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Malaysia

# Port Dickson Power Station Rehabilitation Project

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Field Study : September 21-27, 2008

## 1. Project Profile and Japan's ODA loan


Location of the project site

Port Dickson Power Station
(Power generation facility)

### 1.1 Background :

In 1990s, power demand of the Peninsular Malaysia has dramatically increased due to high economic growth and increase of foreign companies investing in Malaysia. Peak demand increased 1.9 times higher and electricity sale doubled or more during 1992-1998. Thereafter, peak demand was expected to achieve to 12,000MW-14,000MW by year 2005,, with growth rate about 5-7% per year, while the volume of electricity sale was estimated to increase to 70,000GWh-85,000GWh in the same year, with growth rate 5-8% per year. Demand of the power system in the Peninsular Malaysia is mainly concentrated in the Kualalumpur metropolitan area, Putrajaya at southwest of Kuala Lumpur, and area subject to Multimedia Super Corridor, and power demand of these areas was expected to increase further. Amid expectation for the investment in information related industry, there was much demand for high quality of a power generation facility without the occurrence of power failure.

In 1998, total capacity of power supply facility in the Peninsula was 12,617MW, of which Tenaga Nasional Berhad (TNB), a power company of Malaysia, has 62% and Independent Power Producers (IPP) own the rest of 38%. Due to the Influence by the currency crisis at that time, financing for IPP projects became very difficult and caused substantial delay in the project implementation. In this situation, the government of

Malaysia prioritized the development of TNB power source.

1.2 Objective：

The project aimed to demolish oil-fired power plant facilities which is seriously deteriorated and inefficient (240MW out of 600MW in the project[1]) and to replace it with highly efficient combined cycle gas turbine power generation facilities with low emission of poisnous gas, thereby contributing to the stabilization of the power system and diversification of energy source in the Peninsular Malaysia.

1.3 Borrower/Executing Agency： Tenaga Nasional Berhad (TNB) (Guarantee by the government of Malaysia)

1.4 Outline of Loan Agreement：

| | |
|---|---|
| Loan Amount/ Loan Disbursed Amount | 49,087million yen/48,607million yen |
| Exchange of Notes/ Loan Agreement | March 1999/March 1999 |
| Terms and Conditions | Interest rate 0.75%, Rrepayment period: 40 years (Grace Period: 10 years), General Untied Loan |
| Final Disbursement date | June 2006 |
| Main Contractors | PCB Power SDN BHD(Malaysia), Mitsui & Co., Ltd.(Japan), Mitsubishi Heavy Industries Ltd.(Japan) |
| Consultanting Services | Tokyo Electric Power Services Co., Ltd. (Japan) |
| Feasibility Study：(F/S) etc. | 1998 F/S by TNB |

## 2. Evaluation Result

2.1 Relevance (Rating：a)

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

[1] Removal of old facility that used to generate the remaining 360MW and the construction of 750MW class combined cycle gas turbine power generation facility were implemented under “Port Dickson Power Station Rehabilitation Project(2)”, ODA loan agreement in 1999.

2.2.1 Consistency with government policy and measures

Main target of an energy sector in the 7th Five Year Plan (1996-2000) was "ensuring adequate, secure, and cost-effective supplies, utilizing the resources efficiently and minimizing its negative impacts on the environment" One of the measures the government applied to achieve the target was "continued diversification of energy sources", in other words; to promote continuously diversification of energy sources by increasing the use of natural gas, hydro power, and coal, and to reduce heavy dependency on oil. The government upheld the policy to speed up the utilization of gas in power sector and continuously focused on the use of gas.

The 8th Five Year Plan (2001-2005) also upheld the policy to meet the needs of output capacity increase at power generation facilities to meet rising demand, and make a shift from thermal power station to gas-fired power station, which is highly efficient and less environmental burden. However, in the 9th Five Year Plan (2006-2010), the policy was changed to mitigate heavy dependency on gas and increase the use of coal to promote diversification further. Supply of gas to power sector started to be limited (1,350mmscfd[2]) since 2002, and gas supply is currently limited to the existing gas-fired power generation facilities and their replacement.. The project was planned when the government promoted a shift to gas-fired plant. Since the country maintains a certain level of gas-fired power plants in existence or projects already being implemented, the project is still relevant at the present.

The project was consistent with the Malaysian government policy because it aimed at shifting from oil-fired power station to combined cycle gas turbine power station to promote the use of gas instead of oil and dramatically improve energy efficiency and environmental impact.

2.2.2 Consistency with development needs

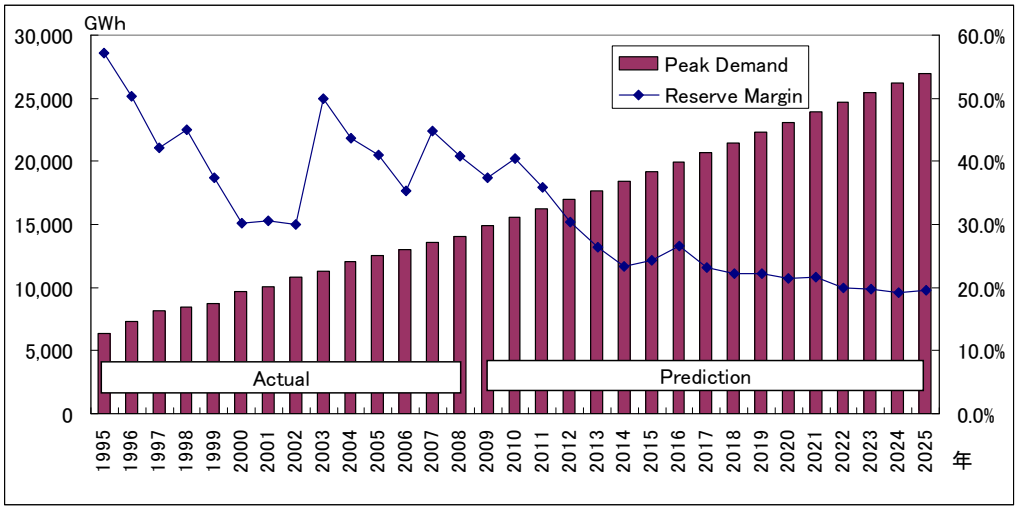
According to electricity demand forecast and analysis at appraisal in 1998, the reserve margin in the Peninsula would be below the target of 30% in 2001 and decrease to less than 4% in 2004, meaning stable supply of power becomes impossible. Thus, strengthening of power generation facilities was emergently needed.

Figure-1 shows peak power demand and actual reserve margin since 1995, and prediction after 2009, at the time of evaluation in 2008. The reserve margin remained satisfactory at around 30-40% since 2001 and 40.8% in 2008 (at the time of post-evaluation). This is because the actual peak demand in 2005 in the 9th Five Year Plan was 12,493MW, lower than the estimate of 15,380MW, predicted at the 8th Five Year

[2] Unit of gas flow rate and an abbreviation of "million standard cubic feet per day".

Plan. However, according to the present facility planning or long-term forecast after the start of power supply by the project, the reserve margin is forecasted to gradually decline after 2011 and reach 21.4% by 2020. In light of this, it can be also confirmed that there is a need for the project at the time of the post-evaluation. For reference, target of the reserve margin was revised to 20%, lower than before, by the government of Malaysia during interim review of the 9th Five Year Plan.

Figure-1：Peak demand and the reserve margin in the system in the Peninsular Malaysia




Source：TNB

Alleviation of environmental burden was necessary considering the location of the power station. Port Dickson is a tourism site close to Kuala Lumpur and schools, hospitals, hotels, residential houses, etc. are located adjacent to the power station. As confirmed at the appraisal, special consideration on environmental impact to the residents and facilities in the area was necessary. Oil-fired power station had been operated over 30 years and renewal of the facility was necessary since emission of poisonous gas increased as a result of serious deterioration.

## 2.2 Efficiency (Rating：b)

Although the project cost was less than the plan, the project period extended relatively to the plan ;therefore, the evaluation on efficiency is moderate.

### 2.2.1 Outputs

Planned outputs of the project was achieved almost as in the plan.. Physical change to the project was an addition of 6 bays (intake points of bus from power generator) relating to the combined cycle power generation facilities and 275kV Gas Insulated Switchgear (GIS). The reason was that in the original plan at appraisal, the existing power generator in Port Dickson was planned to be decommissioned after completion of the project, but later in 2002, the power generator was decided to be used continuously as a standby generator, thus, additional bays and the other relating facilities were needed. This decision is considered appropriate because reserve margin declined during 1998-2002.

Picture-1 : Power generation facility, water drain facility etc.

2.2.2 Project period

The project period prolonged slightly than the plan (119% of the plan). Reason for almost one year of delay was mainly caused by the delay of demolition work of the existing power station. Because of this, the commencement of construction was 10 months behind the schedule.

TNB financed with its own capital for the demolition of the existing facilities (units 1-4, 240MW in total) and held responsible for the implementation. However, the demolition required quite extensive works since it had to take place while operating the other units (5-7), and in addition, it was an attempt never conducted in the country before and the first experience for TNB. Therefore, it took time to review and prepare a plan for the demolition, and delayed the start of the work by 15 months. The demolition work itself also took 2 months longer than planned. Commencement of construction started 10 months behind the schedule and construction took 5 months longer due to changes and others to the outputs. However, parties concerned made efforts to make up for the delay by proceeding the detail design and engineering works earlier than planned. Owing to these efforts, delay of the overall schedule was shortened to one year.

2.2.3 Project cost

Total project cost was 52,687million yen (yen loan: 48,607mil yen) which was lower than the plan of 65,449million yen (ODA loan: 49,087mil yen) (81% of the plan). This is mainly due to the exemption of tax and customs duties by 7,027million yen or 10% of the total project cost, which became applicable after the project start. Major increase in

demolition cost and additional construction cost was offset by this.

2.3 Effectiveness(Rating：a)

The project has produced targeted effects and the objective was achieved; therefore, its effectiveness is high.

2.3.1 Status and effectiveness of operating power station

The rated output of ISO in the original plan was 750MW, but under the condition of temperature at 32 degrees in Malaysia, the test result of the maximum output was 725MW and Tested Annual Available Capacity(TAAC) was 703 MW. As shown in Table-1, capacity factor is over 80% and availability factor is also high at 90%. Availability factor based on ISO rated output is also high at 85% or over. Actual gross thermal efficiency was 55%. As shown in Fugure-2, net electric energy production exceeded the planned indicator by the project for the first time in its history.

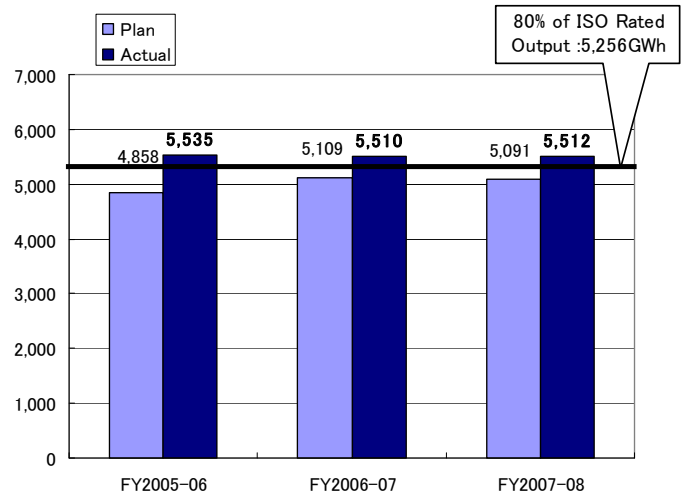
Table-1：Operation status indicator

| Indicator | | FY2005-06 | FY2006-07 | FY2007-08 |
|---|---|---|---|---|
| Plant load factor (%) | Plan | 92.0 | 92.0 | 91.4 |
| | **Actual** | **94.6** | **96.2** | **96.9** |
| Availability factor(%) | Plan | 85.2 | 90.1 | 89.5 |
| | **Actual** | **92.7** | **91.9** | **90.9** |
| Auxiliary power consumption (%) | **Actual** | **2.0** | **1.9** | **1.7** |

Source：TNB

Note：Plant load factor and availability factor above were calculated based on TAAC. Capacity factor is 85% or more by calculation based on rated output. Auxiliary power consumption is the ratio of internal power consumption to gross electric energy production.

Figure-2：Plan and actual of receiving-end output




Source：TNB

Such high availability factor can be explained by small unplanned outage time as shown in Table-2. Ratio of the unplanned outage to total operation hours is 0.94-1.22%, which is lower than the target of the power station, 3.4-4.0%. The number and hours of outage due to human error was reduced from 3times/14hours in FY 2006/07 to 2times/2hours in FY2007/08. The power station keeps detailed record of reasons of accident and reviews them to prevent recurrence of human errors.

Table-2：Outage Times and Hours by Causes

| **Reasons** | | **FY2005-06** | **FY2006-07** | **FY2007-08** |
|---|---|---|---|---|
| Human error | Times | 0 | 3 | 2 |
| | Hours | 0 | 14.16 | 2.16 |
| Mechanical failure | Times | 66 | 6 | 22 |
| | Hours | 528.11 | 18.72 | 410.16 |
| Planned | Times | 22 | 19 | 64 |
| | Hours | 1,587.44 | 2,475.84 | 2,323.44 |
| Total | Hours | 2,115.55 | 2,508.72 | 2,735.76 |

Source：TNB

2.3.2 Reduction of poisonous gas emission

It can imply that the project is effective in reducing emissions of NOx, SOx and $CO_2$ in comparison of previous oil-fired power station based on the actual operation status as shown in Table-3. In terms of the unit of power generation, reduction of almost 100% of SOx, huge proportion of NOx, and about 60% of $CO_2$ is deemed to have been achieved.

Table-3：Reduction of toxic gas emission per unit output (kWh)

| Indicator (unit) | FY 2005~2007 |
|---|---|
| NOx emission reduction (%) | 98 |
| SOx emission reduction (%) | About 100 |
| Carbon dioxide ($CO_2$) emission reduction (%) | 61 |

Source：Calculated based on data provided by TNB

2.3.3 Recalculation of Financial Internal Rate of Return (FIRR)

FIRR was 8.82% by calculation at the appraisal, based on expenses of investment cost, fuel cost, operation and maintenance cost (including tax), and benefit of revenue from electricity sales and project life of 21 years. FIRR recalculated at evaluation was lowered by about 1% to 7.97%, as a result of decrease in project cost, increase in electricity sales revenue, dramatic increase in fuel cost and slight increase in operation maintenance cost.

2.4 Impact

2.4.1 Contribution to stabilization of power system in the Peninsular Malaysia and diversification of energy sources

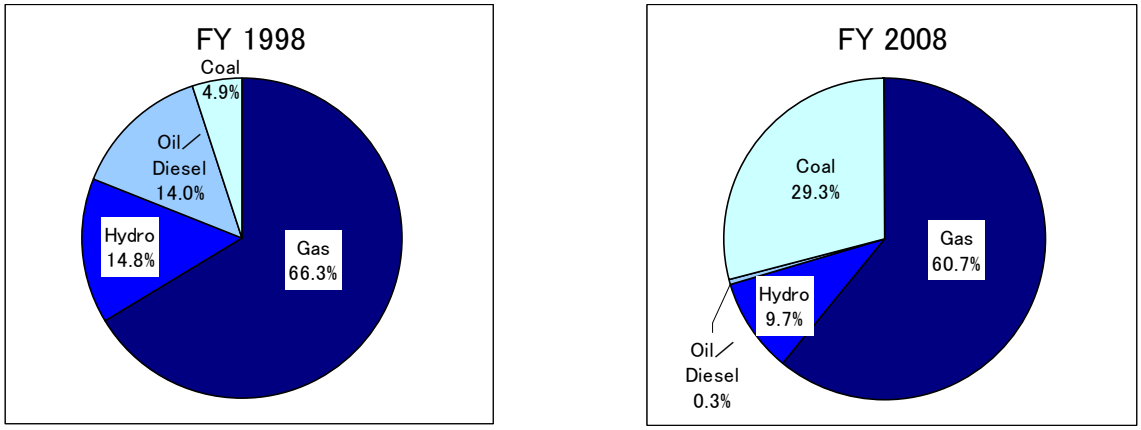
The project can be evaluated for its contribution to TNB that operates power system of the Peninsular Malaysia with the population of about 20 million, by stabilizing power supply with highly reliable power generation facility for the provision of base load electricity[3].

Annual economic growth in Malaysia has been about 5-6% since 2002. With such high economic growth, sales of electricity (means the same as output supply to the Peninsular Malaysia) have increased by 46.2% in 7 years from 56,210GWh in FY2000 to 82,214.8GWh in FY 2007. As shown in Figure-1, peak demand increased by 3,317MW (about 34%) from 9,712MW in FY 2000 to 13,029MW in FY 2006. Electric power generation by the project is about 6% of actual electricity sales of the Peninsular Malaysia power system. Focused on TNB only, which owns 55% of total power stations in the Peninsular Malaysia, the project makes up 6% of their total capacity and 14.5% of total power generation. Highly efficient and reliable source of power like the project is quite important to the whole power system.

In terms of diversification of energy sources, Figure-3 compares the share of power generation capacities by energy sources in the Peninsular Malaysia between 1998 and 2008. Gas reduced by about 6%, oil/diesel oil reduced by about 14%, respectively, and coal increased by about 24% since the government of Malaysia promoted the use of coal as energy sources for power generation. By focusing on TNB, the actual power generation by combined cycle in 2007 occupies 41% of the whole output, and the project contributes to about 27% of this. As shown in Figure-4, natural gas-fired power generation kept declining during 2001-2004, but turned upwards since 2005, when the project started its operation. Accordingly, main contribution of the project is considered in reducing oil based power generation share and increasing gas based power generation at TNB.

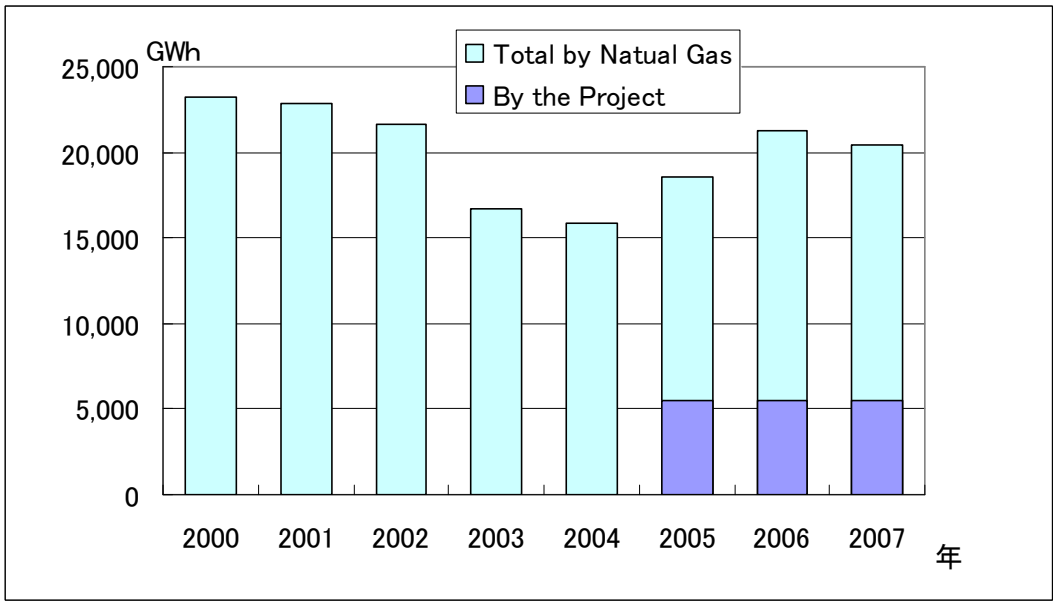
[3]Power supply is divided into the purpose of base load, middle load and peak load. Base load is the basic supply of power which is the most needed.

Figure-3 : Proportion of Electric Power Generation by Energy Sources in the Peninsular Malaysia




Source : TNB

Figure-4 Electric Power Generation by Natural Gas in TNB




Source : Energy Commission "Electricity Supply Industry Malaysia" (2006)p76, (2007) p79, and documents of TNB

2.4.2 Economic impact

Highly efficient gas-fired power generation is considered economically effective in reducing fuel cost. In case of oil-fired power station, fuel cost was about 1,780million Malaysia Ringgit (RM), which is higher by 1,500mil RM, in comparison to 250mil RM, the fuel cost of the gas-fired power station required to produce the same amount of electricity. The project helped in saving the same amount of fuel cost.

2.4.3 Technical impact

According to TNB, followings were newly leant by the project and helped the operation of other power plants (Prai Power Plant) that plans to introduce similar equipment.

- This was the first time for TNB to introduce combined cycle gas turbine equivalent to F-class[4]. There were many things to learn on the operation of the latest equipment, and how to identify problems and take countermeasures.
- Lessons were leant on work planning, progress management and others for keeping operation of some power generator units, while demolishing others and construct new units in the same place.

The project accepts over 1,000 visitors from inside and outside the country as a model power plant of Malaysia. As part of technical cooperation by the government of Malaysia or as part of training or exchanges with Heads of ASEAN Power Utilities/Authorities (HUPUA), people related to electric power business have visited Port Dickson Power Station from neighboring Asian countries.

2.4.4 Environmental impact

The project was implemented at the site of the existing power plant as planned, therefore , land acquisition and resettlement of residents were not conducted. The NOx and SOx emissions was marginal at a smoke stack outlet of the power station of the past several months submitted to Environment Bureau in charge of the project. The results of ambient air monitoring satisfied the standard set by the Environment Bureau, as shown in Table-4. Quality of water and noise level also satisfies the standard set by the Environment Bureau. According to the materials of TNB, $CO_2$ emission from the power station is about 0.38kg/kWh, which is the lowest level among thermal power stations owned by TNB.

[4] F-class gas turbine of Mitsubishi Heavy Industries is one with 1,350□ of temperature at turbine inlet. There are G-class and recently developed H-class gas turbine which have higher performance than F-class.

Table-4 : Volume of gas Emission causing Air Pollution and the results of Ambient Air Monitoring

(September 2007-July 2008)

| Items | Pollutants | DOE Standard | Unit converted from the left standard | Minimum (ppm) | Maimum (ppm) | Average |
|---|---|---|---|---|---|---|
| Emission from Stack | CEMS 1A (NO) | $NO_x$ – 2.0gm $SO_3/Nm^3$ | 560.25ppm | 0 | 55.3 | 18.48 ppm |
| | CEMS 1B (NO) | | | 0 | 30 | 20.33 ppm |
| | CEMS 1A ($SO_2$) | $SO_3$ –0.2gm $SO_3/Nm^3$ | 56.03ppm | 0 | 17.9 | 0.73 ppm |
| | CEMS 1B ($SO_2$) | | | 0 | 14.8 | 0.71 ppm |
| | Main Stack 1A (Dust) | 0.4 gm/$Nm^3$ | 400mg/$Nm^3$ | 2.7 | 47 | 19.16 mg/$Nm^3$ |
| | Main Stack 1B (Dust) | | | 8.7 | 10.7 | 8.55 mg/$Nm^3$ |
| Ambient Air Monitoring | $No_2$ | 0.075 ppm (24 Hour) | | 0.00053 | 0.0031 | 0.0017 ppm |
| | $SO_2$ | 0.04 ppm (24 Hour) | | ND | 0.016 | 0.011 ppm |

Source : Data provided by TNB and Port Dickson Power Station

Note : ND: Not Detectable. CEMS1A and 1B show the volume of emission at the outlet of smoke stack of 2 waste heat recovery steam generator .. Result of the atmospheric environment monitoring is limited to March, April and June 2008. 1gm＝one thousandth of 1g.

According to the division in charge of power plant environment monitoring, results of atmospheric monitoring have dramatically improved compared to obsolete oil-fired power plant[5]. No complaint was filed from a school, a hospital or a resident around the power station after operation of the project was started. Also, according to the Environment Bureau of Negeri Sembilan State in charge of the Port Dickson power station, the volume of contaminated substances emitted by the power station satisfies the set environmental standard and they have never received complaints from local residents. In light of the above, this project is evaluated to have contributed to the improvement of the surrounding environment.

2.5 Sustainability (Rating : a)

No major problem has been observed in the capacity of the executing agency nor its operation and maintenance system; therefore, sustainability of the project is high.

2.5.1 Executing Agency

2.5.1.1 Organization Structure for operation and maintenance

The organization chart of the power station under direct control of Port Dickson Power Station of TNB is as shown in Figure-5. 288 employees used to work at the power station but almost halved to 138 after the start of the operation, owing to the advancement of technology. There are 4 divisions, namely power generation, maintenance & engineering, business support service and personnel & quality divisions. As of 2008, over 100 employees including 30 engineers are allocated to power generation and

[5] Although past data was not available, officials in charge of environmental monitoring said NOx emission reached 70-80ppm or over during monitoring of old oil-fired power plant.

maintenance divisions. Regular checkout is conducted by maintenance engineering division of Port Dickson Power Station and they have a organized system to implement daily operation and maintenance. There are 101 employees (including 27 engineers) in charge of operation and maintenance, considered sufficient to cover necessary works. Overhaul[6] and other periodical maintenance are outsourced to REMACO (TNB Repair and Maintenance Sdn. Bhd), a subsidiary of TNB.

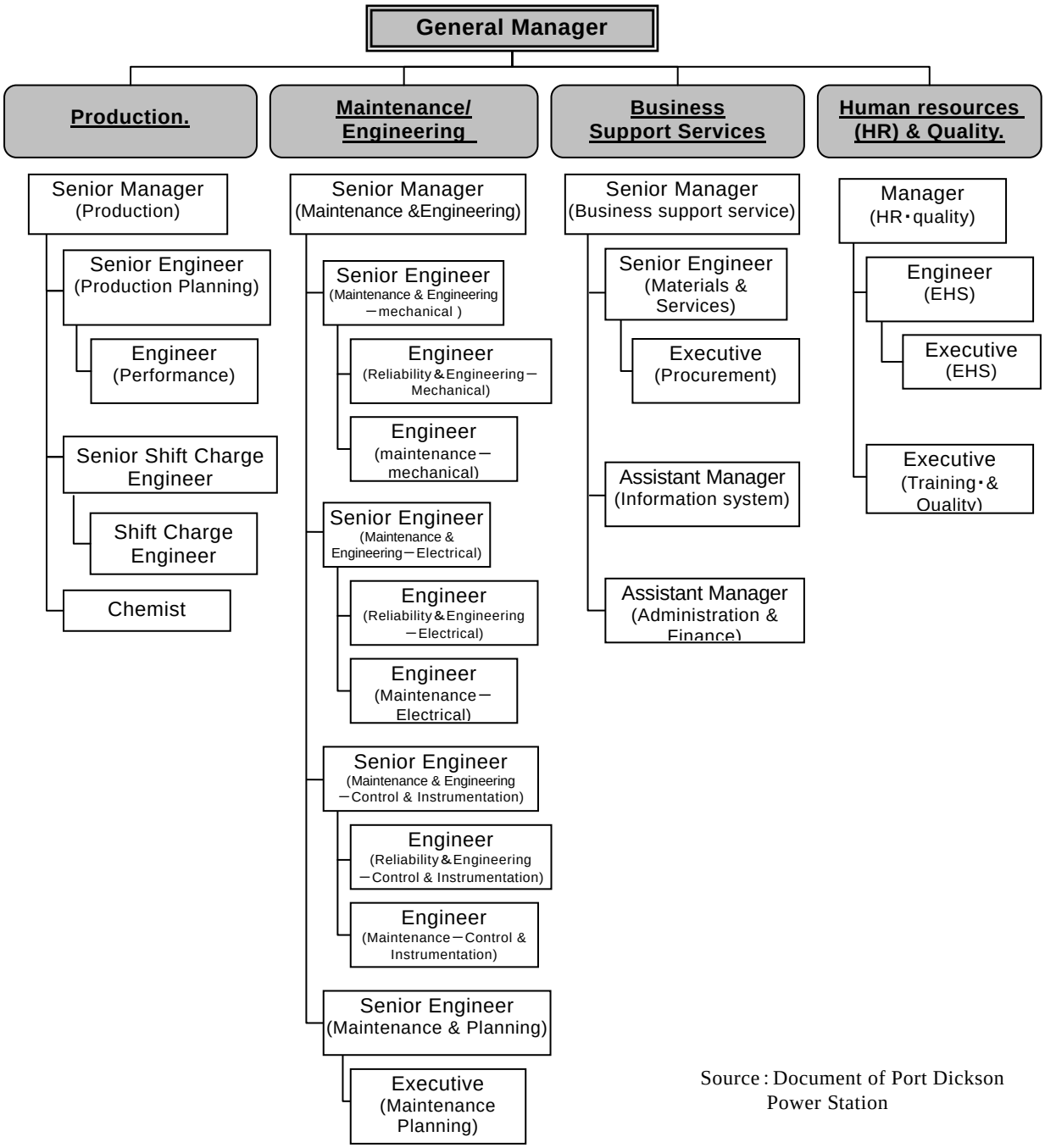
2.5.1.2 Technology for operation and maintenance

Employees in charge of operation and maintenance receive training from contractors and manuals are made available to them. Trainings are periodically conducted every year for employees by the rank and the type of the work. In addition to the trainings of newly hired employees to be in charge of maintenance and regularly provided reeducation of experienced engineers, trainings of system operation by on-the-job training (OJT), etc are also provided.

Annual operation plan (including maintenance and overhaul) was almost completed according to the schedule. Currently, Preventive Maintenance (PM) and Corrective Maintenance (CM) are conducted by the ratio of 3 to 1. In the future, the ratio is planned to be 4 to 1 because emphasis and efforts are put on the prevention of accidents and troubles.

[6] Carry out thorough check/repair from the technical viewpoints of experts.

Figure-5: Organization chart of Port Dickson Power Station




Source : Document of Port Dickson Power Station

Picture-2：Control Room

TNB evaluates its employees working in the power station based on Key Performance Indicator[7]. It is envisaged that the evaluation indicators on technical capacity at both of individual and power station level can enhance the awareness of problems and urge improvements in operation. REMACO, a company to undertake overhaul of the power plant was established in 1995, and skills of its employees are deemed sufficient since they have experiences of providing operations and maintenances in power plants overseas such as Indonesia, Pakistan, Saudi Arabia, in addition to domestic experiences. From the points in the above, technical capacity transferred through this project is sustainable.

2.5.1.3 Financial Capacity for operation and maintenance

Operation and maintenance expenses required at Port Dickson Power Station are financed every year. Revenue and profits continuously increased in the past five years as a whole TNB (as well as a whole TNB group) except for 2005, and marked by a double increase in profit from 2006 to 2007. Electricity sales have increased by 10% or more with relatively moderate increase in operation expenses.

PETRONAS, a Malaysian state owned oil company is supplying gas to the power station, but since September 2008, cost of gas almost doubled and increased O&M cost of the power station. It is unclear to what extent the cost increase affects the whole TNB, because Port Dickson Power Station is one of the power plants owned by TNB. Thus, it is difficult to project long-term trend of fuel cost and other expenses. At this moment, there is no major factor that can influence short-term operation and maintenance of the project.

Table-5：Main financial performance

(Unit：million RM)

| Item | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| (1)Revenue | 15,306.9 | 16,538.3 | 17,561.3 | 18,815.1 | 21,400.6 |
| (2)Operation Expense | 12,943.0 | 14,010.6 | 15,787.1 | 16,601.6 | 17,441.8 |
| (3)Operation Revenue | 3,099.7 | 3,450.4 | 2,599.5 | 2,904.5 | 4,752.7 |
| (4)Depreciation | 2,176.0 | 2,246.4 | 2,217.1 | 2,648.4 | 2,595.2 |
| (5)Profit/Loss before Tax | 1,947.3 | 1,958.6 | 1,601.4 | 2,000.6 | 4,124.4 |

Source：TNB annual report

[7] The indicator includes finance (improvement in sales and budget execution, etc.), customer service (reliability etc. such as unplanned outage hours), internal process (improvement of safety and environment requirements, etc.) and learning and growth (project completion achievement or technical skills etc.).

2.5.2 Status of operation and maintenance

Upon the field survey in the power station, status of operation and maintenance is fine with good facility condition and spare part inventory control. Frequency of daily maintenance is set for item by item and overhaul of gas turbine and steam turbine is done in every 8,000 hours and 2 years, respectively.

Port Dickson Power Station is the best operation and maintenance status among ones owned by TNB in recent years. In FY2007, Port Dickson Power Station performed better than any other thermal power plants of TNB in terms of plant load factor, unplanned outage time, reliability and efficiency, etc based on those indicators. The power station is in the rank of 5 stars in the safety management system, which is the highest rating in TNB evaluation system.. The power plant also performs well in comparison to utilization factor, time of unplanned outage and so on (2001-2007) of the same type gas turbine in the world.

## 3.Conclusion, Lessons Learned and Recommendations

3.1 Conclusion (Rating：A)

In consideration of the delay in the project completion caused by demolition works etc., efficiency of the project is moderate, however, the project is relevant with government policies and development needs and it is highly effective in terms of good operation conditions. At the same time, the project brought about various impacts in environmental, economic and technical aspects. Also, sustainability of the project is high with respect to the organization structure, technical and financial capacity of TNB. In light of the above, overall evaluation of the project is highly satisfactory.

3.2 Lesson learned

Detailed preparation and planning are required in advance for constructing a new facility in the same site of the existing power plant. The project delayed largely behind the schedule since the period required for the preparation had not been taken into consideration. Preparation period of demolition work should have been incorporated in the work schedule.

3.3 Recommendation

No recommendation

**Comparison of Original and Actual Scope**

| Item | Plan | Actual |
|---|---|---|
| (i) Output | (Major Items) | |
| ・ Removal of the existing power plant | Removal of 60MW×4 units | As planned |
| ・ Combined cycle gas turbine power generation facilities | Power station : 750MW class, 2 gas turbines, 2 heat recovery generators, 1 steam turbine, as well as auxiliaries and common facilities, etc. | As planned |
| | Civil work : preparation of site, foundation work, Reconstruction of road and drainage work etc. | As planned , with addition of 6 bays and related facilities of 275 kV GIS |
| | Construction work : main power house building, office building, auxiliaries building, and so on | |
| | Compressor, metering station etc. | As planned |
| ・ Gas supply facility | International : 395M/M<br>Local : 595M/M<br>Total : 990M/M | International : 305M/M<br>Local : 502M/M<br>Total : 807M/M |
| ・ Consulting service | | |
| (ii) Project Period | | |
| ・ Demolition work of the existing power plant | Jan.-Nov., 2000 | Feb. 2002-Feb. 2003 |
| ・ Construction | | |
| PQ~bidding~contract | Feb. 2000-Aug. 2001 | Sep. 1999-Oct. 2001 |
| Construction/ installation | Sep. 2001-Mar. 2004 | Jul. 2002-Jun. 2005 |
| Guarantee period | Mar. 2004-Mar. 2005 | Jun. 2005-Jun. 2006 |
| ・ Consulting service | Jan. 2000-Mar. 2005 | Dec. 1999-Jul. 2005 |
| (iii) Project cost | | |
| Foreign currency | 44,098mil yen | 37,422mil yen |
| Local currency | 21,351mil yen<br>(669,310 thousand RM) | 15,265mil yen<br>(450,928 thousand RM) |
| Total | 65,449mil yen | 52,687mil yen |
| ODA loan portion | 49,087mil yen | 48,607mil yen |
| Exchange rate | 1RM=31.9 yen<br>(As of Nov. 1998) | 1RM＝29.54 yen<br>(Weighted average 2000~2006) |

## Appendix 1： Recalculation of FIRR

| Consumer Price | | | | |
|---|---|---|---|---|
| 年 | Exchange Rate*1(1US$=RM) | Exchange Rate*1 (1US$=Yen) | CPI actual*2 | CPI estimaed (2006=100) |
| 00 | 3.8 | 107.77 | 100.0 | 83.1 |
| 01 | 3.8 | 121.53 | 102.8 | 85.4 |
| 02 | 3.8 | 125.39 | 104.5 | 86.8 |
| 03 | 3.8 | 115.93 | 106.8 | 88.7 |
| 04 | 3.8 | 108.19 | 109.7 | 91.1 |
| 05 | 3.8 | 110.22 | 113.4 | 94.2 |
| 06 | 3.7 | 116.30 | 117.1 | 97.2 |
| 07 | 3.4 | 117.75 | 120.4 | 100.0 |
| 08 | | | 120.4 | 100.0 |

*1= Based on IInternational Financial Statistics Annual Average Exchange Rate (rf) , published by IMF

*2= Basedon International Financial Statistics Consumer Price Index by IMF

Applied CPI in 2007 for 2008 and thereafter

| Recalculation of FIRR | | | | | | | | | Unit：Million US$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cost | | | | | | | Benefit | | Cash Flow |
| 年 | | Investment | Fuel | O&M | Total | Tax | Grand Total | CPI adjusted Total A | Electricity Sale | CPI adjusted Total B | ( =B-A ) |
| 00 | | 2 | | | 2 | | 2 | 2 | | 0 | -2 |
| 01 | | 2 | | | 2 | | 2 | 3 | | 0 | -3 |
| 02 | | 55 | | | 55 | | 55 | 63 | | 0 | -63 |
| 03 | | 45 | | | 45 | | 45 | 51 | | 0 | -51 |
| 04 | | 245 | | | 245 | | 245 | 269 | | 0 | -269 |
| 05 | 1 | 81 | 67 | 12 | 160 | | 160 | 169 | 93 | 99 | -71 |
| 06 | 2 | 24 | 69 | 13 | 107 | 7 | 114 | 117 | 132 | 136 | 19 |
| 07 | 3 | | 89 | 17 | 106 | 23 | 129 | 129 | 192 | 192 | 63 |
| 08 | 4 | | 163 | 16 | 179 | 23 | 202 | 202 | 265 | 265 | 63 |
| 09 | 5 | | 150 | 29 | 179 | 19 | 198 | 198 | 251 | 251 | 52 |
| 10 | 6 | | 158 | 45 | 204 | 15 | 219 | 219 | 260 | 260 | 41 |
| 11 | 7 | | 160 | 25 | 185 | 21 | 206 | 206 | 262 | 262 | 56 |
| 12 | 8 | | 163 | 17 | 180 | 23 | 203 | 203 | 265 | 265 | 62 |
| 13 | 9 | | 159 | 26 | 185 | 20 | 206 | 206 | 261 | 261 | 55 |
| 14 | 10 | | 163 | 18 | 181 | 23 | 204 | 204 | 265 | 265 | 62 |
| 15 | 11 | | 147 | 33 | 180 | 18 | 199 | 199 | 248 | 248 | 50 |
| 16 | 12 | | 163 | 18 | 182 | 23 | 204 | 204 | 265 | 265 | 61 |
| 17 | 13 | | 160 | 29 | 189 | 20 | 208 | 208 | 262 | 262 | 54 |
| 18 | 14 | | 162 | 19 | 181 | 23 | 204 | 204 | 265 | 265 | 62 |
| 19 | 15 | | 163 | 30 | 193 | 19 | 212 | 212 | 262 | 262 | 51 |
| 20 | 16 | | 165 | 20 | 185 | 22 | 206 | 206 | 265 | 265 | 59 |
| 21 | 17 | | 166 | 37 | 204 | 12 | 216 | 216 | 248 | 248 | 32 |
| 22 | 18 | | 168 | 21 | 189 | 21 | 209 | 209 | 265 | 265 | 56 |
| 23 | 19 | | 170 | 31 | 201 | 16 | 218 | 218 | 262 | 262 | 45 |
| 24 | 20 | | 172 | 22 | 193 | 19 | 213 | 213 | 265 | 265 | 53 |
| 25 | 21 | | 173 | 33 | 206 | 15 | 221 | 221 | 262 | 262 | 41 |

| Conditions for FIRR Calculation |
|---|
| ・Project life：21 years after the commencement of operation |
| ・Fiscal Year ： September ～August |
| ・Benefit：Revenue by Eletricity Sale |
| ・Cost: Construction investment, fuel cost, O&M cost, tax |

＊Enterprise Tax is 27%

**Financial Internal Rate of Return (FIRR)**

**= 7.97%**

**(FIRR at appraisal =8.82%)**