Kingdom of Cambodia

FY 2016 Ex-Post Evaluation of Japanese ODA Loan Project

"Greater Mekong Power Network Development Project"

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0. Summary

This project constructed and upgraded 230kV double-circuit power transmission lines and related facilities in the aims to strengthen the electricity supply capacity of the southern Cambodia, Kampot-Sihanoukville region, to respond to the demand for electricity of Sihanoukville and to improve the electrification rate along the area surrounding the transmission lines. This project was in line with development policy including Cambodia's energy/electricity policy, development needs, Japan's ODA policy, in terms of increasing investment in power generation and transmission business and improving electrification rate in rural areas. As such, the relevance of the project is high Although the project cost fell within the plan, the project period greatly exceeded the plan, so that the efficiency is fair. For operation and effect indicators set at the time of appraisal, both electrification rate and distribution loss rate achieved the targets. By this project, it is evaluated that electric power supply has increased significantly in the target area and stable power supply has been realized. Through interviews with large consumers, increase in employment and the number of factories and offices, and improvement of productivity, income and living environment are confirmed. Based on the above, the project has achieved its objectives, so that the effectiveness and impact of the project are high. Regarding the operation and maintenance of this project, there are no particular problems with respect to systematic and technical aspects. Regarding the financial aspect, according to the financial data of Electricité Du Cambodge (hereinafter, "EDC") the operation and maintenance cost of the transmission lines and substations is properly supplied. Transmission lines and substations are well operated and maintained, and even when problems arise, they are being handled appropriately and quickly. Therefore, the sustainability of the effect expressed by this project is high.

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

1. Project Description

Figure 1 Project Location Map

Figure 2 the Stun Hav 230/22kV Transmission Grid Substation

1.1 Background

Cambodia constitutes a part of the Mekong region[1], and in 2007 when the loan agreement was concluded, the political situation was stable and the economy was steadily growing. However, since economic disparity with current ASEAN member countries (Thailand, Malaysia, etc.) was still large in income and living standards, it was a challenge to resolve such disparity and promote "development of the Mekong region" as a unified region. Especially regarding electricity supply, the electrification rate was the lowest level (about 17%) in Southeast Asia and needed to be improved urgently due to the fact that the capacity of equipment was significantly smaller than those of neighbouring countries and there was no nationwide transmission and distribution network. In addition, many of the existing power plants relied on imports of petroleum as fuel, so that the electricity charges were 2 to 7 times higher than those of neighbouring countries. By this project, it was expected that it would become possible to supply inexpensive and reliable electric power from Vietnam through developing interconnection to the transmission lines constructed under the support of other donors[2] and developing a part of the power network of the Mekong region.

1.2 Project Outline

The objective of this project is to improve the electrical power supply to the area from

[1] The Mekong region (consisting of Cambodia, Laos, Myanmar, Vietnam, Thailand and Yunnan Province, China) refers to the Mekong River Valley that runs longitudinally across the Indochinese peninsula, with an area of approximately 2.3 million km^2 (approximately 6 times the size of Japan). The population at the time of appraisal was about 250 million (about twice of the population of Japan).

[2] ADB, the World Bank and the Nordic Development Fund supported the transmission line between Vietnam (Chao Dok) - Takeo - Phnom Penh. The German Reconstruction Finance Corporation (KfW) was supporting the improvement of the transmission line between Kampot and Takeo.

Kampot to Sihanoukville in the Cambodia Growth Corridor, to address electrical demand of Sihanoukville, and to increase rate of electrification, by building 230kV double-circuit transmission lines (about 78km) from Kampot to Sihanoukville, and by newly constructing or strengthening related substations and maintaining an electric distribution system, thereby contributing to the improvement of investment environment and economic development of the region.

Loan Approved Amount/ Disbursed Amount	2,632 million yen/ 2,521million yen	
Exchange of Notes Date/ Loan Agreement Signing Date	March 2007/ March 2007	
Terms and Conditions	Interest Rate Repayment Period (Grace Period) Condition for Procurement	0.01% 40 years (10 years) General Untied
Borrower / Executing Agency	The Royal Government of Cambodia / Electricité Du Cambodge (EDC)	
Project Completion	May 2014	
Main Contractors (Over 1 billion yen)	DOOSAN Heavy Industries & Construction Co., Ltd. (South Korea) / DOOSAN Engineering & Construction Co., Ltd. (South Korea) (JV)	
Main Consultant (Over 100 million yen)	-	
Feasibility Studies, etc.	F/S by the Asian Development Bank (ADB)(December 2005)	
Related Projects	【Technical Cooperation】 ・Development Study "Master Plan Study on Rural Electrification by Renewable Energy" (2004 – 2006) ・Technical Cooperation Project "Capacity and Institutional Building of the Electric Sector" (2004 – 2007) ・Dispatchment of JICA Advisor (Power Sector: dispatched to the Ministry of Industry, Mines and Energy (MIME), 2000 -) 【Loan Project】(Date in brackets is signing date of loan agreement) ・ "Sihanoukville Port Urgent Expansion Project" (November 2004) ・"Greater Mekong Telecommunication Backbone Network Project" (March 2005) ・"Poverty Reduction and Growth Operation" (October 2007) ・"Sihanoukville Port SEZ Development Project" (March,	

	2008） 【Grant Aid】 ・“The Project for Rehabilitation and Upgrading of Electricity Supply Facilities in Phnom Penh (1/2)” (1993) ・“The Project for Rehabilitation and Upgrading of Electricity Supply Facilities in Phnom Penh (2/2)” (1994) ・“The Project for Rehabilitation and Upgrading of Electricity Supply Facilities in Phnom Penh-Phase 2 (Detailed Design) (1998) ・“The Project for Rehabilitation and Upgrading of Electricity Supply Facilities in Phnom Penh-Phase 2 (1/3)” (1999) ・“The Project for Rehabilitation and Upgrading of Electricity Supply Facilities in Phnom Penh-Phase 2 (2/3)”(2000) ・“The Project for Rehabilitation and Upgrading of Electricity Supply Facilities in Phnom Penh-Phase 2 (3/3)” (2001) ・“The Project for the Upgrading and Extension of Electricity Supply Facilities in Phnom Penh” (November 2004) 【World Bank】 ・ Emergency Rehabilitation Project (1993) ・ Phnom Penh Power Rehabilitation Project (1995) ・ Rural Electrification and Transmission Project (2003) ・ Poverty Reduction and Growth Operation (PRGO)(2007 – 2009) ・ Special Rehabilitation Assistance Project (1992) ・ Power Rehabilitation Project (1994) ・ Provincial Power Supply Project (2000) ・ Greater Mekong Subregion Transmission Project (2003)

2. Outline of the Evaluation Study

2.1 External Evaluator

Masumi Shimamura, Mamiko Yano, Mitsubishi UFJ Research and Consulting Co., Ltd.

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.

Duration of the Study: September 2016 - September 2017

Duration of the Field Study: November 15-26, 2016, Feb 7-10, 2017

2.3 Constraints during the Evaluation Study

In conducting this ex-post evaluation, the following points became constraints.

Firstly, this project took seven years and three months (87 months) as the project period, during which the persons in charge were changed frequently in EDC and ADB. As a result, there were restrictions on the collection of information and data of this project, because personnel directly involved in the project were not already enrolled and the storage location of records was unknown. In particular, it was difficult to grasp the details of the financial information of this

project and the relationship between EDC self-financing part and total project cost. It was also difficult to grasp the details about the cause of the delay of construction works of the electricity distribution network.

Regarding operation and maintenance of this project, the EDC's Transmission Department operates and maintains this project and other power transmission projects conducted by EDC nationwide together without distinguishing each other. As a result, it was impossible to grasp expenses and budget of operation and maintenance, techniques of operation and maintenance, structure, and issues in regards only to this project.

Furthermore in Cambodia, development of economic indicators and statistics, national and regional statistical indicators and statistical data are not well developed, so that it is difficult to grasp especially the impact on revitalization of regional economy and poverty reduction.

For the above reasons, evaluation analysis was conducted based only on the obtained information.

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

3.1 Relevance (Rating: ③[4])

3.1.1 Consistency with the Development Plan of Cambodia

At the time of appraisal, the purpose of this project was in compliance with the national development strategy (*the Rectangular Strategy Phase I*, 2004) that regarded reconstruction and development of infrastructure as one of the most important policy tasks, and *the Power Sector Development Plan* (January 2005) that regarded enhancement of investment in power generation projects and power transmission projects and increase of electrification rates in rural areas as the basic policy. In addition, this project was based on *the Power Development Plan* (issued in January 2005, a plan for the construction of power plants until 2018) that regarded construction of fire power plants in the Sihanoukville port city and construction of small- and medium-size diesel power plants for base and peak in local cities as the basic policy.

At the time of the ex-post evaluation, the Royal Government of Cambodia established a *National Strategy Development Plan* (2014-2018), which embodies the national strategy, *the Rectangular Strategy Phase III* (2013-2018). One of the priority pillars is "infrastructure development: electric power development", and priority is given to expansion of electricity supply, realization of electric power access, and coordination of electric power between regions. In addition, the Royal Government of Cambodia emphasizes rural electrification, expansion of power supply, and promotion of construction, maintenance and expansion of transmission lines along with electricity import from neighbouring countries in *the Energy Sector Development Strategy* (2004-2020) and *the Transmission Line Development Plan* (2015-2025). Therefore,

[3] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[4] ③: High, ②: Fair, ①: Low

even at the time of the ex-post evaluation, the objective of this project is consistent with these policies and plans.

3.1.2 Consistency with the Development Needs of Cambodia

At the time of appraisal, the increase in demand for electricity in Cambodia as a whole due to economic growth was largely due to the increase in demand in the growth corridor areas (Phnom Penh and Sihanoukville), and this trend was considered to continue. In these areas, the textile industry, which was the driving force of the Cambodian economy, was densely populated, and from the viewpoint of population increase, the demand for electricity was expected to increase.

According to the actual statistical results (Tables 1) based on the response from EDC, in the Sihanoukville area, the maximum power demand at the time of appraisal was 7.40MW, whereas at the time of the ex-post evaluation, it increased by about 6 times to 44MW, which is 9% higher than that in 2015, and it is also increasing currently. Even in the Kampot area, the maximum electric power demand at the time of appraisal was 3MW, whereas at the time of the ex-post evaluation it increased by 6.7 times to 20MW, which is 18% increase compared to that in 2015, and it is also increasing currently. From these facts it can be said that investment demand for electric power supply facilities continues to exist at the time of the ex-post evaluation.

Table 1 Trend of Maximum Power Demand (Unit: MW)

FY	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Sihanoukville Area	5.35	5.70	7.40	8.60	9.50	10.17	13.40	16.40	18.50	24.80	29.50	40.20	44.00
Kampot Area	3	3	3	4.78	6	7.5	8	8.5	9	9.5	13	17	20

Source: Questionnaire Answer by EDC

At the time of appraisal, supply of imported electricity including that from Vietnam was necessary to meet increasing power demand in the future. Especially for Sihanoukville, the demand for electricity from the Sihanoukville Special Economic Zone which was under development was also expected, making it possible to supply inexpensive electricity from Vietnam by the construction of the transmission lines. Accordingly it was expected that investment would be promoted and cause additional power demand. Therefore, it was an urgent task to respond to future power demand in Sihanoukville and build a stable power supply system.

Also, 230kV transmission lines for importing electricity from Vietnam to Phnom Penh was operating from 2009, based on the bilateral power purchase agreement. The power purchase agreement with Thailand was revised in 2007, and electricity import was continuing. In addition,

in accordance with the agreement with Laos, a 22kV transmission line was completed in 2010 and electricity is being transmitted to Cambodia. In 2015, a 115kV transmission line was constructed to connect the substation in Champasak Province in southern Laos with Kampong Sralau of Preah Vihia province in Cambodia. According to the announcement by Electricity Authority of Cambodia (hereinafter, "EAC")[5], the amount of imported electricity has decreased by 25% compared to the previous year in 2016 and is expected to decrease in the future. However, this is because of increase of the amount of domestic electricity power generation and it does not indicate that the demand for electricity has decreased. From these facts, it can be seen that there is demand for investment in electric power supply facilities throughout Cambodia, including the targeted area by this project at the time of the ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

The Country Assistance Program (February 2002) for Cambodia cites "sustainable economic growth and realization of a stable society" as one of the priority areas of ODA, and it was to focus and support "promoting social and economic infrastructure development and the development of the environment for economic promotion." Regarding the power sector in particular, it regards that "the disparity between the capital and the rural areas in terms of the infrastructure of electricity and electric information communication etc. is remarkable, and from a long-term nationwide perspective, it planned to conduct technical and financial cooperation for policy planning and technical personnel training." The purpose of this project is consistent with this plan.

In JICA's *the Medium-Term Strategy for Overseas Economic Cooperation Operations* (April 2005), infrastructure development for vitalizing private economic activities in the growth corridor area is a priority area, and JICA was planning to promote collaboration with the Asian Development Bank (hereinafter, "ADB"), etc. This project implements power infrastructure development in the region with cooperative financing with ADB, so that this project is consistent with this policy.

According to JICA's *Country Assistance Strategy* (November 2004), constructing transmission lines, importing inexpensive electricity from neighbouring countries, and implementing electricity transmission to domestic bases are effective to overcoming the current situation that a high electricity charge is a hindrance to economic growth and poverty reduction. The objective of this project is also consistent with this policy.

3.1.4 Appropriateness of the Project Plan and Approach

As described later (3.2.2.2), various factors have overlapped with each other regarding the delay of this project and one of them was change of the scope of this project (change of the

[5] Electricity Authority of Cambodia

transmission line route and substation site). After the start of this project, EDC conducted resurvey and it became clear that necessity of construction of a substation in Veal Renh was not urgent, considering the power demand forecast in the Veal Renh area. Also construction of two coal-fired power plants by an independent power producer (hereinafter referred to as "IPP") was decided in Sihanoukville, so that it was expected that the power supply from coal-fired power plants to Sihanoukville would increase through the power transmission system developed by the project. Therefore when EDC conducted a feasibility study in 2010 to confirm the technology, financial and economic feasibility of the 115kV transmission system, it was reported that constructing a 115kV substation in Sihanoukville and transmission lines between the Stung Hav substation and the Sihanoukville substation have high economic efficiency. For this reason, considering power demand, etc., ADB, a co-financing institution of this project, approved EDC's plan of scope change that cancelled construction of the Veal Renh substation and constructed a 115kV substation in Sihanoukville. JICA agreed to add construction of 115kV transmission line from the Stung Hav substation to the Sihanoukville substation. Completion map of this project is as follows (Figure 3).

The scope change of this project occurred for the purpose of further increasing the supply of electricity to the Sihanoukville area. This purpose is consistent with the purpose of this project, "to improve the electrical power supply to the area and to address electrical demand of Sihanoukville." Based on this, the change of plan of this project was consistent with the purpose of this project and the decision was indispensable to develop and increase the project effect. Therefore the decision was considered as appropriate.

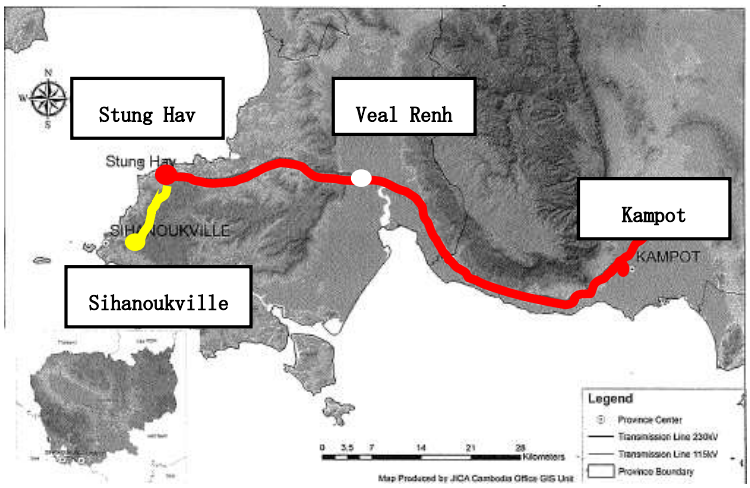

Figure 3 Location Map of this Project

Source: Documents provided by JICA

* Red is transmission lines and substations constructed in line with a plan at the time of appraisal. Yellow is transmission lines and a substation constructed

by additional scope.

* Described with reference to the plot of the Veal Renh station where construction was planned at the time of appraisal (withdrawn later) (white spot).

Based on the above, implementation of this project has been highly relevant to the country's development plan and development needs, as well as Japan's ODA policy. Therefore its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

Plan of outputs of this project at appraisal and actual project outputs at the ex-post evaluation are as Table 2.

Table 2 Planned and Actual Output of this Project

Plan	Actual
①Construction work (a) Construction of 230kV transmission line (Kampot – Sihanoukville (Stung Hav), about 78km, double-circuit) (JICA portion)	①Construction work (a) Construction of 230kV transmission line (Kampot – Stung Hav, 82km, double-circuit) (scope change), construction of 115kV transmission line (Sihanoukville city – Stung Hav[6], 12km, double-circuit)(additional scope) (JICA portion)
(b) Construction of new substations and addition of a substation (construction of new substations in Sihanoukville (Stung Hav) and Veal Renh and addition of a line bay at Kampot substation) (ADB portion)	(b) Construction of new substations and addition of a substation (new construction of the Sihanoukville 115/22kV substation (additional scope), new construction of the Stung Hav 230/22kV substation, addition of 115kV double-circuit line bay at the 230kV Stung Hav substation (additional portion), addition of 230kV double-circuit line bay at the Kampot substation) (ADB portion) *New construction of the Veal Renh substation was cancelled.
(c) Installment of medium and low voltage distribution system (22kV medium voltage line (about 60km), 400/220V distribution line (about 46km), bay line to surrounding households) (JICA portion)	(c) Installment of medium and low voltage distribution system in the area surrounding transmission line construction (22kV medium voltage line (40km) (230/22kV Stung Hav substation – Sihanoukville area), connection of

[6] Transmission line connecting a substation located in Stung Hav district, Sihanoukville state, and a substation located in Sihanoukville city.

	existing 22kV networks and 22kV feeder (Stung Hav substation – surrounding community) (additional scope), introduction of transformer (22kV/400V, 220V) (additional scope)) (JICA portion), 400/220V distribution line (about 46km). Actual output of bay line to surrounding households is not available (there is a possibility to be conducted by EDC's own fund)
②Consulting service(detailed design, bidding support, and implementation supervision) (ADB portion)	② Consulting service(detailed design, bidding support, and implementation supervision) (ADB portion)
③Capacity building for EDC (a) Capacity building of EDC for maintenance of underground distribution networks (JICA portion) (b) Training for the operation and maintenance of high voltage power transmission system (JICA portion) (c) Database system of EDC customers in Phnom Phem (ADB portion) (d) Training for EDC's staffs of environmental and social consideration (ADB portion)	③Capacity building for EDC (a) Not implemented (b) Training for the operation and maintenance of high voltage power transmission system (JICA portion) (c) Improvement of EDC data management system (procurement of hardware and software to establish connected data platform (including reliable backup system and improvement of communication system between headquarters and branches))(ADB portion) (d) Training for EDC's staffs on social, resettlement, and environmental affairs (dispatchment of 2 EDC staffs specialized in social and environment to master degree course) (ADB portion)

Source: Created based on JICA documents, questionnaire reply by EDC, and onsite interview

The project scope was changed as described in above (3.1.4), and construction of the Veal Renh substation that was scheduled at the time of appraisal was canceled and changed to construction of the Sihanoukville 115kV substation. Hence construction of a 115kV double circuit transmission line which connects the Sihanoukville substation and the Stung Hav substation was added to the scope (Figure 3)[7]. In addition, the construction of a medium- and low-voltage distribution network around the transmission line construction area (a 22kV intermediate-pressure line (40 km) from the Stung Hav substation to the Sihanoukville region) was carried out. Also connection of the existing 22kV network and a 22kV feeder line (the

[7] By this, substations between Kampot and Stung Hav were connected by 230kV transmission line, and substations between Stung Hav and Sihanoukville were connected by 115kV transmission line.

Stung Hav substation - neighboring communities) and adoption of transformer (22kV/400V, 220V) were added. EDC reports that EDC has connected the residential households living in the transmission line area with the electricity distribution network with its own funds. However, information to confirm whether such distribution network is equivalent to "400/220V distribution line (about 46 km) and the bay line to surrounding households" or not is not available. Relevance of the scope change is aforementioned (3.1.4), and the change of scope was considered as appropriate.

Details of the contents of the training program to EDC staffs were confirmed by the information of ADB which is the co-financing donor and in charge of the portion. According to the information, in addition to participation in training at the EDC training center, training was conducted in both Cambodia and abroad, including dispatching 14 staffs to Thailand and Vietnam. In addition, two EDC staffs obtained a master degree on resettlement and social environment in Thailand.

Improvement of the data management system was implemented as part of customer management and improvement of fee collecting capacity. Regarding the training of the underground distribution network, it was not carried out because construction of the underground distribution network originally planned at EDC was not carried out.

Figure 4 Data management system at EDC headquarters

Figure 5 Data management system at EDC headquarters (locked state)

Although the construction period of this project was extended, the consulting service period was not extended and ended in 2013 before completion of construction. For the consultant service input (M/M), international consultants of 40M/M and local consultants of 45M/M were assumed. However, the actual implementation increased to 69M/M for the international consultants and 64M/M for the local consultants (Table 3). It was because of an increase in design works and a delay in project implementation. This arises from the aforementioned

scope change of the project, and this change is regarded as appropriate, so that it can be said that an increase in M/M is inevitable.

Table 3 Comparison of the Plan and Actual Results of Consulting Service Input (Unit: M/M)

	Plan	Actual	Balance
International Consultant	40	69	29+
Local Consultant	45	64	19+
Total	85	133	48+

Source: Documents provided by JICA and ADB

3.2.2 Project Inputs

3.2.2.1 Project Cost

The total project cost of this project was 6,179 million yen (of which ODA loan was 2,632 million yen) as planned at the time of appraisal, whereas the actual total project cost was 6,100 million yen (of which ODA loan was 2,521 million yen) that fell within the plan (99% of the plan). Although there were cancellation of construction of the Veal Renh substation[8], addition of construction of the Sihanoukville 115kV substation and 115kV transmission lines (between Sihanoukville city and Stung Hav)[9], and increase of land acquisition cost[10], the actual total project cost fell within the plan due to the yen appreciation.

3.2.2.2 Project Period

The project period planned at the time of appraisal was 46 months, from March 2007 (the date of signing the loan agreement) to December 2010 (the start of business operation of transmission and substation facilities and distribution network). However, in fact, the project period was for 87 months from March 2007 (the signing date of the loan agreement) to May 2014 (the start of business operation of transmission and substation facilities and distribution network), which was significantly longer than planned (189% compared with the plan). As the project was delayed, the loan closing date has been extended. Table 4 shows the result of the project period at the time of appraisal and the ex-post evaluation[11].

[8] Decrease of 12.68 million dollars.
[9] Increase of 14.81 million dollars.
[10] Increase of 3.3 million dollars.
[11] As for the commencement of the project period, it was defined as the timing of "land acquisition/resident relocation" by EDC at the time of appraisal. However, actual "land acquisition/resident relocation" occurred in April 2009 after the date of signing the loan agreement. Therefore, in this ex-post evaluation, the date of signing the loan agreement is set as "project commencement".

Table 4 Plan and Actual Project Period

Item	Plan (at Appraisal)	Actual (at Ex-Post Evaluation)
1. Consulting Service	Feb.2007 – Dec.2010 (47 months)	Dec.2008 – Dec.2013 (61 months)
2. Capacity Building	May 2007 – Aug.2008 (16 months)	Dec.2008 – Dec.2009 (13 months)
3. Land Acquisition and Relocation	Nov.2006 – May 2010 (43 months)	April 2009 – beginning of 2014
4. Bid and Contract	Sep.2007 – Nov.2008 (15 months)	Dec.2009 – May 2012[12] (31 months)
5. Transmission Line Construction	Dec.2008 – Dec.2010 (25 months)	March 2011 – April 2014 (38 months)
6. Distribution System Construction	June 2009 to Dec.2010 (19 months)	March 2011 – April 2014 (38 months)

Source: Documents provided by JICA and a questionnaire reply from EDC

The delay of this project is a combination of various factors. Firstly, the selection of consultants was delayed, and contract with consultants was concluded in December 2008, which was a delay of 21 months. Procurement of the construction contractor[13] was also delayed because it took time for administrative procedures.

In addition, due to the scope change, construction of the Veal Renh substation was cancelled and construction of the Sihanoukville 115kV substation was added, so that the start of the procurement process of contractor was delayed, which became the main factor of the delay of the project. Additional work on the 115kV transmission line delayed the completion of the transmission line construction. In the construction of the Sihanoukville 115kV substation, it was found that the soil quality of the originally planned site was bad and it was necessary to change the location, so that selection of construction site was delayed and start of construction delayed for nine months.

In addition, land acquisition was delayed because negotiations with some residents prolonged about the amount of land acquisition compensation. It could not be confirmed about the reason for the delay in the construction of the electricity distribution network in Sihanoukville.

[12] ADB portion

[13] The construction work of this project (Table 2①) was implemented by turnkey contract (all orders from design to construction are accepted and the subject matters are delivered in a state where it can deliver in a fully operational state).

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

At the time of the ex-post evaluation, the financial internal rate of return (FIRR) and the economic internal rate of return (EIRR) were recalculated, FIRR increased to 22.2% versus 13.6% at appraisal. Table 5 shows cost, benefits, and project life premise of the FIRR. The main factor that increased FIRR from the time of appraisal is that after the project was completed, the cost of electricity import decreased due to the increase in domestic electricity supply. Although recalculation of EIRR was attempted, recalculation was not possible because it was difficult to estimate detailed costs and benefits due to lack of accurate data.

Table 5 Premise of FIRR

Item	Appraisal	Ex-post evaluation
Cost	Project cost, operation and maintenance cost	Project cost, operation and maintenance cost
Benefit	Revenue from electricity sales	Revenue from electricity sales
Project life	30 years	30 years

From the above, although the project cost was within the plan, the project period significantly exceeded the plan. Therefore, efficiency of the project is fair.

3.3 Effectiveness (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

Table 6 shows the targets and results of the operation and effect indicators of this project. Availability Factor on 2014, 2015, and 2016 could not be obtained. Regarding the electrification rate in Kampot, the target value of both 75% in town area and 35% in rural area were exceeded, over the period from completion of the project to 2016, two years after the completion of the project. In Sihanoukville also, over the past 3 years both town and rural areas exceeded the target value of 75% in town areas and 35% in rural areas. Regarding rate of distribution loss, Kampot achieved the target value of less than 12% in the past three years. Sihanoukville also achieved the target value of less than 12% until 2016, two years after the completion of the project. In general, the operation and effect indicators were achieved except for availability factor.

In order to measure the effect of this project in the target area of this project, the trends in the maximum power demand, the receiving end electricity amount, and the amount of electricity sold in Sihanoukville and Kampot region before and after completion of this project were collected as reference indices. Maximum power demand in 2016 is 44MW for Sihanoukville and 20MW for Kampot as shown in Table 1 above, which are higher than before. The amount of

receiving end electricity[14] is 240,303,979kWh in 2016 in Sihanoukville, though it is difficult to compare because information on other years could not be obtained. For Kampot no answer was obtained. The amount of electricity sold in 2016 was 19,356,087kWh /month for Sihanoukville, 8,849,973kWh/month for Kampot, though information on other years was not obtained. However the total amount of electricity sold in EDC as a whole became six times larger from 2006 to 2014, so that an increase in electricity supply was observed. The collection rate for electricity fee is maintained at 100% in any region.

Table 6 Operation and Effect Indicators[15]

	Baseline	Target	Actual		
	2004	2012	2014	2015	2016
	Baseline year	2 years after completion	Year of completion	1 year after completion	2 years after completion
Availability Factor (%)	-	Less than 100%	-	-	-
Electrification Ratio (%) (Kampot)	Town area: 50% Rural area: 8%	Town area: 75% Rural area: 35%	Town area: 85% Town area: 50%	Town area: 95% Rural area: 65%	Town area 100% Rural area 80%
Electrification Ratio (%) (Sihanoukville)	Town area: 60% Rural area: 13%	Town area: 75% Rural area: 35%	Town area: 80% Rural area: 62%	Town area: 87% Rural area: 74%	Town area 95% Rural area 86%
Distribution Loss (%)	Kampot 35% Sihanoukville 13%	Kampot 12% Sihanoukville 12%	Kampot 6.24% Sihanoukville 3.72%	Kampot 4.07% Sihanoukville 4.04%	Kampot 4.72% Sihanoukville 3.34%

Source: Documents provided by JICA and EDC

3.3.2 Qualitative Effects (Other Effects)

At the time of appraisal, as the qualitative effect of this project, stable supply of electricity to the Sihanoukville area and along the main transmission line was expected to be realized.

According to the EDC Sihanoukville branch and the Kampot branch, after completion of this project, electricity supply amount increased in the Sihanoukville area and demand was satisfied. Blackouts which lasted from a half day to whole day before completion of this project now lasts for a short period of about 13 minutes per one time. In the Kampot area, prior to completion of this project, it relied on imported electricity from Vietnam, whereas after completion of this project, the electricity supply improved and the construction of distribution line advanced. There

[14] The amount of electric power received by the target transformer during a year.
[15] Availability Factor: maximum load (MW) / {equipment rated capacity (MVA) × power factor}
Electrification ratio: number of electrified households × 100 / Number of households
Distribution loss: distribution loss (kWh) × 100 / Electricity transmitted (kWh) (Applied to supply work)

were frequent blackouts before, but now the power supply is stable 24 hours. As described above, by completion of this project, it was recognized that the increase in power supply available for 24 hours, and the reduction of blackouts are achieved in each target area, and the stability of power supply in these areas has improved significantly.

According to an interview to a coal-fired power station, the Cambodian Energy Limited (hereinafter, “CEL”) in Sihanoukville which is a beneficiary of this project, the Sihanoukville Special Economic Zone (hereinafter referred to as "SEZ"), the Sihanoukville Port SEZ, and local electric utilities in the Prey Nob region[16] (hereinafter, "REE[17]"), two coal-fired power plants were constructed in Sihanoukville and the capacity of power supply has increased drastically. This project enabled the power supply to Sihanoukville, Kampot and Phnom Penh, contributing to stable power supply in each region. CEL operates a coal-fired power plant since December 2013, and it says that it is impossible to operate the power plant without construction of a 115kV substation by this project. CEL has a capacity of 100MW (50MW×2 units) as of 2016, and expects a sharp rise in electricity demand in the Sihanoukville region in the future. Therefore it plans to expand the capacity per unit from 100 to 150MW in the future. The other coal-fired power plant by the Cambodia International Investment Development Group (CIIDG) supplies electric power with an installation capacity of 270MW (135MW × 2 units). Likewise, completion of this project enabled sufficient power supply to Sihanoukville.

According to the Sihanoukville SEZ[18], it previously used diesel private power generation. However, after completion of this project it is receiving direct supply from EDC. Although blackout was also frequent and long, now it became rare and shorter, so that it states that the increase in electricity supply and stable use became possible. According to REE, in the Prey Nob region, diesel power generation was used before completion of this project. Power usage was limited at 8 hours per day and power outages occurred frequently. Used by 1,200 households, electricity consumption per household was 10kWh. After completion of this project, it became possible to use electricity for 24 hours, there was little power interruption, and the supply became stable. Electricity came to be used by 3000 households and the consumption per household increased to 50kWh.

In light of the comprehensive consideration of this project, it can be said that the power supply has increased and the stable use has been drastically increased for commercial businesses and households in the Sihanoukville and Kampot regions, as a result of completion of this project.

[16] Located between Sihanoukville and Kampot.
[17] Rural Electricity Enterprises
[18] 105 companies invested as of November 2016.

3.4 Impacts

3.4.1 Quantitative Impacts

As an impact of this project, it was supposed that the activation of the regional economy was promoted by the stable supply of electrification and electric power, contributing to the increase in the number of offices and employees. Therefore, it was attempted to obtain statistical data (data on economic activity such as number of registered offices, employees, frequency of outage at each office, etc.) in the Sihanoukville area and the area along transmission lines of this project. However, available data is limited to the 2011 Economic Census and the 2014 mid-year economic survey, and it was difficult to objectively evaluate the promotion of regional economic vitalization. With regard to the number of economically active population and the unemployed, only the data of the 2008 census was obtained, so that it was impossible to evaluate the trend.

3.4.2 Qualitative Impacts

Through on-site interviews, the projects contribution to vitalizing economic activities such as industry and agricultural development, to improving living standards and to job creation in the Sihanoukville region and the area along the transmission line of this project was analysed and reviewed. Particularly in the Sihanoukville SEZ, which was invested by Chinese companies, the production cost was reduced, and the productivity, the number of tenant enterprises, and employment increased. Hence this project seems to contribute to the SEZ to a certain extent. Also in Kampot area, along with the increase in electricity supply, productivity of various plants improved, employment increased, and use of electric appliances by small and medium enterprises became possible and their productivity improved. In addition, regarding this project as a prerequisite, CEL is engaged in a coal-fired thermal power generation project, and employment of CEL is increasing along with the implementation of their project. In the Prey Nob region, REE reported that improvement of electric power supply by this project, enabled use of machinery for production and processing, which brought about various benefit to agriculture, small and medium-sized enterprises, livestock rearing, etc. Also it reports that use of televisions, air conditioners, and cooking appliances, etc. by residents has increased and the living conditions have also improved. It can be said that this project is contributing to the improvement of living standard.

From the above, it is evaluated that this project contributes to vitalization of economic activities such as industry and agricultural development in the target area, improvement of standard of living, and creation of employment.

3.4.3 Other Positive and Negative Impacts

3.4.3.1 Impacts on the Natural Environment

Land to be used for this project was selected in consideration of the environment, neither the center of the Bokor National Park which has a significant impact on the environment, nor residential area was selected,and used the peripheral area[19] in the Bokor National Park where short forest grows and where the land is close to the railroad. This project tried to minimize impact on natural environment such as ecology of wild animals.

Regarding environmental impacts, mitigation measures were presented at the Initial Environmental Survey (IEE[20]) implemented in 2006, and the Design and Construction Contractor (DCC) was selected as the implementing entity. Also, in 2009 the Detailed Environment Management Plan was prepared for this project, and as a negative potential impact that can occur in the land and the surrounding environment, tree loss, crops and environmental destruction, impact on wild animals, atmospheric quality, soil erosion, water quality and soil contamination, noise, health and safety, were confirmed, and mitigation measures against them were presented. During construction, environmental monitoring was conducted by the Korea Electric Power Corporation (KEPCO), a project implementation consultant. Reporting was made to ADB and JICA once every three months. According to EDC and ADB, these mitigation measures were fully implemented. After the commencement of operation, EDC hires external NGOs and conducts monitoring.

As a result of environmental monitoring, no particular problem has been reported. Even by the site visit, evidence of negative influence was not observed.

3.4.3.2 Land Acquisition and Resettlement

Ultimately the number of affected people is 445 households. 12 households became subjects of resettlement and they resettled upon received the payment of compensation (arrangement was done by the residents themselves). There is no change with the plan at the time of appraisal. 887,000 square meters of land were acquired and the affected building was reported to be 1,658 square meters. Relocation of residents and land acquisition have been all completed.

Certain laws concerning land acquisition for the government's public works are not enacted in Cambodia, and the government's Inter-ministerial Resettlement Committee is responsible for rights protection, price valuation, and determination of compensation amount. Real estate acquisition is decided ad hoc for each project by government decision.

In implementing this project, in compliance with *the ADB's Policy on Involuntary Resettlement* (hereinafter "ADB Policy") in 1995, EDC created a 2006 re-settlement framework and conducted land acquisition and resettlement in accordance with the framework. The framework provides guarantee for due process of procedures concerning land acquisition and resettlement, and has heavily protected the households affected.

[19] Even within the national park premises, the peripheral part can be used by the country and residents.
[20] Initial Environment Examination

There were no problems found in appropriateness of procedures of land acquisition and resettlement, such as composition of the land acquisition committee, holding a public hearing, negotiation with residents, calculation of compensation amount. According to EDC Environmental Society Resettlement Department, prior explanation and consultation on the land acquisition were done adequately at public hearing. Although it took time to negotiate with the 4 households about the compensation amount, EDC persuaded the residents with sufficient consultation, and finally agreed with them. From the above, no particular problem was found in the land acquisition and resettlement procedure of this project. In addition, regarding complaints from residents, it can be evaluated that appropriate response was taken by attempting setting up of a focal point and quick response.

Compensation provided to the residents who were subject to land acquisition exceeded reacquisition cost, so that it is considered that the compensation satisfied right value.

According to an interview to EDC, regarding gender consideration, public hearing was arranged for both sexes to participate and they heard opinion equally. Female head households, disabled persons, senior households over the age of 60 were provided compensation with 150 dollars more. As mentioned above, in this project women and men were treated equally in land acquisition and resettlement, single mothers, senior or disable households were given more compensation, employment opportunities were given gender equally, etc., so that this project considered gender and socially vulnerable groups as expected. People who were relocated have moved to another region, such as foreign country or Phnom Penh, so that direct interviews to local residents were impossible.

3.4.3.3 Other Positive and Negative Impact

(1) Decline of electricity tariff

In EDC, the method of setting electricity tariff is different between the area connected to the National Grid (115kV or more transmission line) and the independent system area. In the latter, the electricity tariff is set based on the generation cost of the small scale power plant in the independent system and it becomes higher than the former. It can be thought that as this project made the Sihanoukville and Kampot regions connected to the National Grid, electricity tariff have declined.

Through interviewing to the large consumers etc. in Kampot and Sihanoukville, it was confirmed that after the completion of this project, the electricity tariff became lower in this area. For example, the Sihanoukville SEZ paid $0.1675/kWh as electricity charge to EDC before completion of this project, whereas it decreased to $0.142/kWh as of 2016[21]. The electricity charge of the Prey Nob REE was 2500 riel/kWh[22] before completion of this project, whereas it

[21] The consistency with Table 11 cannot be confirmed.
[22] About 0.618 dollar/kWh（as of April 2017）

decreased to 800 riel/kWh[23] as of 2016.

(2) Poverty Reduction

The area where the distribution network is to be constructed by this project includes rural areas and poor areas, and improvement of the living environment of the local residents by electrification was expected. As mentioned above, this project brought about employment creation, wage increase and improvement of living environment in the target area, whereas, no direct data showing quantitative effect on poverty reduction in this project area was obtained so that it was impossible to evaluate the degree of contribution of this project to poverty reduction.

(3) Benefit to Phnom Penh

This project was aimed at bringing benefits directly to Sihanoukville and Kampot regions. Since the construction of the coal-fired power plants (two plants) in Sihanoukville by IPP was decided unexpectedly after the project began, the EDC implemented a feasibility study and changed the scope of this project. Hence, as a result of this project and the completion of two coal-fired power plants, the power supply to Sihanoukville increased, and in addition to that, 100MW could be supplied to Phnom Penh through the power system between Sihanoukville, Kampot and Phnom Penh. Electricity imports declined by 20% and, according to EDC, it is possible to supply 400MW to Phnom Penh in 2017. In this way, indirectly through the completion of this project Phnom Penh has received large benefits, and the impact beyond the expectation of this project occurred.

Therefore, this project has achieved its objectives. Therefore effectiveness and impact of the project are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

Regarding the personnel composition of EDC officials, highly educated engineers and technical workers are increasing year by year, and human resources of an appropriate level are secured for the operation and maintenance of this project. The transmission department is in charge of the operation and maintenance of this project. The number of power transmission lines handled by EDC is increasing year by year, and whenever a new transmission line is established, the transmission department newly hires and increases the number of staffs[24]. As shown in Table

[23] About 0.197 dollar/kWh（as of April 2017）

[24] The EDC's Transmission Department is responsible for EDC's operation and management of transmission lines across whole Cambodia, and staffs of the Transmission Department are assigned throughout Cambodia. For this reason, the staffs in charge of operation and maintenance of the transmission lines in Sihanoukville and Kampot belong to the Transmission Department of EDC headquarters. On the other hand, the EDC Sihanoukville branch is in charge of operation and maintenance of distribution lines of this project.

7, the number of personnel at each substation was supplemented after completion of this project, and the total number of staffs of the transmission department as of February 2017 was 517, which is said to be enough to carry out appropriate maintenance and management of this project.

Table 7 The Number of Employees of Transmission Department Allocated at Each Substation

	2014 (new staffs)	2015 (new staffs)	2016 (new staffs)	Staffs total (as of Feb.2017)
Sihanoukville Substation	6	-	4	15
Stung Hav Substation	9	-	3	14
Kampot Substation	8	-	2	24

Source: EDC document

Through JICA technical cooperation "Project for Improvement of Transmission System Operation Maintenance" (2013-2015), *the Maintenances Rule for National Transmission Line* was created[25] and applied to maintenance and operation of transmission lines from 2014. The EDC is supposed to make annual patrol plan, and it is said that the monthly patrol plan should also be made based on the plan. The rule also describes the flow of communication between the EDC headquarter and the local workers, and troubles are dealt with in accordance with the flow written in the rule. It is said that the transmission department swiftly copes with the contact from the site through a hot line or a call center and it seems that there is no problem in the process up to the decision making. Therefore, there seems no problem in implementation of monitoring.

The EDC Sihanoukville branch, which is responsible for the operation and maintenance of distribution lines, has 129 staff in 2016 and is responsible for two substations (the Sihanoukville substation and the Stung Hav substation) and five sections (power generation, distribution, control, administration, projects). The personnel on operation and maintenance of distribution lines was sufficient and no particular problem was seen. The number of staffs of the Kampot branch of EDC was 96 in 2016. Although information on the composition was not available, personnel for operation and maintenance was fully sufficient and no problem was seen about the number of staffs.

From the above, there are no major concerns about the institutional aspects of operation and maintenance.

[25] The project also created the rule of operation and maintenance for substations.

3.5.2 Technical Aspects of Operation and Maintenance

During project implementation, training on EDC officials was conducted in Thailand and Vietnam for maintenance of 230kV transmission line, and 14 staff members of the transmission department participated and learned an appropriate maintenance method, a repair method of tower insulator, and how to maintain weekly and monthly maintenance schedule. The trainees are still working at the transmission department, and it is considered to be effective for operation and maintenance of this project. In addition, the above-mentioned *the Maintenances Rule for National Transmission Line* exhaustively prescribes maintenance plan, type of patrol, inspection plan, implementation process, check items, recording method, repair plan, work process, recording method, evaluation, safety measures for operation and maintenance. The EDC's transmission department is implementing operation and maintenance based on this rule, so that the rule contributes to the improvement of the operation and maintenance capacity of EDC staffs. A subsequent project of the technical cooperation project is scheduled in the future, and further guidance for maintenance of 230kV is planned. These are expected to contribute to further strengthening capacity of EDC staffs on operation and maintenance of 230 kV.

EDC has a training center at the EDC headquarters for in-house training, and lectures on general transmission lines and accidents are held there (however, there is no guidance specialized for operation and maintenance of 230kV). New employees of the transmission department and staffs of the same department are occasionally trained when necessary. EDC also offers training through OJT, which also contributes to operation and maintenance of 230 kV.

The EDC Sihanoukville branch is working on training on indices such as SAIFI[26] and SAIDI[27] by a NGO to improve the maintenance capacity for distribution lines. The average annual power outage per customer in 2017 is 0.05 and the average power outage was 20.4 hours. Other technical problems in terms of technology have not been reported.

Despite the fact that no information was obtained on the technology of operation and maintenance at substations, EDC established the above-mentioned training center for all officials, and substation staffs are also able to attend. Therefore, it can be said that the basic training system is established. Also, staffs of the EDC transmission department assigned at substations are also responsible for operation and maintenance of the substations, so that there are no particular concerns regarding their technology. From the above, there seem no particular problems with the technology of operation and maintenance of this project.

[26] SAIFI (System Average Interruption Frequency Index)＝the number of blackout of customers/the number of customers.

[27] SAIDI (System Average Interruption Duration Index)＝total hours of blackout in a year/ the number of customers

3.5.3 Financial Aspects of Operation and Maintenance

In terms of the electricity charge collection system, a data management system has been introduced as a capacity building of this project and it promoted power data backup saving, improvement of mailing system for electricity charge collection and customer service. These allow for more efficient implementation of electricity charge collection.

According to EDC's income statement (Table 8), balance of income and expenditure is surplus every year. Especially in 2015, after the completion of this project, the operating profit increased by about 86 million riel, and no problem was seen in the balance of income situation.

Table 8 EDC Income Statement (Unit: 1000 riel)

	2013	2014	2015
Electricity sales	2,624,680,302	2,958,274,445	3,763,629,241
Connection service fees	35,025,778	39,544,709	34,298,112
Other income	13,809,934	15,392,163	15,722,090
Total Revenue	2,673,516,014	3,013,211,317	3,813,649,443
Purchased power	1,952,554,348	2,243,866,492	2,820,985,078
Fuel costs	38,791,976	29,471,785	6,927,267
Import duty	45,632,751	33,963,181	29,065,630
Salaries and other benefits	101,371,233	125,726,983	153,172,713
Other operating expenses	65,578,646	77,844,015	214,287,293
Depreciation	68,947,387	72,081,334	82,468,483
Amortisation	75,593	157,261	195,512
Operating profit	400,564,080	430,100,266	506,547,467
Net finance costs	13,439,986	49,513,604	39,682,849
Profit before income tax	**387,124,094**	**380,586,662**	**466,864,618**
Income tax expense	83,800,621	78,915,691	98,108,272
Net profit for the year	303,323,473	301,670,971	368,756,346

Source: EDC document

The EDC's balance sheet is as follows (Table 9). The capital adequacy ratio is 40.8% in 2013, 44.6% in 2014, 43.3% in 2015. Each year exceeds 40% and is in favourable condition. With respect to the current ratio, it is 182% in 2013, 303% in 2014, 233% in 2015. Each year exceeds 100% and there seems no problem in payment reserve.

Table 9 EDC Statement of Financial Position (Unit: 1000 riel)

	2013	2014	2015
Assets	3,663,318,285	4,035,797,345	5,079,911,859
Non-current assets	2,170,475,034	2,408,775,320	3,253,874,460
Current assets	1,492,843,251	1,627,022,025	1,826,037,399
Liabilities and equity	3,663,318,285	4,035,797,345	5,079,911,859
Equity	1,495,525,491	1,801,029,804	2,199,916,150
Non-current liabilities	1,348,485,403	1,697,826,071	2,098,802,105
Current liabilities	819,307,391	536,941,470	781,193,604

Source: EDC document

Regarding the trends in maintenance-related budgets and actual allocation since the completion of this project and the start of the operation, as EDC conducts maintenance and management in a centralized manner without distinguishing between this project and other projects, data specific to this project are not available. However, as for the EDC Sihanoukville branch, the budget tends to increase, the annual spending performance is within the budget range, and problems such as insufficient funds cannot be seen in maintenance management. Therefore it seems that the budget necessary for maintenance of transmission lines of EDC including this project is accumulated (Table 10). The budget and performance of the Kampot branch cannot be confirmed.

Table 10 Budget and Actual Allocation for Maintenance and Operation of EDC (Unit: million riel)

	2014		2015		2016	
	Budget	Actual	Budget	Actual	Budget	Actual
Sihanoukville branch	100,316	97,072	143,958	121,594	156,989	140,528

Source: EDC document

According to the future forecast of the Cambodian electricity tariff system obtained through the field survey (Table 11), the electricity tariff for industrial and commercial customers and resident customers are expected to decline from 2015 to 2020. However, according to EDC, as large amount of electricity charges collected from all Cambodia, there is no direct impact on the allocation of the maintenance cost for this project.

Therefore, although some matters could not be reviewed, no particular problem was found in regard to the financial affairs of operation and maintenance.

Table 11 Trend of Electricity Tariff and Subsidies

1. For Industrial and Commercial Customers									
Type	Unit	2005	2010	2015	2016	2017	2018	2019	2020
Purchase directly from feeder MV in GS[28]	USD/kWh	-	0.1225	0.129	0.126				
Purchase from Phnom Penh and Kandal system	USD/kWh	0.149 -0.165	0.179 -0.229	0.177	0.172	0.1675	0.165	0.163	0.162
Purchase from provincial grid and EDC's subtransmission	USD/kWh	0.135 -0.185	0.170 -0.200	0.1725	0.1675	0.165	0.164		

[28] Grid Substation

2. For Residential Customers									
Coverage Area	Unit	2005	2010	2015	2016	2017	2018	2019	2020
Coverage area by EDC	Riel/kWh	720 -1220	820 -1220	820 -920	780	770	750	740	730
Coverage area by licensees (REE)	Riel/kWh	1800 -3000	2400 -3700	1000 -1100	800	790	770	760	750
3. Subsidy Tariff for Poor People and Agriculture Purpose									
Type	Unit	2005	2010	2015	2016	2017	2018	2019	2020
For households use below 50 kWh/month in Phnom Penh and Kandal System	Riel/kWh	-	-	610	610	610	610	610	610
For households use below 10 kWh/month in the provinces which connect to the National Grid	Riel/kWh	-	-	-	480	474	462	456	450
For pumping in agriculture sector use from 21:00 -7:00	Riel/kWh	-	-	-	480	474	462	456	450
For household use below 50 kWh/month in the provinces which connect to the National Grid	Riel/kWh	-	-	-	-	610	610	610	610

Source: EDC document

*Answers were not available on from which year the estimated figures are.

3.5.4 Current Status of Operation and Maintenance

As a result of inspection on the site of this project, the transmission lines, substations, distribution networks and various facilities and equipment were adequately managed and no particular problem was found. Operation and maintenance are carried out at an appropriate frequency in accordance with the above-mentioned *the Maintenances Rule for National Transmission Line*. Check items and work processes are also being implemented in accordance with the new rule, and the system to cope with troubles when they occur is also in place. As a result of on-site inspection, the system is properly installed, kept in a tightly locked, antimicrobial closed room (Figures 4 and 5), and operation and maintenance are properly conducted.

As a problem of operation and maintenance, there is damage to power supply caused by such as poor soil in the rainy season and fear of lightning. In the dry season EDC is taking countermeasures

such as cutting trees, paving roads, and attaching overhead ground wires. In addition, occasional problems such as a car colliding to a steel tower due to an accident, a kite played by a child being entangled with transmission lines occur. However each time technical staffs have resolved within 10 to 15 minutes from occurrence of problems, and the rate of occurrence of troubles was 1 to 1.5% in 2016.[29] According to the IT staff of the Sihanoukville substation, there was a rare issue of the power outage in whole Cambodia as a result of power failure due to the EDC headquarters control system in Phnom Penh. However, now the Stung Hav substation is in place, so that it became possible to supply electric power independently from coal-fired power plants and the problem of such blackouts in the Sihanoukville area was solved by 95%.

KEPCO conducted a survey and banned the use of land within 50m from steel towers by a contract. However, it was reported that the soil around steel towers within 50m is of good quality and sometimes residents excavate and remove soil for use of road construction etc. without permission. When EDC patrol discovered such case, it reports to landowners and local governments (villages or provinces) and asks for guidance to cope with the case.

Regarding the purchase of spare parts, the EDC Transmission Department sets up a spare parts procurement plan for one year from September to August not only for this project but also for all projects by EDC. In the case of parts that cannot be procured domestically, it is necessary to import from other countries. However, in other countries the model used by EDC is often not sold anymore. In that case EDC needs to order production of the spare parts, and it may take time from 4 months to 1 year before acquisition

Regarding distribution lines, although the EDC Sihanoukville branch had been in charge of operation and maintenance of distribution lines up to 22kV, from 2016 it is in charge of operation and maintenance of distribution lines up to 35kV. There are problems such as collision of cars to utility poles, removing of soil around utility poles, cutting and taking out electric wires, etc. Until 2016, when problems occurred, staffs of the EDC Sihanoukville branch headed for repair far from Sihanoukville city, so that it took three hours (2 hours for round trip from the city and 1 hour for repair) to settle the issue. However, automatic detection system was introduced and when problems such as cable disconnection occur, staffs who live in Sihanoukville city can receive alert directly from the system, so that it becomes possible to solve the problem by handset operation within 5 to 15 minutes. It was said that time was saved and it did not become a big problem.

As a result, concerning the operation and maintenance status, although there are some concerns about procurement of spare parts, no particular problem was found.

No major problems have been observed in the institutional, technical, financial aspects and current status of the operation and maintenance system. Therefore sustainability of effects occurred by this project is high.

[29] Calculated by the time spent for solving problems per year.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project constructed and upgraded 230kV double-circuit power transmission lines and related facilities in the aims to strengthen the electricity supply capacity of the southern Cambodia, Kampot-Sihanoukville region, to respond to the demand for electricity of Sihanoukville and to improve the electrification rate along the area surrounding the transmission lines. This project was in line with development policy including Cambodia's energy/electricity policy, development needs, Japan’s ODA policy, in terms of increasing investment in power generation and transmission business and improving electrification rate in rural areas. As such, the relevance of the project is high although the project cost fell within the plan, the project period greatly exceeded the plan, so that the efficiency is fair. For operation and effect indicators set at the time of appraisal, both electrification rate and distribution loss rate achieved the targets. By this project, it is evaluated that electric power supply has increased significantly in the target area and stable power supply has been realized. Through interviews with large consumers, increase in employment and the number of factories and offices and improvement of productivity, income and living environment are confirmed. Based on the above, the project has achieved its objectives, so that the effectiveness and impact of the project are high. Regarding the operation and maintenance of this project, there are no particular problems with respect to systematic and technical aspects. Regarding the financial aspect, according to the financial data of EDC, the operation and maintenance cost of the transmission lines and substations is properly supplied. Transmission lines and substations are well operated and maintained, and even when problems arise, they are being handled appropriately and quickly. Therefore, the sustainability of the effect expressed by this project is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Promotion of Project Effect through Collaboration between Soft Component of Financial Cooperation and Technical Cooperation

In this project, in addition to cooperation on the hard side as construction of transmission

lines and substations, cooperation on the soft side as capacity building has been comprehensively implemented, and it can be said that the effect of this project has been enhanced in total. Acquisition of Master's degree by EDC staffs at the Asian Institute of Technology (Thailand) strengthened EDC's capacity on social and environmental consideration.

In addition, the operation and maintenance of this project follows *the Maintenances Rule for National Transmission Line* set by JICA's technical cooperation project as mentioned above. This covers comprehensively the procedures, methods, systems, check items, etc. concerning the operation and maintenance of the transmission lines and substations. The stringent compliance with this regulation by EDC contributed to the situation in which no particular problems occurred in the operation and maintenance of this project. Thus, during the term of project formulation and implementation, it is desirable for an executing agency and JICA to conduct supports on the sides of both hard and soft under loan cooperation in collaborating with a technical cooperation project, when appropriate, to increase effects of both projects.

End

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs	①Construction work (a) Construction of 230kV transmission line (Kampot – Sihanoukville (Stung Hav), about 78km, double-circuit) (JICA portion)	①Construction work (a) Construction of 230kV transmission line (Kamport – Stung Hav, 82km, double-circuit) (scope change), construction of 115kV transmission line (Sihanoukville city – Stung Hav, 12km, double-circuit)(additional scope) (JICA portion)
	(b) Construction of new substations and addition of a substation (construction of new substations in Sihanoukville (Stung Hav) and Veal Renh and addition of a line bay at Kampot substation) (ADB portion)	(b) Construction of new substations and addition of a substation (new construction of Sihanoukville 115/22kV substation (additional scope), new construction of Stung Hav 230/22kV, addition of 115kV double-circuit line bay at 230kV Stung Hav substation (additional portion), addition of 230kV double-circuit line bay at Kampot substation) (ADB portion) *New construction of Veal Renh substation was cancelled.
	(c) Installment of medium and low voltage distribution system (22kV medium voltage line (about 60km), 400/220V distribution line (about 46km), bay line to surrounding households) (JICA portion)	(c) Installment of medium and low voltage distribution system in the area surrounding transmission line construction (22kV medium voltage line (40km) (230/22kV Stung Hav substation – Sihanoukville area), connection of existing 22kV networks and 22kV feeder (Stung Hav substation – surrounding community) (additional scope), introduction of transformer (22kV/400V, 220V) (additional scope)) (JICA portion), 400/220V distribution line (about 46km). Actual output of bay line to surrounding households is not available (there is a possibility to be conducted by EDC's own fund)
	② Consulting service (detailed design, bidding support, and implementation supervision) (ADB portion)	②Consulting service (detailed design, bidding support, and implementation supervision) (ADB portion)
	③ Capacity building for EDC (a) Capacity building of EDC for maintenance of underground distribution networks (JICA portion)	③Capacity building for EDC (a) not implemented

	(b) Training for the operation and maintenance of high voltage power transmission system (JICA portion) (c) Database system of EDC customers in Phnom Phem (ADB portion) (d) Training for EDC's staffs of environment and social consideration (ADB portion)	(b) Training for the operation and maintenance of high voltage power transmission system (JICA portion) (c) Improvement of EDC data management system (procurement of hardware and software to establish connected data platform (including reliable backup system and improvement of communication system between a headquarter and branches))(ADB portion) (d) Training for EDC's staffs on social, resettlement, and environmental affairs (dispatchment of 2 EDC staffs specialized in social and environment to master degree course) (ADB portion)
2. Project Period	March 2007 – December 2010 (46 months)	March 2007 – May 2014 (87 months)
3. Project Cost Amount Paid in Foreign Currency	N/A	N/A
Amount Paid in Local Currency	N/A	N/A
Total	6,179 million yen	6,100 million yen
ODA Loan Portion	2,632 million yen	2,521 million yen
Exchange Rate	1 US dollar = 118 yen 1 riel = 0.029 yen (As of April 2006)	1 US dollar = 95.70 yen (Average between 2007 and 2014)
4. Final Disbursement	December 2014	