India

FY2021 Ex-Post Evaluation Report of

Japanese ODA Loan “Bangalore Distribution Upgradation Project”

External Evaluator: Junko Fujiwara, OPMAC Corporation

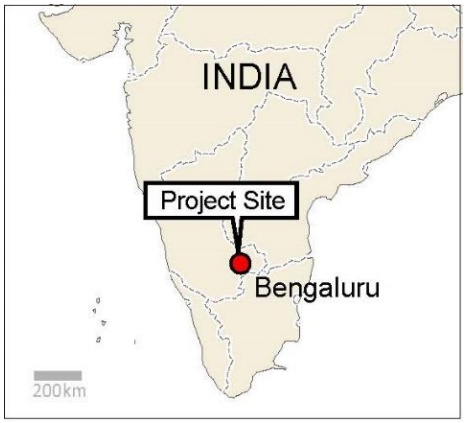
0. Summary

The objective of this project was to improve the reliability of the electricity supply by the development of a distribution automation system in the Bengaluru metropolitan area, which includes the capital city of the State of Karnataka, in southern India, thereby contributing to local economic development and the improvement of living standards for residents in the areas concerned. The project addresses all three of these perspectives: consistency with national and state-level sector development plans and programs, the development needs at the time of appraisal and ex-post evaluation, and the appropriateness of the project plan and approach. The upgrading of telecommunication facilities, distribution automation, and control center development were considered and planned in a pioneering manner within Karnataka and in relation to other states, and were implemented with a coordinated design to optimize the development plan. Although no specific linkage or coordination with other JICA projects was confirmed, the project was sufficiently consistent with Japan's assistance policy at the time of appraisal, and specific results, such as linkage and coordination with assistance provided by the Asian Development Bank, could be confirmed. Therefore, the appropriateness and consistency of the project are high. Although the project cost was within the plan, the project period was significantly longer than planned, resulting in moderately low efficiency. The reasons for the prolonged project period include technical examinations for output changes, delays in re-tendering and the procurement of materials and equipment, redesign of the communication network, delays in frequency allocation, and prolonged period spent for a series of acceptance test and system integration. The operation and effect indicators generally reached the target values, and the qualitative effect of the project, stabilization of the power supply, was also achieved. Effects on business efficiency, such as the promotion of restoration in areas where the distribution automation system has not yet been introduced and the use of data in related departments, were also confirmed. These have led to improvements in customer service and customer satisfaction. In terms of impact, stabilization of the electricity supply did not have an effect on regional GDP or the amount of foreign investment, but it was confirmed that the project improved the living environment and contributed to regional economic development. The project had no impact on the natural environment, and no land acquisition or resettlement occurred. Therefore, the effectiveness and impact of the project are high. The operation and maintenance of the project has no problems in terms of policy and system, nor in the organizational / institutional, technical, financial aspects, or current conditions, and sustainability is ensured. In addition, preventive measures have been taken in terms of

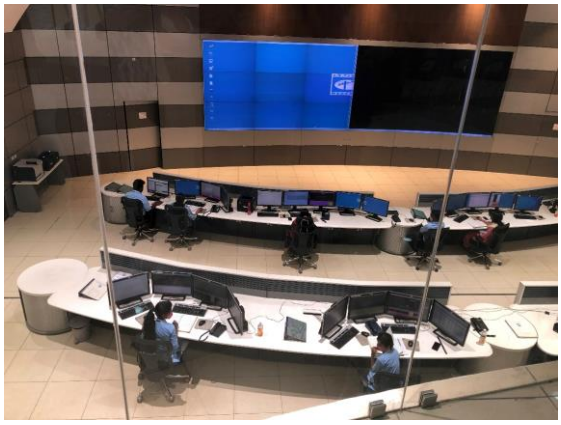
environmental and social considerations and risks. Therefore, the sustainability of the effects of this project is very high.

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

1. Project Description



Project Location (Source: Evaluator)


Control Center constructed by the Project (Source: Evaluator)

1.1 Background

Bengaluru, the capital city of the State of Karnataka in southern India, had been quoted as "Silicon Valley of India", rapidly growing as the hub of the Indian IT industry and was emerging as one of the most popular industrial clusters in India with numerous major global firms, including Japanese firms. As economic activity increased through industrial concentration, Bengaluru's population grew from 3 million in 1981 to 5.7 million in 2001, and electricity demand increased at an average annual rate of about 10%. However, the annual average duration of outage per consumer per annum in Bengaluru was 86.2 hours (in FY2003), much higher than in other metropolitan cities in India like Delhi, Mumbai or Chennai[1]. This had diminished the efficiency of firms due to the shutdown of factory lines, lighting and computers, and meant the inefficient use of captive power, which had a negative impact on local economic activities. Blackouts in city streets that threatened people's safety and breakdown of electric appliances at home. had become a bottleneck in improving the living standards of citizens.

To solve the above issues, the replacement of deteriorated facilities and the installation of insulated wires were promoted under "Accelerated Power Development & Reform Programme" (APDRP)[2]. In addition to such measures, the introduction of a distribution automation system was regarded as effective to reduce the duration and extended area of each outage. However, it was

[1] Delhi: 31.5 hours, Mumbai: 3.5 hours, and Chennai: 21 hours.
[2] Under the APDRP each state was given support for new development and the reinforcement of power distribution facilities with the condition that they implement reforms based on a memorandum of understanding signed with the Ministry of Power of the Government of India.

not among the targets of the assistance schemes of the central and state governments, so budget availability was limited.

Therefore, it can be said that there was a pressing need to implement this project to produce a stable electricity supply in the Bengaluru metropolitan area.

1.2 Project Outline

The objective of this project was to improve the reliability of the electricity supply through the reduction of outage duration by the development of a Distribution Automation System (DAS) and related facilities in Bangalore, the capital city of the State of Karnataka, in southern India, thereby contributing to local economic development and the improvement of living standards for residents in the areas concerned.

Loan Approved Amount / Disbursed Amount	10,643 million yen / 6,975 million yen
Exchange of Notes Date / Loan Agreement Signing Date	March 2007 / March 2007
Terms and Conditions	Interest Rate 0.75% Repayment Period 15 years (Grace Period 5 years) Conditions for Procurement General untied
Borrower / Executing Agency(ies)	The President of India / Bangalore Electricity Supply Company Limited, BESCOM
Project Completion	June 2019
Target Area	Bengaluru metropolitan area
Main Contractor(s) (Over 1 billion yen)	SATEL Oy (Finland) / Efacec Engenharia e Sistemas, S.A. (Portugal)
Main Consultant(s) (Over 100 million yen)	Central Power Research Institute (India) / KEMA INCORPORATED (USA)
Related Studies (Feasibility Studies, etc.)	Special Assistance for Project Formation for Distribution Upgradation Project for Bangalore City (Japan Bank for International Cooperation, 2005)
Related Projects	None

2. Outline of the Evaluation Study

2.1 External Evaluator

Junko Fujiwara, OPMAC Corporation

2.2 Duration of Evaluation Study

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

Duration of the Study: October 2021 – January 2023

Duration of the Field Study: March 9 - 23, June 21 - 25, 2022

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

3.1 Relevance / Coherence (Rating: ③[4])

3.1.1 Relevance (Rating: ③)

3.1.1.1 Consistency with the Development Plan of India

At the time of the appraisal, the Government of India had placed emphasis on rural electrification as one of the critical tasks for rural development and intended to reduce transmission and distribution losses from over 30% to 15% through the improvement of transmission and the distribution network in *the 10th Five-Year Plan* (April 2002 - March 2007). Along with the Plan, the "*Accelerated Power Development & Reform Program*" (APDRP) was started in 2002 to improve the high rate of transmission and distribution losses (at 31.3% in 2004) and to improve efficiency in terms of facilities and finance for the power distribution sector. The program was subsequently restructured to promote IT in the distribution sector and to strengthen its network.

At the time of the ex-post evaluation, the Government of India had implemented the *National Electricity Plan* (NEP) since 2018 in which the promotion of, and conversion to, renewable energy, the development and strengthening of the power transmission and distribution system, the introduction of electric vehicles, etc. were being facilitated[5]. Also, the "*Revamped Distribution Sector Scheme*" (RDSS) is under way from FY2021 to FY2025. This is designed to improve the business efficiency and financial sustainability of the distribution companies of each state, to strengthen the electricity supply infrastructure, promote the installation of smart meters, reduce transmission and distribution losses, and improve the balance of revenue and expenditure. Among these, the upgrade of power distribution facilities and the automation of power distribution are priorities for the promotion of photovoltaic power generation and the introduction of electric vehicles.

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

[4] ④: Very High、③: High, ②: Moderately Low, ①: Low

[5] NEP was under revision as of 2021.

Therefore, the introduction of a distribution automation system in the Bengaluru metropolitan area was relevant at the time of the appraisal as well as the ex-post evaluation.

3.1.1.2 Consistency with the Development Needs of India

At the time of project appraisal, with the rapid industrial development in Bengaluru and its suburbs, the electricity demand in Karnataka State had been increasing at an annual average rate of about 15% for the last four years. The state government had been working on power sector reform since early on, and through the aggressive development of power generation facilities and electricity purchase from neighboring states, the supply and demand of electricity was almost balanced on an annual basis in FY2005. The need to reduce the annual power outage hours per consumer in Bengaluru city is described in "1.1 Project Background." The introduction of a distribution automation system was regarded as effective to reduce the duration and extended area of each outage in addition to the replacement of deteriorated facilities and the installation of insulated electric wires.

At the time of the ex-post evaluation, the development of transmission and substation facilities was underway throughout the Karnataka State, and transmission and distribution losses were improving. As shown in "3.3.1 Effectiveness" below, there had been a reduction in the duration of power outages and an improvement in power supply in the project area, ensuring fairness as a public utility service for all citizens, including socially vulnerable groups. However, as the population of central Bengaluru continued to grow, and industrial activity increased in line with economic development, the need to reinforce power distribution facilities, further utilize the data collected through distribution automation system, and improve the distribution network considering each consumer's characteristics and their wide variety of demands continued to be a pressing issue. Meanwhile, distribution automation had not yet been introduced outside of the project area (i.e., outside Bengaluru city) although it has been promoted within the city, and reduction of power outage duration and frequency and stabilization of power supply voltage was still necessary in industrial parks in the suburban areas.

From the above, it can be seen that the project is consistent with the development needs at the time of the appraisal as well as the ex-post evaluation.

3.1.2 Coherence (Rating: ③)

3.1.2.1 Consistency with Japan's ODA Policy

At the time of project appraisal, Japan's *Country Assistance Program for India (*May 2006) listed three priority targets: i) the promotion of economic growth; ii) improvement of poverty and environmental issues; and iii) assistance for human resources development and exchange

program enhancement. Among these, “i) the promotion of economic growth” included assistance for the development of infrastructure in the power and transportation sectors.

3.1.2.2 Internal Coherence

In the *Medium-Term Strategy for Overseas Economic Cooperation Operations* by JICA, assistance for poverty reduction and infrastructure development for sustainable growth were set as overall priority areas, and the development of economic infrastructure was prioritized as an area for assistance to India. In particular, as “improvement of the distribution network and rural electrification for economic revitalization and poverty reduction by providing a stable power supply” was a priority assistance area, as the power sector was regarded as a major sector for yen-loan assistance to India and shared 40% of the approved amount. No specific synergies or interconnections with other JICA projects were identified at the time of the appraisal or ex-post evaluation, and no collaboration or coordination with other projects in Karnataka was confirmed.

3.1.2.3 External Coherence

At the time of the appraisal, the project was seeking to collaborate with a U.S. Agency for International Development (USAID) project, but this did not materialize. Meanwhile, the Asian Development Bank's Bengaluru Smart Energy Efficient Power Distribution Project has been under implementation in Bengaluru since December 2020. The project covers six districts in the Bengaluru metropolitan area[6]. This includes the conversion of overhead distribution lines to underground cables with optical fiber cables, and the installation of automated ring main units adapted with the distribution automation system. The project was planned during the implementation of this project based on the development plan and design of the power distribution network and the distribution automation system which had been developed under this project. External consistency is also ensured in the implementation of the project through coordination and collaboration between the two projects.

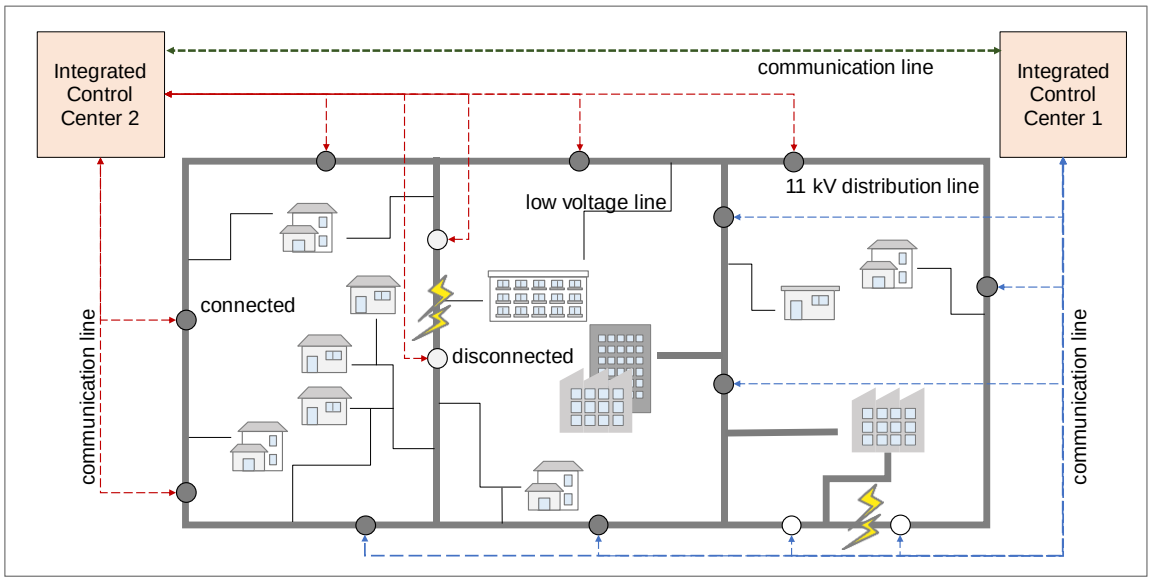
In light of the above, this project has been highly relevant to India’s development plan and development needs, as well as to Japan’s ODA Policy. No specific collaboration or coordination with other JICA projects was confirmed, but linkage / coordination has been made with support provided by the Asian Development Bank. The distribution automation system introduced by the project was one of the pre-conditions for the executing agency to replace existing power distribution lines with new ones in Bengaluru, together with the undergrounding of overhead lines, and the planning and implementation of smart metering. Therefore, its relevance and coherence are high.

[6] The project covered all 14 districts in the Bengaluru metropolitan area, including six ADB projects.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The components of the project are broadly classified into (1) new facilities and equipment related to the power distribution automation system (two control centers, ring main units (RMUs) including communication lines, sectionalizers and etc.), (2) improvement and replacement of existing RMUs, and (3) replacement and new installation of 11 kV distribution lines. (See "Comparison of the Original and Actual Scope of the Project" at the end of this report for details.) The "distribution automation system" refers to a system that monitors and controls the power distribution system via a communications network. Distribution automation system was introduced primarily to minimize the spread of outages per incident and reduce the duration of outages by remotely identifying the section of an outage occurring in the 11 kV distribution network within the Bengaluru metropolitan area from the control centers via the communication network, and operating the RMUs (See Figure 1).



Source: Prepared by the evaluator referring to JICA internal documents and project outputs, as well as publicly available materials from the Electric Technology Research Association of Japan.
Note: The Control Center No. 1 serves the East and South Circles of the Bengaluru metropolitan area, while the Control Center No. 2 serves the North and West Circles.

Figure 1: Project Diagram

Ring Main Unit

Switchgear that integrates the equipment needed to open / close, protect and isolate the power distribution network in an integrated unit that communicates between the 11 kV distribution network and the Control Center.

Sectionalizer

Containing line reclosers and load break switch for 11 kV distribution network including telecommunication interface transmitting system's isolation status to the BESCOM Integrated Control Centers

Source: Photos taken by evaluator (March 2022).

Changes and quantity variances between the planned and actual were identified. Rapid population growth, land development for housing, and urban expansion in the Bengaluru metropolitan area have resulted in the repeated expansion of the 11 kV power distribution network, and the need to update the information from the project formation stage in 2004 on the total length, number, and locations of 11 kV lines. Along with this, the development progress of the entire power transmission and distribution network was also confirmed, and as a result of a comprehensive technical study, the project scope was reviewed during the project implementation.

Specifically, the planned lengths of underground cables and overhead distribution lines were 450 km and 675 km, respectively, but as a result of the review, these were changed to 230.5 km and 949.6 km. It was planned to have three different types of retrofitting works of breakers on the existing RMUs, two of which were self-financed by the executing agency due to the urgency and the rest one they decided to replace RMU itself as they found it was difficult to keep using them. Furthermore, in order to improve response to power outages and speed up restoration work, the location of the telecommunication system was changed from the substations[7] in the original plan to the Division Offices and Sub-Division Offices of the executing agency. In addition, a comprehensive IT system update was underway for the entire BESCOM, and in response to this update, the Business Process IT Application planned for this project was cancelled from the perspective of future system integration.

[7] All substations in the project target area belong to the Karnataka Power Transmission Corporation Limited (KPTCL).

The above change in scope was in line with the project objectives, as it responded to the need to expand the power distribution network due to the rapid population growth and urban expansion of Bengaluru city. In addition, the decision to establish telecommunication facilities within the own area directly controlled and under the jurisdiction of the executing agency, independent and complete from other agencies, was made with a view to speeding up the response to power outages and other incidents. This change was deemed appropriate and necessary. Although there were some changes in the volume and terms of reference of consulting services (see "Comparison of the Original and Actual Scope of the Project" at the end of this report), these changes were deemed reasonable, as they were due to the need to respond to changes in the project design and to avoid duplication with the routine work of the executing agency.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The project cost at the time of planning was 14,205 million yen[8], of which the ODA Loan accounted for 10,643 million yen, while the actual project cost was 8,793.6 million yen (including the ODA Loan portion of 6,976 million yen), which was within the plan (61.9% of the plan) (see Table 1).

Table 1: Planned and Actual Project Cost

Unit: Million yen

Item	Plan (2007)			Actual		
	Foreign currency	Local currency	Total	Foreign currency	Local currency	Total
Equipment procurement and installation	5,075	3,359	8,434	2,314.49	5,728.48	8,042.97
Price escalation	373	215	488	-	-	-
Physical contingency	545	357	902	-	-	-
Consulting services	413	163	576	558.81	70.04	628.85
Land acquisition and resettlement	0	0	0	0	0	0
Tax	0	2,721	2,721	0	-	-
General administration	0	841	841	0	-	-
Interest during construction	143	0	143	102.23	0	102.23
Extension charge				19.56	0	19.56
Total	6,549	7,656	14,205	2,995.09	5,798.52	8,793.61

Source: Documents provided by JICA.
Note 1: Exchange rate: Planned: 1 rupee = 2.52 yen (Sep 2006); Actual: 1 rupee = 1.74 yen (average of 2008 - 2020)
Note 2: Actual cost of price escalation, physical contingency, tax and general administration is included in the actual cost of equipment procurement and installation, and consulting services.

[8] The project identified changes and quantity variances between the planned and actual outputs. If there is a change in the planned outputs assumed at the time of ex-post evaluation, the planned project cost will need to be revised again to match the change in the planned outputs and compared to the actual project cost. However, as shown in "3.2.1 Outputs," the direction of the original plan was generally maintained, the changes were commensurate with the project plan, and as a result of careful attention to the budget plan, changes were examined to remain within the budget range that would fit into the planned project cost. As a result, a review of the planned project cost was not necessary for this ex-post evaluation.

By item, consulting service expenses increased from 576 million yen in the plan to 628.85 million yen in the actual, due to changes in the volume and content of work (see "Comparison of the Original and Actual Scope of the Project" at the end), as well as changes in the unit price of remuneration due to the extended period of work (See "3.2.2.2 Project Period" below). Meanwhile, the actual total project cost is significantly lower than the planned project cost. One reason for this is that the facilities and equipment related to the distribution automation system were initially expected to be procured in foreign currency, but were procured in local currency, resulting in an increase in the share of local currency in the project cost. In addition, the yen appreciated over 40% during the project period compared to the foreign currency exchange rate as it had been at the time of the plan. Therefore, comparing the project cost in yen, the project cost decreased by about 40% compared to the plan as shown above.

Comparing the project cost in rupees, the actual project cost was 5,731.85 million rupees compared to the planned project cost of 5,637 million rupees, which is almost in line with the plan and shows no negative impact on the quality of outputs.

The actual amount of the disbursement of yen loan was significantly reduced to 6,976 million yen, compared to the planned 10,643 million yen. This is because, although the loan disbursement period was extended from July 2015 to March 2017, the project period was also further extended, resulting in difficulties in disbursing the planned amount before the amended loan agreement period was expired. The executing agency responded to the resulting funding shortfall by borrowing from the Government of Karnataka, among other sources.

3.2.2.2 Project Period

The planned project period was 59 months (March 2007 to January 2012), while the actual project period was 148 months (March 2007 to June 2019), which significantly exceeded the plan (250% of the plan). (See Table 2).

Table 2: Planned and Actual Project Period

Item	Planned	Actual
L/A signing	March 2007	March 2007
Consulting services (including selection period)	April 2007 - January 2012	December 2007 - June 2019
Bidding / Contract	May 2008 - July 2009	June 2008 - January 2011
Construction work	August 2009 - January 2012	March 2011 - June 2019

Source: Documents provided by JICA and responses to the questionnaires by the executing agency.
Note 1: The "project completion" was defined, at the time of project appraisal, as the "completion of the commissioning of all components and the completion of capacity building activities."
Note 2: With regard to the actual implementation, both the executing agency and the Consultant confirmed that the consulting service contract period was from May 2008 to April 2020, but that all work had been completed as of June 2019. In addition, "construction work" includes the period of acceptance tests and system integration work.

The main reason for the delay was the prolonged period spent for a series of acceptance tests and system integration after equipment installation. The equipment procured for the project was installed between March 2011 and May 2017, and the equipment had been in operation since September 2013, after which the acceptance tests for all facilities and system integration took approximately three and a half years. This is because not only was the performance of the delivered system verified to meet the specifications, but also it was based on internal and external system integration and linkage, which included the checking and adjusting of compatibility between the equipment purchased under different procurement packages, integration with GIS[9] and the customer information systems and distribution SCADA[10] within the executing agency, and data acquisition in conjunction with SCADA on the KPTCL side. Along with technical examination of the changes in project outputs mentioned above, these measures were the basics required for the project implementation and would improve the quality and the operational convenience of the project after its completion. The executing agency therefore had to give priority to these even at the cost of delaying the project.

Other reasons for delays include delays in contractor selection due to unsuccessful bids and the resulting delays in construction work and the procurement of materials and equipment. Reasons for the delay which were beyond the control of the executing agency, were the height limit imposed on communication towers due to aviation control, which forced the redesign of the communication network, and the delay in frequency allocation by the Government of India.

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

(1) Financial Internal Rate of Return

Since the Financial Internal Rate of Return (FIRR) had not been calculated at the time of the appraisal, it was not recalculated in the ex-post evaluation either.

(2) Economic Internal Rate of Return

The Economic Internal Rate of Return (EIRR) of this project was 14.9% at the time of the project appraisal, with the assumption that the starting point of project life would be the year following project completion. Meanwhile, the starting point of project life was redefined as the year of the signing of the loan agreement at the time of the ex-post evaluation, and the results were the same at 14.7%.

The EIRR recalculated at the time of the ex-post evaluation was 11.5%, which was lower than the EIRR at the time of appraisal. This arose from the fact that the project period had been assumed to be 5 years at the time of the project appraisal, and the benefits, i.e., consumer surplus, were accounted for from the middle of project implementation. The cost savings in

[9] Geographic Information System
[10] Supervisory Control and Data Acquisition

construction of distribution lines and substations were accounted for from the year following the year of project completion. The recalculation was made to account for benefits in line with the actual project period (extended to 12 years) and to reflect actual expenses that saw a significant increase in power purchase costs from the Karnataka Power Corporation Limited.

The assumptions used in the EIRR calculations at the time of the appraisal and at the time of the ex-post evaluation are shown in Table 3.

Table 3: Pre-conditions of EIRR Calculation for the Project

Item	At the time of appraisal	At the time of the ex-post evaluation
Cost	Project cost (excluding tax), Spare parts cost, Power purchase cost, O&M cost	Same as at the time of appraisal
Benefit	Increase in consumer surplus, cost savings in construction of distribution lines and substations	Same as at the time of appraisal
Project life	30 years after project completion	30 years after the loan agreement
EIRR	14.9%	11.5%

Source: Documents provided by JICA.

Although the project cost was within the plan, the project period significantly exceeded the plan. Therefore, efficiency of the project is moderately low.

3.3 Effectiveness and Impacts[11] (Rating: ③)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

The baseline and target values for the operation and effect indicators set at the time of the project appraisal and the actual values collected during the ex-post evaluation are shown in Table 4.

Table 4: Operation and Effect Indicators

Indicators	Unit	Baseline value	Target value	Actual value		
		2006	2014	2019	2020	2021
			2 Years After Completion	Completion Year	1 Year After Completion	2 Years After Completion
Accidental power outage duration	Hour per annum / household	86.2	31.4	16.2	22.8	32.9
Peak load	MW	1,437	2,630	3,081	2,832	2,882
Distribution loss	%	10.62	9	-	-	7.33
Electricity consumption (excluding loss)	GWh	6,067	12,326	18,787	16,545	12,233
No. of staffs dispatched for restoration work	No. / hour per day	702	0	-	-	40
Feeder capacity utilization Index	%	48	75	-	-	69

[11] When providing the sub-rating, Effectiveness and Impacts are to be considered together.

Source: Prepared by the Evaluator based on documents provided by JICA and responses to the questionnaire from the executing agency.
Note: Actual values for 2019 and 2020 were not available for the distribution loss, the number of staff dispatched for restoration work, and the feeder capacity utilization index.

Accidental outage duration per customer was 16.16 hours in the year of project completion (FY2019), 22.76 hours one year after completion (FY2020), and 32.93 hours two years after project completion (FY2021), compared to a target of 31.4 hours. Peak load was 3,081 MW in the year of project completion, 2,832 MW one year after, and 2,882 MW two years after project completion, exceeding the target of 2,630 MW. Distribution loss was 7.33% in FY2021, which exceeded the target. Electricity consumption was 18,786.6 GWh in the year of project completion, 16,545.3 GWh one year later, and 12,232.6 GWh two years after project completion, compared to the target value of 12,326 GWh. The number of staff dispatched for restoration work in the event of a power outage was 40 persons / hour per day in FY2021, compared to the base value (702 persons / hour per day). The feeder capacity utilization index was 68.5% in 2021, 90% of the target value of 75%.

Based on the above, it is judged that the target values for each indicator two years after completion of the project have been achieved or nearly achieved.

Note that the accidental power outage hours per customer decreased to 16.16 hours per household in FY2019, which was far well above the target, but increased to 22.76 hours per household in FY2020 and 32.93 hours per household in FY2021. This is due to (i) occurrence of overhead line equipment failures and wire breakage accidents caused by the unprecedented storms that hit Karnataka in FY2020 and FY2021, and (ii) accidents during the on-soak test of distribution lines replaced from overhead to underground in Bengaluru city[12] which has been largely implemented since 2020. The main reason for the drop in electricity consumption from 18,786.6 GWh in FY2019, the year of project completion, to 16,545.3 GWh in FY2020 and 12,232.6 GWh in FY2021 was the strict lockdown due to the spread of Covid-19, the resulting restrictions on commuting to workplaces and schools in Bengaluru metropolitan area, and the lower electricity consumption by industrial and commercial consumers. Similarly, the peak load also decreased from 3,081 MW in FY2019 to 2,832 MW in FY2020, but the impact of the spread of Covid-19 is judged to have been limited and temporary, given the consistent upward trend from FY2014 to FY2019[13] and the increase in FY2021.

[12] This is part of an ADB funded project. Bengaluru city has many roadside trees, and most of them are large ones. When trees fall due to heavy rains, etc., overhead power lines break, wooden poles collapse, and even in normal times, there is serious damage to power lines due to contact with trees and wild birds, while at the same time there has been high level of unauthorized connections. For this reason, the executing agency has been working for several years to replace bare overhead conductors with covered conductors as well as to convert them to underground cables. It is planned that this work will be completed within the next few years.
[13] 2,479 MW in FY2014, 2,579 MW in FY2015, 2,795 MW in FY2016, 2,835 MW in FY2017, and 3,014 MW in FY2018.

Factors other than the implementation of this project that contributed to the achievement of the target values include significant population growth, economic development and the promotion of industry in the Bengaluru metropolitan area, the replacement of deteriorated facilities, and the promotion of the replacement, insulation, and undergrounding of power distribution lines in the metropolitan area through Asian Development Bank support.

3.3.1.2 Qualitative Effects (Other Effects)

(1) Stabilization of the electricity supply

"Stability of electricity supply" in the power distribution sector largely depends on the state of development of its upstream (power generation and transmission sectors). In parallel with the implementation of the project, the generation capacity became sufficient for the entire Karnataka's electricity demand as new generation sources were secured and other factors. Meanwhile, the KPTCL has also been upgrading, expanding, and strengthening its transmission and substation facilities throughout Karnataka State, including Bengaluru city, which has resulted in improved transmission and voltage stability in the transmission sector.

Under the above circumstance, to evaluate the qualitative effect of the "stabilization of the electricity supply," the average period per accidental interruption per consumer for the three years following the project completion was estimated based on the "accidental power outage duration per consumer (hour per annum / household)", which is one of the operation and effect indicators as well as the immediate effect of introduction of DAS, and the "accidental power outage frequency per consumer (frequency per annum / household)" which was collected separately (Table 5).

As can be seen from the above, the restoration time from accidental power outages per consumer has been getting shorter every year: 34.1 minutes / time in FY2019, 27.3 minutes/time in FY2020, and 24.3 minutes / time in FY2021. Thus, it can be confirmed that the introduction of distribution automation has enabled the rapid identification of the locations of accidents / failure as well as the rapid restoration of power supply to consumers outside of those locations.

Table 5: Trends in outage duration and frequency

Indicators	Unit	2019	2020	2021
		Completion Year	1 Year After Completion	2 Years After Completion
(a) Accidental power outage duration	hours per annum / household	16.2	22.8	32.9
(b) Accidental power outage frequency	frequency per annum / household	28.5	50.0	81.5
(c) Average outage duration (=a / b)	minutes / time	34.1	27.3	24.3

Source: Responses to the questionnaire from the executing agency.

According to key informant interviews with five industrial / commercial consumers (firms)14 in the Bengaluru metropolitan area where the distribution automation system was introduced under the project, three of the five companies who described the power supply as "unstable" before the installation and operation of the equipment procured by the project (before 10 years ago), at the time of the ex-post evaluation, said that the power supply had improved significantly, turning to "very stable" (three companies) or "stable" (two companies). Asked what improvements led them to answer "stable", they replied that the average duration of power outages was "30 minutes" or "half a day" before 10 years ago, but at the time of the ex-post evaluation, this was generally less than one hour ("negligible, a few minutes, " "20 minutes, " or "45 minutes"), and the frequency of outages, which used to occur once every two to three days before 10 years ago, has decreased ("none," "two to three times a month," or "once every four to five days"). In addition, while voltage fluctuations varied according to the responses from before 10 years ago ("rarely occurs," "sometimes occurs," and "frequently occurs"), they are now reported to be improving overall ("never occurs" and "seldom occurs").

The same trend can be observed among domestic consumers[15]. Key informant interviews conducted with four households in areas where the distribution automation system has been installed showed that the electricity supply, which had been "unstable" (four households) before 10 years ago, is now generally stable (three "very stable" and one "stable"). Improvement is also evident in the specific responses. The duration of power outages ranged from 30 minutes to 2 hours before 10 years ago ("30 to 60 minutes" and "1 to 2 hours"), but at the time of the ex-post evaluation, duration was within 20 minutes ("none, negligible, within 5 minutes" and "15 to 20 minutes"). The frequency of power outages was most frequently described as "5 to 6 times a day" before 10 years ago, but these have now been almost eliminated ("none" and "negligible"). Voltage fluctuations were marked as "sometimes" or "frequently" before 10 years ago, but now three of the households respond that they "never" take place.

As a side effect of the project, the contribution of the project to voltage stabilization efforts and reduction in the number of power outages by the executing agency was confirmed in

[14] In selecting the companies to be surveyed, we requested through the executing agency that they (1) have been continuously active at the same address for the past 10 to 15 years, (2) receive power distribution from the executing agency, and (3) would provide an interviewee who would be able to answer specific questions and who would have been in a position to keep data related to the power supply, etc. Interviews were conducted with two manufacturing companies (spring processing, vehicle parts), one garment factory, two IT companies, and one metal parts processing company. Of these, the two IT companies and the metalworking factory were located in an industrial park in Bengaluru City.

[15] Domestic consumers were selected from both the areas where the distribution automation system had been installed and the areas where the system had not been installed (areas with a large number of people not connected to the grid or areas with low electricity consumption). Key informant interviews were conducted with two households and two resident representatives (from housing complexes and local communities) in the installed areas, and with one household and one resident representative in the uninstalled areas.

interviews with them[16]. In general, it can be said that in the areas where the distribution automation system was introduced, the power supply, which was unstable not only in terms of outage duration but also frequency and voltage before the project effects were realized, turned stable and improved at the time of the ex-post evaluation.

For the purpose of comparison, interviews were also conducted with two domestic consumers in an area where the distribution automation system had not yet been installed[17]. These showed that the electricity supply had been "very poor" before 10 years ago, but was now "stable" and "stable with occasional power outages," indicating a certain degree of improvement. In particular, the duration of power outages, which were "6 hours" and "4 to 5 hours" before 10 years ago, was "not a major problem" or "30 minutes to 1 hour" at the time of the ex-post evaluation, and have been drastically reduced. Power outages that occur in areas where distribution automation systems have not yet been installed cannot be restored remotely, but the remote monitoring of the control centers established in this project can identify the approximate area where power outages occur. This shortens the time required for field staff to reach the site of a power outage, and as a result, the time required to complete disconnection and restoration at the point of an accident has been reduced.

The above indicates that in the project area, the electricity supply has been stabilized compared to the level before the project was implemented.

(2) Improvement of the operational efficiency of the executing agency

In addition to the stabilization of the electricity supply, the following effects on the operational efficiency of the executing agency were confirmed.

<u>Promotion of effects of electricity restoration in areas where distribution automation has not yet been achieved</u>

The development of the control centers has enabled real-time remote monitoring of power distribution network in the entire Bengaluru metropolitan area. The data obtained from the monitoring system is also mutually shared and updated with GIS data and customer information

[16] According to the executing agency, current information was collected through the installation of the distribution automation system, which made it possible to monitor the electric power flow. This has led to concrete improvements in customer service, such as the installation of individual voltage stabilization devices, especially for large customers in industrial parks. In addition, based on the information on which sections of the network are with frequent power outages, it is now possible to avoid them by sectionalizers through alternative routes, leading to a reduction in the number of power outages.

[17] The installation of the distribution automation system under the project was carried out with priority given to areas with large populations and industrial areas in Bengaluru City. As the project period was prolonged, the length of power distribution lines in Bengaluru City was rapidly extended, and some areas in the project area remain where power distribution automation has not yet been installed.

held by the executing agency. This has led to the early identification of accidents and breakdowns and shortened staff arrival times, not only in areas where the distribution automation system has been installed, but also in areas in Bengaluru city where the system has not yet been installed.

Data Utilization in Related Departments

With the introduction of distribution automation through this project, data such as outage information, power outage indices, peak load, information on overcurrent and ground fault incidents on each distribution line, the availability of power supply, distribution network operation models, and geographic information on the 11 kV distribution line network is now obtained and accurately quantified. These data are widely shared within the executing agency and is systematically and extensively used for system capacity planning, distribution network configuration studies and expansion, preventive maintenance operations of the distribution network, and day-to-day customer service.

(3) Improvement of executing agency's customer services

The executing agency shares the data obtained from the distribution automation system internally and promptly provides accurate outage information through their websites, smartphone applications for customers, and telephone operators for customer relations. In addition, sales representatives and field staff from the executing agency visit customers from time to time to listen to their complaints and requests to help improve operations.

Regarding the electricity supply by the executing agency, the results of the key informant interviews indicate that both domestic and commercial / industrial customers were at least “satisfied”. In addition to the substantial improvements such as the reduction in the frequency of power outages during the rainy season, reduction of the duration of power outages, and improvements in voltage fluctuation, the respondents also mentioned that the sales staff and field staff are very responsive. They reported that if any problem arises, field staff immediately rush to the scene and respond to customers with abundant and reliable knowledge and skills. This is largely due to smooth communication with the staff of the executing agency and trust in the high level of their technical capabilities.

3.3.2 Impacts

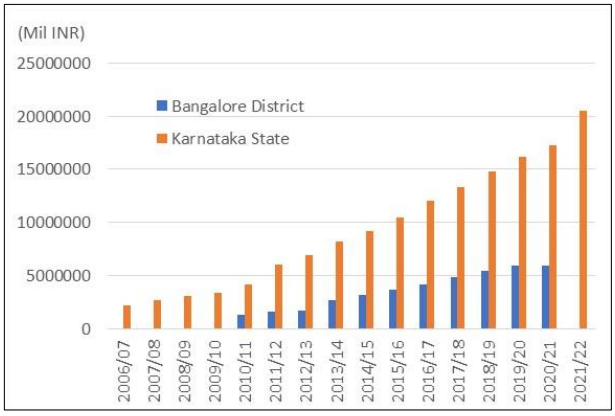
3.3.2.1 Intended Impacts

(1) Quantitative Effects

The “quantitative effects” established at the planning stage of this project are regional GDP and foreign direct investment. The status of these indicators over time is as follows.

i) Growth of Regional GDP

The regional GDP of the entire Karnataka State during the project period is shown in Figure 2. It jumped from approximately 2.1 trillion rupees in FY2006 to approximately 20 trillion rupees in FY2021, a tenfold increase. The GDP of Bengaluru District [18] increased from approximately 1.2 trillion rupees in FY2010 to 5.9 trillion rupees in FY2020, a five-fold increase in 10 years. The GDP of Bengaluru District accounts for 30-40% of that of State and is increasing every year.

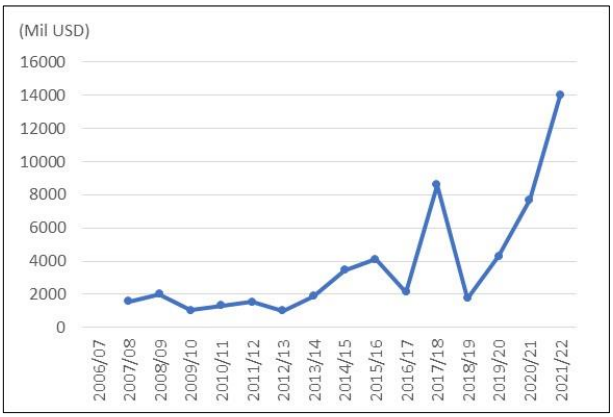


Source: Economic Survey of Karnataka 2021-22, March 2022, Planning, Program Monitoring and Statistics Department of Karnataka State

Figure 2: Trend of GDP of Karnataka State and Bengaluru District

ii) Promotion of Foreign Direct Investment

Figure 3 shows the evolution of foreign direct investment in Karnataka State during the project period [19]. The amount of foreign direct investment has varied from year to year, but according to the "Economic Survey of Karnataka 2021-22", investment in the biotechnology sector increased significantly, even during pandemic that began early 2020. Even considering the external factor of the Covid-19 outbreak, the overall trend over the years shows solid growth.



Source: Economic Survey of Karnataka 2021-22, March 2022, Planning, Program Monitoring and Statistics Department of Karnataka State

Figure 3: Trend of Foreign Direct Investment in Karnataka State

It was difficult to confirm whether and to what extent the project contributed to these "quantitative effects." On the other hand, the contribution of the project to the following "qualitative effects" has been verified.

[18] Karnataka State publishes data on state GDP and district GDP, but not data specific to Bengaluru City. Therefore, we used Bengaluru District GDP as an alternative data set.

[19] Data on the number of foreign investments and data on Bengaluru City or Bengaluru District were not available.

(2) Qualitative Effects

i) Regional Economic Development

In key informant interviews with industrial and commercial consumers, "expansion of employment" and "growth of production activities" were cited as examples of the contribution that the stabilization of the electricity supply has made to the local economy. Specifically, "The reduction in the duration and frequency of power outages has made it possible to operate machinery 24 hours a day," and "Staff members are essentially free from overtime work as shift-based system is introduced, but production activities became expanded because of the fact that the number of power outages has been reduced during regular work hours."

Moreover, in interviews with domestic customers, the following were reported as examples of the contribution that the stabilization of the electricity supply has made to the local economy: "The stabilization of the electricity supply made it possible for people to work at home for long periods of time during the pandemic, which sustained economic activity." "After the lockdown was lifted, companies that made telecommuting an option were able to maintain a variety of work styles, contributing to the revitalization of economic activity."

In addition, the Bengaluru Chamber of Industry and Commerce[20] also recognized and praised at certain extent that "accidental power outages have been significantly reduced," and that "the customer information services have improved."

ii) Investment Promotion in the Bengaluru Metropolitan Area

Interviews with industrial and commercial consumers and the Bengaluru Chamber of Industry and Commerce were conducted to gather examples of the impact of electricity supply stabilization on the investment and living environment and its contribution to the local economy. However, it was difficult to confirm the manifestation of effects related to these impacts.

iii) Improvement in the Living Environment

Key informant interviews with domestic consumers confirmed the following improvements in living conditions:

<u>Various activities at home</u>

While a severe lockdown was imposed during the pandemic, respondents said that they were able to enjoy TV and internet access at home without any problems because there were few power outages in Bengaluru city and the recovery time was short. They also unanimously confirmed that there were no problems with telecommuting or studying at home.

[20] Membership includes more than 1,000 companies (manufacturing, IT, etc.) operating in and around the Bengaluru metropolitan area. The key informant interviews brought together two member companies of the Bengaluru Chamber of Industry and Commerce, three secretariat members, and one civil society organization.

Improvement in public security

They commented that the reduction in the duration and frequency of power outages has resulted in streetlights being on at all times during the night, making the community safer for women in the evenings and at night, and reducing burglaries.

Improvement in electrical appliance breakdowns

Before ten years ago, 3 out of 6 households reported that they experienced appliance breakdowns “sometimes” or “frequently”, but after the project, all 6 households reported that they “never” experienced appliance breakdowns, indicating a change over time.

In general, there were no problems with the amount of contracted electricity, and satisfaction levels were very high, confirming the project's effectiveness and impact.

3.3.2.2 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

In the *Japan Bank for International Cooperation (JBIC) Guidelines for Confirmation of Environmental and Social Considerations* (2002), this project was classified as Category C as it was not included in sensitive sectors or was located in sensitive areas, and was therefore likely to have a minimal adverse environmental impact. The executing agency stated that no environmental impact of the project was anticipated and that no environmental clearance, etc., would be required, and that any environmental impact or pollution that did occur would be minimized by the distribution automation and the improvement of power distribution lines of the project.

As confirmed at the time of the ex-post evaluation, there were no discrepancies between what was anticipated at the time of project appraisal and the actual results, nor was there any environmental impacts during project implementation. The executing agency launched an environmental and social management system in 2021, and an institutional environmental monitoring system has been ensured.

(2) Resettlement and Land Acquisition

As described in (1) above, the project was considered to fall under Category C. Since the distribution automation system and distribution lines of the project were to be installed incidentally to the existing facilities, no resettlement was assumed at the time of planning, and no resettlement or acquisition of land was required for the project implementation.

(3) Gender Equality

At the time of project appraisal, this item was not established and had not been considered. The project is a public utility service by nature and improves the quality of the electricity supply as a universal service, such as by reducing the duration of power outages, which benefits all consumers in the target area.

(4) Marginalized People

As in (3) above, all consumers in the target area were benefited.

(5) Social Systems and Norms, Human Well-being and Human Rights

As with (3) above, the project was a universal service and brought benefits to all consumers in the target area.

(6) Unintended Positive / Negative Impacts

None in particular.

In summary, the operation and effect indicators have generally achieved their target values, mainly in the three main indicators (accidental power outage duration, number of staff dispatched for restoration work, and feeder capacity utilization index).

The qualitative effect of the project, namely, stabilization of the electricity supply, has been achieved as the quality of electricity supplied by the KPTCL has been improved and the reduction of the duration of accidental outages in the distribution area has been confirmed by the executing agency. In addition, the effects of project implementation on the business efficiency of the executing agency have also been confirmed, in areas such as the promotion of restoration in places where distribution automation has not yet been introduced and the use of data in related departments. Stabilization of the electricity supply and business efficiency have led to improved customer service and customer satisfaction.

In terms of impact, the stabilization of the electricity supply had no confirmed effect on regional GDP or on the amount of foreign investment, but it did improve the living environment and contribute to the economic development of the region. There was no impact on the natural environment, and no land acquisition or resettlement occurred. No specific impacts were identified on gender equality, marginalized people and human rights, social systems and norms, or people's well-being. There were also no other positive or negative impacts.

In light of the above, this project has mostly achieved its objectives. Therefore, effectiveness and impacts of the project are high.

3.4 Sustainability (Rating: ④)

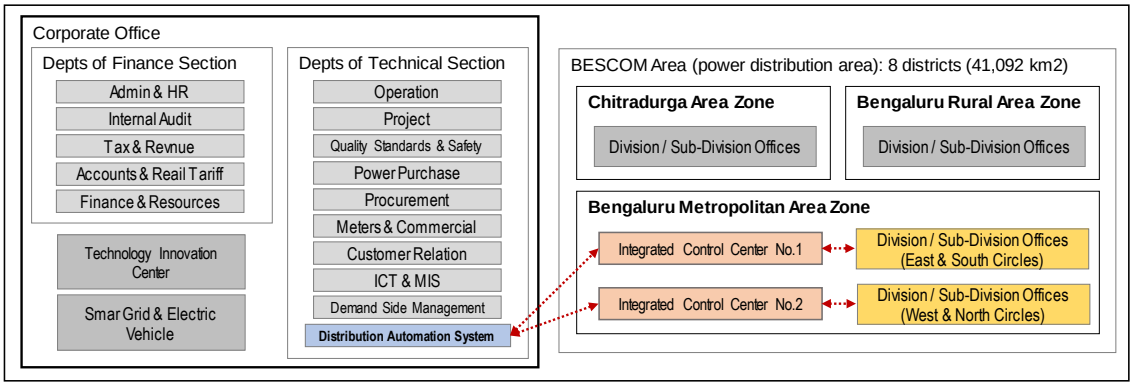
3.4.1 Policy and System

As stated in "3.1.1 Relevance" above, the national and state level sector development plans support and guarantee the project objectives and contents, and are highly consistent with the project and development policies. The upgrade of telecommunication facilities, distribution automation, and the development of control centers were specifically considered and planned in the project prior to their inclusion in the sector development plans and programs at the national and state levels. In addition, overlaps with sector development plans and programs were coordinated and avoided, and the project was designed in a collaborated manner. Moreover, the project laid the groundwork for the introduction of photovoltaic power generation and electric vehicles, which have been promoted in India in recent years.

3.4.2 Institutional / Organizational Aspect

Figure 4 shows an overview of the organization of the entire executing agency. The main organization for the operation and maintenance of the project facilities is the Distribution Automation System Department at the Corporate Office of the executing agency. In addition, operation and maintenance staff are assigned to two control centers and to Division and Sub-Division Offices in the Bengaluru metropolitan area, respectively.

The various data and reports collected by the project facilities are shared among the executives and managers at the Corporate Office, Operation Department, Customer Relation Department, ICT & MIS Department[21], etc., and are widely used in the operation and maintenance of the distribution network (for planning of system capacity and study and expansion of the distribution network configuration), in preventive maintenance operations, and in day-to-day customer service (see above 3.3.1.2 (3) and 3.4.3 below).



Source: Prepared by the evaluator based on information obtained from the executing agency website (https://bescom.karnataka.gov.in/english) and consultations with them.

Figure 4: Organization Diagram of Executing Agency

[21] ICT and MIS are abbreviations of Information and Communications Technology and Management Information Systems, respectively.

Table 6 shows the staffing situation for the operation and maintenance of the project facilities and equipment. Although the number of vacancies is approximately 20% of the total number of staff, they are supplemented by outsourced and deputed personnel. Operators of each control center are dispatched from the contracted professional company. The operation and maintenance management is carried out in cooperation with the Division and Sub-Division Offices on site. In light of the above, the executing agency concludes that there are no operational problems. In addition, since the equipment procured for this project is subject to periodic inspections and replacement of parts under annual maintenance contracts with the venders, no maintenance problems have arisen.

Table 6: Status of staffing for O&M of the project facilities and equipment

Unit: number of person

No	Designation	Sanctioned Post (no.s)	Actual Workforce			Vacancies
			Working Strength	Outsourcing Employees (no.s)	Working Strength (total)	
1	General Manager	1	1	0	1	0
2	Deputy General Manager	4	5	0	5	0
3	Asst. General Manager	21	17	0	17	4
4	Managers (Elect. & Civil)	57	32	15	47	10
5	Account Officer	1	1	0	1	0
6	Asst. Account Officer	2	2	0	2	0
7	Junior Engineer	50	4	39	43	7
8	Assistant	4	2	0	2	2
9	Mechanic Grade-II	2	0	0	0	2
10	Lineman	8	0	0	0	8
11	Asst. Lineman	20	19	0	19	1
12	Daftari (office assistant)	4	0	0	0	4
13	Senr. Personal Assistant	1	0	0	0	1
Total		**175**	**83**	**54**	**137**	**39**

Source: Responses to the questionnaire by the executing agency
Note: “Lineman” indicates those who operate and maintain electric lines, poles and other facilities on site.

3.4.3 Technical Aspect

The implementation of this project has made it possible not only to identify information such as where power outages are occurring, but also to accurately determine peak load, the occurrence of overcurrent and ground fault incidents on each distribution line, the availability of power supply, the status of distribution network connection and operation, and geographic information for the 11 kV distribution line network. The executing agency is working to maximize the use and operation of this data collected by the project facilities, and classifying the skills required for O&M as shown in Table 7.

Table 7: Skills required for O&M

Required skill	Contents	Present capacity
Engineering Fundamentals	Network Planning, relay coordination, drafting of technical specifications.	Good
Computer literacy	IT system for operations and maintenance	Good
Skill for data analysis	Reports and recommendation on data generated	Good
DAS maintenance management skill	BESCOM has maintained DAS (IT System, CS and RTU) without OEM support	Good

Source: Responses to the questionnaire by the executing agency
Note: "Present capacity" is the executing agency's self-evaluation to open question.

In addition, some operation and maintenance management services are outsourced. The contractors are specialists in the IT and communications fields, such as venders and engineering firms. The executing agency not only has knowledge and experience in the communications field but also has a comprehensive understanding of the contents of system maintenance and management to be performed by the venders, so the selection of these contractors is appropriate and proactive supervision is ensured.

Training opportunities for staff are provided as in Table 8. The executing agency is keenly aware of the need to keep up with advances in electricity and communication technology, and technical guidance is provided diligently within the organization. Regarding the operation and maintenance of the distribution automation system, manuals and guidelines on how to operate each piece of equipment have also been prepared.

Table 8: Training Programs

Name of Training Program	Contents	No. of trainees	Frequency
Control Center Operations Training	Training on Control Room Operations, SCADA and DMS Applications (basic level)	217	Half-Yearly
Advanced SCADA-DMS Application Training	Training on effective utilization of advanced SCADA-DMS Applications	148	Quarterly
SCADA-DMS Refresher Training	Refresher Training for working DAS personnel on utilization of SCADA-DMS applications, System Reports and SCADA-Event Management from the System.	101	Half-Yearly
Workshop on DAS for O&M Personnel	Providing guidelines for Operations and Maintenance of DAS Enablers (O&M Personnel and Division / Sub-division Office Technical Staff)	2,188	Half-Yearly
Cyber Security Training	Training pertaining to vulnerability assessment tools and protection of critical infrastructures from threats (DAS System Engineers and IT Engineers)	20	Quarterly
Advanced DAS system training	Training on tools and software that can be utilized for developing additional functions and features (DAS System Engineers and IT Engineers)	41	On Need basis

Source: Responses to the questionnaire by the executing agency
Note: Figures are actual of FY2021.

3.4.4 Financial Aspect

Table 9 shows the executing agency's profit / loss and key financial indicators for the six-year period from FY2015 to FY2020.

Table 9: Profit and Loss and Key Financial Indicators of the Executing Agency

Unit: Million Rupees

No.	Year	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020
1	Income	143,154.4	160,721.1	183,589.8	201,233.9	216,509.2	201,162.8
	Revenue from operations	141,482.3	158,611.7	180,420.5	195,387.4	211,706.9	196,808.4
	Other income	1,672.1	2,109.4	3,169.3	5,846.5	4,802.3	4,354.4
2	Power purchase cost	126,010.1	137,008.3	151,232.1	187,146.0	193,453.5	173,212.0
3	Employees benefits and O&M expenses	9,580.8	9,601.8	12,010.5	14,937.0	16,272.4	16,842.9
	O&M expenses	833.7	882.5	904.2	1,288.7	1,138.3	1,835.8
	Employee's benefits expenses	8,747.1	8,719.3	11,106.3	13,648.3	15,134.1	15,007.1
4	Operating profit before amortization, interest & taxes	9,284.6	11,309.7	11,291.8	13,280.4	18,287.7	23,805.1
5	Depreciation	4,195.6	5,287.5	5,979.2	7,329.8	9,947.4	10,654.8
6	Interest expenses, etc.	3,648.0	5,452.3	3,773.4	2,798.8	6,816.9	9,866.1
7	Net profit before tax	1,441.0	569.9	1,539.2	3,151.8	1,523.4	3,284.2
8	Total assets	166,314.9	193,781.9	199,662.8	228,714.1	254,193.1	283,076
9	Sales profit ratio (profit / Income x100)	6.49%	7.04%	6.15%	6.60%	8.45%	11.83%
10	capital adequacy ratio (equity / total assets x100)	2.51%	3.72%	5.05%	5.23%	6.36%	6.99%

Source: Annual Reports of the executing agency

Note: The new Indian accounting standard has been applied since FY2015.

Almost all of the executing agency's revenues come from the collection of electricity charges. According to the executing agency, the implementation of the project increased electricity consumption by a total of 211.35 GWh (FY2012 to FY2022), contributing to an increase in revenues worth Rs. 902 million.

Although sales revenues decreased in FY2020, this was largely due to the pandemic, and are generally steady. In addition, according to the executing agency, there has been an increase in the supply of electricity from dispersed power sources, such as the purchase of solar and other renewable energy sources, which has also affected revenue from electricity sales.

Since the adoption of the new Indian accounting standard (FY2015), the capital adequacy ratio has grown steadily from 2.51% (FY2015) to 6.99% (FY2020). The sales profit ratio was 6.49% in FY2015 and increased rapidly in FY2019 and FY2020 to 8.45% and 11.83%, respectively. According to the executing agency, Rs. 658.4 million was disbursed annually from FY2011 through FY2020 for operation and maintenance of the project facilities (including such cost as staff remuneration and outsourced maintenance contract expenses). In FY2021 and FY2022, a budget of 348.1 million rupees was allocated for each year, and the executing agency indicated that the budgeted amount would be sufficient to maintain the project facilities and equipment.

The above confirms the high financial soundness and profitability of the executing agency as a whole.

3.4.5 Environmental and Social Aspect

As stated in 3.3.2.2 above, no problems were foreseen in advance, nor have they occurred. Since the organization has established an environmental and social management system, it is judged that there will be no particular problem to be addressed in the future.

3.4.6 Preventive Measures to Risks

No differences were identified in the expression of effects among beneficiaries for effectiveness and impact. The project is a public utility service and, as indicated in the impact above, is based on the assumption that consideration is given to gender and people who are inhibited from equitable participation in society. There were no risks identified in the impact that were not anticipated at the planning stage. In particular, no factors that could affect the sustainability of the results in the future were identified at the time of the ex-post evaluation.

3.4.7 Status of Operation and Maintenance

The evaluator confirmed on site that there were no problems with the operational status of the distribution automation system or facility operation, and data rewriting and server updating were done properly in response to changes in power distribution equipment. Maintenance and management plans and databases for the project facilities were also in place. The maintenance status of the facilities in the two control centers and the outdoor facilities (sectionalizers, remote terminal units, RMUs, underground and overhead distribution lines) was also confirmed to have been problem-free and accident-free up to the time of the ex-post evaluation.

In preparing for the future commercialization (privatization) of the power distribution works and in monitoring the ever-expanding 11 kV power distribution network in Bengaluru city, the executing agency is keenly aware that it is essential not only to simply maintain the distribution automation system equipment, but to update it with an eye to future demand. To this end, they have already taken measures such as updating the equipment in accordance with technological advances and model changes, strengthening cyber security, reflecting information on electric vehicle charging stations and dispersed power sources, and linking the system to the optical fiber network.

No issues have been observed in the policy / system, institutional / organizational, technical, financial, and environmental and social aspects, including the current status of operation and maintenance. (Future) risks have been well mitigated. Therefore, sustainability of the project effects is very high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objective of this project was to improve the reliability of the electricity supply by the development of a distribution automation system in the Bengaluru metropolitan area, which includes the capital city of the State of Karnataka, in southern India, thereby contributing to local economic development and the improvement of living standards for residents in the areas concerned. The project addresses all three of these perspectives: consistency with national and state-level sector development plans and programs, the development needs at the time of appraisal and ex-post evaluation, and the appropriateness of the project plan and approach. The upgrading of telecommunication facilities, distribution automation, and control center development were considered and planned in a pioneering manner within Karnataka and in relation to other states, and were implemented with a coordinated design to optimize the development plan. Although no specific linkage or coordination with other JICA projects was confirmed, the project was sufficiently consistent with Japan's assistance policy at the time of appraisal, and specific results, such as linkage and coordination with assistance provided by the Asian Development Bank, could be confirmed. Therefore, the appropriateness and consistency of the project are high. Although the project cost was within the plan, the project period was significantly longer than planned, resulting in moderately low efficiency. The reasons for the prolonged project period include technical examinations for output changes, delays in re-tendering and the procurement of materials and equipment, redesign of the communication network, delays in frequency allocation, and prolonged period spent for a series of acceptance test and system integration. The operation and effect indicators generally reached the target values, and the qualitative effect of the project, stabilization of the power supply, was also achieved. Effects on business efficiency, such as the promotion of restoration in areas where the distribution automation system has not yet been introduced and the use of data in related departments, were also confirmed. These have led to improvements in customer service and customer satisfaction. In terms of impact, stabilization of the electricity supply did not have an effect on regional GDP or the amount of foreign investment, but it was confirmed that the project improved the living environment and contributed to regional economic development. The project had no impact on the natural environment, and no land acquisition or resettlement occurred. Therefore, the effectiveness and impact of the project are high. The operation and maintenance of the project has no problems in terms of policy and system, nor in the organizational / institutional, technical, financial aspects, or current conditions, and sustainability is ensured. In addition, preventive measures have been taken in terms of environmental and social considerations and risks. Therefore, the sustainability of the effects of this project is very high.

In light of the above, the 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

(1) Project formulation and approach that meet current trends in the relevant field (good practice)

The distribution automation introduced in this project was planned and initiated in advance of the trend to promote the upgrading of telecommunication facilities, distribution automation, and control centers in national and state-level sector development plans across the country. The executing agency played a pioneering role in the introduction of today's smart grid and digitalization, and laid the foundation for the full-scale introduction of renewable energy in the future.

In addition, the executing agency revised the project plan flexibly and accurately by reviewing the 11 kV distribution network development plan to accommodate the needs of the rapidly increasing population while maintaining harmony with the sector development plan. Furthermore, when the current Asian Development Bank-supported distribution line replacement, undergrounding of overhead lines, and smart metering installation was formed, their project components were examined to ensure that their planning should reflect this project.

These approaches at the time of project planning and in early stages of project implementation were proactively adopted by the executing agency, and can be used as good practices and as a reference for similar projects.

(2) Cross-organizational coordination and sector-wide initiatives (good practice)

In implementing the project, the executing agency integrated the distribution automation system installed under the project with other in-house systems and the systems of transmission and substation facilities owned by the KPTCL. Although this was one of the factors that prolonged the project implementation period, a systematic power transmission and distribution network was established in Karnataka, which not only ensured compatibility in data collection, analysis, and sharing, but also made it possible to study the state of the electricity supply by integrating the power transmission and distribution networks.

The project's effect was not limited to this single project, but extended to playing an important role in the electricity supply of the region concerned. The knowledge and experience gained by the executing agency from this successful project will serve as a useful lesson for similar projects in the future.

5. Non-Score Criteria

5.1 Performance

5.1.1 Objective Perspective

The project was continued with the executing agency's own funds after the extended loan disbursement period had expired. JICA India Office understood the executing agency's situation and supported it well, not only during the project implementation period, but also by supervising the progress from the end of the extended loan period (March 2017) to the completion of the project (June 2019). Even under the pandemic from the beginning of 2020, the JICA Office maintained good communications with the executing agency and built a relationship of trust with them. In addition, in conducting this ex-post evaluation, the JICA Office appropriately guided the executing agency in the direction of fulfilling their responsibilities by encouraging them to submit the project completion report.

5.2 Additionality

The executing agency was one of the first in India to make an organizational decision to introduce a distribution automation system. Taking into account the role that distribution automation plays in electricity supply services and the content and direction of the Government of India's development plans and schemes since the time of the project appraisal, the executing agency took the opportunity to review the plan at the start of the project with an eye on the future roles and functions required of a distribution company, and then the project was implemented.

The distribution automation system introduced in this project was completed as a result of individual negotiations with a total of 13 companies that received orders from within India and overseas and there was complicated mutual coordination for communication equipment procured by each company. At the same time, there was also mutual coordination and complementation with other systems within the executing agency. Similar coordination can be seen with the Asian Development Bank-supported project currently underway. Furthermore, there was coordination with transmission and substation equipment systems built by different manufacturers, which had been thought to be extremely difficult for different organizations to achieve together. These are still unprecedented in other states in India. The executing agency hopes to use the knowledge and experience gained through this project to provide consulting and advisory services to distribution companies in other states. In addition, the executing agency is considering the further development of control functions utilizing distribution automation system, as these functions will be indispensable for the introduction of renewable energy, the spread and expansion of dispersed power sources, electric vehicles, and charging stations, which have been promoted in India in recent years.

(End.)

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs		
a) Installation of ring main units (RMUs)	950 Nos.	790 Nos.
b) Installation of line reclosers and sectionalizers	965 Nos.	1,540 Nos.
c) Installation of remote terminal unit (RTU) for RMU	1,976 Nos.	1,590 Nos.
d) Installation of facilities at substations	56 Nos.	- (note)
e) Construction of main control centers	2 Nos.	2 Nos.
f) Retrofitting of existing RMU Operation Devices (ODs) with Vacuum Circuit Breaker (VCB) & Mechanism-two ODs	852 Nos.	Nil
g) Retrofitting of operation mechanism of existing RMUs with Gas Circuit Breaker (GCB)	324 Nos.	Nil
h) Retrofitting of existing RMUs with VCB with automatic operation	2,650 Nos.	Nil
i) Replacement of existing RMU by 3WAY new RMU with two ODs and one VCB	-	200 Nos.
j) Replacement of existing RMU by 5WAY new RMU with two ODs and three VCBs	-	600 Nos.
k) Improvement of underground distribution cable	450 km	230.5 km
l) Improvement of overhead distribution lines	675 km	949.6 km
m) Introduction of BESCOM Business Process IT Application	1 Set	Nil
n) Consulting Services	Work volume: 186 man-months in total <Terms of Reference> i) Review of detailed design, tender assistance, construction supervision ii) Technical transfer for O&M iii) Capacity Development	Work volume: 206.75 man-months in total <Terms of Reference> i) As planned ii) As planned iii) 11 kV Distribution Network Survey
2. Project Period	March 2007 – January 2012 (59 months)	March 2007 – June 2019 (148 months)
3. Project Cost Amount Paid in Foreign Currency Amount Paid in Local Currency Total ODA Loan Portion Exchange Rate	 6,549 million yen 7,656 million yen (3,038 million rupee) 14,205 million yen 10,643 million yen 1 rupee = 2.52 yen (As of September 2006)	 2,995 million yen 5,798.5 million yen (3,605 million rupee) 8,793.6 million yen 6,976 million yen 1 rupee = 1.74 yen (Average between 2008 and 2020)
4. Final Disbursement	March 2017	

Note: It was planned to install at the substations all of which belong to the KPTCL. It however was decided to use the telecommunication system of the executing agency's Division Offices and Sub-Division Offices (See 3.2.1).