Republic of Rwanda

FY2017 Ex-Post Evaluation of Japanese Grand Aid Project
"The Project of Improvement of Substations and Distribution Network"

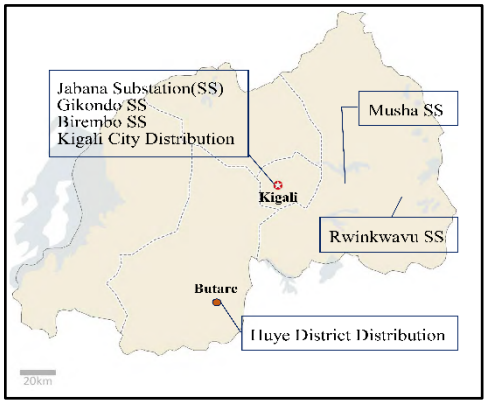
External Evaluator: Ryutaro Koga, Global Group 21 Japan, Inc.

0. Summary

"The Project of Improvement of Substations and Distribution Network" (hereinafter referred to as "this project") was implemented to refurbish/ renew substations at focal points in the power grid based in regions centered in Kigali city and local areas, and to refurbish/ expand distribution networks in order to stabilize the power supply and increase the electrification rates, thereby improving social services and industrial development. This project is part of the Rwandan government's nationwide electrification plan, consistent with its development policy and Japan's aid policy. The necessity of the project was high considering the power situation of the country, and thus the relevance is high. The project cost was about 90% of the planned amount, but the implementation period greatly exceeded the planned amount due to the revisions of overall designs and a re-tendering process that became necessary as part of the work was carried out in advance with the government's own funds. Also, there were some mandatory changes of standards for power equipment which forced design revisions. Therefore, the project's efficiency is considered fair. The power transmission output quantity of the substations has increased significantly beyond the planned amount, and the household electrification rate reached about 90% of the planned coverage. Due to these improvements, the project reduced the risk of large-scale blackouts and stabilized electricity supply to general households, industries etc. It also increased the quality that various social services can provide through the electrification of general households/ local governments/ schools/ health care facilities. Therefore, the project's effectiveness and impact are high. There are no problems in operation and maintenance from the viewpoints of institution, technology and finance. However, the repair of the control buttons at the control room for some of the substations has been delayed. Furthermore, there is some machinery which is not being fully utilized in the Huye District Distribution Network. So, the sustainability of this project is fair.

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

1. Project Description



Project Location

Jabana Substation Refurbished by this project

1.1 Background

At the time of project planning (2009), Rwanda's nationwide electrification rate was estimated to be about 5%, with electrification rates in urban areas including Kigali City, to be about 25%. Low electrification rates were an impediment to improving people's living standards, social services and industrial development. Furthermore, many of the substations and power distribution facilities were built in the 1970s and 1980s, and as the equipment aged, it became impossible to replace old parts, making the risk of large-scale blackouts at times of parts-troubles a concern. In Kigali, urbanization progressed as the population grew from 600 thousand as of 2000 to about 1 million in 2009, further increasing demand and making a stable power supply difficult. This project was planned in response to these urgent issues in the power sector, and based on Rwanda's national electrification plan, *Electric Access Rollout Program (EARP)* - one of the central programs for achieving the targets of the national development plan *Rwanda Vision 2020*.

1.2 Project Outline

This project was implemented to refurbish/ renew substations at focal points on the power grid based in regions centered in Kigali city and local areas, and refurbish/ expand distribution networks in order to stabilize the power supply and increase electrification rates, thereby improving social services and industrial development. Regarding the refurbishment/ extension of the distribution networks, the procurement and installation of low-voltage distribution lines and lead-in lines to each customer were the responsibility of the Rwandan side (excluding the Kigali City distribution network).

E/N Grant Limit/ Actual Grant Amount	2,454 million yen/ 2,287million yen
Exchange of Notes Date/ Grant Agreement Date	March 2011/ March 2011
Executing Agency	Ministry of Infrastructure (MININFRA: competent authority) Energy Development Corporation Limited (EDCL) Energy Utility Corporation Limited (EUCL) (At the time of Grant Agreement, "Energy, Water and Sanitation Authority" (EWSA)
Project Completion	March 2014
Main Contractor	The Consortium of Nishizawa limited and Takaoka Engineering Co., Ltd.
Main Consultant	Nippon Koei Co., Ltd
Cooperation Preparation Survey	October 2009 - January 2011 (The Preparatory Survey on the Project for Upgrading and Expansion of Substations and Distribution Network in the Republic of Rwanda)
Related Projects	"Capacity Building for Efficient Power System Development in Rwanda" (JICA technical cooperation, 2011-2014) "The Project of Improvement of Substations and Distribution Network Phase II" (JICA grant aid, 2016-2018)

2. Outline of the Evaluation Study

2.1 External Evaluator

Ryutaro KOGA (Global Group 21 Japan, Inc.)

2.2 Duration of the Evaluation Study

This ex-post evaluation survey was conducted as follows;

Duration of the Study: August 2017- December 2018

Duration of the Field Study: December 28, 2017-January 30, 2018, April 19-30, 2018

3. Results of the Evaluation (Overall Rating: B[1])

3.1 Relevance (Rating: ③[2])

3.1.1 Consistency with the Development Plan of Rwanda

The Government of Rwanda set a goal for the household electrification rate to reach 35% by 2020 as part of the *National Development Plan Vision 2020* created in 2000. This electrification policy has been implemented based on a medium-term plan (*Economic Development and Poverty Reduction Strategy: EDPRS 2008-2012*) which is formulated based on the NDP and the

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

[2] ③: "High" ②: "Fair", ①: "Low"

nationwide electrification plan (*Electricity Access Rollout Program: EARP*). At the time of planning, this project was highly consistent with these policies. Under the latest Medium-Term Plan II (2013- 2018) and one of its core programs, *EARP II*, the government realigned its goal for the household electrification rate to 70% by 2018. Furthermore, the *National Strategy for Transformation (2017-2024)* set a higher goal of 100% electrification by 2024, including on- and off-grid power. Therefore, this project is sufficiently consistent with the development policies at the time of planning and ex-post evaluation.

3.1.2 Consistency with Development Needs of Rwanda

At the time of planning for this project, the Jabana substation (which is the main substation in the Kigali metropolitan area), the Gikondo substation (which accommodates the National Electricity Control Center (NECC) and controls loads to substations nationwide), and the Musha and Rwinkwavu substations (which are located on the backbone power transmission lines of eastern Rwanda) had aged significantly over time. Replacement of parts such as transformers, breakers, and disconnectors were not possible. Thus, once a failure occurred, the risk of a large-scale blackout would be high. In addition, both the expansion of the distribution network to surrounding areas accompanying the growth of Kigali City, and the refurbishment/ expansion of the aging underground distribution network in Huye District (the second largest city) were necessary. As shown in the table below, the household electrification rate at the time of this ex-post evaluation was about 30% for on-grid, and 41% including off-grid (such as solar power, mini hydropower etc.). Although it has greatly increased since the start of this project, it still lags behind the above-mentioned targets.

Table 1 Household Electrification Rate of Rwanda

Electrification Rate (As of August 2017)	
Nationwide	40.7%
on-grid	29.7%
off-grid	11.0%
Rural Electrification Rate	16.0%

Source: *World Bank Energy Sector Development Policy Finance Report*

At the time of the ex-post evaluation, the equipment installed by this project continues to play an important role in supplying electricity to Rwanda against a backdrop of increased demand. On the other hand, as described in "Effectiveness" (see page 7) below, the load factor of the Jabana and the Gikondo substations is still high, and there is a continuous need to keep them at an appropriate level. From the above, this project is highly consistent with the development needs both at the time of planning and ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

This project was consistent with "Economic infrastructure development/ industrial development" which was the priority area of Japan's *Rwanda Country Assistance Policy (April 2012)* aimed at revitalizing economic activity through economic infrastructure development. It was formulized to establish part of "infrastructure development/ business promotion program" As per the support policies at the TICAD IV[3], the maintenance and management support was introduced to facilitate transmission and distribution networks to improve access to and promote efficient use of electric power. Therefore, this project was highly consistent with Japan's ODA policy at the time of planning.

From the above, the implementation of this project is well-aligned with the development policies, development needs of Rwandan electric power sector, development assistance policy of Japan. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

This project was divided between six facilities/ sites (seven including Birembo SS) as shown in the table below and was all carried out as planned, except for a portion of the Kigali City electricity distribution network. Regarding this exception, the Rwandan side worked on prioritized target areas in advance with domestic government funds, so construction areas were reduced to 1/3 the original agreement. Specifically, out of the four planned project areas, only two areas (Mbandazi and Muyumbu) were implemented in this project. The extension distance of medium- and low-voltage distribution lines was reduced by 38 km (68% of planned length), and the total number of distribution transformers on the distribution network also decreased by 13 units (62% of planned numbers). One of the works the Rwandan side was responsible for, "removal of the former substations in the adjoining sites of renewed Musha and Rwinkwavu substations," has not been completed, but there have been no problems with the operation of these substations. For the Birembo substation, a disconnector necessary for switching the transmission voltage from 70 kV to 110 kV east of Musha was added.

[3] The fourth Tokyo International Conference on African Development: TICAD is an international conference for African development led by the Japanese government and held together with the United Nations, United Nations Development Program (UNDP), African Union Committee (AUC) and Word Bank since 1993.

Table 2-1 Outputs of this project Plan and Actual (Substations Refurbishment and Renewal)

Item	Specification/ Standard	Plan	Actual
Jabana Substation (Refurbishment)			
Main transformer	10MVA, 110kV/15V	2	No change
Outdoor switchgear	Breaker, Disconnector, Instrument Current Transformer, Instrument Transformer	One set	No change
Indoor equipment	15 kV switchgear, Console type control panel etc.	One set	No change
Miscellaneous material for substation equipment	Equipment cradle, Power cable, Control cable	One set	No change
Gikondo Substation (Refurbishment)			
Outdoor switchgear	110 kV Switchgear, Circuit-Breaker, Disconnector, Instrument Current transformer, Instrument transformer, Lightning arrester, etc.	One set	No change
Miscellaneous material for substation equipment	Outdoor iron structure, Equipment cradle, Power cable, Control cable etc.	One set	No change
Musha Substation (Renewal)			
Main transformer	10MVA, 110kV/15kV	1	No change
Outdoor switchgear	Breaker, Disconnector, Instrument current transformer, Instrument transformer, Lightning arrester, etc.	One set	No change
Indoor equipment	15kV switchgear, Control panel	One set	No change
Miscellaneous material for substation equipment	Outdoor iron structure, Equipment cradle, Power cable, Control cable etc.	One set	No change
Building	—	One set	No change
Rwinkwavu Substation (Renewal)			
Main transformer	6MVA, 110kV/15kV	1	No change
Outdoor switchgear	Breaker, Disconnector, Instrument current transformer, Instrument transformer, Lightning arrester, etc.	One set	No change
Indoor equipment	15kV switchgear, Control panel	One set	No change
Miscellaneous material for substation equipment	Outdoor iron structure, Equipment cradle, Power cable, Control cable etc.	One set	No change
Building	—	1	No change
Birembo Substation (Addition)			
Outdoor switchgear	Disconnector	1	No change

Table 2-2 Output of this project Plan and Actual
(Distribution Network Refurbishment and Expansion)

Item	Specification/ Standard	Plan	Actual
Huye District Distribution Network (Refurbishment)			
Ring Main unit	30kV	21	No change
Distribution Transformer	30kV/0.4kV	20	No change
Concrete pillar, Steel pipe	Cables, Terminals, etc.	One set	No change
Building	—	20	No change
30 kV medium voltage distribution line	Underground type	About 16km	No change
400 V low voltage distribution line	Relocate existing facilities	—	No change
Miscellaneous materials for power distribution equipment	—	One set	No change
Kigali City Distribution Network (Expansion)			
15 kV medium voltage distribution line	ACSR	24.9km	7.59km
400 V low voltage distribution line	ABC	30.8km	10.08km
Pillar transformer	15kV/0.4kV	18	5
Concrete pillar	Low Voltage (9m) Medium Voltage (12m)	Total 944	Total 308
Outdoor low voltage distribution board	—	One set	No change
Miscellaneous materials for power distribution equipment	—	One set	No change

Rwandan side works

Plan (As of Cooperation Preparation Survey)	Actual (As of Ex-post evaluation)
(1) Installation and connection of lead-in from low-voltage distribution line to customer (2) Relocation/ refurbishment of SCADA system, Preparation of access road to substations (3) Removal of existing substation equipment (Musa and Rwinkwavu substation) etc.	(1), (2) were completed. (3) was not finished.

Outdoor switchgear
(Gikondo Substation)

Main Transformer
(Musha Substation)

Substation Building
（Rwinkwavu）

3.2.2 Project Inputs

3.2.2.1 Project Cost

The project cost (the portion borne by the Japanese side) was planned to be 2,454 million yen, but the actual cost ended up at 2,286 million yen (93%)[4]. As stated in the section on Project Output, the reason for this decrease in project cost is that the Rwanda government implemented part of the construction of the Kigali City distribution network with their own funds. Including these components conducted by Rwandan side, the initial project scope of this project has been completed.

3.2.2.2 Project Period

The planned project period was from March 2011 to February 2013 (24 months) but was prolonged from March 2011 (G / A) to March 2014 (37 months) (compared to plan 154%[5]). There are two main reasons for this delay. First, a design revision and re-bidding process became necessary as part of the Kigali City distribution network was implemented by the Rwandan government using self-funding, which was not conveyed until the middle of the bidding process. (The first bidding failed due to budget being exceeded, the contracted scope was divided into 2 lots (Kigali city distribution network and others), so in total three biddings were conducted). Second, as there was a partial amendment to the electrical equipment standards in April 2013, the roof structures of the Musha and Rwinkwavu substation buildings had to be changed to the RC structure. Also, for the newly added medium-voltage distribution lines of the Kigali City network, it became necessary to install disconnectors at the end of the section as a safety measure, necessitating additional procurement[6] . Regarding re-bidding, while it is possible that information sharing with the executing agency after starting the project was insufficient, the amendment of the electric facility standards was unavoidable as it is a change that contributes to improve safety.

From the above, although the project cost decreased with the decrease in construction volume, the project period was much longer than planned. Therefore, the efficiency of this project is fair.

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[4] Taking into consideration the decrease in the construction volume of the Kigali City distribution network, the comparison between planned and actual cost would be about 105%, but this amount includes some additional equipment for responding to the correction of the power facility standards, so it was evaluated in comparison with the initial construction cost.

[5] Including 5 months extended for the design change and the procurement of additional equipment such as disconnectors in order to comply with the standard change for the power equipment. Excluding these periods, then it is 133%.

[6] Regarding the installation of disconnectors, this project conducted up to the delivery, and EUCL took over the installation work.

3.3 Effectiveness and Impacts[7] (Rating: ③)

3.3.1 Effectiveness

3.3.1.1 Quantitative effects[8]

In this project, the facilities were refurbished and renewed at four substations, and the distribution facilities were refurbished and expanded in Kigali City and Huye District. With regard to substations, we analyze the effect of this project based on indicators of power transmission output, operation rate and load factor; and for electricity distribution equipment, based on electricity supply quantity and the electrification rates.

(1) Power transmission output (Substations)

Table 3 shows the transition of the power transmission output from 2013 to 2017 of the four substations, which are the main targets of this project. In the Jabana substation and the Musha substation, which had their transformer capacity increased, the power transmission output was estimated to increase by about 15% in six years from 2010 to 2016 (three years after completion of the project). (There were no target values for the other two substations). However, the power transmission output capacity at the Jabana substation and Musha substation has increased by 74% and 81% respectively during the five years from 2013 to 2017. This increase rate greatly exceeded the plan. Although this reflects a drastic increase in electricity demand for both substations, it is judged that the enhancement of both substations by this project made this possible. The power transmission output capacity of the Gikondo Substation (which did not upgrade a transformer) increased by 10% by 2017 (three years after completion of the project). On the other hand, although the transformer capacity was increased at the Rwinkwavu substation, the electricity growth remained at 6%. Because the main customers of the substation are tourism related facilities, such as hotels in Akagera National Park, the increase of other customers has been limited. According to the Rwamagana office of EUCL, the blackouts due to the insufficient transformer capacity and aging of the substation were the major issue, and it is recognized that this project has resolved this issue, which is a different effect from the increase of the power transmission output.

[7] Sub-rating for “Effectiveness” is to be considered with “Impact”.

[8] Indicators of the quantitative effects in the ex-ante evaluation table and the preparation survey differ from each other, and there are gaps between the numerical values of the ex-ante evaluation table and the numerical values obtained during the ex-post evaluation. As the basis for the ex-ante evaluation target value is unknown, this evaluation was conducted with the data obtained in the ex-post evaluation. The indicator of Load Factor was added as the operational conditions of substations (which relates to the project objective of avoiding the risk of large scale blackout) can be understood well by analyzing it together with the Operation Rates. The indicator of Power Sales of the Huye District power distribution network was not able to be obtained and replaced by the Power Supply Amount.

Table 3 Change of Transmission End Electricity Amounts (kWh)

Substation		2017	2016	2015	2014	2013
Gikondo	**Transmission end electricity (kWh)**	**143,391,160**	**123,422,160**	**115,995,236**	**130,628,995**	**130,464,060**
	% Compared with 2013	**110%**	**95%**	**89%**	**100%**	**100%**
Jabana	**Transmission end electricity (kWh)**	**87,488,288**	**86,126,630**	**75,959,420**	**74,143,236**	**50,285,170**
	% Compared with 2013	**174%**	**171%**	**151%**	**147%**	**100%**
Musha	**Transmission end electricity (kWh)**	**40,075,340**	**28,708,430**	**38,366,680**	**27,464,471**	**22,161,400**
	% Compared with 2013	**181%**	**130%**	**173%**	**124%**	**100%**
Rwinkwavu	**Transmission end electricity (kWh)**	**2,282,370**	**3,368,170**	**1,892,230**	**2,029,614**	**2,153,400**
	% Compared with 2013	**106%**	**156%**	**88%**	**94%**	**100%**

Source: Executing Agency

(2) Equipment operation rate (Substation)

Table 4 shows the equipment operation rates[9] of the targeted substations for this project, which is one of the operational indicators for power supply stability. Although available data were only for 2016 and 2017, these data indicate that the operation rate of each substation is more than 99.7%. This is due to the circuit breakers installed by the Rwandan side which prevent blackouts caused by the feeder side (distribution line side) from affecting the entire substation operation. Thus, it is recognized that these substations have been stably operating without large scale blackouts.

Table 4 Equipment operation rate of substations

Substation	2017			2016		
	Stop time (minutes)	Operation time (minutes)	Operation rate (%)	Stop time (minutes)	Operation time (minutes)	Operation rate (%)
Gikondo	1,403	524,197	99.73	1,520	524,080	99.71
Jabana	122	525,478	99.98	128	525,472	99.98
Musha	38	525,562	99.99	52	525,548	99.99
Rwinkwavu	161	525,439	99.97	130	525,470	99.98

Source: Executing Agency

[9] Equipment Operation Rate (%) = Annual operation time (minutes) / Annual total time (= 525,600 minutes) x 100%

(3) Load Factor (Substations)[10]

Table 5 shows the transition of the load factor of the targeted four substations from 2013 to 2017. The load factor of each substation is controlled by NECC located at the Gikondo substation. Reflecting the strong growth in electricity demand, the load factor of Gikondo and Jabana substations, which supply electricity to Kigali City, increased from 60.6% to 67.3% at Gikondo, and 38.3% to 71.2% at Jabana from 2013 to 2017. The high load factor indicates that the facilities refurbished by this project have been stably operated and contributed to the electricity supply of Kigali City. However, it also indicates that further expansion will be required in the near future.

On the other hand, the load factor of Musha substation remains at 48.7%, 1.5% decrease from 2014. Although the load factor of the Rwinkwavu substation is said to be affected by the demand of tourism facilities (hotels etc.) of and around the Akagera National Park, it is as low as 37.2%. This means the difference between the maximum and the average electric power demand is high, indicating that there is a high margin for enlarging the electric consumption as well.

According to the Rwamagana office EUCL, the electricity demand of Musha substation is expected to expand, indicating that further upgrade for the transformer capacity will be needed in the near future, as this area accommodates the industrial park development plan of Rwamagana with many development projects. In addition, the project for electrifying 8,000 households is currently underway, and the number of connections has been increasing at around 3,000 connections/year recently. As for the Rwinkwavu substation, an installed 6 MVA transformer here is deemed more than enough with the current demand. However, considering that this area is a latecomer for electrification, there is a high possibility for the demand to grow significantly in a mid and long time.

Table 5 Change of Substation's Load factor

Substation		2017	2016	2015	2014	2013
Gikondo	Load Factor (%)	67.3%	53.3%	70.3%	67.6%	60.6%
	% Compared with 2013	111%	88%	116%	112%	100%
Jabana	Load Factor (%)	71.2%	64.1%	53.4%	65.4%	38.3%
	% Compared with 2013	186%	168%	140%	171%	100%
Musha	Load Factor (%)	48.7%	35.8%	48.6%	50.2%	57.2%
	% Compared with 2013	85%	63%	85%	88%	100%
Rwinkwavu	Load Factor (%)	37.2%	55.7%	31.7%	33.9%	37.2%
	% Compared with 2013	100%	150%	85%	91%	100%

Source: Executing Agency

[10] The load factor of a substation shows the ratio of the average electric consumption and the maximum electric consumption in a period, and the higher the load factor, the more stable the target equipment operation is with less fluctuation in the load. When it is too high, however, it shows there is little room for responding to rapid demand spikes. The annual load factor in Japan varies from about 55 to 65%, and usually around 60 to 65% in many countries.

(4) Electricity Supply (Huye District Distribution Network)

Table 6 shows the changes in the electricity supplied to the Huye distribution network which has been refurbished and expanded by this project. From 2014 to 2017, the power supply increased 185% in the district, much higher than the target value (15% increase from 2010 to 2016). This increase in electricity supply is due to not only this project, but also the increase in the supply source and capacity. Before this project, the electricity supply to Huye came from the Kigoma substation. However, this substation had frequently caused power transmission halts (power failure) due to the shortage of capacity, and thus the establishment of Lukarara substation was necessitated. Since this new substation started to transmit electricity to the Huye network, the electricity supply has been increased. Compared with the electrification rate of about 80% in Kigali City, that rate in Huye District is only about 31% (on-grid rates as of December 2017). Therefore, it is considered that development demand in this district will continue to be large.

Table 6 Change of Electricity Supply to Huye District

Substation		2017	2016	2015	2014
Kigoma (Butare Feeder)	Transmission end electricity (kWh)	9,546,710	27,341,702	29,196,736	12,205,730
Rukarara	Transmission end electricity (kWh)	25,202,431	484,380	0	0
Total	Transmission end electricity (kWh)	34,749,141	27,826,082	29,196,736	12,205,730
Growth rate	%	285	228	239	100

Source: Executing Agency

(5) Electrification Rate (Kigali City Distribution Network)

Table 7 shows the transition of the electrification rate in the Kigali City Distribution Network Area, which was expanded/ updated during this project. At the time of ex-post evaluation, the electrification rate of Mbandazi was 70% and Muyumbu was 75% (both 2017 values), which was about 90% of the target value of 80%. Therefore, the target values were generally achieved.

Table 7 Change of Electrification Rate in the Kigali City Distribution Network

Unit: %

	Plan (3 years after completion)	2017 Actual (Achieved %)	2013	2010
Nationwide	—	42.3	23.5	10.3
Kigali City	—	80	48	25.9
Mbandazi	80	70 (88)	0	0
Eastern District	—	37		14.1
Muyumbu	80	75 (94)	51	26

Source: JICA, Rwanda Government, Executing Agency
Note: Muyumbu is part of the Kigali City Distribution Network, but belongs to the Eastern District as an administrative district

3.3.1.2 Qualitative Effects (Other effects)

The qualitative effect expected from this project was to avoid the risk of large-scale blackouts. According to the executing agency, the stability of the power supply has greatly improved due to this project, including the reduction of the risk of large-scale blackouts. Outdated equipment that no longer has repair parts such as transformers. in the substations of Jabana, Gikondo, Musha and Rwinkwavu were renewed. The transmission voltage to the east of Musha was boosted from 70 kV to 110 kV, and the 6.6 kV medium voltage distribution lines in Huye District were replaced with the 30 kV distribution lines used in many areas of Rwanda, thereby it now becomes easier to get replacement parts. Furthermore, Rwanda's power generating capacity increased by 2.3 times[11] from 93.5 MW in 2010 to 216 MW in 2017. It is judged that this project contributed to the stabilization of the power supply by smoothly connecting this increase of power generation to consumers through the improvement of substations and distribution equipment.

Based on the above, the implementation of this project improved power supply conditions more than expected, and therefore, the degree of achievement of the project purpose is high.

3.3.2 Impacts

3.3.2.1 Intended Impacts

This project intended to contribute to improving the quality of social services and industrial development by stabilizing the electricity supply and increasing the electrification rate through refurbishing/ renewing the main substations and upgrading/ expanding the electricity distribution networks.

[11] Source: Answers from the executing agency via questionnaire

(1) Impact due to stabilization of electricity supply

It is recognized that this project played a fundamental role for the stable expansion of electricity supply and contributed to prevent the risk of large-scale blackouts (which were likely to occur in the project area without this project), therefore to the sustainable growth and revitalization of economic activities. (see Effectiveness: Qualitative Effect).

(2) Impact from the increase of the electrification rate

With respect to the enhancement of the above-mentioned social services, the improvement of living conditions by strengthening the services of local health care facilities, educational facilities, administrative facilities through electrification were expected. This project has expanded and rehabilitated the distribution networks (Kigali City, Huye District), and also contributed indirectly to the electrification of surrounding areas around major substations by refurbishing/ renewing them. Here we analyze the impact from the improvement of the electrification rate; based on the changes in the electrification rate of general households/ social service facilities and the results of field surveys in electrified areas[12].

Unfortunately, the number of customers and electrification rate by each substation were unknown. Table 8 shows the trend of general household connections and nationwide electrification rates of social service facilities that helps to understand the contribution effects of this project to the improvement of social services. At the time of planning, the number of general customers in the target area of this project was expected to increase 65% three years after the project completion compared to the base year (2010). For school and medical/ health facilities, the growth rate for the electrification were expected to be 64% and 13% respectively. Whereas, as shown in Table 8, the number of general customers has increased more than four times in the seven years from 2010 to 2017 nationwide, and the electrification rate of school facilities has more than doubled. For hospitals and medical facilities which already had a comparatively high electrification rate before this project, had achieved a 100% electrification rate by 2017. Judging comprehensively from the above, it is highly likely that the intended positive impact was achieved in the target area of this project.

[12] In total 106 people were interviewed including focal group discussions from households (7 groups, 87 people), and individual interviews (local government 3, school facilities 2, medical health facilities 2, commercial and industrial owners 10) from 17 different sites.

Table 8 Electrification rates of general households, medical facilities, governmental offices, schools (nationwide)

Target	Category	2017	2014	2010
General Households	(Number of connection)	776,097	473,003	187,624
	(Growth rate %)	414%	252%	100%
Medical/ Health Facilities (Electrification rate %)	Hospitals	100*		90*2
	Health Centers	91*		
Government Offices (Electrification rate %)	Province Office	100*		90*2
	District Office	100*		
	Sector Office	94*		
	Cell Office	56*		
School (Electrification rate %)	Primary Schools	94*		26*2
	Secondary Schools	56*		

Source: Executing Agency *: As of Feb 2018 *2: As of 2011

(3) Major impacts on the improvement of living conditions and industrial development (see Column)

General households enjoy the convenience of using electric appliances (mobile phones, radio, TV, video, etc.). Switching from kerosene lamps (which cause damage to health) to electric lighting, improvement of access to information, and availability of cold beverages, etc. provide a higher standard of living, and changes in the attitude of life are seen. Meanwhile, local government offices have been able to issue certificates more quickly with the introduction of personal computers. At medical health facilities, medical treatment at night with electric lighting has become possible, and medical services improved with the use of various medical equipment such as sterilizers, diagnostic lights, etc. In educational facilities, supplement classes early in the morning and/or after school for the preparation and review of classes have been increased. Furthermore, classes using personal computers have also started at some schools, and thus the quality of education has improved. Many commercial and industrial owners are also aware of the improvement in the quality of electricity such as a reduction in blackouts after the project. The number of new businesses that use electric products such as the welding industry, timber processing industry, barber shop etc. were increased in the new power distribution area. Thus, the effects on business is recognized.

Column: Benefits of electrification obtained from field survey at the ex-post evaluation

Field survey results by group interviews with residents (7 groups from the new electrified areas - Kigali district 3, Rwamagana area 1, Kayonza area 1, Huye area 2--- Total 89 people[13]):

Changes in community after electrification

Changes at the local government of cell level (which bundles multiple villages)

◇ Due to the installation of personal computers and printers at local governments, the quality of reports at those offices has improved with spending less time.

◇ Local governments can access to the central government databases. For example, it is now possible to issue some certificates for social stratum data that are necessary for paying health insurance premiums, the burden of residents having to visit a far-away central office has been eliminated.

◇ Residents are able to communicate with each other at any time with a mobile phone.

◇ Government offices now have bright workspaces (even in twilight hours) which improves work efficiency.

◇ Electric lighting aided in the recognition of suspicious persons at night, reducing theft and improving public order.

Impacts to economic activities

◇ With the increase in lighting and new services, store opening hours were extended until midnight, and customers increased.

◇ Number of new businesses using electric products such as welding, barber/ hairdresser, restaurants, copy service etc. have increased.

◇ Land prices and rents rose as new businesses and population increased.

[13] (Reference)

Home electric appliances owned by residents

(1) Households that own electric bulbs was 100%, mobile phones over 90%. Radio over 50%, TV about 30%, the spread of other electric devices is lower. Benefits of electrification thus majorly surrounds the use of electric lighting and mobile phones.

(2) Most common items residents prefer to buy next; TV, Fridge, Iron, DVD and Electric pot.

Electricity Charge / Connection Charge situation

(1) Average Electricity charge of households is 2.2$ / month. Payment is made by pre-paid method.

(2) "Connection charge" and "wiring cost" in households (total about 80$) are required for connection. Pole fees (if the house is more than 37m away from nearest distribution pole) of 100$ or more per pole are also required. Group residents of Mubare (Rwamagana district) interviewed were not electrified at the beginning because they were spread out from poles, but 99 people in the community jointly requested the electricity company to electrify their area and achieved electrification by paying connection costs jointly (including a 1.8 km stretch, 33 poles).

(3) Rwanda's electrification rate has been increasing rapidly in recent years. One of the keys has been a connection fee installment payment system to reduce the connection cost burden. From the interview results, payment of about 40% or more of the connection fee is made before connection, and the remaining amount is repaid in about one year. If you select split repayment, you pay half of the payment for repayment each time you pay the electricity fee. For this reason, only half of the payment is paid for electricity charges until payment is complete, and there is sentiment that the electricity charge is high for many residents.

Impacts to school facilities

◇ A vocational training school using electric tools and machine tools for vocations such as woodworking, sewing and welding was established.

◇ The motivation of students and faculty members improved after electric lights became available. Morning and evening supplement classes were bolstered. Some of the schools started using personal computers in class.

◇ Students are now able to spend more time at school for study than before due to the electric lighting, and student grades have increased as a result.

Impact on general households

◇ The use of mobile phones, radios, TVs, and videos improved the ability to access to the information for the residents, e.g. the price information of agricultural products or purchased goods, weather information useful for cultivation etc. became available. Disseminating videos for educational purposes such as hygiene management and contraceptive methods to patients/ residents became possible.

◇ Switching from a kerosene lamp (which is harmful to health) to electric lighting stopped the chronic coughing in children, the worry of fire breakouts, and due to the brighter lighting, quality of lifestyle in the night had improved. In addition, services such as mills, copiers, internet cafes which were not available nearby before, were established, and people can now even enjoy cold beverages.

◇ "Electrification" has also led to the creation of some kind of pride towards "My Village". A grocery shop owner pointed out that after electrification the guests began to arrange their appearance when they go out. Many parents pointed out that children have stopped playing outside in the night and time to see TV and learn at homes has increased.

Impact on health facilities

◇ By using medical examination equipment such as centrifuges, the immediate test result became available. Furthermore, specimens can now be preserved by using refrigerator. This makes biopsy services possible to the higher-level medical facilities.

◇ The educational effect of family planning by using TV/ Video was improved, there was a health facility where the number of pregnant patients drastically declined.

◇ Thanks to the refrigerator/ freezer, it became possible to implement a stable vaccination schedule.

◇ It became possible to use a sterilizer necessary for surgical instruments, refrigerators for preservation of drugs and specimens etc., incubator used for premature babies, and a diagnostic light and the like.

3.3.2.2 Other Positive and Negative Impacts

(1) Impact to the Environment

This project did not fall under the large-scale transmission/ distribution sector, and thus negative impacts on the environment was judged as limited. As a result of the screening by the Rwanda Development Agency, only the extension of the Kigali City distribution network was required for an environmental impact assessment (EIA), and EIA was approved in March 2011. According to the executing agency, based on the environmental action plan of the EIA, measures for mitigating soil runoff were appropriately implemented for the construction of the Kigali City distribution network. Regarding the refurbishment/ renewal of substations, and refurbishment/ expansion of Huye District distribution network, it was notified in the official document that an EIA was unnecessary. Regarding the construction of these substations, environmental mitigation measures such as enclosing the sites by fences and avoiding works at night were taken. With regards to Musha and Rwinkwavu substations, removal of the former substations has not been completed, but there has been no adverse environmental impact.

(2) Resettlement / Land purchase

Resettlement of residents has not occurred in this project. In the renewal of the Musha substation and refurbishment of Huye District distribution network, land acquisition (about 230 square meters) occurred at the site of transformer installations etc., and some tree cutting was required. Part of the site at the Musha substation was purchased from a private company and three of the four places in the Huye District distribution were city owned land. One of those located at the Huye center place (Telecom Distribution Post) was initially privately-owned land, but the land owner did not agree. Therefore, it was settled by shifting the location and using the city land. The remaining one was the property owned by the Rwanda Energy Group (the parent company of the executing agency). It was confirmed from the executing agency that compensation has been appropriately made in each case including those for cutting trees in line with the compensation plan.

From the above, the implementation of this project generally went as planned, making the effectiveness and impact considered high

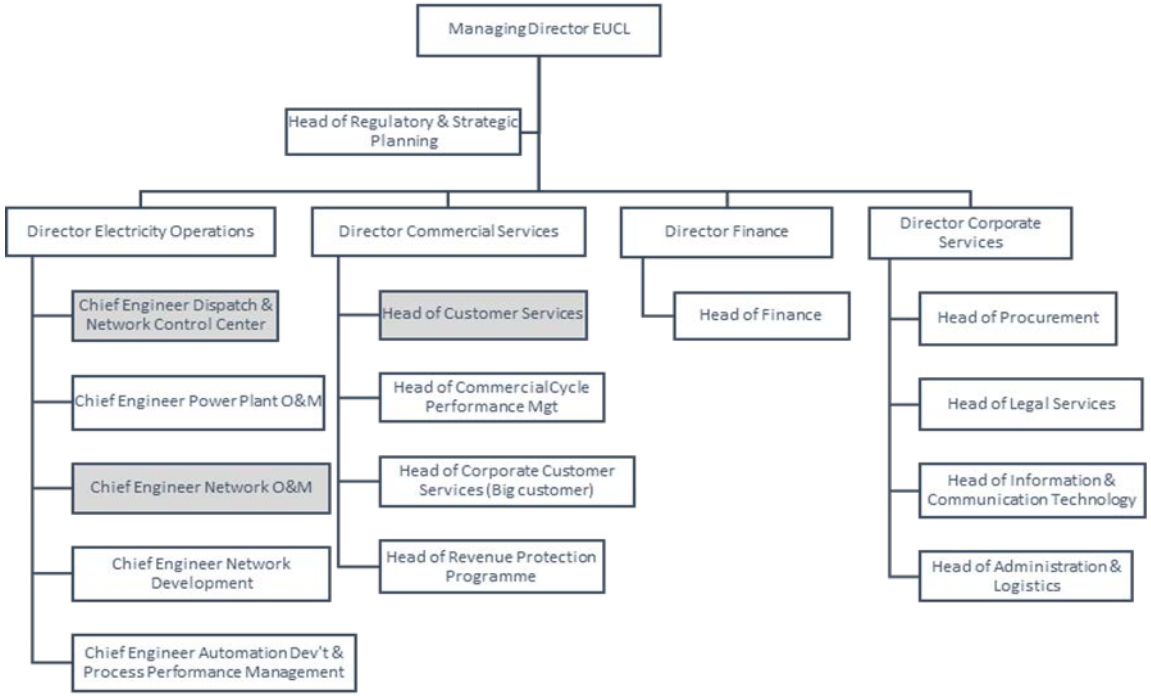
3.4 Sustainability (Rating: ②)

3.4.1 Institutional / Organizational Aspects of Operation and Maintenance

Organizational reforms of the executing agency have been taking place in Rwanda with the aim of creating a more efficient and clear responsibility system for development and operation of

the electric power sector. The executing agency of this project was the Energy and Water Sanitation Authority (EWSA) at the time of the grant aid contract, which changed from the Rwanda Electricity Authority (RECO) at the time of the preparatory survey. Soon after the completion of the project, in August 2014, the Energy Development Corporation Limited (EDCL) and the Energy Utility Corporation Limited (EUCL) were reorganized as subsidiaries of the Rwanda Energy Group (REG), a 100% government-owned public corporation.

EDCL oversees electric power development, and EUCL handles operation and maintenance of the electric power facilities after completion of new facility construction. For this reason, the executing agency for this project is both EDCL and EUCL, but the operation and maintenance of the substations and distribution network after this project completion have been carried out by EUCL. According to the EDCL, there are already 14 IPPs (Independent Private Power Generators) for power generation, but there are no plans to privatize the operation and maintenance of the power transmission and distribution facilities. This newly established organizational structure is still under development, and according to persons concerned with the Ministry of Infrastructure, collaboration is not smooth yet regarding the implementation of operations across organizations. The organization chart of EUCL is shown below.



Source: Executing Agency

Note: Painted boxes show division in charge of operation and maintenance of this project

Figure 1 Organizational Chart of EUCL

The maintenance of substations is carried out by the *Dispatch & Network Control Center* (DNCC) at the *Director Electricity Operations* of EUCL, and for the electricity distribution network, the *Network Operations & Maintenance Units* are in charge of large-scale repairs, etc. Daily inspection and management centering on the electricity distribution network is handled by a regional office under the umbrella of the Director *Commercial Services*. As stated in the "Operation and Maintenance Technology" (p. 18), the substations are managed nationwide by the chief engineers of DNCC from the Gikondo substation in a remote and centralized manner on a 24-hour basis with the SCADA system. As for the distribution networks (both Huye District and Kigali City), there are sufficient staff members as shown in the following table. Thus, there are no particular problems in the operation and maintenance system.

Table 9 Operation and Maintenance Staff

Facility	(Operation staff) + Maintenance staff
Jabana Substation	(2 people x 2 shifts) + 2 people
Gikondo Substation	(3 people x 4 shifts) + 5 people
Musha Substation	(2 people x 2 shifts) + 1 people
Rwinkwavu Substation	(2 people x 2 shifts) + 1 people
Huye District Distribution Network	7 staff (technicians)
Kigali City Distribution Network	40 staff

Source: Executing Agency

3.4.2 Technical Aspects of Operation and Maintenance

In addition to the above-mentioned operation staff, three senior engineers are placed as chief engineers at the Gikondo substation, and they are centrally managing remote substations nationwide 24 hours a day. No particular technical problems in management have been identified. In the Huye District distribution network, EUCL staff by themselves were able to appropriately change the settings and/or replace some equipment parts (transformer, breakers, etc.) necessitated by the increased demand. This indicates that they possess sufficient management skills and knowledge. In the Kigali City distribution network as well, EUCL installed disconnectors by this project at the connection points of the newly added distribution network without any troubles.

In addition, a technical cooperation project, *Capacity Building for Efficient Power System Development in Rwanda*, which aimed to strengthen the Electricity Training Center by training chief engineers/ technicians for distribution, transmission, and generation was conducted in

parallel with this project. Through this project, inspection of transmission lines was conducted between Musha and Rwinkwavu substations before boosting the transmission voltage from 70 kV to 110 kV by the end of the project, and replacement of damaged insulators were proposed. Furthermore, core engineers who received trainings from the technical cooperation project supervised the construction sites for the substations and transmission lines. It is recognized that these concrete collaborations contributed to the improvement of the expertise required for the operation and maintenance of these facilities.

3.4.3 Financial Aspects of Operation and Maintenance

Table 10 shows the financial situation (a profit and loss statement) of EUCL. EUCL has contracted with the government to operate and maintain the government-owned thermal power plants, and has been accepting some grants and subsidies for fuel import tariffs for those thermal power plants, etc. In both 2014/15, 2015/2016 fiscal years, it showed profits even if depreciation expenses are posted. The subsidy is on a downward trend, and it is planned to be eliminated in the future when the financial condition is stabilized. The revenues from power sale have been increasing. The budgets for maintenance are allocated to the enhancement of the electric power facilities, and it was confirmed at the time of the ex-post evaluation in a hearing with EUCL engineers that the necessary capital has been secured. The financial situation in terms of operation and maintenance are not a concern.

Table 10 Income Statement of EUCL

RwF Million

	2015/16	2014/15
Revenue	78,104	58,786
Cost of sales	(67,665)	(60,546)
Gross profit/(loss)	10,439	(1,760)
Grants and subsidies	21,104	28,800
Other income	3,706	1,105
Distribution costs	(9,484)	(9,880)
(Out of above:Repairs and maintenane-distribution)	(3,511)	(2,421)
Administrative expenses	(10,433)	(8,147)
Operating profit before depreciation and amortisation	15,332	10,118
Depreciation and amortisation	(10,447)	(10,087)
Operating profit after depreciation and amortisation	4,885	31
Financial income	98	5
Finance costs	(1,224)	(763)
Profit before income tax	3,759	(727)
Income tax(expense)/credit	(1,889)	1,445
Profit of the year	1,870	718
Other comprehensive income	-	-
Total comprehensive profit for the year, net of tax	1,870	718

Source: Executing Agency
Fiscal Year: July 1 to June 30th
1USD = 862 RwF(April 2018)

3.4.4 Status of Operation and Maintenance

The SCADA[14] system (installed in 2010) operated at DNCC in the Gikondo substation is synchronized with the four substations of this project. And using the newly upgraded 110kV transmission line (boosted from 70kV by this project), they are able to remotely control the substations in a centralized manner. In the defect inspection report for this project, it was pointed out that there were no particular problems in the basic performance of substations and distribution equipment, and overall condition was good. This was confirmed from EUCL even at the time of the ex-post evaluation.

In addition, at the time of defect inspection, following points were reported, and the situation afterwards was checked at the ex-post evaluation.

（1） Damage of the operating buttons of the control consoles in Jabana, Musha and Rwinkwavu substation control rooms: It has been handled by sticking labels under the damaged buttons with the words which were unreadable.[15] The damage has worsened, and the exchange parts have been ordered. Everyday operation is done remotely using the SCADA system, and there are no problems with the function. But since the button that switches to local operation at times of an accident etc. is included as one of the damaged ones, it is recognized that urgent replacement is necessary before any malfunction occurs.

Damaged control buttons of substation control console
(Musha Substation)

（2） As for the Huye District distribution network, it was confirmed that the theft and loss of grounding wires at four of the 21 distribution posts reported at the time of the defect inspection, have already been fully repaired.

[14] Supervisory Control And Data Acquisition
[15] According to EUCL, replacement of the damaged console buttons was requested before, but could not be replaced as the guarantee period had ended.

In the Huye District distribution network, it is required to respond to the sudden increases in demand (replacement of transformers, circuit breakers, etc.) and damages to the underground distribution cables due to road construction. Also, regarding the distribution posts equipped in this project, replacement, repair, and adjustment of breakers and transformers are necessary, and some parts are outdated. Concerning these, however, it was confirmed that the executing agency responded appropriately and continuously using the equipment.

In the Kigali distribution network, damage to a part of the iron fences protecting the outdoor transformer, and loose or unfixed guy- wires (wire for supporting the utility poles) were observed. Damage to iron fence seems to be a problem in general security, but it is necessary to strengthen security measures such as reinforcement of patrolling.

From the above, overall there are no major problems concerning the operation and maintenance regarding institutional, technical and financial aspects. However, regarding the maintenance situation, the repair of the control room console buttons of the substations is delayed. There is equipment in the Huye District distribution network that can't be used. And in the Kigali City distribution network, there are many unfixed/ loose guy-wires. Therefore, the sustainability of this project is considered fair.

Ngoma Distribution Post
(Huye distribution network)

Ring Main Unit
(Huye distribution network)

Medium / Low-voltage distribution line joining pole (Kigali City distribution network)

4. Conclusion, Recommendations and Lessons learned

4.1 Conclusion

This project was implemented to refurbish/ renew substations at focal points in the power grid based in regions centered in Kigali city and local areas, and to refurbish/ expand distribution networks in order to stabilize the power supply and increase the electrification rates, thereby improving social services and industrial development. This project is part of the Rwandan government's nationwide electrification plan, consistent with its development policy and Japan's aid policy. The necessity of the project was high considering the power situation of the country, and thus the relevancy is high. The project cost was about 90% of the planned amount, but the implementation period greatly exceeded the planned amount due to the revisions of overall

designs and a re-tendering process that became necessary as part of the work was carried out in advance with the government's own funds. Also, there were some mandatory changes of standards for power equipment which forced design revisions. Therefore, the project's efficiency is considered fair. The power transmission output quantity of the substations has increased significantly beyond the planned amount, and the household electrification rate reached about 90% of the planned coverage. Due to these improvements, the project reduced the risk of large-scale blackouts and stabilized electricity supply to general households, industries etc. It also increased the quality that various social services can provide through the electrification of general households/ local governments/ schools/ health care facilities. Therefore, the project's effectiveness and impact are high. There are no problems in operation and maintenance from the viewpoints of institution, technology and finance. However, the repair of the control buttons at the control room for some of the substations has been delayed. Furthermore, there is some machinery which is not being fully utilized in the Huye District Distribution Network. So, the sustainability of this project is fair.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

Some of the operation buttons of the control desk in Jabana, Musha and Rwinkwavu substations were damaged. Although replacement parts have already been ordered and there is no obstacle to the current operation, the possibility of malfunctioning in the future cannot be excluded and thus quick repair is desired.

4.2.2 Recommendations to JICA

Nothing.

4.3 Lessons learned

Information sharing of project scope change

In a support project where the construction sites and conditions may change based on the trend of the target district needs (such as a distribution network), it is important for JICA/ Project management consultant to thoroughly grasp the needs of the recipient government/ executing agency and what changes are foreseen through regular consultations etc. so as not to affect (delay) the implementation of the overall plan of the support project.

Although the original sites for the expansion of the Kigali City distribution network (which

was part of this project) was four areas, the Rwandan side had constructed two of the high priority areas with their own funds. The Japanese side recognized this change right after the start of the bidding process for all four areas. As a result, revising the project design and dividing the bidding lot became necessary, and this caused significant delay of the overall construction period. Major reason for this delay is thought to be the insufficient information sharing with the executing agency after commencement of the project. Therefore, it is important to implement some measures for sufficient information sharing from the beginning so that there will be no delays due to such lack of cooperation.

Implementation time and follow-up of defect inspection

It is advisable to conduct the defect inspection within the warranty period, and it is important for JICA to adequately follow up on the issues pointed out in the report.

Damage to the operation buttons of the control desk of Jabana, Musha and Rwinkwavu substations was pointed out in the defect inspection report and countermeasures were taken. However, since the defect inspection was conducted after the warranty period, it was highly possible that the measure taken was not a fundamental one and insufficient. In addition, it is hoped that JICA should confirm the appropriateness of countermeasures with respect to the issues pointed out at the time of the defect inspection, and also to follow up on the content of the problem sufficiently.

END