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Philippines

Tiwi Geothermal Power Plant Complex Rehabilitation Project

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Field Study : September-October, 2008

1. The project outline and yen loan assistance

Location of the project site

Tiwi Geothermal Power Plant

1.1 Background :

Demand of power in the Philippines is concentrated in Luzon Grid by about 75%, however, construction or addition of a new power generation facility didn't take place until the second half of 1980s. Due to the deterioration of facilities, power generation function was seriously deteriorated and chronic power-cut persisted due to the lack of electricity until the first half of 1990s. The basic idea of the 3 energy policies upheld by the government of Philippines were "reliable power supply at reasonable price", "promotion of efficient energy use" and "development of energy with minimum environmental impact". Based on the basic idea, the country targeted to reduce dependency on imported oil from 51.4% in 1986 to 46.9% in 1992 and strengthen geothermal power generation.

The Philippines has the second most abundant geothermal energy in the world after the U.S in production and utilization of geothermal energy.

1.2 Purpose

Enhance the efficiency and reliability of the power generation facilities by repair/replacement of the existing facilities of Tiwi Geothermal Power Plant in the Philippines, effectively use indigenous energy, and ultimately improve the balance of demand and supply of power at Luzon Grid.

1.3 Borrower/implementing organization：

Government of the Republic of Philippines/National Power Corporation：NPC

1.4 Outline of Yen Loan:

Approved loan amount/ Disbursement	7,056 mil yen / 6,408 mil yen
Exchange of notes/Signing of loan agreement	November 1994 / December 1994
Lending terms	Interest rate: 3.0%, repayment period: 30 years (including grace period of 10 years), general untied loan
Disbursement completion	January 2006
Project agreement （worth of 1 billion yen or more）	Marubeni (Japan)
Consultant agreement （worth of 100 mil yen or more）	West Japan Engineering Consultant (West JEC)・Philippines Geothermal, Inc.（PGI）
Feasibility Study (F/S), etc.	1992 Completion of F/S by Japan Consulting Institute 1992 Completion of JICA master plan（Study on Luzon Grid P/P facility repair/maintenance & control improvement plan）

2. Finding (Rating: D)

2.1 Relevance（Rating：a）

It was confirmed that the implementation of the project is consistent with the development needs and policy, both at appraisal and ex-post evaluation. Therefore, relevance of the project implementation is high.

2.1.1 Consistency with government policy and measures

(1) Appraisal

"Mid-term Philippine Development Plan (1987-1992)" at around the project appraisal (January 1993) period says that it is important to strengthen infrastructures because it is the base of sustainable social economic development. In particular, improvement of reliability and efficiency of power supply was prioritized in power sector. The plan

listed utilization of indigenous energy such as geothermal energy, and rehabilitation, improvement and repair of existing facilities as specific measures to be implemented. “Mid-term Philippine Development Plan (1993-1998)” continuously emphasized the use of indegenous energy and encouraged diversification of energy sources for stable supply at low cost. Geothermal power generation was focused as one of the solutions.

The Philippines has continuously implemented a measure to strengthen the use of indigenous energy resources since 1970s. The country emphasized the need to expand power generation capacity based on domestic resources for stable and sufficient power supply at lower cost. In response to severe shortage of electricity since the second half of 1980s, the country positioned geothermal energy as the most promising domestic energy resource to lower the dependency on imported energy resources in “Philippine Energy Plan：PEP 1992-2000”.

In response to the serious lack of electricity mentioned above, the country enacted BOT law in 1990 and Electric Power Crisis Act in 1993 to promote private participation in power generation sector.

Consistency of the project with government policy mentioned in “Mid-term Philippine Development Plan” and “Philippine Energy Plan” above is confirmable because the project emphasizes the importance of utilizing geothermal energy at appraisal. The project was implemented after the country introduced a policy to promote private investment, but this is because the government decided both public and private capitals were necessary to overcome the power crisis. From this perspective, the project is deemed to be consistent with the government’s development policy.

(2) Evaluation phase

Similarly, “Mid-term Philippine Development Plan (2004-2010)” at around the time of evaluation (2008) focused on securing stable and sufficient power supply and promoted the use of domestically produced energy as government policy, while encouraging the reform of power sector led by private corporations. “Philippine Energy Plan (PEP) 2005-2014” upholds effective use of indigenous energy as a sector target, and specifically emphasized the utilization of reproductive energy including geothermal energy.

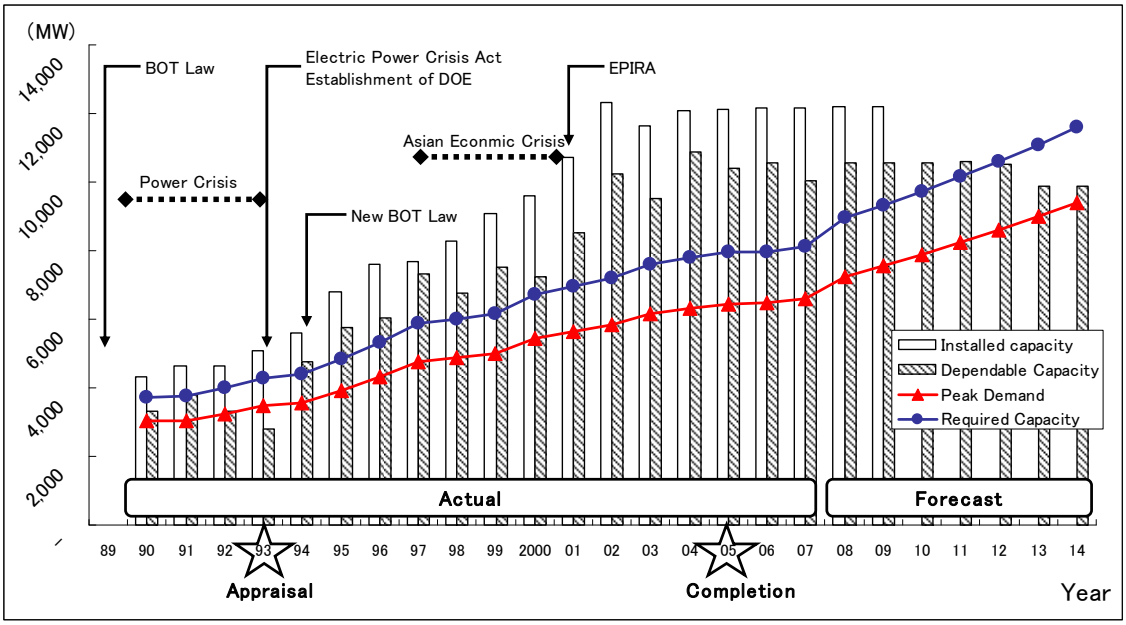
Securing power supply and effective use of domestic energy were emphasized in “Mid-term Development Plan” and “Philippines Energy Plan” continuously at evaluation phases, which underpin the project’s consistency with measures/policy.

2.1.2 Consistency with development needs

Power shortage persisted in the Philippines since the second half of 1980's and peaked by power crisis in 1992-1993, during which power-cut that lasts 5 hours or longer occurred frequently. Development of power supply source, recovery of output and improvement of obsolete power generation facilities were needed for stable power supply. The project was requested by the country as an emergency measure to counter the power crisis by rehabilitating power generation facilities. Accordingly, needs of the project is deemed to have been quite high at appraisal phase.

However, thanks to an active introduction of Independent Power Producer : IPP centering foreign capital, power shortage was resolved by 1994. As shown in Figure-1, power generation facility always had additional capacity of 3,000MW or more beyond the demand, since economic crisis in Asia and at appraisal in 2008. Nevertheless, Power Supply and Demand Outlook (2006-2014) compiled by the Department of Energy: DOE, estimates that power shortage will occur again around 2010, and therefore, strengthening of power generation facility is necessary. Since the target of the project is to promote an effective use of geothermal energy for balanced use of resources and stable power supply, there was a need for the project in times of evaluation, too.

Figure-1 Actual and trend of peak power demand at Luzon Grid, capacity of power generation facility and power generation capacity



Note : Compiled based on NPC document, DOE document, appraisal materials, "Philippines Power Sector Study 1994" from World Bank, and baseline research on power sector by JICA (2001). (Statistics during 1995-2000 was based on NPC and DOE documents) Figures for estimate were based on "Power Supply and Demand Outlook 2006-2014" by DOE. Required Capacity refers to the peak demand plus the reserve margin above the peak demand of 23.4%.

2.1.3 Relevance of the project plan

At appraisal, the project plan targeted repair/improvement of all the existing 6 power

generation facilities (capacity of 330MW in total) of Tiwi Geothermal Power Plant as shown in Table-1.

Table-1 Outline of Tiwi Geothermal Power Plant

Plant	Power generator	Start of operation	Rated output
Plant A	Unit 1	January 1979	55MW
	Unit 2	May 1979	55MW
Plant B	Unit 3	January 1980	55MW
	Unit 4	April 1980	55MW
Plant C	Unit 5	December 1981	55MW
	Unit 6	March 1982	55MW
Total			330MW

Note：Compiled by Tiwi Geothermal Power Plant materials.

However, according to the study on power generation capacity of Tiwi Geothermal Reservoir and the scope of the development (January 1990), electric energy possibly produced by heat reserve there was estimated to be 250MW x 25 years. This can be concluded as an overestimate since the volume of steam was short of even fully operating 4 units at a time of evaluation (2008) as detailed hereinafter, after delayed start of the operation. Further, capacity factor was set at 70% then. Based on the above, it is estimated difficult to achieve 85% availability factor of geothermal power generation facility plan set in Japan then. Facility repair/improvement plan should have been made based on the volume of steam.

After all, the project plan was reviewed in 2001 due to substantial delay in the project start as detailed hereinafter, and it has led to find out the decrease of steam flow. In response to this, power generation facility for repair/improvement was reduced from 6 units to 4 units, which can be evaluated for making operation of the power plant more sustainable by reflecting the actual situation.

As a conclusion, despite overestimation at the appraisal of the project planning, the scope was adjusted to fit the reality for implementation; therefore, the project is highly relevant with “Mid-term Philippine Development Plan”, “Philippines Energy Plan” and development needs at times of both appraisal and evaluation.

2.2 Efficiency（Rating：c）

Project implementation was delayed substantially (261%) and project cost was slightly larger than planned (137% for one facility); therefore, the evaluation for efficiency is low.

2.2.1 Output

As aforementioned, the project was planned to repair/improve all the 6 units at appraisal but actually, partial repair was done to 4 units (1, 2, 5 and 6). This scale back of the repair scope was mainly due to the continuous reduction of steam flow from geothermal well year after year that resulted in limited steam supply. Repair to the 4 units was a partial one focused on recovering function of power plant and safety operation. Changes and addition to the original repair/improvement plan are summarized in Table-2.

Picture-1 : Power generation facilities

Table-2 Summary of changes to project

	Contents	Process/reason of planning/changes
(1) Plan at appraisal (Jan. 1993)	Replacement, repair, installation etc. of turbine, power generator, gas extract device and cooling tower of Units 1~6 (55MW each)	Reviewed necessary scope of repair/ improvement aimed at recovering reliability and effectiveness of units 1~6.
(2) Output at the first contract (Related to the scope change Agreed by former JBIC: May 2001) Implementation period: Jun. 2003~Feb. 2004	Limit repair to the recovery of function and stable operation of 4 units (Unit 1, 2, 5 and 6). After repair, units 1 and 2 are strengthened to 60MW while units 5 and 6 to 57MW. Scope originally planned but excluded due to duplication of scope with NPC project: repair/ replacement of honing machine, control board recorders, indicators, converters and controllers for turbine, repair/ replacement of air conditioning system, replacement of turbine supervisory instrumentation, purchase of equipment for calibration, partial replacement of disconnecting switches for switchyard, repair/check of main cooling water pipeline, procurement of cooling tower materials and environment monitoring equipment.	With reduced steam flow, it was decided that there is no sufficient source of power for 2 units; therefore, only 4 units were subject to repair. In addition, the government of Philippines shifted from "full repair" to "partial repair" based on their own review result, which concluded partial rehabilitation was sufficient to recover the function. According to technical examination by yen loan division of former JBIC (current JICA), the change is reasonable because recovery of function is possible if rehabilitation planned by NPC is properly implemented. Former JBIC requested the government not to make further reduction to the scope.
(3) Output at additional contract (Related to the second scope change Agreed by former JBIC: Feb. 2004) Implementation period: Jun. 2004~Dec. 2005	Added the scope of repair for 4 units (Unit 1, 2, 5 and 6), because it is considered necessary for stable operation. There were 27 newly added repair/improvement items (facilities/parts) in total including replacement of cooling tower for Units 5 and 6, and purchase of Switchgear and motor for gas extract equipment for Units.2.	NPC, a contractor and a consultant jointly carried out a study in Dec. 2001 and May 2002, and confirmed stable operation is difficult, contrary to the expectation. Also, additional repairs turned out to be necessary to satisfy conditions of steam supply contract. The government of Philippines decided to exchange additional contract, to which former JBIC agreed because the addition was originally included as part of the scope and deemed necessary at appraisal, and therefore, necessary to achieve the target of the project.

Note: compiled based on JICA materials.

After changes to the scope explained above, actual output was reduced by 2 units from the original plan because repair of 2 units were excluded from the project. If technical analysis of the situation had been thoroughly conducted at the first scope change, the second change was less likely required.

2.2.2 Project period

The project term was originally set at 51 months after the exchange of yen loan agreement, but it actually took 133 months until repair/improvement was completed and operation of 4 units got started (December 2005), much longer than planned (11 years and 1 month: 261% of the plan). 92 months (7 years and 8 months) have passed after the exchange of loan agreement until receiving approval from the government of Philippines (contract coming into effect), and 41 months (3 years and 5 months) from the contract

entry to the completion of the project. Reasons for the delay are as explained below.

(1) Reasons for the delay before contract becoming effective, after yen loan agreement

(1)-1 Lawsuit over Steam Supply Service Agreement

Steam Supply Service Company filed a lawsuit at a court of arbitration against NPC that owns Tiwi/Mak-ban Geothermal Power Plants [1], complaining NPC rejected renewal of steam supply contract (25 years of contract. Expiration in 1996). NPC also brought the case to a domestic court. Steam Supply Service Company offered to drop charges on condition that Tiwi/Mak-ban Geothermal Power Plants was transferred to them and repair cost was burdened by them in exchange. In this situation, the government of Philippines decided to suspended implementation of the project because they needed time to review many things including whether or not to implement the project, at all. Considering the fact that negotiation of the project contract was completed in April 1999, the project could have been completed 3 years or more earlier if the government had not decided the suspension.

(1)-2 Privatization of power plant

As breakup and privatization of power sector was being promoted in the Philippines, the government spent considerable time reviewing which was more efficient to sell/privatize Tiwi Geothermal Power Plant via yen loan (repair/improvement by direct control of NPC) or privatization (repair/improvement by private company after purchase of the power plant). (Procedure for the project was interrupted[2] until September 2000 (69 months or 5 years and 9 months after the exchange of yen loan agreement), due to the lawsuit and the review of privatization) Facing such circumstances, NPC and former JBIC regularly discussed to advance procurement procedure.

(1)-3 Review for the scope change

While discussions over the aforementioned lawsuit and privatization delayed the project implementation, deterioration of power plant progressed and additional repair/improvement became necessary according to the degree of deterioration. It took additional time to review the scope change and to receive approval for that. The government of Philippines approved the scope change and exchanged the project contract

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[1] Mak-ban Geothermal Power Plant belongs to Luzon Grid that was repaired by yen loan in the same period of this project implementation. One steam supply service company used to supply geothermal steam to both Tiwi Geothermal Power Plant and Mak-ban Geothermal Power Plant under the same steam supply service contract.

[2] The government of the Philippine announced former JBIC the intention to cancel the yen loan project, but they retracted it later and decided to continue the project. Exchanges like this caused the delay too.

in July 2002 (contract became effective).

(2) Development from contract entering into force until the project completion

After the contract became effective, original scope of the project was once fixed in February 2004. However, field study conducted by NPC, the consultant and the contractor concluded that an additional repair was deemed necessary for stable operation of the power plant. Further, additional repair/improvement became necessary to achieve a certain level of power generation capacity and reliability under conditions of Geothermal Resource Sales Contract : GRSC[3]. In response to this, additional contract was concluded in June 2004 and the repair work was completed in December 2005.

2.2.3 Project cost

The actual total project cost (for 4 units) was 6.434 billion yen (of which 6.43 billion yen is yen loan), which fell within the plan of 7.265 billion yen (for 6 units) (of which 7.056 billion yen is yen loan). Cost per unit was 1.68 billion, which slightly exceeded the plan of 1.176 billion yen (increase of 137%). This was mainly due to an extended project period that led to incur additional cost to repair deterioration that took place in the meantime, beyond the scope assumed at appraisal.

2.3 Effectiveness（Rating：b）

Effectiveness of the project cannot be confirmed by comparing the result with the original plan. However, if the project had not been implemented, the power plant would have stopped generating power by now. Therefore, the project has produced certain effects, and its effectiveness is moderate.

2.3.1 Status and effectiveness of operating power plant

In the original plan, repair/improvement of 6 units was expected to achieve 70% of capacity factor and volume of gross power generation at 2,024GWh/year. However, actual volume of power generation is barely half of the target, 1,172GWh (2006) and 890GWh (2007).

[3] GRSC will be applied after completion of Tiwi Geothermal Power Plant and Mak-ban Geothermal Power Plant repair/improvement. Repair by yen loan is positioned as “partial repair”. The two power plants will be owned 100% by private company around May 2009, and fully repaired by the company within the subsequent 4 years.

Table-3 Operation status/initial plan (for all 6 units)

Indicator (unit)	Base (1992)	Target	Actual (2006)	Actual (2007)
Total gross electricity generation（GWh）	**1,998.5**	**2,024**	**1,171.6**	**890.07**
Total net electricity generation（GWh）	1,877.4	1,888	1,081.0	825.8
Total rated output（MW）	330	330	344	344
Dependable capacity（MW）	284.6	231	153.3	112.6
Unit average of capacity factor（%）	**68.9**	**70**	**38.2**	**29.2**
Average availability factor（%）	81.7	-	56.2	43.9
Total operation time（hour）	43,085	-	29,564	23,073
Total forced outage（hour）	261.4	-	399.8	957.2
Total interruption time due to external factors（hour）	683	-	11,037	13,190

Source : Appraisal materials for base and target of capacity factor, calculated based on capacity factor and station use rate for other targets. NPC for actual.

Table-4 Operation status/initial plan (for 4 units subject to repair/improvement)

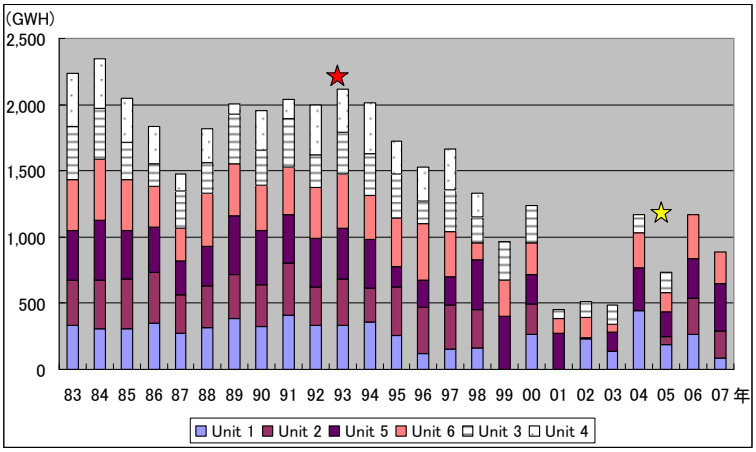
Indicator (unit)	Base (1992)	Target	Actual (2006)	Actual (2007)
Totalgross electricity generation（GWh）	**1,371.3**	**1,349**	**1,171.6**	**890.07**
Total net electricity generation（GWh）	1,289.9	1,259	1,081.0	825.8
Total rated output（MW）	220	220	234	234
Dependable capacity（MW）	199.7	154	153.3	112.6
Unit average of capacity factor（%）	**71.0**	**70**	**57.3**	**43.8**
Average availability factor（%）	79.3	-	84.4	65.8
Total operation time（hour）	27,853	-	29,564	23,073
Total forced outage（hour）	193.3	-	399.8	957.2
Total interruption time due to external factors（hour）	487	-	2,277	4,430

Source : Appraisal materials for base and target of capacity factor, calculated based on capacity factor and station use rate for other targets. NPC for actual.

In comparison, rated output of units 1, 2, 5 and 6 increased by 14MW from appraisal (1992) to after the project completion (2006), but actual output was decreased by 40-50% on average per unit. Main reasons for this are as follows:

- Capacity factor is low and power generation capacity is maintained low. Main reason for this is difficulty in securing sufficient steam volume to operate the 4 units. Steam volume is decreasing by 8-10% a year.
- Typhoon struck an area close to the power plant in November 2006, causing temporary shortage of output by the damage (however, based on utilization status of repaired facilities during out-of-typhoon season (before November 2006), output after the project completion is smaller than that during project planning, due to the lack of steam volume).

Figure-2 Trend of generation

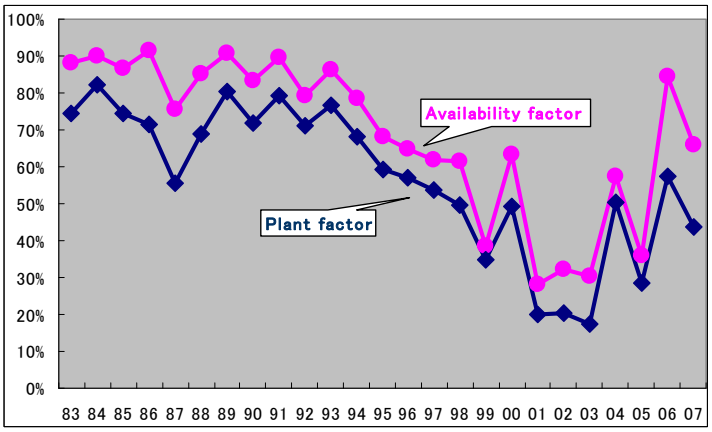


Source：NPC
Note: Red star and yellow star show the timing of appraisal and completion of the project, respectively. Repaired/improved units are 1, 2, 5 and 6. Uptick in output in 2004 was due to temporary operation of units after the first improvement and before the start of additional contract (operation was suspended due to repair work in 2005).

Main contribution to the decline in output is dwindling steam volume and substantial delay in the project implementation. By the time of the project completion, steam flow was simply not sufficient to fully operate the rehabilitated facilities.

On the other hand, deterioration of facilities became obvious since the second half of 1990's, on top of accident caused suspension and dwindling steam flow. Plant load (capacity) factor and availability factor of facilities got as low as 20% for each, as shown in Figure-2 and 3. If the project had not been implemented, the rate could have reached almost zero in 2004 and thereafter. In consideration of this, the project has produced effects of increasing output in 2004 and in 2006 and thereafter, despite reduced steam volume.

Figure-3 Trend of plant load (capacity factor) and availability factor of facilities (rehabilitated 4 units)



Source： NPC

2.3.2 Recalculation of Financial Internal Rate of Return（FIRR）

FIRR increased from 9.2% at planning (appraisal) to 16.8% at evaluation. EIRR (Economic Internal Rate of Return) is difficult to be calculated and analyzed by comparison for evaluation, due to restriction on calculation measures applied for appraisal.

Increase in FIRR was mainly due to (i) increase of fuel cost and maintenance cost by 60%, increase of wholesale power cost to 2 times or more in contrast, and no increase in initial investment because the project scope was narrowed from 6 to 4 units, (ii) substantial delay in the project implementation worsened deterioration of facilities, which extremely widened the difference in outputs between With (with the project) and Without (without the project), for actual value than planned one (at planning, FIRR was based on assumption that capacity factor remains at 63% for Without, but in fact it plummeted to 20% by 2001. FIRR turns negative if the capacity factor remained at 63% for Without), (iii) regardless of substantial delay in starting procurement of materials/equipment and repair work, there was no cost incurred in the meantime, and (iv) repair work was completed as planned and succeeded in temporarily starting operation in 1.5 years of the first contract.

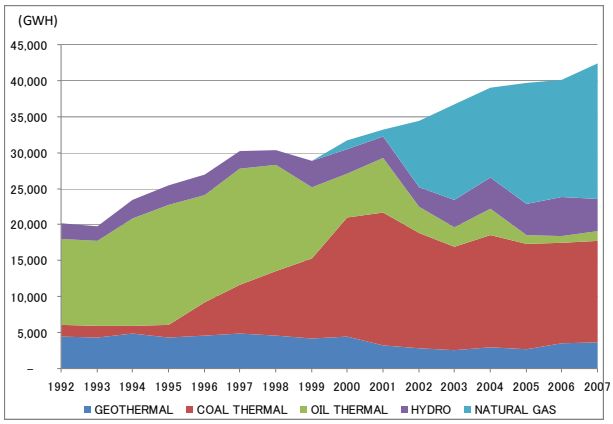
Table-5 Assumptions of IRR

	At planning	At evaluation
FIRR cost	Investment cost, fuel cost and operation maintenance cost (for rehabilitated portion)	Same as on the left. (Apply unit cost as of Nov. 2008 for fuel and maintenance costs in 2008 and thereafter)
FIRR benefit	Income from electricity sales (increase after repair/ improvement) Output was calculated based on capacity factor of 63% for actual, 70% for post rehabilitation and 63% for Without. Assumed 2 units will be closed in 2011 and another 2 in 2012.	Same as on the left. Applied actual output after project implementation until 2007. Applied actual figures for 2008, capacity factor of units 1 and 2 was put at 63% (operate 6 months each in turn) and units 5 and 6 at 75% (full operation), and assumed reduction of output by 8% every year due to dwindling steam volume for 2009 and thereafter. For Without, applied actual until 2002 and assumed output got lower than the actual output of the preceding year by 8% since 2003. Assumed units 1 and 2 will be closed by 2015 for both With and Without.
Project life	19 years (15 years after rehabilitation)	15 years after rehabilitation
Fiscal year	Calendar year	Same as on the left.

2.4 Impact

2.4.1 Contribution to the stabilization of Luzon Grid, diversification of energy sources and use of domestic energy

Figure-4 Trend of Luzon Grid generation by power source



Source : NPC

Compared to the planning stage, output of Tiwi Geothermal Power Plant has decreased as a whole as shown in Table-3 above. Positive impact of the output increase to Luzon Grid as a whole could not be confirmed. Generation share of the power plant to the whole Luzon Grid was 2.8% in 2006 and 2.0% in 2007, which is lower than 10.6% in 1992 when the project was planned. However, if the project had not been implemented, Tiwi Geothermal Power Plant is considered to have almost lost the power generating capacity. The project aimed at promoting an effective use of geothermal energy, which is highly valued as a renewable domestic energy. Since rated output of Tiwi Geothermal Power Plant makes up 30% of the total geothermal power generation at the Luzon Grid (based on rated output), the percentage of geothermal energy to the whole energy produced at the Luzon Grid could have been dramatically reduced without the project.

2.4.2 Economic impact

Geothermal power is an indigenous energy and had positive economic impact to lower fuel cost. Generation of 1kWh of electricity costs 6 times more in case of oil-fired power generation and 1.7 times more for gas-fired power generation in comparison to the cost of steam needed for geothermal power generation. The project was effective in cutting back fuel cost equivalent to 324 mil pesos (in case of gas-fired power generation) - 2.256 billion pesos (in case of oil-fired power generation).

2.4.3 Others

2.4.3.1 Impact to the environment

At first, acquisition of Environment Compliance Certificate : ECC was considered not necessary for the project, because it is a rehabilitation project to recover the function, not involving establishment of a new plant. However, ECC was actually issued in September 2002, and based on that, NPC has been implementing environmental monitoring during and after the project implementation. The result was compiled by NPC every quarter. Environment Control Bureau, local government, power plants, Steam Supply Service Company and NGOs also have started joint monitoring activities.

Picture-2：Environment around the power plant

At the project, equipment to dilute hydrogen sulfide gas was installed to mitigate the impact of the gas emission, as a measure to improve environmental condition. According to the monitoring results, the project satisfies the standard of the country, and so far, no specific problem has been pointed out in compiled reports. Temporary dwellings are sparsely located in areas around the power plant as shown in Picture-2. No serious problem was reported after visiting and hearing from some residents.

2.4.3.2 Impact to social environment, land acquisition and relocation of residents

The project does not involve land acquisition or resettlement because it is a rehabilitation project of existing facilities. According to the provision on tax payment to the local government, 0.01 pesos are taxed per the sale of 1kWh electricity. The project contributed to increase earnings from electricity sales and tax revenue for the local government, resulting in improvement to the standard of living and introduction of social welfare programs for residents in the area.

2.5 Sustainability（Rating：b）

Due to observed concern over the shortage in steam volume and the impact to the sustainability of the project, sustainability of this project is fair.

2.5.1 Implementing organization

2.5.1.1 Structural organization for operation and maintenance

Environment surrounding power sector in the Philippines had dramatically changed from the time of the project appraisal to today. The impact is making changes to the

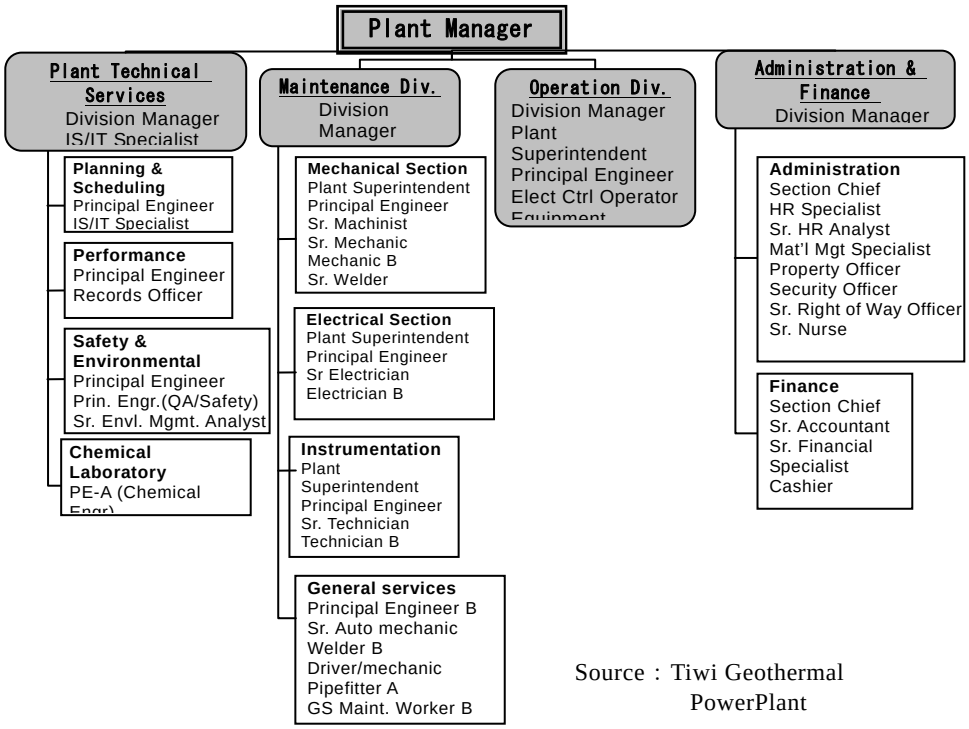
operation and maintenance of the power plant. More specifically, Electric Power Industry Reform Act : EPIRA was enacted and entered into force in June 2001, and because of this, decision was made to split NPC, an implementing organization of the project, into a power generation company and a power transmission company, and privatize each (power generation asset is to be sold).

In response to the reorganization of power sector, bidding of both Tiwi and Mak-ban power plants took place at the end of July 2008, to sell their asset and privatize the two power plants together. AP Renewables (a company newly established to operate Tiwi/Mak-ban power plants), wholly owned subsidiary of Aboitiz Power Corporation （APC） successfully won the bidding.

As of December 2008, operation and maintenance of the power plants were continuously undertaken by Tiwi Geothermal Power Plant Office under NPC, as pre-sellout transitional arrangement. Currently, 167 employees of NPC (2 supervisors, 65 operators, 63 maintenance staffs, 19 administration and finance division staffs and 18 engineers) are working at Tiwi Geothermal Power Plant (see Figure-5).

Handover of the power plant to AP Renewables is planned to take place around May 2009, and operation, maintenance, control and management of the power plants will also be completely transferred from NPC to AP Renewables by then.

Figure-5 Organization chart of Tiwi Geothermal Power Plant



Source : Tiwi Geothermal PowerPlant

2.5.1.2 Technology for operation and maintenance

The power plant has accumulated experiences through 30 years of operation, and operation and maintenance are done based on their own knowhow and technology, without technical assistance from external parties.

According to the operation and maintenance plan of AP Renewables submitted in times of the bidding, the company basically maintains the current employees of Tiwi Geothermal Power Plant for the time being. Also abundant experiences of its parent company Aboitiz Power Corporation are expected to be reflected to the operation and maintenance of the power plant, accumulated by undertaking numerous projects of hydraulic power generation and power transmission projects in the country.

As stated above, there is no structural or technical problem with the current NPC structure. AP Renewables also has abundant power generation project experiences and since they intend to maintain the current employees of NPC, there is no specific concern in terms of technology/structure as of December 2008, in transitional phase.

2.5.1.3 Finance for operation and maintenance

As aforementioned, although output of the power plant almost halved, wholesale power cost has more than doubled compared to the plan. Since steam cost is stable, rate of return for geothermal power generation is high[4].

Table-6 Main financial performance

（Unit：million pesos）

	2005	2006	2007
Operation income	2,748	4,621	3,859
Steam cost	1,082	1,112	789
Operation & maintenance cost	251	230	265
Average selling price（pesos/kWh）	4.48	4.84	4.72
Average steam cost（pesos/kWh）	1.46	0.95	0.87

Source：Tiwi Geothermal Power Plant materials

Note：Cost for operation and maintenance (and cost for drilling) of steamfield are necessary, separate from these costs of the power plant. NPC reimburses the cost to Steam Supply Service Company.

The power plant and Mak-ban Geothermal Power Plant were sold by bidding in July 2008 at 447 mil dollars, which is more than three times of the project cost and Mak-ban

[4] NPC is expected to handover the power plant around May 2009. Failure of the power plant sometimes causes suspension of power generation for several months, since they have low incentive to actively invest in the maintenance and repair needed to maintain the plant operation right now. However, the situation will improve once AP Renewables completely takes over the power plant.

Geothermal Power Plant rehabilitation project cost combined.

Financial condition of Aboitiz Power Corporation, a parent company of AP Renewables is deemed good since they are steadily increasing income from power generation and power transmission businesses, and the ratio of their current assets to current short-term liabilities exceeds 200%.

Table-7 PL Statement of Aboitiz Power Corporation (million pesos)

	2005	2006	2007
Revenue	8,053	8,681	11,312
Profit before tax	2,872	2,275	4,882
Net income	2,444	1,850	4,138

Table-8 Financial ratio of Aboitiz Power Corporation (times)

	2005	2006	2007
Current ratio	2.40	3.33	2.54
Debt-to-equity ratio	0.47	0.41	0.31

Source : (Table-7 and 8) Annual report of Aboitiz Power Corporation

2.5.2 Operation and maintenance status

Units subject to rehabilitation by the project go through detailed examination once in two years and regular check in every quarter. The power plant is operated for 8 hours a day in 3 shifts.

Table-9 Steam supply capacity

(1) Max. steam supply	160-162 MW
(2)Total rated output after repair of units 1,2,5 and 6	234 MW
(3) Max. operation rate ((1)/(2)、based on 4 units)	68-69% (Exceeds total rated output for 3 units)

Source: Based on the hearing survey by NPC

Although operation and maintenance structure is put in place, shortage of steam volume, failure of obsolete facility and damages caused by natural disasters make it difficult to fully operate the 4 units. Problem of steam volume is especially serious because it is barely sufficient to operate 3 units now. As the volume is expected to decrease by 8-10% every year, only 2 units will be operable in just a few years. In this situation, there is a plan to excavate 2 new steam fields that is expected to add about 15MW additional electricity. However, effect of this is considered restrictive because the steam supply capacity will also gradually decline in the future.

3. Conclusion, lesson learned and recommendation

3.1 Conclusion (Rating : D)

Even though the project is relevant with government policy and development needs, the implementation was substantially delayed (low efficiency), effectiveness is restrictive due to steam volume reduction, etc. (moderate effectiveness/impact) and the standard of operation set in the original plan for rehabilitated facilities is unlikely to be achieved, due

to the declining trend of steam volume (fair sustainability). In light of the above, the project is evaluated to be unsatisfactory.

3.2 Lesson learned

(1) In relation to sustainability of geothermal energy, the volume of steam decreases if recovery of hot underground water does not catch up with the extraction of hydrothermal from geothermal reservoir. Tiwi Geothermal Power Plant already had difficulty in operating 6 units at rated output when the project was planned. On top of unfavorable geographical condition of being close to seashore and prone to be affected by seawater, the plant used to operate at rated output of 55MW×6 units, that caused to decrease steam volume year after year. Currently, 2 units are completely closed. The steam volume is hardly sufficient to operate 4 rehabilitated units at rated output. It is important to be mindful about not losing the balance of geothermal reservoir when planning the development or rehabilitation project of geothermal power plant like this.

(2) A big factor that caused the long delay in the project implementation is confusion persisted in the wake of steam supply contract (25 years) expiration in 1996. For planning an energy development project like this, it is important to fully analyze risks and consider measures to control the risks associated with stable supply of fuel source, indispensable for smooth operation after completion of a project.

(3) Deterioration of the existing facilities continued while the project implementation was suspended, leading to increase repair cost per unit and delayed effects from being produced. Mixed with the reform of power sector, introduction of privatization policy and other complex political factors, the project implementation required considerable time for review. However, the government of a borrowing country should have committed more strongly to expedite the project and achieve the target of “stable power supply”. To avoid substantial delay in implementation of project like this, strong commitment of a borrowing country and effective measures of the government of a lending country and JICA are desired if any change to external conditions possibly seriously affecting the project is confirmed in times of progress status monitoring.

3.3 Recommendation

Geothermal power generation is an effective measure to counter global warming because carbon dioxide emission is about one twenties of that of thermal power generation. Also, geothermal power generation is superior as a renewable energy because it enables stable supply of power and suitable for generation of a base load

power[5]. Although evaluation of the project was low as a whole, it does not mean to undermine the superiority of geothermal power generation or the value of geothermal power generation project in general. It is desirable to actively promote geothermal power generation projects in the future, as long as adequate study on geothermal reservoir and natural/social environments is carried out and necessary measures are taken, with cap on extractable steam volume, and implementation is based on detailed project planning.

[5] Base load power is the basic portion of power supply stably provided without being affected by power demand that varies depending on time zones.

Plan／actual comparison of performance

Item	Plan	Actual
(i)Output ・ Rehabilitation of the existing power generation facilities	Breakdown Rehabilitation of 55MW×6 units Turbine: ・Procurement of turbine spare rotor etc, and replacement of control board recorders, etc. Generator: ・Special check of generator, repair of generator AVR, and procurement of tube cleaner for generator hydrogen gas cleaner, etc. ・Installation of a hybrid gas extraction system ・Procurement of various spare tools for repair and environmental monitoring equipment	Rehabilitation and reinforcement of 60MW×2 Units and 57MW×2 units Failure due to an obsolete facility was extensive and drastic revision to the original plan was required to address the situation.
・ Consulting service	Foreign : 60M/M Domestic : 46M/M Total : 106M/M	Foreign : 55.25M/M Domestic : 47.75M/M Total : 103M/M
(ii)Period		
Exchange of loan agreement	Planned in Aug. 1993	Dec 1994
Selection of consultant	Sep 1993-Apr 1994	Jan 1995-Jan 1997
Consulting service	May 1994-Dec 1997	(1)Apr. 1997-Apr 2004 (2)Sep.2004-Nov 2005
Bidding-Contract becomes effective	Sep 1994-Apr 1995	Apr 1997-Jul 2002
Material/equipment procurement/repair work	May 1995-Oct 1997	(1)Jun 2003-Feb 2004 (2)Jun 2004-Dec 2005
Exchange of loan agreement-Completion	Aug 1993-Oct 1997 (51 months)	Dec 1994-Dec 2005 (133 months)
(iii)Project cost		
Foreign currency	7,056 mil yen	6,409 mil yen
Domestic currency	209 mil yen （42 mil pesos）	25 mil yen （12 mil pesos）
Total	7,265 mil yen	6,434 mil yen
Yen loan	7,056mil yen	6,408 mil yen
Exchange rate	1 peso=5.00 yen （as of Nov 1993）	1peso＝2.13 yen （ weighed average during 1997-2005）