Malaysia

Port Klang Power Station Project (Phase 3 /Phase 3-Stage2)

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Tenaga Nasional Berhad[1]
Field Survey: March, 2006

1. Project Profile and Japan's ODA Loan

Location of the project site

Port Klang (Kapar Phase 3) power station

1.1 Background

With the high economic growth, energy demand in the Peninsular Malaysia had grown significantly over the last years with an annual growth rate of 11.4% to 3,447 MW in 1990. Although the growth pace was expected to slow down in the future, energy demand was forecasted to reach 10,448 MW in 2000 with an annual growth rate of 10.6%. Since total installed capacity in 1990 was still 4,576 MW, a serious energy shortage was expected to occur in the future. To fill this gap, construction and expansion of power plants was indispensable option. On the other hand, the Malaysian Government carried out "Four fuel diversification strategy" to enhance the use of indigenous resources and reduce petroleum dependency. The Sixth Malaysia Plan (1991-1995) also envisioned to augment gas supply. The project, to construct 1,000 MW multi-fuel fired power plant, was therefore expected to contribute to both increment of supply capacity and diversification of energy source.

1.2 Objectives

The project's objective was to meet the rapidly increasing demand for energy and assure stable energy supply in the Peninsular Malaysia through construction of a thermal power station (known as Kapar Phase 3 Plant) located adjacent to the existing plants in Port Klang area, and thereby contribute to further economic growth and reducing oil dependence of the country.

[1] "Port Klang Power Station Project (Phase 3/Phase 3-Stage 2)" is jointly evaluated by Taro Tsubogo, the consultant appointed by Japan Bank for International Cooperation (JBIC) and Tenaga Nasional Berhad (TNB), the executing agency of the project with facilitation by JBIC and Economic Planning Unit (EPU).

1.3 Borrower / Executing Agency

Tenaga Nasional Berhad (TNB)/ Tenaga Nasional Berhad (TNB)

1.4 Outline of Loan Agreement

	MXIV-4 (Phase 3)	MXV-1 (Phase 3-Stage 2)
Loan Amount Disbursed Amount	31,966 million yen 29,110 million yen	39,955 million yen 25,684 million yen
Exchange of Notes Loan Agreement	May, 1992 May, 1992	August, 1993 September, 1993
Terms and Conditions - Interest Rate - Repayment Period (Grace Period) - Procurement	 3.0 % p.a. 25 years (7 years) General Untied	 3.0 % p.a. 25 years (7 years) General Untied
Final Disbursement Date	December, 2000	January, 2001
Main Contractors	Ishikawajima-Harima Heavy Industries Co., Ltd. (Japan), General Electric Company / Electric Technical Service Company. (USA/USA)	
Consultant	EPDC International Ltd. (Japan)	
Project Identification and Preparation Study, and Feasibility Study (F/S)	1981 Turbo-alternators Project Loan Agreement (L/A) 1981 Boilers Project L/A 1984 Phase II L/A	

Note: MXVI-4 (Phase 3) only covered the components of boiler and consulting service. MXV-1 (Phase 3-Stage 2) extended the coverage to include the components of turbine and sub-station equipment, upon the request from the Malaysian government.

2. Evaluation Results

2.1 Relevance

2.2.1 Relevance of the project plan at the time of appraisal

At the appraisal, the Sixth Malaysia Plan (1991-1995) regarded the diversification of energy sources and reduction of oil dependency in preparation for oil exhaustion as one of the imperative policy directions. National Energy Policy since 1979 and the subsequent Four-fuel Diversification Strategy since 1980 also promoted the diversification of fuel source (natural gas, hydro, coal) through decreasing oil dependency, and placed the importance on increment of power generation capacity and efficient use of energy. To realize such commitments, the government decided to implement thermal power plant project, which would use coal as main fuel, to meet an increasing demand of energy in the Peninsular Malaysia along with the high economic growth. Accordingly, this project was deemed as relevant.

2.1.2 Relevance of the project plan at the time of ex-post evaluation

The Mid-term Review of the Eighth Malaysia Plan (2001-2005) continuously regards the diversification of energy source (emphasizing more coal use) and efficient use of energy as priority issue. New fuel strategy (Five-fuel Diversification Strategy since 1999) was also prepared to further promote the efficient use of energy and fuel diversification (adding renewable energy) to lessen the dependency on any single fuel source in view of securing a balanced fuel mix for generation and system stability as a whole. Accordingly, this coal-used power plant project, with the purpose of meeting still growing energy demand, is still deemed as relevant.

2.2 Efficiency

2.2.1 Outputs

The project was to construct the multi-fuel fired power plant with total output capacity of 1,000 MW (two power generation units of No. 5 and 6 in Kapar Phase 3[2] plant, 500 MW each) and its related facilities. Beneficiary area spreads over the Peninsular Malaysia with 132 thousand km^2 in size and has a population of about 17.6 millions in total (as of 2000 census). The physical aspect of the original scope was not modified (see the Comparison of Original and Actual Scope at the end of this report).

Figure 1: Project during construction stage

Fuel choice of the plant had been subject to two times of alternation. The plant was initially scheduled to use coal as main fuel (gas as alternative). However, upon the necessity to enhance use of indigenous natural gas, the Malaysian government determined to alter the main fuel of the plant to gas (coal as alternative) at the time of the Loan Agreement of the project (Phase 3-Stage2) in 1992. However, since the power shortage hit the Peninsular Malaysia during 1993 to 1995, this necessitated the government to early complete the other on-going power station projects which were mainly combined-cycle (gas-fired) plants, and to allocate gas supply to those early completed plants. As a result, the government decided again that the main fuel of Kapar Phase 3 plant be altered back to coal during its implementation.

2.2.2 Project period

The project was to be completed in June 1997 upon the take-over (followed by the start of commercial operation) of generation plants to the executing agency.

2 Port Klang Power Station (also known as Sultan Salahuddin Abdul Aziz Power Station) is now called as Kapar Power Station by TNB. Kapar Phase 3 plant means the power plant constructed under the phase 3 of this project, corresponding to the units No. of 5 and 6 in the entire Kapar Power Plant.

However, the actual completion was made in June 2001 with a large delay by 48 months requiring 1.77 times of the planned implementation period (see the Comparison of Original and Actual Scope and Reference for the detail at the end of this report). The delay in completion was partly accounted for by the prolonged tender of civil work contractor, which resultantly brought about the delay in commencement of civil works (18 months) and the subsequent installment works of boiler and turbine.

In addition, after the plant synchronization (the first physical energy supply, identified as start of the plant commissioning), it took some 35 months to complete the required commissioning and the subsequent reliability-run periods, compared to the corresponding planned period of 12 months. This delay was caused by the frequent and alternating occurrence of machine troubles (such as in boiler, turbine, cooling water system and etc.) and extended correspondence time required for such troubles.

2.2.3 Project cost

Actual project cost amounted to 83,977 million Yen, resulting in a large cost reduction (against the estimated value of 158,396 million Yen), since the competitive tender for boiler and turbine systems made the contracted prices much lower than estimated. Devaluation of local currency after the economic crisis also accounted for the decline of the project cost in Yen term.

2.3 Effectiveness

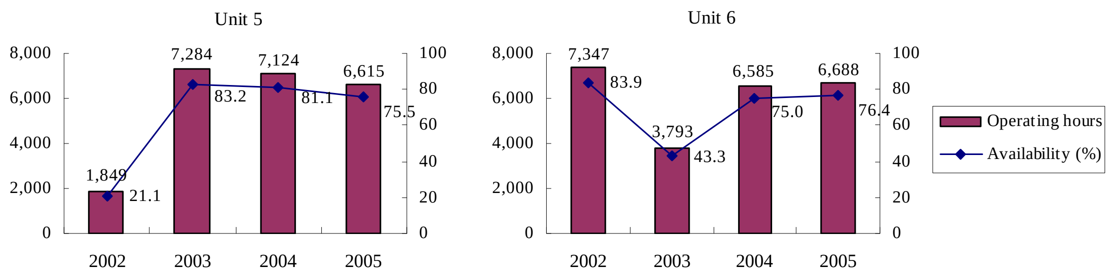
(1) Performance of power plant

Performance of Kapar Phase 3 plant is analyzed in comparison with the target set by the executing agency, focusing on the effect and operational indicators relevant to power plant.

(a) Annual operating hours and availability factor

During the early stage of commercial operation, Kapar Phase 3 plant experienced the lower operating hours and availability factor. It was mostly because the planned outage hours were largely extended due to the occurrence of machine troubles and the longer correspondence time to such troubles than assumed. Such hours of extended planned outage which accounted for 41% of total annual hour for the unit No.5 in 2002, and 39% for No.6 in 2003. In recent years, although not fully achieving the planning target of 80% (the average during the last 4 years for both units), the plant performance has become stabilized.

Figure 2: Operating hours and availability factor (%)



Source: TNB

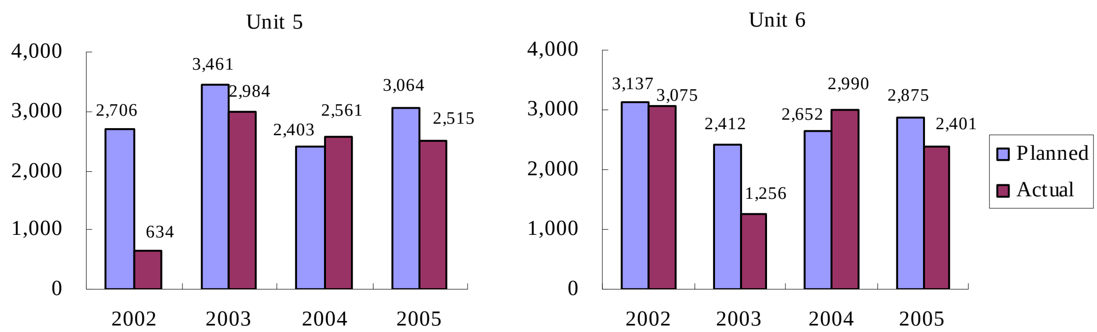
Note: Operating hour = output generating hour (synchronized), availability factor = total operating hour / annual hour

(b) Energy generation and auxiliary power use

Since the start of commercial operation, the maximum output in both units has ranged from 468 to 500 MW. Rated maximum output (500 MW) had not been recorded for the unit No.5 up to the year of 2004 due to its turbine vibration. In 2005, the maximum output was suppressed to 468 MW due to demand and supply adjustment at the side of the energy distributor, TNB.

Along with the plant availability, the plant experienced the lower energy generation during the early stage of commercial operation. In recent years, however, the generation performance shows the stable records in both units, although not fully achieving the planning target. The lesser energy generation than before and planned in 2005 was resulted from the output control under the said supply coordination by TNB.

Figure 3: Gross energy generation (GWh)



Source: TNB

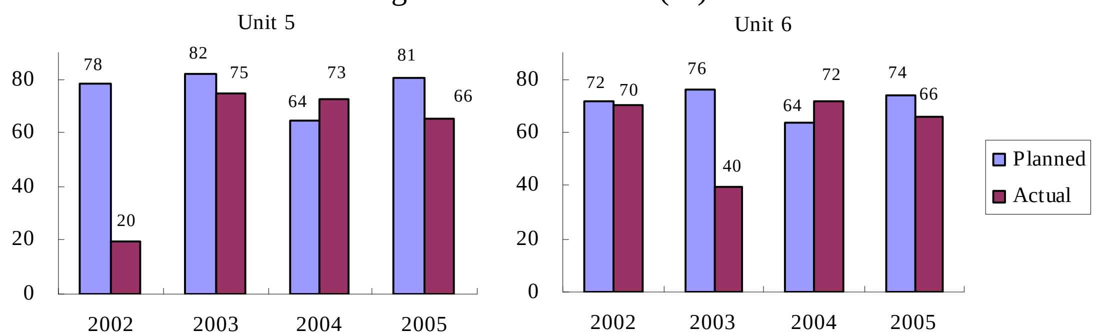
Of the gross energy generation, around 7.5% on average for both units has been consumed as auxiliary power (known as auxiliary power ratio) since the start of commercial operation. At present, auxiliary power ratio records the well-managed figures (7.0% for the unit No.5 and 7.5% for No.6 in 2005), being within the planning target of 7.5%.

(c) Plant load factor

Following the trend of operating hour and energy generation, the plant load factor also experienced the relatively lower marks during the early stage of commercial operation. However, the both units became stabilized since 2004, reaching the referable load factor figure of 70%. Load factor in 2005 was however suppressed down to 66% compared to the year before and planning target as a result of the demand and supply adjustment. Executing agency thought that around 80% of load factor would be realized unless such a restriction was practiced.

Figure 4: Steam turbine installed by the project

Figure 5: Load factor (%)

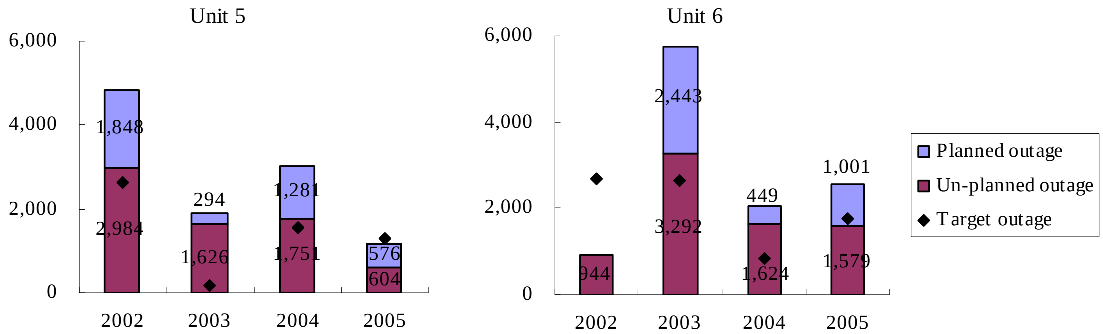


Source: TNB, calculated by the external evaluator
Note: Load factor is based on maximum output and service hour (total annual hour - planned outage hour)

(d) Plant outage

There have been no human errors which lead to the plant outage. The plant outage, except for the planned (scheduled) one, has resulted from the machine troubles which cause un-planned outage. Un-planned outage hours comprise of extended planned outage hour (caused by unforeseen machine troubles during overhaul and preventive maintenance), plant tripping and derating hours. Extended planned outage accounted for the majority of total outage hour, and most of machine troubles, encountered especially in the early stage of commercial operation, were caused by malfunction of electric (plant control) system, turbine system and so on. According to the executing agency, in the early stage of commercial operation, it took difficulty and the longer correspondence time for the executing agency to locate the problems in troubles and their solutions, and the contractor's correspondence to such troubles was not satisfactory enough.

Figure 6: Plant outage hours



Source: TNB
Actual outage hour = Planned outage hour + Un-planned outage hour (equivalent derated outage hour)

The plant has been stabilized in the recent years, and as is declining trend of un-planned outage hours. Executing agency still sees that further efforts need to be made to improve operation of unit No.6 in particular. In this regard, the ratio of un-planned outage (against total annual hours) improves to 12.5% in 2005 from 22.4% in 2002 on average of both units.

Figure 7: Coal yard at the plant

(e) Gross thermal efficiency
At present, Kapar Phase 3 uses coal as main fuel, natural gas and oil only for start-up purpose. Gross thermal efficiency of the plant has recorded the range of 35 to 38% since the operation, which is considered as within the standard level (35 to 40%) in case of coal use.

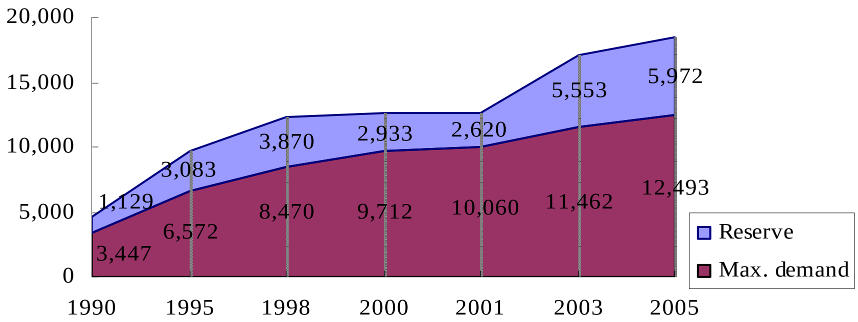
(2) Recalculation of Financial Internal Rate of Return
FIRR was recalculated to be 9.9% reflecting the actual project cost, schedule, the plant performance so far, the present fuel price and tariff indicated by the executing agency, with other conditions kept constant. Although the project cost was largely reduced, recalculated FIRR is lowered[3] compared to 16.2% at the appraisal in case of coal use. It is primarily because that delayed completion and plant performance at the early stage of commercial operation brought about the smaller and late realization of revenue.

2.4 Impact
(1) Contribution to the infrastructure development for economic growth
(a) Improvement of supply and demand balance of energy
In general, energy supply capacity in the Peninsular Malaysia has been sufficient enough to accommodate the growth of energy demand, showing a good range of

[3] If compared to 5.4% of the latest weighted average cost of funds (Annual Report of TNB 2005) of TNB, investment to the project is still deemed as viable use of fund from TNB's standpoint.

reserve margin[4] during the last ten years. Although the reserve margin declined to 23.2% in 2000 due to stagnated power-related investment after economic crisis after once recovery to 32.0% in 1998 as a result of risk aversion for power shortage cautioned to occur in the mid-1990s, continuous government commitment to incrementing supply capacity to accommodate the still growing demand has again recovered the reserve margin up to 32.6% in 2003. Kapar Phase 3 plant with installed capacity of 1,000 MW contributed to such a recovery of the margin, and therefore to further improvement of supply and demand balance of energy without an occurrence of power shortage in the recent years.

Figure 8: Maximum demand and reserve capacity (MW) in the Peninsular Malaysia



Source: TNB, Economic Planning Unit (EPU)

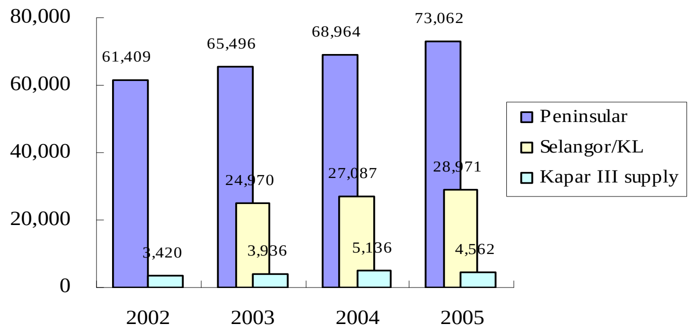
Delay in the project completion had a possibility to cause a tight supply and demand balance of energy during such a delayed period (from 1998 to 2001 in case of this project). During the delayed period, however, construction of other thermal power plants were expedited in response to the pre-cautioned power shortage, and the actual growth of energy demand (7.4% per annum) fell below the projection (10.6% per annum). Accordingly, installed capacity of energy had outreached the maximum demand of energy during the period with a minimum reserve margin of around 20%, causing no critical energy balance situation.

(b) Contribution to energy consumption growth

Energy consumption in the Peninsular Malaysia has increased at the annual growth rate of 6.0% since 2001. Energy consumption in the Selangor state and Kuala Lumpur has recorded a higher growth rate of 7.7% per annum during the last three years. Contribution of energy supply from Kapar Phase 3 plant has accounted for 6 to 7% of total consumption in the Peninsular and 16 to 19% in the Selangor state and Kuala Lumpur since the commercial operation.

Figure 9: Energy consumption and energy supply from the project (GWh)

4 Reserve margin = installed capacity of supply - maximum demand



Source: TNB, Department of Statistics
Note: Energy consumption in the Selangor state and Kuala Lumpur in 2002 is not available.

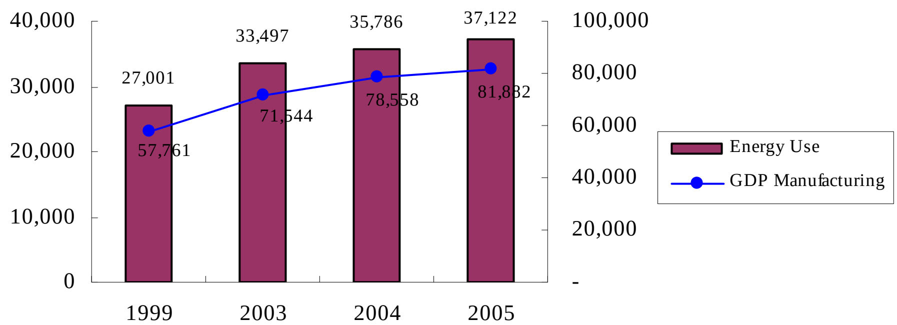
In parallel, the number of customer in every category (household, commercial, industrial) shows the steady growth during the last five years (e.g., 4.4% per annum for household customer, and 5.2 millions of household customer are connected as of 2005). Annual energy consumption per household customer increases to 2,590 kWh in 2005 from 2,100 kWh in 1995, indicating that each household is able to enjoy more energy use compared to before despite the increase of household customer number.

Kapar Phase 3 plant is considered to contribute to realizing the overall growth of energy consumption. It is also noted that rural electrification ratio in the Peninsular is also improved to more than 98% in 2005 from 91% in 1999.

(c) Contribution to industrial growth

Gross Domestic Product (GDP) by manufacturing sector in Malaysia has grown at annual rate of 6.0% during the last six years (in real base), while the energy consumption by industrial customer has increased at the rate of 5.5% per annum during the same period. This may support the assumption that stable supply of energy to industrial sector is one of essential basis of its growth.

Figure 10: Industrial energy use (GWh) and GDP by manufacturing sector (RM mil.)



Source: TNB, Department of Statistics

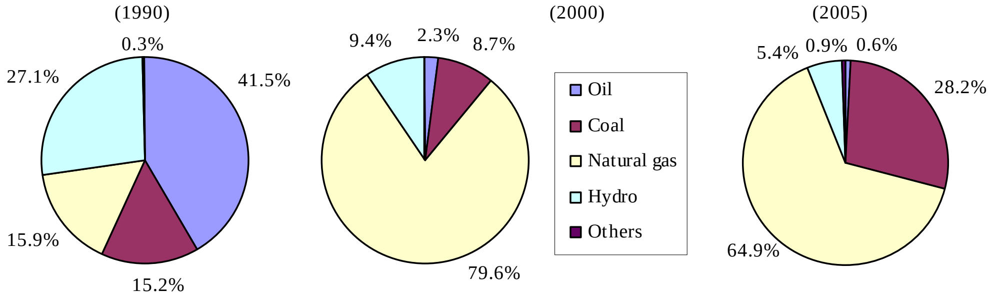
Therefore, the project's contribution to meeting incremental energy use of industrial sector, though partially, is considered to support the growth of

Malaysian industry.

(2) Energy source diversification

Major source of fuel for energy generation used to be oil in 1990, but replaced by indigenous natural gas in the late 1990's driven by Four-fuel Diversification Strategy. However, a concentration on gas use for generation has been eased in the recent years with an increasing share of coal, following the present policy to reduce dependency on any single source and to emphasize coal use. The project which uses coal as main fuel follows this policy direction, and is deemed to contribute to realizing its objective.

Figure 11: Change of energy source by generation



Source: Department of Statistics

(3) Environmental aspects

(a) Airborne pollutant emission

Figure 12: Airborne pollutant monitoring station

Kapar Phase 3 plant was to be designed to ensure that cumulative maximum ground level of SO_2, NO_2, and Total Suspended Particulates (TSP) [5] concentrations (as a result of the entire Kapar plant operation) be below the level set under the Malaysian Air Quality Guideline. The latest record on these airborne pollutants concentration at the ground level shows the lower value than the guideline, although Kapar Phase 3 plant chooses coal[6]. This indicates that fuel combustion and emission system of the plant was properly designed to comply with the guideline.

Table 1: Maximum ground level of airborne pollutant concentrations (ug/m^3 - 24 hours average)

	Aug. '05	Sep. '05	Nov. '05	Dec. '05	Guideline value
SO_2	7.2	58.0	33.3	84.7	105
NO_2	15.5	81.5	36.3	93.2	94
TSP	135.0	45.0	28.5	38.4	260

5 SO_2 = sulfur dioxide, NO_2 = nitrogen dioxide, TSP = suspended particulates such as dust in the air

6 Kapar Phase 3 plant uses the Australian quality coal with sulfur content of less than 1.0%.

Source: TNB
Note: Above figures are of the highest marks among all measuring points (located within 10 to 30 km from the plant) in each month. Kapar plants favorably operate during the above period.

The level of stack emission of the said airborne pollutants is continuously monitored, and is managed to be within the projected limit at the appraisal (average value during one month). Although the emission data on dust (TSP) was not available, it is deemed that the emission level is not issue considering the concentration level at the ground and in the ambient air.

Table 2: Level of stack emission (ppm)

	Average during Feb. '06		Highest mark during Feb. '06		Projected limit
	Unit 5	Unit 6	Unit 5	Unit 6	
SO_2	14	420	44	595	601
NO_2	6	185	33	310	400

Source: TNB
Note: Boiler system of the unit No. 5 outperforms No. 6 in emission efficiency, according to the executing agency.

The level of ambient air quality is also monitored once per every week for 24 hours. Standard or guideline value relevant to this is not set except for dust, but it is deemed that the emission level is not issue considering the concentration level at the ground.

Table 3: Level of airborne emission in the ambient air

	Aug. '05		Sep. '05		Nov. '05		Dec. '05		Guideline value
	Unit 5	Unit 6	Unit 5	Unit 6	Unit 5	Unit 6	Unit 5	Unit 6	
SO_2 (ppm)	71.6	271.0	161.1	434.1	44.7	312.9	18.9	403.0	None
NO_2 (ppm)	65.1	110.0	103.1	234.0	40.3	286.8	11.9	227.2	None
TSP (ug/m^3)	n.a	n.a	260	50	n.a	n.a	n.a	n.a	400

Source: TNB
Note: Monitoring record on dust (TSP) is not available, since the equipment is under maintenance.

(b) Effluent discharge

Executing agency properly monitors the level of effluent discharge from the plant related facilities. The level of effluent discharge (BOD, COD, TSS)[7] from the waste water treatment plant is monitored twice per every month by sample analysis, and is managed to be below the standard applicable for the plant under Environment (sewage and industrial effluents) Quality Regulations. Executing agency also reports that the capacity of the waste treatment plant is sufficient at present to cover all the influents.

Table 4: Level of effluent discharge from waste water treatment plant (mg/l)

[7] Both BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) are major indicators to measure the level of water pollution. Their decline means reduction of organic effluent mass in the water. TSS stands for Total Suspended Solid.

	Aug. '05		Sep. '05		Standard value
	Sample 1	Sample 2	Sample 1	Sample 2	
BOD	5	11	10	< 5	50
COD	15	36	32	12	100
TSS	11	11	13	7	100

Source: TNB

The level of discharge from ash pond is also monitored once per every three month, and managed to be below the same standard, except for one case of COD in December 2005, which was judged as temporary case by the executing agency.

Table 5: Level of effluent discharge from ash pond (mg/l)

	Jul. '05	Aug. '05	Sep. '05	Dec. '05	Standard value
COD	25	23	29	104	100
TSS	82	90	81	91	100

Source: TNB

Judging from the above performances, it is considered that the executing agency has been well performing environmental management so as to comply with the guideline and standard.

(c) Others

Before the project implementation, executing agency has made Environmental Impact Assessment Report approved by Department of Environment in November 1992. The plant and related facilities were built within the property of the executing agency (adjacent to the existing plants), not necessitating land acquisition.

At appraisal, preparation of the third ash pond was an issue, since the existing capacity was to be fully filled upon the operation of Kapar Phase 3. At present, the second ash pond is still able to accommodate coal ash (by-product of coal-firing process), and third one has not been constructed yet[8]. The executing agency is studying whether to construct the third ash pond or to re-use the first one, requiring proper conduct of environmental impact assessment. Around 20% of coal ash (fine ash) is being sold to cement manufactures for re-use. Mangrove replanting in the affected area is continued. Desulphurizer plant is not deemed as necessary, since the airborne pollutant emission has been well managed so far.

Figure 13: Ash trapper installed by the project

2.5 Sustainability

2.5.1 Executing Agency

TNB, executing agency of the project, divested the entire assets of Kapar power plants including Kapar Phase 3 in June 2004 to enhance operational efficiency to the newly established subsidiary, Kapar Energy Ventures (KEV) that is the present O&M organization for the project facility[9]. TNB presently holds 60% of total shares of KEV.

[8] The first ash pond became a widely known flying destination of migratory water birds after its utilization, and recognized as an important habitat of birds in Malaysia, therefore, the executing agency practices considerate pond management.

[9] TNB holds the liability related to the construction of Kapar Phase 3 plant, although the plant was sold to KEV.

2.5.1.1 Technical Capacity

(1) Technical capacity related to O&M

During the project implementation period, some 20 training and lecture programs were rendered by the contractors and consultant to equip O&M staffs of the plant with the updated skill and knowledge concerning the new boiler, turbine and control system, both at the manufacture's workshops and at the plant (as-built condition). During the early stage of commercial operation, however, rather frequent visit of the contractor for the problem location and corrective action was required depending on the nature of troubles. Through such experiences of trouble shooting during the period as well as trainings, KEV and the executing agency consider that necessary skill and knowledge have been transferred to O&M staff. At present, most of technical troubles are properly and promptly corresponded by themselves.

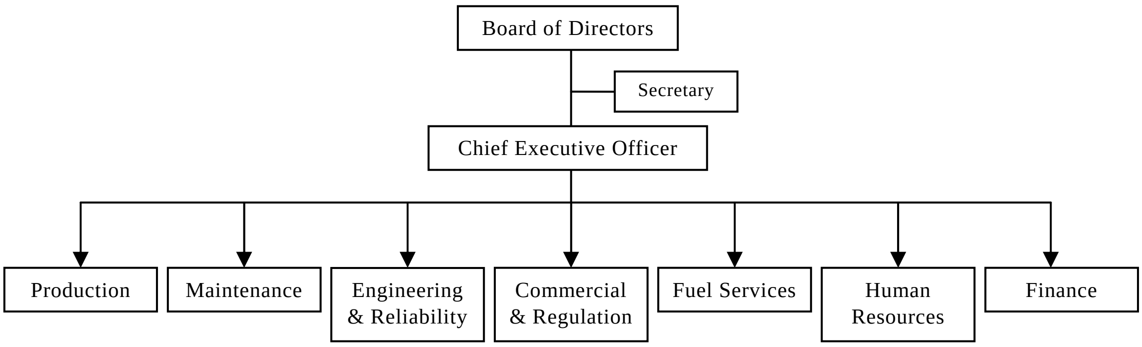
(2) Continuity of training

Training program for O&M staff is continuously conducted by the human resources section of KEV through On-the-Job training and lecture, and mainly targeted to the newly recruited and middle-classed technicians and engineers. No major issue in technical capability is observed.

2.5.1.2 Operation and Maintenance System

Although O&M entity was changed from TNB to KEV, the existing staffs which had experienced O&M for the plant have been seconded to KEV. Although KEV has also recruited its own staff, On-the-Job training to them by the existing staff is adequately conducted. The ratio between the seconded staff from TNB and KEV's own staff is nine to one. KEV at present employs 463 staffs in total, comprising of 91 executives, managers and engineers (university graduates), around 50 administrative staff, 10 to 15 procurement staff, and the rest of technicians and operators (non-university graduates). Present organizational set-up of KEV is shown below.

Figure 14: Organizational set-up of KEV (Kapar Power Plant)



It is also noted that Kapar power plant was certified with quality management system of ISO9002 for the entire plant operation before the divestment in May 2000 (KEV takes over the certification), and KEV further proceeds to documenting, standardizing and improving the plant O&M procedures[10].

2.5.1.3 Financial Status[11]

KEV made the Long-term (25 years) Power Purchase Agreement with the off-taker TNB and energy sale to TNB is the main revenue of KEV. Delivery price of energy, which comprises of capacity (fixed) and energy (variable) portions, is to be annually reviewed and agreed by the both parties at a certain amount of target, except for a portion of fuel charge. Fuel charge, which faces considerable risk of price fluctuation, shall be all transferred to TNB.

In addition, KEV takes a risk of being penalized in case of the markedly lower availability of the plant, and bears the cost of unplanned repairing work. Accordingly, financial performance of KEV depends on how it minimizes un-planned outage and repairing cost, and controls variable O&M expenses (keep them below the target). KEV does not find much difficulty in financial management, and states that operating profit is generated so far as planned. TNB, an energy off-taker from Kapar Phase 3 plant, has also generated profits on a stable manner[12].

The recent trend of major fuel prices is shown below. The price of coal, which is the main fuel for Kapar Phase 3 plant[13], shows an increasing trend during the last five years, reflecting the higher demand in the international market. As explained, however, the higher price is not the direct issue to KEV, since its fluctuation is all borne by the energy off-taker, TNB.

Table 7: Fuel price trend (RM)

	Major origin	1999/2000	2005
Heavy fuel oil	Malaysia	450 per MT	1,110 per MT
Natural gas	Malaysia	6.4 per MMBTU	6.4 per MMBTU
Coal (average)	Australia, Indonesia, China, Malaysia (Sarawak)	110 per MT	202 per MT

Source: TNB

[10] The executing agency (KEV at present) has been also certified with ISO14000 since July 2002 to strengthen environmental management aspect of the plant operation.
[11] Financial report of KEV is not available, since KEV feels it difficult to provide financial report to outside, taking into account the competitive environment with other Independent Power Producers.
[12] Profit (before tax) in the last three years is 1,601 million RM in 2005, 1,959 million in 2004 to 1,947 million in 2003.
[13] At present, 80% of total coal use by Kapar Phase 3 plant is imported from Australia. The rest comes from Indonesia. KEV is not at the position to determine the type of fuel and control the price of procurement. Fuel for energy is procured in bulk by TNB Fuel Services (TNBF) and TNB Coal International (TNBCI) which hold the purchase contract with fuel suppliers. TNBF and TNBCI then supply fuel to generation plants based on the purchase price in accordance to fuel type allocation made by TNB.

2.5.2 Operation and Maintenance Status

Although minor technical troubles (electric / control system in particular) still occur sporadically, facility maintenance including corrective action to technical troubles is properly conducted. Maintenance activity comprises of routine, periodic ones and overhaul. Routine maintenance mainly looks at bearing vibration, motors, electrical equipment, greasing and so on. Periodic maintenance is done every 15 months to look at integrity of pressure vessel, calibration of sensing equipment, servicing of rotating machinery and such. Overhaul is done every 5 years for turbine system and every 2 years for boiler system. No major issue is observed including availability of spare-parts.

3. Feedback

3.1 Lessons Learned

None

3.2 Recommendations

None

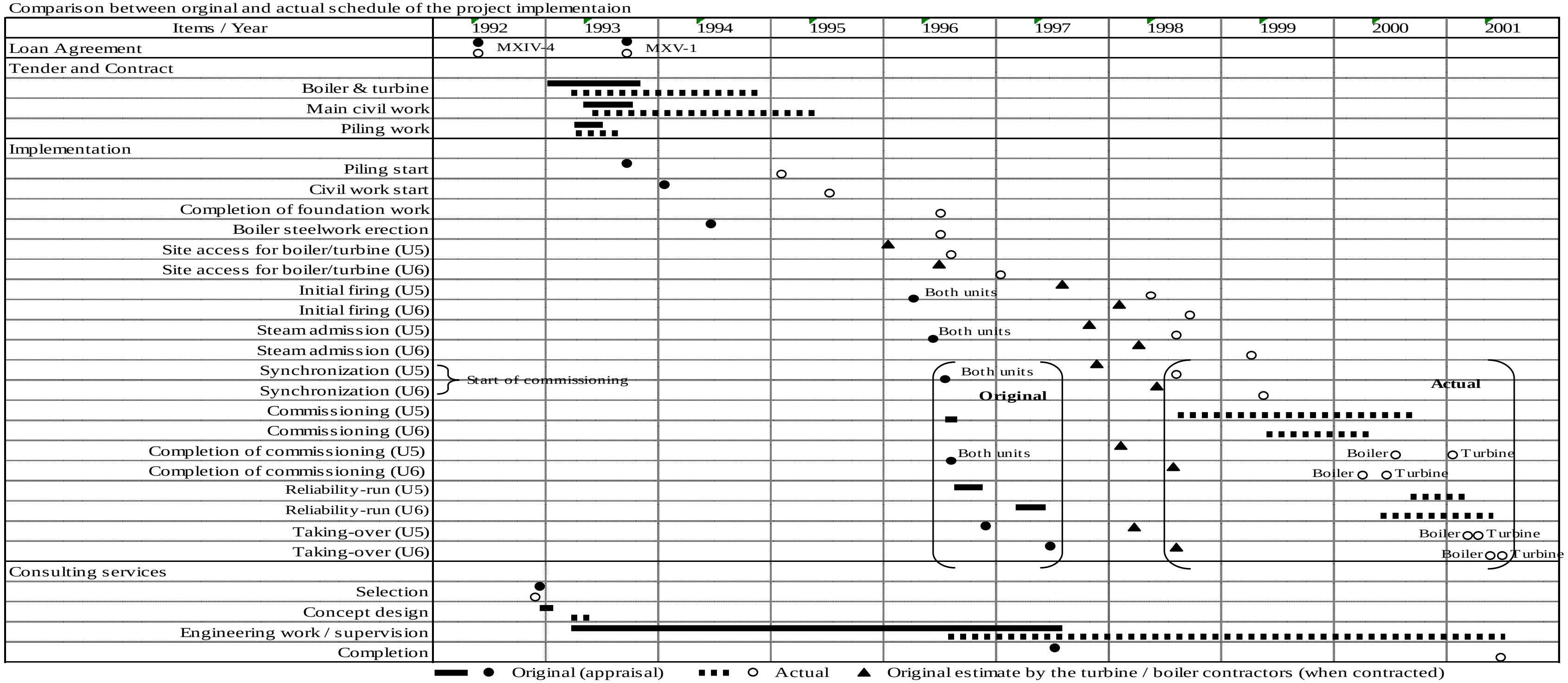
Comparison of Original and Actual Scope

Items	Plan	Actual
(1) Scope	Major sub-items	
Civil engineering works	- Power house building - Chimney (175 m) - Ash pond	- Same as planned
Boiler & auxiliaries	- 2 units of boiler (3,000 rpm reheat, tandem compound, regenerative feed heating, with coal as main fuel, gas and oil as alternative) - Electro-static precipitator (ESP)	- Same as planned, but for fuel type: coal as main, gas as alternative (and start-up), oil as stand-by (and start-up) at present
Turbine and auxiliaries	- 2 units of steam turbine (500 MW for each unit) - Cooling water system - Water treatment plant - Electro chlorination plant (ECP)	- Same as planned
Sub-station equipment	- Inter-bus / generator / distribution transformers - EHV switchgears	- Same as planned
Off-shore pump house	- Cooling water pump house	- Same as planned
On-shore piling	- On-shore piling	- Same as planned
Consultancy and engineering services	- Conceptual design - Engineering work / supervision - O&M manual and staff training Total 1,169.5 M/M	- Same as planned Total 1,386.5 M/M
(2) Implementation Schedule		
<u>Loan Agreement</u>	May 1992 (MXIV-4) Sep. 1993 (MXV-1)	May 1992 (MXIV-4) Sep. 1993 (MXV-1)
<u>Tender and contract</u>		
- Boiler & turbine generator	Jan. 1993 - Oct. 1993	Apr. 1993 - Nov. 1994
- Main civil work	Mar. 1993 - Sep. 1993	Jun. 1993 - Mar. 1995
- Piling work	Apr. 1993 - Jun. 1993	Apr. 1993 - Aug. 1994
<u>Implementation</u>	Sep. 1993 - Jun. 1997	Feb. 1995 - Jun. 2001
- Piling commencement	Sep. 1993	Feb. 1995
- Civil work commencement	Jan. 1994 n.a	Jul. 1995 Jul. 1996
- Completion of foundation work	Aug. 1994 Apr. 1996	Jul. 1996 May 1998 / Sep. 1998

- Boiler steelwork erection	Jun. 1996	Aug. 1998 / Apr. 1999
- Initial firing (unit 5 / 6)	n.a	Aug. 1998 / May 1999
- Steam admission (unit 5 / 6)	Aug. 1996	Jan. 2001 / Jun. 2000
- Synchronization (unit 5 / 6)	Nov. 1996 / Jun. 1997	Apr. 2001 / Jun. 2001
- Commissioning end (unit 5 / 6)		
- Taking-over (unit 5 / 6)		
<u>Consulting services</u>		
- Selection of consultant	Dec. 1992	Nov. 1992
- Engineering work / supervision	Apr. 1993 - Jul. 1997	Apr. 1993 - Jun. 2001
<u>Completion</u>	Jun. 1997	Jun. 2001
(3) Project Cost		
Foreign currency	72,680 million Yen	45,257 million Yen
Local currency	85,716 million Yen	38,720 million Yen
	(1,742 million RM)	(1,100 million RM)
	158,396 million Yen	83,977 million Yen
- ODA loan portion -	71,921 million Yen (31,966 million Yen : MXIV-4) (39,955 million Yen : MXV-1)	54,794 million Yen (29,110 million Yen : MXIV-4) (25,684 million Yen : MXV-1)
Exchange rate	1 RM =49.2 Yen (as of Nov. 1992)	1 RM =35.2 Yen (Average year 1995-2001)

Reference: detailed comparison between original and actual implementation schedule of the project

Comparison between orginal and actual schedule of the project implementaion



Synchronization
Plan : Jul. 1996
Actual: U5: Aug. 98
U6: May 99

Completion of Commissioning
Plan : Aug. 1996
Actual: U5: Jul. 00 (Boiler) / Jan. 01 (Turbine)
U6: Mar. 00 (Boiler) / Jun. 00 (Turbine)

Taking-over
Plan : U5: Nov. 96
U6: Jun. 97
Actual: U5: Apr. 01
U6: Jun. 01

Commercial operation (after taking-over)

Commissioning
Unit 5 (Aug. 99 - Jul. 00: Boiler / Jan. 01: Turbine)
Unit 6 (May 99 - Mar. 00: Boiler / Jun. 00: Turbine)
* Boiler and turbine machine troubles occured one after the other, identification of problems and solutions, and their actions took longer time.

Reliability-run (RR)
Unit 5: Boiler (Jul. 00 - Mar. 01)
Turbine (Jan. 01 - Apr. 01)
Unit 6: Boiler (Mar. 00 - May. 00)
Turbine (Jun. 00 - Jun. 01)
* Boiler and turbine machine troubles occured one after the other with other troubles such as cooling water system , identification of problems and solutions, and their actions took longer time.

* No human errors causing outage occured. Other than planned outage, the followings caused the plant outage (during the early stage of commercial operation);
- unexpected machine troubles during the planned outage, and correspondence to the troubles took longer period than assumed, bringing about extended planned outage.
- machine troubles causing tripping / derating
Machine troubles include electric (plant control) system, turbine system, insulator, boiler water wall, condenser tube, and so on.