Republic of Indonesia

FY 2015 Ex-Post Evaluation of Japanese ODA Loan Project

"Tarahan Coal Fired Steam Power Plant Project"

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0. Summary

This project constructed coal-fired steam power plants with the aim of establishing stable power supply system, and coping with tight supply-demand balance in Lampung in the Southern area of Sumatra Island. The project objectives – to diverse electric power sources by utilizing coal and to improve stability of power supply – are consistent with Indonesia's energy and power policies and with development needs as well as Japan's ODA policy which stipulated the assistance for developing the industrial base; thus, the relevance of the project is high. Although the project cost was within the plan, the project period significantly exceeded the plan; thus, efficiency of the project is fair. As Operation and Effect Indicators of this project were not set at the time of appraisal, the alternative indicators set at the time of ex-post evaluation were confirmed. Most of the executing agency's yearly targets were achieved and the power plants have largely generated its planned effects, producing electricity smoothly. The power plant is located in Lampung where reserve margin is the lowest in Sumatra Island and is playing an extremely important role to reduce power loss and to maintain quality of power supply in this area. Also, the project has been contributing to improving reliability of power supply, to establishing efficient power supply system, to reducing consumption of oil, to accumulating and sharing know-how of the new technology on Circulating Fluidized Bed (hereinafter referred to as "CFB") boiler in the executing agency, and contributing to local industrial development (economic effects). Therefore, effectiveness and impact of the project are high. No negative impacts on natural environment, land acquisition and relocation have been observed. No major problems have been identified in the institutional, technical and financial aspects of the operation and maintenance system as well as in the current status; thus, sustainability of the project effects is high.

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

1. Project Description

Project Location

Tarahan Coal Fired Steam Power Plant

1.1. Background

Electricity demand in the Sumatra Island was increasing responding to rapid economic growth. Especially electricity demand in Southern Lampung area accounted for approximately 40% of that of the whole of Sumatra, and was drastically increasing at an average rate of more than 10% per year. To meet the growing electricity demand of Southern Lampung area, where improvement of stability and reliability of power supply were urgent issues, coal-fired steam power plants and related facilities were constructed based on the Japanese ODA Loan "Engineering Services for Tarahan Coal Fired Steam Power Plant Project" signed in 1993.

1.2 Project Outline

The objective of the project is to increase the power supply in Lampung area in Sumatra Island by constructing coal-fired steam power plants (installed capacity of 200MW: 100MW x 2units) and related facilities for base-load power source, thereby contributing to improving stability of power supply and to increasing the efficiency of power supply system.

Loan Approved Amount/ Disbursed Amount	34,023 million yen / 26,783 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	January, 1998 / January, 1998
Terms and Conditions	Interest Rate 2.7% (Consultant 2.3%) Repayment Period 30 years (Grace period) (10 years) Conditions for Procurement General Untied

Borrower / Executing Agency	Republic of Indonesia / State Electricity Company (PT. PLN)
Final Disbursement Date	September, 2008
Main Contractor (Over 1 billion yen)	PT. Adhi Karya (Indonesia)/ Toa Corporation (Japan) (JV), Marubeni Corporation (Japan), P.T. Doosan Indonesia (Indonesia) / Alstom Corporation (Japan) / Mitsui Miike Machinery Co., Ltd. (Japan) (JV), PT. Alstom Power Energy System Indonesia (Indonesia) / Marubeni Corporation (Japan) / Alstom Power Inc. (USA) (JV)
Main Consultant (Over 100 million yen)	PT Jaya Konstruksi Manggala Pratama (Indonesia) / Tokyo Electric Power Services Co., Ltd. (Japan) (JV)
Feasibility Studies, etc.	・F/S (December, 1988) ・SAPS for Tarahan Coal Fired Steam Power Plant Project (E/S) (February, 1997)
Related Projects	Japanese ODA Loan (Loan Agreement signing year and month in parentheses) ・Tarahan Coal Fired Steam Power Plant Project (E/S) (November, 1993) Technical Cooperation ・Japan International Cooperation Agency (JICA) Development Study “Survey on power sector for the most optimum electric power resource development” (2002) ・JICA Expert (dispatched to the Ministry of Energy and Mineral Resources) (2011-2016) World Bank ・Technical Assistance (Assistance for restructuring corporation and finance led by PLN) ・Java-Bali Power Sector Restructuring and Strengthening Project (2003 - 2013)

2. Outline of the Evaluation Study

2.1 External Evaluator

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

2.2 Duration of Evaluation Study

Duration of the Study: October, 2015 – December, 2016

Duration of the Field Study: February 18, 2016 – March 25, 2016, June 16, 2016 – June 29, 2016

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

3.1 Relevance (Rating: ③[2])

3.1.1 Relevance to the Development Plan of Indonesia

At the time of appraisal, Government of Indonesia adopted National Medium Term Development Plan 1989-1993, which stipulated to promote non-dependence on oil as a basic policy, aimed to support industrial development by diversification of power resources and ensuring stable power supply. Moreover, in a power policy, new power source development in an environmentally-friendly manner was aimed. In this regard, construction of coal-fired power plants which alternate diesel-powered plants was preferred.

At the time of ex-post evaluation, National Medium Term Plan (hereinafter referred to as "RPJMN") (2015-2019) and Long Term Electricity Development Plan (hereinafter referred to as "RUPTL") (2015-2024) by the State Electric Company, PT. PLN (Persero)[3], stipulate to develop power sources which replace the utilization of economically inefficient energy resources such as diesel fuel and to strengthen power capacity through facilitation of energy mix. RUPTL states that planned target for the reserve margin in Sumatra to be 61% by 2024. For additional power source development, improving economical efficiency, utilizing the coal fuel in Sumatra, is promoted. In addition, the Jokowi administration, which was established in 2015, considers "Rural Development" as priority, and put up a policy to allocate funding for developing power supply outside of Java Island on a priority basis.

Therefore, implementation of the project is consistent with energy and power policy in Indonesia both at the time of appraisal and ex-post evaluation.

3.1.2 Relevance to the Development Needs of Indonesia

At the time of appraisal, coping with tight power supply-demand in South Sumatra and establishing stable power supply system were a pressing issue. Electricity demand in South Sumatra area accounted for approximately 40% of that of the whole of Sumatra, and was drastically increasing at an average rate of more than 10% per year. Reliability of power supply of existing power generation facilities was low and coping with rapid growth of power demand and deterioration of generating capacity were urgent issues. Although power source development continued to take place, reserve margin decreased year by year since increase of demand exceeded that of supply, thus, through responding to pressing needs of power demand and developing alternative power source to replace inefficient diesel, it was expected to enhance stability and reliability of power supply and efficiency of power

[1] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[2] ③: High, ②: Fair, ①: Low
[3] PT. Perusahaan Listrik Negara (Persero)

facilities in the region.

At the time of ex-post evaluation, increasing power generation capacity in the area continues to be an urgent issue[4] to tackle with. Especially, Lampung Province is one of the most serious areas facing power shortage. As shown in the Table 1, the reserve margin in Lampung is negative figure, significantly lower than 25%[5], which is considered to be necessary reserve margin for stable power supply, thus alleviation of the supply-demand balance is a pressing issue.

Table 1：Trend of Power Supply-Demand Balance and Reserve Margin
In Lampung System, the Sumatra Island

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
①Maximum Power Demand (MW)	288	387	423	457	482	538	623	690	675	737
②Power Supply (MW)	217	414	407	383	433	516	547	549	671	600
Reserve Margin (%) = (②-①)/①	-24.6	7.0	-3.8	-16.1	-10.1	-4.1	-12.2	-20.5	-0.5	-18.6

Source：Results from questionnaire survey of executing agency
Note：Power supply of power facilities constructed by this project commenced from December, 2007

3.1.3 Relevance to Japan's ODA Policy

The Country Assistance Policy for Indonesia by Japanese Government (prepared in February, 1994) indicated "industrial infrastructure development (economic infrastructure)" as priority area for assistance in Indonesia. In addition, from the viewpoint of rural development, providing assistance outside of Java Island was regarded as priority.

At the time of appraisal, power supply and demand in South Sumatra was tight and it was an urgent issue to improve the power supply and demand balance. Therefore, implementation of this project with the aim of developing power source for economic development in regional areas outside the Java Island was consistent with the above policy.

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

3.2 Efficiency(Rating: ②)

3.2.1 Project Outputs

This project is to construct coal-fired steam power plants (100MW x 2units) and related facilities (coal handling equipment, transmission facilities etc.) at Tarahan Coal Fired Power Plant. In this project, CFB boiler[6] is adopted, which is the first case in Indonesia.

[4] According to RUPTL 2015-2024, demand for power in Sumatra is expected to increase from 31.2TWh in 2015 to 82.8TWh in 2024, an average of 11.6% increase per year.
[5] Source: National Energy Policy (RUKN) 2003-2022 of the Government of Indonesia
[6] In the CFB boiler, coal is burned with combustion mediator (Silica sand). Since the thermal conductivity is

Table 2 shows the comparison of planned and actual project outputs.

Table 2： Comparison of Planned and Actual Project Outputs

Plan	Actual
Civil Works, Procurement of Equipments etc.	
・ Main power generating facilities (boiler, turbine equipment) 100MW x 2units (using Circulating Fluidized Bed boiler)	・ As planned
・ Coal Handling Equipment	・ As planned
・ Ash Handling Equipment	・ As planned
・ Electric facilities	・ As planned
・ Switchyard and transmission facilities (150kV GIS, 150kV transmission lines – 2 lines, 18km)	・ As planned
・ Relevant civil works and construction	・ As planned
Consulting services	
・ Consulting services (Assistance in tendering, construction supervision, inspection, testing and delivery control, assistance in operation and maintenance, assistance in environmental management, transfer of knowledge and technology, personnel training etc.)	・ As planned

Source：Results from questionnaire survey of executing agency

There was no change with respect to project scope for civil works and procurement of equipments etc.

As regards MM of consulting services, while the initial plan was 852MM, it turned out to be 986.66MM in actuality – significant increase of total MM (116% of the planned MM). This was due to the delay of conclusion of coal supply contract, which delayed project implementation. It was deemed necessary for consultants to be on board including prolonged project period, which resulted in increase of their inputs. Although the situation can not necessarily be regarded as efficient, it is understandable from the perspective of quality control.

Turbine in the Power Plant

high inside of the CFB boiler, the materials are burned efficiently. In addition, the combustion temperature is low, leading to lower NO_x emissions. Moreover, CFB boiler makes possible to desulfurize fuels inside the boiler, hence desulfurization equipment is not necessary.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The total project cost was initially planned to be 42,712million yen (out of which 34,023million yen was to be covered by Japanese ODA loan). Since the cost of land acquisition is unclear, comparison between the planned project cost excluding the cost of land acquisition, 42,204million yen, and actual cost excluding the cost of land acquisition, 34,635million yen (out of which 26,783million yen was covered by Japanese ODA loan) is carried out. The actual cost is within the planned cost (81% of the planned amount). In spite of significant increase of consulting services cost, the actual cost is lower than planned cost because of depreciation of the local currency (Indonesia Rupiah) compared with Japanese yen during project implementation.

3.2.2.2 Project Period

The overall project period was planned as 84months, from November, 1997 (conclusion of Loan Agreement) to October, 2004 (completion of warranty period) as opposed to 132months in actuality, from January, 1998 (conclusion of Loan Agreement) to December, 2008 (completion of warranty period), which is significantly longer than planned (157% of the initial plan). Loan period was extended in February, 2005 due to project delay, and the final loan period was set as September, 2008. Main reasons for project delay were: (1) delay of commencement of consultant selection due to economic and social conditions influenced by the Asian currency crisis (1997), (2) delay of identification of the coal kind, and (3) difficulties in negotiations with coal supplier under fluctuating market price of coal, in the absence of the regulation on domestic coal market obligation[7]. Since conclusion of coal supply contract was set as a necessary condition for tender announcement and concurrence of contract of civil works, the delay of coal supply contract has led to delay of tendering as well as overall project schedule.

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

Financial Internal Rate of Return

The financial internal rate of return (FIRR) calculated at the time of project appraisal was 9.8%, on the assumption that sales from power generated from the project to be considered as benefit, expenses for construction cost, fuel cost (coal), limestone cost, and operation and maintenance cost to be regarded as cost, and project life assumed to be

[7] In Indonesia, the new Mining Law enforced in 2009 imposed an obligation of domestic coal supply (obligation of prioritizing coal sale in domestic market) to coal supply companies. However, until 2009, there was no regulation on domestic coal supply obligation, hence, it took time to negotiate with coal suppliers which preferred to export coal.

25years. The FIRR recalculated at the time of ex-post evaluation based on the same assumptions as the appraisal turned out to be 8.9%. The reason for the lower figure in comparison with the figure at the time of appraisal can be attributed to the increase in fuel cost.

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

3.3 Effectiveness[8](Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

Since the Operation and Effect Indicators for this project were not set at the time of appraisal, the indicators (Maximum Output, Plant Load Factor, Availability Factor, Auxiliary Power Ratio, Gross Thermal Efficiency, Outage Hours due to Periodic Maintenance and Inspection, Outage Hours due to Human Error, Outage Hours due to Machine Trouble and Annual Power Production) were established at the time of ex-post evaluation. Since the figures after 2years of project completion, from 2010 to 2012 were not available at the time of ex-post evaluation, comparison was made between the target figures[9] and the actual achievement figures from 2013 to 2015. (Refer to Table 3)

[8] Sub-rating for Effectiveness is to be put with consideration of Impact.
[9] The targeted figures are set based on the contract which is concluded every year between PLN (Headquarter) and PLN Head Unit in Palembang (upper unit of PLN Tarahan), which supervises 10 existing power plants in 4 provinces in Southern area of the Sumatra Island.

Table 3：Operation and Effect Indicators

(Unit 3 and Unit 4 of Tarahan Coal Fired Power Plant[10])

Indicator	Target			Actual		
	2013	2014	2015	2013	2014	2015
	5Years after Completion	6Years after Completion	7Years after Completion	5Years after Completion	6Years after Completion	7Years after Completion
Maximum Output (MW) Note1)	100×2	100×2	100×2	100×2	100×2	100×2
Plant Load Factor (%) Note 2)	89	91	90	90	93	90
Availability Factor (%) Note 2)	81	78	75	82	82	78
Auxiliary Power Ratio (%) Note 2)	12	11	11	11	11	11
Gross Thermal Efficiency (%) Note 2)	-	-	-	38	39	34
Outage Hours due to Periodic Maintenance and Inspection (hour/year) Note1)	2,880	-	1,968	1,767	1,403	1,205
Outage Hours due to Human Error Note1)	-	-	-	-	-	-
Outage Hours due to Machine Trouble Note 1)	1,008	-	1,042	1,032	1,250	1,743
Annual Power Production (GWh/year) Note1)	1,227	1,268	1,291	1,285	1,327	1,227

Source：Information provided by JICA, and results from questionnaire survey of executing agency
Note 1) Total amount of Unit 3 and Unit 4
Note 2) Average of Unit 3 and Unit 4
Note 3) The year of project completion = the year of completion of Warranty Period is 2008

According to the actual achievement figures of the Operation and Effect Indicators, most of the yearly targets were achieved and power plants have been generating electricity mostly smoothly. However, according to the executing agency, the power plants had been encountering unexpected power outages[11] frequently due to troubles s from 2009, two years after the commencement of power plant operation, to 2012 which led to power production loss (GW/h).

Based on the situation mentioned above, it is considered that the target indicators from 2013 to 2015 were adjusted, taking into consideration of the past damages. Therefore it is difficult to analyze the effectiveness of the power plants only by the fact that most of the

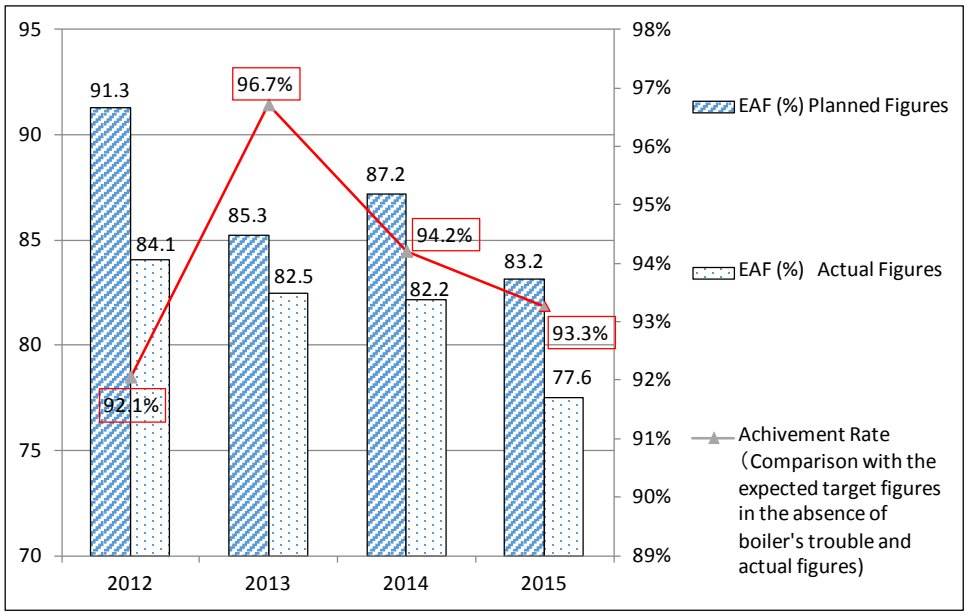
[10] This project constructed the Unit 3 and Unit 4 power plants at the Tarahan coal fired steam power plant. Although the Unit 1 and Unit 2 power plants were planned to be constructed by PLN's own funds, they have not been constructed at the time of ex-post evaluation.

[11] According to the executing agency, as a reason of sudden outage, the abrasion of the boiler pipe by the burning material (Silica sand) of CFB boiler was pointed out. This abrasion was considered as the problem of the design itself.

targets set by the executing agency were achieved from 2013 to 2015.

Accordingly, the Equivalent Availability Factor (hereinafter referred to as "EAF[12]"), which is one of the performance indicators standardized by the executing agency was taken in and comparison between planned figures and actual figures (average figures of Unit 3 and Unit 4) from 2012 to 2015 were made. As a result, it revealed that the power plants have achieved 90% or above the planned targets. (Refer to Figure 1). The planned figures calculated by the executing agency are the expected figures supposing there was no above-mentioned boiler trouble.

Due to the problem in the boiler design, power plants have encountered frequent troubles, which affected the effectiveness such as creation of power production loss. However, the actual achievement of EAF is 90% or above the planned target which is estimated in the absence of boiler troubles. Therefore, it is considered that enough effectiveness has been generated, based on the originally expected level.



Source：Prepared by the evaluator based on the information provided by executing agency

Figure 1： EAF of the Tarahan Coal Fired Steam Power Plant
(Planned Figures and Actual Figures between 2012 and 2015)

3.3.2 Qualitative Effects

Table 4 summarizes the share of net capacity of the power plants in the Central and Southern Sumatra System and in Lampung System.The share in the Central and Southern Sumatra System is 4.74% which implies that the project's contribution to the improvement

[12] EAF (Equivalent Availability Factor)：It is calculated by equalizing the operating ratio (percentage of annual operational hours including stand-by hours), taking the sudden outage time and outage hour due to maintenance into consideration.

of power supply-demand balance and increase of reserve margin in the region is limited. On the other hand, considering that the power plants are located in Southern Lampung area, a largest power demand area, and the share of the net capacity in the Lampung System is 29.67%, it can be said that the power plants play an important role to ensure stability of power supply of the same system and to maintain quality of electric power. (Refer to "3.4 Impact" below.)

Table 4：Share of Tarahan Coal Fired Steam Power Plant (Unit 3 and Unit 4)

Net Capacity[13] (2015)	Net Capacity of the Power Plants (2015)	Share
Central and Southern Sumatra System：3,758MW	178MW	4.74%
Lampung System：600MW		29.67%

Source：Information provided by JICA, and results from questionnaire survey of executing agency

3.4 Impacts

3.4.1 Intended Impacts

Among power facilities constructed by this project, the Unit 3 commenced its operation in December, 2007 and the Unit 4 commenced in October, 2007. Therefore, in regard to the Lampung System, the figures before commencement of operation (before 2007) and the figures after commencement of operation (since 2008) were compared (Refer to the Table 1 above.) Although the reserve margin was minus at the time of ex-post evaluation, the average of reserve margin from 2008, which is just after commencement of operation, to 2015 is -10.7%. Improvement has been seen when compared with reserve margin before this project.

The Lampung System, the area of tightest power demand-supply in the Sumatra Island, adjusts its supply and demand gap through power interchange from other systems of other provinces and from Central and Southern Sumatra System. Considering that the power plants are located in Lampung where reserve margin is the lowest in Sumatra Island, the project is playing an extremely important role to ensure the stability of power supply and maintain quality of power supply in Lampung as well as Central and Southern Sumatra System, hence contributing to the improvement of reliability of power supply[14].

In addition, according to the executing agency, it can be said that the CFB boiler which

[13] Net capacity is equivalent to gross capacity or installed capacity minus the amount of power consumed within a power plant.

[14] The executing agency explained the following as its logic: when the place for power generation is far from power consuming area (when power transmission distance is long), electric resistance increases and power loss increases, hence power voltage reduces. Since power transmission from other systems or provinces can cause increase of the power loss and decline of power voltage, it is important to generate power in the same area with the aim of ensuring the stability of power supply and maintaining quality of power supply.

was adopted in Tarahan power plant, can generate power with lower costs than using the former boilers. Therefore, it can be considered that Tarahan power plant has contributed to the establishment of efficient power supply system. Moreover, the proportion of oil dependence for fuel declined from 6% (483.1GW/h) in 2006 to 1.9% (355.0GW/h) in 2015 in Central and Southern Sumatra System when looking at power production composition ratio based on the fuel kinds, thus, it can be said that Tarahan power plant has contributed to the reduction of oil consumption.

Furthermore, it was confirmed that the accumulated operational know-how on CFB boiler from Tarahan coal fired steam power plant, the first power plant which adopted the CFB boiler in Indonesia, has been utilized for the planning and operation of other power plants[15]. Since the executing agency has established internal knowledge-sharing system for sharing challenges and know-how on boiler maintenance, improvement of technology and accumulation of operation know-how have taken place, and new power plants adopting the CFB boiler have been disseminated all over the country at the time of ex-post evaluation.

3.4.2 Other Impacts

3.4.2.1 Impacts on the Natural Environment

After the Environmental Impact Assessment Report (hereinafter referred to as "AMDAL") was approved in 1992, the revised AMDAL was drawn due to the change of installed capacity (from 130MW to 200MW). In 1996, revised AMDAL was approved together with the Environmental Management Plan (hereinafter referred to as "RKL") and the Environmental Monitoring Plan (hereinafter referred to as "RPL").

The executing agency conducted environmental monitoring before and during the project as well as after commencement of operation, and no particular negative environmental impact has been reported. The results of the environmental monitoring after the commencement of operation show that all the indicators have met national environmental standards regulated by the Indonesian Government (Ministry of Environment). Tarahan power plant is receiving "Certificate of Blue", which authenticates "satisfactory" in complying with the environmental requirements. In addition, no major issue on negative environmental impacts has been identified form the results of interview with local residents[16].

[15] Normally the CFB boilers are utilized for power plants with capacity of around 100MW class. At the time of ex-post evaluation, based on accumulation of know-how at the Tarahan power plant, CFB boilers are introduced in power plants with capacity of around 400MW class. In addition, there are 7 or more coal-fired power plants which have introduced CFB boilers all over the country.

[16] Although the dust was generated during construction of power plant, the countermeasures for the dust (planting bamboos) were taken by the executing agency. Hence, there were no huge negative impacts.

3.4.2.2 Land Acquisition and Resettlement

Regarding land acquisition and resettlement, necessary land was already acquired prior to the project, and resettlement was taken place based on the compensation policy without particular problems. Through interview survey with the local residents, no complaints or problems were identified in regard to resettlement process.

From the above results, this project has generally achieved its objectives as planned. Therefore effectiveness and impact of the project are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

The operation and maintenance of the power plants after project completion is undertaken by PLN Tarahan. Previously, PLN Region IV Office used to be in charge of operation and maintenance of the Tarahan coal-fired steam power plant, however, after restructuring of PLN in 2015, PLN Region IV Office was dissolved and its role has been transferred to PLN Head Unit in Palembang, which is the upper unit of PLN Tarahan. PLN Head Unit in Palembang is in charge of coordinating operation and decision-making within the region, supervising the existing 10 power plants located in Southern area of the Sumatra Island. PLN Tarahan and PLN Head Unit in Palembang have a close cooperation system, hence necessary budget and human resources etc. are duly allocated.

PLN Tarahan allocates division managers who take responsibility for engineering, operation, maintenance, administration and finance under the head of the plant. Approximately 100 staff members work at the whole power plant. As regards necessary number of engineers who are in charge of operation and maintenance, allocated number is more than the target[17] set by PLN Tarahan. Although there was change of organizational structure for maintenance, the responsibilities and decision making process among organizations are clear and there is no particular problem on the operation and maintenance system.

3.5.2 Technical Aspects of Operation and Maintenance

In regard to the CFB boiler, technical troubles had occurred frequently for about 20 times per year since 2009, after two years of commencement of operation, until 2012. As for maintenance, the executing agency couldn't directly contact with the designer of boiler or vender of spare parts[18]. In spite of this situation, the executing agency tried to solve the

[17] PLN Tarahan set up the targeted number of appropriate human resource allocation to be 86 staffs (operation: 48 staffs, maintenance: 38 staffs)

[18] In addition to no assistance from designer of the boiler and contractors, it was unable to contact directly with spare-part venders when exchanging spare parts.

problems and promoted internal knowledge sharing[19], and successfully secures smooth operation now. Moreover, the internal knowledge-sharing system for design and maintenance for next-generation CFB boiler power plants has been established, from experiences and lessons learned acquired from this power plant regarding repair, maintenance management and maintenance plan of CFB boiler. Today PLN has become recognized as one of the specialized agencies on CFB boiler in Indonesia[20].

In regard to operation and maintenance, engineers who have gained sufficient power plant operation experiences and have been qualified by Indonesia Electricity Power Expert Association are undertaking the operation and maintenance work of the power plants. Engineers are required to take training based on their professional areas and levels of qualification. Moreover, on the job training is provided for operation and maintenance staffs. Therefore, it can be observed that adequate management system for human resource development has been established. In addition, the manuals of operation and maintenance and the recording data systems[21] developed by the project are utilized for daily operation and maintenance work. Furthermore, the PLN Tarahan has acquired ISO 90001 (quality management system), ISO 14001 (environmental management system), ISO 28000 (safe management system of supply chain), OHSAS 18001 (occupational health and safety management system) etc., and operation and maintenance of Tarahan power plant has been taken place in conformity with these management systems. Therefore, no particular problem has been identified regarding the technical aspects of operation and maintenance.

3.5.3 Financial Aspects of Operation and Maintenance

The operation and maintenance costs are estimated by PLN Tarahan, and the estimation will be applied for Head Unit in Palembang and then approved by PLN Headquarter. After this process, budget will be allocated based on the contract with Head Unit in Palembang. Table 5 shows comparison of actual budget allocation and actual expenditure of operation and maintenance cost of the power plant after project completion. The power plant's maintenance cost has been properly secured[22], and is well operated and maintained.

Therefore, no particular problem has been identified regarding the financial aspects of operation and maintenance.

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[19] Meetings with the aim of sharing current problems of maintenance and repair of CFB boiler and discussing solutions have been held regularly at the PLN Head Unit in Palembang and PLN Learning Center.

[20] Many domestic and foreign engineers and groups concerned with coal-fired steam power plants have visited to PLN to learn about its technology and management know-how on CFB boiler. Moreover, the technical know-how and experience from Tarahan coal-fired steam power plant are disseminated by sharing the materials through E-learning and other documents at internal portal site and by holing relevant open seminars.

[21] Record data system on the efficiency and performance of the power plant.

[22] It was confirmed that there is no problem on the timing of budget allocation. In case when unplanned additional budgets were necessary, budgets were allocated promptly by ex-post application.

Table 5：Operation and Maintenance Cost of the Power Plant

(Unit: million IDR : Indonesian Rupiah)

2013		2014		2015	
Actual Allocation	Actual Expenditure	Actual Allocation	Actual Expenditure	Actual Allocation	Actual Expenditure
663,711	492,697	552,844	531,338	589,848	573,327

Source：Results from questionnaire survey of executing agency

3.5.4 Current Status of Operation and Maintenance

In Tarahan power plant, the long-term (five year-term) Maintenance Plan has been developed and it sets down the types of maintenance, necessary budget and cycle of maintenance. Based on this, maintenance activities have been conducted appropriately and no particular problem has been observed. Specifically, major inspections (every four years), regular inspections (twice a year (every 4,000hours of operation)), daily maintenance, condition based maintenance, preventive maintenance (inspection of related facilities, etc.) (every 52weeks) and predictive maintenance[23] are conducted.

Regarding regular inspection, the frequency of inspection has been increased[24] since 2009, based on the situation where PLN Tarahan had been encountering frequent boiler troubles. By conducting frequent regular maintenance and inspection activities, frequency of condition based emergency maintenance as well as sudden power shortage was reduced. For example, according to PLN Tarahan, the annual outage hours due to boiler trouble was reduced from 1,316hours (in 2009) to 777hours (in 2015). The number of frequency of boiler trouble was declined as well from approximately 20 times since after 2010 to less than five times a year after 2013. As regards spare parts, the power plant has introduced a supply chain management system and inventory management system (a system which minimum necessary stocks for maintenance are secured and stored in the ware-house of PLN Tarahan), thus, spare parts have been procured on a timely basis.

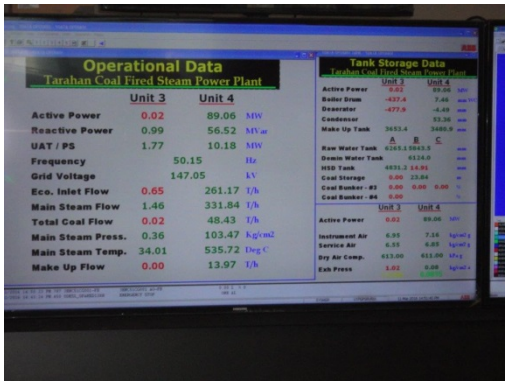
Although there were technical troubles with CFB boiler, based on the lessons learned, the executing agency has been successfully managing and operating the facilities adequately by increasing the frequency of regular maintenance, developing human resources of engineers and establishing adequate inspection system.

Therefore, no particular problem has been identified regarding current status of operation and maintenance.

[23] Maintenance activities for preventing machine troubles in advance by predicting problems beforehand and taking countermeasures.

[24] The frequency of inspection was changed from once a year to twice a year (every 4,000hours of operation) with the aim of reducing the accident rate and preventing sudden outage.

A Staff Bringing Combustion Mediator (Silica Sand) which is Used for CFB Boiler



A Scene of the Central Management Room (Display of the PC Monitor)

Therefore, no major problems have been observed in the institutional, technical and financial aspects of the operation and maintenance system. Therefore sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project constructed coal-fired steam power plants with the aim of establishing stable power supply system, and coping with tight supply-demand balance in Lampung in the Southern area of Sumatra Island. The project objectives – to diverse electric power sources by utilizing coal and to improve stability of power supply – are consistent with Indonesia's energy and power policies and with development needs as well as Japan's ODA policy which stipulated the assistance for developing the industrial base; thus, the relevance of the project is high. Although the project cost was within the plan, the project period significantly exceeded the plan; thus, efficiency of the project is fair. As Operation and Effect Indicators of this project were not set at the time of appraisal, the alternative indicators set at the time of ex-post evaluation were confirmed. Most of the executing agency's yearly targets were achieved and the power plants have largely generated its planned effects, producing electricity smoothly. The power plant is located in Lampung where reserve margin is the lowest in Sumatra Island and is playing an extremely important role to reduce power loss and to maintain quality of power supply in this area. Also, the project has been contributing to improving reliability of power supply, to establishing efficient power supply system, to reducing consumption of oil, to accumulating and sharing know-how of the new technology on CFB boiler in the executing agency, and contributing to local industrial development (economic effects). Therefore, effectiveness and impact of the project are high. No negative impacts on natural environment, land acquisition and relocation have been pointed out. No major problems have been observed in the

institutional, technical and financial aspects of the operation and maintenance system as well as in the current status; thus, sustainability of the project effects is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

The importance of risk analysis in order to ensure implementation of the fuel procurement plan

The main reason for project delay was the failure of securing coal supply in a timely manner. Since conclusion of coal supply contract was set as a necessary condition for tender announcement and JICA's concurrence of contract of civil works, the delay of securing coal supply has led to delay of overall project schedule.

Such significant project delay and extension of disbursement date could have been avoided to some extent by setting schedules based on results of detailed risk analysis and by working out risk control countermeasures prior to the commencement of the project. In this respect, when similar projects are planned in the future, it is necessary to set an appropriate schedule plan and devise risk control measures taking into consideration the expected time necessary for contract negotiation with fuel suppliers and the risk analysis regarding fuel supply purchase contract.

The importance of securing follow-up and after-care system when introducing new technology in a project

This project was the first coal fired steam power plant project which adopted the CFB boiler in Indonesia, and the executing agency has faced with technical boiler troubles. The executing agency tried to solve the problems by taking measures on its own efforts such as conducting frequent maintenance and inspection activities, and sharing lessons learned and knowledge within the organization, thereby successfully secures smooth operation now. On the other hand, there were not enough after-care services from the contractor, therefore additional tasks for the executing agency on maintenance such as repair works and replacement maintenance on its own have increased. In this regard, for some executing agencies, which do not have enough institutional system and capacity, would not have fully

managed the situations. Therefore, in the case of preparing similar projects adopting new technology which the executing agencies do not have prior knowledge and experiences, it is crucial to conduct design for various facilities based on an appropriate risk analysis conducted at the F/S stage and to ensure enough after-care system after the introduction of the new technology t as well.

End

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs	1) Civil Works, Procurement of Equipments etc. ・ Main power generating facilities (boiler, turbine equipment) 100MW x 2units (using Circulating Fluidized Bed boiler) ・ Coal Handling Equipment ・ Ash Handling Equipment ・ Electric facilities ・ Switchyard and transmission facilities (150kV GIS, 150kV transmission lines – 2 lines, 18km) ・ Relevant civil work and construction 2) Consulting Services ・ Assistance in tendering, construction supervision, inspection, testing and delivery control, assistance in operation and maintenance, assistance in environmental management, transfer of knowledge and technology, personnel training etc.	1) Civil Works, Procurement of Equipments etc. ・ As planned ・ As planned ・ As planned ・ As planned ・ As planned ・ As planned 2) Consulting Services ・ As planned
2. Project Period	November, 1997 – October, 2004 (84months)	January, 1998 – December, 2008 (132months)
3. Project Cost Amount Paid in Foreign Currency Amount Paid in Local Currency Total Japanese ODA Loan Portion Exchange Rate	 34,023million yen 8,689million yen (167,096million IDR) 42,712million yen 34,023million yen 1IDR＝0.052yen (As of May, 1997)	 26,783million yen 7,863million yen (639,262million IDR) 34,646millon yen 26,783million yen 1IDR＝0.0123yen (Average between 2001 and2008)