

Country Name	<b>Project for Improvement of Transmission System Operation and Maintenance</b>
Kingdom of Cambodia	

**I. Project Outline**

Background	<p>Along with Cambodia's rapid economic growth, the peak power demand (MW) and the power consumption (GWh) rapidly increased by more than 20% on a yearly average for the period from 2003 and 2010. In order to respond to the situation, establishment of a stable power supply system was an urgent issue. Under the situation, the National Control Center (NCC) was established for appropriate power system operation to supply stably power with high quality. In addition, while a number of network facilities including transmission lines and substations were under construction, there was a shortage of skillful and experienced technical staff on operation and maintenance (O&amp;M) of the newly installed network facilities. Therefore, it was necessary to further strengthen the technical capacity of Electricité du Cambodge (EDC) staff for O&amp;M of the network facilities.</p>				
Objectives of the Project	<p>Through formulation and practice of rules on O&amp;M for transmission line and substation facilities within EDC, trainings of trainers for the Institute of Electrical Science (IES) staff, implementation of On-the-Job Training (OJT) on patrol, inspection and operational safety, the project aimed at stable supply of electrical power in Phnom Penh bulk power system, and thereby contributing to stable supply of electrical power in the Phnom Penh power grid.</p> <ol style="list-style-type: none"> <li>Overall Goal: Electrical power is stably supplied in Phnom Penh power grid<sup>1</sup>.</li> <li>Project Purpose: Electrical power is stably supplied in Phnom Penh bulk power system<sup>2</sup>.</li> </ol>				
Activities of the Project	<ol style="list-style-type: none"> <li>Project Site: Phnom Penh bulk power area (Phnom Penh Special Economic Zone, Kandal Province, Takeo Province, Kampong Speu Province, Sihanoukville Special Economic Zone)</li> <li>Main Activities: 1) Formulation and practice of rules on O&amp;M for transmission line (TL) and substation (SS), 2) Trainings of trainers of IES, 3) OJTs on patrol, inspection, operational safety, etc.</li> <li>Inputs (to carry out above activities) <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>Japanese Side</p> <ol style="list-style-type: none"> <li>Experts: 16 persons</li> <li>Training in the third country: 10 persons (Vietnam and Thailand) and 26 persons (Thailand)</li> <li>Equipment: Circuit breaker, earthing device, hydraulic compression machine, compression dice, etc.</li> <li>Local expenses: cost for project activities</li> </ol> </td> <td style="width: 50%; vertical-align: top;"> <p>Cambodian Side</p> <ol style="list-style-type: none"> <li>Staff allocated: 35 persons</li> <li>Land and facilities: project office in EDC headquarter and NCC, installation places for the training tower and for transmission line, storage for the provided equipment</li> <li>Local expenses: cost for dissolved gas analysis and a license of Power System Simulation for Engineering software</li> </ol> </td> </tr> </table> </li> </ol>			<p>Japanese Side</p> <ol style="list-style-type: none"> <li>Experts: 16 persons</li> <li>Training in the third country: 10 persons (Vietnam and Thailand) and 26 persons (Thailand)</li> <li>Equipment: Circuit breaker, earthing device, hydraulic compression machine, compression dice, etc.</li> <li>Local expenses: cost for project activities</li> </ol>	<p>Cambodian Side</p> <ol style="list-style-type: none"> <li>Staff allocated: 35 persons</li> <li>Land and facilities: project office in EDC headquarter and NCC, installation places for the training tower and for transmission line, storage for the provided equipment</li> <li>Local expenses: cost for dissolved gas analysis and a license of Power System Simulation for Engineering software</li> </ol>
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Project Period	January 2013 – September 2015	Project Cost	(ex-ante) 280 million yen, (actual) 318 million yen		
Implementing Agency	Electricité du Cambodge (EDC)				
Cooperation Agency in Japan	Chugoku Electric Power Co., Inc. Tokyo Electric Power Service Co., Ltd.				

**II. Result of the Evaluation**

<b>1 Relevance</b>
<p>&lt;Consistency with the Development Policy of Cambodia at the Time of Ex-Ante Evaluation and Project Completion&gt;</p> <p>The project was consistent with Cambodia's development policies of "The National Strategic Development Plan" (2009-2013) and (2014-2018) emphasizing the capacity development and institutional reform of EDC, in order to improve electricity supply and management efficiency.</p> <p>&lt;Consistency with the Development Needs of Cambodia at the Time of Ex-Ante Evaluation and Project Completion &gt;</p> <p>The project was consistent with Cambodia's development needs of capacity development of EDC's technical staff for O&amp;M of newly installed network facilities for the stable power supply.</p> <p>&lt;Consistency with Japan's ODA Policy at the Time of Ex-Ante Evaluation&gt;</p> <p>The project was consistent with "The Country Assistance Program for Cambodia" (2002) raising "promotion of development of socioeconomic infrastructure and environmental improvement for economic promotion" as one of the priority areas.</p> <p>&lt;Evaluation Result&gt;</p> <p>In light of the above, the relevance of the project is high.</p>
<b>2 Effectiveness/Impact</b>
<p>&lt;Status of Achievement of the Project Purpose at the time of Project Completion&gt;</p> <p>The Project Purpose was achieved by the time of project completion. Power outage caused by serious accidents or troubles at TL and SS did not occur during the project (Indicator 1). Also, as a result of the analysis of power outage fault data conducted by the project team, it was reasonably indicated that the duration and frequency of the power outage could have been reduced if proper patrol/inspection and review of relay setting have prevented errors and troubles of the power facilities (Indicator 2).</p> <p>&lt;Continuation Status of Project Effects at the time of Ex-post Evaluation&gt;</p>

<sup>1</sup> Phnom Penh power grid is a power system extracting only Phnom Penh from a nationwide power grid called the Cambodia Transmission System (CTS).

<sup>2</sup> Phnom Penh bulk power system is a power system connecting only Phnom Penh.

The Project Effects have been partially continued since the project completion. There have been some serious accidents or troubles in CTS. As for TL, all of accidents have been caused by external factors, such as hits against electricity pylons by wild elephants, touches by objects to conductors. As for SS, a serious accident (blackout, power outage in the whole power system) occurred due to electrical equipment errors at the Grid Station (GS) 4 in June 2017. Also, the duration and frequency of the power outage in CTS have increased in parallel with the introduction of many new SS and TL in CTS and the more interconnection among GSs across the country.

The patrol and inspection of TL and SS complying with the standards and rules, which were introduced by the project, came to be undertaken and still have been safely practiced for TL every five years and SS once a year. Additionally, staff of NCC, the Transmission Unit and the Relay Protection Office have been able to safely operate power system and control facilities with good quality and to make an outage plan to keep the balance of demand and supply. It is considered that these activities have contributed to preventing the occurrence of more serious accidents or troubles in CTS as well as attaining the Overall Goal.

<Status of Achievement for Overall Goal at the time of Ex-post Evaluation>

The Overall Goal has been partially achieved by the time of ex-post evaluation. According to the data on SAIDI and SAIFI in Phnom Penh power grid, SAIDI reduced from 19.9 minutes in 2015 to 15.4 minutes in 2018 and SAIFI also did from 1487.7 times in 2015 to 1246.1 times in 2018. Although the reason for this reduction could be partially due to external factors such as a relative decline brought by an increase in the electricity demand, it is considered that the above-mentioned activities introduced by the project had contributed to the Overall Goal.

<Other Impacts at the time of Ex-post Evaluation>

No other positive or negative impacts of the project were confirmed at the time of ex-post evaluation.

<Evaluation Result>

Therefore, the effectiveness/impact of the project is fair.

#### Achievement of Project Purpose and Overall Goal

Aim	Indicators	Results																																																																																															
(Project Purpose) Electrical power is stably supplied in Phnom Penh bulk power system.	1. Serious accidents or troubles at TL and SS do not occur.  Note: Serious accidents and troubles mean fire on transformer or cut of conductors.	Status of the Achievement: achieved (partially continued) (Project Completion) <ul style="list-style-type: none"> <li>Power outage caused by serious accidents and troubles did not occur at TL and SS during the project.</li> </ul> (Ex-post Evaluation) <ul style="list-style-type: none"> <li>TL: The electricity pylons were collapsed by wild elephants' hit in March 2016. Other accidents happened due to damage of equipment by lightning, cut of conductors by trucks and cranes as well as non-EDC worker, heavy rain and strong wind, equipment error, ground faults by contacts of objects, such as kites, branches, and cranes.</li> <li>SS: In June 2017, a blackout occurred due to electrical equipment error at GS4. Transformers in GS5 and GS7 was fired due to lightnings in January and October 2018, respectively.</li> </ul>																																																																																															
	2. The duration and the frequency of power outage are reduced.  Note: Since the causes of power outage vary and include issues such as balance of power demand and supply, JICA expert will review the detailed causes and judge whether this goal is filled.	Status of the Achievement: achieved (not continued) (Project Completion) <ul style="list-style-type: none"> <li>It was anticipated that if proper patrol/inspection and review of relay setting prevented errors and troubles, the duration and frequency of the power outage could have been reduced.</li> </ul> [Frequency of Power Outage in Phnom Penh bulk power system (Unit: Times)] <table border="1"> <thead> <tr> <th rowspan="2">Causes of Power Outage</th> <th colspan="3">Actual</th> <th colspan="3">Estimation</th> </tr> <tr> <th>2013</th> <th>2014</th> <th>2015</th> <th>2013</th> <th>2014</th> <th>2015</th> </tr> </thead> <tbody> <tr> <td>Contact of substances (tree or something)</td> <td>7</td> <td>8</td> <td>3</td> <td>6</td> <td>4</td> <td>2</td> </tr> <tr> <td>Maintenance</td> <td>-</td> <td>3</td> <td>0</td> <td>-</td> <td>2</td> <td>0</td> </tr> <tr> <td>Others</td> <td>8</td> <td>6</td> <td>3</td> <td>6</td> <td>5</td> <td>1</td> </tr> <tr> <td>Lightning</td> <td>2</td> <td>4</td> <td>2</td> <td>2</td> <td>4</td> <td>2</td> </tr> <tr> <td><b>Total</b></td> <td><b>17</b></td> <td><b>21</b></td> <td><b>8</b></td> <td><b>14</b></td> <td><b>15</b></td> <td><b>5</b></td> </tr> </tbody> </table> [Duration of Power Outage in Phnom Penh bulk power system (Unit: Minutes)] <table border="1"> <thead> <tr> <th rowspan="2">Causes of Power Outage</th> <th colspan="3">Actual</th> <th colspan="3">Estimation</th> </tr> <tr> <th>2013</th> <th>2014</th> <th>2015</th> <th>2013</th> <th>2014</th> <th>2015</th> </tr> </thead> <tbody> <tr> <td>Contact of substances (tree or something)</td> <td>241</td> <td>410</td> <td>122</td> <td>196</td> <td>134</td> <td>11</td> </tr> <tr> <td>Maintenance</td> <td>-</td> <td>332</td> <td>0</td> <td>-</td> <td>199</td> <td>0</td> </tr> <tr> <td>Others</td> <td>222</td> <td>344</td> <td>131</td> <td>108</td> <td>326</td> <td>9</td> </tr> <tr> <td>Lightning</td> <td>90</td> <td>154</td> <td>36</td> <td>90</td> <td>154</td> <td>36</td> </tr> <tr> <td><b>Total</b></td> <td><b>553</b></td> <td><b>1,240</b></td> <td><b>289</b></td> <td><b>394</b></td> <td><b>813</b></td> <td><b>56</b></td> </tr> </tbody> </table> (Ex-post Evaluation) <ul style="list-style-type: none"> <li>Both the duration and frequency of power outage has increased since the</li> </ul>	Causes of Power Outage	Actual			Estimation			2013	2014	2015	2013	2014	2015	Contact of substances (tree or something)	7	8	3	6	4	2	Maintenance	-	3	0	-	2	0	Others	8	6	3	6	5	1	Lightning	2	4	2	2	4	2	<b>Total</b>	<b>17</b>	<b>21</b>	<b>8</b>	<b>14</b>	<b>15</b>	<b>5</b>	Causes of Power Outage	Actual			Estimation			2013	2014	2015	2013	2014	2015	Contact of substances (tree or something)	241	410	122	196	134	11	Maintenance	-	332	0	-	199	0	Others	222	344	131	108	326	9	Lightning	90	154	36	90	154	36	<b>Total</b>	<b>553</b>	<b>1,240</b>	<b>289</b>	<b>394</b>	<b>813</b>
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(Overall Goal) Electrical power is stably supplied in Phnom Penh power grid.	<p>1. System Average Interruption Duration Index (SAIDI) in Phnom Penh power grid.</p> <p>2. System Average Interruption Frequency Index (SAIFI) in Phnom Penh power grid.</p>	<p>(Ex-post Evaluation) partially achieved</p> <ul style="list-style-type: none"> <li>Both SAIDI and SAIFI decreased to some extent when comparing them in 2015 to in 2018.</li> </ul> <p>[Current Situation of supplying Electrical Power]</p> <table border="1"> <thead> <tr> <th></th> <th>2015</th> <th>2016</th> <th>2017</th> <th>2018</th> </tr> </thead> <tbody> <tr> <td>SAIDI (minute)</td> <td>19.9</td> <td>18.7</td> <td>13.1</td> <td>15.4</td> </tr> <tr> <td>SAIFI (time)</td> <td>1,487.7</td> <td>1,370.5</td> <td>1,091.9</td> <td>1,246.1</td> </tr> </tbody> </table>		2015	2016	2017	2018	SAIDI (minute)	19.9	18.7	13.1	15.4	SAIFI (time)	1,487.7	1,370.5	1,091.9	1,246.1
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Source : Terminal Evaluation Report, Data provided by EDC, Questionnaire and Interview with EDC

### 3 Efficiency

Although the project period was within the plan (ratio against the plan: 100%), the project cost exceeded the plan (ratio against the plan: 114%). The outputs were produced as planned. Therefore, the efficiency of the project is fair.

### 4 Sustainability

#### <Policy Aspect>

“The National Strategic Development Plan” (2019-2023) promotes the stable electricity supply in Cambodia through increased public spending on strengthening and expansion of physical infrastructures including electricity. Since EDC is a sole licensee for operating the transmission network of CTS, enhancement of EDC’s technical and management capacity for stable power supply has been backed up by the national policy.

#### <Institutional Aspect>

##### [O&M of the Transmission System]

There has not been any major change in the institutional structure for the transmission system targeted by the project. EDC, especially Transmission Department, takes responsibilities for O&M of the transmission system. Transmission Department consists of NCC, Transmission Unit and Relay Protection Office, and moreover, under Transmission Unit, two divisions (SS Operation and Maintenance Division and TL Patrol and Maintenance Division) are placed.

NCC plays a role in issuing operation orders and has 51 staff members. NCC reported that they perform their role without major problems. Therefore, the number of the staff members is considered sufficient.

The Transmission Unit takes responsibilities for O&M of TL and SS. The TL Patrol and Maintenance Division is responsible for inspection, maintenance and repair of TL with 28 technicians and the Patrol Teams are responsible for patrol of TL with 65 technicians. The SS Operation and Maintenance Division is responsible for inspection, maintenance and repair of SS with 35 technicians. The Operation Team is responsible for operation of 14 SS with 182 technicians. According to the Transmission Department, in terms of the number of maintenance staff, including the Patrol Team, the expansion of the transmission networks with more power supply facilities will require more staff in the future.

Relay Protection Office is in charge of foundation of relay protection, and 21 staff members are allocated. According to the Office, as many TL and SS will open, the number of the staff members is insufficient. To cover the insufficiency, in 2020, 11 new staff members will be recruited.

##### [Training of Trainers]

Training of Trainers have been provided by the Transmission Department and IES. They have fostered a certain number of certified trainers every year since the project completion (2 to 6 trainers in a year for TL and SS, 2 to 4 for relay protection, and 9 for NCC).

#### <Technical Aspect>

The staffs of NCC, the Transmission Unit and Relay Protection Office have sustained the necessary knowledge and skills for O&M of the transmission system. NCC regularly receives trainings from French Development Agency (Agence francaise de developpement: AFD). Transmission Unit conducts a transfer of knowledge and know-how among its staffs on a daily basis. Relay Protection Office has an internal training system for its staffs. Furthermore, under the Phase II of this project, some trainings are provided to improve the specific skills on relay protection, power system analysis (a skill for using PSS/E software), TL, SS, etc.

All of the standards, rules and working procedures formulated by the project are practiced every day, for they are recognized important for improving work efficiency and safety. However, except for Standard and Rule Protection Transmission Line and Busbar 115kv-230kv, they have not been reviewed. The reasons vary from the postpone of review to the unnecessary of review to the lack of staff.

#### <Financial Aspect>

The O&M budget for the transmission network, including TL and SS, has been allocated annually on the request basis by the Transmission Department. A certain amount of budget for the O&M has been allocated to the Transmission Department since the project completion (15.9 billion Riel in the fiscal year of 2016, 8.1 billion Riel in 2017, 6.4 billion Riel in 2018, 24 billion Riel (plan) in 2019). According to the Transmission Department, although the budget has never been sufficient, they comprehend the necessity of securing the budget, and the budget is expected to be continuously secured to some extent.

<Evaluation Result>

Therefore, as there have been some problems from the institutional aspect, the sustainability of the effects through the project is fair.

5 Summary of the Evaluation

The project achieved the Project Purpose but partially achieved the Overall Goal to stably supply electrical power in Phnom Penh power grid. In terms of the sustainability, there is a concern about a shortage of human resources for maintenance of the expanding transmission network. As for the efficiency, the project cost exceeded the plan.

Considering all of the above points, the project is evaluated to be partially satisfactory.

**III. Recommendations & Lessons Learned**

Recommendations for Implementing Agency:

- Staff of EDC have implemented the O&M of the transmission network as the project expected. However, due to lack of capacities and numbers of staff, the Transmission Department and Relay Protection Office sometimes do not fully perform their responsibilities. Therefore, EDC should strengthen the capacity of their staff by reviewing the rules, standards and working procedure formed by the project more frequently and recruit more qualified staffs and train them by former trainees of the project in order to cope with an unexpected demand of staff. Additionally, as the budget of EDC has not been sufficient even at the time of ex-post evaluation, EDC should reserve a budget for improving the lack of human resources.

Lessons Learned for JICA:

- It can be clearly seen that at the time of the project completion, the project totally achieved the project purpose, but after the project completion, the overall goal of the project is partially achieved. It means that the project is not sustainable in the long-term period. Therefore, future projects should consider more on sustainability of the project by encouraging an implementing agency to make a long-term plan after the projection completion.



Training Tower at IES



Transmission Line Maintenance Technical Competition Game held under the Phase II Project at IES in 2019