Islamic Republic of Pakistan

FY 2015 Ex-Post Evaluation of Japanese ODA Loan

"Load Dispatch System Upgrade Project"

External Evaluator: Hisae Takahashi, Octavia Japan, Co., Ltd.

0. Summary

This project was conducted to make the power network[1] more efficient and reliable by modernizing and upgrading the load dispatch system[2] and the related facilities in Pakistan. It is consistent with the development policy of Pakistan, which has focused on power sector reform that contributed to economic growth, and the country's needs to develop an efficient and reliable power network both at the time of appraisal and ex-post evaluation. It is also consistent with the Japanese policy of assistance to Pakistan as of the appraisal. Hence the relevance of this project is high. Though the project cost was within the plan, the project period significantly exceeded the plan for various reasons, such as the delay in the bidding and contract process, the characteristics of the project whereby the new equipment was installed while continuing the operation of existing facilities and equipment, issues of the implementing structure, worsened security and natural disasters, etc. Thus, the efficiency of the project is fair. Thanks to the project, the number of faulty communication reports from load dispatch systems, average restoration time from transmission line failures and the transmission loss rate were reduced, which meant the reliability and stability of the power network were improved. Since impacts such as cost reduction due to efficient power system operation as well as improvement of transparency in the power system were also confirmed, the effectiveness and impact of the project are high. On the other hand, minor issues in National Transmission and Dispatch Company (NTDC)[3], the institution in charge of maintenance, remain in terms of institutional and technical aspects and the current O&M condition. Accordingly, the sustainability of the project effect is fair.

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

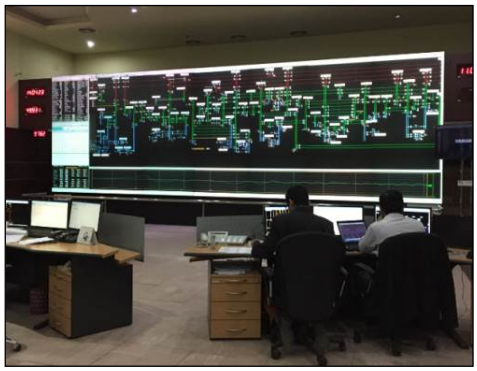
[1] It is a general term expressing an inclusive system from generation to consumption of power, namely organic links of all factors from power plants to transmission lines, substations, distribution lines and then reaching users.

[2] The system supplies stable power to avoid affecting the frequency and voltage by adjusting the power generation depending on the seasons, climatic conditions and time. The system is also tasked with minimizing the scope and time of power failure, particularly caused by thunder, etc., by monitoring and controlling substations and power plants.

[3] NTDC is the only system operator in Pakistan. It receives wheeling charges from the Central Power Purchasing Agency Guarantee Limited. (CPPA) and plays the role of conveyancing power to a transmission and distribution network of local power distribution companies through their power grid system. NTDC has also conducted projects to develop transmission facilities as power resource development by power generation companies has progressed.

1. Project Description

Project location



Power control system display

1.1 Background

In Pakistan which has focused on accelerating economic growth and reducing poverty, power demand[4] has soared alongside rising economic growth. Accordingly, the government addressed the efficient combination of a mass thermal power generation centered on Independent Power Producer (IPP) and the hydroelectric power generation of an inexpensive unit price while executing power sector reform. Also, most of the thermal power generation plants are mainly located in central and southern areas, as opposed to hydroelectric power generation sites in northern Pakistan, which requires efficient and stable operation via mostly a 500/220 kV power grid system. NTDC manages and operates the 500/220 kV power grid system and the national power generation facility, and the National Power Control Center[5] (NPCC) of NTDC plays the main role of operation for power control system. NPCC started its operation in 1990 and had a load dispatch system with a remote monitoring function. However, amid rapid technological innovation, power system expansion and the emergence of IPP, the implementation of stable and smooth power system operation was disrupted, both functionally and in terms of capacity. With this in mind, the project replaced a NPCC data processing system, newly installed remote terminal units (RTUs) in power stations and substations and developed a telecommunication system for efficient and stable power system operation in Pakistan.

1.2 Project Outline

The objective of this project is to make the NTDC power network more efficient and reliable by modernizing and upgrading the load dispatch system of NPCC and related facilities, thereby contributing to the socioeconomic development of Pakistan.

[4] The annual average power demand grew by 4% and over during the periods from 1998 through 2003. (Source: documents provided by JICA)

[5] NPCC is a department of NTDC and based on data from each power plant, they monitor the whole power system and conduct demand control and connection works.

Loan Approved Amount/ Disbursed Amount	3,839 million yen / 3,123 million yen	
Exchange of Notes Date/ Loan Agreement Signing Date	August, 2005 / August, 2005	
Terms and Conditions	Interest Rate Repayment Period (Grace Period) Conditions for Procurement:	1.3% 30 year (10 year) General Untied
Borrower / Executing Agency	The President of the Islamic Republic of Pakistan / National Transmission and Dispatch Company Limited (NTDC)	
Final Disbursement Date	February, 2013	
Main Contractor (Over 1 billion yen)	Alstom Grid Sas (France) / Viscas Corporation (Japan) / Areva T&D (Pakistan) (JV)	
Main Consultant (Over 100 million yen)	-	
Feasibility Studies, etc.	"Feasibility Study" WAPDA, 1994 "Feasibility Study (Review) " NTDC, 2002	
Related Projects	(Technical Assistance) "The Project for Improvement of Training Capacity on Grid System Operation and Maintenance" (2011 – 2014) (ODA Loan) "Dadu-Khuzdar Transmission System Project" (December, 2006) "Punjab Transmission Lines and Grid Stations Project" (I) (May, 2008) "National Transmission Lines and Grid Stations Strengthening" (March, 2010) (World Bank) "Power Sector Reform" (2014-2016)	

2. Outline of the Evaluation Study

2.1 External Evaluator

Hisae Takahashi, Octavia Japan, Co., Ltd.

2.2 Duration of Evaluation Study

This ex-post evaluation was conducted with the following schedule:

Duration of the Study: September, 2015 – January, 2017

Duration of the Field Study: January 10 – January 22, 2016, July 17 – July 22, 2016

2.3 Constraints during the Evaluation Study

Taking over certificate (TOC) for procured equipment was issued by executing agency on September 2014. Besides, the project outputs were largely produced as planned and have also generated an effect as noted below. However, the project remained incomplete at the time of the

ex-post evaluation for the following reasons: 1) Three out of all RTUs installed had not been connected to Supervisory Control and Data Acquisition (SCADA) and not yet operated. Part of the telecommunication system has not been effectively operated due to technical issues. 2) Based on the punch list (a list with which the contractor confirms and resolves troubles affecting equipment or telecommunication system), any troubles including the above, are being followed up by the contractor. Accordingly, mandatory reliability run test which should be conducted after responding the punch list, has not been completed and the defect liability period remains valid. 3) Based on the appraisal documents, the completion date is defined as the end of the defect liability period. Under such circumstances, having observed project output even though the project is yet to complete by definition, the impact, normally confirmed as the medium and long term effects after project completion, was analyzed taking effects across the ages and intended impacts into consideration, though in definition the project is taken as incomplete.

3. Results of the Evaluation (Overall Rating: B[6])

3.1 Relevance (Rating: ③[7])

3.1.1 Relevance to the Development Plan of Pakistan

"Ten Year Perspective Development Plan" (2001 – 2010), a development policy at the time of appraisal, showed the power sector developing strategy, particularly focusing on developing and upgrading the power grid and reducing system losses. In concrete terms, the investment plan for new facilities and equipment also included developing a power grid striving to expand the equipment capacity and reduce transmission/distribution loss[8].

"Vision 2025" (2014), a mid- to long term development plan at the time of the ex-post evaluation, set out to become an upper-middle income country by 2025 and showed seven pillars in key development areas to support growth and development. Key areas included "energy, food and water security", reflecting the objectives to supply stable and reliable power, increase access to power, lower the power unit price by reducing the distribution loss rate, increasing the energy self-sufficiency rate and promoting efficient power demand management, etc. Furthermore, the "National Power Policy", which was formulated in 2013, emphasized improving power demand-supply gaps, lowering unit price for generating power and reducing the transmission and distribution loss rate and so on by 2017.

As noted above, from the time of appraisal through to the time of ex-post evaluation, the development policy and plan in Pakistan have emphasized securing and improving a stable energy supply by developing and upgrading the power grid and by reducing the transmission and distribution loss rate. The project was intended to ensure the efficiency and stability of

[6] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[7] ③: High, ②: Fair, ①: Low
[8] Source: document provided by JICA

power system operation in Pakistan. Accordingly, the project has been relevant to the development plan for Pakistan at the both time of appraisal and ex-post evaluation.

3.1.2 Relevance to the Development Needs of Pakistan

At the time of appraisal, the country addressed issues of how to efficiently combine mass thermal power generation and hydroelectric power generation of an inexpensive unit price to respond a rapid increase in power demand with the economic growth. However, thermal power generation plants are mostly located in central and southern areas, whereas hydroelectric power generation sites are located in northern Pakistan, which requires the 500/220 kV power grid system to operate effectively and reliably. Also the NPCC, which mainly controls the 500/220 kV power grid system and power plants, is prone to frequent telecommunication and equipment failures due to system deterioration, which disrupt stable and smooth power system operation. Accordingly, fundamental modernization and improvement of related facilities were urgently necessary[9].

The capacity of power plants and power demand in Pakistan have increased, even since the appraisal, and the maximum demand/power plant capacity rate peaked at 97% at the time of the ex-post evaluation, meaning the increase of actual capacity to meet the demand would be needed (See Table 1). Moreover, at the time of the ex-post evaluation, power interchange between central and southern areas and northern area continued, requiring not only sufficient power capacities but also system operation for a prompt response to system failure to ensure a stable power supply in Pakistan. Accordingly, the needs to upgrade the load dispatch system with a remote monitoring function for the transmission system, install RTU and upgrade the telecommunication system implemented in this project were confirmed.

Table 1 Peak Demand and Installed Capacity of Power Generation in Pakistan

	2004	2011	2012	2013	2014	2015
Peak Demand (MW)	11,078	18,860	18,940	18,827	21,017	22,083
Installed Capacity (MW)	15,819	20,986	20,499	20,850	22,753	22,745
Peak demand / Installed Capacity (%)	70	90	92	90	92	97

Source: documents provided by NPCC

3.1.3 Relevance to Japan's ODA Policy

Japan's "Country Assistance Program for Pakistan" (February, 2005) emphasized "development of a healthy market economy" as one of the priority areas and underlined the importance of "upgrading and developing economic infrastructure to support the revitalization of the healthy market economy and poverty reduction". JICA's "Country Assistance Strategy for Pakistan" (March, 2005) stressed that economic development was contingent on ensuring a

[9] Source: documents provided by JICA

reliable power supply, both qualitatively and quantitatively and indicated its positive support for the power sector. In addition, developing the transmission system was also underlined as a priority area for assistance, given the critical role of the public sector in the power sector. JICA's "Medium–Term Strategy for Overseas Economic Cooperation Operations" (April, 2005) also designated the development of a healthy market economy as a priority area for support in Pakistan. Furthermore, as a project targeting efficient and reliable power system operation for contributing the social and economic development in Pakistan, its consistency with Japan's priority assistance area in Pakistan is confirmed.

3.1.4 Relevance to Appropriateness of Project Planning and Approach

In the project, NPCC, one of the NTDC departments, almost solely played the role as Project Implementing Unit (PIU). The equipment procured in the project widely includes RTU, telecommunication systems, a telephone network and a central processing system including SCADA, etc. While the NPCC only oversees operation and maintenance (O&M) for the central processing system, O&M for RTU, telecommunication system and telephone network is under the responsibility of the NTDC telecommunication department. Since the NPCC staff lack technical knowledge and experiences of RTU and telecommunication system, cooperation with the NTDC telecommunication department was necessary to procure and install equipment. However the involvement of telecommunication department was limited in the project even at the stage of installing equipment. This hindered the smooth project implementation and was one of the factors delaying it, as described in "3.2.2.2 Project Period".

Issues of implementing structure for smooth project activities remain, given the situation including the lack of scrutiny concerning demarcation of the responsibilities and roles among related departments for equipment at the planning stage. However, the project has been highly relevant to the country's development plan and development needs, as well as Japan's ODA policy. Accordingly, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

Table 2 shows the project outputs (planned and actual). While the actual output was basically as planned, the number of installed RTUs increased considerably from the planned. The major output changes and reasons are as follows:

Table 2 Major Planned and Actual Outputs

Item	Plan	Actual
Installment of central processing system	・Power control system ・ Hardware (Servers, Workstation, Local area network, etc.) ・Data processing system	・As planned ・As planned ・ Limited market operation (Sub function) was deleted from scope of work.
Installment of RTU	9 stations in total (1 power station, 8 substations)	49 stations in total (16 power stations, 33 substations)
Upgrade of telecommunication system	・10 terminal stations ・35 repeater stations (Replacement of communications network between NPCC data processing system and RTU)	As planned
Telephone network	Replacement of existing old network of NTDC	As planned
Development of regional control center	・Telephone network connection with NPCC ・Paint on mimic boards	・As planned ・Paint on mimic boards was deleted from scope as it will not affect the function.
Others	・53 accommodation for engineers and staff of NPCC ・4 vehicles	As planned
Consulting services	Preparation of bidding documents, bidding support, construction supervision, reporting project status (self-funded by NTDC)	Services contents were as planned.[10]

Source: documents provided by JICA and NPCC

Major output changes and reasons:

【Central processing system】

Change: Limited market operation (sub-function) was deleted from the project scope[11]

Reason: The function was a sub-function related to market pricing at the time of power trade. However, this function was decided to be taken by the Central Power Purchasing Agency (CPPA), as a CPPA project, separately. As CPPA oversaw this function, this decision was considered reasonable.

【New installation of RTU】

Change: The number of RTUs installed was increased from 9 stations to 49[12]

[10] The initial contract with the designated consulting company was terminated as planned on April 2008. Along with the extension of the project period, the consulting services also had to be continued. However, given inadequate consulting performance at the bidding preparation stage and the improvement could not be expected, thus the initial contract was not renewed and another consulting company was selected for the remainder of the services.

[11] Source: documents provided by JICA

[12] Source: documents provided by JICA

Reason: At the time of appraisal, the plan was to install new RTUs in 9 power station/substations, while the existing RTUs were to be utilized in the remaining station/substations. However, via the detailed survey results for installing equipment (2008), the consultant found that the old and new RTUs were incompatible and the old RTUs were insufficient as a means of securing proper spare capacity for data which is expected to increase in the future. In case RTUs were incompatible, the data recorded at each station may not be transferred to central processing system properly. Furthermore, if the back-up capacity was not sufficient, it was assumed to be difficult to collect and transfer the data which would be soon increased. It means that the understating the real time situation of each facility and power network would be highly disturbed. Therefore, needs to change the specification of the existing RTUs was raised. Meanwhile, the costs of upgrading the existing RTU far exceeded those of installing new RTUs. With efficiency in mind, the project decided to increase the number of new RTUs installed. This change was made by the executing agency, NTDC, following discussion with consultants and JICA experts concerning the functions, compatibilities and efficiencies of both existing and new RTUs. Based on a request from NTDC, JICA officially approved this output change. Thus this change is considered as reasonable for generating the effectiveness of the project.

RTU installed
(Rawat substation)

Telecommunication system installed
(Substation in Islamabad University)

3.2.2 Project Inputs

3.2.2.1 Project Cost

The actual total project cost was 5,343 million yen (3,513 million yen from Japanese ODA loan) while the planned cost was 5,720 million yen (3,839 million yen from Japanese ODA loan), meaning the total project cost was lower than the planned figure (93% of the original plan). Although the number of RTUs newly installed significantly increased, the major

reasons for remaining within the budget were exchange rate fluctuations[13], tax exemptions on the procured equipment and unused contingency funds[14].

3.2.2.2 Project Period

The project period planned at the time of appraisal was 42 months, August 2005 through January 2009 and the actual period was 126 months, August 2005 through January 2016[15]; far longer than planned (300% of the planned period). Although it should be considered that RTU actual output increased significantly compared to the planned level (544% of the plan), for major outputs other than RTU, there were no significant changes and the ratio of planned to actual value for the project period of each output except RTUs significantly increased compared to the equivalent ratio for outputs (Table 3). Also the "selecting consultants" and the "bidding and contract process" periods before installing RTUs took longer than planned. The major reasons behind this delay were as below. Of the reasons, "Disasters and securities" were external factors; unpredictable as well as inevitable. Furthermore, other external factors such as exceeding planned cost, caused by inflation and fluctuation of the exchange rate, and the changes of the scope also affected the delay of the project. On the other hand, for each factor other than "Disasters and securities", it could be possible for taking measures by carefully assessing the risks which may cause the delay of the project in the survey at the planning stage.

Table 3: The Ratio of Actual to Plan for Outputs and Project Periods

	Output ratio to plan	Ratio of project period to plan
Data processing system	100%	333%
RTU	544%	333%
Telecommunication system	100%	425%
Telephone network	100%	255%
Average ratio to plan	211%	337%

Source: prepared based on the documents provided by JICA and NPCC

Note: The project period is defined from the time of L/A signing to the end of the defect liability period. Table 3 calculated the average ratio to plan of the project period based on each item.

[13] 1 Pakistani rupee (Rs.) was 1.75 yen at the time of appraisal and the average rate between loan periods was Rs.1＝1.35 yen. Furthermore, the procurement and installation of equipment has been continued even after the loan disbursement period. According to the executing agency, the average exchange rate from the commencement of procurement (March, 2010) to the completion of the installation (September 2014) was about Rs.1=0.94 yen.

[14] Based on NPCC response to the questionnaire

[15] The project period is defined from the time of L/A signing (project commencement) to the end of the defect liability period (project completion). However, as noted in "2.3 Constraints during the Evaluation Study", the project remained incomplete at the time of the ex-post evaluation. Therefore, the time of project completion was set as the implementation month of field visit at the ex-post evaluation.

Major reasons of the project delay:

【Delay in bidding】

The bidding took for over four years, although the original plan was to complete it less than a year. NPCC as a PIU and its consultants did not get used to the bidding process for Japanese ODA loans and took a certain period of time for reviewing documents by executing agency, which meant more time than assumed was required for preparation and review of the bidding documents.

【External factors of disasters and securities】

Massive floods occurred twice in Pakistan during the project implementation. Across the Khyber Pakhtunkhwa, Punjab and Sindh Provinces were damaged by flooding in July 2010 and major roads were shut down, which also meant project activities had to be stopped for some time. In addition, the whole of southern Pakistan was damaged by flooding in August 2011, both of which were considered reasons for the six-month delay to the project[16]. Moreover, the Ministry of Home Affairs did not allow project activities to continue due to worsening security in Peshawar following intensified terrorist activities, which also delayed the project. Furthermore, a contracted foreign technical expert of the contractor was also restricted from traveling especially on and after April 2013 due to worsening security in Pakistan, which also delayed the project.

【Design (Setting the project period)】

The project sites were scattered around the country, and the introduction and installation of new equipment were planned while utilizing existing facilities and equipment. Under such circumstances, there was a comment that the procurement and installation period, originally planned as 1.5 years should have been around 3 years[17]. At the time of ex-post evaluation, it is difficult for the evaluator to conduct rigorous verification of the adequacy of project period, which was determined by mutual agreement based on the technical adequacy at the time of appraisal. However, the associated parties of Pakistan (the executing agencies, consultants) underlined that the assessment for setting the project period had been optimistic. Accordingly, it might be though that more careful discussion should be held in setting realistic project period on the grounds of technical matters and project features at the planning stage, but before appraisal.

【Implementation structure】

As shown in “3.1.4 Relevance to Appropriateness of Project Planning and Approach”,

[16] Based on the interview to NPCC
[17] Based on the interview to contracted consultants

NPCC, which is one department of NTDC, played the role of PIU in this project. However, most of the equipment procured should be operated and maintained by the NTDC telecommunication department, not by NPCC. NPCC staff lacked sufficient technical knowledge for the telecommunication system, while the involvement of NTDC telecommunication department in the project was initially limited. Such situation meant cooperation and coordination of installing equipment took time and hindered smooth project progress. Given the difficulties in operating load dispatch system by NPCC alone, it is obvious that the further involvement of the related department in this project, particularly the NTDC telecommunication department, was inevitable from the very start of operations.

【Delay in installation of equipment at the existing facilities】

The project involved installing equipment in the existing facilities. However, it was difficult to obtain the drawings of aging facilities, necessary for to installing the equipment. It took for consultants and contractors longer than planned to understand the site situation, which caused delay in delivery and installation of equipment.

【Issuing TOC before implementing a reliability run test】

In the project, TOC was issued by the consultant on the equipment procured in September 2014 upon substantial completion. Timing of issuance of TOC depends on the condition of contract, and usually it is issued after completing the reliability run test or when the defect reliability period ends, whereupon the balance of the contract amount should be paid to the contractor. According to NPCC and the consultants, the project issued TOC and released final payment before solving punch list items or conducting a reliability run test in line with condition of the contract, however, it might have affected the contractor's performance and served as one of the factors to delay.

Based on the above, although the project cost was within the plan, the project period largely exceeded the plan. Accordingly, efficiency of the project is fair.

3.3 Effectiveness[18] (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

(1) Operation Indicators: number of faulty reports of communication of load dispatch system, restoration time in transmission line failure.

Table 4 shows each baseline and target operation indicators, which were set at the time of appraisal and actual values. The number of reports of faulty communication in the load dispatch system declined from an average 450 times per day before implementing the project

[18] Sub-rating for Effectiveness is to be put with consideration of Impact.

to 18 times per day at the time of the ex-post evaluation. Before the project implementation, frequent telecommunication and equipment failures were caused due to the dilapidated load dispatch system and insufficient capacity of the system. Thanks to new data processing system, RTUs as well as telecommunication system, the function of the system improved as such the number of faulty reports of communication shows a significant decrease though the target is not met as yet.

The actual average restoration time for transmission line failure was shortened to 10 minutes per unit for both 550 and 220kV transmission lines, both of which met their targeted average times of less than 45 minutes/time (550kV transmission line) and 34 minutes/time (220kV transmission line), respectively.

Before implementing the project, it took time to understand the situation and prepare a restoration plan because all the failure information (failure points, etc.) was obtained by phone from each facility (power station/substation). The installed RTUs under the project helped swiftly clarify failure situations, such as the range, power blackout and failure points, on the NPCC display board. Consequently, this shortened the time required to determine the restoration approach and the operation itself, accelerating efforts to resolve failure.

Table 4 Average Number of Faulty Reports of Communication and Average Restoration Time in Transmission Line Failure

	Baseline	Target	Actual	
	2004	2010	2014	2015
	Baseline Year	1 Years After Completion	Completion Year of equipment installation Note	1 Year After Completion of equipment installation Note
Average number of faulty reports of communication (average number/day)	Apprx. 450	10	20	18
Average restoration time in 500kV transmission line failure (min/time)	45	Less than 45	10	10
Average restoration time in 220kV transmission line failure (min/time)	34	Less than 34	10	10

Source: documents provided by JICA and NPCC

Note: The actual value of operation and effect indicators should be indicated at the time of project completion and onward. However, the project was incomplete at the time of the ex-post evaluation, despite completing equipment installation. Accordingly, the effectiveness of the ex-post evaluation was confirmed using actual data of the completed year of all equipment installations (2014) and the following year.

(2) Effect Indicators: Transmission loss rate[19]

The transmission loss rate declined from 7.6% before the project implementation, to 3.8% at the time of the ex-post evaluation and the targeted rate (less than 7.6%) was achieved (See

[19] Transmission loss shows energy wasted in transmission from the power supplier to the substation or each customer. Power generation = consumption + transmission loss. As the transmission voltage is higher, the transmission loss is lower. Also, as voltage declines alongside increased demand, there is a need to maintain the voltage in the system appropriately to decrease transmission loss.

Table 5). A newly installed load dispatch system enabled the power system to be monitored on a real-time basis while maintaining adequate voltage, which contributed to improve the transmission loss rate.

Table 5 Transmission Loss Rate

(Unit: %)

	Baseline	Target	Actual	Actual
	2004	2010	2014	2015
	Baseline Year	1 Years After Completion	Completion Year of equipment installation	1 Year After Completion of equipment installation
Transmission loss rate	7.6	Less than 7.6	5.0	3.8

Source: documents provided by JICA and executing agency

3.3.2 Qualitative Effects (Other effects)

(1) Improving power system reliability

The installation of a new system under the project helped improve power system reliability by decreasing the average restoration time from failures mentioned above. NPCC had used a load dispatch system manufactured in 1985 until the project implementation. Although the system included a remote monitoring function for load dispatch throughout Pakistan, it was prone to telecommunication and equipment failures and it was unable to monitor the power grid regularly due to a lack of capacity along with expanding power system and model obsolescence. The new system installed in the project enables constant monitoring of load information (tide, voltage, etc.) transmitted promptly from each facility on NPCC display board. The NPCC dispatcher can understand the situation of each system on time, operate the power system and control the power flow quickly and on a timely basis as well as responding to faults, which eventually helped improve the power system reliability (See Table 6).

Table 6 Procedures for Responding to Transmission Line Failure
(Comparison between before and after the project implementation)

Timing	Before project implementation	At the time of the ex-post evaluation
The event of failure	Occurrence of transmission line fault ↓	Occurrence of transmission line fault ↓
Assessment of status	Call to each facility and understand the status	Understand the status of the failure on a real-time basis with accurate information on a display board ↓
Development of the restoration plan, restoration	Prepare a restoration plan based on information confirmed over the phone (including inaccurate information) and conduct restoration	Prepare a restoration plan based on accurate information confirmed by the system and conduct restoration
Time required	Average time for restoration 45 minutes (500kV transmission line) 34 minutes (220kV transmission line)	Average time for restoration 10 minutes

Reliability	Information with human intervention may be inaccurate, which makes the restoration work less safe and reliable.	Accurate information via the system helps promote safer and more reliable restoration work.

Source: prepared based on the documents provided by JICA and the interview to NPCC

As shown above, while the planned effects were mostly achieved, additional power stations and substations have been newly installed during or after the project implementation[20]. Further stable system operation is required in future for all the power stations and substations to connect the SCADA system. At the time of the ex-post evaluation, NTDC applied the new support to the Asian Development Bank to connect the SCADA system for power stations and substations which had not yet been connected, etc. Greater effects are expected in future by connecting these facilities to the SCADA system installed in this project[21].

3.4 Impacts

3.4.1 Intended Impacts

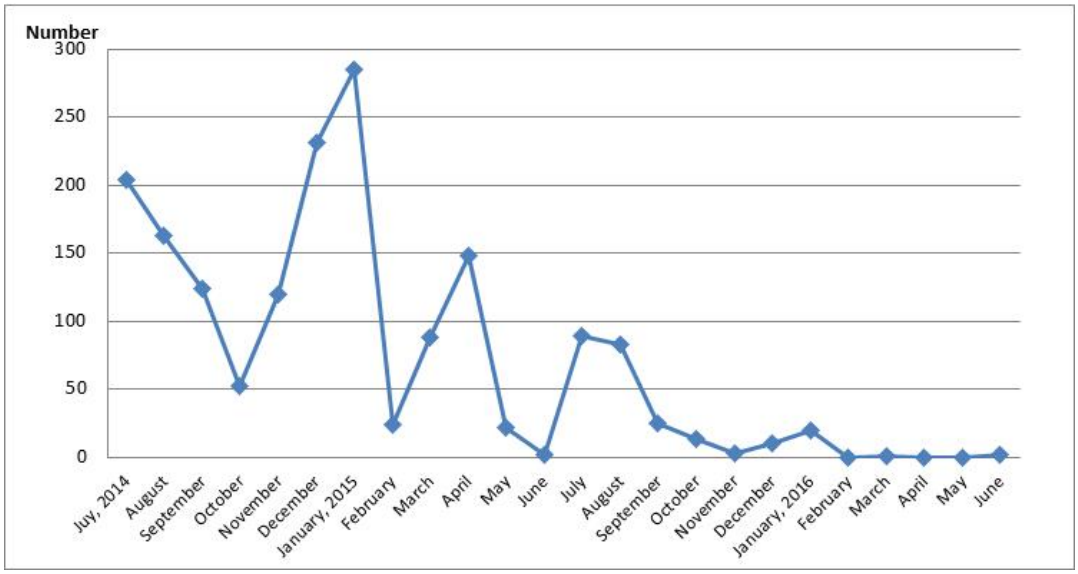
The project was expected to boost socioeconomic development by making power system operation in Pakistan more efficient and stable. However, as indicated in "2.3 Constraints during the Evaluation Study", it may not be possible to analyze the project impact at the time of the ex-post evaluation because the project should be completed after conducting a reliability run test and when the defect liability period ends[22]. Conversely, since the expected operation and effect indicators mostly achieved the target values, some degree of impact can be expected. Hence, based on interviews with executing agencies and consultants, the project impacts, their changes and prospects were analyzed.

(1) Ensuring transparency and stable operation of the power system with accurate information

Figure 1 shows changes in number of frequency variations which exceeded a specified range. The project completed the RTU installation to each facility in September 2014. Later, a certain time was required to connect RTU with SCADA and the connection progressed significantly in 2016, the year when the number of frequency variations exceeded a specified range declined to nearly zero. The frequency variation is determined by the balance of power generation and load (demand). When the frequency is significantly fluctuated, turbines for generator and part of the equipment cannot continue operation and a huge power blackout may occur due to power generation stopping[23]. The installations of SCADA to NPCC and RTU to power stations and substations made it possible to control the frequency by promptly

[20] The number of facilities confirmed at the time of the ex-post evaluation is as follows; 17 IPP stations, 4 hydro power stations, 2 thermal power plants; 23 facilities in total.
[21] Based on the interview with NPCC
[22] Based on the interviews with NPCC and NTDC telecommunication department
[23] In January 2015, significant variation was recorded as almost 300 times (Figure 1), which led to a huge power blackout throughout Pakistan.

understanding and analyzing the balance of each power generation from each facility, total power generation and load demand, which were formerly obtained over the phone from each facility before project implementation[24].



Source: documents provided by NPCC

Figure 1: Changes in the Number of Frequency Variations Exceeding Specified Range

According to the general manager of NPCC, obtaining accurate information and displaying information promptly made it possible to understand the power system status, accurate demand-supply adjustment and related estimates. Accordingly, it is considered that the project implementation ensured the transparency of the power system (meaning adequate operation of the power system, based on real-time information.)

(2) Cost savings

NPCC managed 70 power stations at the time of the ex-post evaluation and generation costs varied among the individual power stations[25]. By upgrading the load dispatch system and related facilities, along with power demand, NPCC can start operation of power stations in order from those with lowest unit price for generating power when more power has to be generated and stop operation of power stations with the highest unit price for generating power when generation is reduced. The relevant figures can be determined instantly and effectively, which allows effective system operation and helps reduce power generation and system operation costs. For instance, the NTDC paid Rs. 930,634 million for fuel in 2013,

[24] Based on an interview with NPCC
[25] The required cost (fuel and O&M) for generating 1 kilowatt (kWh) is Rs. 0.79 at the cheapest power station and Rs. 31.8 at the most expensive power station.

but after installing a new load dispatch system, Rs. 728,953 million in 2014[26], which equated to a cost reduction of 20%[27].

3.4.2 Other impacts

(1) Impacts on the Natural Environment

All the construction related to the project was equipment procurement and installation within the premises of the executing agency. No impact on the natural environment was also confirmed during interviews with the executing agencies.

(2) Land Acquisition and Resettlement

The project procured and installed equipment within the existing facility site. Thus, no land acquisition and resettlement took place as a result of implementing of the project.

As described above, number of faulty reports of communication of load dispatch system, average restoration time in transmission line failure, and transmission loss rate were all reduced and more stable and reliable load dispatch system was confirmed. Thus, this project has largely achieved its objectives and its effectiveness and impact are high.

3.5 Sustainability (Rating: ②)

3.5.1 Institutional Aspects of Operation and Maintenance

As shown in "2.3 Constraints during the Evaluation Study", since the reliability run test had not yet been conducted at the time of the ex-post evaluation, the contractor was continuously responsible for its operation and maintenance. NPCC and NTDC telecommunication department fully start O&M of the equipment on completion of the reliability run test. NPCC, the department overseeing O&M of the central processing system, has 385 staff in total, of whom 124 staff are technical experts. According to the NPCC General Manager, the required number of staff was properly secured. However, O&M of RTU, telecommunication system and telephone network are covered by 120 NTDC telecommunication department staff, 64 of whom are technical experts. According to the chief engineer of the telecommunication department, in order to address the shortage of technical experts, the recruiting process to employ 30 new technical experts has been almost completed, thus the issue is expected to be solved.

The main role of NPCC involves assessing data sent from each facility and operating demand and supply adjustment and system interconnection. Accordingly, technical expertise in the telecommunication system is not specifically required. Under such circumstances,

[26] Source: questionnaire responses to NPCC

[27] Installation of all equipment in the project was completed in 2014.

expertise of NPCC and NTDC telecommunication department are required to operate the load dispatch system. Some equipment is also installed inside a substation and thus, the cooperation with grid station operation (GSO) department of NTDC is also inevitable. However, due to the temporary absence (about 10 months) of the responsible manager of NTDC, who was supposed to manage the whole NTDC, some problems occurred such as a lack of coordination and collaboration among NTDC departments toward project completion. Since a board member (technical person) was assigned to manage and supervise the project toward project completion in 2015, periodic meetings have been held to discuss issues, based on which improvement of the coordination structure can be expected.

3.5.2 Technical Aspects of Operation and Maintenance

NTDC staff are supposed to have a proper technical transfer of O&M from the contractor during the project implementation. Accordingly, at the time of appraisal, technical ability was not considered problematic[28]. Although training was actually conducted in 2011, an interview with NPCC and NTDC telecommunication department revealed that most of the staff trained had been transferred or resigned. Accordingly, the technical knowledge and experiences of O&M transferred at training were not properly applied, meaning that refresher training should be required after completing a reliability run test to conduct O&M properly. According to the chief engineer of NTDC telecommunication department, the staff of the telecommunication department have abilities in terms of basic operation and maintenance of equipment procured but lack proper skills to fix and repair the equipment. For future adequate O&M, training for technical knowledge and experience in electronics devices and a technical expert with electronic engineering will be required in the NTDC telecommunication department[29]. Meanwhile, the contractor, conducting O&M of equipment at the time of ex-post evaluation, has continued On-the-Job Training for the NPCC and Telecommunication department of NTDC. Furthermore, Asian Development Bank is also examining the feasibility of providing technical assistance in terms of O&M capacity, which means improved technical capacity on O&M can be expected.

Although the O&M manual of equipment was distributed when procured, NTDC staff mentioned that the documents called as-build drawing which is required for O&M were kept by the consultant and not shared with NPCC and NTDC telecommunication department and that they requested the consultant to hand them over promptly.

[28] Source: documents provided by JICA

[29] According to the board member (technical person) of NTDC assigned to manage and supervise the project toward completion, for proper O&M, technical computer system skills to recover the system failure for NTDC and technical O&M skills for accessories of Power Line Communication (PLC) for NTDC are required.

3.5.3 Financial Aspects of Operation and Maintenance

The net earnings of NTDC showed a surplus for the past few years and sales also increased every year. At the time of appraisal, power selling charges arrears by distribution companies caused a decline in sales revenue and an operating profit. At the time of ex-post evaluation, however, electricity charges paid by users to distribution companies were credited to the account in trust and the equivalent charges for transmission power were paid to NTDC through CPPA from that account. Furthermore, the adequate price was set by the National Electric Power Regulatory Authority taking oil prices into consideration, which allows NTDC to secure a stable income. Accordingly, NTDC is less prone to serious issues for O&M from a financial perspective.

Table 7 NTDC Income and Expenditure

(Unit: Rs. Million)

Item	2012	2013	2014
Sales	868,459	894,923	1,016,965
Cost of electricity	850,442	878,088	997,128
Sub total	18,017	16,835	19,837
Operating expenses Note 1	18,543	14,771	12,683
Operating profit/loss	-526	2,064	7,154
Other income	3,588	96,860 Note 2	1,609
Finance cost	2,769	749	1,365
Profit before tax	293	98,175	7,398
Taxation	90	38,751	57
Net profit after tax for the period	**203**	**59,424**	**7,341**

Source: documents provided by NTDC finance department

Note 1：Operating expenses in 2013 and 2014 decreased. Since part of the provision for doubtful debt estimated in 2012 was reversed in 2013 and the loss of transmission line was decreased in 2014, the operating expenses decreased compared to previous year.

Note 2：As accumulated provision for doubtful debts was reversed in 2013; other income in 2013 exceeded the levels in 2012 and 2014.

At the time of ex-post evaluation, the contractor was conducting O&M of installed equipment in the project, thus the O&M cost was not covered by the NTDC budget. NTDC will secure an O&M budget once the reliability run test is completed. According to NTDC, the O&M cost required for equipment procured under the telecommunication department is estimated at approximately Rs. 51.4 million annually, which is affordable for NTDC's general budget. It was also explained that the needed O&M cost for equipment installed in NPCC can be also secured, however, the accurate amount is not calculated. Hence, before the reliability run test is completed, it is deemed desirable for NTDC to estimate the accurate O&M cost, including for equipment under NPCC.

As described above, since the O&M cost required can be manageable by the executing agency, there is no concern over sustainability in terms of financial aspects for O&M.

3.5.4 Current Status of Operation and Maintenance

As of the ex-post evaluation, since the contractor is working on solving punch list items, O&M is performed by the contractor. Once all items in the punch list have been responded to, a reliability run test will be conducted for six months and following a one-year defect liability period, the project will finally be defined as completed[30]. Subsequently, O&M will be handed over to NTDC.

The utilization condition of major equipment at the time of ex-post evaluation is summarized as below. According to the NPCC general manager and chief engineer of the telecommunication department, about 80-90% of all major procured equipment is operating.

Table 8 Condition of Utilization of Equipment

Equipment	Condition of utilization
Central processing system	Good.
RTU	3 out of 49 installed RTUs have issues and are not connected to the system. The contractor is working on this issue toward conducting the reliability run test.
Telecommunication system	Due to communication failures, utilization at the time of ex-post evaluation was about 88%. The contractor is in the process of confirming the reasons.
Telephone network	Configuration issues have occurred in Private Automatic Branch Exchange (PABX), which the consultant is trying to fix. Thus, the utilization rate remains at about 60% at the time of ex-post evaluation.
Development of regional control center	The utilization rate for telephone network connections between the regional control center and NPCC is 93%.

Source: interviews with NPPC and telecommunication department

A reliability run test was initially scheduled in July 2014. However, this was yet to be conducted at the time of ex-post evaluation for various reasons; issues of installed equipment connection to the system, telecommunication system errors, restrictions on travel to Pakistan for foreign experts of contractors who is in charge of confirming the issues, also differences in understanding of the contract contents between NTDC and the consultant, a consequent lack of clarity over the role of each department responsible for equipment after the installation, moreover, a lack of coordination among departments in NTDC, etc. During the period of after the first field survey till the second field survey of the ex-post evaluation, a revised schedule for the remaining tasks was prepared, based on which some work was

[30] According to the executing agency, the project will be competed in March 2017.

performed and a certain level of progress was confirmed. Prompt action for full-scale operation of installed equipment is expected toward reliability run test.

In the light of above, some minor problems have been observed in terms of institutional and technical aspect. Therefore sustainability of the project effects is fair.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was conducted to make the power network more efficient and reliable by modernizing and upgrading the load dispatch system and the related facilities in Pakistan. It is consistent with the development policy of Pakistan, which has focused on power sector reform that contributed to economic growth, and the country's needs to develop an efficient and reliable power network both at the time of appraisal and ex-post evaluation. It is also consistent with Japanese policy of assistance to Pakistan as of the appraisal. Hence the relevance of this project is high. Though the project cost was within the plan, the project period significantly exceeded the plan for various reasons, such as the delay in the bidding and contract process, the characteristics of the project whereby the new equipment was installed while continuing the operation of existing facilities and equipment, issues of the implementing structure, worsened security and natural disasters, etc. Thus, the efficiency of the project is fair. Thanks to the project, the number of faulty communication reports from load dispatch systems, average restoration time from transmission line failures and the transmission loss rate were reduced, which meant the reliability and stability of the power network were improved. Since impacts such as cost reduction due to efficient power system operation as well as improvement of transparency in the power system were also confirmed, the effectiveness and impact of the project are high. On the other hand, minor issues in NTDC, the institution in charge of maintenance, remain in terms of institutional and technical aspects and the current O&M condition. Accordingly, the sustainability of the project effect is fair.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

・The operation of a load dispatch system requires cooperation and coordination among related departments in NTDC. During the project implementation, coordination between NPCC, which played the main role as PIU and the telecommunication department, responsible for overseeing the major O&M telecommunication system was not properly made. Therefore, the role and responsibilities remain unclear, which delays necessary work before the start of reliability run test. In NTDC, a board member in charge of managing and

supervising the works towards the completion of this project was assigned in 2015, since then regular meetings to discuss the necessary actions have commenced. NTDC needs to continue this meeting with related departments and clarify each role, including the consultant / contractor, through cooperation and coordination, to facilitate smooth progress in the remaining activities toward project completion.

・A reliability run test for installed system is yet to complete in this project, thus NTDC considers this project incomplete. Accordingly, NTDC needs to get the contractor to work on the items listed in the punch list, conduct the reliability run test immediately and complete equipment hand over to NTDC. In case of slow progress in solving punch list issues, one option could be to start the reliability run test before solving all the issues listed in the punch list with the purpose of detecting issues causing the errors.

・In the course of the project implementation, power stations and substations were newly constructed. There are also hydroelectric and nuclear power generation plants as well as power plants operated by IPP; most of which have not yet been connected to the system. NTDC needs to prepare a plan to connect such power plants / substation to the system promptly, taking technical assistance into consideration, which is currently examined by the Asian Development Bank. To do so, the further utilization of the installed system can be expected.

・Following the defect liability period, meaning after project completion, the following actions are required for proper O&M; 1) NTDC needs to work on securing a budget for O&M of the installed equipment including the system managed by NPCC based on an accurate estimated cost, which needs to be calculated with the cooperation of the consultant and contractor, and 2) NTDC needs to prepare refresher training for staff working for O&M to improve and compensate for the lack of the technical O&M capacity.

4.2.2 Recommendations to JICA

・ Due to the lack of coordination in NTDC, the consultant and contractor still do not fully understand the responsible departments of NTDC when they need employer’s confirmation, which disturbed some work up to the point of ex-post evaluation. JICA has monitored the project regularly for promoting the progress from the commencement of the project and participated in monthly meetings of NTDC commenced about a year ago before the ex-post evaluation. JICA is recommended to continue to monitor the progress of the project through participating in meetings, if needed, and to boost the progress.

4.3 Lessons Learned

<u>Examine the implementing structure with clear role and responsibility of each stakeholder</u>

In this project, NPCC plays almost solely the role of PIU, which hinders the smooth project

implementation and was one of the reasons behind the delay. Not only NPCC, NTDC telecommunication department, which oversees RTU and the telecommunication system, and GSO, responsible for overseeing the facility of grid station are engaged in the load dispatch system operation. Since NPCC staffs are not specialized in equipment and facilities operated and managed by other departments, a lack of technical capacity and less involvement of other departments in the early stage of the project delayed the project. In case the facility or equipment are operated and maintained by several departments as in this project, the executing agency and JICA need to clarify the responsibilities of each department for O&M at the planning stage and role of PIU should be assigned to the institution/department which had highest level of involvement in O&M equipment. Also, it is important that project implementation structure duly involve relevant departments responsible for to be developed facilities and installed equipment in the decision-making process from the beginning of project preparation stage.

Prior arrangements to install new equipment in existing facilities

In this project, equipment was newly installed in existing facilities. According to the executing agency, drawings of the existing facilities, required to install the new equipment, were difficult to obtain. Because of that it took longer time to understand the existing situation, before preparing to install the equipment and connect to SCADA systems properly. Therefore, when installing the equipment in existing facilities, the situation of existing facilities needs to be examined in detail, including obtaining drawings at the planning stage. In case sufficient information is not available before the project starts, it is desirable to plan necessary means to collect information to understand the existing situation and condition, and to set the project period considering the time required for such data collection.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs		
Installment of central processing system	・Power system control ・Hardware (Servers, Workstation, Local area network, etc.) ・Data processing system	・As planned ・As planned ・Limited Market Operation (Sub function) was deleted from scope of work
Installment of RTU	・9 stations in total (1 power station, 8 substations)	・49 stations in total (16 power stations, 33 substations)
Upgrade of telecommunication system	・10 terminal stations ・35 repeater stations (Replacement of communications network between NPCC data processing system and RTU)	・As planned ・As planned (Existing 500/220/132 kV line was replaced by Optical ground wire (OPGW))
Telephone network	Replacement of existing old network of NTDC	・As planned
Development of regional control center	・Telephone network connection with NPCC ・Paint on mimic boards	・As planned ・Paint on mimic boards was deleted from scope of work
Accommodations	53 accommodations for engineers and staffs of NPCC	・As planned
Vehicles	4 vehicles	・As planned
Consulting services	Preparation of bidding documents, bidding support, construction management, reporting project status (self-funded by NTDC)	・As planned
2. Project Period	August 2005 －January 2009 (42 months)	August 2005 －January 2016 (126 months)
3. Project Cost Amount Paid in Foreign Currency Amount Paid in Local Currency Total Japanese ODA Loan Portion Exchange Rate	 4,131 million yen 1,589 million yen （908 million Pakistan Rupee） 5,720 million yen 3,839 million yen 1 Pakistan Rupee = 1.75 yen (As of February 2005)	 4,235 million yen 1,108 million yen （821 million Pakistan Rupee） 5,343 million yen 3,513 million yen 1 Pakistan Rupee=1.35 yen (Average between August, 2005 and February, 2013)