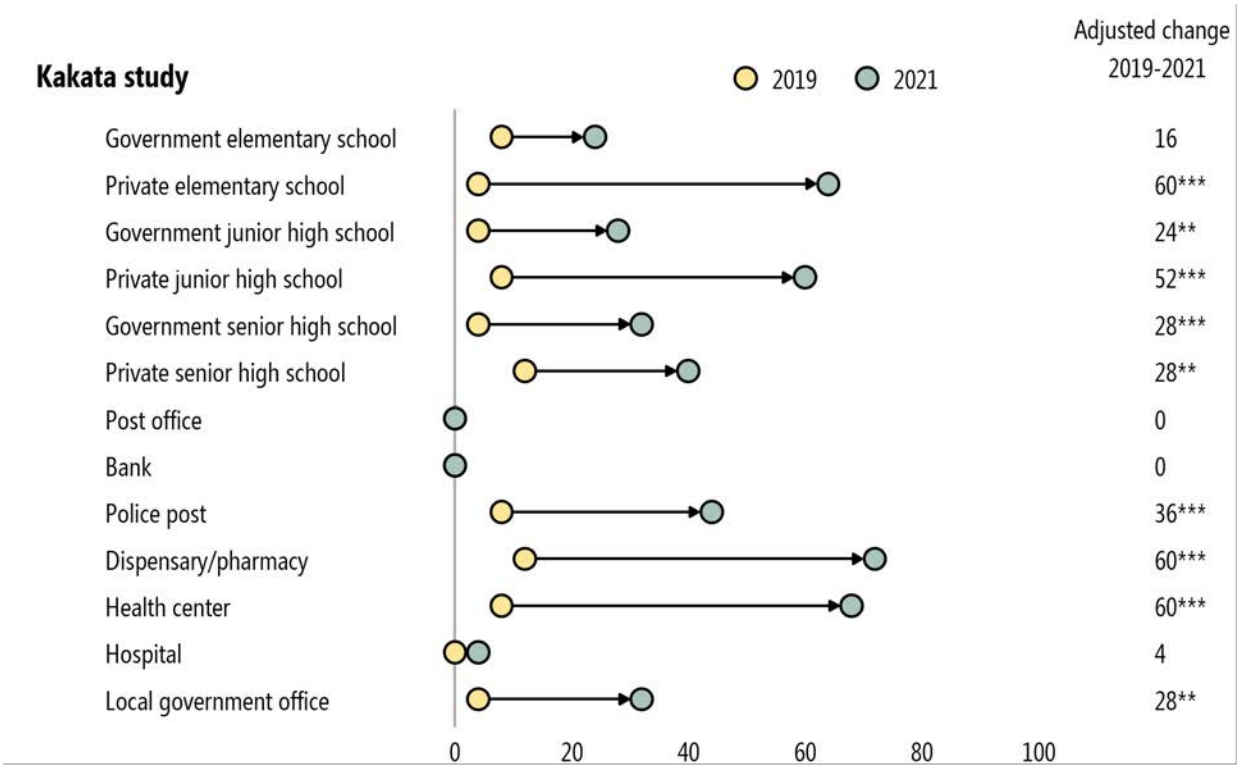
"People will come in the night, then they say gas is finished from the generator…. Maybe they came from an accident and are wounded and lying down… [There is] no current, and we are running up and down to go get gasoline. And some of [the patients] will get angry because they finished paying money and they need good service." — Unconnected health facility in Kakata

Kakata schools also improved operations once connected. Some began operating computer labs and projectors in classrooms, which improved the learning environment and increased student enrollment. Teachers and administrators could prepare materials more easily with printers and photocopying machines, and schools could offer night classes with lighting available.

"Yes, there have been changes in schools … most of them now have affordable energy and a conducive learning environment. You will also find that some of the students stay in school for longer periods and that certain schools have introduced a computer literacy program. So there have been significant changes as a result of the affordability of the LEC current in their various schools." —Household in Monrovia

"Sometimes the students are audio learners, some of them are visual learners. What they see is what they learn. So if the primary school can afford a projector or something to show the children once the current is on, they will put it on so the children will be able to see." —School director in Monrovia

Figure VI.27. Percentage of Kakata communities with LEC-connected services



Source: 2019 and 2021 Kakata community leader surveys.

Notes: Findings are based on 30 community leaders who were interviewed over time.

Safety and security. The study suggests a link between access to electricity and perceptions of safety and security. In Kakata, where access to electricity increased, households and businesses reported improved lighting and increased feelings of safety in their communities after two years (Figures VI.28 and VI.29). There was an increase of 10 percentage points in households and of 18 percentage points in small businesses who reported that there was enough light to walk at night. The share of households and businesses reporting that they felt somewhat or very safe walking in their community at night increased by 29 percentage points and 3 percentage points for small businesses (not statistically significant). Interviewed respondents in newly connected areas felt that streetlights deterred both petty and serious crime in their communities and helped them feel safe walking home.

> *"When we have the current here, the criminal can't come around. First, the criminal used to come here. They come and passed all around, and they open our door and enter our own house, but since the current came, we have not experienced that again." — Household in Kakata*

> *"Like the time current was not in this community. We used to see some bodies lying down right there. Sometimes you see some bodies lying down, but since current came to the community, we haven't seen it yet." —Household in Kakata*

"The coming of the LEC has caused the rate of crime to decrease. At one time, the community was dark—no LEC, no light. A brave rogue could come and steal from us, but because there is now LEC current in this community, the crime rate has decreased. The rogue now flees and goes to another community." —Government official in Kakata

In Monrovia, community and individual access to electricity declined since baseline, but feelings of insecurity increased for much of our sample. Only 28 percent of households and 24 percent of businesses feel there is enough light to walk at night in their community, representing an increase of 6 percentage points for households but a decrease of 11 percentage points for businesses since baseline. In addition, fewer households and businesses reported feeling safe now than at baseline. Decreased access to electricity, as well as the negative effects of a weak economy and Covid-19 on public safety, likely contributed to these declines in feelings of safety in Monrovia.

Figure VI.28. Percentage who say there is enough light to walk at night

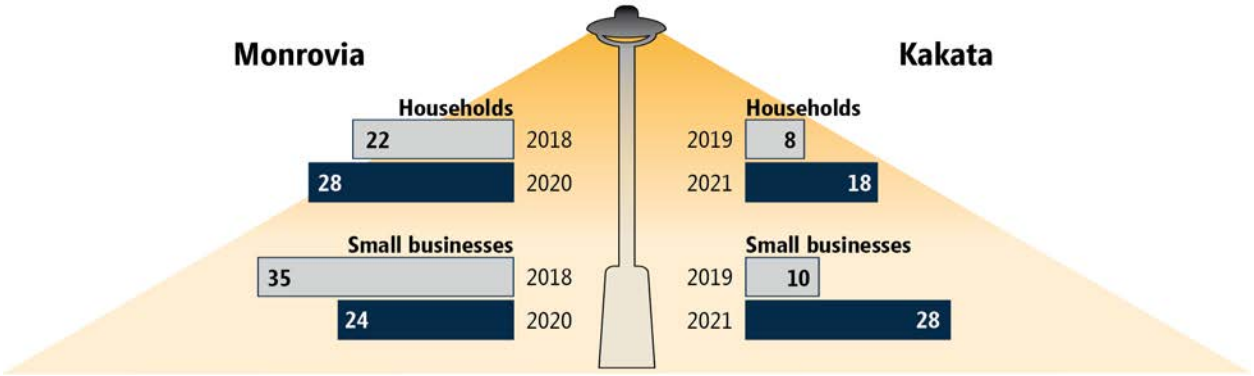
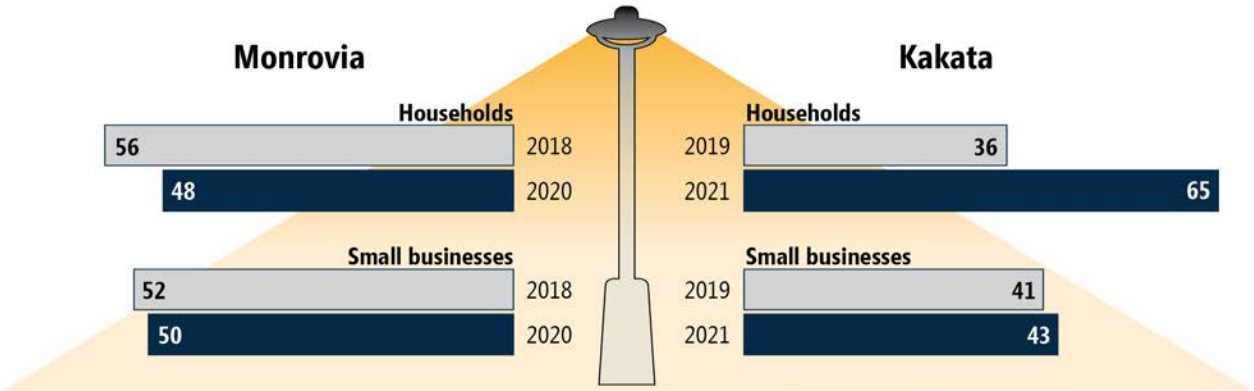


Figure VI.29. Percentage who feel somewhat or very safe walking in their community at night



Source: 2018 and 2020 Monrovia household and small-business surveys; 2019 and 2021 Kakata household and small-business surveys

Notes: Findings are based on 1,183 households and 330 small businesses in Monrovia, 875 households and 402 small businesses in Kakata that were followed over time. Actual sample sizes may vary per outcome because of survey and item non-response.

VII. Cost-benefit analysis

Next, we conducted a cost-benefit analysis of the Liberia Energy Project to assess the extent to which its economic benefits were commensurate with its costs. Specifically, we estimate the monetary value of the project's benefits and costs over a 20-year horizon and then approximate the project's economic rate of return (ERR), a summary measure of its cost-effectiveness (Table VII.1). We explain why our ERR estimate departs from MCC's original estimate prior to the start of the Compact and assess the sensitivity of our estimate to underlying assumptions. Finally, we offer lessons for modelling the economic benefits and costs of future energy projects.

Key findings

- We estimate the project's economic rate of return to be 8.0%
- This suggests that the project may not have been cost-effective. In fact, we estimate the net present value of the investment from 2015 to 2035 to be negative $51,019,841 using a 10 percent discount rate.

Table VII.1. Findings on cost-benefit analysis assumptions and outcomes

Assumptions	Short-term outcomes	Medium-term outcomes	Long-term outcomes
~ A8 LEC increases ability to make customer connections; new customers can afford to pay for electricity; LEC can accommodate increased energy demand during the dry season*	+ Reduced tariffs*	− Increased electricity consumption per customer*	
~ A10 LEC has sufficient manpower, skills, materials, and operational capacity to respond to user requests for connections *	~ Decreased user costs*	+ Increased customer base*	
	− Cost reflective tariffs*		

Notes: + = Assumption met or outcome achieved ~ = At least part of assumption or outcome not met or achieved. − = Assumption not met or outcome not achieved *Outcome assessed in VI. Utility and grid level outcomes.

A. Economic benefits of the project

We assessed the following evaluation question related to the economic model:

Evaluation questions

EQ A4. To what extent, if any, does comparing the assumptions made in the forecasted economic model, actual program implementation, and evaluation findings generate lessons that can be applied to future economic models?

Approach to the CBA

The Liberia Energy Project sought to increase electricity generation, facilitate a decrease in the tariff, and help to increase the reliability and adequacy of electricity. MCC identified households and businesses as the main beneficiaries, including newly connected consumers who gain access to the grid and already connected consumers who benefit from lower cost, more reliable electricity. Following this logic, our cost-benefit analysis incorporates two benefit streams:

- Newly connected households and businesses that shift from higher-cost energy sources to lower-cost LEC electricity and consumers with illegal or indirect connections who increase electricity consumption by gaining access to the grid.
- Already connected households and businesses that may increase consumption because of reduced tariffs and less frequent outages. This includes benefits to already connected consumers with illegal or indirect connections who benefit from access to more reliable energy.

To value these benefits, we use a *consumer surplus* approach, following MCC's CBA guidelines for the power sector (Epley et al. 2021). This approach values benefits for each consumer as the difference between the consumer's willingness to pay (WTP) for electricity consumption and the actual price paid or the tariff rate. The overall benefit is the grand total or consumer surpluses across all existing and new consumers, in addition to any cost savings that accrue to the utility in the form of reduced production costs for electricity. A consumer surplus approach is appropriate because the binding constraint in the country's energy sector was identified to be the supply (MCC 2013), and so benefits come mainly in the form of increased surplus. We model benefits between 2015 to 2035 under a scenario with the project and without (the counterfactual). We take the difference in estimated benefits between the two scenarios to capture the economic benefits (or value-added) of the project during this period.

Table VII.2 describes the main components of the CBA and data sources. The essential components include:

- Consumer counts
- Consumption per consumer
- The tariff rate
- Average unit cost of energy production
- The price elasticity of demand, and
- Consumer WTP

We used LEC's administrative data including measures of consumer counts, consumption, and tariffs. Because we obtained data that were disaggregated by customer [33]type (residential, commercial, government, public corporation, and NGO) and connection type (prepaid and

[33] Throughout this chapter, we use "customer" to refer to legal LEC connections while "consumer" refers to both legal and illegal connections.

postpaid), we modeled benefits for each of these customer categories before aggregating them. We assumed that illegal and indirect connections comprise 65 percent of total LEC connections (based the ACMS in 2021) and that they have similar patterns of behavior as residential prepaid customers in terms of consumption and WTP. We used data on the average WTP of customers from the 2020 Willingness to Pay study conducted by Tetra Tech (2020). (As part of the Liberia Energy Project, Tetra Tech conducted survey experiments with a random sample of connected and unconnected end users to elicit their WTP for monthly LEC service.) Finally, to estimate the effect of tariff changes on electricity consumption, we assumed a constant price elasticity of demand of -0.2. This is the same assumption used in MCC's original CBA and is based on the literature (Bernstein and Griffin 2005; Khanna and Rao 2009).

Table VII.2. Main components of the CBA and data sources

Main component	Data source	
	With project scenario	Without project scenario
Number of customers	• For 2015 to 2021, the model uses actual values from LEC administrative data. • From 2021 to 2035, the model assumes that residential customers increase by 4% annually, commercial customers increase by 1.2% annually, and other customer counts remain constant based on excess supply, population growth, and potential residential connections (the same assumption used in MCC's original CBA). • For illegal connections, we assume that they comprise 65% of total LEC connections following MCC's Asset and Customer Mapping Study in 2020 and that this percentage is stable over time.	• For 2015, the model uses actual values from LEC administrative data • For 2016 to 2035, customer counts are assumed to remain constant • For illegal connections, we use the same assumption as with project scenario.
Consumption per customer	• For 2015 to 2021, the model uses actual values from LEC administrative data. • For 2021 to 2035, consumption per customer increases (decreases) only if the LEC tariff decreases (increases) from the previous period. Consumption changes are based on the assumed price elasticity of demand (the same assumption used in MCC's original CBA). • We assume illegal connections consume 19% less electricity than residential prepaid customers. This follows from our estimate of power theft from LEC administrative data where we found that illegal connections comprise 65% of total customers but consume 60% of total electricity supplied. This also corresponds to evidence from our end user survey data.	• For 2015, the model uses actual values from LEC administrative data. • For 2016 to 2035, consumption per customer increases (decreases) only if the LEC tariff decreases (increases) from the previous period. Consumption changes are based on the assumed price elasticity of demand • For illegal connections, we use the same assumption as the with project scenario.

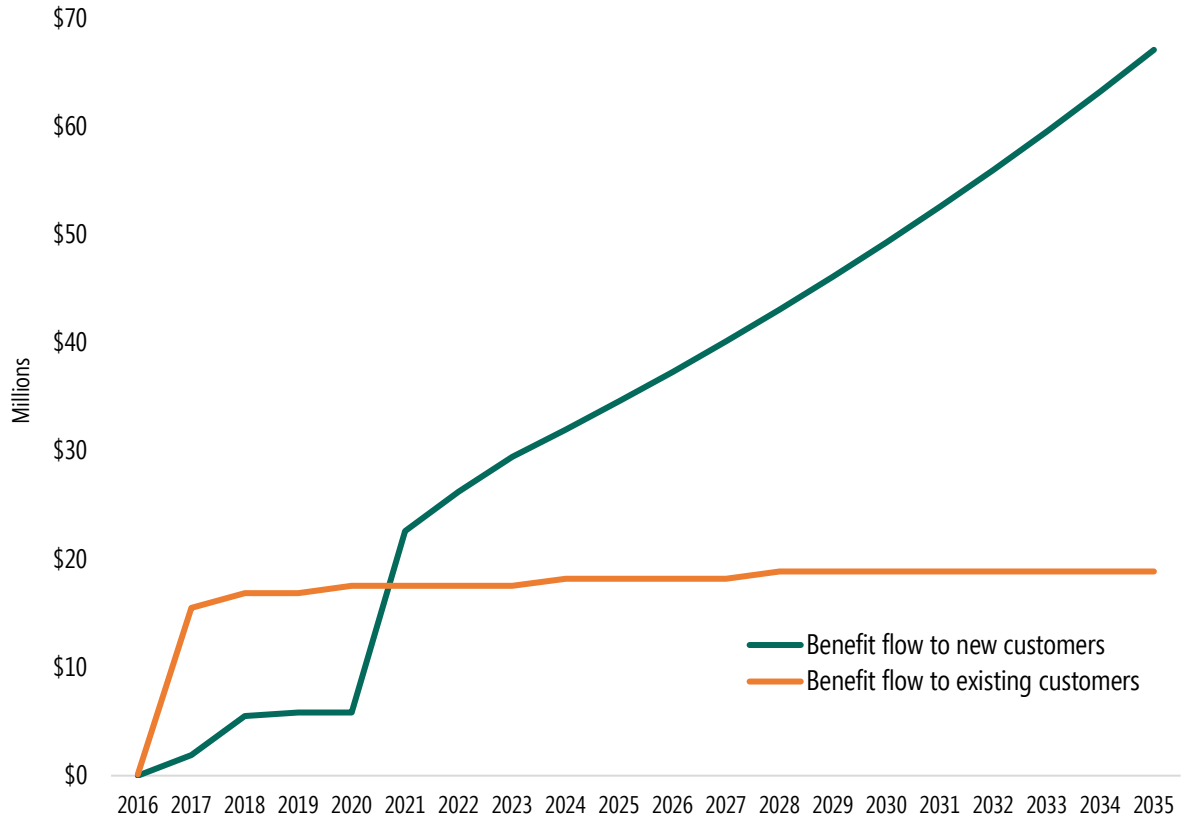
Main component	Data source	
	With project scenario	Without project scenario
LEC tariffs	• For 2015 to 2021, the model uses actual tariffs from LEC administrative data. • For 2022 to 2035, the model uses the new tariffs implemented in January 2022. These are assumed to remain constant absent any new information about how these might change.	• For 2015 to 2035, the model assumes that tariffs follow generation, transmission, distribution, and administration costs based on the McKinsey's Energy and Market Model, the LEC KPI Spreadsheet (September 2016), and MCC staff experience in other countries (the same assumption used in MCC's original CBA).
Average unit cost of production	• For 2015 to 2017, the model assumes that the average unit cost of energy production falls from $0.58 to $0.36 per kWh and remains constant thereafter. The Cost of Service Study (Tetra Tech 2020) estimated that MCHPP would reduce the long run average unit cost of energy production to $0.24 per kWh. However, our evaluation found that this estimate is likely overoptimistic: the study assumed that technical and commercial losses would fall to 23% by 2030. By the end of 2021, combined losses were still at 56 percent. The CBA therefore accounts for 33 percentage points more technical and commercial losses in the long run by using an average unit cost of $0.36 instead of $0.24 per kWh.	• For 2015 to 2035, the model assumes that average unit costs follow generation, transmission, distribution, and administration costs based on the McKinsey's Energy and Market Model, the LEC KPI Spreadsheet (September 2016), and MCC staff experience in other countries (the same assumption used in MCC's original CBA).
Price elasticity of demand	In both scenarios, the model assumes a constant price elasticity of demand of -0.2 for all customers. This assumption is based on the literature (Bernstein and Griffin 2005; Khanna and Rao 2009).	
Consumer WTP	In both scenarios, the model uses the estimated WTP of households and businesses to consume electricity from Tetra Tech (2020). We model the WTP for LEC electricity to follow changes in the price of oil because WTP depends largely on the price of alternative energy sources. Actual and projected data on the price of oil are from the World Bank Commodity Markets Outlook (2022). We assume that illegal connections have the same WTP as residential customers.	

Project benefits

Our estimate of the total value of project benefits is $1,022,642,807 (undiscounted). Figure VII.1 shows the breakdown of this benefit stream for new and existing LEC customers in each period. From 2016 to 2020, the CBA estimates incremental benefits to new LEC customers, tracking the slow growth of customer connections during this period. In 2021, this benefit stream increases significantly following the surge in connections during the end of the compact, steadily increasing until 2035, assuming that new customer connections will continue at a steady pace. At the same time, the CBA estimates the benefit stream to existing LEC customers largely to track the tariff rate, because decreases in the rate translate to lower costs to these customers: the benefit stream increased from 2016 to 2018 because LEC reduced its tariff from $0.50 per kWh to $0.35 per kWh; it increased again in 2022, when LEC began implementing a differentiated tariff schedule of $0.24 per kWh for residential customers and $0.22 per kWh for non-residential

customers. The CBA forecasts this benefit stream to remain constant from 2022 onwards with the current tariff rates.

Figure VII.1. Benefit flows to new and existing consumers



Project costs

Our estimate of the total cost of the Liberia Energy Project is $515,039,257 (undiscounted). Costs include direct project costs, overhead costs, new-connection costs, and repair costs for MCHPP turbines. Table VII.3 presents these costs by year and category. Direct project costs consist of actual costs for the Mt. Coffee Rehabilitation Activity and for the Capacity Building and Sector Reform, Mt. Coffee Support, and the LEC Training Center activities from 2016 to 2021. The amount includes costs to MCC and other donors. Overhead costs are for administration and M&E. New-connections costs are those shouldered by consumers to connect to the grid. Based on interviews with LEC personnel, Tetra Tech's Cost of Service Study Report (Tetra Tech 2020) and data from our household and business surveys in Monrovia and Kakata, we assume that the cost of new connections is $88 per connection for both legal and illegal connections. Repair costs include our estimated cost of repairing MCHPP's Unit 1 turbine in 2021 and the same costs every four years to account for the risk that other turbines might fail in succeeding years, consistent with our evaluation's finding that the utility's financial situation could lead to poor life-cycle maintenance of equipment.

Table VII.3. Liberia Energy Project costs (in USD)

Year	Direct costs		Overhead costs	New connection costs	Repair costs of MCHPP turbines	Total costs
	MCHPP Rehabilitation Activity	Other Activities				
2016	86,019,217	695,357	-	2,216,016	-	88,930,589
2017	136,555,685	3,322,747	4,953,955	1,860,865	-	146,693,252
2018	133,106,408	6,322,473	6,081,614	1,111,985	-	146,622,480
2019	2,857,239	16,062,321	4,572,383	14,843	-	23,506,785
2020	1,314,531	24,689,176	6,208,114	7,395,595	-	39,607,417
2021	437,960	9,685,038	3,392,957	14,485,554	4,000,000	32,001,509
2022–2035	-	-	-	25,677,225	12,000,000	37,677,225
Total						**515,039,257**

Source: Authors' calculation based on MCC cost estimates.

Note: MCC was unable to provide overhead costs for the Liberia Energy Project and the Roads Project separately. Therefore, we used the share of direct compact costs incurred for the Energy Project to allocate the total amount spent on overhead costs.

The Economic Rate of Return (ERR)

We used our estimates of the benefits and costs of the Liberia Energy Project to compute the ERR, defined as the interest rate at which the discounted sum of net benefits (benefits minus costs) is equal to zero. We calculate two versions of the ERR. Both have the same total estimated benefits resulting from increased consumption of electricity. However, one version includes the direct costs of all activities under the project, and the second includes the direct costs of only the

Mt. Coffee Rehabilitation Activity. We prefer the first estimate because all activities were necessary to complete project goals, but we present both versions to allow comparison with MCC's original ERR that included both.

- The ERR that includes all direct costs is 8.0%.
- The ERR that includes the direct costs of only the Mt. Coffee Rehabilitation Activity is 10.5%.

MCC requires that its projects pass an ERR hurdle rate of 10% to be considered worthwhile. These ERRs suggest that the project might not have been cost-effective overall. In fact, the net present value of the investment, defined as the discounted sum of net benefits (benefits minus costs) in each period, is negative $51,019,841 when including all costs.

Comparison to the original CBA

Prior to the Liberia Compact's approval in 2015, MCC's original CBA for the Energy Project resulted in estimated ERRs of 10.7% (including all direct costs) and 13.2% (including direct costs of Mt. Coffee only). In 2017, this CBA was updated with revised parameter values that resulted in ERRs of 8.4% and 10.9% respectively. MCC's original CBA is similar conceptually to that presented in this chapter—the same benefit streams were included, and a consumer surplus approach was conducted. However, our CBA departs from the previous CBA and produces a different estimate of the ERR for the following main reasons that were not anticipated at the start of the energy project:

- **The WTP of unconnected households and businesses for monthly LEC electricity was much lower than anticipated.** The original CBA assumed consumer WTP to be between $0.50 per kWh and $0.72 per kWh for household and business end users. This assumption was derived from a survey the World Bank conducted in Monrovia in 2010. However, as noted above, Tetra Tech more recently conducted an independent study and estimated the WTP to be between $0.30 and $0.40 per kWh for unconnected households. They also estimated a WTP of about $0.39 per kWh for unconnected businesses. Based on these data, our CBA uses a WTP of $0.35 per kWh and $0.39 per kWh for these end users respectively. Because a lower WTP indicates that potential consumers benefit less from shifting away from higher-cost energy sources to lower-cost LEC electricity, this revises our estimate of the ERR downwards relative to the original CBA.

- **New connections were slow to materialize.** The original CBA assumed that new connections would surge immediately after the rehabilitation of Mt. Coffee in 2016: specifically, LEC would add 13,597 new residential customers each year and add 316 new business customers over five years. However, the bulk of customer connections happened only towards the end of the Compact, starting in 2020, as we note in Chapter V (Figure V.32.). Although the project fulfilled its goal of having over 90,000 new LEC connections, this occurred much later than anticipated. Because benefits that occur later are discounted more in a CBA, our estimate of the ERR is lower than the original CBA.
- **Consumption of LEC electricity was lower than expected for existing residential customers.** Based on LEC administrative data, residential customers consume about half the kWh per customer that was assumed in the original CBA, which might have overestimated consumption because of the sparse data on prepaid customers, who consume less electricity. Using lower values for consumption per residential customer revises our estimate of the ERR downwards relative to the original CBA, because decreased consumption translates to lower benefits from the project.

Incorporating these evaluation findings would have produced a considerably lower estimate of the ERR relative to MCC's previous CBA had it not been for the inclusion of beneficiaries that were not in the previous model:

- **We include benefits from the consumption of illegal connections in the model.** This inclusion accounts for 52% of estimated benefits. Illegal connections make up a substantial portion of LEC's consumer base; the ACMS estimates that they comprise 65% of total consumer. Because our model assumes that these consumers grew at the same rate as legal customers, the surge in new illegal consumers added considerable benefits that were counted in the model. Without consumers with illegal or indirect connections in the CBA, the estimated ERR would only be 0.3%.

Sensitivity analysis

The ERR of 8.0% represents our best estimate of the project's cost-effectiveness based on information available at this time. Nevertheless, we assess the sensitivity of this estimate to alternative parameters and assumptions. We focus on identifying potential upper and lower bounds for the ERR—that is, what the ERR would be under the most optimistic and most pessimistic assumptions. First, we present the ERR for the scenario when we exclude illegal connections in the model. Second, we vary values on two critical parameters that affect the calculation of benefits but are difficult to measure accurately:

- **Consumers' WTP.** As indicated above, our preferred estimate uses findings from Tetra Tech (2020), which employed surveys to capture end users' stated WTP for LEC electricity given hypothetical scenarios. The use of this method, however, might not produce accurate results. For example, a study in Kenya found that consumers' actual WTP for an electricity connection was far lower than their initial estimate when faced with a realistic time limit for payment (Lee et al. 2016).

- **Price elasticity of demand.** The CBA assumes a constant price elasticity of demand of -0.2 for existing LEC consumers. Therefore, it is assumed that existing consumers realize a small increase in electricity consumption when tariffs decrease. As mentioned, this assumption is based on the literature (Bernstein and Griffin 2005; Khanna and Rao 2009). However, as the reliability of electricity increase and customer service improves, consumers may become more price sensitivity, implying a higher price elasticity.

In Table VII.4, we show that the ERR is highly sensitive to the inclusion of illegal connections in the model. We estimate an ERR of 8.0% with illegal connections and 0.2% without, noting MCC's ERR standard for cost-effectiveness is 10%. At the same time, we show that with pessimistic or optimistic WTP and price elasticity of demand assumptions, the ERR estimates do not vary as much. To calculate the ERR under pessimistic and optimistic assumptions, we used parameter values that are 20% lower or higher than those used in the preferred CBA model.

Table VII.4. ERR Estimates under optimistic and pessimistic assumptions

	Preferred ERR estimate	ERR under pessimistic assumptions	ERR under optimistic assumptions
	WTP for households = $0.35 per kwH WTP for businesses = $0.38 per kwH Price elasticity of demand = -0.2	WTP for households = $0.28 per kwH WTP for businesses = $0.30 per kwH Price elasticity of demand = -0.16	WTP for households = $0.42 per kwH WTP for businesses = $0.47 per kwH Price elasticity of demand = -0.24
With illegal consumers	**8.0%**	**3.2%**	**12.2%**
Without illegal consumers	**0.2%**	**-3.6%**	**3.5%**

Source: Authors' calculations.

Lessons learned and limitations

A project's cost-benefit estimates inform MCC's investment decisions, so it is essential to consider how future economic models can reflect the most accurate evidence and information. Based on our experience calculating the Liberia Energy Project CBA, we suggest ways to improve underlying assumptions and the data needed to estimate accurate models.

First, our model could have benefitted from better data on parameters that affect subgroup benefits. We recommend that the logic model include specificity on the main beneficiaries and key indicators that will drive CBA benefits so that data needs can be anticipated. For example, our cost-benefit estimate includes illegal connections in the model. We made the best effort to model these consumers in our CBA, but without LEC administrative data on this subgroup, we had to rely on imperfect survey data and the ACMS study. Our survey data did not cover LEC's full catchment area, nor does it specifically target illegal connections as a subgroup. The ACMS was not completed so it does not provide a complete picture of illegal connections. We also do not have information on illegal connections from large businesses or compounds, which we

could have incorporated in the CBA. As a result, we make several (perhaps strong) assumptions to be able to estimate costs and benefits for illegal connections:

- We assumed that consumers with illegal connections have the same WTP for electricity as legal customers, but we acknowledge these consumers are diverse. For example, some illegal connections may be among low-income households or small businesses with relatively low WTP and low consumption. Additionally, some illegal consumers may have relatively high income, WTP, and consumption levels. The high consumption levels of the relatively well-off illegal consumers could easily make up for their small numbers when calculating average demand for electricity. Consequently, it is hard to know whether the assumption of similar WTP is too high or too low.
- We assumed that consumers with illegal connections pay the same connection costs and tariffs as legal customers. While this is unlikely, it is unclear how to monetize the risk they take by consuming electricity illegally. In addition, these consumers probably did have to pay someone to help them make the illegal connection and may have to pay ongoing bribes to stop anyone from turning off their connection, especially for the richer illegal consumers.
- We assumed no deadweight loss associated with the consumption of illegal connections. However, some consumers with illegal connections are effectively heavily subsidized by the utility, and so are unable to internalize the true cost of electricity. This can lead them to overconsume which generates deadweight loss. We were hesitant to calculate deadweight losses in our CBA, absent data on whether and how much illegal consumers overconsume. We also know that some illegal consumption is paid for, however the tariff is paid to a cartel rather than LEC.

Future work on energy CBAs, especially in contexts where illegal consumption is rampant, should consider collecting better and more targeted data on illegal connections.

Second, our CBA findings suggest proximate reasons for why MCC tends to overestimate ERR projections. A 2017 internal study by the agency (Ospina and Block, 2017) noted that around three-fourths of MCC's original project ERRs were above corresponding ERRs that were estimated at project closeout. In the case of the Liberia Energy Project, we outlined reasons the original CBA was overestimated, including: 1) WTP was much lower than anticipated, 2) new connections was slow to materialize, and 3) actual consumption was much lower than expected. In the future, MCC may consider incorporating more pessimistic assumptions around perceived benefits and the implementation timeline to account for these scenarios more accurately.

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VIII. Conclusion

A. The Liberia Compact results

MCC's objective with the Liberia Compact was to provide access to more reliable and affordable electricity. The program logic illustrates how Activity 1 aimed to address constraints in electricity generation by rehabilitating MCHPP and high-voltage transmission infrastructure. Activity 2 aimed to establish the independent authority and invest in a management services contract for LEC.

MCC successfully achieved output-level tasks. MCHPP was rehabilitated and the supporting transmission infrastructure was constructed, and LERC was established and funded for two years. The short implementation period meant that LERC did not fully accomplish all of its plans before Compact closure. Although delayed, the energy sector studies were completed (Operator Census in 2019, Willingness to Pay and Cost of Service in 2021, and the Asset Mapping and Customer Service in 2021). The late completion of these reports delayed utilizing them during the Compact period. The MSC was contracted and operated LEC for 3 years within the Compact and 1.5 years with WB funding, after the Compact. The Compact was also able to invest in a customer service center and in building customer service capabilities.

Despite success at the output level, the short-, medium-, and long-term outcomes in the program logic were not all achieved. Figure VIII.I. presents the logic model with colored symbols indicating whether outcomes were achieved in full or in part. Table VIII.I presents a summary of MCC's outcomes, the assumptions underlying them, and the status of the outcomes and assumptions in 2022. For example, for the outcome and assumption A1 Increased lower cost generation, MCC assumed that MCHPP generation would reduce LEC's operating costs. We explain that rainy season electricity generation increased, and the cost per kWh of hydropower is $0.06 compared to $0.25 for thermal generation, so there was an increase in low-cost generation. However, MCHPP is seasonal and LEC must still meet dry season demand. With increased generation, T&D infrastructure, LEC's costs have increased. Also, the catastrophic failure of Unit 1 reduced MCHPP generation for at least three years.

Investments were able to increase production of low-cost, renewable hydropower, establish LERC and the regulatory framework, and reduce tariffs and user costs. LEC improved some operations, increased electricity quality and reliability and reduced outages, and increased the customer base.

Many energy sector, utility, and grid-level outcomes were not achieved given the Compact length, delays in implementation, underinvestment in the OMT, and LEC's prolonged challenges. For example, power plant facilities have improved but MCHPP had a turbine failure and thermal generators are frequently unavailable due to lack of parts for repairs. LERC is unable to monitor operators and small operators are not yet licensed. Liberia has limited private sector investment in the energy sector given that LEC is not attractive to investors and there are still major barriers to entering the energy market beyond a small or micro generation. LEC has

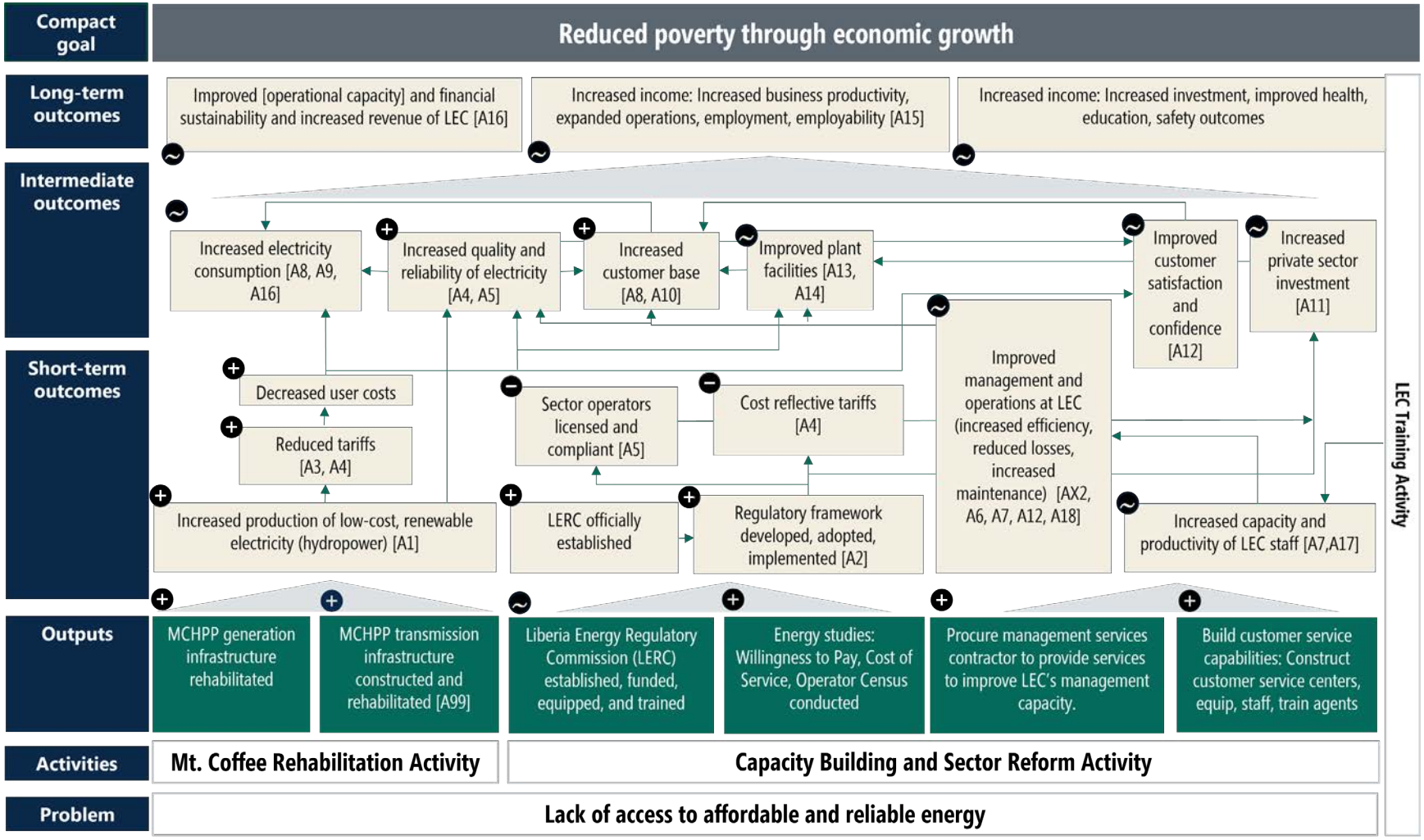
improved capacity but still has major skill gaps and the wrong mix of staff. Customer service has improved, though customer satisfaction is still low.

End-user outcomes have improved, including access to energy, increased consumption for end users not connected at baseline, and improve perceptions of safety. However, delays in T&D construction, dry season outages, Liberia's negative macroeconomic situation, and the COVID-19 pandemic may have reduced end-users' ability to use electricity productively. Long-term financial sustainability at the utility company also remains elusive. While ESBI improved LEC's operational capacity with reforms to the organization's structure, human resources, safety, use of IMS, and financial management, the financial situation is still in crisis with debt LEC cannot pay, very limited cash, and $47 million in losses per year.

The Liberia Compact was unable to overcome political and macro-economic challenges that undermine Liberia's progress. For instance, indicators measuring Liberia's governance are worsening. In the FY2022 scorecard, Liberia received failing scores on fiscal policy, inflation, regulatory quality, trade policy, government effectiveness, and other indicators. Areas of concern include Liberia's poor revenue mobilization and budget management; low competence of civil servants; and the extent to which policies and budgets are linked and monitored, and goals are achieved. As of July 2022, the GoL was still struggling to make payroll.

A five-year, $257 million Compact was inadequate to rehabilitate and ensure MCHPP sustainability, fully reform the utility, and ensure regulatory agency proficiency, particularly given Liberia's low-capacity, post-conflict, post-Ebola context and with implementation during a prolonged global pandemic. Although donors have voiced frustration about investing more than $1 billion in the Liberia Energy Sector over the past decade, rebuilding and establishing a solvent sector require significantly more time, coordination, accountability, and resources than have been invested.

Figure VIII.1. Program logic for Activities 1 and 2



⊕ = Outcome achieved ⊖ = Outcome not achieved ~ = Outcome not fully met or achieved

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

MCC identified outcomes and assumptions in the program logic model (A1-18)		Status of outcomes in 2022
Outcomes	**MCC's assumptions underlying the outcome**	
⊕ **A1: Increased lower cost generation**	Bringing Mt. Coffee online will lower LEC's operating costs.	Rainy season generation increased and the cost per kilowatt of hydropower ($0.06) is less than thermal generation ($0.25). However, LEC's operating costs have increased with new infrastructure to maintain. MCHPP has had one catastrophic unit failure, which reduced generation by 25 percent.
⊕ **A2: Regulatory framework adopted**	Planned technical support from donor(s) will complement MCA-L's intervention. Compact-funded studies will inform the implementation of the regulatory framework, including tariff-setting and licensing operators (power producers).	Regulatory framework has been adopted. LERC's resource shortages delay full implementation. LERC continues to seek donor support to establish itself as an independent regulator. The EU funded several consultants to support LERC. Energy studies inform the sector but are already outdated. Operator census has not yet led to new licensing of majority of small operators.
⊕ **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.	LERC approved tariff reductions in 2022. Although they decreased user costs, they do not reflect costs. The COSS, with outdated assumptions, recommended $0.24 per kWh for residential customers. However more than 90% of customers will pay the social tariff at $0.15 per kWh (residential consumption is averaging below 50 kWh per month). Operational costs averaged $0.47 per kWh.
⊖ **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 tariff does not reflect costs. The 2022 reduction occurred when LEC was chronically operating at a loss, MCHPP had reduced generation due to a turbine loss and a long dry season, the CLSG transmission line was not yet operational, and global fuel costs were skyrocketing. LEC was in a financial crisis (losing $100,000 per day during the rainy season) and unable to make payroll.
⊖ **A5: Operators licensed and compliant**	LERC has the ability and resources to ensure compliance.	Among operators in Liberia, LERC has licensed LEC, Jungle Energy Power, and Totota. Liberia has approximately informal small operators that do not yet meet criteria for licensing.
⊕ **A4, A5: Improved quality, reliability**	Increased electricity generation at MCHPP, LERC's regulation of the energy sector, and tariff-setting process that adheres to LERC's regulation will improve electricity quality and reliability.	MCHPP rehabilitation has led to improved quality and reliability and the MSC met key performance indicators (KPIs); however, outages still occurred frequently (209 per year lasting 204 hours) in 2021.

MCC identified outcomes and assumptions in the program logic model (A1-18)		Status of outcomes in 2022
Outcomes	**MCC's assumptions underlying the outcome**	
AX2, A6, A7, A12, A18: Improved LEC management and operations	LEC improves ability to use data for problem solving and decision making and has capacity and resources to manage operations, including reducing losses, increasing collections, and performing routine maintenance; LERC standards are effective. Customer willingness to pay increases. The MSC effects long-term change in LEC operations, and stakeholders support changes. There is sufficient staff capacity and continuity at LEC in order to accomplish MSC capacity building objectives.	LEC has had chronic, severe resource constraints. Delays (T&D, CLSG power, connections, the IMS database, training), the lack of OPEX and CAPEX (US $137 million requested), political interference, and power theft mean the utility loses about US$48 million per year, with 62% of generated electricity unpaid. Maintenance is ongoing but inadequate given equipment, materials, and vehicle shortages. Some improved customer service practices. LEC returned to Liberian management in July 2022.
LEC training system	ESBI will have the capacity to implement training. Training of trainers' system is effective.	The training scope was reduced and delayed. Still, LEC has made notable progress since 2018 including establishing the Training and Development Department, developing a Training Policy and in-house trainings, and partnering to support training. External partner funding is needed.
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.	In 2018, 80 percent of LEC staff had less than five years of utility experience. LEC's capacity remains below needs, especially given complicated generation, and T&D requirements. Political interference in staffing means many LEC staff were politically installed, rather than hired based on capabilities.
A8, A9, A16: Increased electricity consumption	LEC increases connections. New customers can pay for electricity; LEC can accommodate dry season demand. Increased generation capacity and T&D investments increase electricity quality and reliability. Customers pay for electricity.	LEC has made tens of thousands of new connections (mostly low-consuming and low-paying residential customers). LEC is unable to accommodate dry season demand without the CLSG transmission line, given the high cost of thermal generation. While paying customer numbers have increased, ongoing power theft losses cost LEC about $47 million per year.
A8, A10: Increased customer base	LEC increases ability to make customer connections. New customers can afford to pay for electricity; LEC can accommodate increased energy demand during dry season. LEC has enough manpower, skill, materials, and operational capacity to respond to user requests for connections.	After long delays in donor T&D projects, connections are quickly increasing, with 90% of end users consuming less than 50 kWh per month. Large customers slow to connect (due to dry season outages) but would yield more revenue for less effort. LEC needs 60,000 meters to make connections and normalize customers. LEC must absorb the $33 connection fee and meter cost ($50).[34]

[34]According to LEC, the real average cost under donor funded projects is about US$800 - US$1000 per connection. Safely connecting 60,000 new customers requires investments in MV network, added transformers, and the LV network.

MCC identified outcomes and assumptions in the program logic model (A1-18)		Status of outcomes in 2022
Outcomes	**MCC's assumptions underlying the outcome**	
~ **A11: Increased private sector investment**	A clear regulatory framework is a critical requirement for private-sector investment.	LERC has licensed LEC,Jungle Energy Power and Totota. The remaining and informal, small operators are unlicensed. It does not appear that LERC or MCC investments or LERC have led to increased investment. A recent USAID-funded study identified critical obstacles and risks to private investment.
~ **A12: Improved customer satisfaction**	Better quality electricity would improve customer satisfaction.	There have been modest improvements in customer satisfaction, particularly among businesses.
~ **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.	LEC is currently unable to invest in lifecycle maintenance and capital. Donors intend to extend T&D lines, but without adequate master planning and an overarching strategy that recognizes infrastructure needs and weaknesses.
~ **A15: Improved: outcomes, health, safety, education**	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.	End users have been negatively affected by the COVID-19 pandemic and its sequelae and Liberia's weak economy. However, end users do report some positive outcomes, including business development, income-generating activities, and improved health and safety.
~ **A16: LEC has increased revenue financial sustainability**	Customers pay for the electricity they consume.	LEC was in a financial crisis in 2018 that worsened. T&D failures, slow connections, excessive power theft, poor billing and collections, no OPEX or CAPEX to solve problems, and political interference undermine LEC's financial position.

⊕ = Outcome achieved ⊖ = Outcome not achieved ~ = Outcome not fully met or achieved

MCC (and other stakeholders) had assumed that MCHPP would solve most energy supply needs during the rainy season and the CLSG transmission project would provide power to LEC customers during the dry season. Additionally, stakeholders assumed that LEC could maintain thermal plants and afford light and heavy fuel oil (LFO and HFO) for generators, repairs, and other costs necessary to keep thermal plants operating. However, 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 incompatible 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 carries debt for past fuel purchases and still does not have a plan for 2023.

MCC also assumed that, with the MSC on board, LEC would stabilize within six months to a year. The MSC stepped into a bankrupt utility, with deficiencies beyond every stakeholder's understanding. The LEC board was unable to provide adequate oversight and guidance throughout the Compact. MSC/LEC withstood ongoing political interference, political will for utility turnaround was minimal, and donors added new connections, but not resources to maintain new assets. No OPEX or CAPEX meant that the MSC could identify but not solve problems. The assumption was that T&D infrastructure would be adequate to take on tens of thousands of new customers connected. Stakeholders learned over time that the infrastructure could not handle the increased load. In addition, a rise in theft further overwhelmed the T&D network. Stakeholders did not anticipate how sophisticated the system of theft had become and thought the MSC could reduce power theft just by disconnecting indirect customers. However, the LEC cartel is "a sophisticated operation" that organizes wide-scale theft. It is bolstered by political cronyism, MoL efforts to protect thieves employed by LEC, and MoJ failure to prosecute. Loss reduction requires intensive political will, significant investment, and consistent effort.

Liberia's history, politics, challenges, and complexities needed more time, resources, coordination, and strategizing to overcome. Moving forward, accomplishing energy sector progress, improved electricity access, and a sustainable utility requires applying lessons learned to future planning, implementation, and resource allocation.

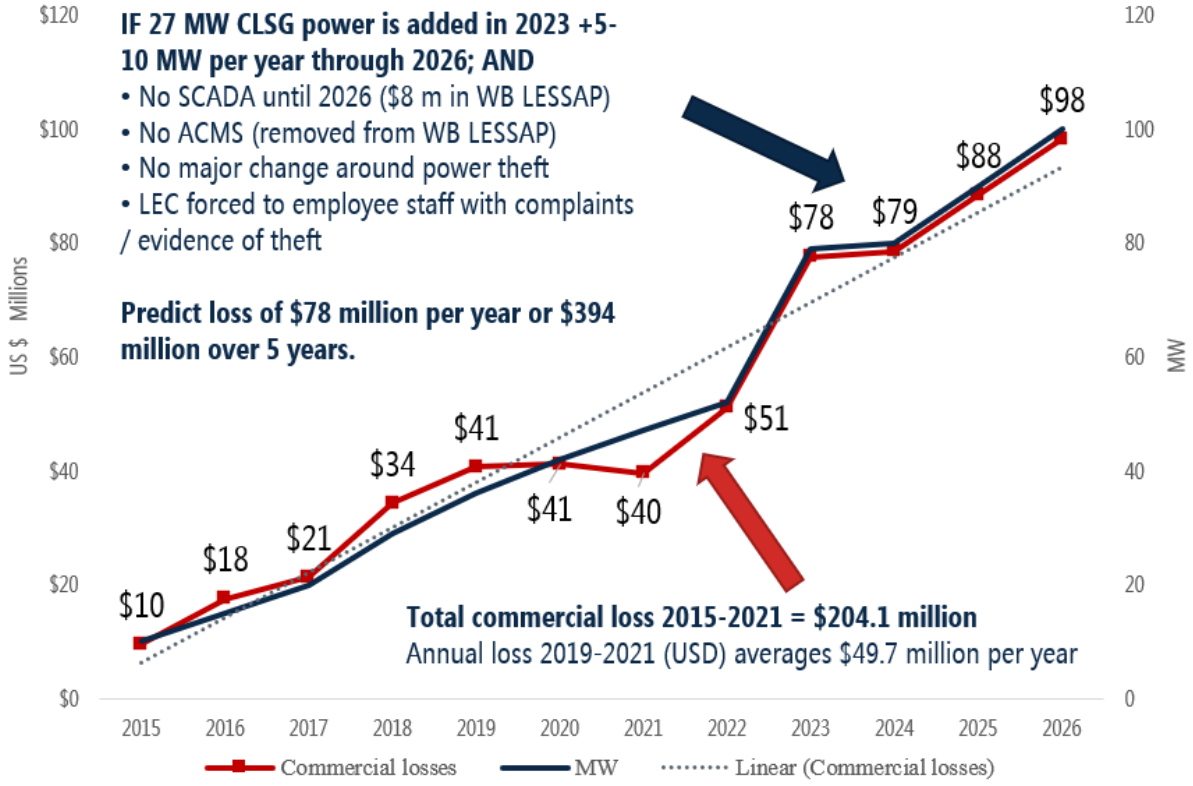
Finally, in this next post-MSC phase, we offer the following recommendations to the Liberian energy sector to avoid the scenario whereby increased power with the reduced tariff – no SCADA until 2026, no ACMS, and no major efforts to reduce power theft or political interference in staffing – results in a loss of $78 million per year (or more) and $394 million over five years. We recommend postponing use of CLSG until the following items have been completed:

Based on a thorough analysis of all data, we offer the following Compact-wide lessons:

1. Strengthen the due diligence process and a conduct a robust political economy analysis and landscape analysis during Compact development to ensure activities are informed by the historical, political, economic, and social context, and in anticipation of future major political events (such as presidential elections).
2. Plan for the realities of the context, in this case a post-conflict country with weak governance, longstanding corruption, limited donor coordination, and exceptionally low human-resource capacity. Identify points of leverage and develop expectations, mechanisms, and penalties to combat unwanted political interference and corrupt actors.
3. Energy is political. Acknowledge, strategize, implement, and communicate with this understanding.
4. Design activities with evidence-based timelines and worst-case risk prevention strategies. In the most challenging contexts, assume that more time, resources, supports, and leverage will be needed to achieve goals. Consider Compact length, then plan for and prioritize sustainability during Compact design and afterwards.
5. Energy projects should be strategic, planning for 20, 30, 40 years in the future and for 24 hour a day, 7 day a week, 365 day per year supply and demand. While MCHPP rehabilitation was collaborative and responsive to the GoL's requests, it was not the most strategic investment in Liberia's long-term energy development. MCHPP's seasonal 78 MW generation means that demand will exceed supply in several years. Constructing a new plant upstream would have costed less, taken less time, and been able to deliver 125 MW of renewable hydropower. Additionally, MCHPP only generates six months a year, leaving half the year without power. The low-quality LV network leads to daily outages.
6. Coordinate across donor agencies. Ensure that financial disbursements include conditions for governments to meet and ensure that donor partners do not undermine conditions.
7. Better support implementation and problem solving with robust and dynamic M&E processes— pushing beyond indicator tracking to problem identification and solution development—to inform real-time collaborative problem solving.
8. Improve MSC implementation and chances of success by designing contracts that better align resources (such as OPEX and CAPEX) and staffing (numbers and capabilities) to specific needs, Compact and Activity goals, desired outcomes, and contextual realities. Require MSC's to prioritize high-quality communications and information sharing, navigate politics, and utilize data systems.
9. Invest in data democratization, such as sharing data through dashboards. All stakeholders, GoL, LEC, and donors should have access to data dashboards that provide all the data sources available in this report. Decisions can be made with historical, contemporary data and analysis on hand so implications can be understood.

10. Finally, in this next post-MSC phase, we believe the Liberian energy sector could face a scenario in which losses grow to $78 million per year (or more) and $394 million over five years (**Figure ES.13)**. This is likely as Liberia begins utilizing CLSG power without 1) a digital SCADA until 2026, 2) complete ACMS data, 3) drastic actions to reduce power theft among large customers, and 4) major efforts to reduce political interference in LEC staffing. *Note the actual loss will likely be greater given this estimate does not fully capture losses due to the reduced tariff. We acknowledge that IMF funding reduces the burden on LEC for CLSG consumption, but risks persist without coordinated action.* To avoid this scenario, we recommend the following:

Figure VIII.2. Predicted loss over time with CLSG, no SCADA until 2026, and no ACMS



- Adjust the tariff to be cost-reflective. Rates for large customers can cross subsidize the rate for low-income customers *if large customers pay* for electricity consumed. Rates must cover the cost of generation, T&D, and overhead.
- Invest in the (long overdue) T&D SCADA system, at a cost of $8 to $10 million.
- Complete the ACMS and integrate data into operations for regular updating, at a cost of $1 million per year.
- Install high security meters (HSM) at the homes and compounds of all political leaders and large businesses with a national media launch. Publicize bills and payment.

- Implement a more robust approach to power theft. Stakeholders argued that LEC should be resourced to investigate complaints of theft against LEC staff. The Ministries of Labor and Justice should transparently report on benchmarks of progress towards removing and prosecuting staff that engaged in power theft. For LEC staff accused of facilitating large scale theft, procedures should include immediate suspension without pay, followed by an independent external investigation within 7 days. If found guilty, the worker is dismissed, their pension is forfeited, and they are banned from GoL or donor employment, while details of the crime are publicized. There should be mandatory sentencing and no parole.
- The Ministry of Justice (MoJ) must make progress on benchmarks for timely prosecution of those committing power theft, with transparent reporting to stakeholders.

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References

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. "Electricity Regulatory Index for Africa 2019." Abidjan, Cote d'Ivoire: AfDB, 2019. Available at https://africa-energy-portal.org/sites/default/files/2019-12/ERI%202019.pdf. Accessed August 9, 2022.

African Development Bank. "Electricity Regulatory Index for Africa 2020." Abidjan, Cote d'Ivoire: AfDB, 2020. Available at https://africa-energy-portal.org/sites/default/files/2020-11/Electricity%20Regulation%20Index%202020.pdf. Accessed August 9, 2022.

African Development Bank. "Electricity Regulatory Index for Africa 2021." Abidjan, Cote d'Ivoire: AfDB, 2021. Available at https://africa-energy-portal.org/sites/default/files/2021-12/08122021%20ERI%20report%202021.pdf. Accessed August 9, 2022.

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.

Andersen, Thomas Barnebeck, and Carl-Johan Dalgaard. "Power outages and economic growth in Africa." Energy Economics, vol. 38, 2013, pp. 19–23.

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

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

Azorom. Contract Monitoring Consultant (CMC) for Management Services Contract (MSC) for Liberia Electricity Corporation (LEC). Annual Report, January to December – 2021. Millennium Challenge Account-Liberia (MCA-L). Dublin.

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

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

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

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

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

Ballah, 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. "Impact Analysis of Rural Electrification Projects in Sub-Saharan Africa." The World Bank Research Observer, vol. 27, no. 1, February 2012, pp. 33–51.

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.

Bernstein, Mark A., and James Griffin. "Regional Differences in the Price-Elasticity of Demand for Energy." Report prepared for the National Renewable Energy Laboratory. Santa Monica, CA: RAND Corporation, 2005.

Bos, Kristine, Duncan Chaplin, and Arif Mamun. "Benefits and Challenges of Expanding Grid Electricity in Africa: A Review of Evidence from Developing Countries." Energy for Sustainable Development, vol. 44, 2018, pp. 64-77.

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/.

Carr, Darragh and Murray Thomson. "Non-Technical Electricity Losses." Energies, vol. 15, no. 6, 2022. Available at https://www.mdpi.com/1996-1073/15/6/2218/htm. Accessed August 9, 2022.

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. Accessed August 9, 2022.

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.

Deloitte Consulting LLP. West Africa Energy Program Liberia Electricity Corporation. Covid-19 Impact Assessment. Washington, DC: United States Agency for International Development, January 2021.

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. "Liberia Electricity Corporation Management Services Contract Review 2020." Monrovia, Liberia: ESBI, January 2021.

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

Epley, Brian, Francis Mulangu, and Derick Bowen. "Power Sector Cost-Benefit Analysis Design Principles." Millennium Challenge Corporation, July 2021.

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.

ESRI, OpenStreetMap contributors, HERE, Garmin, FourSquare, METI/NASA, and USGS. 2021.

Fobben, K. WAEP Memo: Franchising Activity: Memo on Reservations for Franchisee Model in Maryland and Grand Gedeh. Deloitte. 2021.

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.

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.

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, 2012a, 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.

Khanna, Madhu, and Narasimha D. Rao. "Supply and Demand of Electricity in the Developing World." Annual Review of Resource Economics, vol. 1, 2009, pp. 567–596.

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

Lee, Kenneth, Eric Brewer, Carson Christiano, Francis Meyo, Edward Miguel, Matthew Podolsky, Javier Rosa, and Catherine Wolfram. "Barriers to Electrification for 'Under Grid' Households in Rural Kenya." Development Engineering, vol. 1, 2016, pp. 26–35.

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 Energy Regulations Commission. "Draft LERC Bylaws." 2019

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

Liberia Electricity Corporation. "Asset & Customer Mapping Study: Final Report." Presentation to MCC, Washington, D.C., March 31, 2021.

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

Liberia Energy Regulations Commission. "National Census of Electricity Operators." Final report, August 29, 2019. Available at https://lerc.gov.lr/pg_img/National%20Census%20of%20Electricity%20Operators%20(NCEO)%20-%20Final%20Report%20Archived.pdf. Accessed July 31, 2022.

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.

Manitoba Hydro International, 2016 in USAID. 2019. « Best Practice for performance-based management contracts for the power sector.

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.

McKinsey & Company, Inc. "Liberia utility private sector partnership options." Report submitted to USAID, Washington, D.C. October 2015.

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

Millennium Challenge Corporation (MCC). "Liberia Constraints Analysis." Washington, DC: MCC, September 2013. Available at https://assets.mcc.gov/content/uploads/2017/05/Liberia_CA_withCover.pdf. Accessed August 13, 2022.

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, Matthew Ribar. "Evaluation Design Report for the Liberia Energy Project: Activities 1 and 2." Report submitted to the Millennium Challenge Corporation. Washington, DC: Mathematica Policy Research, September 2018.

Miller C., K. Bos, P. Ravindranath, P. Abarcar, A. Mamun, M. Spitzer, J. Page, L. Meyer, J. Claxton, J. Cook, and S. Bryk. "Evaluation of the Liberia Power Compact's Mt. Coffee Hydropower Plant Rehabilitation and Capacity Building and Sector Reform: Baseline and Interim Findings." Washington, DC: Mathematica, July 2020.

National Association of Regulatory Utility Commissioners (NARUC). "Guidelines for Advancing Economic and Quality of Service Regulation in Africa's Electricity Sector." Washington, DC: NARUC, August 2021. Available at https://pubs.naruc.org/pub.cfm?id=1E215369-1866-DAAC-99FB-B7EFFB08159E.

New York Times. "Coronavirus World Map: Tracking the Global Outbreak." July 31, 2022. Available at https://www.nytimes.com/interactive/2021/world/covid-cases.html?. Accessed July 31, 2022.

Nduhuura, Paul, Abdellatif Zerga, and Matthias Garschagen. "Power Outages in Africa – An Assessment Based on Regional Power Pools." PAUWES Research-2-Practice Forum 2018, July 11, 2018. Available at https://ssrn.com/abstract=3212006

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.

Ospina, Sandra, and Marissa Block. "2016 Report on Closeout ERRs." 2017. Report. Millennium Challenge Corporation: Washington, D.C.

Johnson. J. (2012). "Theories of change in anti-corruption work." U4 Anti-Corruption Resource Centre. October 2012. No 6.

Reuters. "Liberia: the latest coronavirus counts, charts, and maps." July 15, 2022. Available at https://graphics.reuters.com/world-coronavirus-tracker-and-maps/countries-and-territories/liberia/. Accessed July 31, 2022.

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.

Saito, Mika. "Four Things to Know on How Liberia is Reforming Its Economy Amid COVID-19." International Monetary Fund, December 21, 2020. Available at https://www.imf.org/en/News/Articles/2020/12/18/na121820four-things-to-know-on-how-liberia-is-reforming-its-economy-amid-covid19. Accessed July 31, 2022.

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.

Tata Power Company Limited. "Capacity Building for System Loss Reduction (LEC): Final Inception Report." Report submitted to the Millennium Challenge Account-Liberia, Monrovia. December 2020.

Tata Power Company Limited. "Final Network Study Report." Report submitted to the Millennium Challenge Account-Liberia, Monrovia. December 2020.

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.

Tetra Tech. "Final Willingness to Pay Survey Report." Report presented to the Millennium Challenge Account-Liberia, Monrovia. December 16, 2020.

Tetra Tech. "Cost of Service Study Report and Cost Reflective Electricity Pricing Model." Report presented to the Millennium Challenge Account-Liberia, Monrovia. January 5, 2020.

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.

Wood, Robert. "Best Practices for Performance-Based Management Contracts for the Power Sector." Report submitted to USAID, September 2018. Available at https://www.usaid.gov/sites/default/files/documents/1865/ECO_RTI_2018_Performance-Based-Management-Contracts-Best-Practices.pdf

World Bank. "Access to electricity (% of population) – Liberia." 2020a. Available at https://data.worldbank.org/. Accessed July 28, 2022.

World Bank. "Commodity Markets Outlook: The Impact of the War in Ukraine on Commodity Markets." Washington, DC: World Bank, April 2022. Available at https://openknowledge.worldbank.org/bitstream/handle/10986/37223/CMO-April-2022.pdf. Accessed August 9, 2022.

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

World Bank. "Operation and Maintenance Strategies for Hydropower: Handbook for Practitioners and Decision Makers." Washington, DC: World Bank, March 2, 2020b. Available at https://www.worldbank.org/en/topic/energy/publication/operation-and-maintenance-strategies-for-hydropower. Accessed July 28, 2022.

World Bank. "Liberia Macro Poverty Outlook." Washington, DC: World Bank, April 2022. Available at https://www.worldbank.org/en/publication/macro-poverty-outlook. Accessed July 28, 2022.

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. "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 Data. Data.world.bank.org/indicators. Accessed August 10, 2022.

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