FY2020 Simplified Ex-Post Evaluation Report of Japanese Grant Aid Project

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Duration of the Study: September 2020–October 2021
Duration of the Field Study (Remote Survey): January 2021–May 2021

Country Name	Project for Rehabilitation of Monrovia Power System
The Republic of Liberia	

Location of the project site

Interior view of the powerhouse building

I. Project Outline

Background	The 14-year civil war between 1989 and 2003 in Liberia devasted basic infrastructure, including power supply facilities. When it ended, many refugees settled in the capital region. However, while nearly one-third of Liberia's population was concentrated in Monrovia, the household electricity rate in Monrovia city was extremely low at 4.4% in 2012. In 2009, the government of Liberia formulated the "National Energy Policy: An Agenda for Action and Economic and Social Development" (hereinafter referred to as "NEP") with the goal that 30% of the urban and peri-urban population would have access to reliable and modern energy[1] services by 2015. The government of Liberia also stated that while in the long term it would need to promote renewable energies for power generation, in the medium term, diesel power generation would be essential for rapid power restoration during the recovery stage from the civil war. However, the capacity of the power generation facilities was utterly insufficient to achieve the goals outlined in the NEP, and there was an urgent need to develop infrastructure to supply a stable power. Under these circumstances, the government of Liberia requested the government of Japan to implement this project to meet the urgent power demands of the capital region of Monrovia during the recovery stage after the conclusion of the civil war.			
Objectives of the Project	The objective of the project is to establish a stable power supply system by installing Heavy Fuel Oil Diesel Generation Equipment (hereinafter referred to as "HFOD Generation Equipment"), thereby contributing to activating socio-economic activities and stabilizing the lives of residents in the capital region of Monrovia.			
Contents of the Project	1. Project Site: Bushrod Island Power Station in Monrovia city 2. Japanese side: (1) Procurement and installation: 1) HFOD Generation Equipment (5 MW × 2 sets), 2) mechanical auxiliary equipment for generation equipment, 3) electrical auxiliary equipment for generation equipment, 4) electrical auxiliary equipment for heavy fuel oil transfer pump, 5) vehicles for maintenance, and 6) spare parts and maintenance tools (2) Construction: 1) powerhouse building, 2) pump house building (3) Soft Component: Technical transfer of operational and preventive maintenance for the HFOD Generation Equipment 3. Liberian side: <Before construction> Ground leveling <During construction and after the start of service> Final connections to the existing diesel generation equipment, assignment of engineers and operators to participate in the soft component and training, and procedures for entitling tax exemptions			
Implementation Schedule	E/N Date	1. December 13, 2012 2. October 15, 2015 (First amendment: Increase in the grant limit) 3. October 24, 2016 (Second amendment: Extension of implementation period)		
	G/A Date	1. December 13, 2012 2. March 25, 2015 (First amendment[2])	Completion Date	October 14, 2016 (Date of a final handover of procured equipment)

[1] According to the "National Energy Policy: An Action Agenda for Economic and Social Development" (2009), it was estimated in 2004 that the primary energy source for households in Liberia was traditional woody biomass, with over 95% of the population relying on firewood or charcoal for cooking and heating and palm oil for lighting. In contrast, reliable modern energy was assumed to be fueled by fossil fuels, renewable energy, and other sources.

[2] As a result of the suspension of construction work and evacuation owing to the Ebola outbreak, additional costs for construction and consultancy costs and equipment procurement were required.

		3. December 6, 2016 (Second amendment[3])		
Project Cost	<E/N grant limit, G/A grant limit> 2,037 million yen (after the amendment: 2,237 million yen) <Actual grant amount> 2,234 million yen			
Executing Agency	Liberia Electricity Corporation (hereinafter referred to as "LEC")			
Contracted Agencies	Equipment Procurement: Mitsubishi Corporation Main Contractor: Dai Nippon Construction Main Consultant: Yachiyo Engineering Co., Ltd.			

II. Result of the Evaluation

<Summary>

The project was implemented with the aim of establishing a stable power supply system in the capital region of Monrovia by installing the HFOD Generation Equipment. The relevance of the project is high as it was completely consistent with Liberia's development policies and development needs and Japan's development assistance policies at the time of ex-ante evaluation. As for effectiveness, it was confirmed that the HFOD Generation Equipment procured in the project has played an important role in supplementing the power supply capacity of the LEC and that it has contributed to establishing the stable power supply system during the dry season.[4] As for the impacts, it was confirmed that the project contributed to the improvement of the business environment, the stable operation of commercial and public facilities, and the improvement of residents' living conditions through the improved power supply in the dry season. Thus, the effectiveness and impacts of the project are high. In terms of the project implementation, the project cost was as planned, but the project period exceeded the plan; thus, efficiency is fair. Regarding sustainability of the project, there are no particular concerns about institutional and organizational aspects. In the technical aspect, although there is a concern about the technical capacity to perform large-scale periodic maintenance including overhaul[5] and major repairs anticipated in the future. However, it is expected that the technical capacity of the LEC will be strengthened through the ongoing JICA's technical cooperation project. On the other hand, there are financial concerns about large-scale periodic maintenance and major repairs, as well as in the current status of operation and maintenance where overhauls have yet to be implemented. Thus, sustainability of the project is fair.

In light of the above, the project is evaluated to be satisfactory.

Overall Rating[6]	**B (Satisfactory)**	**Relevance**	③[7]	**Effectiveness & Impacts**	③	**Efficiency**	②	**Sustainability**	②

<Special Perspectives Considered in the Ex-Post Evaluation/Constraints of the Ex-Post Evaluation>

Due to the coronavirus disease 2019 pandemic (hereinafter referred to as the "COVID-19 pandemic"), travel to Liberia for a field survey of the ex-post evaluation was canceled. Instead, the external evaluator collected information remotely through online meetings and other means. As for the interviews to assess the project impacts, the external evaluator provided guidance and instructions for a local consultant in advance and they were conducted by the local consultant under the supervision of the external evaluator.

1. Relevance

<Consistency with the Development Plan of Liberia at the Time of Ex-Ante Evaluation>

In Liberia's medium-term economic growth and development strategy, the *Agenda for Transformation: Steps toward Liberia Rising 2030* formulated in 2012, "infrastructure and economic transformation" was identified as one of the four pillars for the five-year period from 2012 to 2017, with a particular emphasis on infrastructure development in the power sector. In addition, the NEP (2009) set a medium-term goal that 30% of the population in the urban and peri-urban areas would have access to reliable and modern energy services by 2015, whereas many residents were using their own power generation and traditional woody biomass fuels at the time of ex-ante evaluation. Furthermore, in the *LEC's Electric Master Plan* developed in 2012, a medium-term target was set to increase the number of residential and commercial connections in Monrovia city by approximately 10 times: from 8,660 in 2012 to 86,999 by 2015. Since the project aimed to establish a stable power supply system, it is considered that the project was consistent with the development policies of Liberia at the time of ex-ante evaluation.

<Consistency with the Development Needs of Liberia at the Time of Ex-Ante Evaluation>

Although the government of Liberia had a long-term policy of promoting power supply from renewable energies such as hydropower, it was a pressing issue to urgently restore power during the recovery stage from the civil war. In addition, since the generation capacity of hydropower declines during the dry season, it was assumed that hydropower alone would be insufficient to meet peak power demands in the dry season. Specifically, while the estimated peak power demand in the capital region of Monrovia in 2015 was 67 MW, it was confirmed that there would be a shortage of approximately 10 MW of power in the dry season, even after taking into account (1) existing diesel generation equipment (15 MW), (2) HFOD Generation Equipment (20 MW) planned at the time of ex-ante evaluation with support from the World Bank and funds from the government of Liberia, (3) hydropower generation from Mount Coffee Hydropower Plant (hereinafter referred to as "Mt. Coffee Plant") during the dry season (5 MW), and (4) imported power from the West African Power Pool (18 MW). The project was designed to supplement the shortage of power during the dry season on an emergency basis as part of the recovery from the civil war by procuring the HFOD Generation Equipment (10 MW), and thus it is considered to be consistent with the development needs of Liberia at the time of ex-ante evaluation.

[3] The due date for project completion in the G/A was October 2016. However, it became difficult to issue a completion certificate by the due date because some of the procured generation equipment was damaged in September 2016. Therefore, the due date of the project was extended to August 31, 2017.

[4] Liberia has a dry season (November to April) and a rainy season (May to October).

[5] Overhaul is maintenance work which involves disassembling equipment into parts and inspecting it (cleaning, repairing, replacing parts, etc.), and reassembling it in a shape.

[6] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

[7] ③: High, ②: Fair, ①: Low

<Consistency with Japan's ODA Policy at the Time of Ex-Ante Evaluation>

In the *ODA Charter* (2003), "sustainable development" was listed as one of the four priority issues, and "development of economic and social infrastructure" was emphasized. In addition, the *ODA Databook by Country* (2012) also indicated that the assistance would be focused on the development of urgent infrastructure such as electricity and on strengthening the capacity for operation and maintenance. Furthermore, in the *Yokohama Action Plan* (2008) formulated at TICAD IV, it was mentioned that the cooperation on electricity infrastructure and a stable power supply would be reinforced. Therefore, it can be said that the project was consistent with Japan's ODA policies at the time of ex-ante evaluation.

<Evaluation Result>

In light of the above, the relevance of the project is high.

2. Effectiveness/Impacts

<Effectiveness>

To measure the achievement status of the project objective, establishment of a stable power supply system, indicator ① "Capacity of generation equipment" and indicator ② "Fuel cost per unit power generation," which were set in the ex-ante evaluation, shall be examined. In addition, the ex-post evaluation set indicator ③ "Power generation" and indicator ④ "Operating time" of HFOD Generation Equipment procured in the project as supplementary indicators to examine the utilization status of the HFOD Generation Equipment.

Indicator ① is set to be the power capacity in the dry season of the entire generation equipment operated by the LEC. The breakdown of the target value of 50 MW is 15 MW of existing diesel generation equipment, 30 MW of the HFOD Generation Equipment (10 MW procured in this project, 10 MW supported by the World Bank, and 10 MW financed by the Government of Liberia), and 5 MW of the Mt. Coffee Plant in the dry season. The total capacity of generation equipment at the time of ex-post evaluation was 68 MW, thus achieving the target value, and the HFOD Generation Equipment procured in the project alone also achieved the target. At the time of ex-ante evaluation, the power supply capacity of the Mt. Coffee Plant in the dry season was assumed to be 5 MW, but as of December 2016, one generation unit with a capacity of 22 MW was installed. Furthermore, with the support of Norway, the World Bank, and other donors, facilities in the Mt. Coffee Plant have been rehabilitated and progressively constructed, reaching a total capacity of 88 MW (4 units of 22 MW each) in 2018. In this way, the Mt. Coffee Plant was expanded more than predicted and can operate at least one unit (22 MW), even during the dry season when water storage at the plant is reduced.

Indicator ② is set to be "Fuel cost per unit power generation" through the year of the HFOD Generation Equipment procured in the project. While the target value was 7.87 US cent/kWh (75% reduction rate), the actual value in 2019, three years after the completion of the project, was 22.66 US cent/kWh (reduction rate of 27%) and was 16.62 US cent/kWh (reduction rate of 47%) in 2020.[8] One of the reasons for the limited reduction is that this indicator reflects the fact that the shorter the operating hours, the lower the operational efficiency and thus the higher the fuel cost. As described below, the Mt. Coffee Plant was expanded more than predicted, and the HFOD Generation Equipment is mainly utilized only in the dry season. Accordingly, the operating time did not increase, which lowered the operational efficiency and limited the reduction of the figures in the indicator. As a result, the indicator fell short of the target. However, the limited achievement of the indicator is the result of reducing the overall fuel cost of the LEC by expanding the operation of a less expensive hydropower plant to ensure a stable power supply. In other words, limiting the operation of the HFOD Generation Equipment and promoting the reduction of the overall fuel cost of the LEC are part of the measures to establish a stable power supply system, which is the objective of this project. Therefore, the fact that the project has not achieved the target value of the indicator does not mean that it has not contributed to the achievement of the project objective.

With regard to supplementary indicators ③ "Power generation" and ④ "Operating time," the data for the period from 2017[9], when the project was completed, to 2020, when the ex-post evaluation was conducted, were compiled and analyzed monthly to examine the utilization status during the dry and rainy seasons. As shown in the bar graph in Figure 1, the power generation of the HFOD Generation Equipment procured in the project (supplementary indicator ③) increased only from January to April, which is the dry season and when the operation of the Mt. Coffee Plant declines. In addition, the operating time (supplementary indicator ④) also increased only from January to April, as shown by the line graph in Figure 1.

According to the LEC, the Mt. Coffee Plant has been expanded as part of its efforts to promote power with the less expensive renewable energy, and the HFOD Generation Equipment procured in the project plays an important and supplemental role in maintaining a stable power supply during the dry season when hydropower generation declines. In addition, the HFOD Generation Equipment is utilized as a backup during maintenance at the Mt. Coffee Plant.

Therefore, as indicator ① shows, it was confirmed that the HFOD Generation Equipment procured in the project has played a role in enhancing the power supply capacity of the LEC. As for indicator ②, the reduction rate of fuel cost per unit of power generation was lower than expected due to the expansion of the Mt. Coffee Plant with a less expensive fuel cost, and the HFOD Generation Equipment was supplementarily operated only in the dry season. The measure to supplementarily operate the HFOD Generation Equipment was taken to promote the "establishment of the stable power supply system" of the LEC, which is also the objective of this project. In addition, as shown by the supplementary indicators, the HFOD Generation Equipment plays an important role in sustaining a stable power supply during the dry season; thus, the effectiveness of the project is high.

[8] At the time of the project planning, the price of heavy fuel oil was calculated at US$0.765 ℓ, while the selling price of fuel oil in Liberia was US$0.811 ℓ in 2019 (May) and US$0.769 ℓ in 2020 (August), suggesting that there was no significant change in the price of heavy fuel oil. (Converted at 1 ton = 1.176 liters) (Sources: Preparatory Survey Report of the project and Liberia's Ministry of Commerce and Industry)

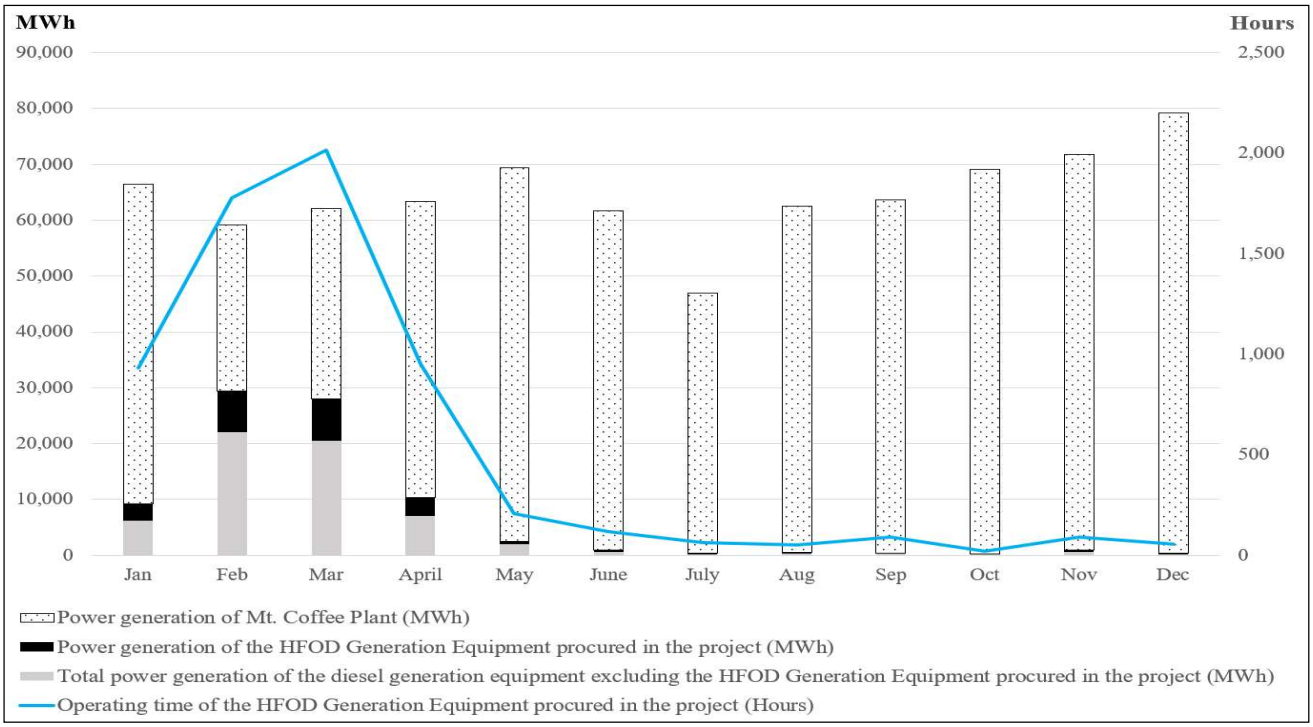
[9] For two reasons, the analysis is made based on data from 2017–2020, excluding 2016. The first reason is that the HFOD Generation Equipment, including that procured in this project, started to be used sequentially in 2016, so the data on operating time and power generation in 2016 were significantly larger than usual due to commissioning and adjustment required after the installation of the equipment. The second reason is that the equipment procured in the project was installed and utilized from September 2016; thus, there are no data from January to August 2016.

Table 1. Quantitative indicators

Indicators		Baseline value	Target value	Actual value				
		2012 Planning year	2018 (1) 3 years after completion	2016 Completion year	2017 1 year after completion	2018 2 years after completion	2019 3 years after completion	2020 4 years after completion
Indicator ①: Capacity of generation equipment (MW)		Total 8	Total 50	Total 69	Total 68	Total 68	Total 69	Total 68
Breakdown	Existing	8	15	9	8	8	9 (2)	8
	The project	–	10	10	10	10	10	10
	World Bank	–	10	10	10	10	10	10
	Liberian Government	–	10	18	18	18	18	18
	Mt. Coffee Plant (Dry season)	–	5 (3)	22 (4)	22 (4)	22 (4)	22 (4)	22 (4)
Indicator ②: Fuel cost per unit power generation (US cent/kWh) [Reduction Rate (%)] (5)		31.25 [0%]	7.87 [75%]	N/A	20.44 [35%]	19.35 [38%]	22.66 [27%]	16.62 [47%]
Supplementary Indicator ③: Power generation of the HFOD Generation Equipment procured in the project (MWh) (6)		–	–	7,875 (7)	3,791	6,596	7,132	5,849
Supplementary Indicator ④: Operating time of the HFOD Generation Equipment procured in the project (Hours) (6)		–	–	2,321 (7)	940	1,852	1,994	1,592

Sources: Materials provided by the executing agency

(1) At the time of ex-ante evaluation, the target year (three years after project completion) was set to be 2018. However, the project was delayed due to the suspension of construction work and evacuation caused by the Ebola outbreak and the actual project completion year was 2016. Thus, the actual target year is 2019.
(2) The capacity of existing diesel generation equipment increased by 1 MW in 2019 due to the rehabilitation and repair of some equipment.
(3) The capacity of power generation in the dry season.
(4) The minimum capacity of power generation in the dry season. The maximum capacity of power generation in the rainy season reached 88 MW in 2018.
(5) The existing diesel generation equipment uses only diesel oil as fuel, but the HFOD Generation Equipment procured in the project uses both heavy oil and diesel oil as fuel, which reduces the unit cost of fuel; thus, it was expected to reduce the figures in the indicator.
(6) The actual annual data may be larger than the figures shown in the table because some monthly data are missing.
(7) The data for 2016 only covers the period from September to December because the handover of the procured equipment started in September. Especially in October and November, operations increased because of the adjustment of the newly introduced equipment.



Note: Some monthly data are missing.
Source: Prepared by the evaluator based on data provided by the executing agency.

Figure 1. Monthly power generation of diesel generation equipment and Mt. Coffee Plant, as well as monthly operating time of the HFOD Generation Equipment procured in the project (Cumulative amount from 2017 to 2020)

<Impacts>

To assess the impacts of the project, which is to "activate socio-economic activities and stabilize the lives of residents in the capital region of Monrovia," the ex-post evaluation conducted interviews targeting two medical facilities (John F. Kennedy Medical Center (a tertiary

national hospital) and Redemption Provincial Hospital), two educational facilities (The University of Liberia and Stella Marie Polytechnic), three business enterprises (a supermarket, a restaurant, and a hotel), and ten residents. As previously mentioned in the effectiveness section, since the HFOD Generation Equipment procured in the project is mainly utilized during the dry season, the ex-post evaluation focused and assessed the impacts during the dry season. Regarding the selection of medical and educational facilities, the same facilities as those for which information was collected during the ex-ante evaluation were selected to assess the changes in activities at the facilities before and after the project. The interviewees of business enterprises and residents were selected intentionally from those who have been running or living in the area around the Bushrod Island Power Station where the HFOD Generation Equipment was installed by the project. In addition to the fact that the random sampling method was not utilized, the interviewees agreed to be interviewed after being briefed about the project; thus, it is possible that they have a favorable view of the project, and the information obtained may be biased.

(1) Improvement in the operation of medical facilities

At the John F. Kennedy Medical Center, prior to the implementation of the project, the power supply was unstable. Consequently, it hindered the use of diagnostic equipment such as X-ray fluoroscopy equipment, storage of medical supplies requiring refrigeration such as vaccines and blood, and the printing of medical reports and other documents. At the time of ex-post evaluation, no such problems were observed. In addition, prior to the implementation of the project, surgical equipment could not be used due to unstable power supply, and many patients had to be referred to other private hospitals. However, at the time of ex-post evaluation, surgeries were able to be performed at the hospital safely and smoothly regardless of the season.

At the Redemption Provincial Hospital, prior to the implementation of the project, the connection to the LEC grid was stopped due to the large voltage fluctuation which caused breakdowns of expensive medical equipment, and the hospital was receiving power 24 hours a day from its own power generators. Since the completion of the project, the power supply from the LEC has been relatively stable at night, so the power from the LEC has been used as well. In addition, LEC power supply outages during the dry season have been reduced by half. However, since the power supply is still insufficiently stable, the hospital uses its own power generators during the daytime. One of the reasons for the unstable power supply of the LEC is thought to be the prevailing illegal power connections in the surrounding areas.

(2) Improvement in the operation of educational facilities

At the University of Liberia, prior to the implementation of this project, the use of electrical appliances such as air conditioners, projectors, and printing machines was hampered by unstable voltage and frequent power outages. Consequently, the University had no choice but to use its own power generators, which cost more to operate than the LEC's electricity. According to the University, after the completion of the project, the power supply from the LEC has been stable throughout the year, enabling online classes and efficient operation of the facility.

At Stella Marie Polytechnic, the school was not connected to the LEC grid since before the implementation of the project and used its own power generators to provide night classes. At the time of ex-post evaluation, the school was still not connected to the LEC grid and stated that it would continue to operate its own power generators until problems such as power outages were dramatically resolved to conduct night classes and to use practical training equipment.

(3) Revitalization of economic activities

According to interviews with the managers of the supermarket and the restaurant, prior to the implementation of the project, their businesses were severely affected by frequent power outages which prevented them from using cash registers and damaged their frozen products because freezers could not be used. After the completion of the project, the frequency of power outages during the dry season was reduced[10] and voltage fluctuations were improved. As a result, the air conditioners, freezers, refrigerators, and cash registers can be used throughout the year, leading to improved customer services and sales. In addition, the frequency of use of their own power generators, which cost about three times as much as paying for the LEC's electricity, has been reduced, resulting in a significant reduction in electricity costs.

According to an interview with the hotel manager, the hotel purchased two backup generators in 2013 to ensure the quality of customer services such as a provision of air-conditioning. However, since the completion of the project, the hotel has had little need to use the generators because the LEC now provides a stable power supply throughout the year.

(4) Improvement in residents' quality of life

To assess the changes in the power supply situation and the subsequent changes in their lives, ten residents[11] were interviewed. Nine out of ten residents answered that the power supply situation in the dry season improved compared to the situation before the project. Prior to the implementation of the project, the average frequency of power outages during the dry and rainy seasons was 5.1 times per week (dry season) and 2.5 times per week (rainy season), respectively. At the time of ex-post evaluation, the frequency was reduced to 1.8 times per week (dry season) and 1.0 times per week (rainy season).[12] Prior to the implementation of the project, unstable power supply and frequent power outages severely hampered people's daily lives as home appliances (refrigerators, air conditioners, televisions, etc.) could not be used and/or broke down due to voltage fluctuations. In addition, eight out of ten households were using alternative generation equipment such as private power generators and solar power panels before the implementation of the project. However, there are some households that the high purchase and fuel costs were straining the family budgets. Some households with tight family budgets were unable to purchase alternative generation equipment and had to wait for the power outage to be restored or go to places where electricity was available. At the time of ex-post evaluation, many opinions were observed that they no longer needed to worry about the trouble with their home appliances because the frequency of power outages during the dry season had dramatically decreased, and the voltage had become stable. In addition, the interview results show that their quality of life has improved as they can now sleep well even on hot nights because of the availability of air conditioners and fans, and children can study at night without worrying about power outages. Furthermore, prior to the implementation of the project, some respondents had to use rechargeable home appliances due to the unstable power supply, but at the time of ex-post evaluation, they said that they no longer needed to use rechargeable home appliances throughout the year because of the improved power supply during the dry season. Some also said that their family budgets improved because the power supplied by LEC, which is less expensive, became available on a stable basis throughout the year, and the use of private power generators, which are expensive to operate, decreased.

[10] At the supermarket, the frequency of power outages during the dry season decreased from 5 times a week to 2 times a week, and at the restaurant, from 4 times a week to 2 times a week.

[11] The targets by sex: 5 males and 5 females. Average age: 37 years old.

[12] The frequency of power outages obtained from the interviews with 10 residents is the number of outages perceived by the respondents; thus, the average frequency of outages may differ from the actual number of outages.

Therefore, although there were some facilities that were not connected to the LEC's power grid, the stable power supply during the dry season resulted in many cases of improved facility operations and business environment, as well as improved residents' quality of life, suggesting that the project contributed to the revitalization of socio-economic activities and the stabilization of residents' lives.

<Other Impacts>

(1) Impacts on the natural environment

At the time of ex-ante evaluation[13], it was assumed that the amount of exhaust gas from the HFOD Generation Equipment would be small and that the impact on air pollution would be minimal by installing generation equipment that met Japanese regulatory standards, which were stricter than Liberia's air environment standards. In the implementation of the project, environmental protection measures were taken as planned, such as raising the height of the chimney as much as possible (18 m) based on the structure of the building.

In addition, since there were concerns about water pollution due to the discharge of waste oil at the time of ex-ante evaluation, measures were taken to prevent the discharge of waste oil into the ocean by installing a waste oil treatment system and treating it appropriately. According to the LEC, the waste oil has never been discharged into the ocean and treated appropriately. At the time of ex-post evaluation, the incinerator used to dispose of the waste oil was malfunctioning. Therefore, it was confirmed that the waste oil was collected manually and it has been properly stored in tanks in accordance with the guidelines of the Liberia Environmental Protection Agency, and there is a plan to sell the waste oil for reuse.

Other measures regarding waste, noise, and vibration were also properly taken, and no major accidents or problems were reported. Although monitoring reports were not available, according to the LEC, the monitoring was properly conducted, and no negative impacts on the natural environment were observed.

(2) Resettlement and land acquisition

Since the HFOD Generation Equipment procured in the project was installed in the power station owned by the LEC, no land acquisition or resettlement occurred.

(3) Impact from a gender perspective

According to the LEC, 5 women out of 48 were employed as operators of equipment, including the HFOD Generation Equipment procured in the project at the Bushrod Island Power Station, with two of them working as supervisors. At the time of ex-post evaluation, three of the five women were transferred to the Hydro Power Plant Division. As such, the project has supported the promotion of gender equality, women's empowerment, and women's employment.

<Evaluation Result>

In light of the above, it was confirmed that the HFOD Generation Equipment procured in the project has played an important role in "establishing a stable power supply system." It was also confirmed that the project has contributed to the improvement of the business environment, enabling more stable operation of commercial and public facilities and enhancing residents' living conditions throughout the year by improving the power supply during the dry season. Therefore, the effectiveness and impacts of the project are high.

3. Efficiency

<Project Outputs>

Although minor design changes[14] (additional installation of three tanker connections and an increase in the capacity of the buffer tank from 10 m^3 to 40 m^3) were made to reduce the risk of fuel acceptance, the outputs were basically produced as planned.

<Project Cost>

At the time of ex-ante evaluation, the project cost for the Japanese contribution was estimated to be 2,037 million yen. However, since 200 million yen were expected as additional costs (evacuation, standby, and recovery costs) due to the Ebola outbreak, the G/A was amended in March 2015, and the project cost was increased to 2,237 million yen. The increase in cost due to the Ebola outbreak is not taken into account in the evaluation judgment because it is an external factor. The actual project cost for the Japanese contribution was 2,234 million yen. The project cost for the Liberian contribution was estimated to be 33 million yen at the time of ex-ante evaluation, but the actual amount could not be confirmed due to the unavailability of data. Accordingly, the evaluation decision is made based on the Japanese contribution only. Therefore, the actual project cost was 2,234 million yen against the planned cost of 2,237 million yen, which is judged to be as planned (100% of the planned cost).

<Project Period>

At the time of ex-ante evaluation, the project period was assumed to be 24 months (December 2012 (G/A signature) to November 2014 (the month of final handover of equipment)). However, due to the following reasons, the actual project period lasted for a period of 47 months (December 2012–October 2016).

(1) Ebola outbreak (20-month delay)

Due to the Ebola outbreak, the construction work was suspended from August 2014 to October 2015 (15 months). In addition, it took approximately five months to prepare for the resumption of the project (rust removal and other restoration work).

(2) Minor design changes (1-month delay)

Construction of a new tanker connection[15], increase in the capacity of the buffer tank[16], etc.

(3) Repair of procured equipment (2-month delay)

[13] At the time of ex-ante evaluation, the project was classified as Category B in accordance with the *Guidelines for Environmental and Social Considerations of the Japan International Cooperation Agency* (2004).

[14] The cost of the design changes was covered by the residual budget.

[15] Since the existing pipeline passes through some private property, allowing an unspecified number of people to access the pipeline, a new tanker connection was built.

[16] The original plan with a buffer tank capacity of 10 m^3 required a tanker truck to refuel with heavy oil every four hours for continuous operation of the generator. To avoid refueling in the middle of the night, the capacity of the buffer tank was changed to 40 m^3 with a maximum refueling interval of 16 hours.

A part of the generation equipment procured in early September 2016 was damaged[17], and it was repaired in October 2016.

Since the Ebola outbreak is the external factor, the delay period (20 months) caused by it is not taken into account in the evaluation judgment. Therefore, the actual project period is 27 months compared to the planned period of 24 months, which is considered a delay of only 3 months from the planned period (113% of the planned period).

<Evaluation Result>

In light of the above, the project cost was as planned, but the project period exceeded the plan; therefore, the efficiency of the project is fair.

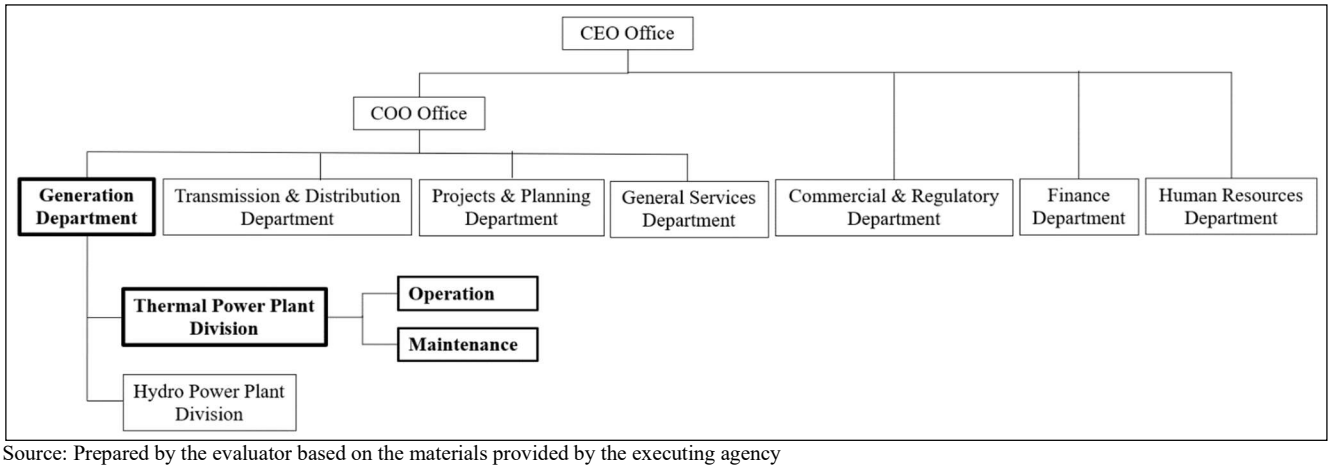
4. Sustainability

<Institutional and Organizational Aspect>

At the time of the ex-ante evaluation, the management structure of the LEC had been undermined due to the prolonged civil war. To address this situation, a management contract was signed in 2010 among three parties, i.e., Manitoba Hydro International (a Canadian private company), the Ministry of Lands, Mines and Energy (the lead agency at the time of ex-ante evaluation), and the LEC to strengthen the management structure in terms of technical, managerial, and administrative functions. The contract was extended until December 2016. Subsequently, with financial support from through the Millennium Challenge Corporation[18] by the U.S. government, the LEC signed a Management Services Contract (hereinafter referred to as "MSC") with ESB International (an Irish private company) for the period from January 2018 to January 2021. Thereafter, with the support from the World Bank, the MSC was extended for another two years (until January 2023). This will be expected to further strengthen the management structure of the LEC. It should be noted that the lead agency of the project has been changed to the Ministry of Mines and Energy following a reorganization of ministries in 2019.

As for the organizational structure of the LEC, the Thermal Power Plant Division under the Generation Department is responsible for the operation and maintenance of the HFOD Generation Equipment. In terms of staff allocation, 34 staff members are in charge of the operation of the generation equipment, 14 staff members are in charge of the maintenance of the generation equipment at the Bushrod Island Power Station, and sufficient staffing is in place to ensure proper operation and maintenance. Some of the staff are assigned to the Hydro Power Plant Division during the rainy season when the operation of the generation equipment at the Bushrod Island Power Station is reduced.

Therefore, there are no particular concerns regarding institutional and organizational aspects.



Source: Prepared by the evaluator based on the materials provided by the executing agency

Figure 2. Organizational structure of the LEC related to the operation and maintenance of the HFOD Generation Equipment

<Technical Aspect>

At the time of ex-ante evaluation, there was a shortage of skilled technical personnel for operation and maintenance caused by the civil war. However, technical transfers were carried out based on management contracts with Manitoba Hydro International as well as ESB International, and the technical and management capacity of LEC staff has been strengthened.

At the time of ex-post evaluation, routine maintenance and inspection work is performed without any problems using working checklists and other tools, partly because technical transfer of operation and maintenance of the HFOD Generation Equipment was provided through training using operation and maintenance manuals in the soft component of the project. However, according to the LEC, the capacity needs to be strengthened for large-scale periodic maintenance, including an overhaul of generation equipment as well as for major repairs which are anticipated to be needed in the future. For example, the HFOD Generation Equipment procured in the project needs to be overhauled every 4,000 hours of operation. However, overhaul has not been done, despite the fact that it has been operating for over 6,000 hours. In this context, JICA's technical cooperation project "The Project of Capacity Development for Diesel Generator Maintenance" was launched in 2020, expecting to strengthen capacity by conducting training and developing manuals for large-scale periodic maintenance and major repairs. Furthermore, given that JICA provided assistance[19] in Sierra Leone with procurement of similar equipment and technical transfer prior to this project, the LEC is planning to dispatch engineering staff to Sierra Leone for the purpose of exchanging techniques and knowledge.

Therefore, although technical issues related to large-scale periodic maintenance and major repairs anticipated in the future were identified, these issues are expected to be improved through the JICA's technical cooperation project launched in 2020.

[17] The engine intake valve fell off, and the cylinder was damaged.
[18] A bilateral aid agency of the U.S. government
[19] Sierra Leone, "The Project for Urgent Improvement of Electric Power Supply System in Freetown" (2007) and "The Project for Capacity Development for Maintaining Power Supply Facilities" (2011–2019).

<Financial Aspect>

At the time of ex-ante evaluation, the LEC's electricity sales revenues had been increasing year by year, but fuel costs were also increasing significantly. For this reason, profitability remained unimproved and the LEC faced a difficult financial condition.

At the time of ex-post evaluation, according to the LEC, the MSC has been improving its financial status, but the deficit persists. Part of the deficit has been covered by government subsidies, but financial situations are far from sound. In addition, the LEC is suffering from electricity theft in the form of illegal power connections. According to the President's Annual Message[20] for 2019, 40% of the electricity produced by the LEC is recovered through billing, but technical losses account for 12% and the remaining 49%[21] was lost due to electricity theft and other reasons, resulting in annual losses of more than US$35 million. In response to this serious situation, the government of Liberia enacted the *Electricity Theft Act* in 2019 to severely punish those who create illegal power connections. In response to the enactment of the Electricity Theft Act, the LEC has been holding community forums to raise awareness among residents.

As part of the efforts to improve its management, the LEC is not only promoting the further expansion of its power supply capacity and increasing the number of customers but also reducing the cost of fuel, which accounts for most of the cost of power supply, by reducing the operation of diesel generation equipment which requires relatively high fuel costs and expanding the use of less expensive hydropower generation. Furthermore, the LEC plans to promote the import of lower-cost electricity through frameworks such as the West African Power Pool and the Côte d'Ivoire-Liberia-Sierra Leone-Guinea (CLSG) Interconnector Project.

Table 2. Situation of financial balance of the LEC

(Unit: 1,000 USD)

	2017	2018	2019
Recurring income (A)=(B)+(C)	40,572	48,981	39,634
Operating income (B)	24,007	25,443	22,848
Non-operating Income (C)	16,565	23,538	16,786
Recurring expenses (D)=(E)+(F)	41,946	50,757	46,759
Operating expense (E)	22,904	20,252	30,261
Non-operating expense (F)	19,042	30,505	16,498
Recurring loss (G)=(A)−(D)	(1,374)	(1,776)	(7,125)
Tax (H)	–	–	–
Net income/loss (G)−(H)	(1,374)	(1,776)	(7,125)

Source: Materials provided by the executing agency

As for the operation and maintenance costs of the diesel generation equipment operated by the LEC, including those procured in the project, the necessary budget for daily maintenance costs has been allocated and spent, as shown in Table 3. On the other hand, the costs for large-scale periodic maintenance and major repairs anticipated in the future are not included in the budget. Continuing to operate the equipment knowing that it is faulty or inadequate will further increase the load on the procured equipment and increase the cost of parts replacement, which can worsen the operating balance. The LEC is aware of the need to secure sufficient budget in advance to carry out such maintenance and repairs in a timely manner and is going to discuss with the Finance Department to address this issue.

Table 3. Budget and expenditure for daily maintenance of the diesel generation equipment including those procured in the project

(Unit: USD)

		2017	2018	2019	2020
Daily maintenance	Budget	297,701.00	297,701.00	300,000.00	305,000.00
	Expenditures	56,419.16	33,596.33	136,150.00	160,577.00

Source: Materials provided by the executing agency

Therefore, there is a financial challenge in performing large-scale periodic maintenance and major repairs anticipated in the future for the HFOD Generation Equipment.

<Current Status of Operation and Maintenance>

As mentioned above, the HFOD Generation Equipment procured in the project has not been overhauled even though the total operating time has already exceeded 6,000 hours; therefore, its operation has to be further restricted. Moreover, the COVID-19 pandemic has delayed the progress of the West African Power Pool and the international interconnection project. Likewise, the dispatch of experts for JICA's technical cooperation project has also been delayed, and there are concerns that further delays in the implementation of the overhaul could impose further burdens on the HFOD Generation Equipment.

As for the procurement status of spare parts, which is essential for proper operation and maintenance, according to the LEC, it is difficult to procure them in a timely manner due to financial issues. Although spare parts and tool consumables will be provided through JICA's technical cooperation project, there are concerns about the status of operation and maintenance from the perspective of sustainability.

Therefore, it is considered that there are some issues in the status of operation and maintenance.

<Evaluation Result>

In light of the above, there are no particular concerns in terms of institutional and organizational aspects. As for the technical aspects, some concerns are identified regarding the technical capability for large-scale periodic maintenance and major repairs anticipated in the future, but these concerns are expected to be improved through the ongoing technical cooperation project. However, there are financial concerns

[20] Second session of the fifty-fourth legislature (January 2019)

[21] The total is 101%, but it is written as the source.

about large-scale periodic maintenance and major repairs, as well as some issues with the status of operation and maintenance, as overhauls have not been carried out even after 6,000 hours of operation. Therefore, the sustainability of the project is fair.

III. Recommendations & Lessons Learned

Recommendations to the Executing Agency: Budget analysis for appropriate implementation of large-scale periodic maintenance and major repairs anticipated in the future

The ex-post evaluation identified technical and financial concerns about large-scale periodic maintenance and major repairs. As for the technical aspects, the ongoing JICA technical cooperation project is expected to improve the situation. However, regarding the financial aspect, it is difficult to carry out large-scale periodic maintenance and major repairs in a timely and appropriate manner because no budget has been allocated to such activities. Therefore, it is recommended that the Thermal Power Plant Division under the Generation Department should estimate and present the specific budget required for large-scale periodic maintenance, including overhaul and major repairs anticipated in the future, and then initiate discussions with the Finance Department. It is advisable that the budget for large-scale periodic maintenance and major repairs be arranged from the next fiscal year.

Recommendations to JICA: None

Lessons Learned for JICA:

(1) Technical assistance for large-scale periodic maintenance and major repairs anticipated in the future

In the soft component of the project, technical assistance for operation and preventive maintenance of the HFOD Generation Equipment was provided, and the capacity for routine maintenance and inspection work was strengthened. However, due to insufficient technical capacity for overhaul, it had not been implemented even though the operation time exceeded 6,000 hours when the technical cooperation project started in 2020. If the need to improve the technical capacity of the executing agency for large-scale periodic maintenance including overhaul and major repairs, is identified during the project planning, the grant aid project may combine the procurement of equipment with a soft component including a technical transfer for large-scale periodic maintenance and major repairs. Alternatively, as needed, it is desirable to start the formulation of a technical cooperation project in a timely manner soon after the procurement of equipment. In this way, necessary maintenance and repairs can be carried out in a timely and appropriate manner, and sustainable utilization of the procured equipment and facilities can be ensured.

(2) Setting indicators that take into account not only the procured generation equipment but also the operation status of other types of power generation facilities

This project was implemented to supplement the urgent need for power capacity with diesel generation equipment during the dry season, when hydropower generation decreases while hydropower generation was expected to be expanded in the long term. Among the two indicators set at the time of project planning, the target value of "Capacity of generation equipment" was set considering the capacity of hydropower generation during the dry season. In contrast, the other indicator, "Fuel cost per unit power generation," was set with a target value for the whole year, even though this indicator was highly dependent on the operation status of other power generation facilities operated by the executing agency, specifically the operation status of the hydropower generation during the rainy and dry seasons. As a result, it was not possible to accurately confirm the status of achievement of the project effects in the dry season delivered by the HFOD Generation Equipment procured in the project. Therefore, when the operation status of other power generation facilities is considered to affect the project outcomes like this project, it is desirable to set the indicators with consideration of the influence of the operation of other types of power generation facilities.

Diesel engines

Power generator