Republic of Indonesia

FY2017 Ex-Post Evaluation of Japanese ODA Loan

"Keramasan Power Plant Extension Project"

External Evaluator: Kenichi Inazawa, Octavia Japan Co., Ltd.

0. Summary

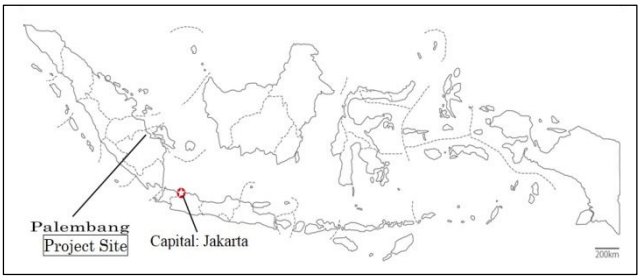
This project aimed to increase the electricity supply capacity, to improve the stability of supply, and to mitigate tight supply-demand conditions for grid electricity at Keramasan Power Plant connected to the South Sumatra Grid on the island of Sumatra, by expanding the plant's combined cycle power generating facilities; thereby, contributing to improve the investment environment and economic development in the South Sumatra area. Relevance of this project is high because of its confirmed consistency with the policies on the development of new power generation facilities and electricity supply presented in the *General Plan for National Electricity*[1] established by the Government of Indonesia and the *Electricity Supply Business Plan* prepared by the State Electricity Company (Perusahaan Listrik Negara; hereinafter; "PLN"), the executing agency, and with the country's development needs for addressing growing electricity demand as well as the assistance policy of the Japanese government. As for efficiency, project outputs were implemented mostly as planned, and project costs were within the initial plan thanks to the effects of foreign exchange rates and the tax exemption placed on gas turbine generating facilities. In contrast, the project period exceeded the plan by a large margin because more time was required than anticipated for selection procedures for the consultant and contractor. Thus, the efficiency is fair. In terms of the project's quantitative effect indicators, maximum output, plant capacity factor, plant availability, gross thermal efficiency, and net electric energy production have generally achieved target values since 2015, and because it is believed that this is underpinning the avoidance of risk of tight supply-demand for electricity and the stable supply of electricity within this grid, the effectiveness and impact of this project are high. There are no particular concerns in terms of institutional, technical or financial aspects of the PLN Keramasan District Office (Hereinafter; "PLTGU Keramasan"), which is responsible for the operation and maintenance of this project. Although a fuel nozzle for the Unit 1 generating facility burned out in February 2017, requiring repairs, and operations were stopped until the end of October 2017, at the time of the ex-post evaluation, repair work had been completed and operations restarted. There have not been other problems in terms of the operation and maintenance of other equipment and facilities. Thus, the sustainability of the

[1] Indonesian is Rencana Umum Ketenagalistrikan Nasional (RUKN).

effects realized through this project is high.

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

1. Project Description



Project Location

Power Plants Developed by this Project

1.1 Background

Indonesia faced tightening supply-demand conditions for electricity following the country's population growth and economic development. Prior to the start of this project (2004), electricity demand was expected to grow at a rate of about 6.4% per year on average, with the total capacity of power generation facilities required by 2013 estimated to be approximately 7,400MW for Java and Bali, approximately 1,300MW for South Sumatra, approximately 1,200MW for North Sumatra, approximately 600MW for Batam, and approximately 400MW for South Sulawesi. As a result, the country was faced with the pressing need to address this growing demand for electricity. In particular, in the South Sumatra area, where this project is located, robust economic growth was forecast for the future given the active investment taking place, while at the same time the supply-demand balance of electricity was expected to tighten in the near future. In addition, since the Asian Currency Crisis of 1997, PLN faced difficulties in developing new power plants using its own funds; therefore, development funded by other sources, including those outside the country, was considered an urgent task.

1.2 Project Outline

The objective of this project is to increase the capacity of electricity supply, alleviate tight power demand and supply situation, and improve the stability of supply, by expanding combined cycle power generation facility in Keramasan Power Plant connected to the South Sumatra Grid on the island of Sumatra, thereby contributing to improve the investment

environment and economic development in the South Sumatra area.

Loan Approved Amount/ Disbursed Amount	9,736 million yen / 9,677million yen
Exchange of Notes Date/ Loan Agreement Signing Date	March 29, 2005 / March 31, 2005
Terms and Conditions	Interest Rate: 1.3% Repayment Period: 30 years (Grace Period: 10 years) Conditions for Procurement: General Untied
Borrower / Executing Agency	Republic of Indonesia / State Electricity Company (PT. PLN)
Project Completion	December 2014
Main Contractors (Over 1 billion yen)	Marubeni Corporation (Japan)
Main Consultants (Over 100 million yen)	-PT. Connusa Energindo (Indonesia) / CHUBU Electric Power Co.,Inc. (Japan) / Electric Power Development Co.,Ltd. (Japan) /PB Power（NZ）Ltd （New Zealand）（JV）- NEW JEC Inc. (Japan)
Related Studies (Feasibility Studies, etc.)	F/S: March, 2003
Related Projects	None

2. Outline of the Evaluation Study

2.1 External Evaluator

Kenichi Inazawa, Octavia Japan Co., Ltd.

2.2 Duration of Evaluation Study

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

Duration of the Study: July 2017 - August 2018

Duration of the Field Study: October 2-15, 2017 and February 11-15, 2018

3. Results of the Evaluation (Overall Rating: A[2]).

3.1 Relevance (Rating:③[3])

3.1.1 Consistency with the Development Plan of Indonesia

According to the *General Plan for National Electricity* prepared by Indonesia's Ministry of Energy and Mineral Resources in April 2004, the installed generating capacity of the entire

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

[3] ③: High, ②: Fair, ①: Low

country was declining due to aging facilities, among other factors. Also, this same plan forecasted that the South and North Sumatra Grid would see tightening supply-demand following future population growth and economic development. The plan cited the importance of hydroelectricity for North Sumatra, gas for South Sumatra, and geothermal resources for Lampung as future energy sources. In other words, it can be said that this project, which expanded combined cycle power generation facilities in South Sumatra fueled by gas as an energy source, was consistent with the development policies of the Indonesia government.

At the time of the ex-post evaluation, the Government of Indonesia prepared the *National Energy Policy*[4] in January 2014. This policy has stated a target of increasing the entire country's generating capacity from 51GW in 2014 to 115GW by 2025 and 430GW by 2050. In the *General Plan for National Electricity* (2012 to 2031) at the time of the ex-post evaluation, an electricity supply plan has been stated focusing on the avoidance of electricity supply shortages and the development of gas and pumped storage power plants for peak demand load to minimize the use of fossil fuels. Furthermore, PLN, the executing agency for this project, has established an *Electricity Supply Business Plan*[5] in 2012 (running from 2012 to 2021). This plan advocates the alleviation of electricity supply shortages, further improvements in electricity reliability and quality, and reduction in basic production costs by optimizing the power mix, etc., as goals to be achieved. At the same time, PLN has indicated it will work to lower emissions of greenhouse gases under its philosophy of "activities with an eye on the environment." As part of this, PLN is aiming to transition from the use of fossil fuels to the use of gas at gas-fired thermal power plants in order to lessen its use of fossil fuels[6].

In light of the above, through the time of appraisal and ex-post evaluation, the Government of Indonesia continues to place importance on the development policy of the electric power sector including the improvement of electricity supply capacity. Thus, the project is acknowledged as consistent with the policies and measures laid out in the national plan and sector plan both at the time of appraisal and at the time of the ex-post evaluation.

3.1.2 Consistency with the Development Needs of Indonesia

Prior to the start of this project, peak demand on the South Sumatra Grid was expected to nearly double from 1,132MW in 2003 to 2,429MW in 2013. The installed generating capacity

[4] Indonesian is *Kebijakan Energi Nasional (KEN)*
[5] Indonesian is *Rencana Usaha Penyediaan Tenaga Listrik (RUPTL)*
[6] According to *Electricity Supply Business Plan* and PLN, the reason for this shift is directly linked to the reduction of greenhouse gas emissions.

of this same grid in 2003 was 1,607MW, but in 2007 a diesel-fired power plant in operation was expected to be decommissioned due to aging, and as a result, the supply capacity was expected to drop by about 273MW, the capacity of this power plant. Given this, PLN faced difficulty in delivering a stable supply of electricity since 2008 and it predicted that it would face similar difficulties in addressing peak demand of the future. In other words, increasing new installed generating capacity on the grid was an urgent task.

At the time of the ex-post evaluation, Indonesia continues to be at high risk of tightening supply-demand conditions for electricity. According to PLN, it is recognized that when the supply reserve ratio of electricity in Indonesia drops below 30%, the risk of tightening supply and demand becomes high. Table 1 shows the supply-demand results for electricity for the South Sumatra Grid. Electricity demand is rising, and the reserve ratio continues to fall when looking at the results up to 2016. The reserve ratio stood at 16.2% in 2016, indicating the need for improvement as yet. Additionally, Table 2 shows the electricity supply-demand and future forecast (2018 to 2021) for the South Sumatra Grid. The table indicates that the supply-demand condition has been tight up to 2018. Taking into account the above, the Government of Indonesia is striving to secure generating capacity by promoting nationwide, including the South Sumatra area, the program called "35,000MW for Indonesia[7]" to expand power generation facilities with an additional output of approximately 35,000MW. Moreover, PLN is striving to achieve a stable supply of electricity by implementing *a transformer expansion project in Gunawan*, South Sumatra, and *the Sumatra program for reinforcing the electricity grid*, which aims to improve the electricity supply system of the South Sumatra Grid.

Table 1: (Actual) Electricity Demand and Supply for the Southern Sumatra Grid (2010-2016)

	Unit	2010	2011	2012	2013	2014	2015	2016
Peak demand	MW	2,140.7	2,321	2,520.5	2,749.2	2,955.4	3,143.4	3,513.4
Installed capacity	MW	2,569.3	2,858	3,164	3,227.9	3,836.1	3,904.7	4,083.3
Reserve ratio *Note	%	20	23.1	25.5	17.4	29.8	24.2	16.2

Source: PLN
Note: The reserve ratio by PLN is calculated as "(Installed capacity ÷ peak demand) - 1)".

[7] Indonesian is *35.000 MT Untuk Indonesia*.

(Reference) Table 2: Future Prediction of Electricity Demand and Supply for the Southern Sumatra Grid (2018-2021)

	Unit	2018	2019	2020	2021
Peak demand	MW	3,889	4,279	4,958	5,679
Installed capacity	MW	4,634	6,204	7,480	8,756
Reserve ratio	%	19	45	51	54

Source: PLN

In light of the above, securing power generation capacity and achieving stable supply of electricity at the time of appraisal and ex-post evaluation are major issues for the South Sumatra Grid. Thus, it can be said that the project is consistent with the development needs of the area both at the time of the appraisal and at the time of the ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

The Government of Japan's *Country Assistance Program for the Republic of Indonesia* (November 2004) cited "sustainable growth led by the private sector" as one of the important areas of focus. The same document cited economic infrastructure development for the improvement of the investment environment as one way of supporting the fulfillment of this important area of focus. Meanwhile, JICA prepared the *Medium-Term Strategy for Overseas Economic Cooperation Operations* (April 2002), which cited "infrastructure development aimed at economic growth" and "support for regional development" as important areas of focus. It clearly stated that support will be provided to encourage economic development through the development of economic and social infrastructure, including electricity, as a specific way of fulfilling this policy. Moreover, JICA established the *Country Assistance Strategy for Indonesia* (September 2004), which cited the development of an environment for growth led by private sector investment as one of the important areas of focus. Within the assistance policy for major sectors, it specified the four points of stable supply of electricity, greater efficiency of the electric power sector, increased electrification rate, and environmental measures as issues facing the electric power sector. In addition, the policy stated, "Actively support the new construction and expansion of generating facilities in the region and projects for expansion of the coordinated transmission grid, aimed at a stable supply of electricity in the major economic centers of Sumatra and Sulawesi."

In light of the above, this project is considered to have strong consistency with Japan's assistance policy because the electricity supply created by the generation facilities developed by this project can be expected to underpin the economic growth of the island of Sumatra.

This project has been highly relevant to the Indonesia'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 expanded combined cycle power generation facility in Keramasan Power Plant connected to the South Sumatra Grid on the island of Sumatra. Table 3 contains planned and actual outputs of this project. The outputs were largely in line with the original plan.

Table 3: Planned and Actual Outputs of this Project

Planned at the Time of Appraisal (2004)	Actual at the Time of Ex-post Evaluation (2017)
1) Construction Works, Procurement of Equipment, etc	
(a) Combined Cycle Power Generation Facility (80 MW class) ① Installation of gas turbine and generating facilities (two units) ② Installation of steam turbine and generating facility (two units) ③ Installation of heat recovery steam generator (two units) ④ Extension of accessory equipment (gas supply equipment, 150 kV switchyard, etc.) necessary for the above equipment (b) Related Civil Engineering and Construction Work (c) Cooling Water System (d) Desalination, Pure Water Equipment (e) Spare Parts (quantity necessary for operation / repair for 2 years after start of operation)	Mostly implemented as planned. (The capacity of the gas combined cycle power generation facility changed to 75 MW.)
2) Consulting Services	
(a) TOR related to the construction and operation of power station: ①Detailed design, ②bidding assistance, ③ construction supervision, ④ performance evaluation, ⑤assistance for operation and maintenance, ⑥assistance for environmental management, ⑦ technology transfer and human resource development, etc.	Implemented as planned.

(b) Assistance for strengthening planning functions of PLN and South Sumatra local government officials: ①Assistance for electric power supply and demand anticipation, ② establishment of anticipation system, ③ assistance for optimum power supply development plan capacity, ④assistance for transmission and distribution cable construction plan, ⑤ assistance for making investment plan	

Source: Documents provided by JICA, answers on questionnaire and on-site visits (actual results at the time of ex-post evaluation)

1) In regard to the capacity of the gas combined cycle generating facilities under the category of construction work and procurement of equipment, changes were made at the time of the detailed plan after the start of the project, with the rating from 80MW in the initial plan to 75MW. The reason for this change is cited as the daytime temperature near the Keramasan Power Plant is high causing the generating efficiency to fall[8]; therefore, it was determined through a field investigation at the time of the detailed plan that it would be difficult to increase the output to 80MW[9].

3.2.2 Project Inputs

3.2.2.1 Project Cost

The plan at the time of the project's appraisal called for a total project cost of 11,455 million yen (of this, 9,736 million yen was to be covered by yen loans). In contrast, the actual total project cost was 10,414 million (of this, 9,677 million yen was covered by yen loans), indicating the cost was within the plan (91% versus the plan). The reason for this is because the budget included taxes on imported items such as gas turbine generating facilities since the possibility that the Government of Indonesia would not exempt these taxes could not be eliminated, but in actuality, these taxes were exempted after the start of the project[10]. In addition, fluctuations in

[8] In typical gas combined cycle power generation, when there is a large difference between the exhaust temperature of the gas turbine and the outside air temperature, the amount of power generated by the gas turbine will increase, but conversely, when there is a small difference between the exhaust temperature and outside air temperature, the amount of power generated by the gas turbine will decrease.

[9] Installed generating capacity of "planned value of 80MW" at the time of the appraisal was set based on the possibility of changes due to the bid results of the contractors.

[10] According to PLN, in most cases imported items for state-affiliated projects in Indonesia are non-taxable, but sometimes these items are not tax exempted. Policy wise, procedures to apply for a tax exemption are required, which

foreign exchange rates (strong yen, weak dollar, and weak rupiah) during the project period are also cited as a factor.

3.2.2.2 Project Period

At the time of the project's appraisal, the project period was planned for the six years (72 months) from March 2005 to February 2011. In actuality, the project period was nine years ten months (118 months), from March 2005 to December 2014, greatly exceeding the plan (164% versus the plan). The major causes of this delay are cited as: 1) more time than expected was required within PLN for procedures concerning the selection of the consultant, and the timing of selection start was delayed, 2) more time than expected was required for contractor selection procedures and negotiations with regard to the detailed design and procurement, and 3) trial operation was delayed. More specifically, at the timing of initial firing, supplied gas pressure was lower than required pressure specified by the turbine manufacture. Table 4 shows the initial plan and actual periods of each of the project's components.

Table 4: Initial Plan and Actual Periods of This Project

	Original Plan (At the time of Appraisal: 2004)	Actual (At the time of Ex-post Evaluation: 2017)
(The Whole Project)	March 2005 – February 2011 (72 months)	March 2005 – December 2014 (118 months)
1) Selection of Consultant	April 2005 – September 2006	May 2006 – November 2007
2) Consulting Services	April 2006 – February 2011	November 2007 – December 2014
3) Detailed Design and Procurements	April 2006 – March 2008	August 2008 – March 2011
4) Construction Works	April 2008 – February 2010	April 2011 – November 2012
5) Trial Run	October 2009 – February 2010	May 2013 – December 2013
6) Defect Liability Period	March 2010 – February 2011	December 2013 – December 2014

Source: JICA documents, answers on questionnaire

means waiting for the decision handed down by the Central Government. Therefore, these taxes were included in the project cost prior to the start of the project.

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

Financial Internal Rate of Return (FIRR)

At the time of the project's appraisal, the financial internal rate of return (FIRR) was calculated to be 14.1% based on income from the sale of electricity as the benefits, the costs required for the project and operation and maintenance costs as the costs, and the project life after the start of provision as 20 years. A recalculation using the same conditions yields an FIRR of 12.7%. The reason why this figure decreased is cited as the investment period (work period) was extended slightly and the timing of investment recovery was delayed. In addition, when the start of the project life was set as the year of the L/A signing, the FIRR at the time of the project's appraisal was 12.8%, while a recalculation at the time of the ex-post evaluation yielded a result of 8.8%. This is because the time was required from L/A signing to the start of provision; thus, the provision period under the project life was shortened, causing the benefits to be reduced. The construction cost required for this project was within the initial plan, and because the electricity sales price forecast at the time of the project's appraisal was higher than expected (at the time of appraisal: US7 cents/kWh → at the time of ex-post evaluation: US8 cents/kWh or more) and the purchase cost of natural gas (fuel cost) as well as maintenance costs, too, were within the initial assumptions, the rate of decrease in the recalculation was held in check.

Based on the above, project outputs were implemented mostly as planned, and project costs were within the initial plan thanks to the effects of foreign exchange rates and the tax exemption placed on gas turbine generating facilities. In contrast, the project period exceeded the plan by a large margin because more time was required than anticipated for selection procedures for the consultant and contractor. Consequently, while the project cost was within the plan, the project period exceeded the plan; thus, the project's efficiency is fair.

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

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

Two gas turbine generating facilities (Unit 1 and Unit 2) were developed as the main component of this project's gas combined cycle generating facilities. Table 5 presents the quantitative effect indicators of this project. The target values were set at the time of the

[11] Sub-rating for Effectiveness is to be put with consideration of Impacts.

project's appraisal (2004) and actual results represent those recorded after the generating facilities commence operations.

Table 5: Operation and Effect Indicators (Target and Actual) of this Project

Indicator	Target (2012)	Actual			
		2014	2015	2016	(Reference) 2017 Note 3
	One year after the project completion	At project completion's year	One year after the project completion	Two years after the project completion	Three years after the project completion
【Operation Indicators】					
1) Maximum Output (Unit: MW)	82 *Note 1	75.0	73.23	75.23	75.0 *Note 4
2) Plant Capacity Factor (Unit: %)	75 or more *Note 2	57.15	83.54	92.05	48.90
3) Plant Availability (Unit: %)	85 or more	55.25	83.80	97.73	52.74
4) Gross Thermal Efficiency (Unit: %)	46 or more *Note 1	39% (Unit 1) 41% (Unit 2)	39% (Unit 1) 39% (Unit 2)	40% (Unit 1) 41% (Unit 2)	N/A (Not calculated)
【Effect Indicator】					
5) Net Electric Energy Production (Unit: GWh/year)	523 *Note 1	430	542	598	211

Source: JICA documents (Target), Answers on questionnaire (Actual)
Note 1: At the time of appraisal, it was said that there would be possibility of change, depending on future bidding results, however no new target value was set.
Note 2: Likewise, at the time of appraisal it was said that there would be possibility of change, depending on power supply operation.
Note 3: It is data until around end of August, 2017. At the time of ex-post evaluation (October 2017), since data throughout the year has not been calculated, it is treated as a reference.
Note 4: It ranged from 73 to 75 MW (Unit 1 and 2) from January to February 2017, about 40 MW from the middle of February to around August (Unit 2 only). The average output until August 2017 is 56.0 MW.

The following provides an analysis and review concerning each indicator:

1) Difference between the target value and actual result of maximum output

The initial target value was largely achieved as explained in 3.2.1 Project Outputs. The results for 2017 (average figures) is 56MW, which is lower than the target value. It is because PLTGU Keramasan, which is responsible for the operation and maintenance of the Keramasan Power Plant, carried out major maintenance (periodic maintenance performed after approximately 16,000 hours of operation after installation of the gas turbine generating facilities) on the Unit 1 in February 2017, and found that the fuel nozzle on the Unit 1had burned out requiring repair work on the turbine; as a result, the turbine was shut down until the

end of October 2017. The background of the fuel nozzle burnout and operation stop of Unit 1 is as follows; When PLTGU Keramasan replaced the fuel nozzle of Unit 1 as part of periodic maintenance in February 2017, the fuel nozzle component was sent to a local Indonesian vendor who inspected, processed and refurbished it. This component was reinstalled in the Unit 1 and the gas turbine was restarted, but irregular fuel injection occurred, causing the fuel line and turbine interior to burnout and damaging the turbine blades, etc. Using its own funds, PLTGU Keramasan immediately requested the turbine manufacturer[12] to make repairs and work began. The repairs were completed by mid-October 2017 and at the time of the ex-post evaluation the Unit 1 was operating normally. With regard to what happened, an interview with the vendor revealed, "The gas turbine used for this project is high performance, with both thermal efficiency and output high; thus, the replacement of components must be handled carefully. The type[13] of turbine is only one of a few used in the world. Related parts should be genuine and procured from the manufacturer.[14]" Precision components such as the fuel nozzle must normally withstand temperatures 1,300 Celsius or more, so they must be of high quality. Although it is understood that it takes time to procure components from outside Indonesia and the cost for delivery is high[15], it was desirable that PLTGU Keramasan should have replaced genuine component instead of from a local vendor[16], when exchanging parts that require high quality.

2) Plant capacity factor[17] and 3) Plant availability[18]

Plant capacity factor in 2015 achieved the target value, while plant availability nearly achieved it. In 2016, both indicators cleared the target value at a rate higher than initially anticipated. As

[12] The vender that manufactured and delivered the gas turbine generating facilities through the project's contractor.
[13] There were around 150 units as of 2017.
[14] The manufacturer has indicated that it does not believe there were any problems in terms of the skills and work details of maintenance staff of PLTGU Keramasan associated with the turbine repair work. In addition, it indicated that after the Unit 1 generating facility was shutdown in February 2017, the process of repair request, components procurement, and actual repair work was carried out promptly. The interview also confirmed that fundamental output and thermal efficiency have been secured through trial operations post repair and actual operations.
[15] According to interviews with the management of PLTGU Keramasan, when procuring special components from outside the country, it requires upwards of six to twelve months from procedure to delivery and installation, depending on the type of component. Also, management indicated that the cost was about 60% higher when procuring components from outside the country compared to the cost of procuring the same component from a domestic vendor.
[16] The periodic maintenance for the Unit 2 (As in Unit 1, periodic maintenance for Unit 2 is carried out after 16,000 hours) was performed in mid-November 2017 (nine-day period from November 11 to 18). Taking into account the history with Unit 1, PLTGU Keramasan obtained genuine components for the replacement parts. Both Unit 1 and 2 undergo around 10 days of periodic maintenance, and there are no differences in the work performed, according to interviews with PLTGU Keramasan. The steam turbines and other facilities and equipment used in this project had yet to reach the periodic maintenance interval at the time of the ex-post evaluation. As one example, the main parts of steam turbine are replaced at intervals of approximately 10 years from the beginning of operation.
[17] Calculated as follows: Annual generation amount / (Rated output x Annual hours) x 100
[18] Calculated as follows: (Annual operation hours /Annual hours) x 100

covered above, in 2017 the Unit 1 generating facility was shut down from February to October; thus, the values for each indicator dropped because of lower output. As supplemental information, the main reason why the values in 2014 were lower for each compared to the actual results of other years is because part of the intake filter (filter used for collecting outside air) for Unit 2 was damaged and repairs had to be made[19]. This shutdown period caused both the plant capacity factor and plant availability to decline for the year.

4) Gross thermal efficiency[20]

Since the completion of this project, gross thermal efficiency has ranged around 40% in general. Although this is slightly lower than the target value, according to PLTGU Keramasan, "The target value is merely based on the facility specification at the time of the plan and not the actual target. P3BS, a division[21] of PLN that is responsible for operation planning of the electricity grid on the island of Sumatra, issues orders and determines the operation policy of power plants. In actuality, there is no problem with the operation of facilities. PLTGU Keramasan can increase or lower thermal efficiency by adjusting the output, but it is following the orders of P3BS. Thus, the target value can vary from the time of the plan."

5) Net Electric Energy Production [22]

In 2015 and 2016, the net electric energy production was higher than initially anticipated. Data for 2017 is up to August 31, but for the reason covered above, the amount was lower than the previous year due to the fact that the gas turbine power generation of the Unit 1 stopped operating for a certain period[23].

[19] At the time of the ex-post evaluation, neither PLTGU Keramasan nor manufacturer confirmed the cause unknown. According to an interview with the manufacturer, as a result of peeling of the aluminum film in the duct applied after passing through the filter, the inside of the duct was blocked by the peeled aluminum film and cooling was no longer performed. Therefore, the turbine was stopped for 4 months from September to December 2014. Since it was in the warranty period from December 2013 to December 2014 (see 3.2.2.2 Project Period, Efficiency), the manufacturer repaired mainly at no cost.

[20] It is calculated by (Amount of annual electricity generation × 860) ÷ (amount of annual fuel consumption × fuel heating value) × 100.

[21] P3BS is a division of PLN located in Pekanbaru, the city of Riau Province in central Sumatra Island, Indonesia. The division is in charge of operating instructions for thermal power generation and adjustment of electricity supply.

[22] Net electric energy production indicates the amount of electricity generation obtained by subtracting the electricity used in the power plant from the amount of electricity generation (amount of electricity production) produced at the power plant. The amount of electricity generation is affected by the plant capacity factor and plant availability.

[23] As supplementary information, the reason why the actual figure in 2014 is low is that the Unit 2 was stopped operating for a certain period as it was already mentioned.

In either case, the repair work was completed at the time of the ex-post evaluation and the gas turbine generating facilities were operating normally. Taking this into account, it can be determined that the project's initially anticipated effects are generally realized.

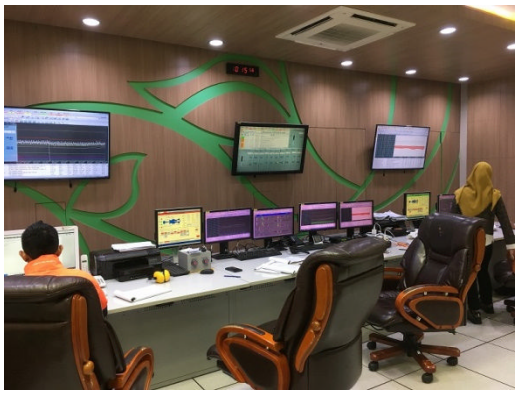


Photo 1: Management Control Room of This Project

Photo 2: Generator for Gas Turbine Unit 1

3.3.1.2 Qualitative Effects (Other Effects)

・Improving the stability of supply and avoiding tight electricity supply-demand conditions in the South Sumatra Grid

Prior to the start of this project, forecasts indicated that electricity supply-demand for the South Sumatra Grid would soon become tight due future population growth and economic development, along with large inflows of investment capital into the South Sumatra area. Therefore, achieving a stable electricity supply through the development of power plants was an urgent task. As Table 1 indicates, electricity demand is rising and the reserve ratio is falling. According to PLN, if the reserve ratio falls below 30%, the risk of tight supply-demand becomes greater. The total installed capacity of the South Sumatra Grid is presented in Table 1, while the total generating capacity of the Keramasan Power Plant is about 350MW (maximum), and of this, the project's installed capacity is 75MW (about 21% of the entire grid mix). The installed capacity of this project is not very large when viewed as a percentage of the grid's installed capacity. However, as Table 1 indicates, taking into account the fact that the reserve ratio increased from 2013 to 2014 around the completion of this project, the installed capacity of this project can be seen as lifting the reserve ratio of the South Sumatra Grid, and it is presumed that it is contributing to the avoidance of tight electricity-supply demand conditions.

Reference: Trend of electricity consumption in South Sumatra Province

Table 6 shows the electricity consumption in South Sumatra Province since 2005. It can be seen that the consumption tends to increase.

(Reference) Table 6: Trend of Electricity Consumption in South Sumatra Province

(Unit: GWh)

2005	2006	2007	2008	2009	2010
1,621.57	1,769.47	1,969.61	2,217.13	2,654.79	3,031.49
2011	2012	2013	2014	2015	2016
2,958.02	3,834.93	4,127.33	4,431.95	4,737.48	4,938.55

Source: PLN

Reference: Future electricity demand and future prospects for the South Sumatra Grid

As Table 2 indicates, the supply-demand condition up to 2018 tends to be tight, but in 2019 and beyond the “35,000MW for Indonesia” for reinforcing generating capacity mentioned in 3.1.2 Consistency with the Development Needs of Indonesia will be completed including for the South Sumatra Grid, which is expected to increase the installed capacity. As a result, the reserve ratio is expected to increase greatly thereafter.

3.3.2 Impacts

3.3.2.1 Intended Impacts

Contribution to Improve the Investment Environment and Economic Development on the Island of Southern Sumatra

Table 7 contains changes in grid connection contracts for PLN’s electricity services in South Sumatra Province, Table 8 contains changes in gross regional domestic product (GRDP) of South Sumatra Province, Table 9 contains changes in the amount of money being invested in South Sumatra Province (investment from domestic and foreign sources), and Table 10 contains changes in electricity sales revenue amount for the South Sumatra Grid.

Table 7: Changes in Grid Connection Contracts for PLN’s Electricity Services in South Sumatra Province

Classification	2011	2012	2013	2014	2015	2016
General house	1,197,649	1,179,848	1,304,651	1,630,885	1,746,804	1,845,736
Factories	421	449	488	547	598	687
Private enterprises	49,093	44,298	47,617	60,188	63,267	68,110
Public	20,859	19,240	21,145	27,772	30,234	33,326

facilities						
Governmental agencies	4,434	3,922	4,268	5,649	6,203	6,573
Lights in the public roads	2,956	3,004	3,365	4,093	4,658	5,176
Total	1,275,412	1,250,761	1,381,534	1,729,134	1,851,764	1,959,608

Source: PLN

Table 8: Changes in Gross Regional Domestic Product (GRDP) of South Sumatra Province

(Unit: one billion rupiah)

2010	2011	2012	2013	2014	2015 Note*
194,013	226,667	253,265	281,997	308,406	332,727

Source: Statistics Bureau of Indonesia (South Sumatra Branch Office)
Note: Estimated value in 2015
Remarks: This GRDP is the actual price including natural gas and oil sector.

Table 9: Changes in the Amount of Money Being Invested in South Sumatra Province (Investment from domestic and foreign sources)

(Unit: one trillion rupiah)

	2011	2012	2013	2014	2015	2016
Domestic	1,115	690	313	643	855	193
Foreign	525	905	1,408	1,109	1,121	2,955
Total	1,640	1,595	1,721	1,752	1,976	3,148

Source: State Government of South Sumatra

Table 10: Changes in Electricity Sales Revenue Amount for the South Sumatra Grid

(Unit: million rupiah)

2014	2015	2016
5,542,416	6,490,702	6,660,273

Source: PLN

As Table 7 indicates, the number of contracts for all categories has risen over the most recent six years. According to Table 9, although it cannot be said that domestic investment is increasing, foreign investment is increasing. In actuality, the growth in agriculture and mining is large. The amount increased greatly year on year in 2016, which can be attributed to the large investments in mineral resource extraction and agriculture in Palembang, the province's capital, and to the entry of four major foreign companies in the state's mining sector. These companies are believed to be major users of electricity, which explains the rampant increase in electricity demand. Table 10 indicates the changes in electricity sales revenue amount. Since the price differs for contract type, area and conditions, a detailed unit price of electricity prices could not be determined, but it can be confirmed that the price of electricity has increased in general over the most recent three years[24].

[24] As supplementary information, the population growth rate in South Sumatra Province is 1.48% (2015, source is https://knoema.com/atlas/Indonesia/South-Sumatra/Growth-Rate-of-Population (December 15, 2017 Access)), while the whole population growth rate of Indonesia is 1.04% (2017, source is

However, as discussed above, the installed capacity of this project is not very large compared to the total installed capacity in South Sumatra Province; therefore, its contribution to the number of contracts, GRDP shown in Table 7, investment amount shown in Table 9 and electricity sales income shown in Table 10 is not very large either. Meanwhile, interviews with the PLN headquarters and PLTGU Keramasan yielded the following comment, "Without transmission from the Keramasan Power Plant, the reserve ratio for the South Sumatra Grid would be low and there would some form of impacts on the investment environment or economy. With the capital of Palembang experiencing economic development and population growth, a stable supply of electricity is required and the role that this power plant plays will only become more important in the future." Thus, it is believed that PLN has determined that this project has contributed to the stability of electricity supply in the entire province of South Sumatra.

In light of the above, it can be said that this project plays a role in the fact that a stable supply of electricity from an increase in generating facility capacity underpins economic development in the provincial capital of Palembang and the South Sumatra area.

3.3.2.2 Other Positive and Negative Impacts

1) Impact on the Natural Environment

This project is applied to "Japan Bank for International Cooperation's Guidelines for Confirmation of Environmental and Social Considerations" (enacted in April 2002). The preparation of the environmental impact assessment (EIA) report for this project was not required per procedures set forth in Indonesia. For the implementation of this project, PLN prepared an environmental management policy (UKL) and environmental monitoring policy (UPL) [25], and obtained approval from the Environmental Impact Monitoring Bureau (BAPEDALDA) of Palembang City in October 2004.

PLTGU Keramasan conducts monitoring based on UKL and UPL, and it was confirmed through interviews with PLTGU Keramasan and field visits that no negative impacts on the environment (mainly, air pollution, water quality, loud noises, vibrations and negative impacts on the ecosystem, etc.) have occurred after the completion of this project. The area around the Keramasan Power Plant is neither a densely populated residential area nor a commercial area.

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http://worldpopulationreview.com/countries/indonesia- population / (Access on December 15, 2017)). Because the former population increase is relatively high, there is also possibility that it may act on the actual value of such statistical data.

[25] Environmental Management Policy (UKL) is to manage air pollution, vibration / noise, water quality, impact on ecosystem. The environmental monitoring policy (UPL) is to monitor the progress of UKL and the actual situation.

Table 11 provides the most recent environmental monitoring results for the Keramasan Power Plant. Given that the results data all fall under the environmental standards of Indonesia, environmental impacts on the surrounding area are determined to be minimal[26].It was also confirmed through interviews that there have been no incidents or complaints of adverse health effects on local residents.

Table 11: Environmental Monitoring Results
(Most recent data: measured on August 21, 2017)

Monitoring Index	Unit	Environmental Standards in Indonesia	Actual *Note
Sulfur dioxide (SO_2)	$\mu g/Nm^3$	365	41.75
Hydrocarbon (HC)	$\mu g/Nm^3$	160	0
Dust	$\mu g/Nm^3$	230	134.25
Nitrogen dioxide (NO_2)	$\mu g/Nm^3$	150	39.25
Noise (dB)	dB	70	49.25

Source: PLTGU Keramasan
Note: It shows the average value of four sampling points at Keramasan Power Plant

PLTGU Keramasan carries out regular environmental monitoring within the project site, including the facilities developed as part of this project. Within PLTGU Keramasan, there is a division called K2L, where five employees are responsible for monitoring operations. If any problem arises, K2L will be the center and will take immediate action to resolve it. When necessary, monitoring results are shared with the government of South Sumatra Province and the City of Palembang. It was confirmed through interviews with K2L that no countermeasures were implemented based on monitoring results because no particular negative impacts or problems concerning the environment have occurred since the completion of the project.

2) Resettlement and Land Acquisition

This project did not result in resettlement or land acquisitions. There was no need for the new acquisition of land or for resettlement because the generating facilities of this project were constructed on the site of the Keramasan Power Plant.

[Summary of Effectiveness and Impact]

The target value has largely been achieved with respect to the actual value in 2015, which is

[26] Although monitoring data on water quality, vibration and ecological effects were not available, it was confirmed that the water quality, vibration and ecological effects have cleared the Indonesian environmental standards, through an interview with PLTGU Keramasan.

the target year (one year after project completion) of the operation and effect indicators (quantitative effect indicator). In addition, this project plays a role of avoiding tightness situation of electricity supply and demand which is foreseen in the future and stable supply of electricity. Thus, it can be said that this project has been supporting to improve the investment environment and economic development in the southern part of Sumatra Island. Based on the above, effectiveness and impact of this project are high.

3.4 Sustainability (Rating: ③)

3.4.1 Institutional Aspect of Operation and Maintenance

The executing agency of this project is PLN. PLTGU Keramasan is responsible for the operation and maintenance of the generating facilities developed by this project, and there are 52 employees who engage in the operation and maintenance of the gas combined cycle generating facilities developed by this project. The PLN headquarters (Jakarta) supervises PLTGU Keramasan and both parties conduct regular reporting concerning operations and maintenance work[27].

The workforce in PLTGU Keramasan appears to be sufficient. It was confirmed through onsite visits and interviews with PLTGU Keramasan management that the staff are allocated to each department without shortage or overage and right person is assigned for the right job. The generating facilities developed by this project require an operating system that is 24 hours a day 365 days a year; thus, staff work three shifts, performing management, maintenance and regular inspection work.

In light of the above, it is considered that there is no major problem regarding institutional/organizational aspects of operation and maintenance of this project at the time of ex-post evaluation.

3.4.2 Technical Aspects of Operation and Maintenance

PLTGU Keramasan employs a large number of staff with a wealth of operational experience and knowledge. Tests measuring the operational knowledge of staff responsible for operation and maintenance are carried out once every year (practical test and written test). Skills are categorized into three levels (Level 1 to 3). Level 3 employees supervise and instruct other staff. This ensures technical skills for operations and maintenance.

[27] According to the PLN Headquarters, there is no particular problems with regard to the organizational structure of PLTGU Keramasan as the sufficient personnel have been assigned for operation and maintenance of this project.

A manual has also been prepared on operation and maintenance related to this project's facilities. At the time of the field survey, it was confirmed that this manual is being utilized in a timely manner. At the time of trial operations of these facilities immediately prior to completion of this project, the manufacturer of the gas turbine and other facilities conducted onsite training and seminars on operations for PLTGU Keramasan staff. An employee who took part in this training commented, "I am putting to use what I learned, together with the manual provided, in daily maintenance work."

In regards to training programs, in 2017 after the completion of this project, 34 and 7 employees from PLTGU Keramasan participated in the "steam turbine operation training" and "facility asset management training," respectively. On-the-job training is also provided as needed to newly hired employees.

In light of the above, it is judged that there are no technical problems concerning the operation and maintenance of this project.

3.4.3 Financial Aspects of Operation and Maintenance

Table 12 shows the maintenance cost (most recent four-year period) related to facilities and equipment developed by this project. After operations began in 2014, the budget has been allocated without shortage or overage to PLTGU Keramasan from the PLN headquarters. In 2017, major periodic maintenance required every 16,000 hours was performed, which increased the budget relatively. According to PLTGU Keramasan, "Every year sufficient budget is allocated to maintenance work. There has been no shortage of maintenance due to budget shortfall."

Table 12: Maintenance Cost Related to Facilities and Equipment Developed by this Project

(Unit: one million rupiah)

	2014	2015	2016	2017
Amount of Budget Allocation	N/A (No data)	N/A (No data)	17,259	105,708
Used Amount (Actual)	2,097	5,248	15,711	7,793 *Note

Source: PLN
Note: Data as of the end of September 2017

For reference, PLN's overall fiscal report (profit/loss statement) is shown in Table 13. PLN's electricity sales continue to rise every year. As ④ in the Table indicates, however, PLN would be in the red if it were not for electricity subsidies provided by the Central Government. In other

words, PLN's finances are supported by government subsidies. PLN sells electricity at a cost cheaper than the cost of supply following the "public service mandate," which is a policy of the Central Government. The losses incurred from this are offset by subsidies from the government. At the same time, it was confirmed through interviews with the PLN headquarters that electricity rates are gradually increasing with the aim of achieving stable management of its power generating business.

(Reference) Table 13: PLN's Overall Fiscal Report
(Profit/loss statement of most recent three-year period)

(Unit: million rupiah)

Item	2014	2015	2016
①Operating revenue (Income of electricity sale, etc)	193,417,941	217,346,990	222,821,956
②Operating expenses	247,806,289	225,574,076	254,449,802
③Operating balance =①-②	(54,388,348)	(8,227,086)	(31,627,846)
④Electricity subsidies provided by the Central Government	99,303,250	56,552,532	60,441,520
⑤Operating balance after allocation of subsidies =③+④	44,914,902	48,325,446	28,813,674
⑥Balance of financial income and expenses	(29,910,833)	(64,238,881)	(12,837,193)
⑦Profit before tax =⑤+⑥	15,004,069	(15,913,435)	15,976,481
⑧Tax exemption allowance	(3,934,699)	21,939,942	(5,427,843)
⑨Profit after tax =⑦+⑧	11,069,370	6,026,507	10,548,638

Source: PLN
Note: Numbers in parentheses indicate minus

Table 14 shows PLN's overall balance sheet. From 2014 to 2015, the depreciation methods of tangible fixed assets were revised following changes in accounting principles, increasing from 518,235,453 million rupiah in 2014 to 1,235,026,088 million rupiah in 2015. As an example, later in 2016, non-current liabilities decreased year on year and current liabilities remained at largely the same level, but current assets increased and capital has not declined consistently; thus, the financial soundness of PLN is determined not to pose any particular concerns.

(Reference) Table 14: PLN's Overall Balance Sheet
(Most recent three-year period)

(Unit: million Rupiah)

Item	2014	2015	2016
①Fixed assets	518,235,453	1,235,026,088	1,173,608,898
②Current assets	85,423,738	79,344,793	100,967,332
③Total assets (①＋②)	603,659,191	1,314,370,881	1,274,576,230
④Capital	164,671,226	804,709,617	880,797,712
⑤Non-current liabilities	351,429,688	389,441,371	272,155,163
⑥Current liabilities	87,558,277	120,138,893	121,623,355
⑦ Total capital and liabilities (④+⑤+⑥)	603,659,191	1,314,370,881[28]	1,274,576,230

Source: PLN

In light of the above, it is considered that there is no particular problem on the financial aspect of the operation and maintenance of this project.

3.4.4 Status of Operation and Maintenance

At the time of the ex-post evaluation, the operating status of the gas combined cycle generating facilities, cooling tower and related facilities developed by this project is good. Maintenance work is carried out according to the categorizations of periodic and regular maintenance. As for periodic maintenance, major maintenance is performed once every 16,000 hours with a large budget allocated to this work. Regular maintenance is broken down into work carried out every half year, every three months, every month, every week and every day. As discussed above, PLTGU Keramasan establishes a maintenance implementation plan every year and carries out operations and maintenance following this plan.

Although the procurement of spare parts and response at the time of periodic maintenance on the Unit 1 generating facility in February 2017 cannot be viewed as necessarily appropriate, in all other cases, procurement is being carried out properly in general. As for the damage and repairs to the Unit 1 generating facility (fuel nozzle) that occurred in February 2017, by the end of 2017 PLN agreed with a Japanese company on maintenance inspections and support for the gas turbine generation facilities at the gas combined cycle generating facility. Specifically, PLN employees will be in charge of maintenance work for the generating facilities (as covered before,

[28] Total data of ④ to ⑥ will be 1,314,289,881 million Rupiah. Meanwhile, because this data is provided by PLN, it is set as current description.

there are no problems in terms of technology or skill level), and the Japanese company will be responsible for advice and procurement support when replacing parts with genuine parts at the time of major maintenance (periodic maintenance every 16,000 hours). As discussed above, the replacement parts for the Unit 2 were replaced with genuine parts during the periodic maintenance that has already been performed.

No major problems have been observed in the institutional, technical, financial aspects and current status 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 aimed to increase the electricity supply capacity, to improve the stability of supply, and to mitigate tight supply-demand conditions for grid electricity at Keramasan Power Plant connected to the South Sumatra Grid on the island of Sumatra, by expanding the plant's combined cycle power generating facilities; thereby, contributing to an improved investment environment and economic development in the South Sumatra area. Relevance of this project is high because of its confirmed consistency with the policies on the development of new power generation facilities and electricity supply presented in the *General Plan for National Electricity* established by the Government of Indonesia and the *Electricity Supply Business Plan* prepared by PLN, and with the country's development needs for addressing growing electricity demand as well as the assistance policy of the Japanese government. As for efficiency, project outputs were implemented mostly as planned, and project costs were within the initial plan thanks to the effects of foreign exchange rates and the tax exemption placed on gas turbine generating facilities. In contrast, the project period exceeded the plan by a large margin because more time was required than anticipated for selection procedures for the consultant and contractor. Thus, the efficiency is fair. In terms of the project's quantitative effect indicators, maximum output, plant capacity factor, plant availability, gross thermal efficiency, and net electric energy production have generally achieved target values since 2015, and because it is believed that this is underpinning the avoidance of risk of tight supply-demand for electricity and the stable supply of electricity within this grid, the effectiveness and impact of this project are high. There are no particular concerns in terms of institutional, technical or financial aspects of the PLTGU Keramasan, which is responsible for the operation and maintenance of this project. Although a

fuel nozzle for the Unit 1 generating facility burned out in February 2017, requiring repairs, and operations were stopped until the end of October 2017, at the time of the ex-post evaluation, repair work had been completed and operations restarted. There have not been other problems in terms of the operation and maintenance of other equipment and facilities. Thus, the sustainability of the effects realized through this project is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Securing steady supply of spare parts requiring high quality

Precision components such as the fuel nozzle of the gas turbine generating facilities require high quality. As for repair work including the replacement of spare parts for the project's precision equipment, PLN consigned procurement and delivery to a local company because of the time required for procurement from outside Indonesia as well as the high cost of delivery. As a result, a defect in the locally manufactured product caused damage to the turbine. In regards to procurement of components that require high quality in similar projects in the future, even if there is a premise that procurement of locally manufactured goods is realized at a low cost and delivery in a short period of time, it is desirable for executing agency, during the project implementation or before completion, to confirm the procurement policy which ensures that genuine products are steadily used even after completion of the project, and also to ensure that the budget for parts purchase will be secured for several years.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs	1. Procurement/Construction (a) Combined Cycle Power Generation Facility (80 MW class) 1) Installation of gas turbine and generating facilities (two units) 2) Installation of steam turbine and generating facility (two units) 3) Installation of heat recovery steam generator (two units) 4) Extension of accessory equipment (gas supply equipment, 150 kV switchyard etc) necessary for the above equipment (b) Related Civil Engineering and Construction Work (c) Cooling Water System (d) Desalination, Pure Water Equipment (e) Spare Parts (quantity necessary for operation / repair for 2 years after start of operation)	1. Procurement/Construction Mostly implemented as planned. (The capacity of the gas combined cycle power generation facility changed to 75 MW.)
	2. Consulting Services (a) TOR related to the construction and operation of power station: 1) detailed design, 2) bidding assistance, 3) construction supervision, 4) performance evaluation, 5) assistance for operation and maintenance, 6) assistance for environmental management, 7) technology transfer and human resource development, etc. (b) Assistance for strengthening planning functions of PLN and South Sumatra local government officials: 1) Assistance for electric power supply and demand anticipation, 2) establishment of anticipation system, 3) assistance for optimum power supply development plan capacity, 4) assistance for transmission and distribution cable construction plan, 5) assistance for making investment plan	2. Consulting Services Implemented as planned.

2. Project Period	March 2005 – February 2011 (72 months)	March 2005 – December 2014 (118 months)
3. Project Cost Amount Paid in Foreign Currency	8,090million yen	9,169million yen
Amount Paid in Local Currency	3,365million yen （280,416million Rp.）	1,245million yen (132,644million Rp.)
Total	11,455million yen	10,414million yen
ODA Loan Portion	9,736million yen	9,677million yen
Exchange Rate	1 Rp.=0.012 yen 1USD=110.36 yen （As of September, 2004）	1Rp.=0.009386 yen 1USD=88.862 yen （Average between 2007 and 2014, based on rates issued by the IMF's International Financial Statistics Data)
4. Final Disbursement	January 2016	