CHAPTER 6
POWER SYSTEM ANALYSIS

Chapter 6 Power System Analysis

6.1 General of the Power System Analysis

Power system analysis on the southern system in Pakistan was carried out to examine the necessity of the system reinforcement of the existing power system upon development of the proposed coal-fired thermal power plant (hereinafter referred to as CFPP) in Lakhra, which is expected to start commercial operation in 2020. PSS/E ver. 33.4.0, the same power system analysis tool, was utilized for the analysis.

6.2 Impact of new Lakhra Power Plant to the Existing Power System

6.2.1 Scope of the Study

The power system analysis for the study consists of the following items:

1) Power flow analysis for the 500kV power system in southern area of Pakistan as of January 2021

2) Transient stability analysis of the 500kV power system in southern area of Pakistan as of January 2021

6.2.2 Analysis Model

The analysis models for both power flow and transient stability analyses were developed based on the relevant data provided by NTDC:

1) PSS/E case files for the power flow analysis obtained on November 28th, 2013.
2) PSS/E dynamic data obtained in October, 2013.

3) Annual Summary of Generation Addition as of November 2013.

The following assumptions were made in order to develop the analysis modes:

1) For the generator model of the new CFPP in Lakhra, the generator constants of similar scale were applied.

2) The same type of the conductor as that of the existing line in the same section between substations was applied if reinforcement of the section(s) was/were necessary.

3) Arbitrary amount of reactive power sources (static condensers) were connected to the buses to maintain bus voltage within the allowable level if the bus voltage exceeds the lower/upper limit.

4) For the power flow analysis, transmission capacity of each transmission section was based on the data on the transfer limit (MVA) provided by NTDC.

5) Only the low water case (January 2021) was considered since it was considered the severer condition rather than high water case taking into account the direction of the power flow that is toward the load center in the central part of the country in both low water and high water cases. Almost all Hydel Power Plants are located in North due to geological situation in Pakistan, while Thermal Power Plants are located in South in consideration with fuel supply, so that Power flow from South to North is more dominant in low water season. The bias of power flow would lead instability and severer condition on the power system.

6) As the connection scheme from the existing 500kV transmission line to the proposed Lakhra power plant, two-circuit □ connection between Jamshoro - Dadu line were assumed.

7) 2 units of generators (600MW x 2) were assumed for Jamshoro power plant[1].

8) The power output of Thar CFPP was set out as 1,200MW, which was same value as that of NTDC's plan.[2]

Assumed power plants for the simulation are listed in Table 6.2-1.

Table 6.2-1 List of Power Plants Assumed in PSS/E Analysis Model in Section 6.2

Name of Power Plant	Total Output	Unit Capacity and Number of Units
Lakhra	600MW	600MW x 1 unit
Gadani	6,000MW	600MW x 10 units
K-2/K-3	2,200MW	1,100MW x 2 units
Bin Qasim	1,200MW	600MW x 2 units
Thar	1,200MW	600MW x 2 units
Jamshoro	1,200MW	600MW x 2 units

Source: JICA Survey Team

6.2.3 Power Flow Analysis

(1) Evaluation Criteria

The evaluation of the power flow analysis results were based on the transmission planning criteria (in terms of both the power flow and bus voltages), which were described in Chapter 3. The evaluation only covered the 500kV transmission system.

[1] 1 unit of generator (600MW x 1) was assumed for Jamshoro power plant in the analysis model for comparison among the three candidate power plant locations based on the information that ADB changed the policy of financing, namely, financing for 1 unit.

[2] The power output of Thar CFPP was set out as 3,600MW based on the information provided by TECB in November 2013 for comparison among the three candidate power plant locations in the previous chapter, which was much severer power flow condition than that of NTDC's original system plan.

(2) Study Cases

Two study cases were set out depending on whether the Lakhra CFPP exists or not as shown in Table 6.2-2.

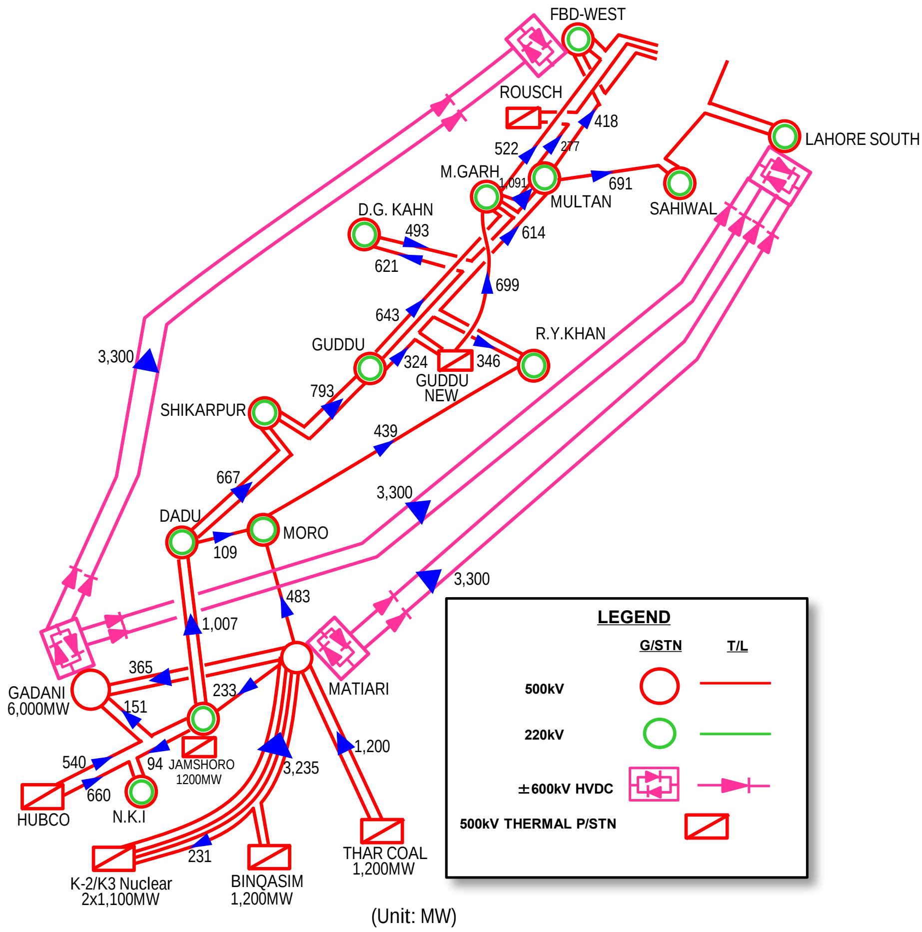
Table 6.2-2 Power Flow Analysis Study Cases

With/Without Lakhra CFPP	Case Name
Without	PF-WLK
With	PF-LK (PF 1-1)

Source: JICA Survey Team

(3) Analysis Results

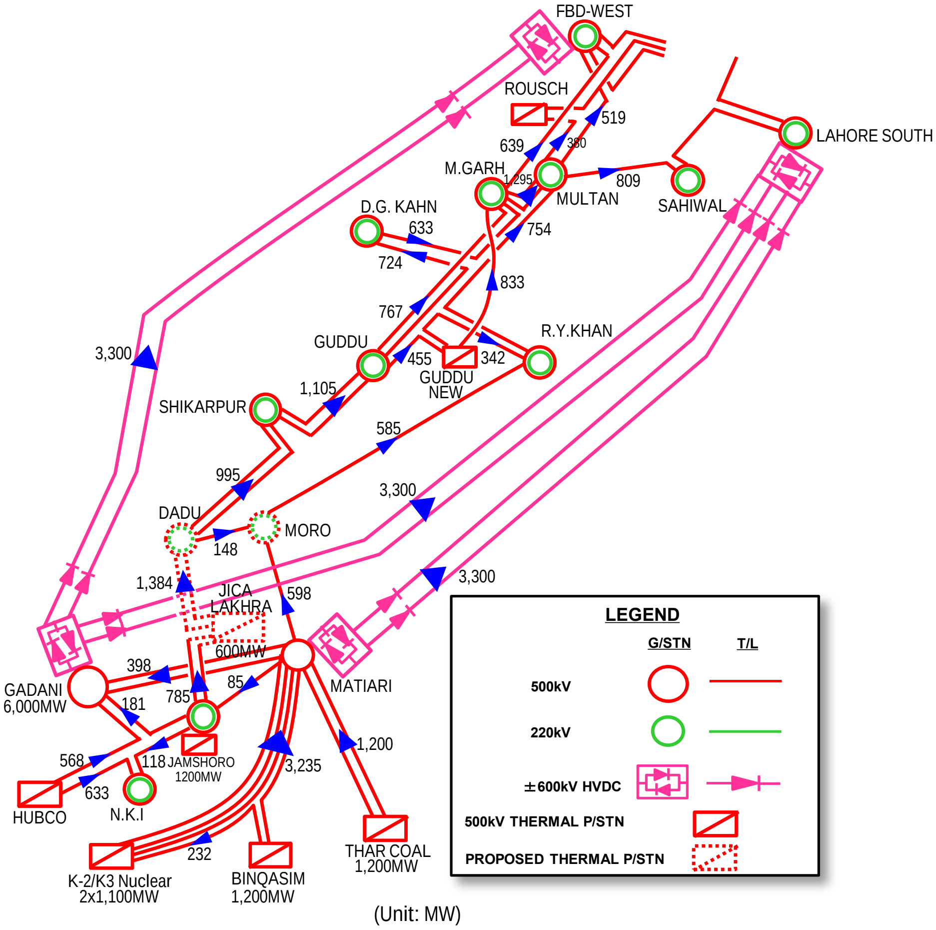
Under the normal operating condition, no overloading or voltage violation occurred to the 500kV power system in the South for both PF-LK (PF 1-1) and PF-WLK cases. The power flow diagrams for the normal operation condition are shown in Figure 6.2-1 and 6.2-2, respectively. The PSS/E power flow diagrams are shown in Appendix 6.3.



Source: JICA Survey Team

Figure: 6.2-1 Power Flow under Normal Operating Condition (Without Lakhra CFPP (PF-WLK))

Under N-1 contingency condition, no overloading occurred to any section for both PF-WLK case and PF-LK (PF 1-1) case. There was no voltage violation for both PF-WLK and PF-LK (PF 1-1) cases.



Source: JICA Survey Team

Figure: 6.2-2 Power Flow under Normal Operating Condition (With Lakhra CFPP (PF-LK: PF 1-1))

6.2.4 Transient Stability Analysis

(1) Evaluation Criteria

The power system was considered “stable” if the amplitude of oscillation waveforms of the rotor phase angle difference between arbitrary two generators of the south system is likely to be damped and converged under N-1 contingency condition.

(2) Study Cases

Two study cases were set out depending on whether the Lakhra CFPP exists or not as shown in Table 6.2-3.

Table 6.2-3 Power Flow Analysis Study Cases

With/Without Lakhra CFPP	Case Name
Without	ST-WLK (ST1-1)
With	ST-LK

Source: JICA Survey Team

As the severe single contingency condition, a single circuit 3-phase short circuit fault at the sending end of the 500kV transmission sections between Jamshoro substation and Multan substations as well as those which were connected to Jamshoro and Matiari substations were selected.

The study cases and the fault sections are summarized in Table 6.2-4 The cells with “Y” indicate that the sections are relevant to the analysis, while the gray cells are not applicable for the study case in question.

The fault sequence for the analysis is shown in Table 6.2-5.

Table 6.2-4 Study Cases

Case / Fault Section	ST-LK (ST 1-1)	ST-WLK
Jamshoro S/S – JICA Lakhra PP	Y	
JICA Lakhra PP – Dadu New S/S	Y	
Jamshoro S/S – Gadani S/S	Y	Y
Jamshoro S/S – NKI S/S	Y	Y
Jamshoro S/S – Dadu New S/S		Y
Dadu New S/S – Moro S/S	Y	Y
Matiari S/S – Gadani S/S	Y	Y
Matiari S/S – Jamshoro S/S	Y	Y
Matiari S/S – Moro S/S	Y	Y
Moro S/S – R. Y. Khan S/S	Y	Y
R. Y. Khan S/S – Multan S/S	Y	Y
Dadu New S/S – Shikarpur S/S	Y	Y
Shikarpur S/S – Guddu S/S	Y	Y
Guddu S/S – Muzaffargarh S/S	Y	Y
Guddu S/S – D. G. Khan S/S	Y	Y
Guddu New PP – Muzaffargarh S/S	Y	Y
Muzaffargarh S/S – Multan S/S	Y	Y

Source: JICA Survey Team

Table 6.2-5 Fault Sequence

Time	Sequence
0 ms	3-phase short circuit fault occurred to a circuit of 500kV transmission line
100 ms	Clear fault and open the faulted circuit
10 s	End of calculation

Source: JICA Survey Team

(3) Study Results

The oscillation waveforms of the generator rotor phase angle difference between a generator of HUBCO power plant and that of other principal power plants in the south system for all cases were shown in Appendix 6-1 (Without Lakhra Power Plant Case) and 6-2 (With Lakhra Power Plant Case), respectively. The analysis results are summarized in Table 6.2-6.

Table 6.2-6 Transient Stability Analysis Results

Case / Fault Section	With Lakhra P/S ST 1-1	Without Lakhra P/S
Jamshoro S/S – JICA Lakhra PP	Unstable	
JICA Lakhra PP – Dadu New S/S	Unstable	
Jamshoro S/S – Gadani S/S	Unstable	Stable
Jamshoro S/S – NKI S/S	Unstable	Stable
Jamshoro S/S – Dadu New S/S		Stable
Dadu New S/S – Moro S/S	Stable	Stable
Matiari S/S – Gadani S/S	Unstable	Stable
Matiari S/S – Jamshoro S/S	Unstable	Stable
Matiari S/S – Moro S/S	Unstable	Stable
Moro S/S – R. Y. Khan S/S	Stable	Stable
R. Y. Khan S/S – Multan S/S	Stable	Stable
Dadu New S/S – Shikarpur S/S	Stable	Stable
Shikarpur S/S – Guddu S/S	Stable	Stable
Guddu S/S – Muzaffargarh S/S	Stable	Stable
Guddu S/S – D. G. Khan S/S	Stable	Stable
Guddu New PP – Muzaffargarh S/S	Stable	Stable
Muzaffargarh S/S – Multan S/S	Stable	Stable

Source: JICA Survey Team

For "Without Lakhra" power plant case, the south system was proved to be stable in the case of any single circuit fault of the 500kV transmission lines. On the other hand, for "With Lakhra" power plant case, the system became unstable when a single circuit fault occurred to any sections from/to Jamshoro substation, Matiari switching station, and Lakhra power plant.

6.2.5 Influence of new Lakhra Power Plant

As the results of power flow and transient stability analyses, it is concluded that the proposed connection scheme for the proposed Lakhra power plant leads to instability in south system in the case of single circuit fault of some transmission sections. Hence further study on alternative connection schemes is necessary to resolve the issue.

Generally, addition of the number of circuits in the sections which cause instability in the system is considered effective way to improve the stability; however, there is a restriction that it was not accepted by NTDC to add another or more than two circuits to the existing 500kV transmission lines from Jamshoro substation to up-country due to difficulty in land acquisition for the right-of-way and construction. Therefore, as one of the alternative ways to satisfy the need of stability improvement, it is worth examining the additional connection to Matiari switching station, making a certain portion of the power flow divert to another transmission route to up-country through Moro and R. Y. Khan substations to Multan substation. Alternative connection methods are examined in Chapter 6.3.

A series of power system analysis in this chapter was carried out based on the condition that Lakhra power plant had only one unit of generator. It is expected that ensuring the system stability becomes more difficult if future expansion of Lakhra power plant, in other words, addition of another unit of generator is materialized. Furthermore, this situation becomes much severer if power development in Thar Desert area proceeds in much larger-scale as the information by TCEB shows. The power flow analysis results described in the previous chapter showed the necessity of reinforcement of existing and planned HVAC 500kV transmission lines in many sections. Increase in the number of circuits may make it possible to increase the transmission capacity of the line; on the flip side however, the short-circuit fault current level increase as well.

Another option to consider the improvement of power system expansion is direct connection of HVDC 600kV from Thar Coal Field to Lahore area, the load center of the country in order to evacuate the bulk power, to restrain the reinforcement of HVAC 500kV transmission lines in a number of sections, and to improve the system stability. Although the stability of power system is enhanced with the direct connection, the additional DC connection is not affordable of the cost.

6.3 Comparison of Alternative Connection Schemes

Power system analysis for alternative connection schemes was carried out in order to confirm if the alternative system configurations resolve the system instability problem inherent in the prospective connection scheme described in the previous section.

6.3.1 Analysis Model

The PSS/E base file for both power flow and transient stability analyses is the same one which was used for a series of analysis done in the previous section. As for the output of large-scale power plants in the southern area, two scenarios were assumed as shown in Table 6.3-1. The scenario 2 considered the situation that commencement of commercial operation of Gadani, K-2/K-3, and Bin Qasim power plants was expected to be delayed.

The different analysis model for the fault current analysis, which was provided by NTDC, was used for the 3-phase short circuit fault current calculation.

Table 6.3-1 Output of Large-scale Power Plants

Scenario 1	All the large-scale power plants in southern area are in operation: - Gadani CFPP: 6,000MW - K-2/K-3 Nuclear PP: 2,200MW - Bin Qasim PP: 1,200MW - Thar CFPP: 1,200 MW - Jamshoro PP: 1,200MW - Lakhra CFPP: 600MW
Scenario 2	- Gadani CFPP, K-2/K-3 Nuclear PP, Bin Qasim PP: Out-of-service - Thar CFPP: 1200MW - Jamshoro PP: 1,200MW - Lakhra CFPP: 600MW

Source: JICA Survey Team

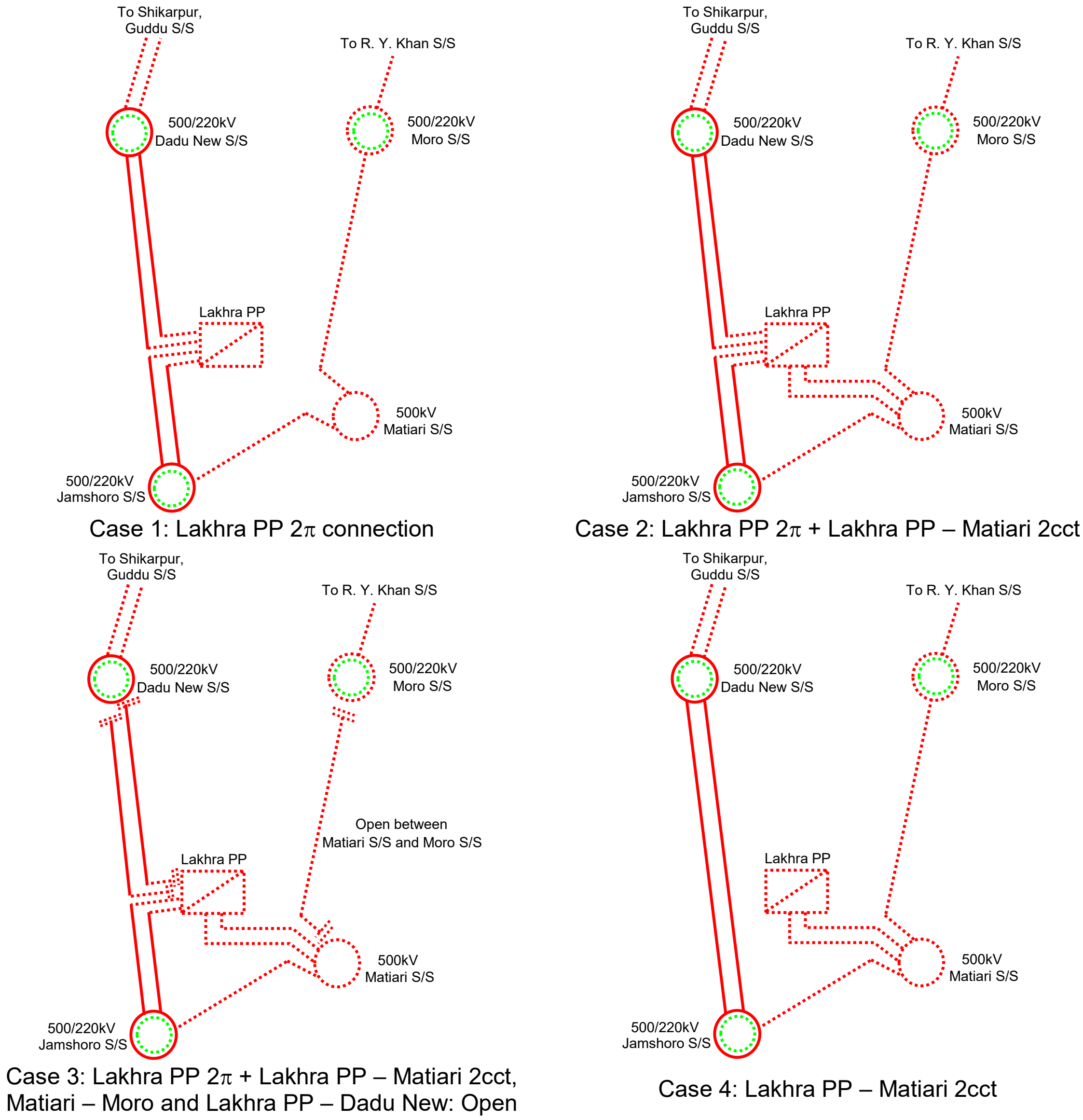
6.3.2 Power Flow Analysis

(1) Evaluation Criteria

The evaluation of the power flow analysis results were based on the transmission planning criteria (in terms of both the power flow and bus voltages), which were described in Chapter 3. The evaluation only covered the 500kV transmission system.

(2) Study Cases

Four study cases were set out based on the difference in the connection schemes as shown in Figure 6.3-1. Table 6.3-2 shows all the study cases considered. The analysis of Case 1-1 was excluded since the analysis model and its condition are the same as those used in section 6.3 and 6.4. The Case 4 was the connection scheme that was additionally proposed by NTDC. Only Case 4-1 was considered for the analysis to check the power flow situation under the severest power generation condition.



Source: JICA Survey Team

Figure 6.3-1 Connection Patterns for the Analysis

Table 6.3-2 Study Cases

Connection Pattern		Lakhra PP 2π	Lakhra PP 2π + Lakhra PP - Matiari 2cct	Lakhra PP 2π + Lakhra PP - Matiari 2cct, Matiari-Moro and Lakhra PP – Dadu New: Open	Lakhra PP - Matiari 2cct (NTDC's Proposal)
Case (X)		1	2	3	4
Generation	All planned large-scale Power Plant in South Area in Operation (PF X-1)	PF 1-1*	PF 2-1	PF 3-1	PF 4-1
	All of the Large-scale Power Plant in Southern Area but Thar Power Plant are out-of-service (PF X-2)	PF 1-2	PF 2-2	PF 3-2	

Source: JICA Survey Team

<NOTE> * Study on PF 1-1 was excluded in this section since the analysis model and its condition are the same as those used in Section 6.3 and 6.4.

(3) Analysis Results

Both under normal operation and N-1 contingency conditions, no overloading or voltage violation occurred to the 500kV system for all of the study cases in Table 6.3-1.

6.3.3 Transient Stability Analysis

(1) Evaluation Criteria

The same evaluation criteria are applied as described in the section 6.3.1.

(2) Study Cases

Four study cases were set out depending on the difference in the connection schemes for the new Lakhra CFPP as shown in Table 6.3-3.

Table 6.3-3 Study Cases

Connection Pattern		Lakhra PP 2π	Lakhra PP 2π + Lakhra PP - Matiari 2cct	Lakhra PP 2π + Lakhra PP-Matiari 2cct, Matiari-Moro and Lakhra PP – Dadu New: Open	Lakhra PP - Matiari 2cct (NTDC’s Proposal)
Case (X)		1	2	3	4
Generation	All planned large-scale Power Plant in South Area in Operation (ST X-1)	ST 1-1*	ST 2-1	ST 3-1	ST 4-1
	All of the Large-scale Power Plant in Southern Area but Thar Power Plant are out-of-service (ST X-2)	ST 1-2	ST 2-2	ST 3-2	

Source: JICA Survey Team

<NOTE> * Study on PF 1-1 was excluded in this section since the analysis model and its condition are the same as those used in Section 6.3 and 6.4.

As the severe single contingency condition, a single circuit 3-phase short-circuit fault near the sending end of the 500kV transmission sections which are directly or indirectly connected to the Lakhra CFPP were selected as shown in Table 6.3-4. The cells with “Y” indicate that the sections are relevant to the analysis, while the gray cells indicate that the sections are not applicable for the study case in question. The same fault sequence as shown in Table 6.3-3 was applied to the stability analysis.

Table 6.3-4 Applicable Fault Sections for each Study Case

Case / Fault Section	ST 1-2	ST 2-1	ST 2-2	ST 3-1	ST 3-2	ST 4-1
JICA Lakhra PP – Dadu New S/S	Y	Y	Y			
JICA Lakhra PP – Matiari S/S		Y	Y	Y	Y	Y
Jamshoro S/S – JICA Lakhra PP	Y	Y	Y	Y	Y	
Jamshoro S/S – Dadu New S/S						Y
Jamshoro S/S – Gadani S/S	Y	Y	Y	Y	Y	Y
Jamshoro S/S – NKI S/S	Y	Y	Y	Y	Y	Y
Jamshoro S/S – Matiari S/S	Y	Y	Y	Y	Y	Y
Coal Gadani PP – Gadani S/S		Y		Y	Y	Y
Matiari S/S – Gadani S/S	Y	Y	Y	Y	Y	Y
Matiari S/S – Moro S/S	Y	Y	Y			Y
K-2/K-3 PP – Matiari S/S		Y		Y	Y	Y
Bin Qasim PP – Matiari S/S		Y		Y	Y	Y
Thar PP – Matiari S/S	Y	Y	Y	Y	Y	Y
Dadu New S/S – Moro S/S	Y	Y	Y	Y	Y	Y
Moro S/S – R. Y. Khan S/S	Y	Y	Y	Y	Y	Y
R. Y. Khan S/S – Multan S/S	Y	Y	Y	Y	Y	Y
Dadu New S/S – Shikarpur S/S	Y	Y	Y	Y	Y	Y
Shikarpur S/S – Guddu S/S	Y	Y	Y	Y	Y	Y
Guddu S/S – Muzaffargarh S/S	Y	Y	Y	Y	Y	Y
Guddu S/S – D. G. Khan S/S	Y	Y	Y	Y	Y	Y
D. G. Khan S/S – Muzaffargarh S/S	Y	Y	Y	Y	Y	Y
Guddu S/S – Guddu New PP	Y	Y	Y	Y	Y	Y
Guddu New PP – Muzaffargarh S/S	Y	Y	Y	Y	Y	Y
Guddu New PP – R. Y. Khan S/S	Y	Y	Y	Y	Y	Y
Muzaffargarh S/S – Multan S/S	Y	Y	Y	Y	Y	Y

Source: JICA Survey Team

(3) Study results

The oscillation waveforms of the generator rotor angle difference between a generator of Muzaffargarh power plant and that of other principal power plants in the south system for all cases were shown in Appendix 6-1 to Appendix 6-6. The analysis results are summarized in Table 6.3-5.

Table 6.3-5 Transient Stability Analysis Results

Case / Fault Section	ST 1-2	ST 2-1	ST 2-2	ST 3-1	ST 3-2	ST 4-1
JICA Lakhra PP – Dadu New S/S	Stable	Stable	Stable			
JICA Lakhra PP – Matiari S/S		Stable	Stable	Unstable	Stable	Stable
Jamshoro S/S – JICA Lakhra PP	Stable	Unstable	Stable	Unstable	Stable	
Jamshoro S/S – Dadu New S/S						Unstable
Jamshoro S/S – Gadani S/S	Stable	Unstable	Stable	Unstable	Stable	Unstable
Jamshoro S/S – NKI S/S	Stable	Unstable	Stable	Unstable	Stable	Unstable
Jamshoro S/S – Matiari S/S	Stable	Unstable	Stable	Unstable	Stable	Unstable
Coal Gadani PP – Gadani S/S		Unstable		Unstable		Unstable
Matiari S/S – Gadani S/S	Stable	Unstable	Stable	Unstable	Stable	Unstable
Matiari S/S – Moro S/S	Stable	Unstable	Stable			Unstable
K-2/K-3 PP – Matiari S/S		Stable		Stable		Stable
Bin Qasim PP – Matiari S/S		Stable		Stable		Stable
Thar PP – Matiari S/S	Stable	Stable	Stable	Stable	Stable	Stable
Dadu New S/S – Moro S/S	Stable	Stable	Stable	Stable	Stable	Stable
Moro S/S – R. Y. Khan S/S	Stable	Stable	Stable	Stable	Stable	Stable
R. Y. Khan S/S – Multan S/S	Stable	Stable	Stable	Stable	Stable	Stable
Dadu New S/S – Shikarpur S/S	Stable	Stable	Stable	Stable	Stable	Stable
Shikarpur S/S – Guddu S/S	Stable	Stable	Stable	Stable	Stable	Stable
Guddu S/S – Muzaffargarh S/S	Stable	Stable	Stable	Stable	Stable	Stable
Guddu S/S – D. G. Khan S/S	Stable	Stable	Stable	Stable	Stable	Stable
D. G. Khan S/S – Muzaffargarh S/S	Stable	Stable	Stable	Stable	Stable	Stable
Guddu S/S – Guddu New PP	Stable	Stable	Stable	Stable	Stable	Stable
Guddu New PP – Muzaffargarh S/S	Stable	Stable	Stable	Stable	Stable	Stable
Guddu New PP – R. Y. Khan S/S	Stable	Stable	Stable	Stable	Stable	Stable
Muzaffargarh S/S – Multan S/S	Stable	Stable	Stable	Stable	Stable	Stable

Source: JICA Survey Team

As Table 6.3-5 shows, the south power system becomes unstable regardless of the difference in the connection schemes if all of the large-scale planned power plants in the south are in operation. On the other hand, if some of the power plants are assumed to be out-of-service, the 500kV power system is likely to be stable. This result suggests the necessity of further expansion of the trunk transmission system to evacuate the bulk power generated by the planned power plants.

As the consequence of the studies of alternative connection methods on both power flow and transient stability mentioned above, the Case 1 in Figure 6.3-1 (Lakhra PP 2□ connection) was selected for the connection scheme for Lakhra PP in consideration with increase of erection cost of additional transmission line to Matiari S/S for case 2 and 3.

6.4 Conclusions

Table 6.4-1 Summary of Power System Analysis

Case Number		1-1	1-2	2-1	2-2	3-1	3-2	4-1
Case Description	Connection Method	Lakhra PP 2π		Lakhra PP 2π + Lakhra PP - Matiari 2cct		Lakhra PP 2π + Lakhra PP-Matiari 2cct, Matiari-Moro and Lakhra PP – Dadu New: Open		Lakhra PP - Matiari 2cct (NTDC's Proposal)
	Assumed Generation	All planned large scale Power Plant in South Area in Operation	All of the Large scale Power Plant in Southern Area but Thar Power Plant are out-of-service	All planned large scale Power Plant in South Area in Operation	All of the Large scale Power Plant in Southern Area but Thar Power Plant are out-of-service	All planned large scale Power Plant in South Area in Operation	All of the Large scale Power Plant in Southern Area but Thar Power Plant are out-of-service	All planned large scale Power Plant in South Area in Operation
Result of Power Flow Analysis		√ (No Overload)	√ (No Overload)	√ (No Overload)	√ (No Overload)	√ (No Overload)	√ (No Overload)	√ (No Overload)
Result of Transient Stability Analysis		(Unstable)	√ (Stable)	(Unstable)	√ (Stable)	(Unstable)	√ (Stable)	(Unstable)
Construction Cost			Low		high		high	
Evaluation			Selected					

Source: JICA Survey team

Table 6.4-1 shows summary of Power System Analysis in this Chapter. A series of power system analyses for new Lakhra CFPP was carried out in several cases.

No overloading occurred to any section through all simulation cases, 1-1 to 4-1 by power flow analyses, on the other hand, transient stability analyses resulted in instability with all planned power plants as conducted for case 1-1, 2-1 and 3-1.

On the other hands, the connection of new Lakhra power plant in case 1-2, 2-2, and 3-2 concluded steady with specific power plants which we assumed to be installed by 2020 from viewpoint of realization on schedule. Among the stable cases, the case 1 (2π connection to existing 500 kV transmission line between Jamshoro and Dadu New substations) was consequently selected most feasible in consideration with additional erection cost of transmission line to Matiari S/S.

For the reference, additional Study including wind generation and HUBCO extension was studied in Appendix 6-7.

CHAPTER 7
CONCEPTUAL DESIGN

Chapter 7 Conceptual Design

7.1 Outline of the Project

7.1.1 General

The technical outline for the power plant of the Project is shown below.

- ✓ Unit capacity and load operation
  - Nominal capacity of 660 MW including auxiliary power consumption
  - Net plant output is 600 MW
  - The plant is for both base load and middle load operation
- ✓ Plant configuration
  - One Ultra Super Critical (USC) system of a boiler, a turbine generator and auxiliaries
  - USC once-through boiler with Pulverized Coal (PC) firing
  - Single reheat condensing, tandem-compound steam turbine
  - Totally enclosed, three phase,50Hz, synchronous generator
  - Auxiliary plants; coal handling system, ash handling system, water treatment system
- ✓ Fuel to be burned
  - Blended coal with 80% sub-bituminous coal and 20% lignite will be burned
  - 100% sub-bituminous coal will be burned when lignite is not available
  - Auxiliary light fuel oil is used for startup and support firing at low plant load
- ✓ Emission control
  - Particulate matter control: ESP efficiency: 99.7%
  - SO_x control: FGD efficiency:80%
  - NO_x control:Low NO_x firing technology in the boiler
- ✓ Grid connection
  - Grid connection of 500 kV transmission lines
- ✓ Water supply
  - The cooling water is fresh water from the Indus River
  - Water-cooled condenser paired with a natural draft type cooling tower

7.1.2 Specifications for Unit Operation

(1) Total Plant Condition

The net rated output of the turbine is the output measured at terminals of the transmission line. The plant is designed to continuously generate 100% gross output under the following conditions:

Table 7.1-1 Conditions of Rated Power Output

Unit capacity (Net)	MW	600
Main steam pressure at main stop valve inlet	MPa	24.1
Main steam temperature at main stop valve inlet	^{o}C	593
Reheat steam pressure at reheat stop valve inlet	MPa	4.2
Reheat steam temperature at reheat stop valve inlet	^{o}C	593
Condenser vacuum	kPa abs	11.1
Cooling water temperature	^{o}C	35.6
Turbine speed	rpm	3,000
Generator power factor	Lagging	0.85
Generator voltage	kV	22 or 24

Generator frequency	Hz	50
Unit efficiency (Gross) (LHV) (Sub-bituminous 80%, Thar 20%)	%	42.3
Unit efficiency (Gross) (LHV) (Sub-bituminous 100%)	%	42.5
Auxiliary power consumption	%	6.5

Source: JICA Survey Team

(2) Unit Operation

The purpose of this plant is to supply fundamentally base load power to the grid. It is required to have high reliability and capability for supplying the power demand in order to respond to rapid changes in load.

- Load changes from minimum to base load. Minimum load is the condition in which the boiler can be operated without support of liquid fuel and it shall not be more than 35% of rated load
- Load changing rates (i) from 50% load to 75% load and (ii) from 75% load to rated load are to be 3%/min in the case of only sub-bituminous coal
- Sliding pressure operation shall be applied during load, ranges from 50% to 90%

The maximum temperature variation of the main steam temperature and reheat steam temperature should be:

During normal operation	:	+8 °C,-8°C
During load change	:	+10 °C, -15 °C

In case of power grid failure, this plant should be transferred to house load operation, which is a stand-by condition for synchronizing immediately after the recovery from an electrical failure.

The bypass system should have the function to override the house load operation from the rated load when triggered by a grid accident. If some mills can be stopped and the pressure peak of the main steam pipe system can be controlled within the design pressure, the capacity of the bypass system may be decreased. A practical achievement should be explained for decreasing the capacity and 70% will be the minimum capacity.

7.2 Basic Study and Selection of Major Facilities

7.2.1 Steam Condition, Unit Size and Mixed Coal

(1) Unit Size

The criteria to chose plant size was discussed in chapter 3.4.2, and as the result of it,

600MW (Net) was decided suitable as the Project.

(2) Steam Condition

1) Selection of Pulverized Coal Combustion Technologies

A coal fired power system consists of the following types:

- Pulverized coal combustion (PC)
- Fluidized bed combustion (FBC)
- Integrated gasification combined cycle (IGCC)

The power generation facilities are very public in nature and must be designed to minimize the occurrence of any problems that would disrupt operation or restrict power supply. There are very few coal-fired experiences in Pakistan; therefore, it is considered that the technical risks in adopting this immature technology should be avoided.

The vital criteria in selecting which type to be used for the Project are shown below:

- Reliability for continuous production of power -- good commercial record
- Modern and economical design -- high plant performance and low long-term project costs
- Plant operation and maintenance -- matured control system and minimum maintenance
- Environmental impact -- stable emission control

The most vital item above is the reliability, and it is discussed in three types.

As for the PC fired power plant, there are three types in commercial operation; Sub-C, SC and USC. Although detailed comparison will be shown later, a PC-fired power technology has been developed long ago with a stable operation record.

As for the FBC boiler, there are two types, namely, Atmospheric FBC (AFBC) and Pressurized FBC (PFBC). AFBC has been used in many occasions for the range of 350 MW; however, there are little operation records for the 600 MW class. Besides this, the units are more complicated in terms of operation and maintenance. The PFBC is still under development; therefore, it is not considered for the Project even though it will give high thermal efficiency in the future. It is judged that both types of FBC are not suitable for the Project.

The IGCC type has been developed and in commercial operation since 1996; however, the technology was not considered to be matured enough. Most of IGCC plants are under the process of improvement and so this type is not suitable for the Project.

2) Selection of Steam Condition

The PC type is considered to be the best at this stage in the above description. The criteria for choosing the steam condition among the three was discussed in Chapter 3.4.2, and as a result, Ultra Super Critical type of 24.1MPa/ 593°C/ 593°C, which may be sometimes categorized as SC, was decided to be suitable for the Project

(3) Boundary Condition of Moisture Content of the Mixed Coal

Fundamental policy for coal firing in the Project is as follows.

- The boiler of the project is designed to burn 100% of imported sub-bituminous coal with vertical and roller type pulverizers.
- In addition to that, Thar coal will be mixed up to 20%, the reason of which will be described next.

Based on many experiences in boilers firing sub-bituminous coals in the world, moisture content of 30% is considered as the boundary condition for the boiler equipped with vertical and roller type pulverizers.

If the moisture is much more, troubles will be brought about, such as decreasing of mill outlet temperature under the limit for stable firing or increasing of blockage possibility in pipes due to wet coal.

Therefore, in the study of the boiler basically designed to burn sub-bituminous coal with vertical and roller type pulverizers, the moisture content of coal should be kept within the limit of 30%. Major characteristics of the sub-bituminous and Thar lignite coals are shown in Table 7.2-1.

Table 7.2-1 Major Characteristics of the Coals

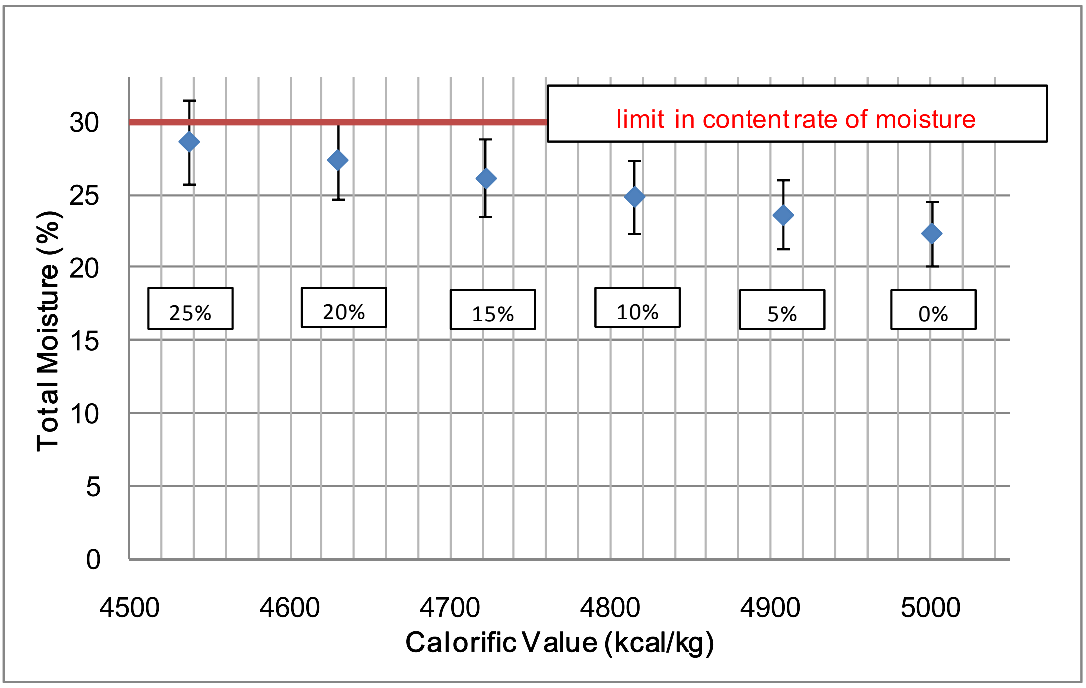
Proximate Analysis		Sub-bituminous Coal	Thar Coal
High Heating Value	kcal/kg	5,000	3,146
Total Moisture	% as received basis	22.4	47.6
Ash	% as received basis	8.06	7.8
Volatile Matter	% as received basis	35.77	25.0
Fixed Carbon	% as received basis	33.77	19.6
HGI	--	50	70 - 80

Source: JICA Survey Team

In the case of mixing ratio of 20% Thar coal and 80% sub-bituminous coal in weight, the moisture content of uniformly mixed coals is calculated as follows:

Total Moisture after mixing in normal design basis: 27.44 % ((22.4 x 80+ 47.6 x 20)/100= 27.44)

Total moisture dependency on mixture ratio of Thar coal and sub-bituminous coal with deviation bar (10%) is shown in Figure 7.2-1 as below.



Source: JICA survey Team

Figure 7.2-1 Total Moisture Dependency on Mixture Ratio of Thar Coal and Sub-bituminous Coal

It seems that there is still some allowance of increasing the mixing ratio of Thar coal, however, taking account of deviation of 10% on moisture contents, the moisture content of sub-bituminous coal 80%: Thar coal 20% would be upper limit.

As shown in Figure 7.2-1, the calorific value of mixing ratio of sub-bituminous coal 80%: Thar coal 20% is within 10% lower than that of 100% sub-bituminous coal, 5000kcal/kg, hence, as for designing of boiler with the above mentioned mixture rate, same design condition and size can be applied with the condition in case of use of 100% sub-bituminous coal.

The actual pulverizing and firing tests in an experimental furnace is required with preparation of approximately 5 to 6 drums to judge the limitation of blending ratio. However this will be possible after the actual production of Thar coal.

7.2.2 Configuration of Major Plant and Equipment

(1) Major System

The major systems of the plant consist of the following:

a. USC boiler and pulverizing mill system

- ✓ One once-through boiler: 2,200 t/h (BMCR), 24.1 MPa, 593 ^{o}C / 593 ^{o}C
- ✓ Main fuel: Sub-bituminous coal (80%) and Thar coal (20%)
- ✓ One pulverized coal preparation and feeding system including mills and primary air fan sets
- ✓ Two air heaters

b. Flue gas treatment system comprising of ESPs and FGD systems

- ✓ Two electrostatic precipitators (ESP)
- ✓ One flue gas desulfurization system (FGD)

c. Steam turbine and condensate and feedwater system

- ✓ One tandem compound steam turbine: Nominal 660 MW, 24.1 MPa, 593/593 ^{o}C
- ✓ One digital electro-hydraulic turbine control system
- ✓ One condensate system, four stages of low pressure (LP) heaters and one deaerator
- ✓ Two turbine driven boiler feedwater pumps and one motor driven feedwater pump
- ✓ Three stages of high pressure (HP) heating system

c. Electrical power generator and power export system

- ✓ One electric generator: 776 kVA, 22 or 24 kV, 50 Hz, cosφ 0.85
- ✓ One static-type exciter
- ✓ One AVR system
- ✓ One power system stabilizer (PSS)
- ✓ One main transformer
- ✓ One unit auxiliary transformer
- ✓ One start-up transformer

d. Cooling water system by cooling tower

- ✓ One natural draft cooling tower and cooling water pump set
- ✓ One closed circuit cooling water system

The coal for the power plant is processed for feeding into the boiler, where the coal is burned in the furnace, and then steam is generated and heated by the super heater and re-heater. After being fed into the steam turbine, the steam rotates the turbine and generator.

Cooling water is required for condensation of the steam at the low-pressure end of the steam turbine. The cooling water is cooled through the cooling tower, where it is cooled by the atmospheric air.

The flue gas from the boiler is passed through a series of environmental treatment equipment, such as ESP and FGD, where the pollutants in the gas are removed before being discharged into the atmosphere.

The auxiliary system for the main plant will have the following number of equipment with corresponding capacity:

Table 7.2-2 Main Equipment Configuration

Equipment	Number / %	Notes
Forced Draft Fans	2 / 50%	
Induced Draft Fans	2 / 50%	
Primary Air Fans	2 / 50%	
Gas Recirculation Fans	2 / 50%	
Cooling Air Fans	2 / 50%	
Mills	6 / 20%,	One is for stand-by - manufacturer's proposal
Circulating Water Pumps	2 / 50%	
Condensate Pumps	3 / 50%	Capable of supplying additional LP turbine bypass spray flow in case of rated bypass condition
Boiler Feed Pumps	2 / 50% turbine driven 1 / 25% motor driven	

Source: JICA Survey Team

(2) Balance of Plant

The balance of plant systems includes the following:

- ✓ Coal handling, unloading, storage and supply system
- ✓ Ash handling system including boiler bottom ash removal system
- ✓ Utilities and waste management system
- ✓ Fresh water supply system
- ✓ Water treatment system including demineralized water system
- ✓ Wastewater treatment system
- ✓ Fire protection system
- ✓ Hydrogen generation system
- ✓ Emergency electric diesel generator
- ✓ Compressed air systems

The design of the Project should provide reasonable operational flexibility such as reasonable redundancy of backup system for the production of electricity. The Project should be designed for safety, easy accessibility, and maintainability to allow for fast and efficient maintenance of equipment at minimum cost.

7.2.3 Consideration of Water Supply

The proposed thermal power plant will require a definite quantity of water to be utilized as the boiler water and the cooling water. The water supply systems are presented in Figure 7.2-2.

: Proposed route for the additional water conveyance pipeline

Source: Google Earth, JICA Survey Team

Figure 7.2-2 Location of Proposed Water Intake Facility and Water Conveyance Pipeline

The general description for the proposed water supply system is listed below.

- ✓ The additional water intake facility will be installed in the Indus River which will be located approximately 3 km downstream of the existing water intake tower.
- ✓ The additional water conveyance pipeline will be installed along the existing road, which is approximately 6.5 km in length.

- ✓ The raw water treatment system will be installed in the newly-proposed thermal power station in order to satisfy the required water quality for the cooling tower, the boiler, and the administration building.

- ✓ The wastewater treatment system will be installed to treat the wastewater generated from each facility in the thermal power station appropriately before discharging into public water bodies.

The additional wastewater drainage pipeline will be installed at the same route as the proposed water conveyance pipeline which is approximately 3.8 km in length, and the treated wastewater will be discharged into the existing water channel. The detailed study will be discussed in Section 7.3.8 (6), (7), (8), (9).

7.2.4 Environmental Requirement and Pollution Abatement

(1) Environmental Regulation Value

For the projet, IFC standards are adopted. Environmental regulation value according to IFC standards is shown in Table 7.2-3. IFC standards are classified two categories, Non-degraded airshed (NDA), degraded airshed (DA), but NDA is applied on this project, because only a few factory exist near Lakhra plant.

Table 7.2-3 Environmental Regulation Value according to IFC standards

Pollutant	Class	Standards	Unit
SOx Emission	NDA	200 - 850	mg/ Nm^3
NOx Emission	NDA	510	mg/ Nm^3
Particulate Matter	NDA	50	mg/ Nm^3

Source: IFC standards

NDA = Non-degraded airshed

(2) Forecast of Pollutant Emission

Because no data relevant to actual flue gas exists in this feasibility study, there is no alternative but to carry out forecast pollutant emission based on coal quality data. Both coal qualities of the import coal and Thar coal are shown in chapter 5.

A forecast of SOx emissions is shown in Table 7.2-4. The forecast value of daily SO_2 emissions concentration in case of imported coal 100 % burning and mixed imported coal 80% / Thar coal 20 % burning are 2,269(mg/ Nm^3) and 3,436 (mg/ Nm^3) respectively. Because Forecast of SOx Emission is over SO_2 emission standard, it is necessary to install pollution abatement equipment (flue gas desulfurization).

Table 7.2-4 Forecast of SOx Emission

Item	Formula	Imported coal 100%	Imported coal 80%, Thar coal 20% In weight ratio	Unit
Caloric value of coal	a	5,000	4,629	kcal/kg
Plant efficiency	b	39.69%	38.89% (HHV)	
Plant capacity	c	660		MW
Unit coefficient	d	860		kcal/kWh
hourly calorie consumption	e=c*d* 1000/b	1,430,083,144	1,459,501,157	kcal
hourly coal consumption	f=e/a	286,017	315,282	kg
Wt % of Sulfur	g	0.70%	1.06%	
hourly sulfur emission	h=f*g	2,002	3,342	kg
Molecular weight of Sulfur	i	32		
Molecular weight of SO_2	j	64		
hourly SO_2 emission	k=h*j/i	4,004.2	6,684.0	kg/h
Exhaust gas emission per unit weight	l	6.17	6.17	Nm3/kg
hourly exhaust gas emission	m=l*f	1,764,723	1,945,287	Nm3/h
Exhaust gas concentration	n=h*1,000,000 /m	2,269	3,436	mg/Nm3

Prepared by JICA Study Team

Forecast of NOx Emission is shown in Table 7.2-5. In estimation under assumption that is installed Low-NOx burner on this project, Both of Forecast value of SO_2 emission concentration in case of imported coal 100 % burning and mixed imported coal 80% / Thar coal 20 % burning are at most 261 (mg/ Nm^3). Because Forecast of NOx Emission is not over NO_2 emission standard, It is not necessary to install pollution abatement equipment expect Low-Nox burner.

Table 7.2-5 Forecast of NOx Emission

Item	Formula	Imported coal 100%	Imported coal 80%, Thar coal 20% In weight ratio	Unit
Exhaust gas concentration (in ppm)	a	At most 200	At most 200	ppm
Exhaust gas emission per unit weight	b	6.17	6.17	Nm3/kg
Exhaust gas weight per unit weight	c	8.04	8.04	
Exhaust gas concentration	d=a*c/b	At most 261	At most 261	mg/Nm3

Prepared by JICA Study Team

Forecast of PM Emission is shown in Table 7.2-6. Forecast value of PM emission concentration in case of imported coal 100 % burning and mixed imported coal 80% / Thar coal 20 % burning are 12,982(mg/ Nm^3) and 14,645 (mg/ Nm^3) respectively. Because forecast of PM emission is over PM emission standard, It is necessary to install pollution abatement equipment (Electrostatic Precipitator).

Table 7.2-6 Forecast of PM Emission

Item	Formula	Imported coal 100%	Imported coal 80%, Thar coal 20% In weight ratio	Unit
Caloric value of coal	a	5,000	4,629	kcal/kg
Plant efficiency	b	39.69%	38.89% (HHV)	
Plant capacity	c	660		MW
Unit coefficient	d	860		kcal/kWh
hourly calorie consumption	e=c*d* 1000/b	1,430,083,144	1,459,501,157	kcal
hourly coal consumption	f=e/a	286,017	315,282	kg
Wt % of ash	g	8.90%	8.37%	
Fly ash ratio	h	90%		
hourly PM emission	i=f*g*h	22,910	28,489	kg/h
Exhaust gas emission per unit weight	j	6.17	6.17	Nm3/kg
hourly exhaust gas emission	k=j*f	1,764,723	1,945,287	Nm3/h
Exhaust gas concentration	l=i*1,000,000/k	12,982	14,645	mg/Nm3

Prepared by JICA Study Team

(3) Installation of the Flue Gas Desulfurization

It is strongly recommended that Flue Gas Desulfurization (hereinafter called FGD) should be installed due to cut down the amount of SOx emission on this feasibility study.

Design condition is set up 850 mg/Nm3 as environmental regulation value. SOx Emission after FGD is shown in Table 7.2-7. It is necessary to install FGD with removal efficiency of 80% or over in order to satisfy environmental regulation value.

Basic specification regarding FGD is mentioned in subchapter of Pollution Abatement.

Table 7.2-7 SOx Emission at outlet of FGD

FGD removal efficiency	SOx Emission at outlet of FGD (mg/ Nm3) (in case of mixed coal burning)	Standard value (mg/ Nm3)	Judge
99%	34	<850	Applied
95%	172		Applied
90%	344		Applied
80%	687		Applied
70%	1,031		NOT Applied

Source: JICA Study Team

(4) Installation of an Electrostatic Precipitator

It is strongly recommended that Electrostatic Precipitator (hereinafter called ESP) is installed due to cut down the amount of PM emission on this feasible study.

Design condition is set up 50 mg/Nm3 as environmental regulation value. PM Emission at outlet of ESP is shown in Table 7.2-8. It is necessary to install ESP with removal efficiency of 99.7% and over in order to satisfy environmental regulation value.

Basic specification regarding ESP is mentioned in subchapter of Pollution Abatement.

Table 7.2-8 PM Emission at outlet of ESP

ESP removal efficiency	PM Emission at outlet of ESP (mg/ Nm3) (in case of imported coal burning)	Standard value (mg/ Nm3)	Judge
99.7%	44	<50	Applied
99.6%	59		NOT applied
99.5%	73		NOT applied
99%	146		NOT applied
95%	732		NOT applied
90%	1,465		NOT applied
80%	2,929		NOT applied
70%	4,394		NOT applied

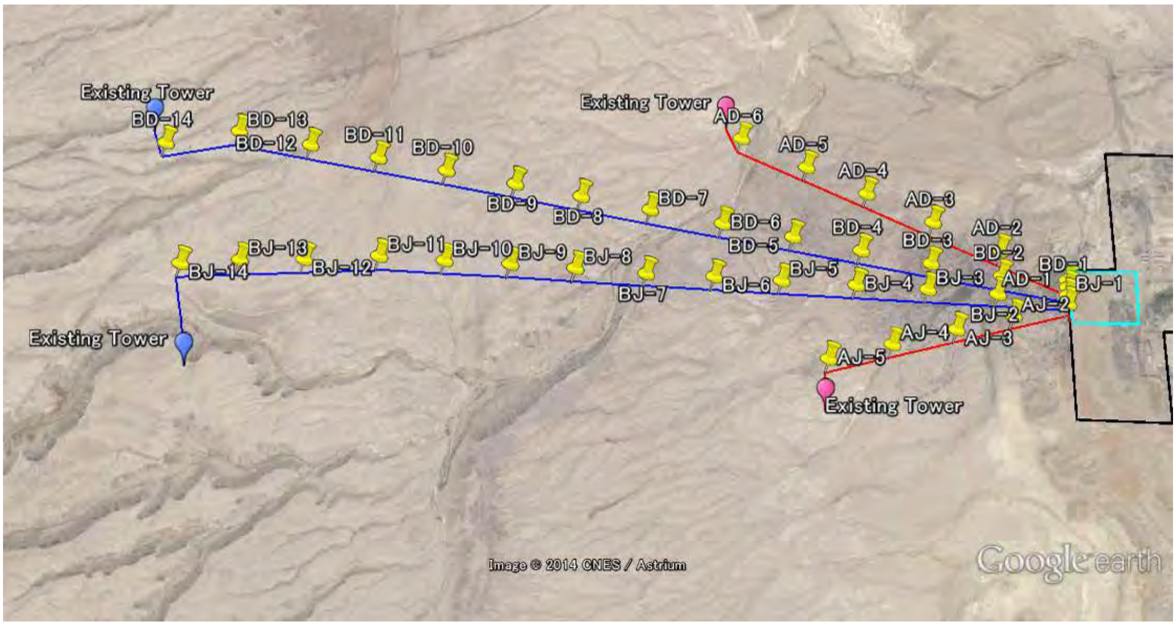
Source: JICA Study Team

(5) Selection of Low NOx Burner

The low NOx Burner is sellected due to cut down the amount of NOx emission on this feasible study. Due to install low Nox burner amount of NOx emission reduces at most 200 ppm (261mg / Nm3), then satisfies regulation value of 510 mg/ Nm3. Basic specification regarding Low NOx Burner is mentioned in subchapter of Boiler and Auxiliaries.

7.2.5 Transmission Line Route

As the result of power system analysis, 500kV switching station at Lakhra power station is to be connected to existing 500kV transmission line between Jamshoro and Dadu by 2cct ˜-connection as shown in Figure 7.2-3.



: Proposed route for the connection of Existing 500kV Line -A

: Proposed route for the connection of Existing 500kV Line- B

Source: Google Earth, JICA Survey Team

Figure 7.2-3 Route Map of 500kV Transmission Line from Lakhra Power Station

In order to supply generation power at commissioning test stage of power plant, it is necessary to complete the 500 kV transmission lines until November, 2020.

(1) Connection to Existing 500kV Line- A

Description of conductor of the existing 500kV transmission line for near side of power station (Line-A) and photo of existing 500kV transmission line are as shown below;

Table 7.2.9 Conductor of Existing 500kV Transmission Line

Item	Description
Kind of Conductor	Greely
Number of Conductor per phase	3
Current Capacity (3 conductor per phase, conductor temperature 75°C <atmosphere 40°C>)	1,830 A

Source: Prepared by JICA Survey Team based on NTDC source

Source: JICA Survey team

Photo 7.2-1 Existing 500kV Transmission Line-A surrounding of Lakhra Power Station

a. Direction of New Dadu

Transmission line route starts from Lakhra Power station and goes straight to the existing Tower. Total distance will be approx. 1.9 km, and construction of new tower will be six as shown in Table 7.2.10

Table 7.2.10 Tower Alignment

Tower	LAT	LONG	Elevation	Remarks
No.AD-1	25.703429°	68.261460°	49m	Tension Type
No.AD-2	25.704754°	68.261500°	46m	Suspension Type
No.AD-3	25.706042°	68.264632°	47m	Suspension Type
No.AD-4	25.707331°	68.267483°	53m	Suspension Type
No.AD-5	25.708542°	68.276780°	54m	Suspension Type
No.AD-6	25.709867°	68.276780°	57m	Heavy Angle Type
Existing	25.711240°	68.276780°	56m	Suspension Type

Source: JICA Survey Team

b. Direction of Jamshoro

Transmission line route starts from Lakhra Power station and goes straight to the existing Tower. Total distance will be approx. 1.4 km, and construction of new tower will be five as shown in Table 7.2.11.

Table 7.2.11 Tower Alignment

Tower	LAT	LONG	Elevation	Remarks
No.AJ-1	25.702408°	68.276722°	49m	Tension Type
No.AJ-2	25.701907°	68.274082°	48m	Suspension Type
No.AJ-3	25.701344°	68.271343°	49m	Suspension Type
No.AJ-4	25.700723°	68.268262°	49m	Suspension Type
No.AJ-5	25.700123°	68.265222°	55m	Heavy Angle Type
Existing	25.698710°	68.265210°	55m	Suspension Type

Source: JICA Survey Team

(2) Connection to Existing 500kV Line-B

Description of conductor of existing 500kV transmission line for farther side of power station (Line-B) and photo of existing 500kV transmission line are shown as below;

Table 7.2.12 Conductor of Existing 500kV Transmission Line

Item	Description
Kind of Conductor	Greely
Number of Conductor per phase	4
Current Capacity (4 conductor per phase, conductor temperature 75°C <atmosphere 40°C>)	2,440 A

Source: Prepared by JICA Survey Team based on NTDC source

Source: JICA Survey team

Photo 7.2-2 Existing 500kV Transmission Line-B surrounding of Lakhra Power Station

a. Direction of New Dadu

Transmission line route starts from Lakhra Power station and goes straight to the existing Tower. Total distance will be approx. 4.5 km, and construction of new tower will be fourteen as shown in Table 7.2.13.

Table 7.2.13 Tower Alignment

Tower	LAT	LONG	Elevation	Remarks
No.BD-1	25.703118°	68.276769°	50m	Tension Type
No.BD-2	25.703643°	68.273695°	53m	Suspension Type
No.BD-3	25.704217°	68.270363°	61m	Suspension Type
No.BD-4	25.704790°	68.267042°	65m	Suspension Type
No.BD-5	25.705405°	68.263797°	70m	Suspension Type
No.BD-6	25.706011°	68.260433°	79m	Suspension Type
No.BD-7	25.706641°	68.256970°	94m	Tension Type
No.BD-8	25.707224°	68.253652°	101m	Suspension Type
No.BD-9	25.707775°	68.250496°	115m	Suspension Type
No.BD-10	25.708368°	68.247183°	115m	Suspension Type
No.BD-11	25.708960°	68.243886°	118m	Suspension Type
No.BD-12	25.709560°	68.240596°	136m	Suspension Type
No.BD-13	25.710176°	68.237145°	144m	Tension Type
No.BD-14	25.709736°	68.234359°	144m	Heavy Angle Type
Existing	25.710269°	68.233925°	149m	Suspension Type

Source: JICA Survey Team

b. Direction of Jamshoro

Transmission line route starts from Lakhra Power station and goes straight to the existing Tower. Total distance will be approx. 4.7 km, and construction of new tower will be fourteen as shown in Table 7.2.14

Table 7.2.14 Tower Alignment

Tower	LAT	LONG	Elevation	Remarks
No.BJ-1	25.702779°	68.276730°	48m	Tension Type
No.BJ-2	25.702937°	68.273443°	48m	Suspension Type
No.BJ-3	25.703084°	68.270129°	55m	Suspension Type
No.BJ-4	25.703287°	68.266718°	60m	Suspension Type
No.BJ-5	25.703493°	68.263163°	68m	Suspension Type
No.BJ-6	25.703675°	68.259949°	73m	Suspension Type
No.BJ-7	25.703808°	68.256713°	85m	Tension Type
No.BJ-8	25.704040°	68.253355°	94m	Suspension Type
No.BJ-9	25.704217°	68.250280°	107m	Suspension Type
No.BJ-10	25.704392°	68.247176°	104m	Suspension Type
No.BJ-11	25.704594°	68.244085°	114m	Tension Type
No.BJ-12	25.704460°	68.240586°	127m	Suspension Type
No.BJ-13	25.704432°	68.237588°	131m	Suspension Type
No.BJ-14	25.704292°	68.234813°	136m	Heavy Angle Type
Existing	25.704550°	68.234540°	146m	Suspension Type

Source: JICA Survey Team

(3) Major Equipment

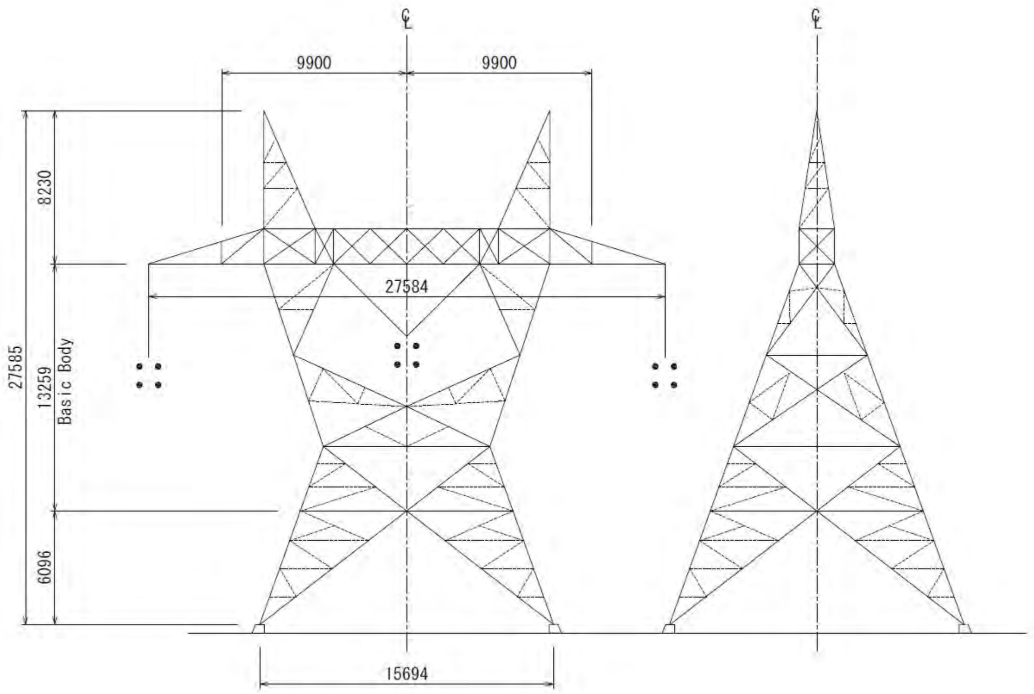
Major equipment and typical drawings of 500kV towers are shown in Table 7.2.15

Table 7.2.15 List of Major Equipment

No.	Description	Unit	Qty.
1	Tower	Nos.	39
2	Conductor (GREELY)	km	147
3	Shield Wire	km	13
4	OPGW (ϕ150 mm^2 * 2	km	26
5	Insulator 80kN (Light Angle: 144 per tower * 8, Heavy Angle: 144 per tower *4)	Nos.	1,728
6	Insulator 160kN (Light Angle: 432 per tower * 8, Heavy Angle: 432 per tower * 4, Suspension: 216 * 27)	Nos.	11,016
7	Conductor accessories, hardware and grounding sets, etc.	Lot	1

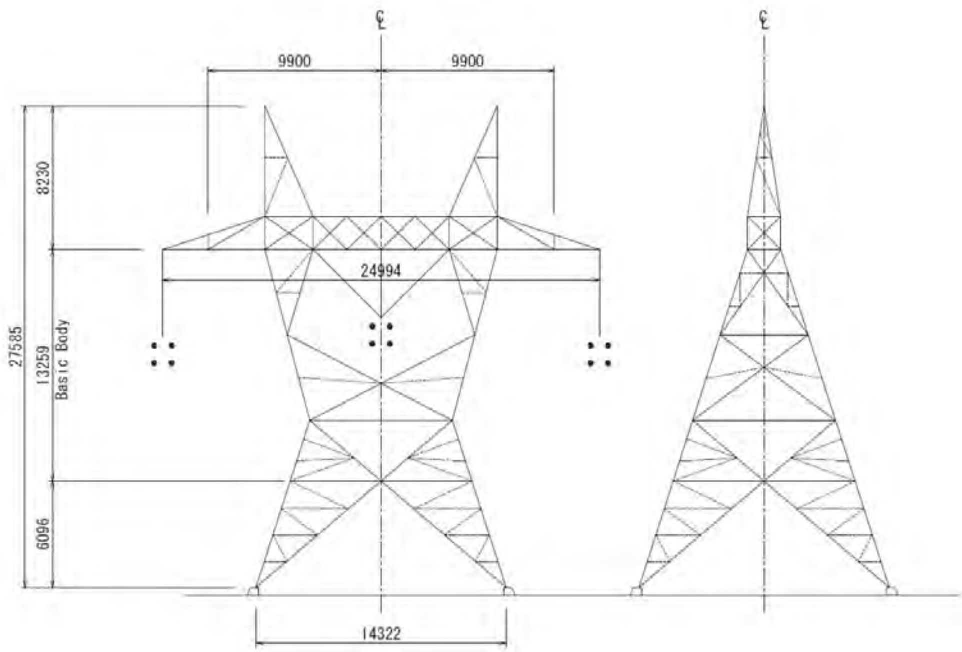
Source: JICA Survey Team

From the viewpoint of cost reduction, NTDC uses the standard tower except special areas. For the existing 500kV transmission lines between Jamshoro and new Dadu also use the standard towers as usual. The drawings of standard towers applied under the Project are shown as follows.



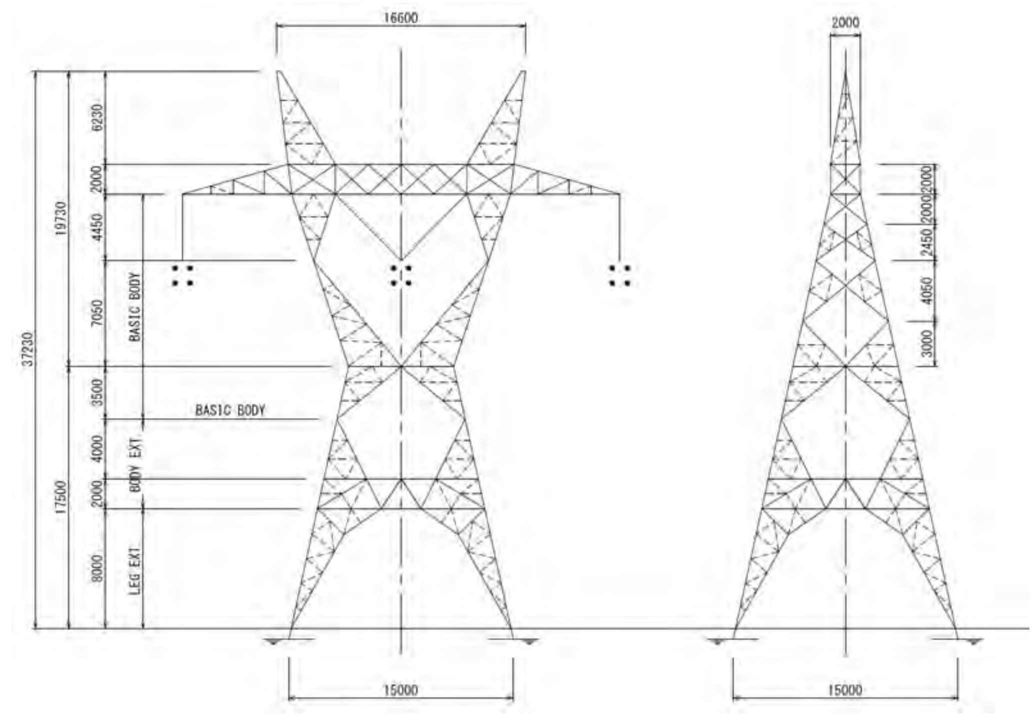
Source: prepared by JICA Survey team based on NTDC drawings

Figure 7.2-4 500kV Transmission Line Tower: Large Angle Type



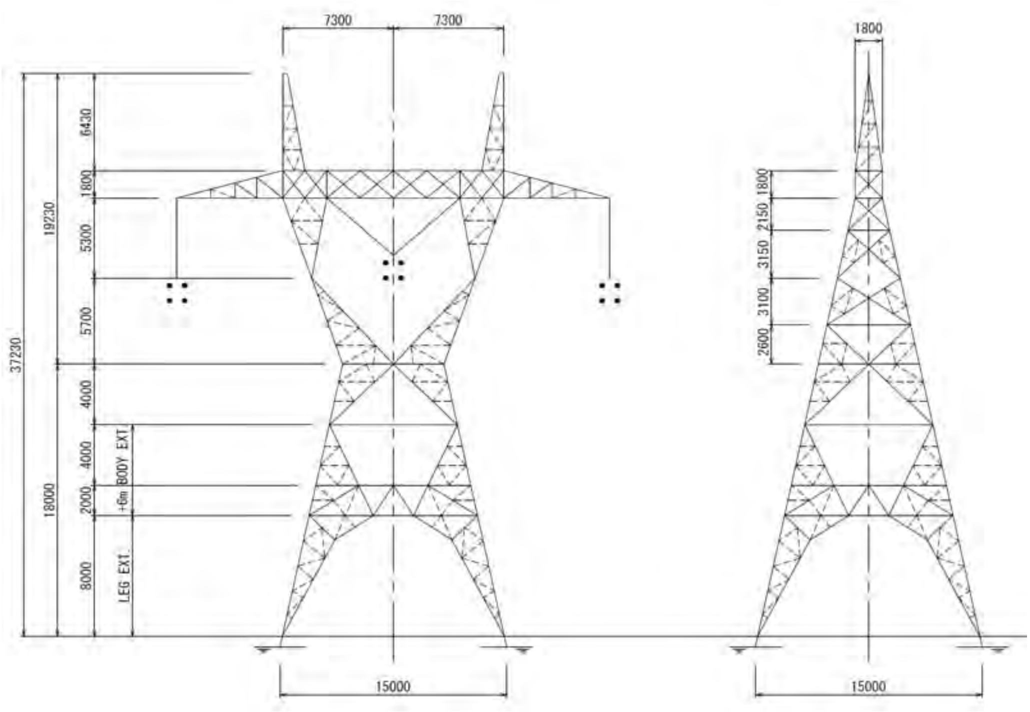
Source: prepared by JICA Survey team based on NTDC drawings

Figure 7.2-5 500kV Transmission Line Tower: Light Angle Type



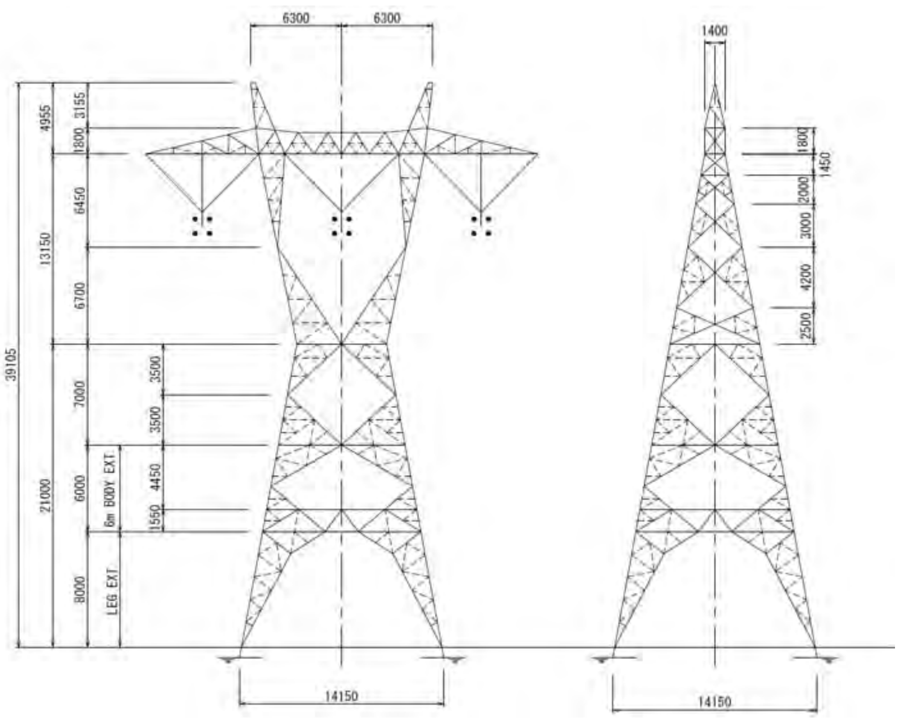
Source: prepared by JICA Survey team based on NTDC drawings

Figure 7.2-6 500kV Transmission Line Tower: Large Angle Type (body extension)



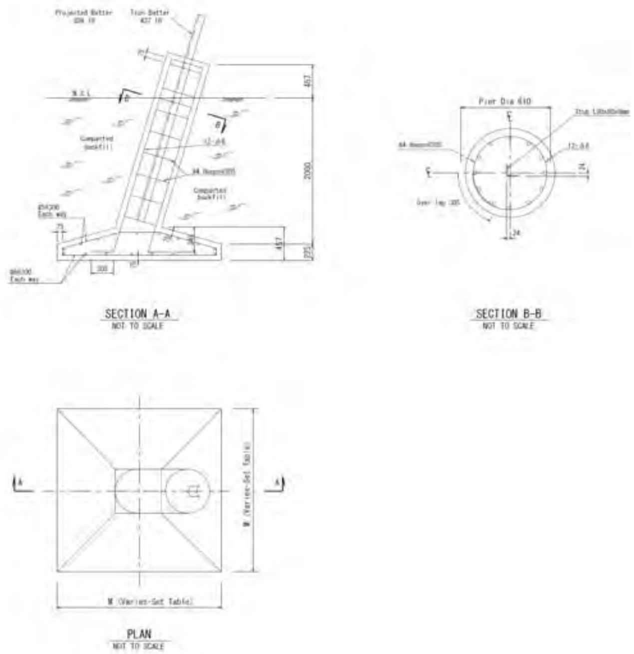
Source: prepared by JICA Survey team based on NTDC drawings

Figure 7.2-7 500kV Transmission Line Tower: Light Angle Type (body extension)



Source: prepared by JICA Survey team based on NTDC drawings

Figure 7.2-8 500kV Transmission Line Tower: Suspension Type (body extension)



Source: prepared by JICA Survey team based on NTDC drawings

Figure 7.2-9 Reinforced Concrete Foundations

(4) Construction Cost

Construction cost for the 500kV Transmission line between Lakhra Power station and existing 500kV transmission line is as shown in Table 7.2.16.

Table 7.2-16 Construction Cost for 500kV Transmission Line Between P/S and Existing Line

This table is masked because it includes confidential.

7.3 Plant Design Consideration

7.3.1 Design Criteria

The Lakhra Power Station will supply electric power as base load. The main plant equipment and their design concepts should be based on the following fundamentals:

- ✓ The power generation facilities will have a very public nature and must be designed to minimize the occurrence of any problems that would disrupt operation or restrict power supply.
- ✓ It is vital to ensure safety and reliability in the planning, design, and construction of the facilities and to offer a high availability with low forced outage rate.
- ✓ Immature technology will not be acceptable and all plants must be fully supported by manufacturer's warranties and indemnities.
- ✓ In order to attain safety and reliability, it is very important to consider the use of duplex and redundant configurations in auxiliary systems in case the system suffers from heavy wear or erosion. An appropriate level of redundancy including fail safe technology shall be designed in each system and the power plant shall, in general, be designed such that the failure of any single auxiliary item of the plant shall not result in the total loss of a generating unit.

- ✓ The plant should be modern and economically attractive, in terms of both capital cost and running cost. It is essential that the power plant is designed to have high plant performance and to minimize long-term project costs.
- ✓ All components of the power station shall be designed, selected, and installed to ensure high reliability and minimal maintenance.
- ✓ The design lifetime for all plants and equipment shall be 30 years. The features, materials and the plant should be chosen to provide an optimum techno-economic solution over this period taking into account the likely costs of operation and maintenance.
- ✓ Modern technology is also applied to reduce the impact on the environment, especially for boiler flue gas, such as particulate material, SOx and NOx.
- ✓ Plant equipment should be designed and manufactured according to international standards, arid climate, and environment temperature, humidity and dust conditions.
- ✓ Main plant equipment has the practical operation of over 15 years.

7.3.2 Codes and Standards

The new power plant will be designed, manufactured, assembled, and tested following international codes and standards. Predicted applicable standards and codes for the Project are shown below:

ACI	:	American Concrete Institute
AISC	:	American Institute of Steel Construction
AISE	:	Association of Iron and Steel Engineers
AISI	:	American Iron and Steel Institute
ANSI	:	American National Standard Institute
API	:	American Petroleum Institute
ASCE	:	American Society of Civil Engineers
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing and Materials
AWS	:	American Welding Society
BCP		Building Code of Pakistan
BS	:	British Standards Institute
DIN	:	Deutsche Institute
HEI	:	Heat Exchange Institute
HI	:	Hydraulic Institute
IEC	:	International Electrical Code
IEEE	:	Institute of Electrical and Electronics Engineers

ISA	:	Instrument Society of America
IMC	:	International Mechanical Code
IPC	:	International Plumbing Code
ISO	:	International Standards Organization
JEC	:	Japan Electro – technical Committee
JEM	:	Japan Electrical Manufacturer's Association
JIS	:	Japan Industrial Standards
MBMA	:	Metal Building Manufacturer's Association
NESC	:	National Electrical Safety Code
NEMA	:	National Electrical Manufacturer's Association
NFPA	:	National Fire Protection Association
OSHA	:	Occupational Health, Safety, and Environment Administration
TEMA	:	Tubular Exchanger Manufacturer's Association

In case any update is adopted, revised codes and standards shall be adopted for the Project.

7.3.3 Site Layout

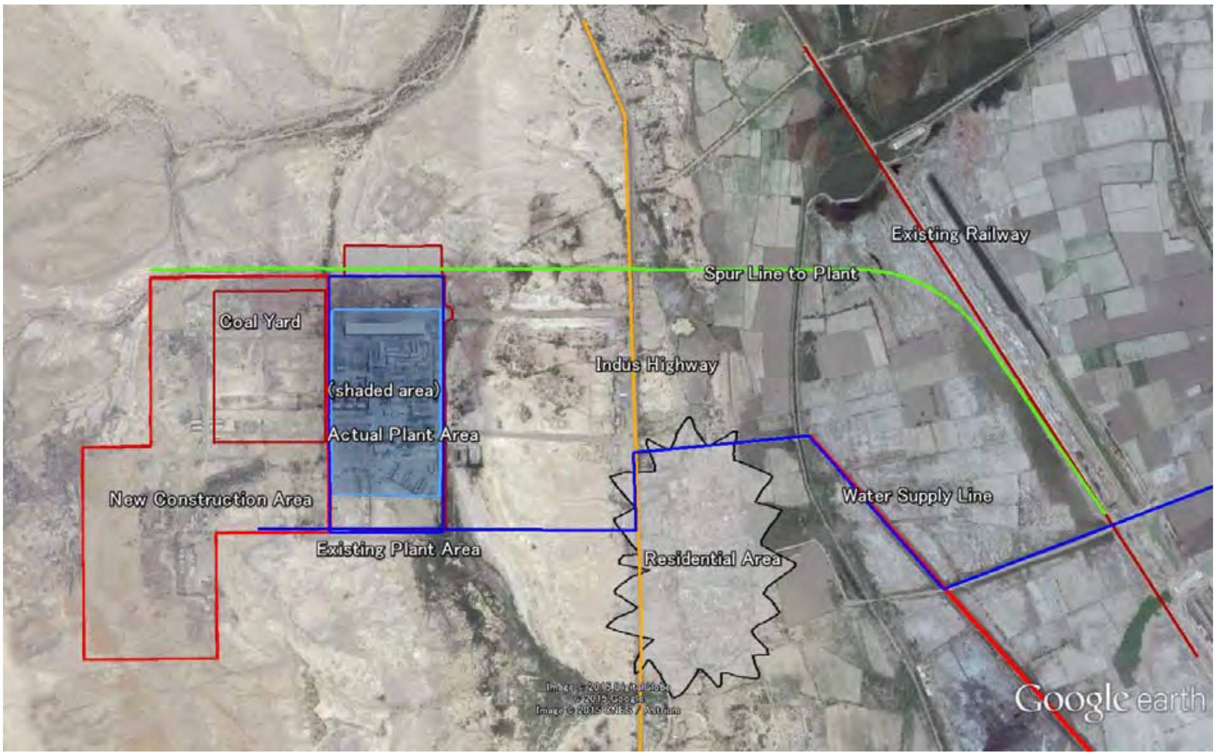
(1) Basic Concept of Plant Layout

- ✓ As the new plant will be installed in the premises of the existing Lakhra Power Station, which has potential of privatization, the infrastructures for the plant are planned independently so as not to intervene in the existing plant, namely, the access roads between the new coal handling yard near from Budapur station and the new plant, and intake water pipe between Indus River and the power plant.
- ✓ The new coal handling yard on the trunk railway (Kotri Junction to Khanot) for transporting imported coal is newly constructed considering the environmental and social aspects.
- ✓ Two access roads, one for normal use and the other for local coal (Thar coal) transportation, between Indus Highway to the new plant are developed.
- ✓ Water pipe from the Indus River to the plant is installed along the road for normal use.
- ✓ For minimizing space in the existing plant area, only the north and south spare spaces will be used.

(2) Route of Coal Transportation to Power Plant

Imported coal is transported to the power station by railway from Port Qasim. The existing trunk railway from Karachi to Peshawar, branched at Kotri in Jamshoro, runs from south to north, around 2 km away, east of the power station.

To avoid crossing the residential area, the spur line shall be planned at the north side of the power station. Therefore, it is recommended to locate the coal yard at the north area in order to connect to the spur line easily as shown in Figure 7.3-1.



Source: JICA Survey Team

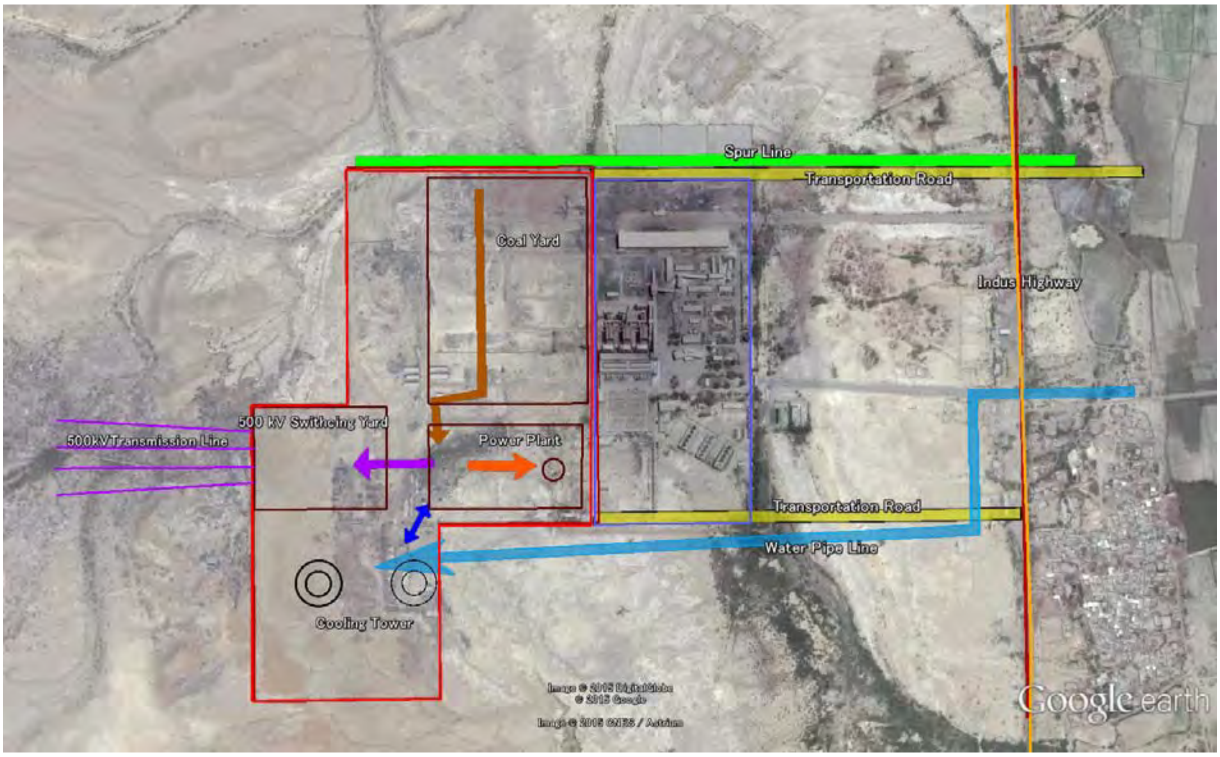
Figure 7.3-1 Imported Coal Transportation Route

(3) Plant Layout Plan

For locating each facility in the area, the simple flow of coal, power, gas, and water is considered.

- ✓ Existing two 500 kV transmission lines run west of the power station, each Π-branched, then four 500 kV lines are connected to the switching station. Then the switching station is located in the west side.
- ✓ As described in the previous clause, the coal yard is located in the north.
- ✓ For supplying coal to the boiler, and connecting the generated power to the switchyard by overhead conductor, the power plant is recommended to be located near both. Then the power plant is located between the south of coal yard and east of the switchyard.
- ✓ Cooling towers are located at the south part of the area.

Figure 7.3-2 shows the basic location of each facility of the plant.



Legends

Coal Flow	Flue Gas Flow	Power Flow
Water Flow	Circulation Water Flow	

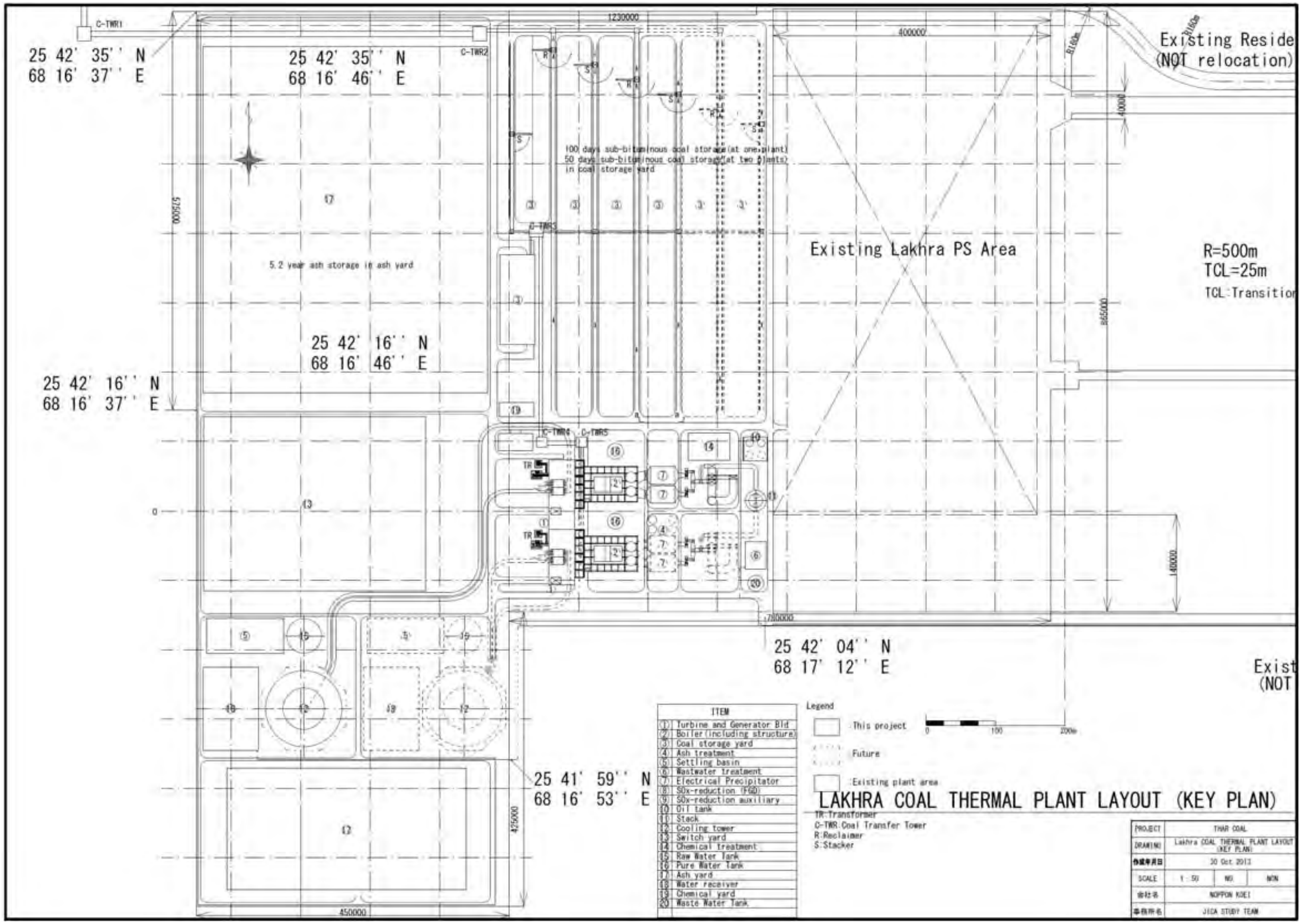
Source: JICA Survey Team

Figure 7.3-2 Plant Layout Plan

Figure 7.3-3 shows layout plan for new power plant.The project aims to develop first unit drwan with solid lines only, and the second unit drawn with dashed lines are not planed so far. However, in case the second unit develop next to the first unit, there are major advantages;

- ✓ Supressing initial erection cost using common facilities such as switching yard, transmission line, water facilities, spur line and so on.
- ✓ Effective and practical use of personnel of GENCO IV in cooperation between first ad second units. Easy to educate and keep skilled workers and engineers.
- ✓ Common use of spare parts if the same unit is installed as seond unit.

As mentioned in Chapter 6, it is impossible to plan two units in Lakhra with current status of NTDC's planning. However, there is possibility to connect two units with revision of the plan in future.



Source : JICA Survey Team

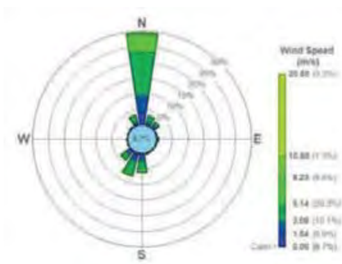
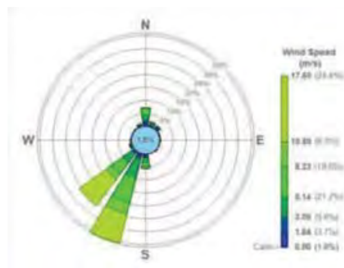
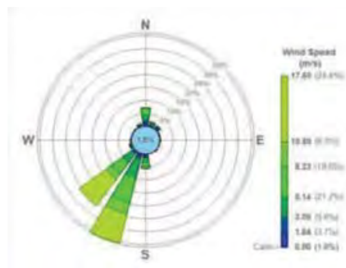
Figure 7.3-3 Plant Layout

(4) Cooling Tower Location

- ✓ The circulation water pipe between the condenser, near the turbine, and the cooling tower is around 5 m in diameter. It is preferred to have a short distance so as to reduce the construction cost.

- ✓ The yearly wind direciton of from 2010 to 2011 at Jamshoro is recorded and analyzed in Figure 7.3-4. Applying the wind direction at Lakhra, 5 months of North to South wind and 7 months of Southwest to Northeast wind, two cooling towers are arranged east to west so that the two plumes do not interfere.

- ✓ For the influence by the plume from the cooling tower, it is not necessary to consider this since the SO_2 is reduced by the FGD as explained in the next clause.

Oct 2010 to Feb 2011	March to June 2011	July to Sept 2011
 Mainly North to South	 Mainly Southwest to Northeast	 Mainly Southwest to Northeast

Source: Environmental Impact Assessment of Jamshoro Power Generation Project, Hagler Bailly Pakistan

Figure 7.3-4 Wind Direction of Jamshoro Area

(5) Considerations for Location of the Cooling Towers

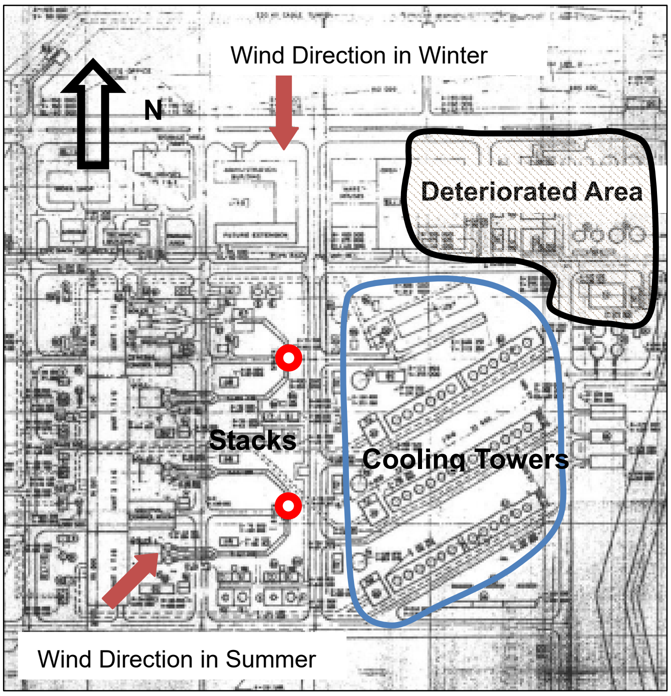
1) Influences of Plume from the Cooling Towers

According to a DOE Document[1], the influences caused by the plume from both mechanical draft and natural draft cooling towers are reported as follows: "a condition peculiar to mechanical draft cooling towers is that, under certain atmospheric conditions, a visible plume forms above the cooling tower. This plume can have deleterious effects (i.e., fogging, icing, corrosion) to nearby infrastructure. In the case of a natural draft (hyperbolic) cooling towers at fossil-fired power plants, there is the potential for sulphuric acid mist formation from the

[1] Electricity Reliability Impacts of a Mandatory Cooling Tower Rule or Existing Steam Generation Units, October 2008, U.S. Department of Energy

comingling of the water vapour and smokestack plumes of SO2."

According to CEO of Lakhra Power Station, the facilities in Jamshoro Power Station located northeast of the mechanical draft cooling tower have been deteriorated in its 25 years of operation. The deterioration may be caused by the above as quoted, "plume can have deleterious effects (i.e., fogging, icing, corrosion) to nearby infrastructure". Furthermore, sulphuric acid might be formed by a mixture of water vapour from the cooling tower and SO_2 from stack, due to high sulphur emission from stack burning 3.5% sulphur content oil without FGD.



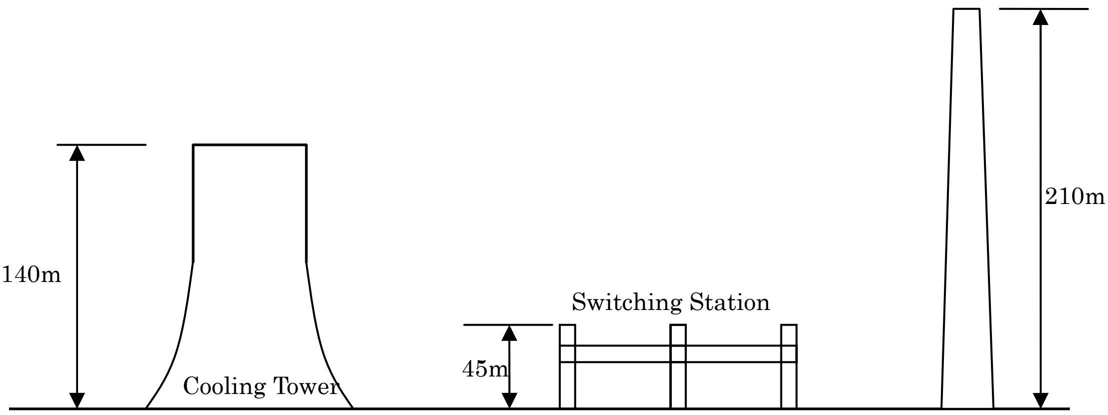
Source: JICA Survey Team

Figure 7.3-5 Deterioration of Facilities in Jamshoro Power Station

Locations of the stacks, cooling towers, and the deteriorated area are shown in Figure 7.3-5. During summer, wind direction is southeast.

2) Natural Draft Cooling Tower

Although there is the description, "In the case of a natural draft (hyperbolic) cooling towers at fossil-fired power plants, there is the potential for sulphuric acid mist formation from comingling of the water vapour and smokestack plumes of SO2", since the emission of SO_2 is enough to be reduced to comply with the world standard, and the height of the natural draft cooling tower to be applied in the plant will be 140 m, and the height of stack will be 210 m, it is not necessary to consider the influence of the plumes from the cooling tower.



Source: JICA Survey Team

Figure 7.3-6 Relative Height of Cooling Tower, Stack and Structure of Switching Station

7.3.4 Mechanical System

(1) Steam Turbine and Auxiliaries

1) General

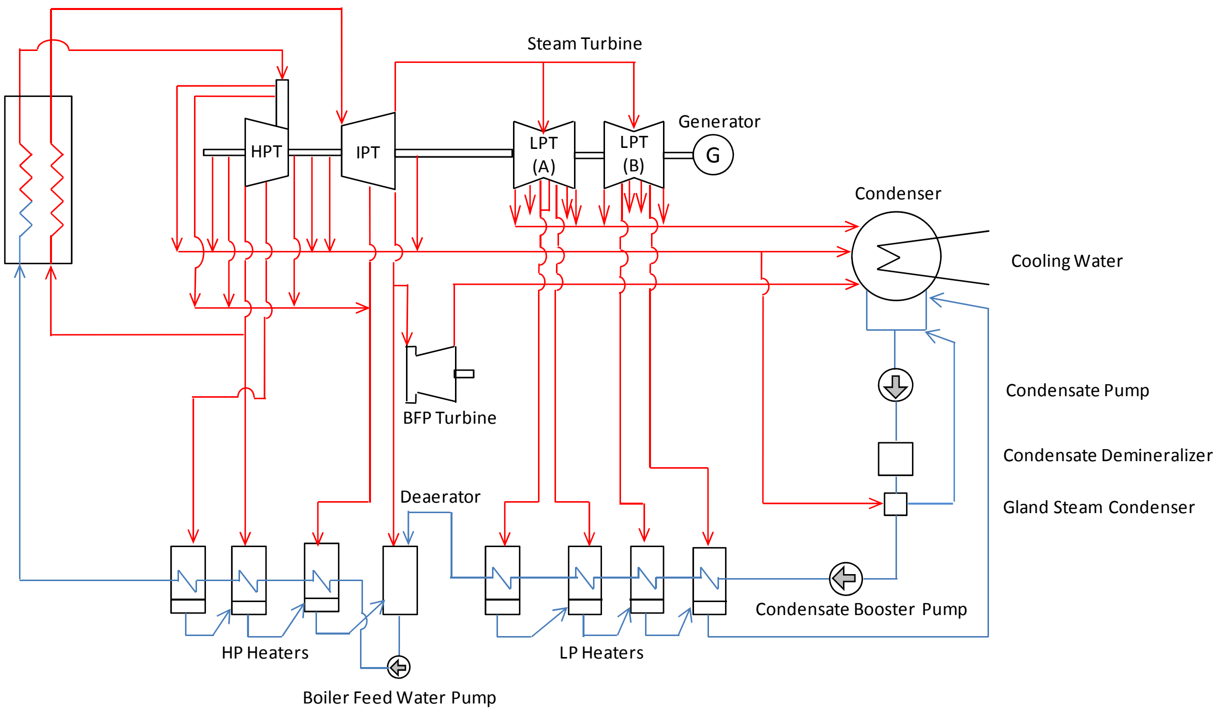
a. Development of the plant turbine

In line with the enhancement of steam conditions and increase in single unit capacity, thermal turbine plants have been developed with large and more complex cycle compositions and systems. The main solutions that have been adopted are the following:

Regenerating and reheating methods have been incorporated into the turbine cycle. Boilers have been converted from natural circulation systems to forced once-through systems. Water treatment has become more stringent. The number of turbine cylinders has increased from two to three, or five in line with the growing size of unit capacity.

Boiler feed pumps (BFPs) have evolved from simple motor systems to steam turbine-driven systems as a result of improved performance and thermal efficiency.

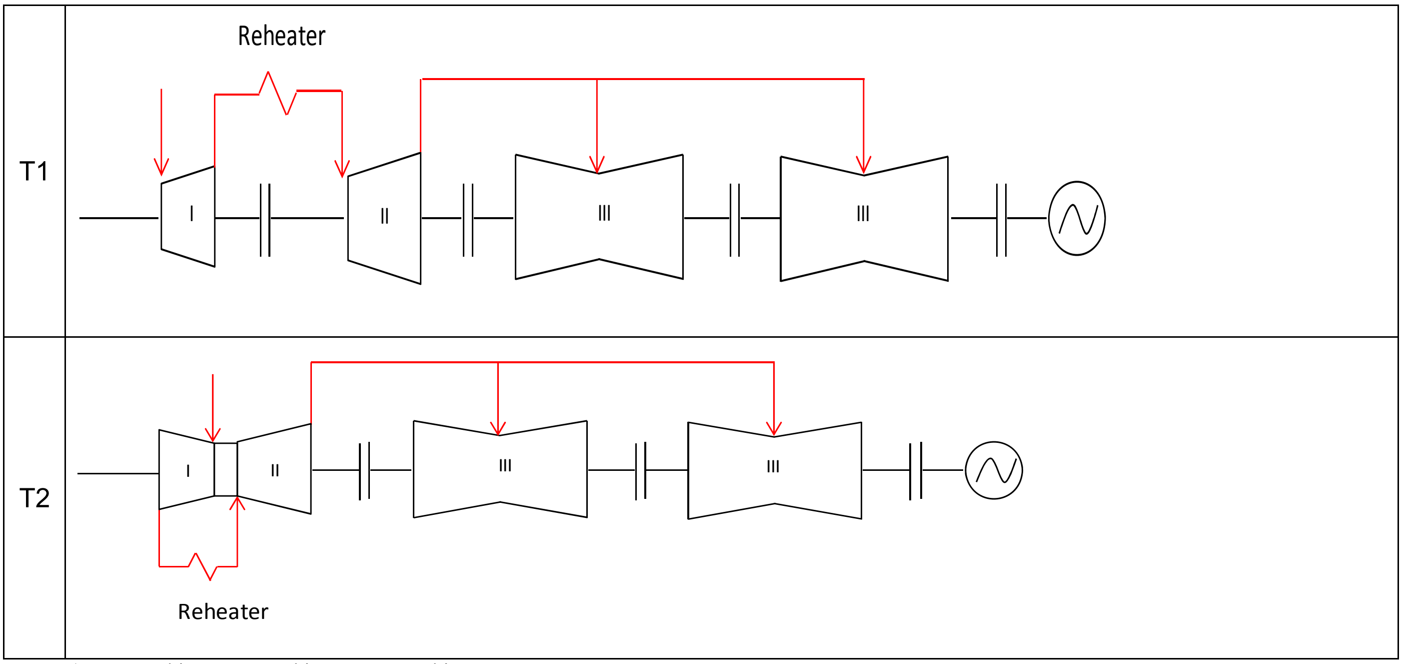
The composition of a large turbine system is illustrated in the following drawings.



Source: JICA Survey Team

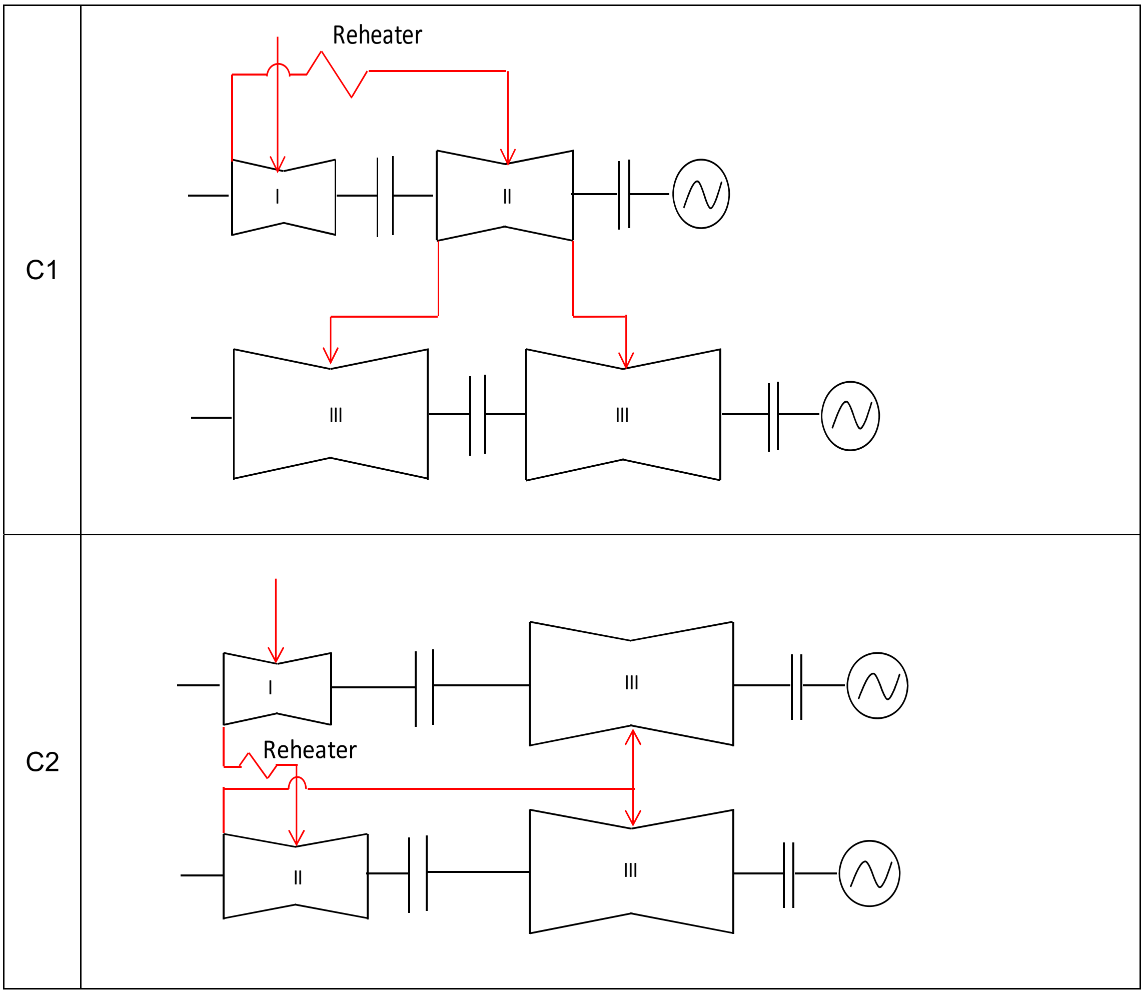
Figure 7.3-7 Main System Diagram of a Large Turbine Plant

A steam turbine model consists of either tandem or cross compound types and high, intermediate and low pressure turbines are combined to comprise units as shown in Figures 7.3-8 and 7.3-9.



NOTE) I: HP Turbine, II: IP Turbine, III: LP Turbine
Source: JICA Survey Team

Figure 7.3-8 Tandem Compound Turbines



NOTE) I: HP Turbine, II: IP Turbine, III: LP Turbine
Source: JICA Survey Team

Figure 7.3-9 Cross Compound Turbines

Both types are adopted over wide output ranges. The comparison of the two types is shown in Table 7.3-1 below.

Table 7.3-1 Comparison of Cross Compound Type and Tandem Compound Type

Item	Tandem Compound Turbine	Cross Compound Turbine
Configuration	One shaft	Two shafts
Rotating speed	3,000 rpm	a) 3,000 rpm + 3,000 rpm or b) 3,000 rpm + 1,500 rpm
Generator	One generator	Two generators 4 poles for 1,500 rpm
Half speed synchronization	Not necessary (Easy operation)	Necessary
Expandability for unit capacity	Base	Easier owing to low speed of LP turbines
Practical accomplishment	Many for 660 MW class	Many for 660 MW class
Price for the same capacity	Base	Higher

Source: JICA Survey Team

In accordance with the above comparison, the cross compound turbines are selected for the highest capacity units. On the other hand, the tandem compound turbines are commonly selected after the development of research for the stability of long shaft turbines.

b. Turbine plant at Lakhra

In a large-scale thermal power unit, the steam turbine is one of the most important equipment. A steam turbine must meet reliability, stability, and economical performance. Therefore, the steam turbine and auxiliary equipment for nominal gross power of 660 MW for the new power plant must have stable design and practically proven through operation in other similar-capacity units. For the Project, the tandem compound type is selected.

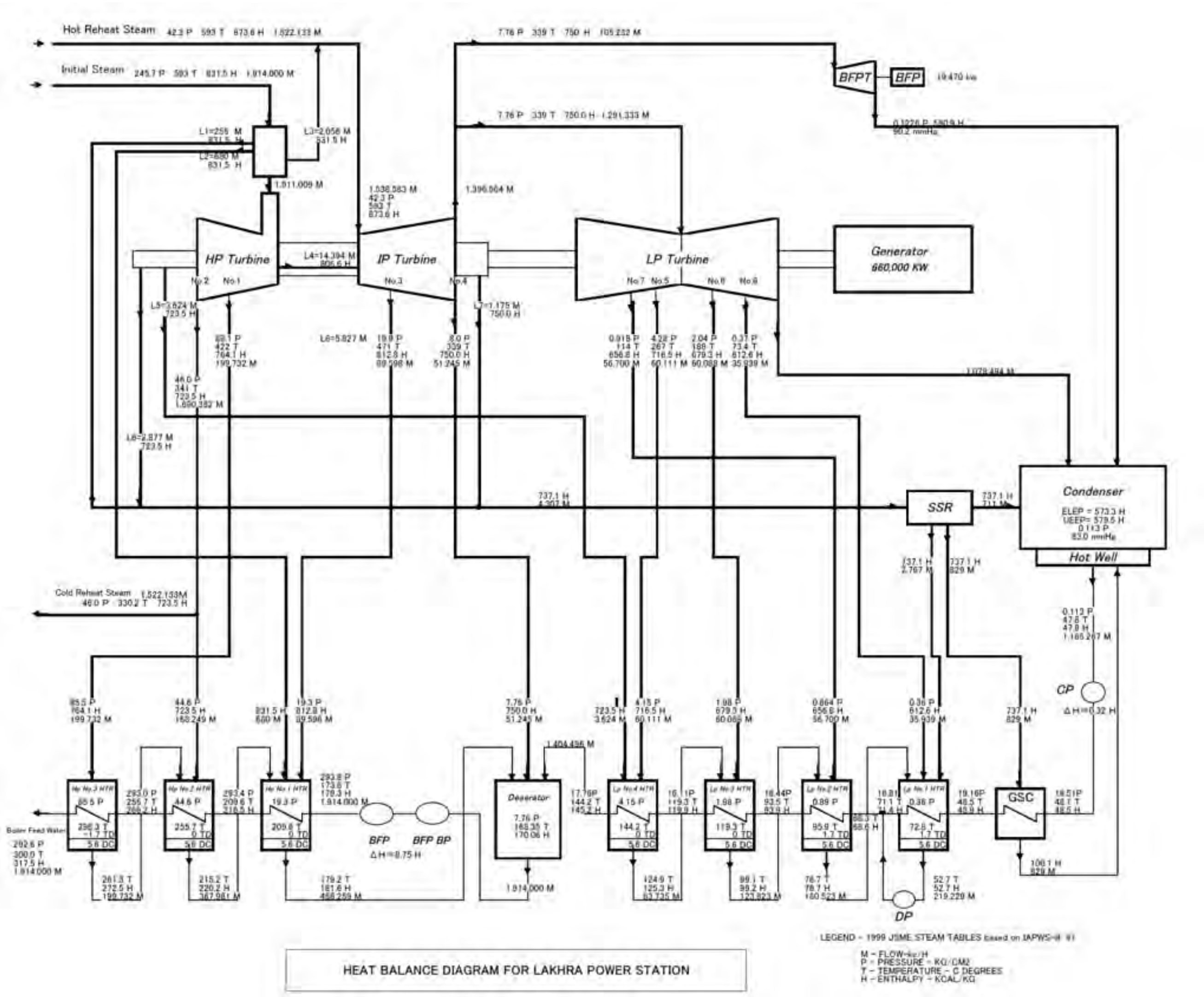
Table 7.3-2 Main Design Specifications for the Turbine Plant

Equipment		Specification
Main Turbine		
Basic Specification	Type	Tandem Compound Condensing Turbine
	Rated speed	3000 rpm
	Main steam pressure	24.1 MPa
	Main steam temperature	593 ^{o}C
	Hot reheat steam pressure	4.2 MPa
	Hot reheat steam temperature	593 ^{o}C
	Main steam flow	1,900 t/h
	Exhaust steam pressure	11.1 kPa abs

Source: JICA Survey Team

c. Heat balance of turbine plant

Schematic diagram of Heat balance is shown in next page.



Source: JICA Survey Team

Figure 7.3-10 Schematic Diagram of Heat Balance

d. Main equipment and systems

In the turbine system, the following main equipment/systems will be provided:

- ✓ Steam turbine and generator
- ✓ Turbine-generator control system
- ✓ Hydraulic oil system
- ✓ Lubricating oil system
- ✓ Gland seal steam system
- ✓ Main steam and hot/cold reheat systems
- ✓ HP bypass and LP bypass systems
- ✓ Extraction steam system and Feedwater drain systems
- ✓ Condenser
- ✓ Condensate system
- ✓ Deaerator
- ✓ Boiler feedwater system
- ✓ Condensate make-up system
- ✓ Cooling water system

2) Main Specifications of the Steam Turbine

a. Cylinder configuration

As the condensing reheat tandem compound has steam extractions, the steam turbine type for this capacity of 660 MW class is very popular and widely used; hence, this type is adopted for the plant.

For this class of steam turbine, there are two common types of tandem compound turbine cylinder arrangements depending on the turbine manufacturer:

- ✓ Separate HP, intermediate pressure (IP), and LP cylinders, (T1 in Figure 7.3-7) or
- ✓ Combined HP and IP cylinders and separate LP cylinder (T2 in Figure 7.3-7).

In this technical design, the second one is selected for the following advantages over the other: more compact arrangement, less number of bearings, simpler maintenance, and higher operational reliability.

The following features must be met:

- ✓ Ease in handling, assembling, disassembling, and maintenance;
- ✓ Minimum thrust load; and
- ✓ Sensibly controlled thermal expansion between cylinder pedestals.

b. Turbine rotors

The critical speeds of HP, IP, LP, and generator rotors are normally not the same, as a result while coupled (forming a single turbine shaft), the turbine-generator system will have several critical speeds. The system therefore should be designed with:

- ✓ minimum number of critical speeds
- ✓ a safety speed range of at least +/-10% rated speed

c. Turbine blades

There are many types of turbine blades. Each turbine manufacturer has developed its own design of turbine blades. Nevertheless, the following are several common requirements for blades of large-capacity steam turbines:

- ✓ High-quality material used, proper manufacturing and processing procedure, good aero-dynamic property
- ✓ Stable and high efficiency operation
- ✓ Ease in assembling/disassembling
- ✓ Designed and manufactured to ensure high reliability, accurate geometrical and aero-dynamical profiles, and having capability of avoiding damages due to vibration at any turbine speed

d. Journal bearings

All the bearings shall be of a pressurized lubricating type having continuous lube oil supply and discharged with two functions: lubrication and cooling.

e. Thrust bearing

The function of the thrust bearing is to prevent the turbine shaft from moving in both directions, i.e., forward and backward. The thrust bearing shall be capable of handling maximum thrust load at any operation condition.

f. Turbine steam valves

Steam valves come together with the turbine set. The following are major requirements for turbine steam valves:

Table 7.3-3 Major Requirement of Turbine Steam Valves

Valve	Main Requirement
Main stop valves	Absolutely tight when closed, with quick response and high closing speed
Main control valves	High responsiveness and accuracy
Reheat stop valves	Absolutely tight when closed, with quick response and high closing speed
Reheat control (intercept) valves	High responsiveness and accuracy

Source: JICA Survey Team

g. Turbine bypass system

The single reheat steam turbine equipped for the Project is provided with a bypass system which comprises of:

- ✓ HP bypass system: connecting main steam pipe, upstream of main stop valve, to HP turbine exhaust piping
- ✓ LP bypass system: connecting the hot reheat pipe, upstream of reheat stop valve, directly to main condenser

The turbine bypass system allows:

(i) To shorten start-up time

- ✓ The system flexibly conducts most of the unit start-up modes (cold start, warm start, hot and very hot starts) and shortens the time required to start the turbine with rapidly increasing main steam and reheat steam temperatures to desirable values prior to admission to the turbine.

(ii) To stabilize combustion in the boiler at low load

- ✓ The system accepts flexible load variations, especially at low load, without much effect on boiler operation.

(iii) House load operation capability

- ✓ In the event of total load rejection and disconnection from the external network, the unit could operate safely at the “House Load”, feeding only the unit auxiliary services

In this operation mode, the boiler will be operated with reduced fuel in a limited rate to minimum load. On the other hand, the turbine-generator load will be suddenly decreased to the house load demand, and any excessive steam generated will be bypassed to the main condenser.

- ✓ The heat capacity of the bypass system for this purpose should be at least 70% steam flow at the beginning of the load rejection such that the main steam pressure must not exceed the design pressure of the main steam system. (Practical accomplishment is necessary for decreasing the capacity and 70% shall be the minimum.)
- ✓ The HP bypass spray will be supplied from the outlet of the boiler feedwater pumps (BFPs) and the LP bypass spray will be supplied from the outlet of the condensate pumps (CPs).
- ✓ Both BFPs and CPs shall have enough capacity to supply spray water.

3) Turbine Auxiliary Equipment/Systems

a. Lubricating oil system

The steam turbine and generator shall be accompanied with a lubricating oil system. The system's main functions are:

- to continuously supply lubricating oil with proper temperature and pressure to all journal bearings of the turbine and generator, and to thrust bearing;
- to supply lubricating oil to the turbine's turning gear mechanism; and
- to supply to the generator hydrogen seal oil system, in case this arrangement is adopted.

Because of the very important role of this system over the turbine-generator operation, it is required that the system should be designed with a triple-redundant arrangement of lubricated oil pumps which are main oil pumps, stand-by pumps and emergency oil pumps.

b. Jacking oil system

In turbine design, one jacking oil system will be provided to assist turbine rotor turning for turning gear operation and maintenance purposes.

c. Control oil system

Having incorporated the turbine control system in order to control all the turbine operation modes via the main steam control valves and intercept valves, the control oil system must be designed to meet the following requirements:

- Stability in maintaining hydraulic oil pressure in the system including the situation that several turbine valves operate at the same time (at a turbine trip for instance).
- Hydraulic oil shall be a nonflammable type, has good quality, and under constant high pressure conditions.

d. Turning gear device

This is a turbine component having the following functions:

- Slowly rotates the turbine rotor at a slow speed prior to steam admission to the turbine when starting up and it shall be automatically disengaged at a set turbine shaft speed.
- Slowly rotates the turbine rotor automatically at a slow speed following rundown period after a turbine trip.

e. Gland steam system

The gland steam system is incorporated with turbine sealing packing to ensure the tightness at the location where the rotor shafts come out of the casings.

A gland seal regulator automatically controls the pressure to the gland seals over the entire load range. The gland exhausts are condensed in the gland steam condenser and the seal system when the regulator is out of order.

f. Turbine vent and drain system

A comprehensive drain and vent system shall be provided with the steam turbine. All the drained clean condensate shall be routed directly back to the condenser or via a flash tank, for water saving purposes.

g. Turbine control and monitoring system

The turbine control system shall be of state-of-the-art design having the following features:

- The system should be a modern digital electro-hydraulic control (D-EHC).
- The system should record reliability in other units which are similar in capacity and configuration.

Necessary control and protection philosophies are:

✓ Clear separation between two basic functions: control and protection/monitoring.

✓ There should be at least two probes for the independent processors responsible for the important parameters so that any single failure in control tasks shall not cause a turbine trip.

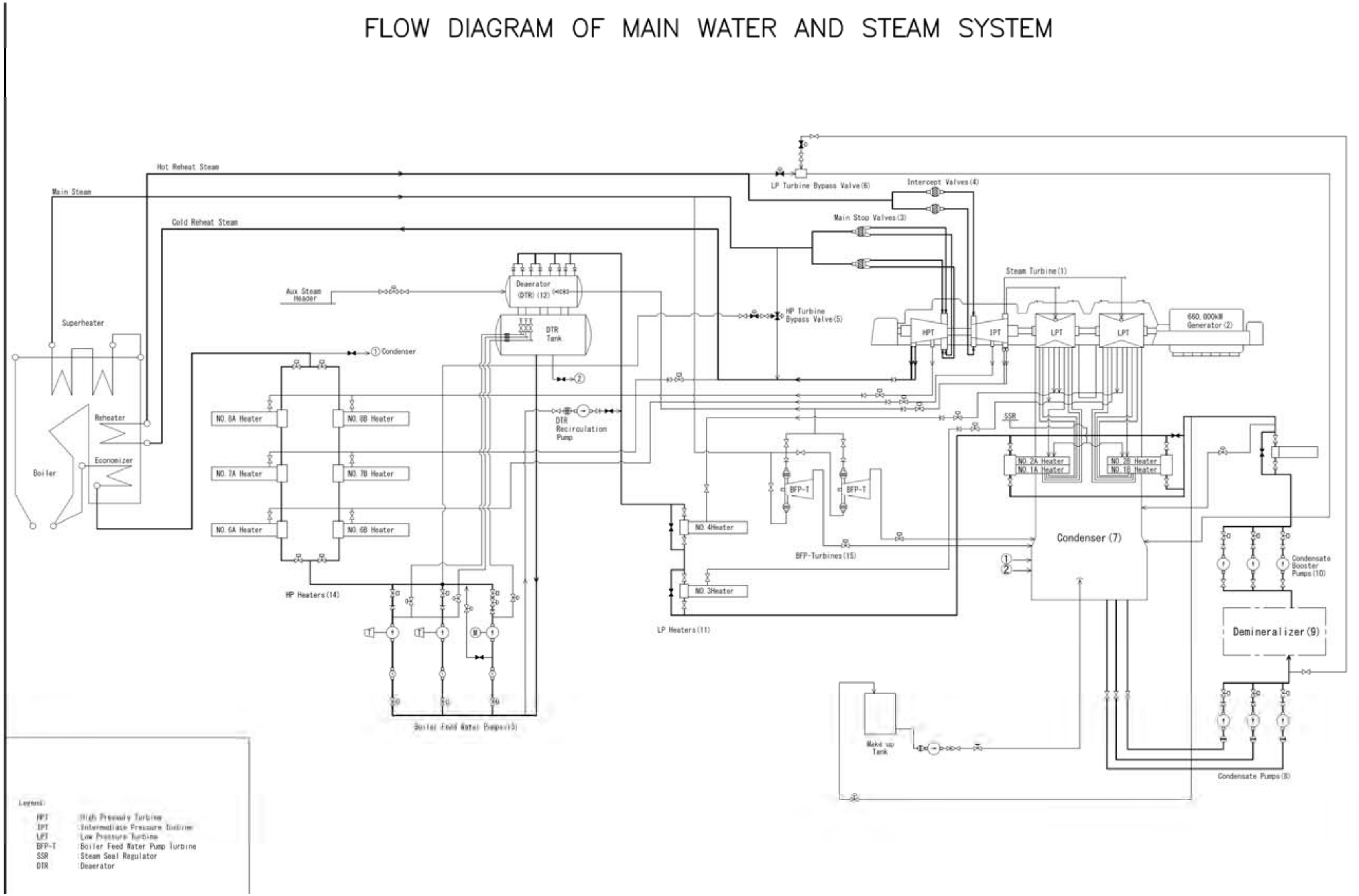
✓ Automatic turbine speed control over entire speed range (from turning gear speed to rated speed) in all operation modes.

✓ Automatic turbine load control and load change rate control over entire load range in coordination with boiler control functions.

4) Turbine Plant Auxiliaries

a. General

Flow Diagram of Main Water and Steam System is shown in Figure 7.3-11.



Source: JICA Survey Team

Figure 7.3-11 Flow Diagram of Main Water and Steam System

The nomenclature of the equipment numbers in the Figure 7.3-4 is as follows

Table 7.3-4 List of Facilities in the Flow Diagram of Main Water and Steam System

No	Name of Equipment	Reference clause
1	Steam turbine	7.3.4 (2) 1)
2	Generator	7.3.5 (1)
3	Turbine main stop valves	7.3.4 (2) 2) f
4	Turbine intercept valves	7.3.4 (2) 2) f
5	HP turbine bypass valve	7.3.4 (2) 2) g
6	LP turbine bypass valve	7.3.4 (2) 2) g
7	Condenser	7.3.4 (2) 4) b
8	Condensate pumps	7.3.4 (2) 4) c
9	Demineralizer	7.3.4 (2) 4) d
10	Condensate booster pumps	7.3.4 (2) 4) c
11	LP heaters	7.3.4 (2) 4) f
12	Deaerator	7.3.4 (2) 4) g
13	Boiler feedwater pumps	7.3.4 (2) 4) h
14	HP heaters	7.3.4 (2) 4) i
15	BFP turbines	7.3.4 (2) 4) h

Source: JICA Survey Team

Main specifications of turbine auxiliaries are summarized in the following Table 7.3-5.

Table 7.3-5 Main Specifications of Turbine Auxiliaries

Equipment		Specification
Condensate System		
Condenser	Type	Surface type, divided water box, single pass type
	Tube Material	Cu-Ni or stainless steel
Condensate Pumps	Type	Vertical pit type
	Capacity	50% 3 sets
Condensate Booster Pumps	Type	Horizontal centrifugal pump
	Capacity	50% 3 sets
Condensate Polishing Plant	Type	Mixed bed type
	Capacity	50% 3 sets
Condenser Vacuum Pumps	Type	Water sealing type
	Capacity	100% 2 sets
Feedwater Heating System		
Feedwater Heaters	Type	Horizontal U-tube type
	Stage	LP: 4 satges, HP: 3 stages
Deaerator	Type	Horizontal tray and spray type
	Capacity	100% 1 set
Feedwater Pump System		
Feedwater Pumps	Type	Turbine driven multi stage pump
	Capacity	50% 2 sets
Startup Feedwater Pump	Type	Motor driven centrifugal pump
	Capacity	25% 1 set
Feedwater Booster	Type	Horizontal centrifugal type

Pumps	Capacity	50% 2 sets & 25% 1 set
Cooling Water System		
Circulating Water Pumps	Type	Vertical type
	Capacity	50% 2 sets
Closed Cooling Water Pumps	Type	Horizontal centrifugal type
	Capacity	50% 2 sets

Source: JICA Survey Team

b. Main condenser

General design requirements

The condensing system condenses the exhaust steam from the turbine and generates a vacuum condition at the turbine outlet corresponding to cooling water temperature.

The following are the main requirements on condenser design:

- Surface type, cooling water cooled by the cooling tower.
- The condenser shall be installed with split water boxes in such a way that one half of the tube bank may be taken out of service under loading conditions of the turbine. Under such conditions, the unit must be capable of carrying at least 60% of turbine's maximum continuous rating.
- The condenser shall have provisions to receive the LP bypass steam from the hot reheat line after pressure reduction and de-superheating from the LP bypass station without undue noise, vibration and erosion of any parts.
- The condenser shall be able to receive the exhaust steam from the boiler feed pump turbine, low pressure heater drains, both in normal operation or emergency drains, deaerator overflow, other drains, and make-up water.

Sample of main specifications

The sample specifications of the condenser are listed below.

Table 7.3-6 Specifications of Condenser

Items	Specifications
Type	Surface condensing, divided water box, single pass type
Condenser vacuum	11.1 kPa abs. (83 mmHg abs.)
Condensing capacity	60,000 t/h
Source of cooling water	Cooling water from cooling tower
Cooling water inlet temp	34.6 °C
Cooling water temp. rise	45.6 °C
Tube cleanliness factor	80-90%
Water velocity in tubes	2.2 m/s

Source JICA Survey Team

c. Condensate pumps

Three 50% duty capacity condensate pumps are to be provided. Each pump should be capable of transferring at least 55% of the sum of condensed steam, any drains and make-up water from the condenser at the maximum vacuum are obtainable under the turbine capability condition. Three 50% duty capacity condensate booster pumps will be arranged considering the proper system configuration.

d. Condensate polishing plant (CPP) (Demineralizer)

During plant operation, condensation is contaminated due to several reasons:

(i) Impurities under ionic dissolved form due to chemical and mechanical erosion of the metal material of equipment and piping.

(ii) Condenser tube leaks and river water penetrates into the system.

(iii) Air ingress into the system.

The plant with a once–through boiler shall be provided with mixed bed CPP arranged at the ground floor of the turbine hall. It will consist of three parallel ion exchanger trains; two is in operation while the third is on standby or regenerating the resin using hydrochloric acid and caustic soda. The system treatment capacity should be equal to 100% of the total condensate flow.

The wastewaters from the regeneration process will be piped to the waste collection basin for further treatment and neutralization and then used in ash sluicing to the disposal pond.

e. Condenser auxiliaries

<u>Condensate make-up system</u>

The system should have the following functions:

- ✓ making-up condensate to the plant steam-water cycle when required
- ✓ withdrawing condensate from the cycle in case of excess
- ✓ filling up the condenser before starting the unit

<u>Condenser air removal system</u>

The condenser air removal system will consist of two 100% mechanical vacuum pumps, one of which will hold the vacuum in the condenser during operation. They are of the water ring, electric motor-driven type and equipped with necessary piping, valves, and controls to operate fully automatically. A mechanical hogging pump will be provided to evacuate air from the condenser shells during unit startup. Each condenser is arranged with a DC-operated vacuum breaker valve, which will be used when rapid vacuum breaking becomes necessary and the unit is fully shut down.

Condenser on load tube cleaning system

The sponge, rubber ball type condenser on the load tube cleaning system should be provided. The system will operate continuously and automatically with tube cleanliness factor of at least 80%. A backwash arrangement for the ball collecting strainer should be provided. An automatic ball withdrawal will be done on the strainer prior to backwashing.

f. Low pressure feedwater heaters

Condensate in the condenser hot well is pumped by the condensate pumps. The condensate is purified through the demineralized system, boosted up by condensate booster pumps and transferred to the deaerator through the gland steam condenser and the LP feedwater heaters. The flow required to maintain the deaerator storage tank level is controlled by modulating control valves installed upstream of the LP feedwater heaters. Drains of each LP feedwater heater is cascaded to the next lower feedwater heater and finally to the condenser.

g. Deaerator

Functions of the deaerator are as follows:

- ✓ Removing non-condensable gases dissolved in condensate to a maximum oxygen content of 7 ppb at its outlet
- ✓ Functioning as a feedwater heater of mixing type
- ✓ Condensate storage tank for boiler feedwater pumps
- ✓ Receiving condensate drains from HP heaters

The design requirement for the storage tank should have a storage capacity adequate to at least 8 minutes of feedwater flow at maximum guaranteed load of the unit.

Especially for once-through boilers, LP clean up line is adopted from the deaerator bottom to the condenser. At the beginning of the plant start-up, LP feedwater should be cleaned up under water quality control system.

h. Boiler feedwater pumps and turbines

The boiler feedwater pumps (BFPs) are one of the most important elements in the steam-water cycle of a plant. The stable and reliable operation of the boiler feedwater pumps plays a vital role in the whole system performance.

Boiler feedwater pumps take condensate from deaerator storage tanks and pump it to the inlet header of the boiler's economizer through a set of feedwater control systems and feedwater heaters. The BFP configurations are two 50% capacity pumps driven by BFP turbines and one 25% motor-driven pump.

Features of the feedwater system are the following:

- ✓ High flexibility in operation.
- ✓ Designed and constructed suitably to continuously operate in high temperature and high pressure conditions.
- ✓ Stable operation over entire load range, from no load up to maximum guaranteed load.
- ✓ Quick response to load change demand.
- ✓ The boiler feedwater pump shall comprise of six or seven stages: booster pump and main pump in series, of which the booster pump suction is connected to a deaerator storage tank. This arrangement helps increase pressure of the main pump suction, decreasing the possibility of eroding the main pump impeller thus improving operation stability of the pump system.
- ✓ One motor operated pump is equipped in parallel to the two main turbine driven pumps. This pump supply feedwater during plant start-up and at low load with a feedwater flow control valve.

<u>Boiler feedwater pump turbine</u>

Two boiler feed pumps are connected with steam turbine drive called BFP turbine or BFP-T, while in case of small size of power plant all boiler feed pumps are driven by motors.

Comparison between turbine operated boiler feedwater pump (T-BFP) and motor operated boiler feedwater pump (M-BFP) is shown below.

Table 7.3-7 Comparison between T-BFP and M-BFP

Item	M-BFP	T-BFP
Driver	Motor	Steam turbine
Capital cost	Base	Higher
Operation cost	Base	Lower (Higher plant net efficiency)
Operation by operator	Base	Not easy but usually by automation
Plant operation	Base	Much adaptive for sliding pressure operation
Control responsibility	Base	Quick response
Other	Large inrush current	None

Source: JICA Survey Team

In case of a large thermal power plant more than 300MW, T-PFP is used taking advantage of higher efficiency and plant adaptive control feature. Selection of turbine driven boiler feedwater pumps are natural for this project.

The turbine and feedwater pump should be capable of operating continuously from minimum speed to the speed of rated load condition.

The BFP-Ts usually receive extraction steam from the outlet of main turbine IP cylinder and at low load they receive high pressure main steam. The turbine exhaust is connected to the surface condenser.

The turbines are equipped with horizontally split casing, centerline supported with integral dual admission steam chest with separate high and low pressure control valves, high and low pressure stop valves, lubricating oil systems and remotely operated turning systems.

In case of the BFP-T, feedwater flow demand signal is given to the flow control device of the BFP-turbine, namely LP or HP steam control valves. They are controlled by use of digital governing control system.

i. High pressure feedwater heaters

Three stages of HP feedwater heaters are installed between the boiler feedwater pumps and the boiler economizer.

Drains for each HP feedwater heater cascade onto the next lower feedwater heater and finally to the deaerator. The HP clean up line should be adopted from the outlet of the top heaters to the condenser. After the LP feed water clean-up at the plant start-up, HP feedwater's quality should be controlled under the administrative level.

j. Optimum number of feedwater heaters

The number of feedwater heaters (no. of turbine extraction stages) is determined based on the techno-economic optimization study.

The more extraction stages, i.e., the more number of heaters, the better turbine heat rate, while the initial investment cost becomes more expensive with a higher maintenance cost.

For a plant of this size, the number of extraction stages is generally considered to be 7 or 8 including deaerator. Recently, in other new thermal power plants having the same unit size as this plant, the techno-economic studies have shown that the configuration of 4 LP heaters – deaeator – 3 HP heaters is the most suitable for 600-660 MW steam turbine cycle. Therefore, this management is adopted in this technical design.

k. Condenser cooling system

Relation between condenser cooling, vacuum, and plant efficiency

Steam turbines extract power from steam as it passes from high pressure and high temperature conditions at the turbine inlet to low pressure and lower temperature conditions at the turbine outlet. Steam exiting the turbine goes to the condenser, where it is condensed into water.

The condensation process creates the low pressure conditions at the turbine outlet. Lower exhaust pressure results in greater generation of energy that is available to drive the turbine, which in turn increases the overall efficiency of the system.

The exhaust pressure of the steam turbine (or vacuum) is a function of the temperature maintained at the condensing surface which is dependent on the design and operating conditions within the condensing system (e.g., surface area, materials, cooling fluid flow rate) and especially the temperature of the cooling water used to absorb heat and reject it from the condenser.

Condenser cooling

The use of a different cooling system can affect the temperature maintained at the steam condensing surface. This difference can result in a change in the efficiency of the power plant. The cooling systems are different between the inland site and the coastal site as mentioned in Chapter 3.4.3. In addition to that the use of dry cooling systems has gradually expanded over the years at mainly cool or cold areas in response to the withdrawal and discharge of large volumes of cooling water.

Cooling tower system

The function of any cooling technology is to transfer waste heat from the turbine to the environment as efficiently as possible. In a wet cooling system, heat rejection from a cooling tower is primarily due to the evaporation, or latent heat, of water into the surrounding air and is responsible for approximately 80% of the tower's cooling capacity. Sensible heat transfer, which results from the direct contact between warm water and cooler surroundings, provides the remaining 20%.

Because wet cooling towers rely primarily on evaporation, their overall efficiency is governed by the differential between the circulating water temperature in the tower and the wet bulb temperature of the ambient atmosphere. The wet bulb temperature measures the ambient air temperature (also referred to as the "dry bulb" temperature) and the relative humidity of the surrounding atmosphere. By accounting for the saturation level of the atmosphere, the wet bulb temperature represents the additional cooling capacity that can be exploited by wet cooling towers through evaporation. Thus, wet cooling towers function most efficiently in environments where the relative humidity is low and the surrounding atmosphere can more rapidly accommodate evaporative heat loss.

The design of wet cooling towers is based on the "approach" temperature, which is the difference between the temperature of the water exiting the cooling tower and the ambient wet bulb temperature. The approach temperature is critical to estimating the overall size and cost of the cooling tower, and is fixed prior to design based on the ambient conditions and the desired cooling capacity.

In general, as the wet bulb temperature increases, the economically achievable approach temperature will decrease. An industry practice is to start with an approach temperature of 4 – 5 ^{o}C. The cooling tower (CT) design of this Project is shown in Table 7.3-8.

Table 7.3-8 Cooling Tower Specifications

Items	Specification
Design Wet Bulb Temperature	28.6 ^{o}C
Cooling Tower Approach	6 ^{o}C
Cooling Tower Range (Hot Water Temperature to CT – Cold Water Temperature from CT)	11 ^{o}C
Circulating Water Flow	About 60,000 m^3/h
Blow down	About 300 m^3/h
Make-up Water to the System	About 1,650 m^3/h

Source JICA SurveyTeam

The water characteristics are shown in Table 7.3-9

Table 7.3-9 Circulating Water Chemistry

Parameter	Makeup Water	Circulating Water
Temperature, ºC	35	35.6 - 45.6
pH	7 - 8.5	7 - 8.5
Conductivity, µmhos/cm	350 - 500	1,500 - 2,200
Suspended solids, mg/l	15 - 50	40 - 90
Total hardness, mg/l as CaCO3	80 - 150	250 - 500
Total dissolved solids, mg/l	200 - 500	1,000 - 1,600

Source: JICA Survey Team

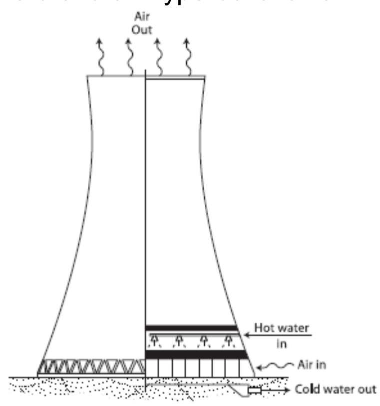
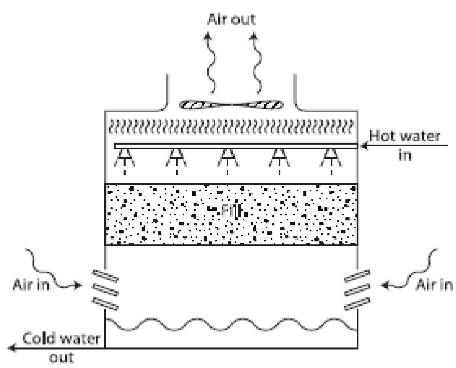
In order to maintain chemical levels as indicated above, water from the cooling tower basin will be continuously removed through blowdown and dumped into the wastewater collection basin for reuse in various plant services, such as ash handling and coal dust suppression.

In addition to blowdown, periodic chlorination by injection of sodium hypochlorite through diffusers will be executed. The ph control will be done by injection of sulfuric acid into the CT. The chemical dosage for the safe operation is monitored and controlled by the local control system.

<u>Two types of wet cooling towers</u>

There are two types of wet cooling tower systems for large thermal power stations. One is the natural draft type and another is the mechanical draft type. The mechanical draft type is separated into the induced type and the forced type, but forced type is not applied to large flow. The characteristics of the natural draft type and mechanical induced draft type are shown in Table 7.3-10. Due to less operating cost and trouble-free maintenance, the natural draft type is recommended for the large-scale power plant at an inland site. In case water supply is not sufficient, the dry cooling system may be applied. But if the dry bulb temperature is high, the turbine output will be restricted and plant efficiency will be decreased considerably. In addition to that, there are few installation and operation records of high-exhausting pressure turbines in large capacities. The dry cooling system is not recommended for the Project.

Table 7.3-10 Comparison of Two Types of Cooling Towers

Item	Natural Draft Type	Mechanical Draft Type
Typical sketch	Natural draft hyperbolic tower 	Induced draft tower 
Principle	Stack effect increases with height	Induced draft by fan
Application	High heat loads and large water flow Common in large power plant	Common in industrial use
Operation cost	Base <US 10 $/kW>	High (Fan motor load) <US 10$/kW+ α
Maintenance cost	Base <US 7 $/kW>	High (Fan and motor maintenance) <US 7 $/kW)
Capital cost	High (Large tower size) <US 44 $/kW>	Low <US 32 $/kW>
Operation limit	————	Fan is more susceptible to vibration and corrosion
Temperature control	Cooling water temperature control is difficult	Temperature control is better
Seismic condition	To be quakeproof	Better
Noise	Base	Noise protection required

Source: JICA Survey Team

Having less operating cost and trouble-free maintenance, the natural draft type is recommended for a large scale power plant located at an inland site.

The term "cooling towers" usually calls to mind the tall, hyperbolic shape of a natural draft cooling tower. These towers rely on the naturally-occurring chimney effect that results from the temperature difference between warm, moist air at the top of the tower and cooler air outside.

- ✓ Overall tower height is 140 m or more.
- ✓ Base diameter is about 110 m.
- ✓ Hyperbolic concrete shell.
- ✓ Filled with material made of PVC or treated wood in the interior.

Circulating Water Pumps

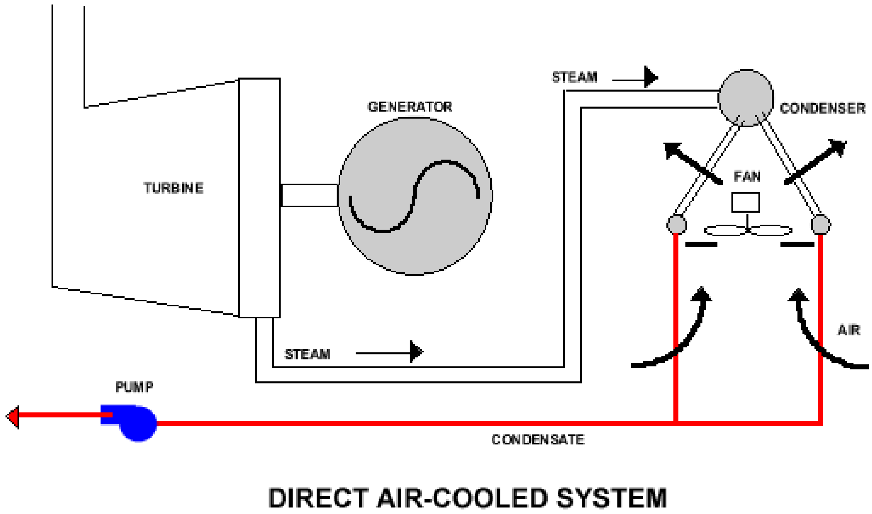
Water cooled by the cooling tower will be collected in the cooling tower concrete basin, which will have an extension that serves as the pumps' intake structure. For the natural draft hyperbolic tower, a common intake structure for all pumps will be provided. There will be two 50% capacity vertical wet pit-type circulating water pumps. Their discharge head will be 30 m of water column, necessary to overcome the pressure drop through the condenser, piping system and to raise the water to the elevation required for water distribution.

The pump pit will be designed to be deep enough so that the water level in the pit satisfies the pump's required NPSH (net positive suction head). In order to reduce the required NPSH, the pumps will be operated at a relatively low speed not to exceed 500 rpm, and will be designed with a first stage that requires a low suction head. Each circulating water pump will be equipped with an automatically-controlled, motor-operated butterfly discharge valve that will be fully closed when the pump is stopped and fully opened during pump operation.

Dry air cooled system

Dry air cooled system is so named because the removal of heat from the steam cycle is accomplished through sensible heat transfer (convection and radiation) rather than through latent heat transfer (evaporation) that is characteristic of wet cooling systems. By relying solely on sensible heat transfer, dry air cooled systems eliminate the need for a continuous supply of cooling water to the condenser, thus reducing many of the environmental concerns associated with once through or wet cooling systems—such as adverse impact on aquatic ecosystems, consumptive use of water resources, and plume or drift emissions.

The use of dry air cooled system at steam electric power plants began largely as an alternative to once-through or wet cooling systems in areas where water resources were limited, but their application has gradually expanded over the years at mainly cool or cold areas in response to the withdrawal and discharge of large volumes of cooling water.



Source: Cost/Performance Comparisons of Alternative Cooling Systems（by J.S. Maulbetsch and other, CE/C/EPRI Advanced Cooling strategies/Technologies Conference, Sacramento, California, June 1-2, 2005)

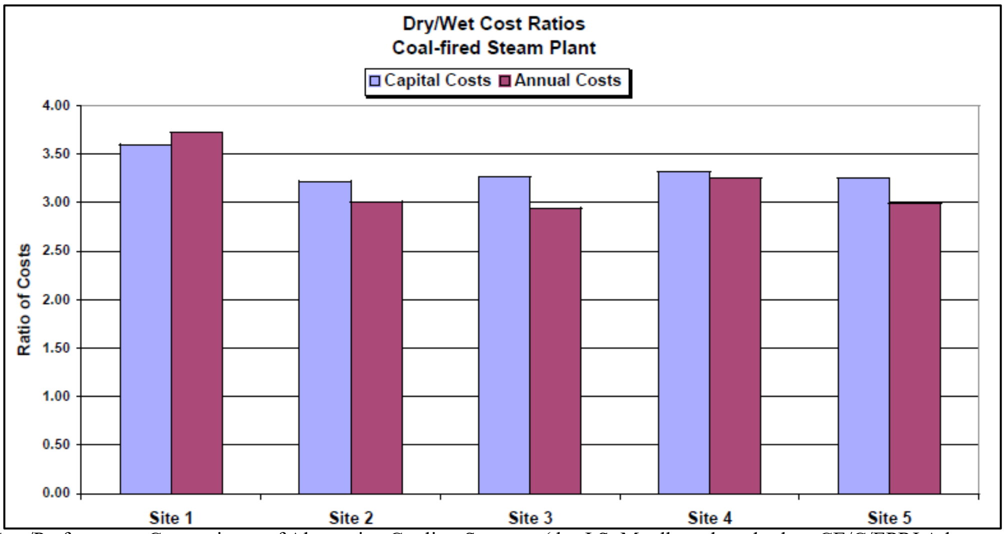
Figure 7.3-12 Direct Air Cooled Condenser System

Comparison between Wet cooling and Dry air cooled system is shown in Table 7.3-11.

Table7.3-11 Comparison between Wet cooling and Dry air cooled system

Items	Wet cooling system	Dry air cooled system	Reference
Heat Removal by	Water evaporation	Air convection and radiation	
Plant Efficiency	Base	Lower (about2%)	Ref. A
Turbine Back Pressure	Base	Higher (Cause of low efficiency)	
Cost (Capital)	Base (1.0; <US 44$/kW>)	Higher (3.0-3.5)	Ref. A (Fig. b)
Cost (Operation)	Base (1.0; <US 17 $/kW>)	Higher (3.0-3.5)	Ref. A (Fig. b)
Auxiliary Power	Base	Larger (more fans)	
Water consumption	Moderate amount	Less	
Maintenance	Mechanical type: Fans Natural type: No motor	Much more Fans	
Wind Effect	Base	Large	
Actual sites	Cool to Hot area	Cold to Cool area	

Source: Prepared by JICA Survey Team based on "Cost/Performance Comparisons of Alternative Cooling Systems（by J.S. Maulbetsch and other, CE/C/EPRI Advanced Cooling strategies/Technologies Conference, Sacramento, California, June 1-2, 2005)"



Source: Cost/Performance Comparisons of Alternative Cooling Systems (by J.S. Maulbetsch and other, CE/C/EPRI Advanced Cooling strategies/Technologies Conference, Sacramento, California, June 1-2, 2005)

Figure 7.3-13 Dry/wet Cost Ratios

The characteristics of dry condenser are the higher capital cost and higher operation cost in spite of one merit of low volume of cooling water consumption.

In addition to that, in case of hot area the steam turbine would be a special high exhaust pressure LP turbine which would not be commonly designed or manufactured. As a conclusion of this clause, dry condenser system is not recommended.

I. Analytical Study on Cooling Tower System in Lakhra

Natural draft cooling tower system in Lakhra and Dry air cooled system near Karachi are analytically investigated and the effect of Wet bulb temperature change and dry bulb temperature change are evaluated respectively for power output and condenser vacuum in detail.

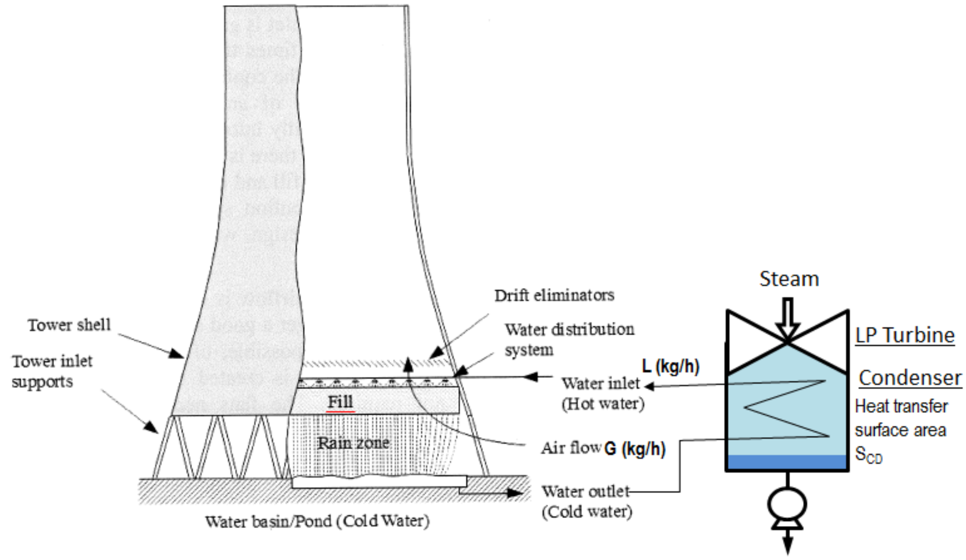
Study of natural draft cooling tower system in Lakhra

Base conditions for cooling tower and condenser system are listed in table 7.3-12, and schematic diagram is shown in figure 7.3-14.

Table 7.3-12 Base Conditions for Cooling Tower and Condenser System

Parameters	Data	Notes
System configuration		Figure 7.a
Power output	660MW	Gross output
Wet bulb Air Temperature	28.6 °C	Dry bulb temp: 41.5 °C & Relative humidity: 39% (From weather report data)
Turbine exhaust Vacuum	83mmHga	
Cooling Tower Diameter	110m	
Cooling Tower Height	140m	
Condenser surface area	37,200m2	
Additional cases for wet bulb temperatures		28.6 (+3, +6, -3, -6) °C

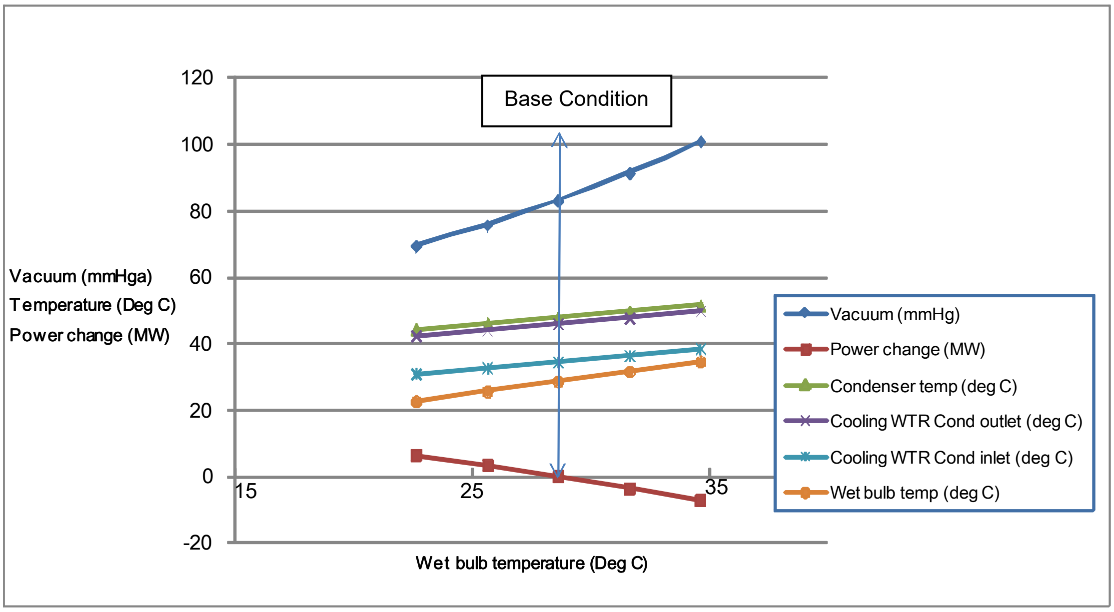
Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.3-14 Schematic Diagram of Cooling Water System

Figure 7.3-15 shows the condenser data in accordance with the wet bulb temperature change.



Source: JICA Survey Team

Figure 7.3-15 Cooling System Data Corresponding to the Wet Bulb Temperature

Essential result of the output is shown in table 7.3-13.

Table 7.3-13 Essential Result

Item	Unit	Wet bulb Temperature change				
Wet bulb Temperature	°C	22.6 (-6.0)	25.6 (-3.0)	28.6	31.6 (+3.0)	34.6 (+6.0)
Condenser Vacuum	mmHga	69.4	75.7	83.0	91.3	100.9
Power output	MW	666.4	663.3	660.0	656.5	652.9
Power change	MW	+6.4	+3.3	(Base point)	-3.5	-7.1

Source: JICA Survey Team

Power output of the steam turbine is decreased when the wet bulb temperature is increased.

This decrease, for example, is owing to the increase of the condenser vacuum which corresponds to the increase of wet bulb temperature.

m. Closed Cooling Water System

In the closed cooling water system, heat from the following plant equipment will be removed and then water is returned to the cooling tower. Cooling water temperature will not exceed 40 ºC under all operating conditions.

- ✓ Steam turbine lubricating oil coolers
- ✓ Generator hydrogen coolers
- ✓ Generator seal oil cooler
- ✓ BFP turbine lubricating oil cooler
- ✓ Condensate pump motor cooler
- ✓ Boiler auxiliaries coolers
- ✓ Air compressor, inter- and after-coolers
- ✓ Sampling coolers

(2) Boiler and Auxiliaries

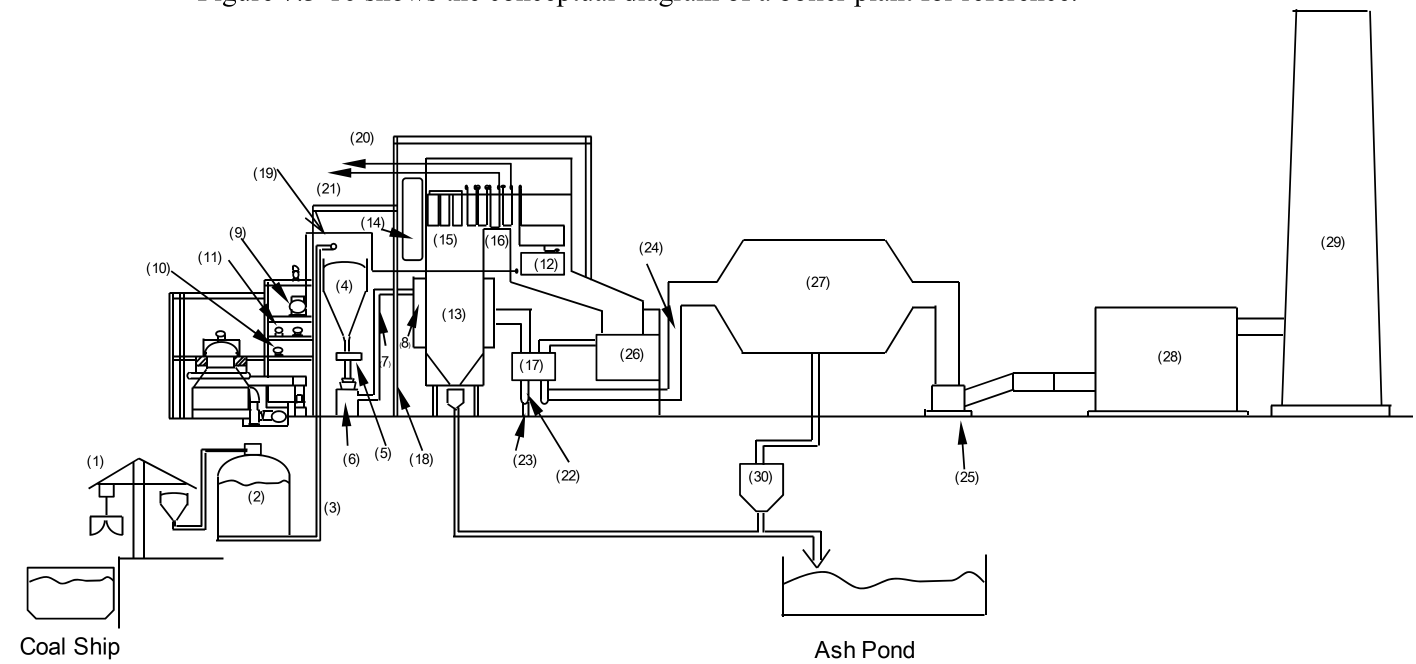
1) General

The boiler is supplied with pure warm water from the boiler feed pump through high pressure feedwater heaters, producing high pressure and high temperature steam in order to drive the steam turbine and generator with the combustion of pulverized coal. Coal supply comes from the coal yard via conveyors that bring the coal to the coal bunkers located in front of the boiler. Coal feeders arranged under the bunkers feed the coal to the pulverizers located under the feeders. Then, pulverized coal is supplied to burners arranged along the boiler furnace waterwall.

The boiler and auxiliary system consists of the following:

- ✓ Furnace, super heaters, reheater, economizer for pressure parts
- ✓ Coal supply, pulverizing and burning system
- ✓ Light fuel oil supply and burning system
- ✓ Air heaters, forced draft fans, primary air fans, induced draft fans, gas recirculation fans for air supply and flue gas discharge
- ✓ Soot blowers for ash removal from boiler heating surfaces
- ✓ Electrostatic precipitators (ESP) for fly ash removal from flue gas
- ✓ Flue gas desulfurization (FGD) system
- ✓ Ash removal system for clinkers and fly ash, and an ash disposal system to the ash pond
- ✓ DeNOx system for NOx removal from flue gas, if necessary (See, p. 5)

Figure 7.3-16 shows the conceptual diagram of a boiler plant for reference.



Source: Prepared by JICA Survey Team

Figure 7.3-16 Conceptual Diagram of a Boiler Plant

The nomenclature of the equipment numbers in Figure 7.3-16 is as follows:

Table 7.3-14 List of Facilities for the Conceptual Diagram of a Boiler Plant

No.	Name of Equipment	Reference clause
1	Coal unloader	Not applied in this project
2	Coal storage yard, with or without a roof	Coal yard portion
3	Coal supply conveyors to boiler	7.3.8.4
4	Coal bunkers	7.3.1 (1) 4) c
5	Coal feeders	7.3.1 (1) 4) d
6	Pulverizers	7.3.1 (1) 4) e
7	Pulverized coal supply piping to boiler	-----
8	Burners arranged on windboxes	7.3.1 (1) 4) f
9	Deaerator for boiler feedwater	Turbine portion
10	Boiler feed pumps	Turbine portion
11	High pressure feedwater heaters	Turbine portion
12	Economizer	7.3.1 (1) 4) a
13	Furnace	7.3.1 (1) 4) a
14	Water separator	7.3.1 (1) 4) a
15	Superheaters	7.3.1 (1) 4) a
16	Reheaters	7.3.1 (1) 4) a
17	Regenerative air heaters	7.3.1 (1) 4) i
18	Boiler support steel structures	7.3.1 (1) 4) b
19	Boiler feedwater piping	-----
20	Main steam piping to HP turbine	-----
21	Reheat steam piping to IP turbine	-----
22	Forced draft fans	7.3.1 (1) 4) h
23	Air ducts	7.3.1 (1) 4) h
24	Flues to ESP	-----
25	Induced draft fans	7.3.1 (1) 4) h
26	DeNOx system, if required	Not applied in this project

27	Electrostatic precipitators	7.3.1 (1) 4) j & 7.3.7 (2)
28	Flue gas desulfurization plant	7.3.7 (1)
29	Stack	7.3.7(4) 5)
30	Fly ash silos	7.3.8 (5)

Source: Seminar Report 1988 by Thermal and Nuclear Power Engineering Society

2) Types of Boilers

There are three types of boilers for utility applications:

- ✓ Natural Circulation Boiler
- ✓ Controlled Circulation Boiler
- ✓ Once-through Boiler

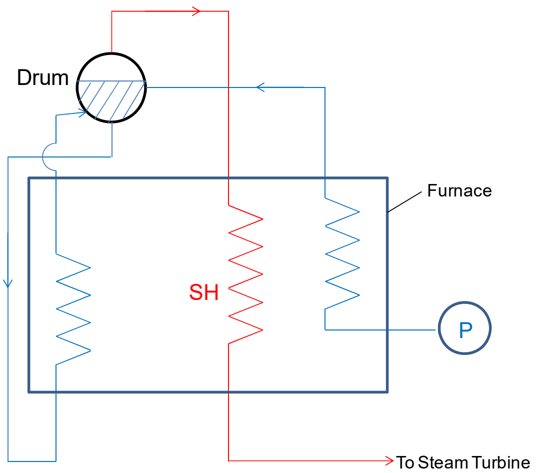
Comparison of the three types is shown in Table 7.3-15.

Table 7.3-15 Comparison of Boiler Types

Items	Drum Type		Once-through
	Natural Circulation	Controlled Circulation	
Operating Pressure	Limited to Sub-critical Pressure	Limited to Sub-critical Pressure	Sub-critical Pressure, Super-critical and USC
Plant Efficiency	Relatively Low	Relatively Low	High
Steam Drum	Required	Required	Not Required
Circulation Pump	Not Required	Required	Not Required
Arrangement of Waterwall Tubes	Vertical Only	Vertical Only	Both Vertical and Spiral
Required Purity of Feedwater	Relatively Low	Relatively Low	High Purity Required
Required Times for Start up	Relatively Long	Relatively Long	Short, No Drum
Operation Control	Relatively Easy	Relatively Easy	Require High level Control

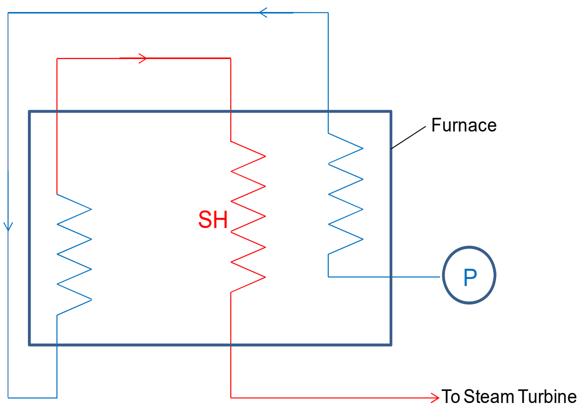
Source: JICA Survey Team

The conceptual diagrams of both types of boilers are shown in Figures 7.3-17 and 7.3-18 below.



NOTE: Blue Lines: Water Flow
Red Lines: Steam Flow
Source JICA Survey Team

Figure 7.3-17 Conceptual Diagram of Drum Type Boiler



NOTE: Blue Lines: Water Flow
Red Lines: Steam Flow
Source JICA Survey Team

Figure 7.3-18 Conceptual Diagram of Once-through Type Boiler

In the drum type boiler, water from the economizer is supplied into the drum from where the water flows down to the bottom headers of the furnace waterwall. From the headers, water is introduced into the waterwall tubes where the water is heated up until saturation temperature is reached and vapor is produced. The vapor is separated from the saturated water in the drum, and then supplied into the superheater tubes.

In the once-through type boiler, water from the economizer is supplied directly into the bottom headers of the furnace waterwall. The once-through boiler can be applied to both sub-critical and super-critical pressure operations. The water is heated in the waterwall tubes that produce steam in the upper part of the waterwalls. The steam is supplied into the superheater tubes.

Mainly due to SC and USC, the once-through boiler is adopted in the new power plant in the Project. Moreover, the once-through type has advantages over the other types such as the small amount of boiler water and the absence of a drum, hence making it better for load change and shorter start-up time.

On the other hand, the once-through type requires a higher level control system and higher purity of feedwater than the drum type. As for the drum type boiler, the vapor flow is separate from the water, which is why solutions are concentrated into the circulated water. The evaporation endpoint is not fixed like in the drum type boiler. All feedwater entering the once-through system is warmed up, evaporated, and superheated in a once-through mode. Solutions of boiler water precipitate remain as deposition in water tubes. Subsequently, this would be the reason for blockage of water flow and pipe leaks caused by their absorption of heat. In general, volatile substances such as ammonia and hydrazine are used for water quality control treatment. The demineralizer is also adopted in the once-through mode of water treatment.

The basic concept of the boiler and auxiliaries is as follows:

- ✓ The boiler is of USC pressure, single reheat type with a balanced draft system.
- ✓ The boiler is an outdoor type with a roof and an enclosure around the burner area due to the ambient conditions of the site.
- ✓ The boiler is designed as direct firing of the specified coals.
- ✓ Light fuel oil is used for ignition, warm-up and flame stabilization purposes in low load less than 35% of rated output.

The boiler and auxiliary system includes the following:

- ✓ Utility type boiler complete with auxiliary equipment, draft systems and air-heaters, etc.
- ✓ Coal supply and burning system including coal bunkers, feeders, pulverizers, fuel piping,

coal burners, igniters and necessary equipment for direct firing.

- ✓ Air heaters, forced draft fans, induced draft fans, primary air fans, gas recirculation fans, cooling air fans and air ducts and gas flues with associated facilities and attachments.
- ✓ Electrostatic precipitators with associated facilities.
- ✓ Main feedwater piping from the final HP feedwater heater outlet to the boiler.
- ✓ Main steam piping from final superheater outlet to the HP turbine inlet main stop valves.
- ✓ Cold reheat steam piping from HP turbine outlet to the reheater inlet and hot reheat steam piping from the reheater outlet to the LP turbine inlet stop valve.
- ✓ HP turbine bypass system.
- ✓ Interconnecting piping with valves for the boiler.
- ✓ Sootblowing system.
- ✓ Thermal insulation for all equipment.
- ✓ Auxiliary steam system including interconnecting piping with the auxiliary boiler.
- ✓ Light fuel oil storage and supply system.
- ✓ Structural steels required to support the boiler and auxiliary equipment
- ✓ Boiler house elevator system up to the top of the boiler steel structure.

The outline specification of the Project is shown in Table 7.3-16 below.

Table 7.3-16 Outline Specifications of the Boiler Plant Equipment

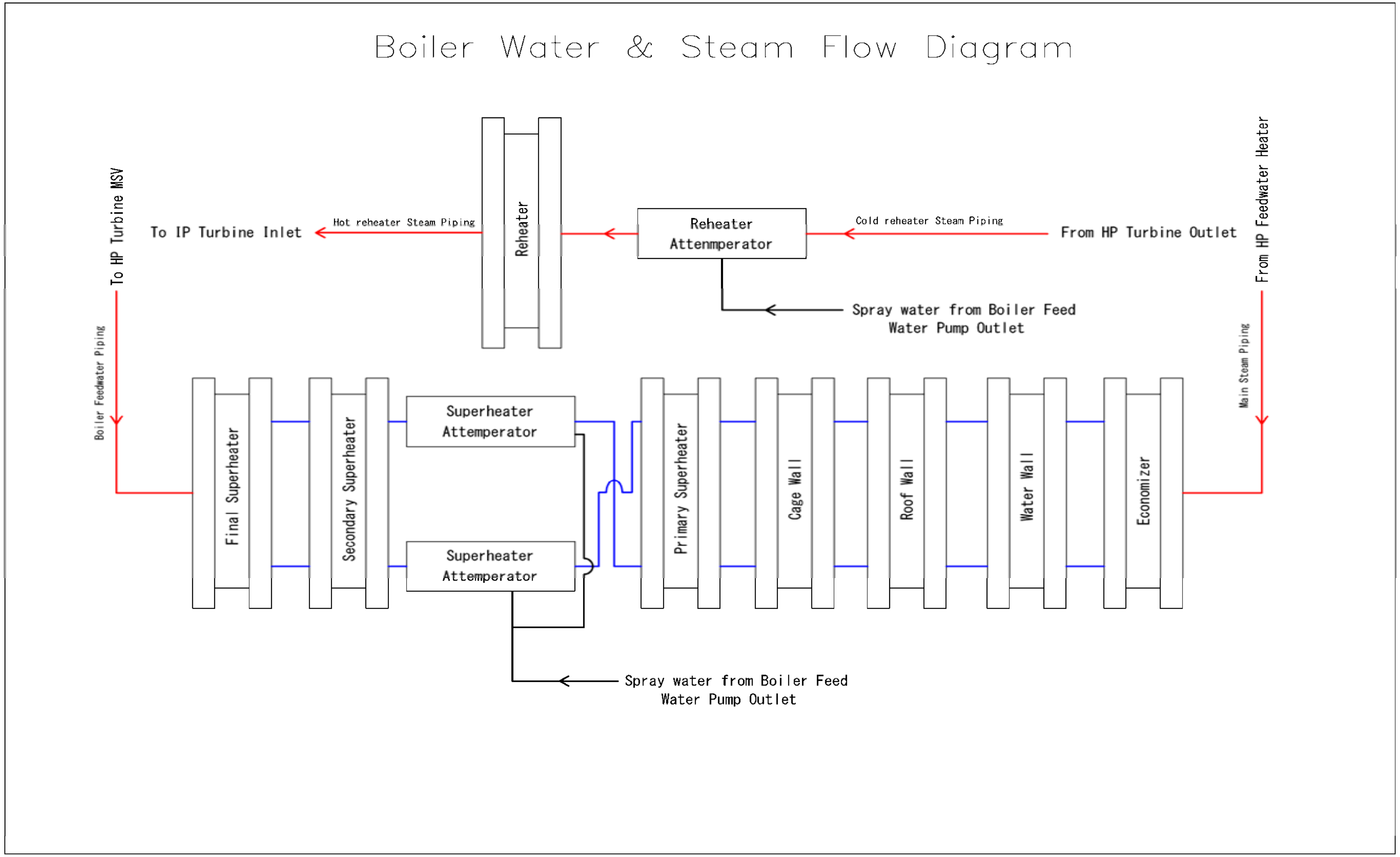
Equipment		Specifications
Boiler		
Basic Description	Type	Once-through, Variable Pressure, Reheat Type
	Main Fuel	Coal Firing
	Supporting Fuel	Light fuel Oil for Ignition and Stabilization of Firing
	Draft System	Balanced Draft Type
	Installation	Outdoor Type Supported by Structural Steels with Roof and Local Enclosures Around Burners
Basic Specification	Evaporation	2,200 t/h @ BMCR (Boiler Maximum Continuous Rating)
	Main Steam Pressure	24.5 MPa @ BMCR
	Main Steam Temperature	596 °C
	Reheat Steam Temperature	596 °C
	Flue Gas Temperature	140 °C @ Regenerative Air heater Outlet, BMCR
Coal Firing System		
Coal Bunkers	Type	Conical Type with Circular or Square Section
	No. Installation	6 Sets
	Storage Capacity	16 Hours of Boiler Operation with One Bunker Out of Service @ BMCR
Coal Feeders	Type	Gravimetric Type
	No. Installation	6 Sets
Pulverizers	Type	Vertical Roller Type
	No. Installation	6 Sets
Coal Burners	Type	Low NOx Type
	No. Installation	Determined by Detailed Design
Oil Burners	Type	Determined by Detailed Design for Light fuel Oil
	No. Installation	Determined by Detailed Design
Draft System and Others		
Forced Draft Fans (FDF)	Type	Axial Flow Type with Variable Pitch Blades
	No. Installation	2 Sets
Induced Draft Fans (IDF)	Type	Centrifugal Type with Variable Speed Hydraulic Coupling
	No. Installation	2 Sets
Primary Air Fans (PAF)	Type	Centrifugal Type with Inlet Damper Control
	No. Installation	2 Sets
Gas Recirculation Fans (GRF)	Type	Centrifugal Type with Inlet Damper Control
	No. Installation	2 Sets
Regenerative Air heaters (AH)	Type	Vertical Counter Flow, Tri-sector Type
	No. Installation	2 Sets
Electrostatic Precipitators (ESP)	Type	Collecting Electrodes Type
	No. Installation	2 Sets

Source: JICA Survey Team

3) Operation Requirements

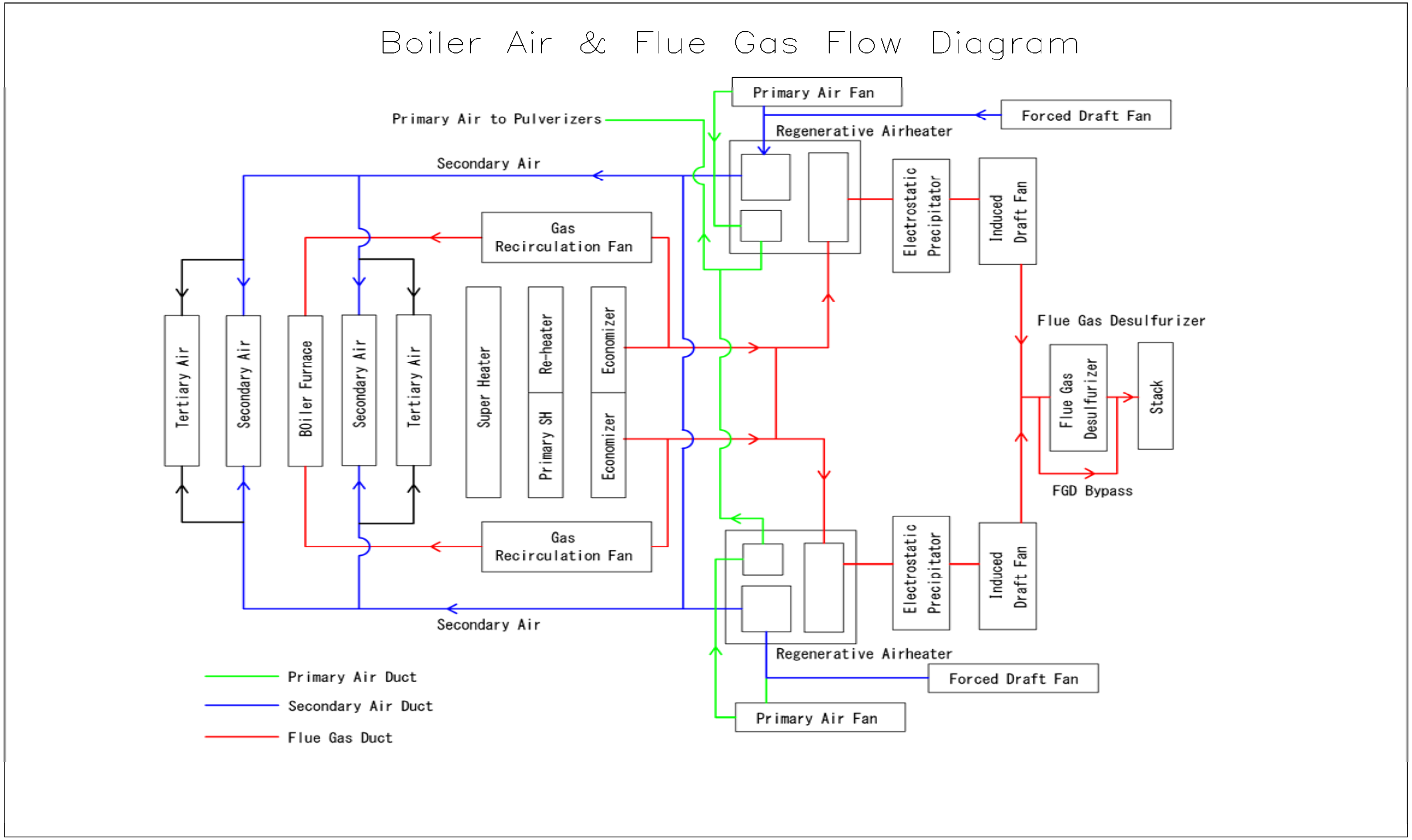
The boiler is designed to attain the following conditions:

- ✓ Boiler Maximum Continuous Rating (BMCR): 2,200 ton/h
- ✓ Rated Output (RO): 660 MW
- ✓ Main Steam Pressure (MSP) at HP Turbine Inlet: 24.1 MPa
- ✓ Steam Pressure at Boiler Outlet: 24.5 MPa
- ✓ Main Steam Temperature (MST) at HP Turbine Inlet: 593 ^{o}C from 50% RO to BMCR
- ✓ Steam Temperature at Boiler Outlet: 596 ^{o}C
- ✓ Reheat Steam Temperature (RST) at LP Turbine Inlet: 593 ^{o}C from 50% RO to BNCR
- ✓ Steam Temperature at Boiler Outlet: 596 ^{o}C
- ✓ Boiler is capable of constant pressure operation and also sliding pressure operation in normal service between 50% and 90% RO.
- ✓ Boiler thermal efficiency is not less than 83% at the RO with higher heating value (HHV) of the specified coal.
- ✓ Unburned carbon in bottom ash and fly ash is not more than 20% at the RO with firing the specified design coal.



Source: JICA Survey Team

Figure 7.3-19 Conceptual Boiler Water and Steam Flow Diagram



Source: JICA SurveyTeam

Figure 7.3-20 Conceptual Boiler Air and Flue Gas Flow Diagram

4) Design of Boiler and Auxiliary Equipment

a. Boiler

The boiler is a once-through type equipped with furnace waterwalls, roof walls, cage walls, superheaters, reheaters, water separator and economizers. The boiler pressure parts are designed with ASME boiler and pressure vessel code or other standards equivalent to the ASME codes.

The boiler is a gas tight type with membrane walls and/or gas tight casings.

The boiler is a balanced draft system type equipped with forced draft fans (FDFs) and induced draft fans (IDFs). It is an outdoor installation with roof and suitable enclosures in burner zones for safe and easy operation and maintenance. It is equipped with six coal pulverizing systems with coal bunkers and coal feeders, and is operated with any five coal pulverizing systems up to BMCR with one system in stand-by.

The boiler furnace waterwalls are equipped with opposed or tangential firing low NOx burners without a De-NOx system. A typical concept of a low NOx burner is shown in Figure 7.3-17.

The boiler is equipped with gas a recirculation and a temperate spray system to maintain the main steam temperature at the HP turbine inlet. The superheater temperate spray system is arranged in the final superheater inlet steam piping. As for emergencies, the boiler is equipped with a reheater temperate system in the cold reheat piping.

b. Boiler support steel structure

The boiler support steel structure is designed to support the boiler including associated piping systems, and the duct and flue systems. Outdoor type structures are adopted for the roof, enclosures, platforms, walkways, stairs, and ladders.

An elevator system is equipped with steel structure.

Two sets of stairs are provided on each side of the boiler, from the basement level to the highest level of the boiler. Walkways are provided around the boiler and appropriate interconnecting walkways and stairs between the equipment, such as the turbine house, deaerator bay, central control room, pulverizer bay, air heaters, electrostatic precipitators, and so on are provided.

c. Coal bunking system

Six coal bunkers are installed in front of the boiler. The total usable capacity of the bunkers with design coal firing is sixteen hours of operation with one bunker out of service at BMCR operation. Bunkers are of a circular or square section, mass flow type. Bunkers are fabricated with steel stiffened plates. The slope section of the bunkers should have a minimum slope of 70^o to ensure the steady flow of coals. The slope section is internally clad with stainless steel of not less than 6 mm thickness to facilitate coal flow and to minimize erosion and corrosion of the walls. Bunkers are provided with a hatch below the coal gate to permit the discharge of coal. Power-operated shut-off gates are provided at the bunker exit. Bunkers are equipped with air-canons to avoid coal stagnation by dislodging it. The ventilation system is provided in the bunker room with a design capacity of seven times the volume of a bunker room per hour.

d. Coal feeders

Gravimetric coal feeders are located at the coal bunker outlets on the operating floor level. Coal feeders are adjustable over the full operating range of the pulverizers. Coal feeders have an enclosed explosion-proof housing in accordance with the requirements of the latest edition of NFPA. The feeders also have weighers for local and remote indication of the rate of flow, as well as a totalizer. Coal feeders are provided with light mounted inside the feeder casing so that the flow of coal can be observed at all times through an observation window.

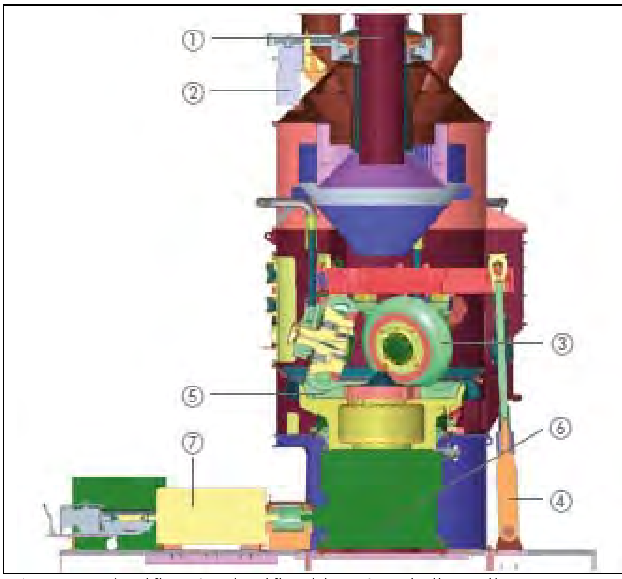
e. Pulverizers

Pulverizers receive raw coal from the coal feeders and supply pulverized coal to burners in the boiler furnace waterwalls in order to meet the boiler operating requirements.

There are three types of pulverizers:

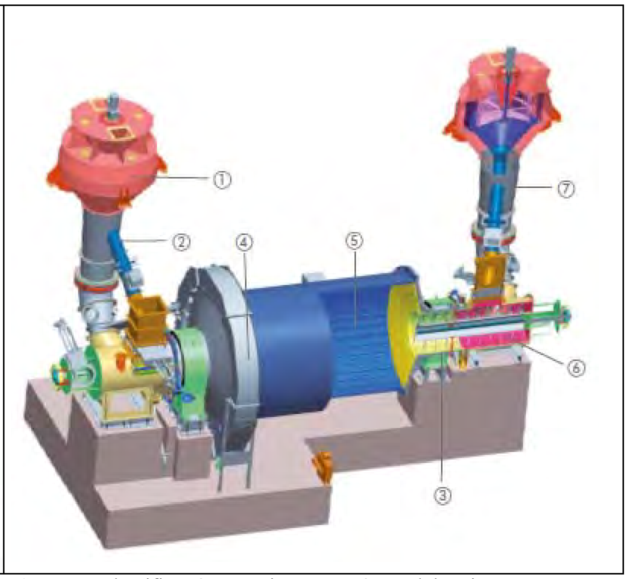
- ✓ Vertical Roller Type
- ✓ Horizontal Tube and Ball Type
- ✓ Beater Wheel Type

The schematic diagrams of pulverizers are shown in Figures 7.3-19, 7.3-21, and 7.3-23.



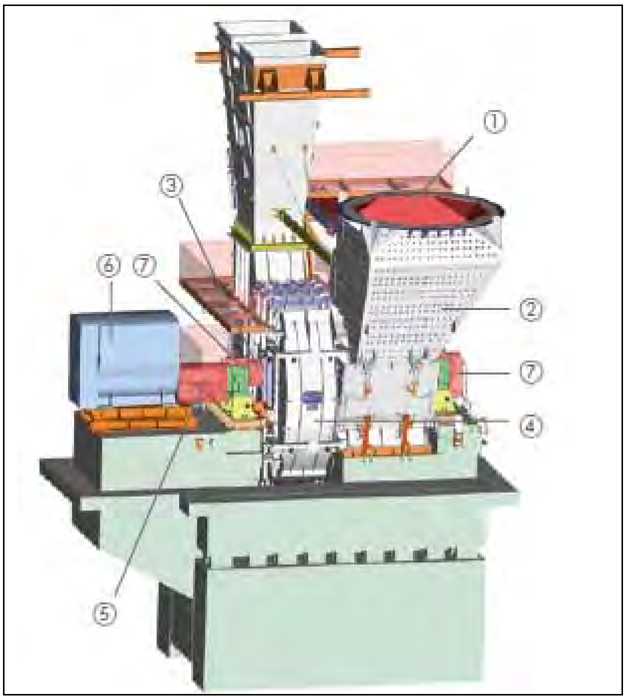
1 :Rotary classifier, 2: Classifier drive, 3: Grinding rollers
4: Hydro-pneumatic system, 5: Grinding table,
6: Gear, 7: Motor
Source: Hitachi Power Europe Service GmbH

Figure 7.3-21 Vertical Roller Type



1: Rotary classifier, 2: Oversize return, 3: Neck bearing
4: Drive gear rim, 5: Grinding ball filling,
6: Feed spiral conveyor, 7: Classifier riser
Source: Hitachi Power Europe Service GmbH

Figure 7.3-22 Horizontal Tube and Ball Type



1: Flue gas gate valve, 2: Inlet housing, 3: Beater shaft,
4: Beater wheel, 5: Coupling,
6: Motor, 7: Bearing
Source: Hitachi Power Europe Service GmbH

Figure 7.3-23 Beater Wheel Type

Comparison of pulverizer types is shown in the following table.

Table 7.3-17 Comparison of Pulverizer Types

Type of Pulverizer	Vertical Roller Type	Horizontal Tube and Ball Type	Beater Wheel Type
Application to Kind of Coal	Bituminous Coal, Sub-bituminous Coal	Anthracite Coal	Lignite Coal
Pulverizing Action	Grind down by Rollers on Table	Clashing Impact by Steel Balls	Clashing Impact by Wheel Blades
Power Consumption	Relatively Low	Relatively High	Relatively High
Required Space	Small	Large	Large
Fineness Adjustment	Easy	Easy	Not so easy
Vibration	Low	High	High
Noise	Low	High	High

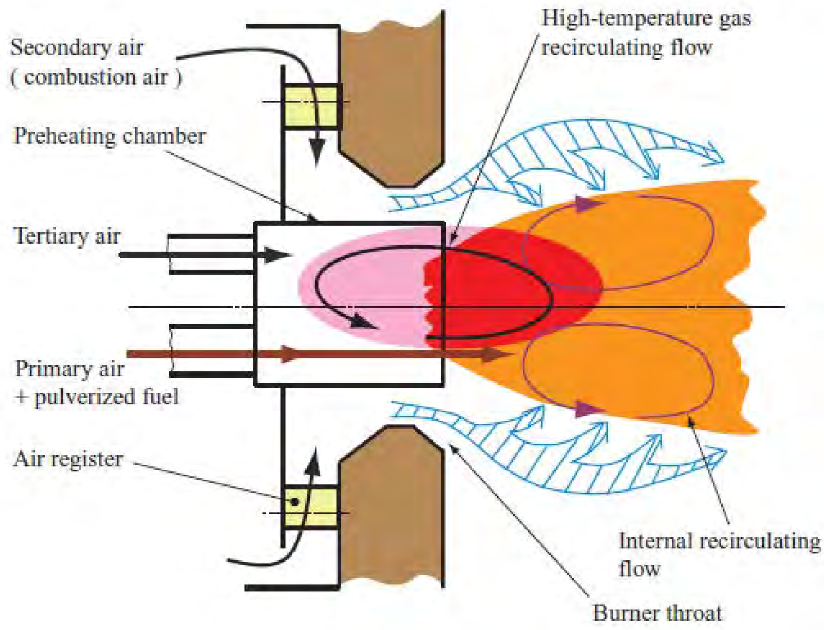
Source: JICA survey team

Based on the above comparison of pulverizer types, the vertical roller type is selected for the Project which is mainly suitable for sub-bituminous coal. The number of the pulverizers is six including one stand by at the BMCR operation with the specified worst coal. The fineness of pulverized coal is not less than 90% passing the 200 mesh, and not less than 99% passing the 50 mesh. Pulverizers are located in the coal bunker bay at the basement floor level under the coal feeders. All rotating parts of pulverizers are capable of safely withstanding all acceleration forces at normal operation speed. A pulverizer lubrication system has a suitable oil cooler and it functions reliably at the maximum operating temperature. Suitable classifiers are provided in each pulverizer to ensure requisite fineness to supply the burners. The classifiers permit the operators to vary the fineness of the coal delivered from the pulverizers since it is designed such that adjustments can be made when the pulverizer is in operation. The internal parts of the pulverizer should be specially selected to give a long economic life. Two electric hoists and a common runway beam are provided for maintenance purposes. A definite air to coal ratio is automatically maintained for any given load. At the same time, the temperature of the primary air entering the pulverizer, in relation to the coal-air ratio, is adjusted taking into consideration the total moisture in the coal in order to evaporate all the surface moisture at the pulverizer. Suitable valves and dampers are provided to permit maintenance of any pulverizer and/or seal air fan while the remaining pulverizers are in service. A shut off damper is provided at the inlet of each pulverized coal pipe.

f. Coal burners

Burners have proven design and suitable for stable combustion of the specified coal with low

NOx production. Nox emission from the boiler outlet flue gas can be maintained lower than the environmental regulation without a De-Nox system.



Source: IHI Engineering Review

Figure 7.3-24 Typical Concept of Low NOx Burners

Burners are designed to keep the unburned carbon in ash (clinkers under the furnace and fly ash) less than 20% in weight of the ash. Pulverized fuel piping from the pulverizers to the burners is composed of an abrasion-resistant type of material and routed in such a way as to minimize erosion and to avoid settlement of pulverized coal in the pipework. Pulverized fuel pipes are made of steel, with 10 mm thickness. Pipe elbows are flanged and with not less than 6 mm ceramic lining or 30 mm basalt lining. Suitable stairs, ladders, platforms, and galleries are provided for access to pipe runs for inspection and maintenance.

g. Start-up oil system

A light fuel oil system is provided for ignition, start-up and supporting at low load operations of the boiler. The light fuel oil system has two storage tanks, each with 4,000 kL usable capacity. Light fuel oil tanks are designed in accordance with the API Standard No. 650 and its Appendix E. A suction heater is provided for each light fuel oil tank. A complete set of light fuel oil supplying system is provided for the boiler. Light fuel oil burners and igniters with necessary piping work for the boiler are provided.

If cost of light fuel oil is high, Class A heavy oil may be considered as an alternative fuel. However, Class A heavy oil requires continuous circulation with heating the oil for sudden requirement by trip of the unit and/or low load operation. Continuous heating of the oil requires additional relatively complicated system/ equipment including oil cooling equipment and means continuous energy loss for keeping temperature of the oil at around 90 deg. C.

Therefore, if provability of use of oil firing is not high, adopting of light fuel oil is recommended.

h. Draft system

The draft system is a balanced draft system with forced and induced draft fans. The draft system includes the following equipment:

- ✓ Forced Draft Fans (FDFs)
- ✓ Induced Draft Fans (IDFs)
- ✓ Primary Air Fans (PAFs)
- ✓ Gas Recirculation Fans (GRFs)
- ✓ Cooling Air Fans (CAFs)
- ✓ Air Ducts and Flues

FDFs are axial flow types with variable pitch blades using hydraulic control. Two FDFs of 50% duty with driving motors are installed. The capacity of the FDFs is not less than 1.2 times that of BMCR's air requirement with the worst specified coal including excess air and air heater leakage. Static pressure of the FDF is not less than 1.3 times the pressure required to deliver the air volume needed to meet the calculated design capacity requirements as stated above.

IDFs are of the centrifugal type, using variable speed hydraulic coupling or frequency control, together with an inlet control vane or inlet damper control. Two IDFs of 50% duty with driving motors are installed. The capacity of IDF is not less than 1.2 times that of BMCR's air requirement with the worst specified coal including an air heater leakage and with a temperature 10 ^{o}C higher than the expected gas temperature at BMCR. The static pressure of the IDF is not less than 1.3 times the pressure required to displace the gas volume needed to meet the BMCR requirement as stated above.

PAFs are of constant speed, centrifugal type with inlet damper control. Two PAFs of 50% duty with driving motors are installed. The capacity of the PAFs is not less than 1.2 times that of BMCR's primary air requirement with the worst specified coal taking into account the changeover of the stand-by pulverizer, air heater leakage and temperature rise in FDF due to friction loss. The static pressure of the PAF is not less than 1.3 times that of the pressure required to deliver the air volume needed to meet the BMCR requirement as stated above.

GRFs are installed for the reheat steam temperature control. GRFs are of the constant speed, centrifugal type with inlet damper control. Two GRFs of 50% duty with driving motors are installed. The capacity of a GRF is not less than 1.2 times the recirculation requirement with the worst specified coal. Static pressure of GRFs is not less than 1.3 times the pressure required to deliver the gas volume needed to meet the requirement as stated above.

Two CAFs are installed; one fan is driven by an alternating current (AC) motor and another by a direct current (DC) motor for emergency operations. All air ducts are designed for the maximum flow velocity of 20 m/s. All gas flues are designed for the maximum flow velocity of 15 m/s. An air flow metering device is installed in each FDF suction air duct.

Table 7.3-18 Specifications of Fans

Item	FDF	IDF	PAF	GRF	CAF
Number of Installation	2 sets	2 sets	2 sets	2 sets	2 sets
Duty of One Set	50%	50%	50%	50%	50%
Type of Fan	Axial Flow type with Variable Pitch Blades	Centrifugal type	Centrifugal type	Centrifugal type	Centrifugal type
Control	Hydraulic	Hydraulic	Damper	Damper	Damper
Capacity Margin for Required Fluid Flow	20%	20%	20%	20%	--
Pressure Margin for Required Pressure	30%	30%	30%	30%	--
Other Requirement	--	--	--	--	One is driven by AC motor, Other one by DC motor

Source: JICA Survey Team

i. Regenerative air heaters

Regenerative air heaters are of the vertical counterflow regenerative elements-rotating type with rotor housing, flanged connections for air ducts and gas flues, cylindrical cellular type rotor with labyrinth seals, heating elements, self-aligning, anti-friction bearings, lubricating system, supports, soot blowing, water washing and fire fighting system complete with fire detecting devices and all piping, valves, supports and drainage. Two 50% duty tri-sector regenerative air heaters are installed. The heating elements of the air heaters are packed in baskets of convenient weight and dimensions to facilitate maintenance. The main motor drive is a constant speed electric motor. The motor has a double shaft extension to allow hand cranking. Cold-end elements are Corten steel or any equivalent. The types of elements are the double undulated (DU) type or an equivalent for high and medium temperature zones, and the notched flat (NF) type for low temperature zones. Automatic adjustable radial and circumferential seals shall be provided to minimize leakage from the air side to the gas side. The amount of air leakage shall not be more than 7% of the flue gas flow entering the air heater.

j. Electrostatic precipitators (ESP)

As a complete dust collection system, an ESP is designed for the specified coal-fired boiler at BMCR.

ESP is welded steel structure and consists of two parts of parallel chambers which are suitable for 50% of the flue gas flow at BMCR.

Gas temperature drops should not exceed 7 ^{o}C as measured at the inlet and outlet flues.

The ESP is designed and guaranteed to have a dust concentration of less than 50 mg/m^{3}N (dry) as measured at an outlet in BMCR condition for any type of coal.

A number of fields have decided to keep the outlet dust concentration below 200 mg/m^{3}N (dry) under the condition of outage of any one bus-section. Insulator components are provided with a system, proven to maintain the support insulators above dew point of the flue gas. Flue gas velocity in precipitators should be less than 1.5 m/s at BMCR when firing the design coal.

Auxiliary equipment composed of grounding rods are provided to ground high voltage equipment during de-energizing. Warning signs shall also be provided. An off-load washing system is provided. A gas distribution system is provided for uniform distribution of flue gas and shall be selected in accordance with the ash analysis to avoid deposits within the system.

Dust hoppers have the capacity for nothing less than eight hours of dust collection at BMCR when firing the design coal. It is recommended that the first hoppers are designed for double capacity as opposed to the other hoppers. Discharge electrodes are rigid frame types. Collecting electrodes are shaped or baffled so as to prevent re-entrainment of the dust collected. Collecting electrodes are supported from beams at roof level.

ESP is provided with two separate rapping systems, one for the discharge electrodes and another for the collecting electrodes. Each rapping system is independently and automatically controlled. Each rapping system is controlled from the plant control room and the number of rapping cycle per hour is variable.

High voltage transformer-rectifier sets are provided to energize the electrodes for optimum performance of the precipitators. A disconnecting switch is installed between the transformer-rectifier set and insulator compartment. Insulator compartments are provided with a hot air ventilation system to prevent insulator breakdown.

k. Soot blowing system

A complete set of automatic steam-operated soot blowing system is provided for cleaning the boiler furnace water-walls, superheaters, reheater, economizer and airheater elements. Steam for the soot blowers is taken from the superheated steam line before the final superheater. All soot blowers are capable of operating manually and sequentially in series from the central control room. Local manual operation shall also be provided for testing. A sufficient numbers of wall blowers are installed to provide full coverage of anticipated slagging zones. Fully retractable soot blowers are deployed for cleaning of superheaters, reheaters and economizers. Half retractable soot blowers may be arranged on low gas temperature zones. Air heaters are equipped with the appropriate type of soot blower.

7.3.5 Electrical Equipment

(1) Main Generator System

The generator output is decided to be 660 MW. An exciter will be selected for the static excitation system and stator cooling will be selected for the direct water cooling system. The basic specifications for the generator and main auxiliaries are shown in Table 7.3-19 below.

Table 7.3-19 Specifications of the Generator

Items	Specification
Generator	
Type	Horizontal Three Phase, AC Synchronous Generator with Rotating Field, Cylindrical Rotor and Totally Enclosed
Rated Capacity	660 MW, 776 MVA
Rated Voltage	22 kV or 24 kV, 3 phase 50 Hz
Power Factor	0.85
Cooling System	Stator Coil･･･Direct Water Cooling Rotor Coil･･･Direct Hydrogen Cooling with gas pressure of 4 bars or higher
Exciting System	Static Excitation System with a Power System Stabilizer
Winding Connection	Y-Connection
Short Circuit Ratio	0.55 (assumed)
Winding Insulation Class	Class F (Temperature Rise Class B)

Efficiency	99% or higher
Other Characteristics	to comply with IEC 34
Applicable Standard	IEC 34 and the relevant standard shall be applied
Auxiliaries of Generator	
Items	Amount of Items
Hydrogen Cooling System	one set
Hydrogen Gas Supplier	one set
Seal Oil Unit	one set
Stator Cooling Water Feeder	one set
Carbon Dioxide Displacement System	one set
Main Circuit Equipment of the Generator	
Items	Amount of Items
Isolate Phase Bus	one set
Neutral Point Grounding Equipment	one set
Potential Transformer	one set
Surge Absorber	one set

Source: JICA Survey Team

1) Design Concept

The progress of the materials and production technology of the generator, cooling methods in particular, insulating materials and excitation systems have been remarkable, and as a result of the quality and reliability of the generators from small to large capacity, machines have been highly improving. It depends on the know-how and the production experience of the manufacturers. However, suitable generator specifications, such as the power factor, short circuit ratio, and exciter responsibility can be decided by paying attention to the characteristics of the connected grid system.

2) Electrical and Mechanical Characteristics

The rating conditions shall be designed based on international standards such as the IEC 34-1 (Rating and Performance) and IEC 34-3 (Specific requirement for turbine type synchronous machine).

a. Rated capacity

The rated capacity of a generator (kVA) is decided by the rated output of the turbine and the power factor. If the power factor is small, a relatively larger generator is required for generating the rated load.

The power factor will be determined considering the grid condition in the Lakhra area and it will be assumed to be 0.85 in the Project. The turbine capacity is 660 MW, the rated capacity of the generator will be 776 MVA (660 MW×1 / 0.85 = 776 MVA).

b. Rated voltage

The most suitable generator voltage will be decided from the viewpoint of cost minimization and the design standard of the manufacturer. The rating voltage of this generator will be tentatively decided as 22 kV or 24 kV which is adopted for large-capacity generators.

c. Short circuit ratio

The short circuit ratio is designed based on the stability of the electric power system and the exciter’s responsiveness. If the short circuit ratio is large, the voltage control of the generator and the stability of the electric power system will be improved; however, the weight and cost of the generator will be increased and the generator will be so-called iron-machine. Recently, the short circuit ratio for a large machine is decreased to a smaller value, around 0.55.

In this feasibility study, the short circuit ratio of 0.55 is to be chosen.

d. Voltage regulation

The generator will be operated within the fluctuations of ±5% of the rated voltage during the operating condition of the rated capacity, frequency, and power factor.

e. Insulation class

The insulation of the F class will be applied to stator coils and rotor coils. The temperature rise limit is of the B class.

f. Temperature rise limit

Parts of the generator will be designed as not to exceed the temperature rise limit. An example of the temperature rise limit is shown in Table 7.3-20.

Table 7.3-20 Temperature Rise of the Generator

Machine Part or Coolant		Rise Limit	Max. Temp
Cold Coolant (by thermometer)	Water	45 °C	--
	H_2 gas 4 bar	60 °C	--
Stator Winding (by embedded detector)		80 °C	125 °C
Rotor Winding (by resistance)		70 °C	130 °C
Stator Core (by resistance)		80 °C	125 °C

Source: Handbook for Thermal and Nuclear Power Engineers (Published by Thermal and Nuclear Power Engineering Society of Japan)

g. Unbalanced current

If the following unbalanced current flow occurs, the generator becomes unstable:

- ✓ Ground current of one line
- ✓ Ground current between the lines or the unbalanced short circuit current flows

The allowable limit for continuous unbalanced load greatly depends on the materials and the structure of the equipment. In the case of large-capacity direct cooling generators, the allowable limit is said to be $(I_2)^2 t = 10$.

Where, I_2: Anti-phase current corresponding to the condition that rating armature current is 1 (per unit)

t: Accident duration time (s)

h. Coil connection of the generator

The wye connection of the armature coil is to be adopted due to the following points:

- ✓ There is the neutral point; a ground relay can be connected through high resistance or the transformer.
- ✓ In the case of a delta connection, armature windings will be heated when the third

harmonics circulates through each phase. But for wye connections, there is no heating because the third harmonics does not circulate through each phase.

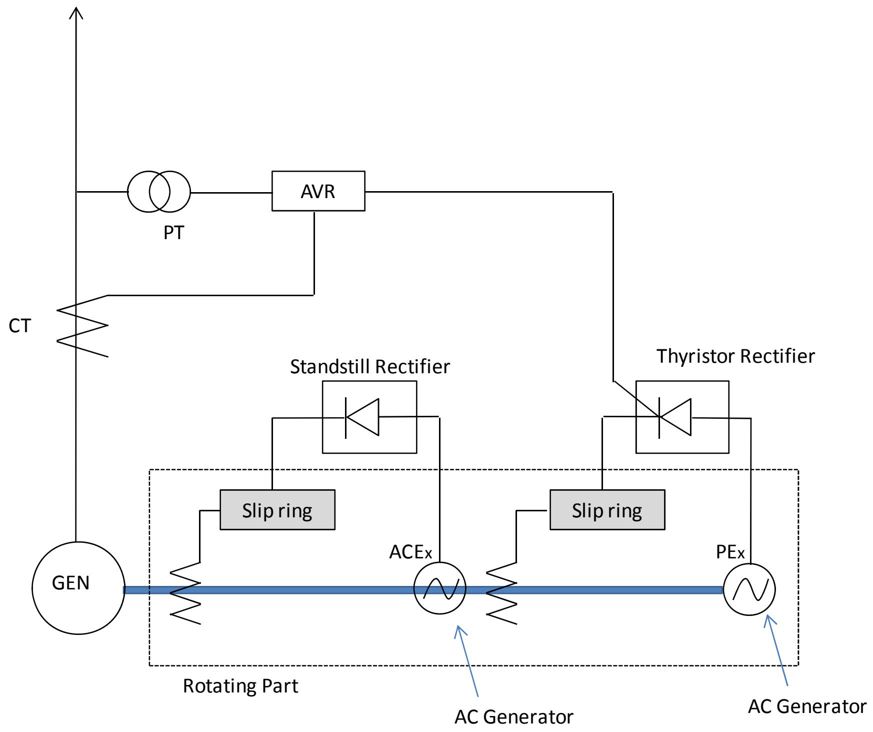
- ✓ In the case of a wye connection, the wye phase voltage is 1/√3 of the line voltage; therefore, the insulation of the armature coil is assured to be better.

3) Excitation System

There are two most common types of excitation systems for large machines, namely, rotating and static. The rotating type excitation system, called the AC excitation system, is divided into two. One is the commutator-less excitation system and the other is a brushless excitation system. Recently, for large-capacity generators, two systems are generally adopted, namely, commutator-less excitation system and static excitation system.

a. Commutator-less excitation system

The system configuration is shown in Figure 7.3-25. A rectifier is installed at a place separate from the rotating exciter. A pilot-exciter is connected directly to the generator. The electric current from the exciter is rectified in the rectifier and is supplied to the field winding of the generator. The merit of this system is its easy maintenance because of the lack of a commutator.



Source: JICA Survey Team

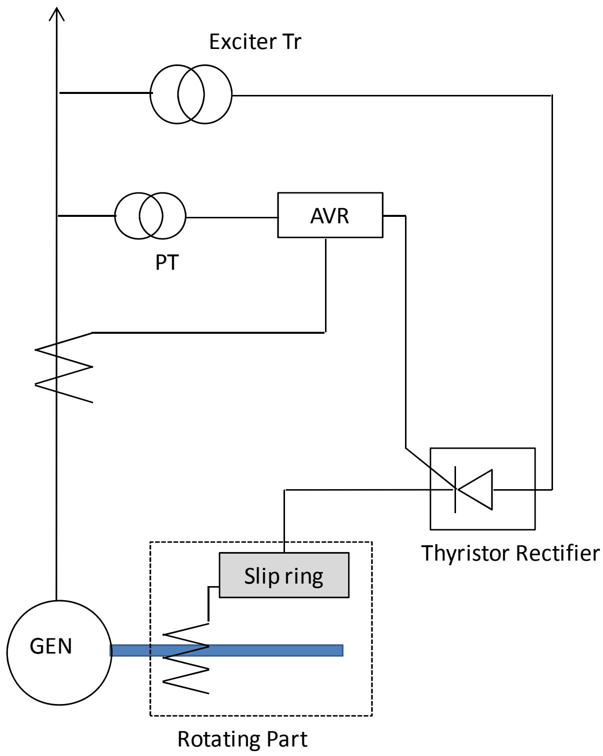
Figure 7.3-25 Commutator-less Excitation System

b. Static excitation system

The configuration of this system is shown in Figure 7.3-26. The feature of the static excitation system is as follows:

- ✓ The absence of a rotating exciter reduces the total length of the turbine-generator.
- ✓ With a static excitation system, there are no rotary parts except for a brush collector ring. Hence, the failure rate of the static excitation system is reduced.
- ✓ As the static excitation system comprises mainly of static components, it gives much easier maintenance and inspection.
- ✓ It gives quicker response time than the rotating system. Hence, the overall time constant of the generator system is reduced and the system stability is much improved.

Based on the above reasons, the static excitation system will be adopted in the Project.



Source: JICA Survey Team

Figure 7.3-26 Static Excitation System

The following facilities will be equipped for the excitation system:

- ✓ Excitation Transformer

The excitation transformer is a three-phase dry type transformer for indoor installation.

✓ Automatic Voltage Regulator (AVR)

The automatic voltage regulator shall also include functions of an over excitation limiter, under excitation limiter, voltage/frequency limiter, and an AVR monitoring and protection system among others.

✓ Power System Stabilizer

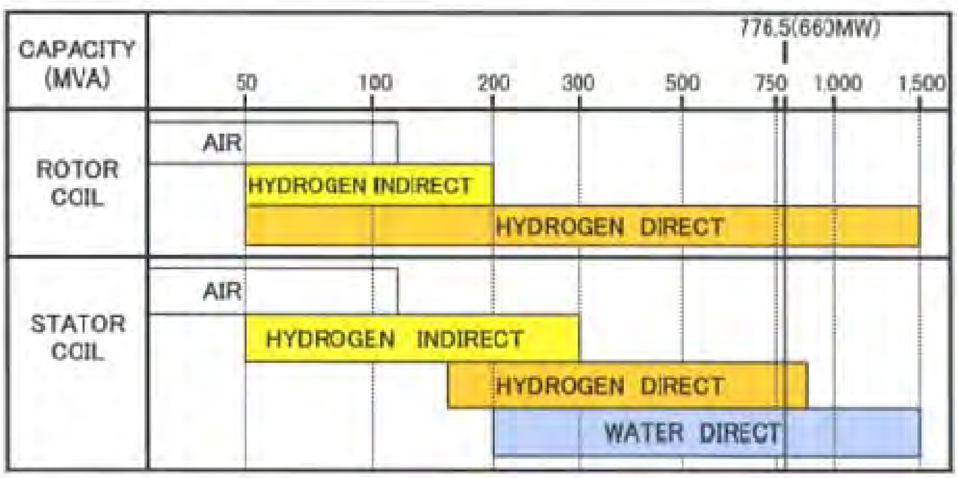
The power system stabilizer is proposed to improve the dynamic stability limit of the power system when the synchronous generator is in parallel operation with other generators in this system. The power system stabilizer can counteract the system's instability when detected through the action of the static excitation system. Also, a power system stabilizer allows the generator to have a wide range of reactive power capability.

4) Generator Cooling System

General guidelines for selection of a cooling system for the capacity of the generator are shown in Figure 7.3-27.

There are two types of stator cooling methods for a 700 kVA machine. Water cooling is adopted for the large generator because of the good cooling performance.

As for rotor cooling, hydrogen gas direct cooling will be applied to the large-capacity machine. A large amount of heat from rotor conductors can be directly cooled by the hydrogen when taking advantage of the high heat transfer rate feature and the little wind loss.



Source: Ujung Pandang Coal Fired Thermal Power Plant Feasibility Study Report.

Figure 7.3-27 Choice of Cooling System for the Capacity of the Generator

(2) Transformers

The main transformer capacity is selected as 720 MVA. One unit auxiliary transformer and one start-up transformer will be installed. These transformers' basic specifications are shown below.

Table 7.3-21 Specifications for Transformers

Item	Specification
Main Transformer	
Type	Outdoor, Forced Oil and Forced Air Cooled Type (OFAF)
Rated Capacity	720 MVA
Rated Voltage	Primary Voltage (Low Voltage) : Same Generator 22 kV or 24 kV Secondary Voltage (High Voltage) : Same System Voltage 500 kV with On-Load Tap Changer (OLTC)
Number of Phases	3 phase 50 Hz
Cooling System	Forced Oil Forced Air Cooling System
Winding Connection	Low Voltage Delta / High Voltage Wye
Grounding System	High Voltage Neutral Point Direct Grounding
Impedance Voltage	14% (assumed) at rated capacity
Winding Temperature Rise	60 °C (at Oil Forced Circulation, Forced Air Cooling)
Terminal	LV terminal : Bushing, connected HV terminal : Outdoor bushing HV neutral terminal : Outdoor bushing
Standard	IEC 76
Unit Auxiliary Transformer	
Type	Outdoor, Oil Natural Circulation and Forced Air Cooled (ONAF), 3 Winding Type
Rated Capacity	70 MVA
Rated Voltage	Primary Voltage (High Voltage) : Same Generator 22 kV or 24 kV Secondary Voltage (Low Voltage) : 6.9 kV
Number of Phase	3 phase 50 Hz
Cooling System	Oil Natural Circulation and Forced Air Cooling System
Winding Connection	High Voltage Delta / Low Voltage Wye × 2 Winding
Grounding System	Low Voltage Neutral Point Transformer / Resistor Combination
Impedance Voltage	8-10% (assumed) at rated capacity
Winding Temperature Rise	55 °C (at Oil Natural Circulation and Forced Air Cooling)
Terminal	HV terminal : Isolated phase bus duct LV terminal : Non-segregated bus duct

	LV neutral terminal : Outdoor bushing
Start-up Transformer	
Type	Outdoor, Oil Natural Circulation and Forced Air Cooled (ONFA), 3 Winding Type
Rated Capacity	70 MVA
Rated Voltage	Primary Voltage (High Voltage) : 500 kV Same System Voltage with On-Load Tap Changer (OLTC) Secondary Voltage (Low Voltage) : 6.9 kV
Number of Phase	3 phase 50 Hz
Cooling System	Oil Natural Circulation and Forced Air Cooling System
Winding Connection	High Voltage Wye / Low Voltage Wye × 2 Winding with embedded Delta
Grounding System	Low Voltage Neutral Point Transformer / Resistor Combination
Impedance Voltage	8-10% (assumed) at rated capacity
Winding Temperature Rise	55 ^{o}C (at Oil Natural Circulation and Forced Air Cooling)
Terminal	HV terminal : Outdoor bushing LV terminal : Non-segregated bus duct LV neutral : Outdoor bushing
Power Transformer	
Type	Indoor, Forced or Natural Circulate Air Cooled Dry Type (AF or AN)
Rated Capacity	2,000 kVA and 3,000 kVA (to be decided after the detailed design of auxiliary power system)
Rated Voltage	Primary Voltage (High Voltage) : 6.6 kV Secondary Voltage (Low Voltage) : 440 V
Number of Phase	3 phase 50 Hz
Cooling System	Self-cooling System
Winding Connection	High Voltage Delta/Low Voltage Delta
Grounding System	Low Voltage Neutral Point Resistance Grounding
Impedance Voltage	Manufacturer's Standard
Winding Temperature Rise	75 ^{o}C (H class is applied but limit is B class)

Source: JICA Suvey Team

1) Main Transformer

a. General description

The main transformer will be rated to transmit the generator output capacity, which has less transformer losses, to the high voltage switchyard. The main transformer will be a three-phase, oil-filled two-winding unit located outdoor in the transformer bay, and will be designed to operate in an environment characterized by an ambient air temperature rated in the range between 10 ^{o}C and 45 ^{o}C.

The low-voltage winding will be delta connected and the high-voltage winding will be solidly grounded wye connected. The main transformer will be connected to the generator by isolated phase bus (IPB) ducts. The main transformer, which will be equipped with an on-load tap changer, will have a tie line connection to the switchyard via an overhead transmission line.

The transformer’s load tap changer will be used to bring the system’s voltage up or down to the necessary level required by the unit auxiliary transformer. The medium-voltage switchgear buses will have backup power provided to them by a connection to the similar switchgear bus of the start-up transformer.

b. Capacity

The capacity of the main transformer will be applied, deducted from the capacity of the unit auxiliary loads in consideration of the progress of reliability improvement of the unit auxiliary transformer and economy of the equipment as well.

In the Project, the main transformer capacity of 720 MVA, which is on the safe side, will be applied. This came from a deduction of the unit auxiliary loads capacity, approximately 50 MVA from the generator capacity of 776 MVA.

c. Impedance voltage

Generally, the low impedance voltage is desirable from the viewpoint of voltage regulation and stability of the power system, but the short circuit current of the secondary system and the interrupted current of the breaker increase at the time of short circuit accidents. Furthermore, it is necessary to strengthen the equipment thermally and mechanically.

Therefore, it is necessary to carefully study the design of the impedance voltage of the transformer based on short circuit capacity calculations. Generally, guidelines for the relationship of the nominal voltage and impedance voltage of a transformer are shown in Table 7.3-22.

Table 7.3-22 Relation with Nominal Voltage and Impedance Voltage

Nominal Voltage (kV)	11	22	33	66	77	110	154	187	220	275	500
Impedance Voltage (%)	4.5	5	5.5	7.5	7.5	10	11	12	13	14	14

Source: Handbook for Thermal and Nuclear Power Engineers (published by Thermal and Nuclear Power Engineering Society of Japan)

2) Unit Auxiliary Transformer

The unit auxiliary transformer will be rated to supply all unit auxiliary loads to permit the maximum output capacity of the unit. The unit auxiliary transformer will step down the generator voltage to the voltage of the auxiliary power system. And all the unit auxiliary power will be received from the generator via the isolated phase bus ducts.

The unit auxiliary transformer will be a three-phase, oil-filled, three-winding transformer located outdoors in the transformer bay adjacent to the main transformer. Their high-voltage windings will be delta connected and their low-voltage windings will be double wye connected, grounding transformer/resistor combination to limit ground faults. Cables or non-segregated bus ducts will connect the unit auxiliary transformer low-voltage terminals to the 6.6 kV switchgears.

The unit auxiliary transformer rated capacity has to be adjusted following discussions and negotiations of loading details with the plant suppliers and the load values are indicative estimates for system design purposes. However, the unit transformer should be decided so that the total auxiliary load will not exceed 90% of the rated transformer capacity.

The auxiliary power consumed by the plant is expected to be 7% to 8% while the unit is under full output. In this feasibility study, the auxiliary power will be calculated based on estimated load and will be applied with 70 MVA to approximately 7.0% of the generator capacity of 776 MW as a margin.

The transformer's impedance will be determined by the optimum auxiliary system voltage regulation, the limitations of the switchgear short-circuit duty, and the ability to start the largest motor connected to the system with the other loads operating.

The high voltage will be applied with 22 kV or 24 kV, same as the generator voltage. The low voltage will be selected as 6.6 kV.

3) Start-up Transformer

When the power plant starts up, the station auxiliary equipment will receive power from an electric grid via the start-up transformer. However the start-up transformer will usually receive power from the switchyard and will be rated to supply power to the facilities for common use and emergency power supply of the station.

When the unit auxiliary transformer is out of service, the station start-up transformer will tentatively supply all units and station auxiliary loads.

Therefore, the capacity of the start-up transformer is the same capacity of one unit auxiliary transformer, which is 70 MVA.

The start-up transformer will be a three-phase, oil-filled, three-winding transformer located outdoors in the transformer bay adjacent to the main transformer. Their high-voltage windings will be wye connected and their low-voltage windings will be double wye connected with embedded delta, grounding transformer/resistor combination to limit ground faults. Cables or non-segregated bus ducts will connect the station auxiliary transformer's low-voltage terminals to the 6.6 kV switchgears.

4) Power Transformer

The power transformer will usually receive power from the 6.6 kV metal-clad switchgear and will be rated to supply power to the 440 V load center.

Therefore, the function of the power transformer is to step down 6.6 kV of the auxiliary power system to 440 V of the power system.

(3) Auxiliary Power System in the Station

Auxiliary power system is composed of unit auxiliary power system, common auxiliary power system and DC/emergency system. Main equipments are included metalclad switchgear, load center, control center, electric board, DC battery/UPS system and diesel generator. Those equipments' basic specifications are shown in table 7.3-23.

Table 7.3-23 Specification of Auxiliary Power System

Items	Specification
Metalclad Switchgear	
Rated Voltage	7.2kV
Beaker Type	Vacuum Circuit Breaker or SF6 Gas Circuit Breaker
Rated Current	3,000A or 3,150A (for receive and bus tie)

	2,000A, 1,200A(1,250A) or 630A (for feeder)	
Interrupted Current	40kA and over (25kA and over for 630A breaker)	
Load Center		
Rated Voltage	440V	
Beaker Type	Air Circuit Breaker	
Rated Current	(for receive and bus tie) (for feeder)	3,000A or 3,200A 1,000A (1,250A) or 800A
Interrupted Current	60kA and over (40kA and over for 800A breaker)	
Control Center		
Rated Voltage	440V	
Beaker Type	Mould Type Circuit Breaker (MCCB)	
Rated Current	(for receive)	1,000A
	(for feeder)	400A /or under
Interrupted Current	25kA and over	
Diesel Generator		
Type	Indoor, Brushless 3phases Synchronous Generator	
Rated Capacity	about 3,000kW (3,750kVA)	
Rated Voltage	AC440V 50Hz	
Power Factor	0.8(lag)	
Insulation Class	Class F (Temperature rise class B equivalent)	
Constitution of Diesel Generator Facility	(a) Diesel Engine (c) Fuel Feeding System (e) Intake and Exhaust Air System (g) Diesel Generator	(b) Cooling Water System (d) Lubricate Oil System (f) Stating System (h) Ventilation and Fire Protection Equipment of the Building
DC Power System		
Battery	Lead calcium type One set (2x100%)	
Battery Charger	One set (2x100%)	
DC switch Board	One set	
Distribution Switchgear and Board	One set	

Source: JICA Survey Team

1) General Description

a. Redundancy Principle

The AC auxiliary system will be designed to allow the continued functioning at full load of the generating unit with unit auxiliary transformer or start-up transformer being taken out of service.

b. High Reliability

The design of the electrical system for auxiliary power circuit and the selection of the equipments are carried out in consideration of reliability, performance, economy and operability. It is necessary that the selected equipments have the good operating experience by the latest technology.

c. Auxiliary Loads and Auxiliary Transformer Capacity

A coal fired thermal power station has specialty that unit auxiliaries power such as coal handling, ash processing, coal pulverizer and larger environmental measures facilities are equipped. Therefore unit auxiliary power ratio reaches 7 to 8% of the generator rated output. On the Project, unit auxiliary power ratio is set with approximately 7.0% for calculation of auxiliary circuit capacity in consideration of facilities upsizing by lignite coal 20% mixture. In addition, samples of approximate auxiliary loads are shown Table 7.3.24.

The capacity of the unit auxiliary transformer will be selected 70MVA of the capacity from the generator output 776MVA x 0.07=54.3MVA as having margin in this feasibility study. The capacity of the start-up transformer will be selected the same capacity 70MVA as the unit auxiliary transformer.

d. Voltage Level and Interrupting Current

When the short circuit accident in medium voltage auxiliary circuit occurs, the interrupting current exceeds 40kA in 6.6kV medium voltage circuit, because the capacity of the unit auxiliary transformer and the start-up transformer are large together. In addition, if 11kV is applied the circuit voltage, the interrupting current is controlled by less than 40kA. But costs of the equipment rise when 11kV is adopted.

However, if 6.6kV auxiliary power circuit is considered to be 2(two) systems by dividing 6.6kV secondary side of the both transformers in two, the interrupting current is controlled by 40kA or less. In addition, by being considered to be 2(two) systems by dividing, spread of accident is reduced. In consideration of economy, reliability and operability of the equipment, 6.6kV second side of the transformer will be divided in two in this case.

Table 7.3-24 Sample of Approximate Auxiliary Loads

No	Name	Rated Output (kW)	Quantity	Input Power (kVA)	MCS Group	Remarks
1	Primary Air Fan	1.900	2	4,420	A:1set, B:1set	
2	Pulverised Mill	1,000	5	4,650	A:3set , B:3set	1 set spare
3	Forced Draft Fan	2,400	2	3,920	A:1set, B:1set	
4	Induced Draft Fan	5,200 (2,600×2)	2 (Motor×2)	8,480	A:2set , B:2set	Tandem Motor
5	Gas Recirculation Fan	1,600	2	2,600	A:1set, B:1set	
6	Boiler Feed Pump for Start-up	4,000	1	(4,100)	B:1set	For Start Up and Low Load
7	Boiler Feed Booster Pump	540	2	1,160	A:1set, B:1set	
8	Condensate Pump	250	2	580	A:1set, B:1set	1 set spare
9	Condensate Booster Pump	560	2	1,200	A:1set, B:1set	1 set spare
10	Circulating Water Pump	2,200	2	4,700	A:1set, B:1set	
11	Auxiliary Cooling Water Pump	480	1	520	A:1set, B:1set	1set:spare
12	Feeder for $DeSO_x$ MCS	8,000kVA	1	7,200	A:1set	
13	Transformer for ESP LC	3,000kVA	1	2,700	B:1set	
14	Auxiliary Power	3,000kVA	2	5,400	A:1set,	

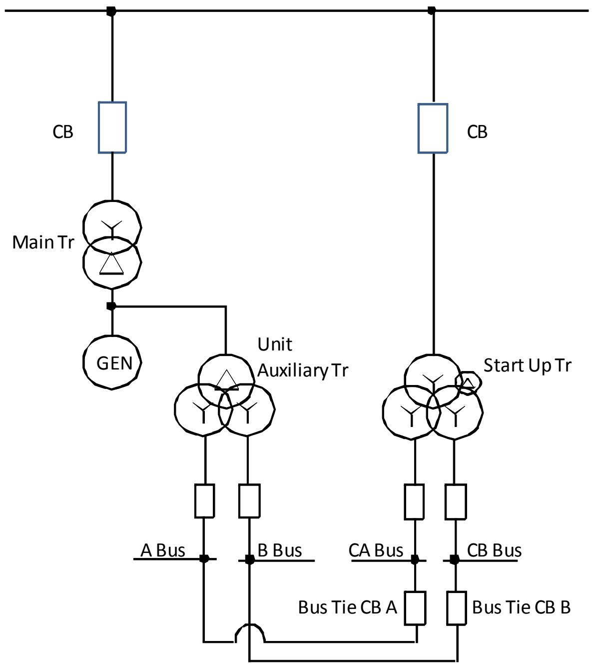
	Transformer for LC				B:1set	
	Total Unit Auxiliary Loads (kVA)	47,530 kVA / 776,000 kVA = 0.061				
15	Conveyer for Coal	260	2	620	CA:1set CB:1set	
16	Auxiliary Air Compressor	400	1	460	CA:1set CB:1set	1set :spare
17	Instrument Air Compressor	250	1	290	CA:1set CB:1set	1set:spare
18	Forced Feed Blower(for Ash Handling)	660	2	1,560	CA:1set CB:1set	
19	Transformer for Coal Yard LC	2,000kVA	1	1,800	CA:1set	
20	Transformer for Ash Handling LC	2,000kVA	1	1,800	CB:1set	
21	Power Transformer for Emergency LC	3,000kVA	1	2,700	CA:1set	
22	Power Transformer for Common LC	3,000kV	1	2,800	CB:1set	
	Total Common Auxiliary Loads (kVA)	11,930 kVA / 776,000 kVA = 0.015				
	Total Auxiliary Loads (kVA)	59,460 kVA 776,000 kVA = 0.077				

Legend) MCS:Metal Clad Switchgear, LC: Load Center, A:Unit A Group MCS, B:Unit B Group MCS,

CA: Common A Group MCS, CB:Common B Group MCS

Source: JICA Survey Team

The secondary side of the unit auxiliary transformer and the start-up transformer will be divided two winding and each other will be connected in the bus of auxiliary power circuit. An example of the one-line diagram of auxiliary power circuit is shown in Figure 7.3-28.



Source: JICA Survey Team

Figure 7.3-28 One-line Diagram of Auxiliary Power Circuit

2) System Configuration

a. Design Concept

Main and auxiliary electrical power system are required as shown on the attached One Line Diagram Drawing, which provides power for both normal and emergency operation of the unit and common auxiliary equipment.

Under normal circumstances the auxiliary power supply for the unit equipment will be derived from the output of a generator unit via the unit auxiliary transformer. And the auxiliary power supply for the common equipment will be derived from the start-up transformer..

It will be proposed that rating parameters and plant specifications be based on IEC Standards and that voltage levels of 6.6kV and 440V will be adopted as follows.

- ✓ 6.6kV, 3phase, 3wire is for motors rated above 200kW and for bulk power distribution.
- ✓ 440V, 3phase, 3wire is for motors rated less than 200kW and other 3phase loads.
- ✓ AC 220V, 2wire is for small loads requiring single phase power.

- ✓ AC 110V, 2wire is for essential control circuits and emergency drives.

The 6.6kV medium-voltage system consists of four separate switchgear buses that is unit A, B common A and B. The 6.6kV system will be designed to provide sufficient power to satisfactorily the connected unit loads or common loads and to serve as the supply for 440V low-voltage system.

The 440V low-voltage system will serve as the supply to electric motors and other loads rated 440 volts and below. The power source will be the medium-voltage system by means of 6.6kV-440V step down transformer.

b. Unit Auxiliary Power System

The unit has one auxiliary transformer and it's the secondary low-voltage side is divided into two windings by 6.6kV. The systems which are divided two are connected to the buses of the auxiliary power system for a boiler and a turbine.

Under normal conditions, each 6.6kV bus is configured in a simple radial configuration fed from its upstream supply unit auxiliary transformer with a normally open the breaker interconnecting the two bus sections..

In the event of a unit trip or loss of the unit auxiliary transformer, a fast transfer to the start-up transformer will be initiated. The transfer will utilize a contact of the incoming feeder breaker from the unit auxiliary transformer to initiate the closing of the start-up transformer supply breaker. The transfer will be supervised by a synchro-check relay and will also be inhibited for a bus fault on the 6.6kV system or lack of voltage on the backup supply bus.

The 440V load center or motor control center will be either radial connected to the supply source or of a split bus arrangement with a normally open the breaker interconnecting the two bus sections. When the split bus arrangement is used, each bus section will be fed from a separate transformer, and the tie breaker will be interlocked to allow it to be closed only when one of the primary source feeders is open. The operation of the transfer from one transformer to the other and the operation of the tie breaker are to be done manually.

In order to set above design concept, following systems are compared and Conventional system is selected.

Table 7.3-25 Comparison between Conventional System and GMCB System

Item	Conventional System (No GMCB System)		GMCB System	
Normal Unit Start-up				
-Aux. power supply	By Start-up TR		By Auxiliary TR	
-Synchronization	Main TR H.V. side CB		GMCB	
- TR Transfer	From Start-up TR to Aux. TR at about 25% load (Automation transfer)		Not necessary	#
House load Operation				
-Parallel Off	Main TR H.V. side CB		Main TR H.V. side CB	
- Synchronization	Main TR H.V. side CB (Same as start-up mode)	#	Main TR H.V. side CB (Different CB from start-up by GMCB)	
GMCB Cost	Non	#	GMCB cost	
Necessary Capacity of Start-up TR	Start-up 25% aux. load + Common load		Common load (Capacity can be smaller)	#
Practical accomplishment	Many for 660MW class	#	Not so many for 660MW class	
# : Merit of the system, GMCB : Generator Main Circuit Breaker TR : Transformer, H.V. : High Voltage, CB : Circuit Breaker				

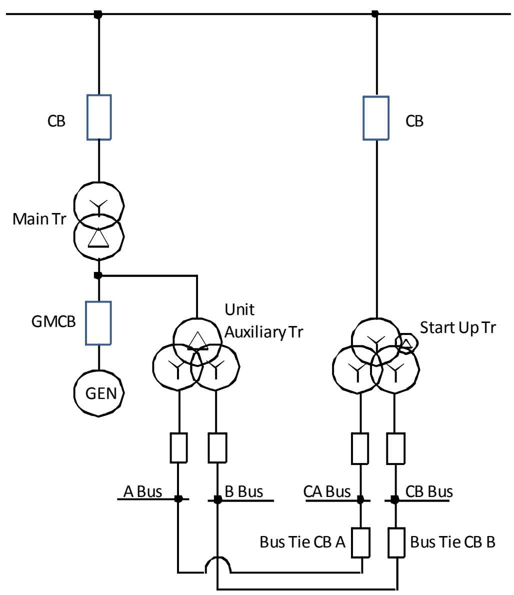
According to the above comparison, Conventional system is recommended because of the following merits,

-Price of the system is lower because of no GMCB. (Around several ten million Rs)

-Synchronization is simple by the same CB for Start-up mode and for House load operation.

-There are so many cases of practical accomplishment for 660MW class.

An example of the one-line diagram of auxiliary power circuit with GMCB is shown in below.



Source: JICA Survey Team

Figure 7.3-29 One-line Diagram of Auxiliary Power Circuit with GMCB

c. Common Auxiliary Power System

The common auxiliary power system has one start-up transformer and it's the secondary low-voltage side is divided into two windings by 6.6kV.

The common auxiliary power system will supplies the electric power for common facilities. Therefore emergency equipments, coal storage yard and coal handling equipments and ash handling equipments, etc. are installed at common auxiliary power system. Generally, the common auxiliary power system will be supplied from the start-up transformer.

The electric power of the 440V emergency bus will be supplied from the 440V common bus usually via emergency load center. But when this power is not received, emergency power will be supplied from a diesel generator. The electric power of the important auxiliary machines and the valves of the plant will be supplied from this emergency bus.

d. Direct Current (DC) Power System

The plant DC power supply systems will be provided to supply power to the various DC loads required for station operability recovery from a sustained loss of AC power.

Under normal conditions, with AC power available, the power to the DC system will be supplied by the battery chargers. The charge will be maintained slightly higher than battery open-circuit voltage so as to maintain a "float" condition on each cell.

With a loss of AC power, the DC loads will be supplied by the battery itself. Upon restoration of AC power, the chargers will resume servicing the DC load requirements as well as recharging the batteries.

The batteries will be of the lead calcium or nickel cadmium type. The batteries will be sized to supply power for a period of time consistent with that required to place the units in a shutdown condition and to prevent equipment damage following a loss of AC power. Battery sizing will be adjusted based upon aging and temperature correction factors.

Battery chargers will be sized on the premise of supplying normal DC station loads while concurrently recharging the respective battery from a design minimum to full charge within 24 hours.

The DC system will comprise a nominal 110V DC station system with 2x100% batteries and 2x100% battery chargers in this feasibility study.

The minimum acceptable level of reliability in the system is that it should meet its full operational requirements with one battery out of service. Batteries will be rated such that one battery can meet the requirements of the generating unit for a minimum period of 60 minutes in the event of a total loss of AC supplies. This protects the security of the plant in the event of a battery failure and permits off-line boost charging, discharge testing etc.

Batteries will be located in a location separate from other plant equipment. Ventilation will be provided to minimize the potential for hydrogen accumulation. Heating and/or cooling of the batteries will be as required to minimize capacity de-rating due to low temperatures, and to reduce the impact on battery life caused by elevated temperatures.

The DC 110V system will serve the following.

- ✓ DC supply for safe shutdown of turbine and boiler auxiliaries such as the lubricating oil pumps etc, in the immediate aftermath of a total loss of normal AC supplies
- ✓ Controls and Instrumentation Equipment
- ✓ Uninterruptible AC Power Supply (UPS) system
- ✓ Emergency Lighting etc.

e. Un-interruptive Power Supply Equipment (UPS, CVCF)

The AC 110V un-interruptive power supply equipment will supplies a high quality stable power with constant voltage and constant frequency appropriate to the demand of the load side.

The AC 110V UPS system will comprise two inverter/static switch modules, connected in a parallel redundant mode, such that they normally share the load. Upon the failure of one module, it will automatically shut down and the other module will take the full load.

This system will allows either module to be taken out of service for maintenance, leaving the remaining module to supply the load.

Under normal operation, the UPS power will be supplied from AC to DC rectifier feeding a DC to AC inverter. The station battery also will feeds into the inverter so that there is a constant power source if AC power is lost.

The AC 110V UPS system will service the following.

- ✓ Fire Protection and Monitoring
- ✓ Control Equipment

- ✓ Turbine Supervisory Equipment
- ✓ Workstation and Emergency lighting etc.

3) Switchgear and Electric Board

a. Basic Plan

The auxiliary power system will be planned with the following voltage and the switchgear as shown in table 7.3-26.

Table 7.3-26 Auxiliary Power System

Medium Voltage	AC: 6.6kV	Metalclad Switchgear (to use a vacuum circuit breaker or SF6 gas circuit breaker)
Low Voltage	AC 440 V	Load center (to use an air circuit breaker)
		Control center (to use a mould type circuit breaker)
	AC 220 V	Control panel (to use a mould type circuit breaker) and Distribution panel
	AC110V	Distribution panel
	DC110V	

Source: JICA Survey Team

The following voltage and the switchgear will be applied to the following load.

- ✓ 200kW and over in motor capacity : 6.6kV Metalclad switchgear
- ✓ 90kW and over, less than 200kW in motor capacity : 440V Load center
- ✓ Less than 90kW in motor capacity : 440V Control center

The basic specifications of the switchgear in auxiliary power system are shown below in this feasibility.

b. Medium Voltage Metalclad Switchgear

Unit auxiliary and common auxiliary group will be installed to two auxiliary power system of 6.6kV A, B and common A, common B respectively.

The 6.6kV switchgear will be of the metal-clad, fully enclosed and arcing fault contained type. Circuit breakers and switching devices will be horizontally withdrawable and their mechanisms will be electrically operated. The interruption technology is vacuum type or SF6 gas type.

Circuit breakers of the same continuous current rating will be interchangeable. Likewise, switching devices of the same rating will be interchangeable.

Circuit breakers will be rated 40kArms symmetrical for interrupting duty and short-time current rated for a period 1 second.

The switchgear will be equipped with all necessary interposing relays, auxiliary relays, switches and contacts as required.

c. Low Voltage Load Center

Unit auxiliary and common auxiliary group will be installed to two auxiliary power system of 440V A, B and common A, common B respectively.

The low voltage switchgear will be of the metal clad, fully enclosed type using air circuit break technology.

Main incoming, bus section and interconnector switching will employ circuit breakers

Equipment of like kind and of the same continuous current rating will be interchangeable.

Main power supplies switchgear will be rated 60kA rms symmetrical for interrupting duty and short-time current rated for a period of 1 second.

The circuit breaker will be of the withdrawable type, electrically operated stored energy type circuit breaker.

The switchgear will be equipped with all necessary interposing relays, auxiliary relays, switches and contacts as required.

d. Low Voltage Control Center

A necessary group number will be installed to unit auxiliary and common auxiliary group. All 440V contactor will be of the enclosed, electro-magnetically operated air break type. With 70% voltage at the coil terminals, the contactors will be not chatter or part when motor starting current is flowing.

All breakers and contactors of the same rating will be interchangeable. The switchgear will be equipped with all necessary interposing relays, auxiliary relays, switches and contacts as required.

e. Electric System Board

An electric system board will be installed in the central control room. And on-off switching condition of the breaker and operating condition of electric system will be displayed. Electric system including to the switchyard for the connection to the electric grid will be displayed in this system board. This board is comprised the following contents.

- ✓ Simulated Electric System Display Panel
- ✓ Lump Indicator
- ✓ Control Switch for Breaker

Distribute Board and Local Operating Board

4) Electrical Motors

a. General

All medium and low voltage motors will be designed to start fully loaded by the driven equipment and to accelerate their connected loads to rated speed with a minimum of 80% of rated terminal voltage.

Motors 200kW and larger will be fed from the 6.6kV switchgear. Motors smaller than 199kW will be fed from the 440V voltage load center or motor control center. Motors that are smaller than 0.75kW will be fed single phase AC220V. DC motors will be powered from DC110V system.

All motors will be totally enclosed. In all cases except special instances such as submersible motors, the primary coolant will be air. The preferred secondary coolant will be air but water is acceptable, where manufacturer's standard or the overall pump/ motor/ bearings system requires water to achieve an optimum standard design.

b. Service condition

Motor for unit or common auxiliary service will be capable of running satisfactorily under the most onerous service conditions for five minutes with the supply at the motor terminals as low as 75% of system rated voltage with frequencies within the range 48.5 to 51Hz.

Unless otherwise approved, AC motors will be three-phase cage induction type with a rated speed not exceeding 1500rpm and suitable for starting direct-on-line. If special starting equipment is required, it will be provided with the associated motor and interconnecting cabling.

The duty point load of the motor will be not more than 90% of its nameplate rating.

DC motors will be capable of driving the associated plant continuously under the most onerous service conditions when the voltage at the motor terminals varies within the limits 95% and 110% of the system rated voltage and of running satisfactorily for one hour under the most onerous service conditions when the voltage at the motor terminals is 80% of the system rated voltage.

Unless otherwise approved, the insulation system used on all motors will be rated at Class F, but the limit of temperature rise will be not exceeding that nominated for Class B insulation.

5) Emergency Generator Systems

a. General

The emergency diesel generator system is utilized to supply AC power to selected plant loads following a loss of station AC power.

This generator will be supplied complete with accessory component required for the operation of the diesel engine.

Diesel electric generator and its auxiliaries will be independent operated and capable meet all power requirements in the Power Plant.

b. Design Principle

The diesel engine rating will be adequate of continuous power for boiler /turbine units and associated auxiliary plants providing in a safe condition following a shut-down under emergency conditions with a margin of at least 10%.

The diesel will receive a start signal from an under-voltage relay from the emergency bus. Following a brief time delay to override any transient under-voltage, the diesel will start and come up to rated frequency and voltage. The operator will then close the breaker to energize the diesel to the emergency service bus of unit.

Diesel generator will be self-contained requiring no external power source for starting.

The loads to be supplied by the diesel generator in an island condition are emergency equipments such as following equipments.

- ✓ AC turbine turning gear
- ✓ AC turning gear oil pump
- ✓ AC hydrogen seal oil pump
- ✓ AC turbine oil tank vapour extractor
- ✓ Battery chargers
- ✓ Plant control room lighting(via battery chargers/UPS)

Diesel generator will be able to start with remote operation by hand or automatic.

Shutdown of the diesel generator will not occur automatically on restoration of normal AC supplies, but only by manual operation action.

Starting time that is required time reaching the rated load after receiving a start signal will be shortened to minimum time from 20seconds to 30seconds.

6) Electrical Protection System

a. Plant Protection Philosophy

The unit plant (boiler, turbine and generator) will be equipped with protection systems which trips the plant in case of dangerous conditions or when critical process variables exceed their permissible values. The unit protection system will provide high reliability and yet avoid spurious trips through the use of redundant signals.

b. Protection System Design Feature

Comprehensive protection is provided by a combination of hardware and software systems to minimise dependence on operator.

Process protection to include unattended automatic protection operations, including run-back actions or plant tripping.

Protection systems designed to achieve maximum system reliability and availability.

Fail safe- designs to be employed throughout for normal and emergency operation of the plant.

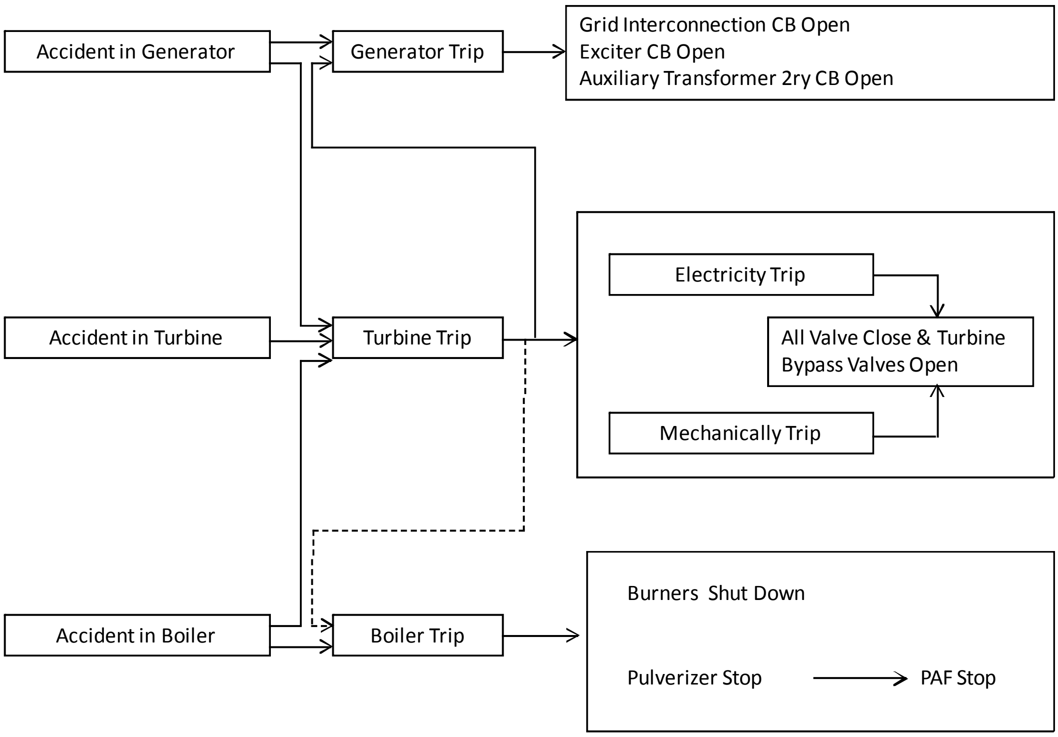
Have redundant and reliable power supplies with no signal point of failure fed from Uninterruptible Power Supplies (UPS) power supply system.

Protection systems ensured that the plant shuts down safety in case of a unit trip.

Protection operations segregated from control system.

c. Generator Main Circuit

For the protection method of unit, a protection interlock will be taken each other so that an accident will not spread at the time an accident of a boiler, a turbine or a generator. The concept of the protection interlock method of the unit is shown in Figure 7.3-30.



Source: JICA Survey Team

Figure 7.3-30 The Concept of the Protection Interlock Method of the Unit

For the related equipments, an automatic trip method will be applied, so that the damage to give generator facilities becomes minimum and the disturbance to give a power system is minimized when a serious accident occurs.

At the time of the accident of the generator, follows are tripped as the related equipments.

- ✓ Turbine Trip

- ✓ Main Circuit Breaker Trip for Connected Electric Grid.
- ✓ Main Circuit Breaker Trip for Main Circuit around a Generator.
- ✓ Generator Field Circuit Breaker Trip
- ✓ Auxiliary Transformer Circuit Breaker Trip

In case of the accident at the grid system, the main circuit breaker will be opened and the plant system is transferred to House load operation, where the turbine generator supplies auxiliary power inside the unit.

(4) Other Electrical Equipment

As other electrical equipment, there are communication facility, lighting and miscellaneous facility, earthing and lightning protection system and cable system. The specification of this equipment will be selected at the detail design stage.

1) Communication Facility

a. General Description

The Communication facilities of the power station are the equipments which are necessary to keep the operation and the maintenance of the power station a better state in the power system operations. There are the communication facilities with the outside and in the inside.

b. Remote Communication Facility

There are three kinds of methods in remote communication facilities. That is, it is depend on cables, carrier waves and radio. Power line carrier wave communication, microwave communication and optical fiber communication is generally used from cost and experience. With the remote communication facility, the power feeding command and the remote monitoring data of power station (SCAD) will be transmitted.

c. Yard Communication Facility of the Power Station

The purpose of yard communication is the communication between members of operation and maintenance in the yard and monitoring of the main place of the yard. In this, yard telephones, paging devices and industrial monitoring TVs etc. will be installed in the necessary places.

2) Lighting and Miscellaneous Power Facility

a. General Description

The AC440V or AC220V power system will be provided for the distribution of power outlets, welding outlets, lighting system and anti-condensation heaters for the site. The source of power will be the station supply system.

A lighting system will be provided for the site to enable the convenience and safe operation of plant and equipment and the movement of personal.

An emergency and exit lighting system (derived from the UPS) will be installed for the safe passage of personal and for the plant to be operated safely in the event of loss of normal AC supplies.

Lighting in hazardous locations will be specifically designed for use in those areas. The lamp installation at hazardous areas is according to International Standards for Hazardous Areas.

Aviation red obstruction lighting will be provided in accordance with International Standards and the Recommended Practices of the International Civil Aviation Organisation.

b. Lighting General Requirement

The requirement of the lighting facility is as follows.

Safety

The safety state will be accomplished by the next matter.

- ✓ The illumination intensity of a required part is suitable.
- ✓ The difference of the illumination intensity with the circumference is not large.
- ✓ There is no glare.

Fatigue of Operator

According to the experience, fatigue of operator is influenced by a kind of the illumination. Therefore it is necessary to pay attention to not only the illumination density but also a colour tone.

Maintenance and Management

By the size of the area to light up and the illumination density to be necessary, the lighting equipment to be chosen changes. It is necessary to be chosen the lighting equipment which the maintenance and the management are easy, considering its length of life.

3) Earthing and Lighting Protection System

a. General Description

The earthing and lightning protection will include the installation of the comprehensive meshed earth grid which is enhanced by driving rods and by connection to reinforcing steel in concrete piles and foundations.

The earthing system will be adequately designed and installed to the switchyard, power station site and the external plants.

b. Earthing Protection System

The earthing device contributes to the safety operation of the power station by protecting the facility and the human body from a ground fault and a thunderbolt electric current. By being connected to the earthing mesh, the following matter will be satisfied.

- ✓ To be able to integrate because a outer cover of all electric equipment and a steel structure are connected to grounding mesh with a ground wire of appropriate size surely.
- ✓ To be suppressed the grounding resistance of the whole grounding low to limit a rise in voltage at the outside accident.

c. Lightning Protection System

The main function of the lightning protection system are catching, before the structure is struck by lightning directly and are preventing doing damage to the structure, by making the ground discharge a lightning current safety. It is necessary to study it at details design stage whether a lightning rod is necessary for which structure facilities.

Design policy is shown as follows.

The lightning protection systems will be strongly interlinked with the plant earthing system through suitable conductors.

The lightning protection will be determined at soil testing duration on chemical, resistively configuration and moisture content.

The lightning protection will be designed based on stable satisfy for all equipment and transformer.

4) Cable System

a. General

The cable systems connect the power sources to the electrical equipment and devices. Here, the power cables less than 6kV of the second side of the unit auxiliary transformer and the start-up transformer and the control / communication cables are described as follows.

b. Cabling Requirement

When planning cable type and routes (racking, conduits etc) the EPC Contractor will comply with the following requirements.

Cables will also be segregated to ensure in the event of damage (e.g. fire) to a particular section of the cable systems (e.g. duty and standby supply cables shall be installed via separate routes).

Cables will also be separated to ensure electromagnetic compatibility between various types of cables. For this purpose all cables are to be categorised into four types, namely;

- ✓ Type 1 : H.V. power cables i.e. 6.6kV cables
- ✓ Type 2 : L.V. power cables i.e. AC 440/220V or DC220V.
- ✓ Type 3 : Control cables i.e. AC 220V or DC 220V & lower, analogue signals
- ✓ Type 4 : Communications cables i.e. Telephones, data networks, LAN's

The minimum separation between the various "Types" shall be as follows;

- ✓ Type 1 to Type 2 : 1000mm
- ✓ Type 2 to Type 3 or 4 : 300mm
- ✓ Type 1 to Type 3 or 4 : 600mm
- ✓ Type 3 or Type 4 : 100mm

These separation distances may be smaller for short runs where cables enter cubicles or crossover or encounter an obstruction (e.g. pipe)

Where a number of cable ladders / trays are required within a particular cable run, the minimum distance between adjacent ladders and trays will be 300mm. This distance may be smaller for short runs in areas where obstacles exist (e.g. pipe).

c. H.V. Power Cables (Type1)

Except the part of the bus-duct, CV cables (Cross linked polyethylene Vinyl sheath cable) will be used in 6.6kV Systems.

d. L.V. Power Cables (Type2)

Heat-resistance CV cables (Cross linked polyethylene Vinyl sheath cable) will be used on AC 440V, AC 220V and DC 110V System.

e. Control Cables (Type3)

Heat-resistance CVV cables (Vinyl insulation vinyl sheath control cable) will be used on control cables

f. Instrumentation Cables (Type4)

Heat-resistance CVV cables (Vinyl insulation vinyl sheath control cable) will be used on instrumentation cables.

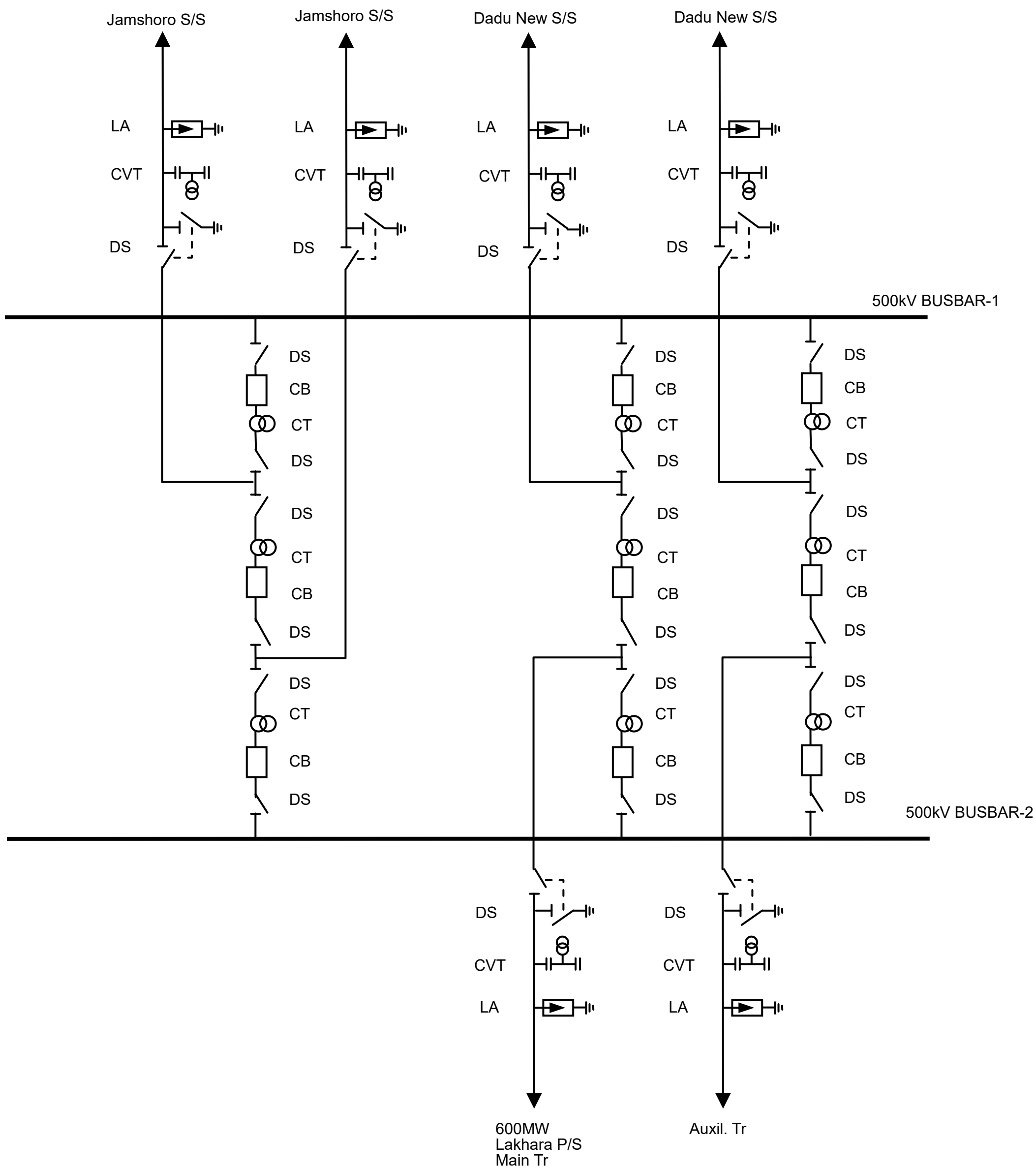
g. Cables Installation

Cables, cable supporting systems and cable accessories shall be in a neat and professional manner. Special attention shall be placed on the requirements of communication cabling to ensure electro-magnetic compatibility.

(5) Switching Station at Lakhara Power Station

1) General

Single line diagram of the 500 kV Lakhra Switching Station is shown in Figure 7.3-31. In order to connect to existing two (2) 500kV transmission lines, the 500kV Lakhra Switching Station is constructed four (4) outgoing feeders.



Source: JICA Survey Team

Figure 7.3-31 Single Line Diagram of 500kV Lakhra Switching Station

2) Specifications and Quantities of Major Equipment

The specifications of equipment applied are in accordance with the standards of NTDC. General electrical requirements for 500 kV equipment and specifications of 500 kV switchgear are as follows:

a. General Electrical Requirements for 500 kV Equipment

i)	Nominal system voltage	500 kV
ii)	Rated voltage (rms value) (Highest voltage for equipment)	550 kV
iii)	Rated frequency	50 Hz
iv)	Rated lightning impulse withstand voltage (peak value) - For other equipment	1,550 kV
v)	Switching impulse withstand voltage, dry and wet (peak value) - For other equipment: phase-earth	1,175 kV
vi)	Rated current	3,150 A
vii)	Rated short-duration withstand current (3 s)	63 kA

b. Specifications of 500 kV Switchgear

All main facilities installed under the Project should be of outdoor type. Major specifications of the equipment are as follows:

i)	Circuit Breakers	- Single pole, SF6 gas type - Rated voltage: 550 kV - Rated normal current: 3,150 A - Short-circuit breaking current: 63 kA - Operation sequence: O-0.3s-CO-3min-CO - Rated short-duration power-frequency withstand voltage (rms): Phase to earth and between phase: 620 kV Across open breaker: 800 kV - Rated lightning impulse withstand voltage (peak): 1,550 kV
ii)	Disconnecting Switches (DS)	- Single pole, Vertical break type - Rated voltage: 550 kV - Rated continuous current: 3,150 A - Rated short-duration withstand current: 63 kA - Rated short-duration power-frequency withstand voltage (rms): Phase to earth and between phase: 620 kV Across open breaker: 800 kV - Rated lightning impulse withstand voltage (peak): 1,550 kV 220 V DC motorized and manual operation
iii)	DS with Earthing Switch	-Same as item b)
iv)	Current	- Rated voltage: 550 kV

	Transformers	- 3000-2400-2000-1250-750/1A, 5P20 & cl. 0.2, 30 VA
v)	Current Voltage Transformers	- Capacitive Type -Voltage ratio: 500 /√3 kV, 110 /√3 V, 110 /√3 V -Accuracy and burden; secondary (measurement): 0.2, 100 VA tertiary (protection): 3P, 100 VA -Coupling capacitance: ≧6,900 pF
vi)	Surge Arresters	- Station type metal oxide arresters with surge counter - Arrester rated voltage (rms): 420 kV - Rated discharge current: 20 kA

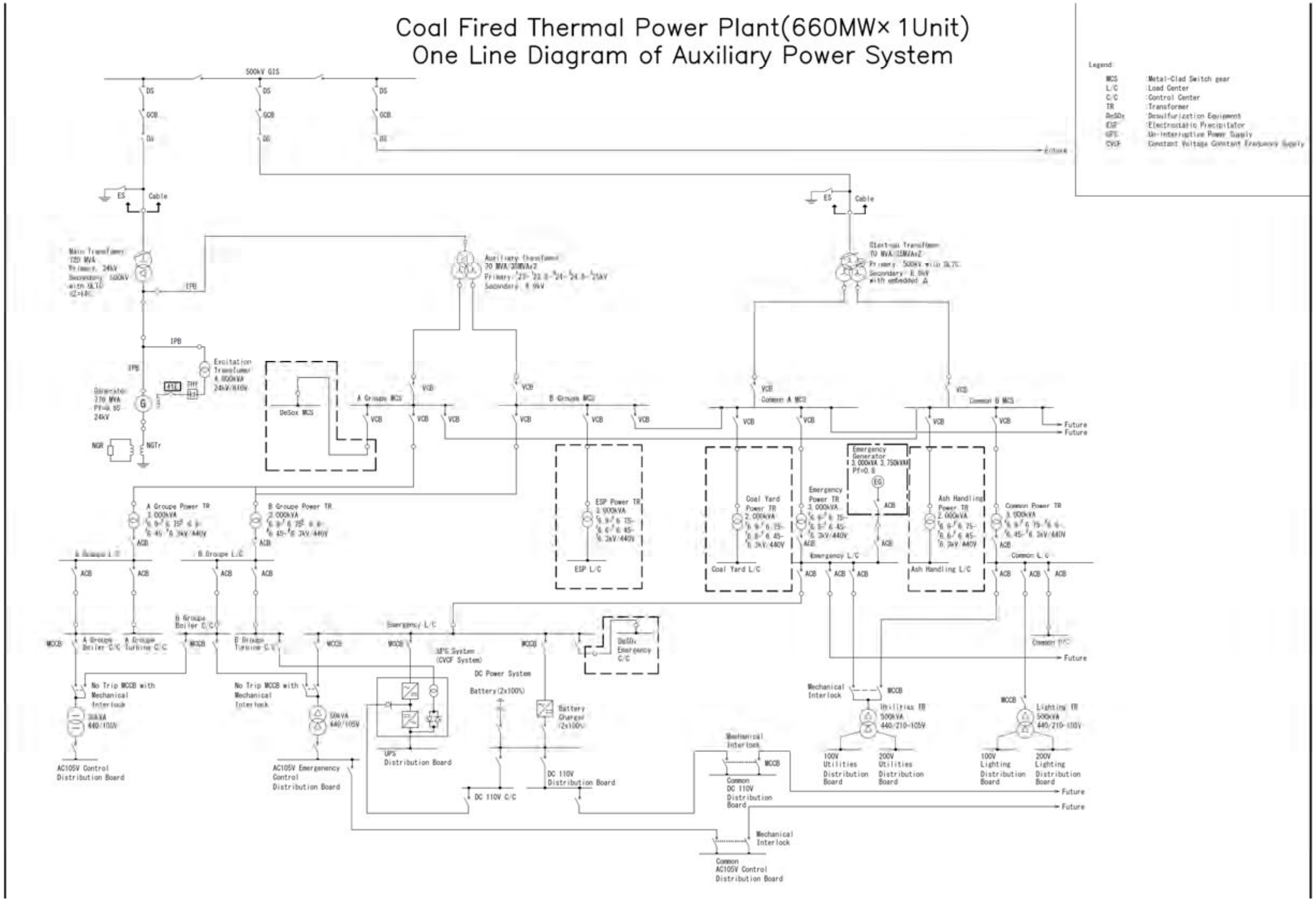
c. Quantities of Major Equipment

With reference to the single line diagram, the quantities of main facilities of each substation required for the Project are shown in Table 7.3-27.

Table 7.3-27 Quantities of Major Equipment

No.	Major Equipment	Quantity
i)	Circuit breakers	9 sets
ii)	Disconnecting switches	18 sets
iii)	DS with earthing switch	6 sets
iv)	Current transformers	9 sets
v)	Current voltage transformers	2 sets
vi)	Surge arresters	6 sets

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.3-32 Single Line Diagram

7.3.6 Controls and Instrumentation

(1) Objectives and design philosophy of control system

1) Objectives

The main objectives of the C&I scheme are as follows:

- ✓ To allow safe start-up, synchronizing, shut-down, emergency tripping, control and monitoring of all major plant equipment.
- ✓ To allow the optimized and efficient use of all plant equipment.
- ✓ To maximize the availability of all plant.
- ✓ To incorporate a maximum level of automatic control under all specified conditions (run up, normal operation, disturbance, runbacks and rundown) automatically and/or under remote manual control.
- ✓ To provide facilities for comprehensive monitoring, storage and presentation of information concerning plant conditions.
- ✓ To provide facilities for comprehensive testing and presentation of information concerning of system and plant performance.
- ✓ To centralize plant monitoring and control facilities.
- ✓ To reduce start-up and shut-down sequence times to a minimum whilst minimizing mechanical and thermal stresses imposed on the plant.

2) Design Philosophy of Control System

a. Overview

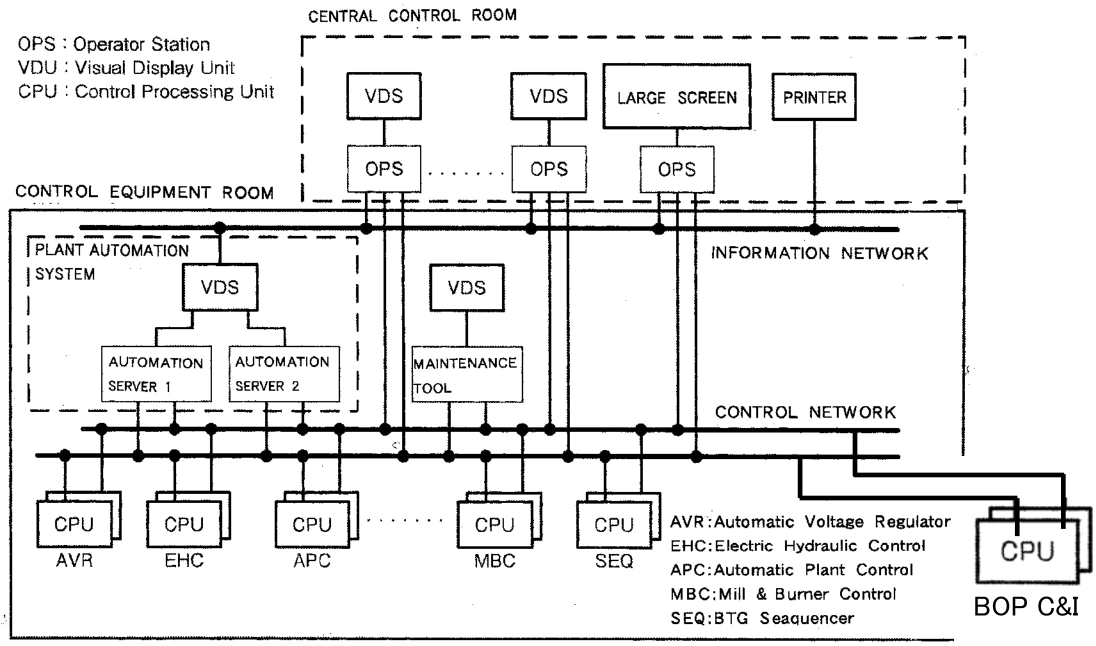


Figure 7.3-33 Conceptual Diagram of Control System

Source: JICA Survey Team

The control and monitoring system to be supplied for Lakhra TPP shall be an Integrated Control and Monitoring System based on commercially available Distributed Control System (DCS) hardware. The hardware and software platforms offered shall be from systems designed and proven for thermal power plant applications.

All equipment provided shall be of current design and manufacture and commercially available from the system or equipment manufacturer. Components and parts offered for this service must have demonstrated in service hours at other coal fired thermal power plants of similar size and complexity & continued serviceability in foreign countries for at least five years.

b. Integrated control & monitoring system

One typical design of the Integrated control & monitoring system for Lakhra TPP will comprise:

- Unit control and monitoring system, and

- BOP control and monitoring sub systems.

The Unit control and monitoring system will include followings.

- Automatic plant control system (APC)
  (composed of unit co-ordinated control, boiler master control and turbine master control)
- Mill and Burner Control System (MBC),
- Electro Hydraulic Control System for turbine (EHC),
- Plant automation system (Automatic plant start and shut down control system)

BOP systems are equipped with following control and monitoring systems by the DCS.

- Flue Gas Desulfurization (FGD) control,
- Electrostatic Precipitator (ESP) control
- Coal feed and coal unloading control system
- Ash discharge control system,
- Cooling water system and Cooling tower control system
- Water treatment control system
- Waste water treatment plant control system,
- Air compressors control system,
- Station electrical control system,
- Fire protection system,
- Diesel Generating facilities control system,.

c. Design requirements

The Integrated control and monitoring system shall comprise a process monitoring, function display, processing, data logging, data storage, data history systems and data retrieval, alarm processing, process reporting and other functions for unit and station operation.

All control and monitoring facilities shall be suitable to industrial and hot weather conditions. Individual requirements are as follows:

- ✓ Maximum safety for the equipment and plant personnel.
- ✓ Reliable, high available & predictable control.
- ✓ Efficient operation of the plant under all operational conditions.

The malfunctions of any component or loss of power supply is to lead to fail-safe condition and be alarmed.

Redundancies shall be provided so that the failure of a single component shall not contribute to abnormal or unsafe conditions, degrade the performance or shorten the life of the plant and monitoring system.

Protection systems for the boiler, the turbine and all critical trip inputs shall have full redundancy of hardware.

The system is to provide accurate and reliable information to the plant operators, maintenance staff, engineering staff and management to allow decisions to be made and actions be taken to ensure safe, reliable and efficient operation of the equipment.

The integrated Man Machine Interface system (MMI) is based on the graphics database and information system.

Control and monitoring of main plant from a centralized plant control room.

The system shall have functions of process calculations, alarms, history storage and data retrievals.

All process control systems shall be microprocessor based with electrical transmission of all process measurements and control signals.

(2) Control system structure and functional requirement

1) Control and monitoring system structure

The control systems shall utilize a multi-level hierarchical control structure. One typical hierarchical control structure divides plant control into several distinct control levels such as follows:

a. Unit control level

The Unit control level will control followings:

- Unit co-ordinated control of boiler and turbine
- Start up or shut down the entire unit plant using a single control command. Through the start-up or shut-down sequences at the sub-unit control levels to start up or shut down unit appropriately.

b. Master group control Level

The master group control level contains a collection of functional drive groups.

Followings are examples;

- Vacuum up and break system
- Furnace purge system
- Feed pumps system start-up and shutdown
- Air and gas system start-up and shutdown

c. Functional group control

The functional group control level is based on a group of drives used solely to support the operation of a single major drive. For example, a boiler feed pump will require drives for lubrication pumps, discharge valves, recirculation valves, hydraulic coupling and gland water. All of these drives are grouped together so that they can be controlled from a single logic source.

d. Drive level control

Drive level control is the control function of individual motors or other drives, such as pump motor or valve control drive.

The Control system mentioned above will incorporate the following design features:

- ✓ The sequence control system will be hierarchically organized into distinct levels.
- ✓ Standard software modules and DCS interfaces to motor and actuator switchgear control circuits.
- ✓ The automatic sequence control system will be independent of the plant protection system.
- ✓ Automatic sequence control will carry out pre-start checks.

2) Unit plant modulating control functional requirements

a. Unit co-ordinated control system

This control system provides overall control of the boiler and turbine, including the capability limits and other overrides that occur in the event of any restrictions on unit operation.

Unit Load (MW) Control

Frequency bias control

The unit co-ordinated control system will give the control signals to the turbine master of the desired electrical output of the unit and to the boiler master which corrects amounts of fuel, water and combustion air are supplied to the boiler..

The unit co-ordinated controls will include the following essential features:

- ✓ Ability to allow unit load to be varied automatically and remotely from the central load dispatch center.
- ✓ Facilities to allow the unit to automatically participate in the regulation of system frequency.
- ✓ Ability to operate in either fixed or sliding pressure control.
- ✓ Automatic reduction of unit output on the loss of certain major auxiliaries, or on the occurrence of certain abnormal conditions.

b. Plant control modes and modulating control functions

<u>Load Control Modes</u>

Automatic regulation of the boiler/turbo-generator output will be carried out in one of the following control modes, depending on the operating requirement and condition of the plant at the time.

<u>Unit co-ordinated control mode:</u>

In which co-ordinated signal is gives to the turbine master and the boiler master.

<u>Boiler Follow mode:</u>

In which fuel and combustion air are regulated automatically to maintain constant steam pressure at turbine stop valves while turbine governor is varied manually. Turbine governor setting shall determine the unit load through operator control.

<u>Turbine Follow mode:</u>

In which fuel and combustion air are varied manually by manipulating a single control station while turbine governor is adjusted automatically to match boiler capability as reflected by variations of steam pressure.

c. Boiler modulating control functions

Combustion air flow control

Fuel flow control;

- ✓ Feedwater flow control including BFP turbine control
- ✓ Superheater steam outlet temperature control

- ✓ Reheater steam outlet temperature control
- ✓ Furnace pressure control
- ✓ Flue gas oxygen control
- ✓ Combustion gas exit temperature control
- ✓ PF Mill fuel, Primary air and mill outlet temperature controls etc.

d. Turbine-Generator modulating control functions

- ✓ Turbine speed control by Digital Electro Hydraulic Control
- ✓ Turbine load control
- ✓ Turbine inlet steam pressure control
- ✓ HP/LP Turbine bypass control
- ✓ Main turbine lube oil temperature control
- ✓ Main turbine gland steam press control
- ✓ Condenser level and Condensate circulation controls
- ✓ HP and LP Feed heater level control
- ✓ Deaerator level and pressure control.
- ✓ Generator stator water temperature control
- ✓ H_2 cooler distilled water pressure control
- ✓ Generator H_2 gas temperature control
- ✓ Generator seal oil pressure control etc.

e. Digital Electro Hydraulic Control

The turbine shall be fitted with a Digital Electro Hydraulic Control system (D-EHC) which regulates turbine speed/load both during turbine run-up and on load operation.

The digital control system will be triple or dual system.

When high pressure hydraulic system is used, the system will use fire resistant hydraulic fluid in a high pressure hydraulic power pack to drive electrohydraulic positioners which will be provided for the governing valves.

Triple redundant turbine speed sensors will input to the control system to allow control of the turbine from barring speed to synchronous speed and allow overspeed tests to be carried out when required. The speed sensor heads will detect the speed of a toothed wheel on the turbine shaft.

f. Turbine Bypass System

General

High pressure and low pressure turbine steam bypass systems shall be installed and operate to divert steam from the steam pipe line before the turbine emergency stop valves to the cold reheat steam pipe line and from the hot reheat pipe line to the condenser. The bypass systems will incorporate pressure and temperature control valves to allow de-superheating of the steam prior to application to the reheater and to the condenser.

Functional Requirements

The Turbine Bypass system will allow the boiler to be operated to raise pressure or increase steam temperature without admitting steam to the turbine or using excessive boiler blow down or excessive drain flow to the condenser. The following conditions are the criteria under which the bypass system shall operate:

Shortening start-up time

Warm and hot boiler and turbine restarts will be accomplished using the flow through the bypass system to match HP and re-heat steam temperatures to the turbine metal temperatures prior to the turbine roll on steam.

House load operation capability

In the event of a turbine trip the bypass system will control the main steam pressure and the reheater steam pressure to prevent operation of the boiler safety valves and the resultant high noise levels which would occur with that operation. This emergency operation of the bypass systems will control the maximum superheater and reheater pressures within the limits set .

Stabilizing combustion in the boiler at low load

During extreme transient load decreases, which do not result in a turbine trip, the turbine bypass system will in conjunction with the reduction in boiler firing rate, limit the rate of rise of the superheater and reheater pressures within the limits set by the boiler manufacturer. This will be accomplished by reducing the turbine steam flow to supply "house load" and allow external load to be restored without the delays associated with refiring of the boiler or run-up of the turbine.

3). Turbine Run Up System

a. Control functions

A turbine run up system shall be provided for hot, cold and warm starts. The system will include the following control functions:

- Automatic warming of main and reheat steam piping.
- Turbine pre-start checks.
- Automatic run up to of the turbine speed at a uniform rate.
- Holding turbine speed at a low value for rub-checks.
- Holding turbine speed at selected levels for heat soak period.
- Automatically excite, synchronize and apply initial load to the generator.
- Automatic turbine/generator loading up to rated load

b. Turbine rotor stress monitoring

The control system will receive from the plant measurements of steam pressure and temperature, differential expansion of the casings and rotors; inner and outer metal temperatures of the casings, vibration measurements, shaft eccentricity measurements, speed and any other measurement necessary to determine the level of stress in the rotors and casings of the turbine. The on line rotor stress analysis will provide realtime stress displays and allowable run up parameters for acceleration, speed hold points and hold durations, initial load, initial load hold time, loading rate etc. These run up parameters will control the turbine speed via the D-EHC whilst at the same time optimizing the run-up to allow it to occur as quickly as possible.

The turbine run up system will also operate in conjunction with the turbine bypass system to ensure that there is adequate and not excessive steam flow through the HP turbine to avoid undesirable impact heating of the HP turbine blades.

(3) Plant Information System

A plant information system shall be provided as part of integrated control system.

The plant information will gather process data from the plant and make it available to operators and plant engineers. The function of the plant information system will be:

- Data collection.
- Single point trend, group trend and alarm summary

- Trend log summary, sequence of events log and process graphic displays
- On line and real time plant performance calculations
- Logging & reports (e.g.. Sequence of events, reports, post trip report, plant performance and environmental reports).
- Long term data storage onto optical storage library.
- Long term data retrieval for operation and engineering analysis.
- On-line system documentation storage and retrieval.

As part of the unit plant information system both a boiler and turbine stress monitoring system will be provided which will calculate component stress based upon past and present operating conditions. It will be possible to interface these systems to the unit co-ordinated control system to limit rates of load change.

Printers will be provided to support programming and configuration changes. Failover capability will be provided with no loss of data.

(4) Field Instrumentation

All necessary process and equipment parameters will be monitored to enable the operator to supervise and control the plant from the plant control room. All plant mounted sensors of the same measurement type are to be provided by the same supplier to ensure a consistent standard of equipment, reduce spares handling, facilitate maintenance and ensure consistent installation arrangement.

The instrumentation would incorporate the following design features:

All analog transmitter signals used for modulating control purposes of main equipment would be at least duplicated. The monitoring system would allow operator selection of the input to either transmitter or the average value. The duplicated signals are compared and alarmed if a significant deviation occurs. The control loop would trip to manual and alarm if the signals deviate from each other. The deviation value and time delay to trip would be settable, with the deviation also variable as a function of the signal range.

Important analogy process measurements which generate a unit trip, (e.g. furnace pressure transmitters) would use triplicated transmitter signals and a two out of three voting algorithm.

(5) Central Control Room

In the central control room there will be operator consoles and interfaces from which the plant is operated. On the console three or four of operator station and Visual Display Units (VDU) will be installed with interface to the DCS. In the center of the control room a large video screen is located for the plant operators sitting at his console.

7.3.7 Pollution Abatement

(1) Flue Gas Desulfurization (FGD)

Many types of FGD systems are produced worldwide. Comparison for Some Types of FDG is shown in Table 7.3-28. By reason of feasible to install CCS (Carbon Capture System) later, it is desirable to exhaust flue gas with SO2 as low as possible, therefore Lime - gypsum method is recommended.

Specification of FGD is shown in Table 7.3-29

Table 7.3-29 Specification of FGD

Equipments	Specification	Number
Absorber Module, Recirculation Pumps, Bleed Pumps, Oxidation Air Blowers, Agitators, Dewatering Cyclones, Process Makeup Water Pumps, others	Treatment gas capacity 3,300,000Nm3/h, Efficiency 70-95% variabe	1 set

Source: JICA Study Team

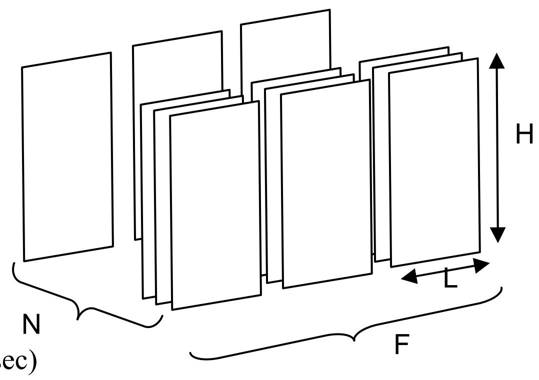
(2) Electrostatic Precipitator (ESP)

As mentioned, it is necessary to install Electrostatic Precipitator with removal efficiency of 99.5% and over in order to satisfy environmental regulation value.

It is known that efficiency of Electrostatic Precipitator is decided on by their volume.

Matts formula which is used to estimate required volume is shown below. And Set of size of precipitator is shown in Table 7.3-30.

$\eta = 1 - \exp(-[SCA \cdot WR]^n)$



η: Precipitator efficiency by Matts formula

WR: Movement speed of PM

SCA: Precipitator ratio (A/Q)

A: Square of precipitator (m2)

Q: Treatment gas volume in precipitator (m3/sec)

n :Constant value (Decided on dust condition, but usually the value n=0.5 is adopted)

Table 7.3-28 Comparison for Some Types of FDG

Items	Lime-gypsum (Wet) Water Saving Type	Magnesium hydroxide (Wet)	Spray-dryer (Semi dry)	Circulation (Semi dry)	Utilizing fly ash (Dry)
Initial Cost	68 - 87 mil USD	48 - 61 mil USD	48 - 63 mil USD	44 - 66 mil USD	76 - 96 mil USD
Operational Cost (in twenty years)	35 – 39 mil USD	39 – 42 mil USD	29 – 32 mil USD	29 – 32 mil USD	15 – 16 mil USD
Efficiency	> 95% Highest efficiency	> 90%	> 70% Low efficiency	> 90%	> 90%
Necessary Water (annual)	1,500,000～1,750,000 m^3	1,500,000～1,750,000 m^3	1,050,000～1,250,000 m^3	1,050,000～1,250,000 m^3	150,000～170,000 m^3
Kind of Chemicals (Toxicity)	Limestone (Calcium hydroxide invades membrane and the skin, especially eye)	Magnesium hydroxide (No problem)	Quick lime (Calcium hydroxide invades membrane and the skin, especially eye)	Quick lime (Calcium hydroxide invades membrane and the skin, especially eye)	Slaked lime (No problem)
By-products	Gypsum	$MgSO_4$	Gypsum	Gypsum + Ash + Quick lime	Gypsum + Ash+ Slaked Lime
Utilization of By-products	Gypsum can be reused for wall or ceiling materials for building.	MgSO4 can be reused as desulfurization agent.	Gypsum can be reused for wall or ceiling of building materials.	By-product not can be reused, as it becomes cocktail	By-product not can be reused, as it becomes cocktail.
Space for Installation	Large area is needed.	Large area is needed.	Large area is needed.	Large area is needed.	Large area is needed.
Abating Dust (PM)	Dust is expected to be abated by FGD.	Dust is expected to be abated by FGD	efficiency of abating PM is decreased	As efficiency of abating PM is decreased	
Extensibility with CCS*	This type is suitable in case of installation of CCS* later	This type is un-suitable in case installation of CCS* later	This type is un-suitable in case installation of CCS* later	This type is un-suitable in case installation of CCS* later	
Conclusion	The efficacy is the highest, so it is suitable in case of installing of CCS later.	The efficacy is low relatively, so it is un-suitable in case of installing of CCS later..	The efficacy is very low, so it is un-suitable in case of installing CCS later.	The efficacy is low relatively, so it is un-suitable in case of installing CCS later.	There are few supply records. Most expensive in initial cost. Supplier is limited
Recommendation	Recommend to Apply				

*CCS: Carbon dioxide Capture Storage (CCS) remains the phase of practical application. As per request from Pakistan government side, extensibility with CCS is included evaluation items.

Prepared by JICA Study Team

Table 7.3-30 Set of size of precipitator

Item	Value	Unit	Remark
H: Height of precipitator	6.0	m	
L: Length of precipitator	4.5	m	
D: Depthth of precipitator	9.0	m	
N: Number of gas way	25	ways	
F: Number of field	3	fields	
A: Square of precipitator	2,025	m^2	=H*L*N*F
Qh: Treatment gas volume in precipitator per hour	2,073,000	m^3/h	
Qsec: Treatment gas volume in precipitator	576	m^3/sec	
S:Inlet square of precipatator	54	m^2	
S:Inlet square of precipatator	10.7	m^2/sec	
η : Efficiency of precipitator	99.781	%	

7.3.8 Common Facilities

(1) Fire Protection

The fire protection system is installed in order to detect and suppress fires, minimize hazards to station personnel, and reduce property loss due to fire.

The fire protection system will consist of water supply system, foam extinguishing system, hand-held distinguishers. Major fire protection area is shown in Table 7.3-31

The fire protection system should be in conformity with the Pakistan standards and with National Fire Protection Association (NFPA) or equivalent international standards. Any signal of fire detectors and suppressers should be transmitted to the main control room and the administration buildings, and will be alarmed.

Water supply system will provide for fire water tank, fire pump house, underground header and sprinklers and hydrants. Fire pump should include the motor driven fire pumps, the emergency diesel fire pump, and pressure maintenance jockey pump. The emergency diesel pump has tank with capacity of amount of fuel oil no less than 8 hours operation at full load. In addition, the inlet of the emergency pump will be connected with raw water tank, in order to supply only when all other options have been exhausted or failed. The underground header will constructed of cement-lined ductile iron or high-density polyethylene (HDPE) pipe. Each hydrant should be installed in distance less than 75m with together. Sprinkler can be classified in wet pipe sprinkler system, dry pipe sprinkler system, pre-action sprinkler system and deluge sprinkler system. Wet pipe sprinkler system is the most popular one with automatic sprinkler heads attached to a piping system containing water and connected to a water supply. Dry pipe sprinkler system that are attached to a piping system containing air or nitrogen under pressure, Dry pipe sprinkler systems are installed in areas where wet pipe systems may be inappropriate such as areas where freezing temperatures might be expected. Pre-action sprinkler system is almost same with point as piping system containing air or nitrogen under pressure. The difference, however, is that water is held from piping by an electrically operated valve, known as a pre-action valve. Valve operation is controlled by independent flame, heat, or smoke detection. Deluge fire sprinkler systems are used where special hazards create a concern for rapid fire spread. These systems provide a simultaneous application of water over the entire hazard to ensure fast and effective suppression of the fire. Water is not present in the piping until the deluge valve is tripped, reducing the risk of leakage or damage to unseen areas of the plant.

Foam fire extinguishing system is used where is assumed to be occur incident to be unsuitable for water supply system, such as oil fire. Foam fire extinguishing system is put out fire by both cooling effect according to water included foam and asphyxiating effect according to blocking air. Foam fire extinguishing system is divided broadly into two categories according to the chemical involved, namely air foam fire extinguishing system and chemical foam fire extinguishing system. But, chemical foam fire extinguishing system is considered obsolete and is installed little to new plant. Air foam fire extinguishing system consists of water source, fire pump, air form concentrate, proportioner, form maker.

Table 7.3-31 Major fire Protection Area

Area	Detection or Actuation Type	Suppression Type	Notes
Turbine Room	None	Water	Hose Stations at main floor and mezzanine
Boiler Room	None	Water	Hose Stations each side all major floors
Coal Transfer towers, Crusher House, and Tripper Area above Silos	Spot Type Smoke Detectors	Water	Dry pipe sprinklers
Coal conveyors	Linear heat detection	Water	Deluge sprinklers
Coal mills (Pulverizers)	Temperature switch	Water	Internal deluge spray
Administration Building, Locker Rooms, Toilet Areas, Telephone and Communications Rooms, Storage Rooms	Spot Type Smoke Detectors	Water	Wet pipe sprinklers
Water Treatment Building	Spot Type Smoke Detectors	Water	Wet pipe sprinklers
Maintenance Shops, Warehouse	Manual pull station (at each doors)	Water	Wet pipe sprinklers
Fuel Oil Storage Tanks	None	Foam	Foam canons
Fuel Oil Truck Unloading Area	None	Foam	Foam canons
Steam Turbine and Generator Bearings	Spot Type Smoke Detectors	Water	Pre-action sprinklers
Turbine Oil Tanks, Piping, Hydrogen Seal Oil	Linear heat detection	Water	Deluge sprinklers
Battery Room	Smoke Detectors	Water	Pre-action sprinklers
Control Room	Smoke Detectors	Water	Pre-action sprinklers
Electrical Equipment Room, Electronics Room, Cable Spreading Room	Spot Type Smoke Detectors	Water	Pre-action sprinklers
Main Transformers, House Transformers, Auxiliary Transformers	Linear heat detection	Water	Deluge sprinklers
Switch Yard	None	Hand held distinguishers	
Emergency Generator	Vendor standard	Vendor standard	
Intake Pumphouse	None	Hand held distinguishers	

Source: Prepared by JICA Study Team

(2) Fuel Oil Storage and Transfer

The fuel oil storage and transfer system is installed in order to supply oil to main boiler for ignition and warm-up of the main boiler and to the auxiliary boiler and to the black-start generator.

Although existing Lakhra plant has fuel oil storage, because existing Lakhra plant may be privatized in future, it is available to plan fuel oil storage independently against existing one on this project.

Design condition for oil storage and transfer is shown in Table 7.3-32. Both light diesel oil and heavy diesel oil is applicable as fuel for mentioned usage, but, light diesel oil is more suitable from perspectives of environment and serviceability, flexibility.

Oil storage and transfer is shown in Table 7.3-33. It is recommended that approximately 1,000 kL storage tank is installed.

Oil tanks are installed in concentric in oil yard, oil retaining wall is constructed around tanks as civil work. And form fire distinguishing system and oil receiving equipment should be prepared around the tank as auxiliary facilities of fuel oil storage.

Table 7.3-32 Design Condition for Oil Storage and Transfer

Item	Design Condition	Notes
classification of oil	Light diesel	
Assumed condition	Sum of figure in condition below	
1. Ignition of start up	Two times available during 10 hours at 20% of full load	
2.Auxiliary boiler	One time available during 15 hours at full load of auxiliary boiler with 10 t/h of steam generation capacity	
3.black-start generator	One time available during 72 hour at full load of black-start generator	

Source: Prepared by JICA Study Team

Table 7.3-33 Oil Storage and Transfer

Item		Notes
1. Ignition of start up	620kL	
2.Auxiliary boiler	14kL	
3.black-start generator	37kL	
total	671kL	

Source: Prepared by JICA Study Team

(3) Coal Unloading and Handling System

1) General

Coal unloading and handling system is the system in order to receive, store, and deliver coal. But two type coals, sub-bituminous and Thar coal, will be used in new Lakhra plant, then receiving way of coal, amount of coal store is so different respectively according to coal type. So Coal unloading and handling system for sub-bituminous and coal unloading and handling system for Thar coal is planed separately. And coal delivery to Lakhra plant is described in mentioned chapter 5.

Coal unloading and handling system on this project is designed under consideration that the future plant with capacity of 600 MW net (hereinafter called the future plant) will be constructed along with this project plant with capacity of 600MW net (hereinafter called this project plant).

2) Sub-bituminous coal

Comparison of coal storage is shown in Table 7.3-34. Five (5) type systems as coal storage system exist. But, three (3) types, gabled building, dome, silo as classified in indoor storage type are not available according to 2 reasons, taking very higher cost than outdoor storage type, having danger of dust explosion. Bulldozer / Scraper is not available in case of required large capacity as this project. Therefore Stacker / Reclaimer system is recommended.

Table 7.3-34 Comparison of Coal Storage

	Outdoor storage		Indoor storage		
	Stacker / Reclaimer	Bulldozer / Scraper	Gabled building	Dome	Silo
Land ratio	100	100	100	45	30
Cost ratio	100	70	300	300	330
Multi type coal storage	possible	possible	possible	NOT possible	NOT possible
Coal clogging	NOT occur	occur	NOT occur	NOT occur	occur
Equipments	Stacker / Reclaimer	Bulldozer	Scraper type Reclaimer	Table feeder	Puddle feeder
Automatic operation	possible	NOT possible	possible	possible	possible
Track record	Major	Major	Major in Europe	Minor	Minor
Scattering power body	occur	occur	NOT occur	NOT occur	NOT occur
Noise	High	High	High	High	Low
Dust explosion	NOT danger	Danger in underground	Danger	Danger	Danger
Large capacity	possible	NOT possible	possible	possible	possible
Evaluation	recommended	NOT recommended	NOT recommended	NOT recommended	NOT recommended

Source: Prepared by JICA urvey Team based on the document publicized by Thermal and Nuclear Power Engineering Society in Japan

Coal unloading and handling system for sub-bituminous coal is classified the primary line that ties from spur railway to coal yard and the secondary line that ties from coal yard to boiler.

In the primary line, at first, coal is unloaded from coal wagon at coal discharge pits, and is received at hopper that is installed underground. Then coal is conveyed to coal yard via several coal towers by belt conveyor. At the end, coal is seeded on coal pile by stacker

In the secondary line, at first, coal is reclaimed from coal pile to by reclaimer, and is received at hopper that is installed underground. Then coal conveyed to coal banker that is installed near boiler via coal towers by belt conveyor. At the end, coal is pulverized from 30 mm to 40 mm of size by set of 6 coal mills, borne to boiler burner on air supplied from forced- draft fan.

Due to being assumed that no Thar coal come to Lakhra plant in start-up period, it is suitable to plan under situation with 100 % sub-bituminous coal burn. At full load, plant with capacity of 600 MW net consumes sub-bituminous coal approx. 6,800 tons/day under situation with plant efficiency of 36.4% and heating value of 5,000 kcal / kg as shown in below.

(Daily consumption of coal)
= (Net output power of plant) / {(Net plant efficiency) × (calorific value of coal)} × (Conversion coefficient) × 24 hours
= 600 <MW> / (36.4<%> × 5,000 <kcal / kg>) × 860 <kcal/kWh> × 24 (h)
≅ 6,800 <tons / day>

Setting on plant factor with 80%, then the annual coal consumption per unit will be approx. 2.0 million ton/year. This is means that it is feasible to consume approx. 13,400 tons daily and approx. 4.0 million tons annually after construction of the future plant with same capacity.

(annual consumption of coal in case of plant factor with 80 %)
= (Daily consumption of coal) × 365 (days) × 80 %
= 6,800<tons / day> × 365 (days) × 0.8
= 1,985,000 ≅ 2,000,000 <tons / year>

Design condition and specification for coal unloading from coal discharge pits to coal yard are shown in Table 7.3-35, Table 7.3-36 respectively. Prior to entering discharge area, train with 40 coal wagons is divided to 2 formations with 20 coal wagons (hereinafter called “wagons formation”). One wagons formation is hauled by shunting locomotive to the coal discharge pit via leading track and stop on the pit location and discharge coal. Further this wagons formation move length of 2 wagons, then stop and discharge coal. This work is repeated until completion of discharge of all wagons. Then this wagons formation is hauled to the shunting line and stays temporary there, another wagons formation is carried out discharge work. Coal wagons are hopper type and they shall be open hopper manually on discharging. Unloaded coal drop into hopper that is installed underground. On top of hopper, bar cover is installed in order to prevent excessively large lumps of coal into hopper. Coal is dropped on belt conveyor in width of 1,200mm through vibration coal feeder that is installed under hopper, and is delivered to coal crusher tower, then is crushed in size from 30 mm to 80mm. Coal is put on belt conveyor again, which is transported to coal yard, is seeded on coal pile by stacker with capacity of 1,500 t/h.

Table 7.3-35 Design condition for coal unloading from coal discharge pits to coal yard

Item	Design condition	Notes
Amount of transportation of coal per train	2,400 ton / train	
Unloaded time of coal from train	2 hours / train	
Conveyor	120% capacity against coal receiving, 2 line	Specified by transportation capacity
Stacker	120% capacity against coal receiving	

Source: Prepared by JICA Study Team

Table 7.3-36 Specification for coal unloading from coal discharge pits to coal yard

Item	Specification	Notes
Conveyor	1,200mm wide, 1,500t/h, 2 line	
Stacker	1,500t/h	

Source: Prepared by JICA Study Team

Design condition and specification for coal storage are shown in Table 7.3-37, Table 7.3-38 respectively. In order to store coal with amount of approx. 56 days consumption as much as Jamshoro's, five (5) and half piles are planned as coal yard with including expansion area in future. Size of coal pile is set in width of 50 m and in length of 550 m and in height of 6 m. Because it is said that repose angle of coal is in angle of 15 degree, Upper hem of trapezoid shaped by coal pile is in width of approx. 5 m. Setting on specific gravity of coal with 1.2, then gross weight per coal pile will be approx. 108,900 ton/pile, and it means that it is feasible to store coal with amount of approx. 588,060 ton in coal yard.

(Gross weight of a pile)

= [{(bottom width of pile) + (top width of pile)} / 2] × (height of pile) × (length of pile) × (specific gravity of coal)

= [{50 (m) + 5 (m)} / 2] × 6 (m) × 550 (m) × 1.2

≅ 108,900 (t / pile)

(Capacity of coal yard in weight)

= 108,000 (t / pile) × 5.4 (piles)

= 588,060 (t)

Daily consumption of coal per plant is approx. 6,800 ton/day, one pile can supply coal about 16 day. Then three (3) and half piles are constructed on this project, and two (2) piles constructed in future. Two stacks with capacity of 1,800 t/h are installed on the Project, One stack with same capacity is installed in future.

Table 7.3-37 Design Condition for Coal Storage (coal pile)

Item	Design condition		Notes
	Case of one unit	Case of Two units	
Heating value of coal	5,000 kcal/kg		
Plant Efficiency	36.4%		
Plant factor	80 %		
Plant Capacity	600MW net x 1Unit	600MW net x 2Units (in future)*	
Daily coal consumption	6,800t/day	13,600t/day	
Minimum required storage	40 days	40 days	

* Room to develop another plant is just mentioned. There is no plan of second plant so far.

Source: Prepared by JICA Study Team

Table 7.3-38 Specification for Coal Storage (coal pile)

Item	Specification		Notes
	Case of one unit	Case of Two units (in future)*	
Volume of coal pile	108,900 ton/pile (50m x 550m x 6m, specific gravity 1.2)		
Coal pile in number	3.4 piles	5.4piles	
Total coal storage in weight	370,260ton	588,060t	
Total coal storage in remaining supply days	55 days	44 days	

* Room to develop another plant is just mentioned. There is no plan of second plant so far.

Source: Prepared by JICA Study Team

Coal is reclaimed from coal pile to by reclaimer, and is received hopper that is installed underground. As coal with amount of 280 t/h is consumed per one plant, it is necessary to install reclaimer with capacity of its double under consideration in future plant expansion. Two reclaimers with capacity of 1,800 t/h are installed on the Project, one reclaimer with same capacity is installed in future. Then coal conveyed to coal banker that is installed near boiler via coal towers by belt conveyor in width of 800mm. Finally coal is pulverized from 30 mm to 40 mm of size by set of 6 coal mills with capacity of 50 t/h respectively.

3) Thar coal

Coal unloading and handling system for Thar coal consists of coal storage with shed, overhead travelling crane, hopper and coal feeder, belt conveyors. Coal is transported from Thar mine by truck, unloaded on coal storage with shed. Overhead travelling crane is installed at shed, grasp and drop coal on hopper installed underground.

Mentioned operation and system structure is almost same with existing Lakhra plants'.

At full load, plant with capacity of 600 MW net consumes Thar coal approx. 1,100 tons/day under situation with plant efficiency of 36.4% and heating value of 3,146 kcal/kg. Setting on plant factor with 80 %, then the annual coal consumption per unit will be approx. 0.3 million ton/year. This is means that it is feasible to consume approx. 1,066 tons daily. As Thar coal has lower procurement risk than imported coal after their mining starting, e.g. view point of transportation, price alteration, Thar coal request fewer amount of storage than imported coal. Then amount of storage of Thar coal is set approx. 7,500 ton as seven (7) days consumption. Capacity of overhead travelling crane is set 50 ton as its one time operation per hour, and capacity of coal conveyor is set 100 t/h.

(4) Mixed Coal Facilities

1) General

Blending imported sub-bituminous coal with domestic lignite (Thar coal) results in a change in the quality and properties of the fuel fired.

High ash content in coal affects furnace sizing and requires larger capacities of electrostatic precipitators. Moisture, fixed carbon, grind ability give affect respectively, but affect of combination of each contents are unknown without testing actual combustion. Therefore, generally, boiler designer will try combustion test prior to starting his design, because enough amount of Thar coal must be prepared until contract agreement.

2) Methodology of coal mixture

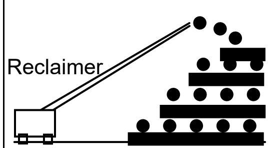
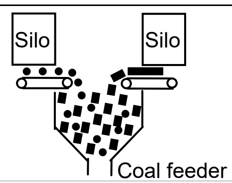
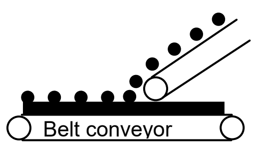
There are three (3) methods use in blending coals of different grades or sources. Comparison of coal mixing method is shown in Table 7.3-39.

Feasible first mixing method is method of blending in coal yard. This method is stacked each imported coal and Thar coal at same pile in horizontal layers one above other. Each layer of coal has constant thickness that is calculated by the mix ratio of fuels. When coal is reclaimed by reclaimer buckets, two type coals are blended each other, then homogenized coal is dropped on belt conveyor. The advantage of this system is that it does not require other equipment. But, this system has three (3) major disadvantages. First one is that it is not flexible to alter mixing ratio. The mix ratio of coal is decided on when coal is layered on the pile, only after the pile is used up, different mix ratio of coal can be set. Second disadvantage is that it is difficult to bed coal in constant thickness. Thickness of each layer varies due to mixing ratio, and this method is not suitable when one layer is very thin although mixing ratio must be less than 1:3. Third disadvantage is that this method requires vast area. About 30% of coal the coal yard space will be used coal blending. As conclusion, this method is not recommended.

Feasible second mixing method is method of blending on outlet of silo. This method uses independent system that consists of separate silos, hoppers, feeders, belt conveyor. Two type coals are stored in separate silos, imported coal is discharged onto a conveyor belt in constant amount per unit time, and then Thar coal is discharged at a controlled rate onto a conveyor belt due to control feeder, mixed coal feeds into the boiler silos. The advantage of this system is that it is flexible to alter mixing ratio. Blending is achieved accurately by this method and the blending proportion can be varied as desired. But, the disadvantage of this system is that higher cost than other system is required. The cost of the silo, gravimetric feeder, and additional conveyor belts increase the capital costs, and the system will need additional controls for the coal reclaim operation. As conclusion, this method is not recommended.

Feasible third mixing method is method of blending on belt conveyor. This method uses coal handling system without installing independent system for coal mixture. Two type coals are stored in separate silos, imported coal is discharged onto a conveyor belt in constant amount per unit time, at same time Thar coal is discharged at a controlled rate onto a conveyor belt due to control feeder, mixed coal feeds into the boiler silos. The advantage of this system is that it is flexible to alter mixing ratio. Blending is achieved accurately by this method and the blending proportion can be varied as desired. As conclusion, this method is recommended.

Table 7.3-39 Comparison of Coal Mixing Method

	In coal yard	On outlet of silo	On belt conveyor
Image ▬ Imported coal ● ● Thar coal			
Operation summary	Stacking imported coal and Thar coal in layers in coal yard, when reclaiming, mixing them	Storing imported coal and Thar coal in silo, when discharging, mixing them	Storing imported coal and Thar coal at each pile, when delivering to boiler, mixing them.
Mixing equipment	Reclaimer	Coal feeder (independently)	Belt conveyor
Advantage	Not requiring other equipment	Flexible to alter mixing ratio	Simple, Flexible to alter mixing ratio
Disadvantage	Not flexible to alter mixing ratio Difficult to bed coal in constant thickness Requiring vast area	Higher cost than other system	NON
Evaluation	Unrealistic NOT recommended	NOT recommended	Recommended

Source: Prepared by JICA Study Team

3) Blending condition of imported coal and lignite coal

Specifications of imported coal and lignite coal are in big difference, therefore, it is recommended to monitor each trends relating to combustion as follows.

- ✓ Boiler furnace draft trend
- ✓ Flow volume trend
- ✓ Super heater and re-heater water spray flow trends

Coal blending is in good condition if these trends are stable. However, in case of unstable condition such as cyclic changes or hunting trends, the examples of solution are listed as follows.

- ✓ Transition to manual mode in order to control more accurately
- ✓ Boiler load reduction
- ✓ Single coal (imported coal) burning

4) Mixed Coal Facilities

As mentioned, independent equipments as mixed coal facilities are not required. But, in order to maintain ideal condition of coal mixture, it is strongly recommended to more deeply consider monitoring and control in detail design phase.

(5) Ash System and Ash disposal

1) General

Coal includes generally ash contents from 5% to 30 % by their weight, thought its value is different according to their type. Pulverized coal burn in boiler furnace, then generating ash is stored into hoppers are located in boiler bottom and in exhaust gas duct. Ash system is a set of equipment that discharges ash from boiler continuously or intermittently in order to maintain boiler operation.

Table 7.3-40 Design Condition and Ash Production

Item	Design condition		Notes
	Case of one unit	Case of Two units	
Ash ratio in weight	10.04%	10.04%	Imported coal
Daily coal consumption	6,800 t/day	13,600 t/day	
Daily ash production	680 ton	1,360 ton	
Plant factor	80%	80%	
Annual ash production	198,560 t/year	397,120t/year	

Source: Prepared by JICA Study Team

2) Extra ash landfill

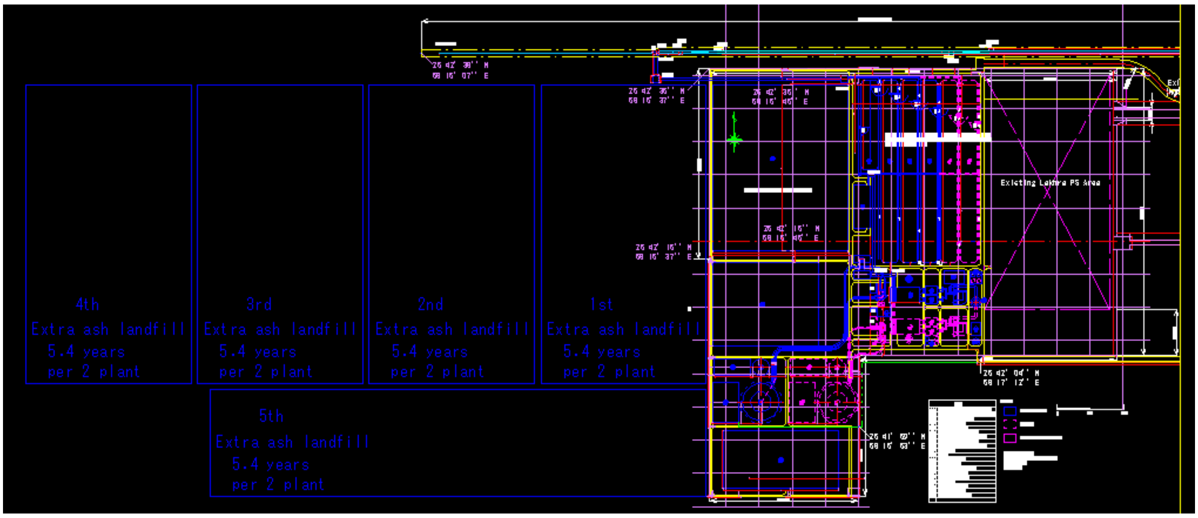
Introduced thermal plant with high quality, at least 30 years or over plant can be in operation continuously and stably, but it will require vast area as ash landfill during their life cycle. On the other hand, it is not desirable to prepare ash landfill with vast area at beginning period of plant operation due to increase initial cost. Therefore, it is reasonable to construct ash landfill at beginning period of plant operation, then to construct extra ash landfill with decreasing remaining landfill capacity.

The procedure of construction of extra ash landfill is shown below,

a) On this project, constructing ash landfill with capacity for 5 years or over.
b) Applying budget for adding on extra ash landfill in fiscal year which remaining landfill capacity decrease less than 3 years.
c) Constructing ash landfill with capacity for almost 5 years in next year mentioned application.
d) Return to b)

Pan added on extra ash landfill based on above procedure for 30 years from starting operation is shown in Figure 7.3-34. And alteration of ash landfill area is shown in Table 7.3-41. It is required to construct extra ash landfill 5times, total area of extra ash landfill is 2,545,000m2 (630 Acres).

It is necessary to execute land acquisition, relocation of plant border (fence), road construction, ash treatment bank construction in order to add on extra ash treatment. But, no dwelling is in planed area for extra ash treatment at period of this feasibility study, hence it is no matter to acquire land. And it is desirable to design with attention to next plan at each plan for adding on extra ash treatment.



Source: JICA Survey Team

Figure 7.3-34 Plan Added on Extra Ash Landfill Based on Above Procedure for 30 Years from Starting Operation

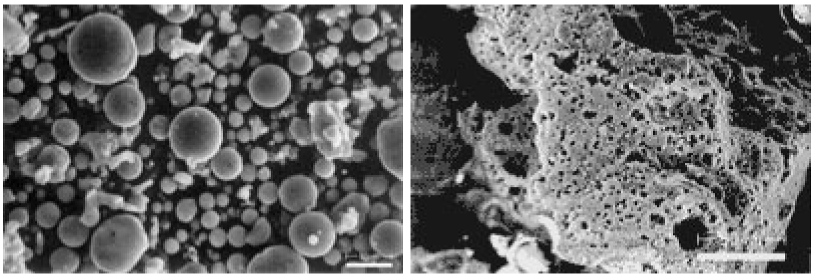
Table 7.3-41 Alteration of Ash Landfill Area

	extra ash landfill area	remaining landfill capacity*1	Total landfill area
Initial ash landfill	265,000m2 (175mx345m, 410mx500m)	5.2 years /one unit	265,000m2
1st extra ash landfill	450,000 m2 (900mx500m)	5.4 years / two units	715,000 m2
2nd extra ash landfill	Ditto	Ditto	1,165,000 m2
3rd extra ash landfill	Ditto	Ditto	1,615,000 m2
4th extra ash landfill	Ditto	Ditto	2,065,000 m2
5th extra ash landfill	480,000 m2 (1500mx320m)	5.4 years / two units	2,545,000 m2

*1 Based on assumption one plant operation for several years from beginning of plant operation
Source: Seminar document held by Thermal and Nuclear Power Engineering Society in Japan

3) Ash treatment type

Ash of coal is classified fly ash and clinker ash. Fly ash is fine powder collected at ESP or AH or Eco. 90 % of entire production of ash of coal flies over as fly ash, almost ingredient of fly ash is particulate matter with 0.1 mm or less in diameter. Clinker ash is ash that dropped on boiler bottom, and they are ruined from massive ash and collected. 10 % of entire production of ash of coal becomes clinker ash. Appearance and closed up picture through microscope of fly ash and clinker ash is shown in Photo 7.3-1.



Fly ash x1,500 clinker ash x300

Source: Fly ash association Japan

Photo 7.3-1 Appearance and Closed up Picture through Microscope of Fly Ash and Clinlker Ash

Clinker ash disposal methodology is shown in Table 7.3-42. Clinker ash disposal methodology is classified Wet type and Dry type, and Wet type has longer history and more track record than Dry type. Dry type is comparatively new methodology since developed in 1980s, but has advantages as 1) no need water, 2) simple component, 3) lower operation cost. Recently Dry type is adopted in 1,000 MW class coal fired thermal plant in Japan, and earns reputation of high reliability. Therefore MAC system as Dry system is recommended.

Fly ash disposal methodology is shown in Table 7.3-43. Combination vacuum/pressure pneumatic ash conveying system which has advantage of cost and limitation of conveying length is recommended.

Table 7.3-42 Clinker Ash Disposal Methodology

	Dry	Wet	
	Clinker conveyor	Chain-conveyor	Jet pulsion pump
Landfill with wet ash	Just dry clinker	Possible	Possible
Transport route	easy	difficult	easy
Limit distance for transportation	N/A	Not limited	1.3km
maintenance	easy	difficult	easy
Cost ratio	150	95	100
Evaluation	Recommended	Not recommended	Not recommended

Source: Seminar document held by Thermal and Nuclear Power Engineering Society in Japan

Table 7.3-43 Fly Ash Disposal Methodology

	Vacuum Conveying System	Pneumatic Conveying System	Combination vacuum/pressure pneumatic ash conveying system
Landfill disposal	Available	Available	Available
Limitation of conveying length	Less than 300m "P"	Less than 1,500m "G"	Less than 1,800 "E"
Cost(%) Least cost system is described "100%"	140 "P"	110 "G"	100 "E"
Evaluation	"P"	"G"	"E"

Legend:"E" means Excellent, "G" means Good, "P" means Poor.
Source: Seminar document held by Thermal and Nuclear Power Engineering Society in Japan

(6) Water Supply and Discharge System

The proposed thermal power plant will require the definite quantity of water to utilize as the boiler water and the cooling water. The outlines of water supply and drainage facilities are proposed as follows.

1) Designed Intake and Conveyance Water Amount for the Proposed Thermal Power Plant

As discussed before the required water amount is estimated as below, which is based on the water balance diagram of the proposed thermal power plant.

- Water for the cooling tower = 0.47m^3/sec (16.5cusecs)
- Water for the generation process = 0.014m^3/sec (0.5cusecs)
- Water for other purposes = 0.062m^3/sec (2.2cusecs)

The total required water amount is estimated 0.546m^3/sec (19.1cusecs).

Based on the Japan Design Regulation of Water Utility 2012[2] (Hereinafter called Japanese regulation of water), the intake water amount is generally designed to be on the safe side and to be estimated approximately 110% of the required water amount with consideration for the water loss between the intake point and the water treatment plant. Therefore, the designed intake and conveyance water amount is estimated 0.6m^3/sec (21.0cusecs) as shown below.

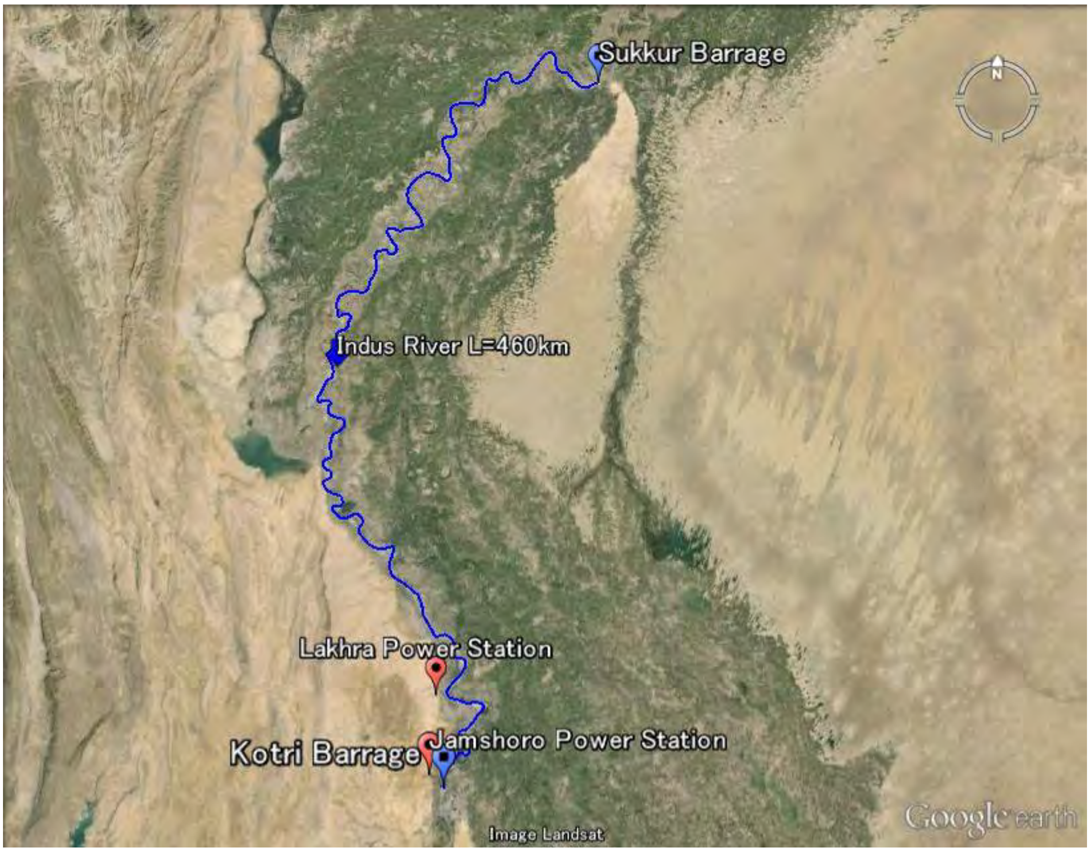
Designed intake & conveyance water amount = 0.546m^3/sec x 1.1 = <u>0.60m^3/sec (21.0cusecs)</u>

2) Location of Water Intake Point

i) Water Flow & Level of Indus River

The irrigation department of Government of Sindh has monitored the water flow of Indus River at some locations, and they locate the monitoring point of water flow at the upstream part of Kotri Barrage which is the only monitoring point between Kotri Barrage and Sukkur Barrage. The locations of Kotri Barrage and Sukkur Barrage are illustrated in Figure 7.3-35.

[2] Issued by Japan Water Works Association



Source: Google Earth, JICA Survey Team

Figure 7.3-35 Location of Kotri Barrage and Sukkur Barrage

The monthly average water flow from 2005 to 2013 monitored at the monitoring point of the upstream point of Kotri Barrage is shown in Table 7.3-44.

Table 7.3-44 Monthly Average Water Flow at the Upstream Point of Kotri Barrage from 2005 to 2013

(unit: m^3/sec)

Month / Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	averrage	Max	Min
January		202	312	128	153	94	331	179	230	204	331	94
Febrary		249	319	138	77	70	199	206	342	200	342	70
March		61	663	66	98	99	223	67	302	197	663	61
April	1,067	74	1,212	87	159	109	158	104	294	363	1,212	74
May	849	272	1,484	144	211	156	326	246	219	434	1,484	144
June	901	1,062	984	664	776	500	1,082	282	725	775	1,082	282
July	3,632	925	3,077	1,370	901	1,465	1,273	1,014	1,506	1,685	3,632	901
August	7,035	5,529	2,754	3,128	2,083	13,355	1,081	1,192	5,546	4,634	13,355	1,081
September	1,644	3,584	1,675	969	809	11,057	4,585	2,973	4,214	3,501	11,057	809
October	360	502	450	419	363	1,646	1,028	728	533	670	1,646	360
Novenber	184	288	159	145	159	858	280	290	323	298	858	145
December	110	278	67	119	93	461	227	129	120	178	461	67

Source: Irrigation department of Sindh

There are no exiting facilities which intake water from Indus River between Sakkur and Kotri barrage except existing Lakhra and Jamshro plants. Moreover, there are only two plans to develop the facilities which intake; one is Jamshoro plant and another is new Lakhra plant. The minimum water flow after April of 2005 is 61m^3/sec, and as discussed above, the designed amount of water intake is calculated 0.60m^3/sec which corresponds approximately to 1% of the minimum water flow. In addition, according to EIA report of new Jamshoro plant, water intake quantity of 1.13 m^3/s planned in total (sum of existing and new Jamshoro power plant). Therefore, even in dry season the water can be taken from Indus River around the existing Lakhra thermal power station from the view point of water flow. However, the water right for intake shall be approved by the IPD (Irrigation and Power department) in Sindh province before the intake facilities will be designed. Our team and GENCO staff had explained the location and the intake volume for IPD at site on Dec. 2013. After river flow passing the planned intake point and Kotori barrage, the side of the right bank flows for irrigation water and the left bank flows for water supply to Karachi city area.

ii) Selection of the Location of Water Intake Point

As the candidate site for the water intake point, three sites described in Figure 7.3-36 can be proposed.

All Candidate Sites

Candidate Site-1 and 2

Candidate Site-3

Source: Google Earth, JICA Survey Team

Figure 7.3-36 Locations of Candidate Sites for Water Intake Point

The feature of each candidate site is compared as described in Table 7.3-45.

Table 7.3-45 Comparison Table of the Candidate Sites for Water Intake Point

	Candidate Site-1	Candidate Site-2	Candidate Site-3
Location	● Around the existing water intake tower and pumps for Lakhra P.S. ● At the curve of river	● Approximately 2km downstream of the Candidate Site-1 ● At the straight part of river	● Around the existing water intake tower for Jamshoro P.S. ● At the straight part of river
Length & Construction Cost of Pipeline	4.6km	6.5km	37.0km
Potential for Sustainable Water Intake	● The existing water intake tower for Lakhra P.S. cannot be operated in dry season only because the shape of river has been changed by the sedimentation. ● The shape of river around the Candidate Site-1 has a high probability to be changed by the future sedimentation and the change of river flow in rainy season and dry season. ● The Candidate Site-1 also has a high probability not to be operated through the year because the Candidate Site-1 will be located at the curve of river.	● The candidate Site-2 will be located at the straight part of Indus River. ● The length of the straight part is approximately 10km. Therefore, the shape of river around the Candidate Site-2 is not expected to be changed significantly. ● The Candidate Site-2 is expected to be operated through the year differently from the Candidate Site-1 as shown in Figure 7.3-36. ● If the water level in dry season is not enough to for the pump equipments to intake, the intake structure should be designed for pump equipments to be emplaced under the river bed so that stable intake can be achieved even in dry season.	● The existing water intake tower for Jamshoro P.S. can take and convey enough water though the year. ● The Candidate Site-3 also can take and convey enough water to the proposed thermal power station through the year.
Evaluation	The construction cost will be the most inexpensive among the three options. However, the sustainable water intake	The full-year water intake will be expected although the water level of Indus River is lower than the Candidate	The sustainable and stable water intake will be expected because the water level of Indus River is highest and the

	will not be expected because this site will be located at the curve of river and the shape of river has a high probability to be changed by the future sedimentation. △	Site-3. In addition, the length of pipeline is shorter than the Candidate Site-3. Therefore, the Candidate Site-2 is selected as the proposed water intake point. ◎	most stable among the three options. However, the length of pipeline will be about 37km and be the longest. Therefore, the Candidate Site-3 is proposed as the alternative to the Candidate Site-2. ○

Source: JICA Survey Team

The situations of Indus River around the Candidate Site-2 in the dry seasons in the last decade are presented in Figure 7.3-37 on the next page, which shows the water intake point of the Candidate Site-2 was on the deposited sand in some dry seasons. The deposited sand had been caused by the corrosion of river bank at the curve located just upstream of Candidate Site-2. Therefore, the protection work for the river bank is required. The protection works are categorized as shown in Table 7.3-46 based on the flow velocity in river.

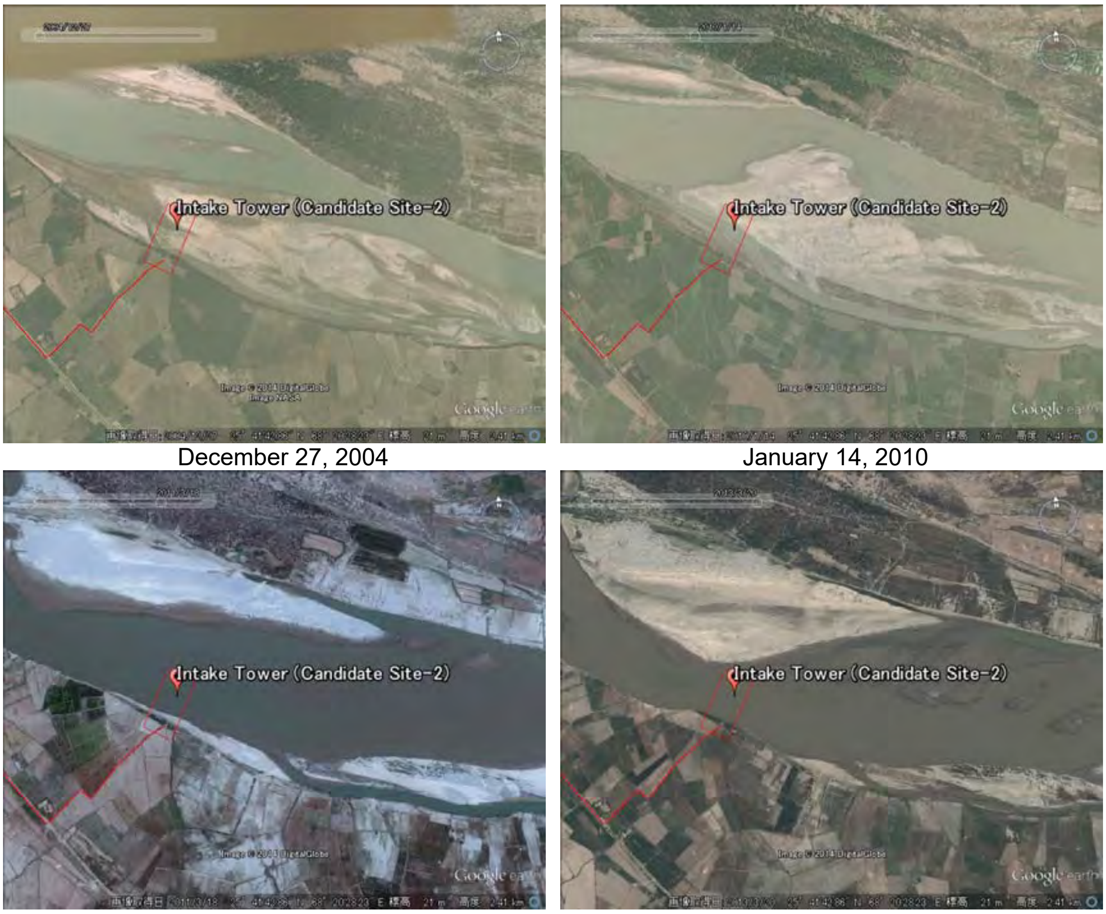
Table 7.3-46 Comparison Table of the Bank Protection Method

Method	Target Flow Velocity (m/s)
Vegetation	~2
Sheet Type	~3
Wood Type	~4
Gabion Type	~5
Stone Type	~7
Concrete Type	~7

Source: JICA Survey Team

The design flow velocity is calculated with the maximum flow rate in the last decade, the river width and the water depth of rainy season, accordingly the design flow velocity is calculated to be 4.9m/sec. Based on Table 7.3-46, the bank protection by gabion is proposed to be implemented at the curve point as illustrated in Figure 7.3-38 in order to intake river water at Candidate Site-2 sustainably.

Under the condition that the protection work for river bank as discussed above, the Candidate Site-2 can be evaluated as the proposed water intake point for the additional Lakhra thermal power station.



December 27, 2004 | January 14, 2010

March 18, 2011 | March 20, 2013

Source: Google Earth, JICA Survey Team

Figure 7.3-37 Situation of Indus River around the Candidate Site-2 in the Dry Season from 2004 to 2013

Source: Google Earth, JICA Survey Team

Figure 7.3-38 Locations of Proposed Site of the River Bank Protection

3) Route of Water Conveyance Pipeline

The existing water conveyance pipeline is approximately 4.6 km length which is installed along the street and is crossing the railway and the Indus Highway as shown in Figure 7.3-38. The existing water conveyance pipeline has been installed aboveground from the intake point to the crossing point of railway and has been installed underground from the crossing point of railway to Lakhra power station.

An additional water conveyance pipeline will be necessary to be installed for the newly-proposed thermal power station. Two candidate routes for the additional water conveyance pipeline are proposed as described in Figure 7.3-39, one is a route using the same route as the existing water conveyance pipeline whose distance is approximately 7.8km (blue line in Figure 7.3-39), and the other is a newly-proposed route along the another road between the additional intake point and Lakhra power station whose distance is approximately 6.5km (red line in Figure 7.3-39). The newly-proposed route is selected as the route of additional water conveyance pipeline for the following reasons.

- Generally water pipeline is installed along the public road in order to make it easy to maintain, repair and replace the water pipeline. Therefore, additional water pipeline will not be installed other than the public road.
- The distance of the newly-proposed route is 1.3km shorter than the route of existing water conveyance pipeline, thus the construction cost of the newly-proposed route will be lower.

: Route of existing water conveyance pipeline

: Proposed route for the additional water conveyance pipeline

Source: Google Earth, JICA Survey Team

Figure 7.3-39 Routes of Existing and Proposed Water Conveyance Pipelines

4) Scales & Capacities of Water Intake Facilities and Water Conveyance Pipeline

The size and quantity of proposed pumps for water intake and water conveyance pipeline are calculated as shown in Table 7.3-47 which is based on the Japanese regulation of water. The typical type of pumping equipment in Japan which can be taken a large volume of water is double suction vortex pump. Therefore, the type of pumping equipment used for the water intake facility for the proposed thermal power plant in Lakhra will be the double suction vortex pump which is adapted into Japan Industrial Standard (JIS). Moreover, in order to reduce construction cost, the pumping equipment is to be a general product of manufactures not to be a special order product.

Table 7.3-47 Calculation Table of Pipeline and Pump

No.	Code	Item	Calculation Value	Unit	Formula	Reference / Remarks
1	Q_1	Total Volume of Water Conveyance	36	m^3/min	$1m^3$/sec * 60sec	Current Plan
2	N_1	Number of Pump Unit per One Pumping Station	3			
3	Q_2	Discharging Volume of Unit Pump	12	m^3/min	Q_1/N_1	
4	v	Discharging Flow Velocity of Unit Pump	1.5	m/sec		Standard Value
5	D_1	Diameter of Unit Pump	0.5	m	$146*(Q_2/v)$^0.5	Not more than 0.5m (JIS Standard)
6	D_2	Diameter of Water Conveyance Pipe	0.7	m		
7	C	Coefficient of Flow Rate	110			Standard Value
8	L_1	Total Length of Pipeline	6,500	m		Current Plan
9	N_2	Number of Steps of Pumps	1			
10	L_2	Water Conveyance Length per Unit Pump	6,500	m	L_1/N_2	
11	H_1	Total Actual Head	30.0	m		Current Plan
12	ha	Actual Head per Unit Pump	30.0	m	H_1/N_2	
13	hl	Loss of Water Head in Pipeline	25.60	m	$(10.666*Q_1$^1.85)/(C^1.85*D^4.87)*L_2	Formula of Hazen-Williams
14	hv	Velocity Head	0.11	m	v^2/2g	
15	H	Total Head per Unit Pump	55.72	m	ha+hl+hv	Not more than 100m (General Product of mfr)
17	Np	Rotary Speed of Pump	1000	min^{-1}		Standard Value (Japanese Regulation of Water)
18	Ns	Specific Speed of Pump	169.86		Np*Q^0.5 / H^(3/4)	
19	Ha	Atmospheric Pressure	10.33	m		Standard Value (Japanese Regulation of Water)
20	Hp	Satured Steam Pressure	0.43	m		30℃
21	Hs	Suction Actual Head	0	m		
22	Hl	Loss of Head in Suction Pipe	0	m		
23	hsv	Available Suction Head	9.90	m	Ha-Hp+Hs-Hl	
24	S	Suction Specific Speed	1200			Standard Value (Japanese Regulation of Water)
25	Hsv	Required Available Suction Head	4.11		(Np*Q^0.5 / S)^(4/3)	
26	hsv-Hsv	Judgment of Cavitation	5.79	m		>1: OK

Source: JICA Survey Team

Based on the above mentioned concept, the prior conditions of the number of pumps, the specification of pump and the diameter of the conveyance pipe are configured that 1) Diameter of unit pump is not more than 0.5m, 2) Total head per unit pump is not more than 100m.

From the above calculation in Table 7.3.46, the specifications of pump and pipe are estimated as below.

- Number of pump = 3
- Discharging volume of unit pump = $12m^3$/min
- Diameter of unit pump = 0.5m
- Total head per unit pump = 56m
- Diameter of water conveyance pipe = 0.7m

5) Preliminary Cost Estimate

The preliminary construction cost of the proposed water supply facilities are listed in Table 7.3-48.

Table 7.3-48 Preliminary Construction Cost of Water Supply Facilities

This table is masked because it includes confidential.

6) Proposed Tasks to Be Addressed at the Detailed Design Stage

In the next detailed design stage, the following tasks are proposed be conducted in order to implement this project.

- To decide on the detailed water intake point with consideration for the seasonal data of water level and the future forecast of sedimentation in Indus River (At this moment, the Candidate Site-2 which is located at the end point of the snaking stream is selected as the most proposed intake point, because generally the inside of the snaking stream is dead water region and the earth and sand are easy to become deposited.
- To apply to the Irrigation Department of Government of Sindh from GENCO for the additional water right and the permission of installation of the additional river structure including the water intake tower and the protection work of river bank in Indus River with submitting the required amount of water intake and the detailed information about the additional river structure
- To plan the additional space of intake pumps at the water intake tower particularly in prospect of the second thermal power plant which has not been planed yet. As mentioned in section 7.3.3, two units at the same place will bring a lot of advantages.

(7) Wastewater Drainage Facilities

The wastewater generated from the thermal power station should be discharged to public water bodies through the wastewater drainage facilities after the appropriate wastewater treatment. The outline of wastewater drainage facilities is proposed as follows.

1) Wastewater Generation from the Proposed Thermal Power Plant

As discussed before, the required water amount is estimated as below, which is based on the water balance diagram of the proposed thermal power plant.

- Wastewater from the cooling tower = 0.088m^3/sec (3.1cusecs)
- Wastewater from the power generation process = 0.010m^3/sec (0.34cusecs)

Total wastewater generation is estimated <u>0.098m^3/sec (3.4cusecs)</u>

2) Route of Wastewater Drainage Pipeline

The wastewater which will be generated from the newly-proposed thermal power station is proposed to be discharged to the same water channel as the existing Lakhra power station through an additional wastewater drainage pipeline using a pump. The route of the additional wastewater drainage pipeline is proposed to be the same route as the proposed water conveyance pipeline discussed above because this route is the shortest between the newly-proposed thermal power station and the existing water channel. The proposed route of the additional wastewater drainage pipeline is approximately 3.8km length and the outline of the proposed route is described in Figure 7.3-40.

Source: Google Earth, JICA Survey Team

Figure 7.3-40 Proposed Route of Additional Wastewater Drainage Pipeline

3) Scales & Capacities of Wastewater Drainage Pipeline

The diameter of wastewater drainage pipeline is calculated from the following equations which are based on Japanese regulation of water.

$H=10.666\ C^{-1.85}\ D^{-4.87}\ Q^{1.85}\ L$ (Hazen-Williams Equation)

H = Loss of water head = 74m (Maximum withstanding pressure of polyvinyl pipe)

C = Coefficient of flow rate = 110 (Standard value)

D = Diameter of pipe (m)

Q = Water flow = 0.098m^3/sec

L = Length of pipeline = 3,850m

$D = (H\,C^{1.85} / 10.666\,Q^{1.85}\,L)^{4.87} = 0.258m \rightarrow 0.3m$

From the above calculation the diameter of wastewater drainage pipeline is proposed to be 0.3m.

4) Preliminary Cost Estimate

The preliminary construction cost of the proposed wastewater drainage pipeline is as follows.

- Diameter of pipeline = 0.3m
- Length of pipeline = 3.8km
- Preliminary construction cost = XXX million Rs.

“XXX” stands for “The information is masked because it includes confidential.”

(8) Feed water Treatment System

The raw water which is conveyed from Indus River should be treated to meet the required water quality for the boiler and the cooling tower of the newly-proposed thermal power plant. The outline of feed water treatment system is proposed as follows.

1) Required Water Quality

The required water quality for the boiler and the cooling tower of the newly-proposed thermal power plant is listed in Table 7.3-49, which is based on Japanese Industrial Standard.

Table 7.3-49 Water Conditioning for Feed Water for Once-through Boiler

Parameters	Unit	Water Quality
pH (at 25°C)	mg/L	8.5 to 9.7
Electric conductivity (at 25°C)	mS/m	0.025 max
Dissolved oxygen	μgO/L	7 max
Iron	μgFe/L	10 max
Copper	μgCu/L	2 max
Hydrazine	$\mu g N_2H_4/L$	10 max
Silica	$\mu g Sio_2/L$	20 max

Source: Japanese Industrial Standard

2) Water Quality of the Raw Water

The existing results of water quality analysis of Indus River are listed in Table 7.3-50.

Table 7.3-50 Results of Water Quality Analysis

Parameters	Unit	Indus River Upstream of Intake point of Jamshoro PS	Kalri Baghar Canal
Al	μg/L	7	91
As	μg/L	3	3
B	μg/L	97	150
Ba	μg/L	60	100

Cd	μg/L	<1	<1
Cr	μg/L	<1	<1
Cu	μg/L	2	1
Hg	μg/L	<0.5	<0.5
Mn	μg/L	17	1
Ni	μg/L	<1	<1
Pb	μg/L	<1	<1
Sb	μg/L	<1	<1
Se	μg/L	<10	<10
Zn	μg/L	<5	15
BOD	mg/L	<4.0	4.0
COD	mg/L	<5.0	<5.0
NH_3	mg/L	<0.5	<0.5
Nitrate	mg/L	0.22	-
TDS	mg/L	462	444
TSS	mg/L	12.5	17
Phosphates	mg/L	<0.1	<0.1
pH		7.3	7.2

Source: EIA report of Jamshoro Power Generation Project

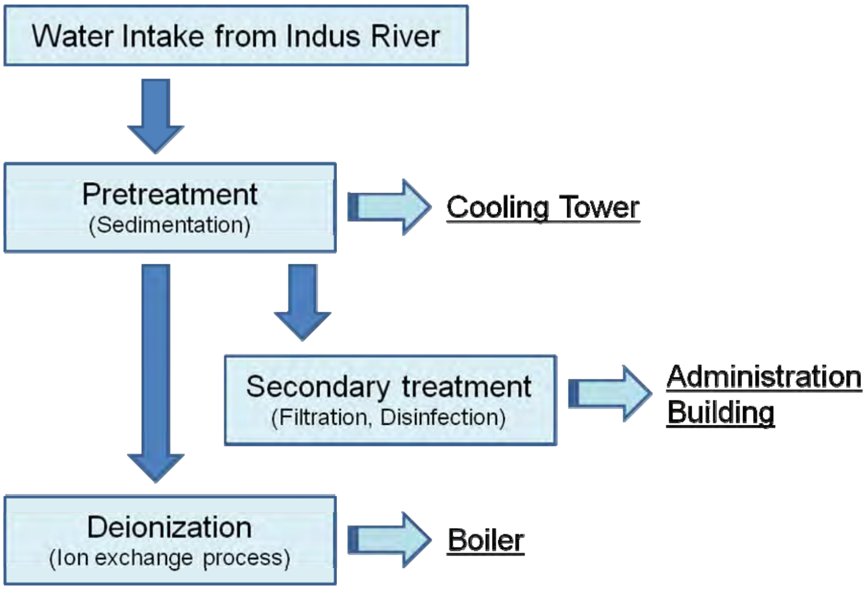
2) Additional Water Quality Data to Be Investigated for the Detailed Design

The feed water treatment process will be designed on the basis of the characteristic of raw water. In order to execute the detailed design of the feed water treatment, the following measurement items are required, therefore, in the next detailed design stage it is necessary to conduct the raw water analysis of Indus River and collect the full-year data about the following measurement items.

Required Parameters: Ca, Mg, Na, Fe(Total iron), Cl^-, SO_4^{2-}, NO_3^-, SiO_2, HCO_3, P, TSS, TOC, COD, pH, Turbidity, Electric conductivity, Water temperature

3) Proposed Water Treatment Process

The raw water which is conveyed from Indus River will be treated through the following steps based on the experiences and methodologies of Japanese manufacturers of water treatment facilities, which is illustrated in Figure 7.3-41.



Source: JICA Survey Team

Figure 7.3-41 Proposed Raw Water Treatment Step

i) Firstly the pretreatment of raw water is required to remove sand and suspended solid matter with a sedimentation tank.
ii) After the pretreatment the deionization process is required to supply pure water to the boiler with an ion exchange process.
iii) In addition, the filtration and disinfection processes are required to supply domestic water.

This water treatment process is not Japan's unique process but the widely prevalent process.

In the newly-proposed thermal power station of Lakhra, these two kinds of water treatment facilities are proposed to be developed.

4) Preliminary Cost Estimate

The capacities and preliminary construction costs of the above-mentioned two water treatment processes which include the pretreatment process and deionization process are described in Table 7.3-51.

Table 7.3-51 Proposed Feed Water Treatment System

This table is masked because it includes confidential.

(9) Wastewater Treatment System

Generally in thermal power plants the wastewater is generated from the power generation process, the coal stock yard, the ash pond, the desulfurization equipment, the cleaning process of equipments and the everyday living of office staff. The wastewater from thermal power plants must be treated appropriately before discharging to public water bodies in order to meet the effluent standard and mitigate the effect on the water environment. The outline of wastewater treatment system for the additional thermal power station in Lakhra is proposed as follows.

1) Required Water Quality

Ministry of Environment of Government of Pakistan has established the National Environmental Quality Standard for Municipal & Liquid Industrial Effluent. The standard value of effluent quality for the case of discharging to inland waters is summarized in Table 7.3-52.

Table 7.3-52 Environmental Quality Standard for Municipal & Liquid Industrial Effluent

Parameter	Standard value	Parameter	Standard value
Temperature or Temperature Increase	$40^oC \pm 3^oC$	Cadmium	0.1
pH value	6-9	Chromium (trivalent and hexavalent)	1.0
Biochemical Oxygen Demand $(BOD)_5$ at 20^oC	80	Cooper	1.0
Chemical Oxygen Demand (COD)	150	Lead	0.5
Total Suspended Solids (TSS)	200	Mercury	0.01
Total Dissolved Solids (TDS)	3500	Selenium	0.5
Oil and Grease	10	Nickel	1.0
Phenolic compounds (as phenol)	0.1	Silver	1.0
Chloride (as Cl^-)	1000	Total toxic metals	2.0
Fluoride (as F^-)	10	Zinc	5.0
Cyanide (as CN^-) total	1.0	Arsenic	1.0
An-ionic detergents (as MBAS)	20	Barium	1.5
Sulfate (SO_4^{2-})	600	Iron	8.0
Sulfide (S^{2-})	1.0	Manganese	1.5
Ammonia (NH_3)	40	Boron	6.0
Pesticides	0.15	Chlorine	1.0

(unit: mg/L)

Source: Ministry of Environment

The wastewater from the proposed thermal power station in Lakhra must be treated to meet the effluent standard

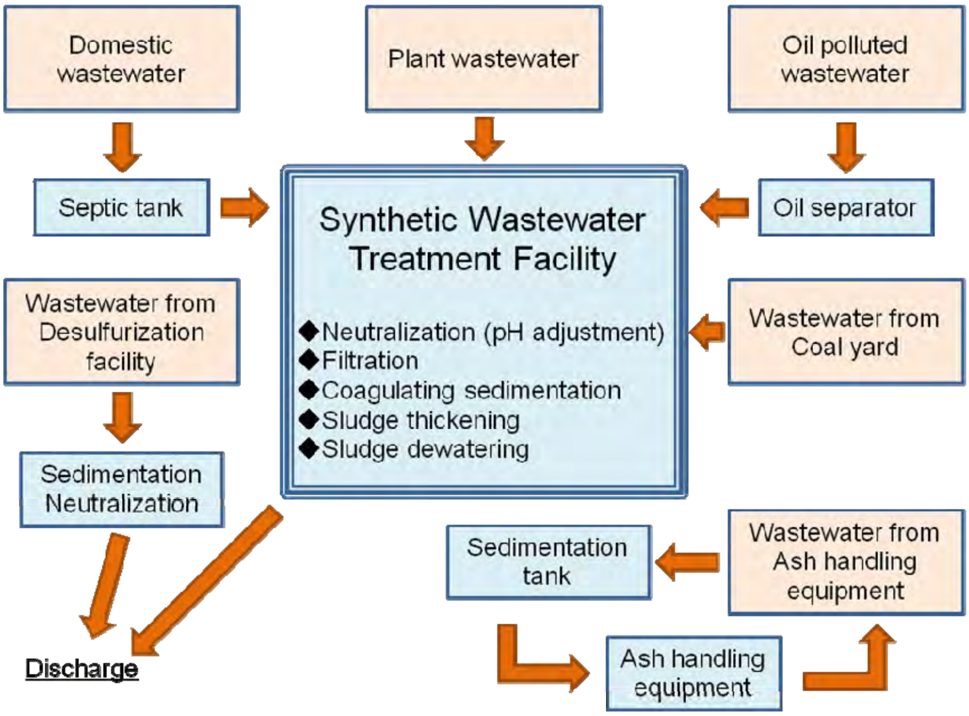
2) Proposed Wastewater Treatment Process

In Japan the wastewater from thermal power station is generally treated with the following methodologies as described in Table 7.3-53 and Figure 7.3.42.

Table 7.3-53 Japanese Solution to Wastewater from Thermal Power Station

Kind of wastewater	Solution
Plant wastewater and others ● Recycled wastewater used by condensate demineralizers ● Bearing cooling wastewater ● Recycled wastewater used by feed water equipment ● Wastewater used for equipment cleaning	The synthetic wastewater treatment facility is installed to treat wastewater by coagulation, sedimentation, filtration and neutralization.
● Wastewater from coal yard	Tanks for storing coal yard wastewater are installed. The water stored in the tanks is used as the water for sprinkling on the equipment used in coal yards. Because tanks may overflow caused by rain, pipes are laid to lead the water to the synthetic wastewater treatment facility.
● Wastewater from ash handling equipment	Sedimentation tanks are installed. After ash is sedimented in the tanks, the supernatant water is recycled to be used as ash water treatment.
● Wastewater from desulfurization facility	The equipment for treating wastewater from desulfurization facility is installed. The wastewater is treated by coagulation, sedimentation and neutralization. Additionally, part of the wastewater is recycled to be used as ash humidifying water.
● Domestic wastewater	Water purifier tanks are installed. After the purification in the water purifier tanks, domestic wastewater is treated in the synthetic wastewater treatment facility.
● Oil polluted wastewater	After oil polluted wastewater is treated in the oil polluted wastewater treatment facility to separate its oil, the wastewater is further treated in the synthetic wastewater treatment facility.

Source: Japanese power company



Source: JICA Survey Team

Figure 7.3-42 Outline of Proposed Wastewater Treatment System

Basically, every kind of wastewater is treated in the synthetic wastewater treatment facility or the individual treatment facilities with the processes of coagulating sedimentation, filtration and neutralization before discharging public water bodies. This water treatment process is not Japan's unique process but the widely prevalent process. This wastewater treatment system described in Table 7.3-53 and Figure 7.3-42 is proposed to be developed in the newly-proposed thermal power station in Lakhra.

3) Preliminary Cost Estimate

The capacity and the preliminary construction cost of the proposed wastewater treatment system are as follows.

- Wastewater treatment capacity = 36m^3/hr (0.098m^3/sec, 3.4cusecs)
- Wastewater treatment process = coagulating sedimentation, filtration, neutralization (pH adjustment), sludge thickening and sludge dewatering
- Preliminary construction cost = XXX million Rs.

  "XXX" stands for "The information is masked because it includes confidential."

7.3.9 Civil and Buildings

(1) Natural Condition

1) Climate Condition

Monthly temperature of 5 years from 2008 to 2012 at Hyderabad is shown in Table 7.3-54. The temperature of the monthly average is between 17.1°C (Jan) and 33.6°C (May). The climate is usually drying except short monsoon from July to September.

Table 7.3-54 Monthly Temperature at Hyderabad

Unit : °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	15.8	18.7	27.7	30.8	33.3	33.4	32.3	30.6	31.5	30.3	25	19.6
2009	18.1	22.5	27.5	31.3	34.4	33.6	32.7	31.7	30.6	29.5	24.2	19.7
2010	18.6	21.1	29.3	32.3	33.9	32.9	32.6	31.4	31.1	30.4	24.2	18.1
2011	17.1	20.7	26.5	30.1	33.3	33.9	32.6	30.6	28.6	30	25.1	19
2012	16	18.1	25.1	30.7	33.3	33.3	32.3	31.6	30.1	28.4	24.8	19.1
Average	**17.1**	20.2	27.2	31.0	**33.6**	33.4	32.5	31.2	30.4	29.7	24.7	19.1

Source : Climate Data Processing Centre of Pakistan Meteorological Department

Monthly rainfall of 5 years from 2008 to 2012 at Hyderabad is shown in Table 7.3-55. The annual rainfall average of this period at Hyderabad is 153.1mm and the rainy season starts June to September.

Table 7.3-55 Monthly Amount of Rainfall at Hyderabad

Unit : mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2008	8.8	0.0	1.0	14.5	0.0	0.7	8.0	103.8	0.0	0.0	0.0	19.8	156.6
2009	0.7	0.2	0.4	0.6	0.0	0.3	137.8	62.2	0.0	0.0	0.0	0.0	202.2
2010	0.4	0.4	0.0	0.0	0.0	76.5	29.5	85.9	18.0	0.0	3.4	0.0	214.1
2011	0.0	0.0	0.0	0.0	0.0	0.0	4.1	10.4	56.9	0.0	0.0	0.0	71.4
2012	7.0	0.0	0.0	11.4	0.0	0.0	3.2	2.2	96.2	0.0	0.0	1.0	121.0
Average	3.4	0.1	0.3	5.3	0.0	15.5	36.5	52.9	34.2	0.0	0.7	4.2	153.1

Source : Climate Data Processing Centre of Pakistan Meteorological Department

The maximum rainfall of 1,500mm, however, caused a flood of Indus River in 2010. However, Lakhra Power Station was not damaged due to the flood, because there are approximately 18m of elevation difference between Indus River and the power station.

2) Soil Condition

The Lakhra is located approximately 32km north-west of Hyderabad in the Sindh Province of Pakistan. From a geological point of view, the Surjan Fault is found out only 10km west of the site. Also, the Jhimpir Fault is found out approximate 38km south of the site.

According to the results of test pit at 5 locations in Lakhra power station, the soil condition depth almost consists of sand, gravel, lime stone, and shale up to 5.0m.

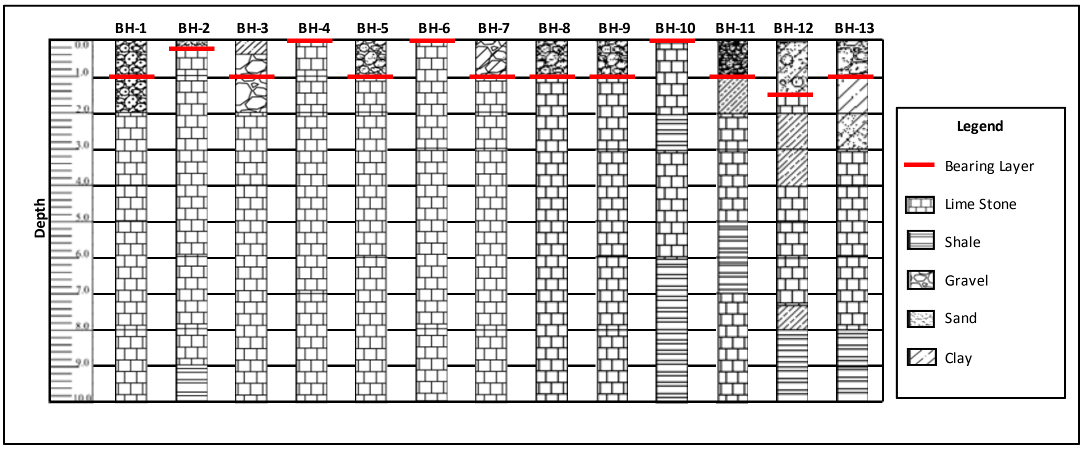
Photo 7.3-2 Soil Condition (1)

Photo 7.3-3 Soil Condition (2)

On the other hand, according to the result of plate load test at 5 locations in the power station, ultimate bearing capacity is more than 1600kPa.

3) Selection of Foundation

Each soil condition based on the result of boring test that carried out at 13 locations in Lakhra power station and depth of bearing layer are shown in Figure 7.3-43. The bed rock, sand layer which have N value more than 30 and clay layer which have N value more than 20 are defined as bearing layer.



Source: JICA Survey Team (Consolidated Engineering Services Ltd.)

Figure 7.3-43 Stratum Condition and Bearing Layer

The Spread foundation will be applied to the equipment's foundation of the power station, because bearing layer of all boreholes exist depth of shallower than 2.0m. Additionally, equipment's foundation which has high position of gravity centre such as stack and cooling tower will have to be considered a rock anchor to cope with an uplift due to overturning of horizontal force.

(2) Hydrological Condition

1) River System between Sukkur Barrage and Kotri Barrage

The cooling water for the power plant will be supplied from Indus River between Sukkur Barrage and Kotri Barrage. From the river system, Kotri Barrage is located at downstream approximately 460km from Sukkur Barrage, main river is flowing with meandering stream of the river alignment and developing the sand bar due to river bed load transportation. The tributary river from Mancher Lake (flesh water lake) is joining at approximately 170km upstream from Kotri Barrage, however it is hardly ever discharged during dry season. the basic information of Sukkur and Kotri Barrage is shown in table 7.3-56. Both barrage is distributing the water for irrigation, industry and drinking to surrounding area.

Table 7.3-56 Basic Information of Sukkur and Kotri Barrage

	Sukkur Barrage	Kotri Barrage
Barrage Length	1,440m	910m
Number of Gates	66	44
Design Discharge	25,485.1m^3/s	24,777.2 m^3/s
Actual Observation of Inflow	1,444.2 m^3/s	518.2 m^3/s
Actual Observation of Outflow	377.6 m^3/s	0 m^3/s

Source: Irrigation & Power Department

Proposed intake gate is located approximately 6.5km far towards south-eastern, and location of intake gate and pipeline is shown in Figure 7.3-44. The detailed study for site selection of intake gate will be discussed in Section 7.3.8 (6) to be described.

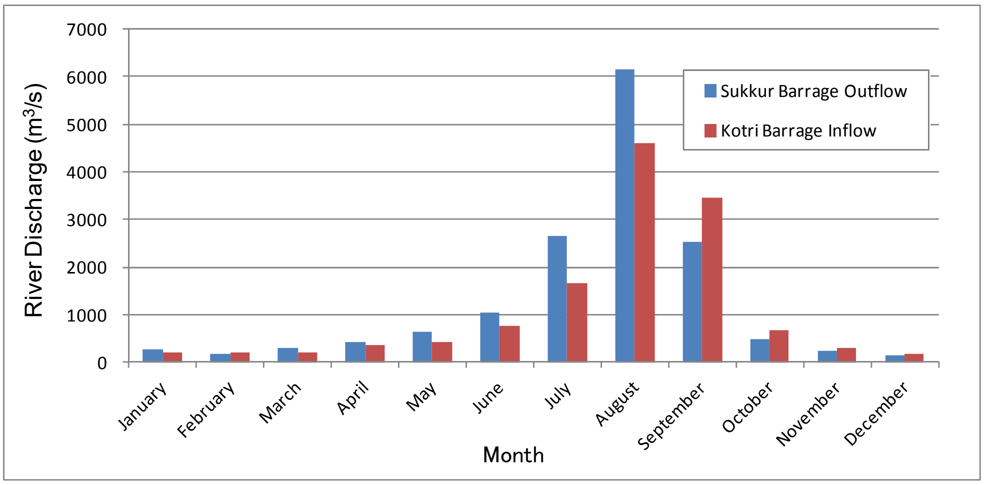
Source: JICA Survey Team (Google Earth Pro)

Figure 7.3-44 Proposed Intake Gate and Pipeline

According to the river discharge data of outflow of Sukkur barrage and inflow of Kotri barrage, the river discharge is as much as the between the both barrage in dry season. In the rainy season, the discharge is decreasing as flow to downstream due to the water supply for

Irrigation system. Comparison with monthly average of river discharge of Sukkur Barrage and Kotri Barrage is shown in Figure 7.3-45.

From above reason, the cooling water will be not restricted in the rainy season, however, there is possibility that volume of water intake from Indus River is limited in the dry season. In that case, it will be required to construct the facility for storage of water as the drought management.



Source: JICA Survey Team

Figure 7.3-45 Comparison River Discharge between Sukkur and Kotri Barrage

2) Hydrological Analysis

The river discharge of monthly average past 9 years is shown in Table 7.3-57. It is upstream discharge at Kotri Barrage which obtained from Irrigation & Power Department, Government of Sindh (IPD).

Table 7.3-57 Inflow Discharge at Kotri Barrage

Unit : m^3/s

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Ave
January	-	200	309	127	151	94	328	178	228	144	195
February	-	246	316	137	76	69	197	205	339	-	198
March	-	60	657	65	97	98	221	66	299	-	196
April	1057	74	1201	86	158	108	157	103	292	-	360
May	842	269	1471	143	209	154	324	244	217	-	430
June	893	1052	975	658	769	495	1072	280	718	-	768
July	3600	917	3049	1358	893	1452	1262	1005	1492	-	1670
August	6972	5480	2729	3101	2065	13236	1071	1181	5497	-	4592
September	1630	3552	1660	960	802	10958	4544	2947	4176	-	3470
October	357	498	446	416	360	1631	1019	722	528	-	664
November	183	286	157	144	157	851	277	287	320	-	296
December	109	276	67	118	92	457	225	128	119	-	177

Source : Irrigation & Power Department Government of Sindh

The river has the rainy season from June and the dry season from October. However, the weather of August and September in 2010 (the discharge of the Indus: 13,236m^3/s in August, 10,952m^3/s in September) were extremely abnormal through the nation, which resulted in the big flood. Based on Table 7.3-56, the maximum discharge is estimated 6,972m^3/s, and the minimum is 60 m^3/s for the un-uniformed analysis. Where, abnormal value when big flood occurred were excepted. According to river cross section, it was measured by topographical survey at 5 sections including proposed intake gate.

- Manning's "n" Value : 0.04 (Natural Stream)
- River Slope : 0.0006 (riverbed slope between upstream and downstream)

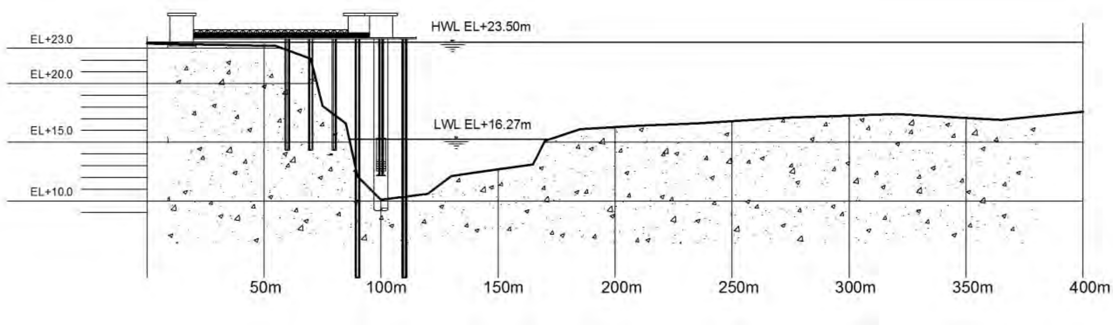
The result of un-uniform analysis at proposed intake gate which shall be calculated accordance with above condition is shown in Table 7.3-58.

Table 7.3-58 Result of Un-uniform Analysis at Intake Gate

	Water Level	Water Depth	River Width	Flow Velocity	Froude Number
Rainy Season	23.50m	13.45m	1000.99m	1.49m/s	0.21
Dry Season	16.27m	6.22m	238.58m	0.11m/s	0.02

Source: JICA Survey Team

From the above results, the water depth for intake will be ensured during dry season. However, the intake facility must be considered the structure in order to avoid the sand containing, as the countermeasure of segmentation due to slow flow velocity. The proposal intake gate drawing is show in Figure 7.3-46.

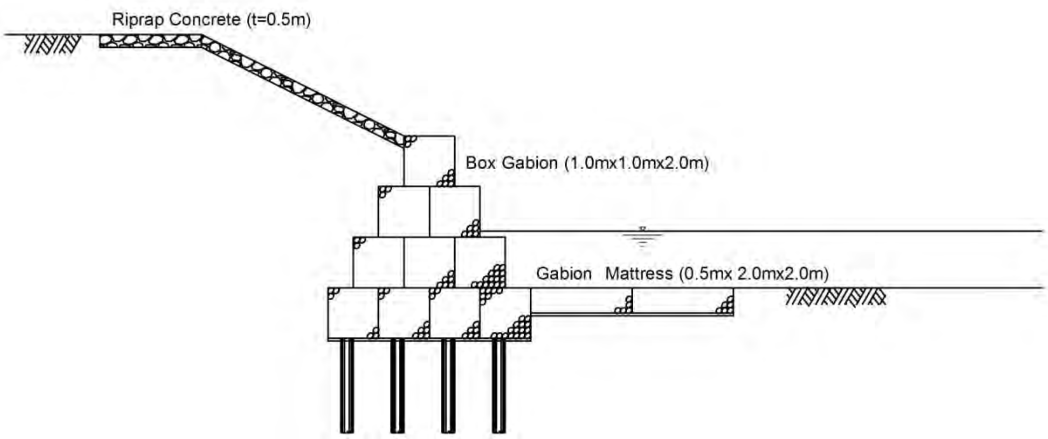


Source: JICA Survey Team

Figure 7.3-46 Proposed Intake Gate Drawing

3) Bank Protection

The cultivated area around the intake gate, the bank is eroded by water attack because of the curved alignment. If the bank doesn't have protection, the bank might be collapse. The protection works shall be set up the erosion area in order to avoid the flash out and erosion by flexible protection such as gabion. The bank protection drawing is show in Figure 7.3-47.



Source: JICA Survey Team

Figure 7.3-47 Proposed Bank Protection Drawing

4) Water Right

GENCO shall request the water right attached the location map, intake method, intake structure and demand volume to administrating section of IPD. After application, IPD confirm the possibility of intake from river system, river discharge and problem of construction of river structure with GENCO staff. In some case, GENCO shall be held the work shop for the stakeholders and the public announcement according to EIA. If no comment from the relation organization, the water right will be approved by IPD.

(3) Design Condition

For the concrete design, the structure and the foundation for equipments and facilities of the power station shall be applied the Standard of the Ministry of House and Works (MOHW), based on the ACI 381 and American Society for Civil Engineers (ASCE).The material of the building shall be observed American Society for Testing and Materials (ASTM).

In Pakistan, the standard for the building constructed by concrete structure is to follow the Pakistan Building Code (PBC), which is consisted by Pakistan Engineering Council's Core Group (PEC), National Engineering Services Pakistan (NESPAK), and International Code Council (ICC).

1) Basic Load Combination

Where load and resistance factor design is used, the structure and all portions shall resist the most critical effects from the following combinations of factored loads for structure and foundation design. The load combination cases are shown in Table7.3-59.

Table 7.3-59 Load Combination

Case 1	1.4D
Case 2	1.2D+1.6L+0.5(L_r or S)
Case 3	1.2D+1.6(L_r or S)+(f_1L or 0.8W)
Case 4	1.2D+1.3W+f_1L+0.5(L_r or S)
Case 5	1.2D+1.0E+(f_1L+f_2S)
Case 6	0.9D+(1.0E or 1.3W)

Source: Pakistan Building Code

Where, "D" means dead load, "L" means live load, "L_r" means roof live load, "S" means Snow load, "W" means load due to wind pleasure, "E" means earthquake load. "f_1" is coefficient of live load and "f_2" is coefficient of roof live load.

2) Dead Load

Dead loads consist of the weight of all materials and fixed equipment incorporated into the building or other structure.

3) Live Load

Live loads are those loads produced by the use and occupancy of the building or other structure and not include dead load, construction load, or environmental load such as wind load, snow load, rain load, earthquake load or flood load.

4) Snow Load

Potential unbalanced accumulation of snow at valleys, parapets, roofs structure and offsets in roofs of uneven configuration shall be considered as a snow load.

5) Wind Design

The minimum basic wind speed at any site shall not be less than as specified by the local regulatory authority. Until detailed wind data is available, all the structures inland shall be designed to resist a minimum wind velocity of not less than 120km per hour (75mph) at a height of 10m (33ft) and all the structures along the coast shall be designed to resist a wind velocity of not less than 130km per hour (80mph) at a height of 10m (33ft).

Design wind pressures for buildings, structures and elements therein shall be determined for any height in accordance with the following formula:

P = Ce Cq qs Iw

Where; C_e = combined height, exposure and gust factor coefficient

C_q = pressure coefficient

I_w = importance factor

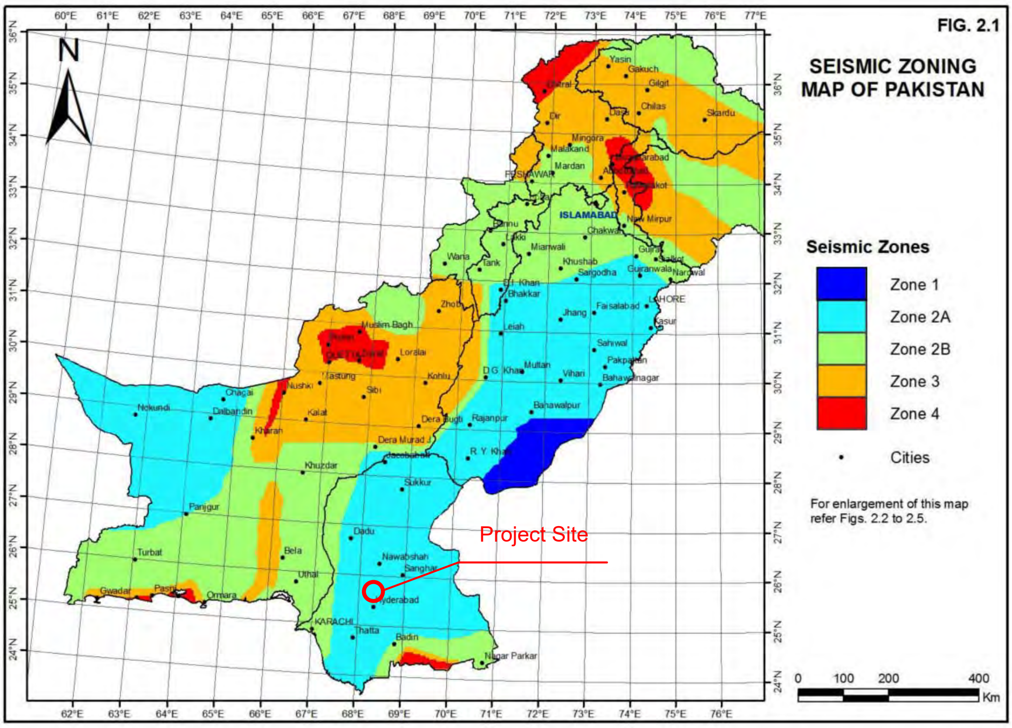
P = design wind pressure

q_s = wind stagnation pressure at the standard height of 10 meters (33 feet).

6) Earthquake Design

Earthquake design for the structure in the power station is applied by the PBC and Unified Building Code (UBC). These specifications provide the guidelines for ascertaining parameters for building's design including every foundation.

Based on the seismic zoning map of Pakistan, the power station is assigned zone 2A area.



Source: Pakistan Meteorological Department

Figure 7.3-48 Seismic Zoning Map

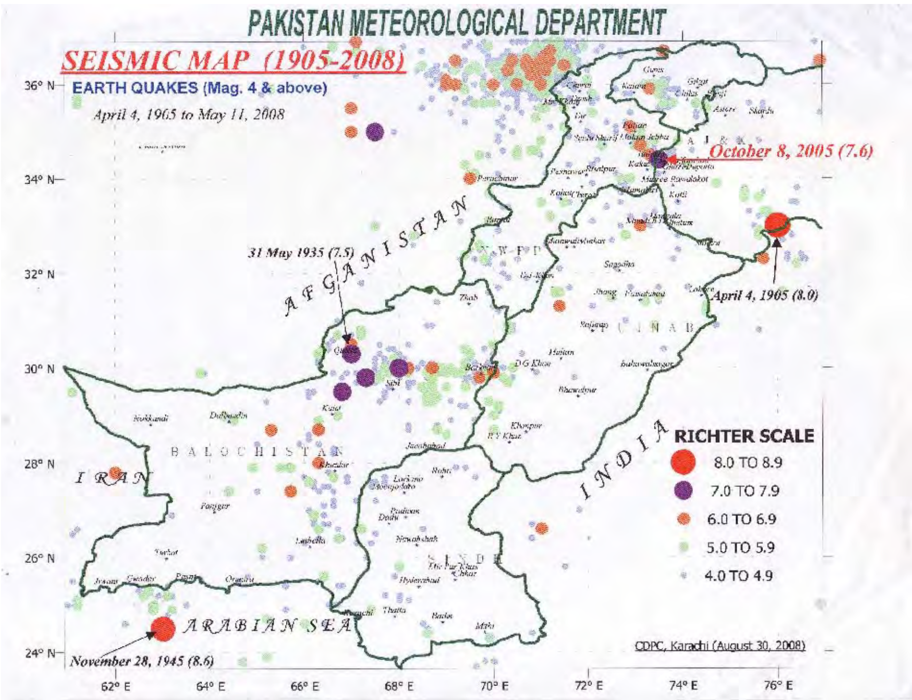
According to the Meteorological Pakistan Department, the seismic records from 1900 are shown in Table 7.3-60, and seismic map is shown in Figure 7.3-49.

Table 7.3-60 Seismic Record in Pakistan

Year	Location (Magnitude)
1905	Nearby Lahore (8.0)
1935	Nearby Balochistan (7.5)

1945	Arabian Sea (8.0) *Occurring Tsunami 5.0m height in Coastal Area*
1974	North Pakistan (6.2)
2005	Nearby Gilgit (7.6)
2008	Nearby Balochistan (6.4)
2011	Nearby Balochistan (7.2)
2013	Arabian Sea (7.7)

Source: Pakistan Meteorological Department



Source: Pakistan Meteorological Department

Figure 7.3-49 Seismic Record

A study of the earthquake magnitude, the location and distance of the active fault system around the sites indicates that the zoning system around the power station should be reviewed. There were 11 earthquakes of magnitude varying from 4.3 to 6 on the Richter scale which occurred from 1819 to 1980 in the vicinity of the sites.

Two major active fault systems, which called Surjan Fault and Jhimpir Fault, are also found in the vicinity of the power station. The Surjan Fault is north-south trending and located west of the power station, and cuts quaternary deposits. The maximum magnitude of the earthquake associated with the fault is of the order of M=6.1+ on the Richer Scale. The Jhimpir fault is north-west trending and located south west of the power station. A number of epicenters were located on this fault so far. The fault has produced an earthquake of M=5.6+ on the Richter scale.

For the above reasons, design parameters of earthquake are as Table 7.3-61.

Table 7.3-61 Seismic Parameter

Design Parameter	Design Value	PBC Code
Seismic Zone	2A	Fig 2.3
Peak Horizontal Ground Acceleration	0.08 to 0.16g	Table 2.1
Seismic Zone Factor “Z”	0.15	Table 5.9
Seismic Coefficient “C_a”	0.12 to 0.30	Table 5.16
Seismic Coefficient “C_v”	0.12 to 0.50	Table 5.17
Near Source factor “N_a”	1	Table 5.18
Near Source Factor “N_v”	1	Table 5.19
Seismic Source Type	C	Table 5.20

Source: Pakistan Building Code

Structures shall be designed for ground motion producing structural response and seismic forces in any horizontal direction. The following earthquake loads shall be used in the load combinations.

$E = \rho\ Eh + Ev$

Where, E = the earthquake load on an element of the structure resulting from the combination of the horizontal component, E_h, and the vertical component, E_v

E_h = the earthquake load due to the base shear, V

E_v = the load effect resulting from the vertical component of the earthquake ground motion and is equal to an addition of "$0.5C_aID$" to the dead load effect, D, for Strength Design

ρ = Reliability/Redundancy

The total design base shear, V in a given direction shall be determined from the following formula:

$V = (C_v\ I / R\ T) \times W$

Where, I = Importance factor

R = Numerical coefficient representative of the inherent over strength and global ductility capacity of lateral force-resisting systems

T = Elastic fundamental period of vibration, in seconds, of the structure in the direction under consideration

W = The total seismic dead load

7) Liquefaction Parameter

Based on subsoil condition at Thar area, the liquefaction potential for the power station is the followings.

In case of seismic, liquefaction will occur and the stability of equipment's foundation will not be ensured due to the shake as settlement and the decrease of the horizontal resistance. The condition of liquefaction is indicated by the followings.

I. An alluvium stratum within GL-20m depth.
II. Uniform grain of Sand (less than 35% of Sand grain diameter of 0.075mm)
III. Saturation by the ground water
IV. N value will be less than 15.

The evaluation can check the following formula ;

F = (Resistance of liquefaction) / (Resistance of Shearing)

In case of F will be less than 1, the sand stratum will result in liquefaction, the foundation will be reduced to resistance of horizontal and plasticity reaction.

Therefore, design for structure and foundation of Lakhra Power Station do not be required to consideration of liquefaction, because N value was over 13 all the location based on result of boring test.

(4) Main Structure for Power Station

The civil works are designed to perform the necessary operational function of the power station. All design shall take into account of geological and topological conditions, such as wind and seismic forces. The coal storage yard and receivers will be installed at the north-west of the existing power station. Then imported coal will be carried from Karachi by railway and lignite from Thar coalfield by railways. The ash yard is located at the western in the new power station.

1) Land Preparation of Power Station

The existing power station has a vacant space of approximate 112ha of area including the existing plant and approximate 77.6ha the land is available to the project's power plant. There are undulation of 15.0m between EL.+34.0m at east Northern and EL.+49.0m at west Southern in the power station. The land preparation should be considered of the two stage formation due to undulating, the low level of the formation is planning to EL.+38.0m and high level is set EL.+41.0m, respectively. The ground is covered the weathered rock of limestone and shale, hence, levelling of the site area will be prepared by bulldozers with ripper.

2) Main Building for Steam Turbine and Generator

The main building to be installed turbine and generator is constructed by RC structure which is 110m length (long span) and 50m length (short span). The foundation is designed spread type to consider the bearing capacity. The superstructure is consisted the column (1.0m x 1.0m) and the beam (0.30m x 0.60m) with the fifth floors. In the workshop area for maintenance, there is the overhead travelling crane of the 100t's capacity on the column. The control room is set up at same level of generator floor.

3) Boiler and Coal Banker

The foundation for boiler and coal banker is designed by the spread type in order to avoid the overturning due to horizontal forces and set up the rock anchors to hold the uplift. The rock anchors are 30m length of 50mm diameter and filling up the underground using by the cement milk. The superstructure is fabricated by the Mechanical works on the foundation.

4) ESP and FGD

The electrostatic precipitator (ESP) and flue-gas desulfurization (FGD) equipment are supported by the spread foundation because of the lighter facility than the boiler. The superstructure is fabricated by the steel structure.

5) Stack

According to environmental standard, the stack height is estimated higher than 200m. The stack is constructed of an exterior freestanding concrete chimney shell and independent interior steel liners of flue ducts. The bottom and the middle diameter at 100m height of concrete chimney is planning 30m and 20m with tapered type, respectively. The foundation is designed the octagon shape with 32m diameter. The rock anchors will be set up on the foundation to cope with the uplift due to overturning of horizontal force. The construction method is carried out the slip or jumping form method.

6) Cooling Tower

The cooling system is the natural draft type and the tower is designed as cylinder of 110m diameter at bottom. At 80m height, the cylinder is planning 60m tapering. The foundation is designed as the octagon shape of 120m diameter such as the stack foundation. The construction method is applied the slip or jumping form method same as stack.

7) Coal Storage Yard

The coal storage capacity is 630,000m^3 for 55 days consumption, and one coal storage yard is estimated by 50m x 550m, and has 3.5 piles in the power station. The import coal will be carried from Karachi by the railway and the Thar coal will be carried by railway. The railway pulls trains into the coal storage yard directly. After unloading coal from the wagon to hopper, the coal will be carried to stocker by the belt conveyer. The civil works is consisted the rail foundation of stacker, reclaimer, belt conveyer and hopper.

8) Ash yard

The ash discharged from boiler and ESP is planning to be carried to ash yard as a slurry by pressure pump. The good quality ash such as fly ash is stored to silo in power station for recycling of material. The ash yard is designed the 5 years storage capacity. The yard is enclosed by 2.0m height embankment to avoid the over flow and the bottom will be set up by clay soil of 200mm thickness with waterproof PVC's sheet to cope with the penetration into underground.

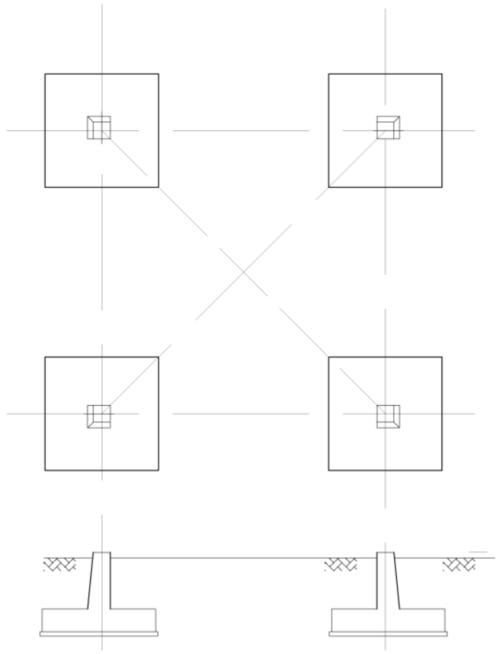
9) Intake and Pile Line for Cooling Water

The intake gate for cooling water shall be constructed and installed the riverbed in the Indus River which is located at 6.5km from the power station. The jetty is designed 100.0m distance supported by steel pile of 500mm diameter. The pump house is designed by the concrete building with PC pile.

10) Transmission Line

For the connection between the power station and existing transmission line, it is necessary to construct the new transmission lines which have four line and total length of approximately 12.5 km with steel towers of nos. 40. The selection of proposed alignment will be described in Section 7.2.5.

In case of design the foundation of steel tower, it must consider the load on the foundation come into the compression and the tension which mainly occur by wind. According to the result of geological investigation, it is easy to cope with compression load, because supporting layer exist shallow depth and it has bearing capacity more than 1600 kPa. On the other hand, because of tension load will be coped by self weight and earth covering load, foundation shape and excavation depth have to be considered to stabilize. The proposed shape of foundation is individual footing type as shown in Figure 7.3-50.



Source: JICA Survey Team

Figure 7.3-50 Proposed Foundation Shape

Outline of main structures for Lakhra Power Station are shown in Table 7.3-62.

Table 7.3-62 Main Structure

Main Structure	Structure	Foundation
Main Building for Turbine and Generator	RC Building X direction: 110m / Y direction: 50m With 100t Overhead Travelling Crane	Spread Foundation and individual pedestal for turbine
Boiler and Coal Banker	Boiler: Steel member for superstructure X direction: 100m / Y direction: 60m	Spread foundation with column for superstructure
Electrostatic Precipitator	ESP: Steel structure X direction: 45m / Y direction: 60m	Spread foundation with column for superstructure
Flue- Gas Desulfurization and Auxiliaries	FGD and Auxiliaries: Steel structure X direction: 75m / Y direction: 75m	Spread foundation with column for superstructure
Stack	Exterior: Concrete chimney (tapered type) Shell Diameter: 30m / Stack Height: 200m Interior: Steel Liner (flue ducts) Liner diameter: 10m / Liner height: 200m	Spread foundation with rock anchor
Cooling Tower	Cylinder Type / Tower Height: 140m Bottom Diameter: 110m / Top Diameter: 60m	Spread foundation with rock anchor
Coal Storage Yard	Reclaimer, stacker and belt conveyer	Spread rail foundation for reclaimer, stacker and belt conveyer
Ash Yard		Clay layer at bottom base
Transmission Line	Steel Structure Tower	Spread foundation with chimney column for steel leg and anchor
Intake Gate	Pump Station: RC structure with block wall Jetty and Platform: Length 100m	Steel pile for pump station and Jetty

Source: JICA Survey Team

(5) Cost Estimation for Civil and Building works

Cost estimation for civil and building works is shown in table 7.3-63.

Table 7.3-63 Cost Estimation for Civil Works (USD)

This table is masked because it includes confidential.

7.4 Operational Indicator

7.4-1 Operational Indicator

Operational indicators for evaluating operational condition of the plant, namely the plant is operating properly, quantitatively is set as listed in Table 7.4-1 in consideration with all study in Chapter 7.

Table 7.4-1 Operational Indicator

	Name of indicator	Indicator	Target	
Basic	Maximum Output (MW)	Same as left	Designed maximum output of the Plant 660MW	
Basic	Plant Load Factor (%)	Annual generated power /（Rated output kW x 8,760）x 100	80%	
Supplemental	Availability Factor (%)	(Annual Operating Hours / 8,760)×100	85%	
Supplemental	Auxiliary Power ratio (%)	(annual auxiliary power/annual generated power at generator)x 100%	6.5%	
Basic	Gross Thermal Efficiency (%)	(Annual generated power×860)/ (annual consumed coal ×coal calorific value)×100	42.5% when 100% imported coal	
Basic	Outage Hours by Cause (hours/year)	Same as left	Human error	0 hours
			Machine trouble	360 hours
			Planned outage	960 hours
Supplemental	Outage Times by Cause (times/year)	Same as left	Human error	0 time
			Machine trouble	3 times
			Planned outage	1time

Source: JICA Survey Team referring to "Japan ODA Loan Reference of Operational and Effect Indicators July 2014"

7.4.2 Effect Indicator

Effect indicators for evaluating effect of the plant for beneficially or for the region quantitatively are set as listed in Table 7.4-2.

Table 7.4-2 Effect Indicator

	Name of indicator	Indicator	Target
Basic	Maximum Output （MW）	Same as left	Designed maximum output of the Plant 660MW
Basic	Net Electric Energy Production (GWh/year)	Same as left	4,200GWh/year

Source: JICA Survey Team referring to "Japan ODA Loan Reference of Operational and Effect Indicators July 2014"

CHAPTER 8
OPERATION AND MAINTENANCE MANAGEMENT

Chapter 8 Operation and Maintenance Management

8.1 Operation and Management Conditions of the Existing Plant in Pakistan

8.1.1 Site Survey in the Jamshoro Power Station

The main characteristics and operation factors of the Jamshoro Power Station are shown in Table 8.1-1 and Table 8.1-2, respectively.

Table 8.1-1 Main Characteristics of the Jamshoro Power Station

Item	Unit No. 1	Unit No. 2	Unit No. 3	Unit No. 4
Start of Operations	Jan.1990	Dec.1989	Jun.1990	Jan.1991
Boiler Manufacturer	Mitsui Shipbuilding Japan	Harbin Boiler China		
Turbine / Generator Manufacturer	Fuji Electric Japan	Harbin Turbine/Electric China		
Rated Installed Capacity	250 MW	200 MW		
De-rated Capacity	220 MW	170 MW		
Fuel	Furnace Oil	Gas/Furnace Oil		
Main Steam Pressure /Temperature	169 kg/cm3 540 °C	140 kg/cm^3, 541 °C		

Source: JICA Survey Team

The operational factor is managed by Unit 1 (Block I) and Units 2 to 4 (Block II) separately.

Table 8.1-2 Operational Factors of Power Station

	Axially Power Consumption (%)		Utilization Factor (%)		Load Factor (%)		Gross Efficiency (%)		Forced Outage (hours/month)
	FY2011	Aug. 2013	FY2011	Aug. 2013	FY2011	Aug. 2013	FY2011	Aug. 2013	FY2011
Block I	10.05	8.0	35.7	66.6	49.1	77.1	32.8	34.3	7
Block II	10.67	9.9	21.6	58.6	35.7	57.6	26.6	31.3	80

Block I : No.1 Unit (Japan) Block II : No. 2, No. 3, and No. 4 average (China)

Source: JICA Survey Team

Auxiliary power rates of each plant are around 10%, and the auxiliary power of Block I is 0.62% lower than Block II in FY2011

The annual utilization factor of Block I is 14%, which is higher than that of Block II, in FY2011.However, the monthly averages of both Block I and Block II sharply improved to

66.6% and 58.6%, respectively, in August 2013, when the replacement of the economizer and high pressure heater tube works were carried out from August to December 2012.

The duration of the standby mode of all four units was 7,478 hours in total, which is almost one fourth of the total time in a year. This is because of the shortage of demineralised water caused by frequent forced outages in 2012. However, some troubles such as plugging of pre-air heaters still continue at present. The cause of these troubles is due to the failure of the facility structure. Therefore, there are some technical problems in the operation and maintenance.

Currently, the control system of all plants is an analogue-type system. Such system is already obsolete and therefore will be replaced by a distributed control system (DCS) as financed by the United States Agency for International Development (USAID).

The maintenance conditions of major facilities such as the drum and burners area are properly done since the commencement of operation after commission (refer to Photo 8.1-1 and Photo 8.1-2). In the case of the adoption of new technology such as USC plant for the new Lakhra Power Station, it is possible to properly operate and maintain the plant by engineers and technicians with well strategic trainings focusing on the difference between USC and sub-critical plants.

Source: JICA Survey Team

Photo 8.1-1 Drum (Jamshoro No. 1)

Source: JICA Survey Team

Photo 8.1-2 Fuel Burner (Jamshoro No. 1)

8.1.2 Site Survey in the Hub Power Station

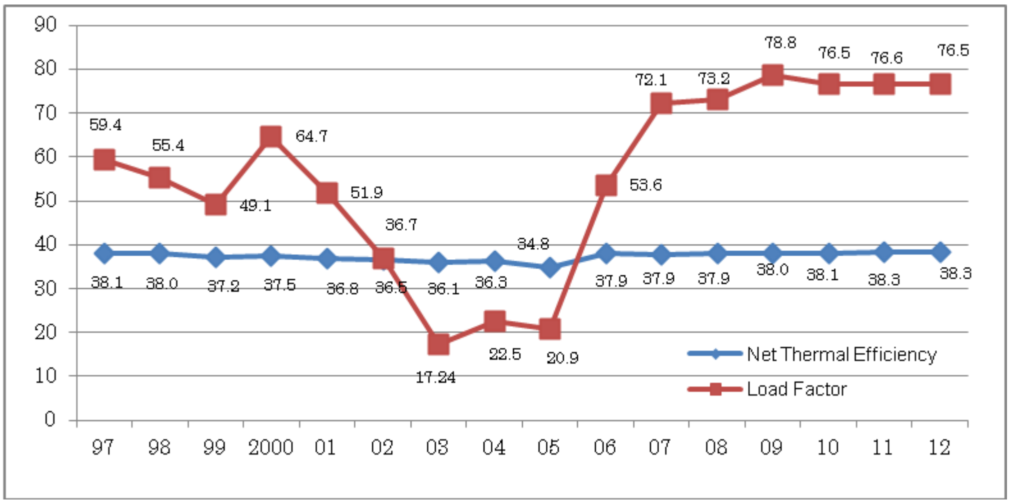
The main characteristics and operation factor of the one reference Hub Power Station is shown in Table 8.1-3.

Table 8.1-3 Main Characteristics of a Hub Power Station

	Unit No. 1	Unit No. 2	Unit No. 3	Unit No. 4
Start of Operations	Jul. 1996	Sep. 1996	Nov. 1996	Mar. 1991
Boiler Manufacturer	IHI Japan			
Turbine / Generator Manufacturer	Ansaldo Italy			
Rated Installed Capacity	323 MW			
Average Load Factor from Commercial Operation	56.5%	54.7%	58.8%	52.8%
Auxiliary Power Consumption	7%			
Fuel	Furnace Oil			
Main Steam Pressure /Temperature	170 kg/cm^3, 540 °C			

Source: Prepared by the JICA Survey Team

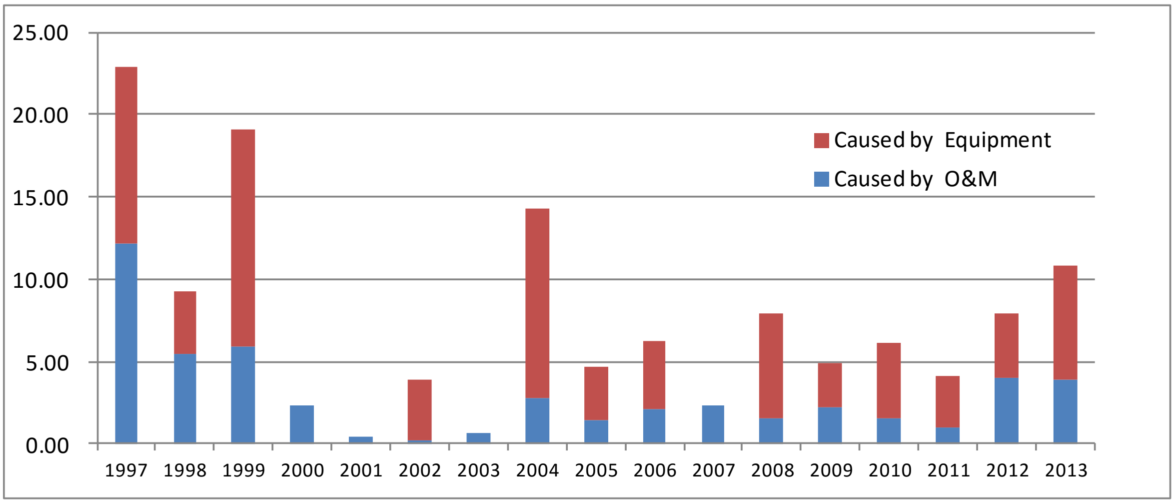
Auxiliary power consumption is 7%, and it is 3% lower than the Jamshoro Power Station due to taking seawater cooling system.



Source: Presentation by the Hub Power Station

Figure 8.1-1 Trend of Net Thermal Efficiency and Load Factor

Figure 8.1-1 shows the net thermal efficiency and load factor of the power plants after commencement of its operation in 1997. The load factors from 1997 to 2006 are relatively low, and especially from 2003 to 2005, these were extremely low, as the power demand in the network had been low due to excess installed capacity. After 2007, the net thermal efficiency was maintained at 38% and the load factor was over 70%. These operational data show the power station provides the base load.



Source: Presentation by the Hub Power Station

Figure 8.1-2 Trend of Breakdown Forced Outage

The trend of forced outage is shown in Figure 8.1-2.

Forced Outage Rate (FOR) is calculated using the "Forced Outage Hours / (Forced Outage Hours + Utilization Hours)" equation.

FOR is classified into two categories; red bars show the ratio of "caused by equipment" and blue bars describe the ratio of "caused by O&M". High FORs (from 9% to more than 20%) were recorded during the first three years and FY2004. The reasons for the increase are mainly on the major equipment, such as turbine valve, generator and main transformer, hence, initial failure or improper construction is surmised. In addition, the ratio of "caused by O&M" are especially high in the first three years, which would also be mainly caused by initial failure or improper construction. The repair work on them is complicated and unique apart from the conventional operation and maintenance work, and therefore, it would be difficult to handle for inexperienced engineers and technicians soon after starting commercial operation. Otherwise, the blue bars' ratios are improved to less than 4% after FY2000. This implies that proper management and O&M are carried out.

Equipment troubles increased again in 2012 and 2013. These troubles were caused by boiler tube leakage due to by deterioration. In response to the deterioration, the Hub Power Station carried out replacement work in 2013.

8.1.3 Evaluation for Operation and Maintenance Management Conditions in Pakistan

Judging from the conditions of the Jamshoro Power Station and Hub Power Station, almost all failures occurred due to troubles in the facilities such as initial failure, mistaken in design, poor quality (boiler tube), and deterioration. Supposedly, there will be a few cases of malfunction on the maintenance or missed operation. As the Hub Power Station has highly reliable facilities, such as boiler (supplied by IHI) and turbine/generator (supplied by Ansaldo), high reliability operation (up to 70% load factor at present) can continue.

On the other hand, the organization of GENCO I seems to be old fashioned and obsolete. As described in Clauses 2.10.2 and 2.10.3, the number of staff in the Jamshoro Power Station is four times that of Hub Power Station.

Therefore, the organization of the new power station of the Project should be formulated based on the Hub Power Station[1] and it is necessary to pursue the formulation of a more practical organization.

8.1.4 Thar Mine Mouth Power Station Project Planned by SECMC

The SECMC, in the private sector, is one of the leading organization/company which develop coal fired thermal power plant in Pakistan as explained in Chapter 2.

Corresponding to coal mining development, SECMC concluded an EPC contract and detailed engineering work has already begun for Phase I of a coal-fired power plant project (2x300 MW). Although SECMC's project implementation was scheduled to start in the second half of 2014 initially, the delay of coal mining development affected the project implementation while commercial operation is expected to start in 2018.

The total number of staff is planned to be at 350 and 300 for Phase I (2x 330 MW) and Phase II (1x660 MW), respectively.

SECMC has a plan to train 37 core experts to manage a total of 650 staff for power plant operation in two years before the operation of the power plant, and all staff will be trained in the ENGRO chemical plants or at other projects of the ENGRO groups. Also, it has a plan to dispatch staff to a foreign power station for on-the-job training (OJT).

The ENGRO groups have common and related technical standards such as environmental regulations, safety control, and production quality control. The training plan for the Project is prepared in accordance with these SECMC's plans.

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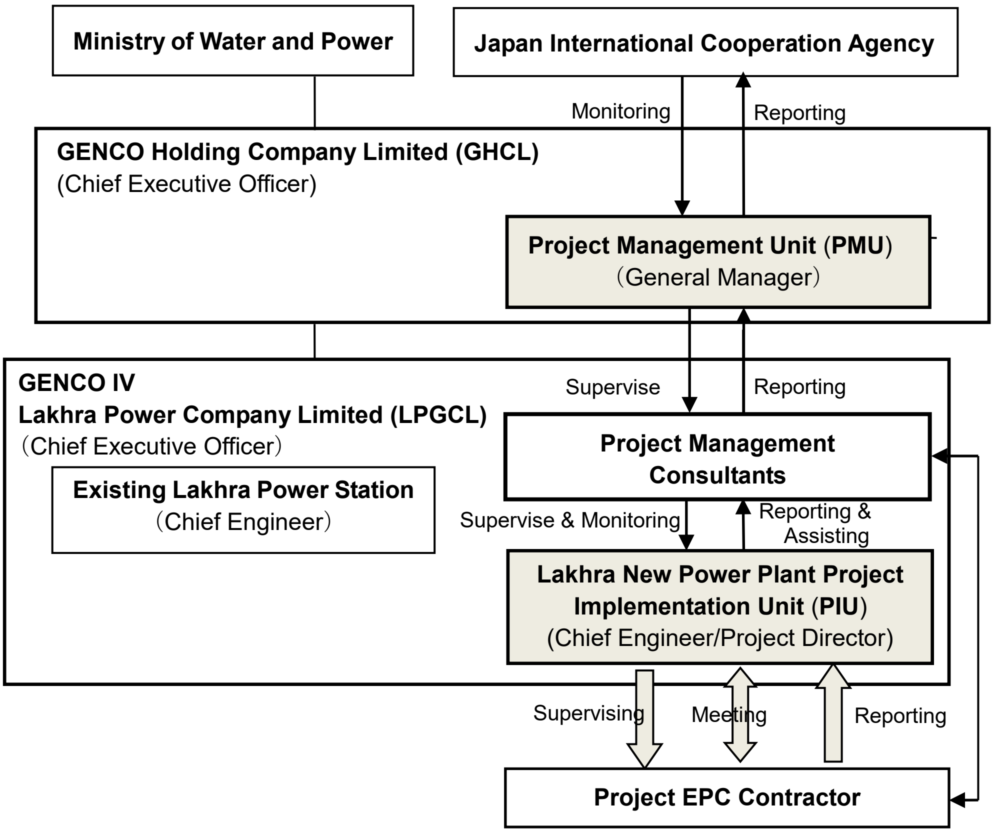
[1] The system which Hub Power Station adopts is relatively new in Pakistan, and the automatic control system installed is likely the same kind of system as Japanese power plants. New power plant will be able to refer to Hub Power Station in O&M if new Lakhra Power Station installs a similar system under the Project.

8.2 Organization of the New Power Station under the Project

8.2.1 Project Promotion Plan

The Lakhra Coal Fired Power Plant Construction Project is presumed to promote the management structure shown in Fig 8.2-1. The GHCL is the executing agency and it is necessary to establish a new project management unit (PMU) in the GHCL, and a project implementation unit (PIU) in the construction site.



Source: JICA Survey Team, with reference to GENCO Holdings Plan

Figure 8.2-1 Management Structure of the Project

Table 8.2-1 shows the decision maker after approval of PC-1 for new power plant compared with existing power plant.

Table 8.2-1 Decision Maker of the Plants

Existing Power Plant	New Power Plant (after approval of PC-1)
All budget including operational and maintenance cost - Board of Director of each power station	Procurement of consultant for construction - Board of Director of GENCO HD Procurement of EPC contractor - Board of Director of GENCO HD

Source: JICA Survey Team

8.2.2 Tasks of the PMU

Each project establishes a dedicated PMU at GHCL to manage implementation of the project financed by investors, such as JICA in general. The PMU functions as one window facilitator for internal and external communications and coordination with stakeholders such as NEPRA, NTDC, Pakistan Railway, Sindh Works & Service (road) and Government of Sindh (GoS) including SEPA. The task of the PMU is management of the project taking into account the schedule, the budget and the technical specifications in general. The PMU is also in charge of environmental and social safeguard requirements whether there are being satisfied in the execution of the project under the umbrella of GHCL. In addition, the PMU is also responsible for the coordination of the training program for each project. For the Project, a PMU will be established at the initial implementation stage.

The positions and basic pay scale(BPS) structure for the PMU is shown in Table 8.2-2. The PMU also includes support staff as needed for better supervision, coordination and workload management. The PMU staff should have appropriate relevant academic qualifications, with experience working in specialty areas.

Table 8.2-2 Position and BPS of Project Management Unit (PMU)

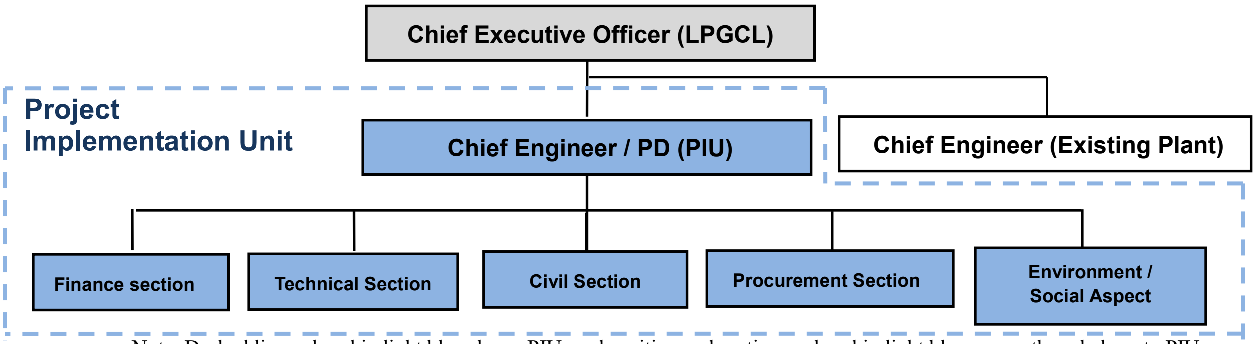
Position	BPS Scale	Num.
General Manager (D&D) Overall In charge of PMU		1
Director Technical	BPS-19	2
Deputy Directors	BPS-18	2
Assistant Directors	BPS-17	2
Director (Monitoring & Evaluations)	BPS-19	2
Deputy Directors	BPS-18	2
Assistant Directors	BPS-17	2
Director (Environment)	BPS-19	1
Deputy Director (Environment)	BPS-18	1
Assistant Director (Environment)	BPS-17	1

Note: BPS, Basic Pay Scale (Government Servant Salaries)

Source: Hearing from GHCL

8.2.3 Organization for the Construction Stage

Establishment of the project implementation unit (PIU) is recommended to carry out the construction stage management at the Lakhra site. The PIU is responsible for planning, giving instructions to consultant and contractor, plant design, construction supervision, and witnessing performance tests. Following government policy, related regulations or laws will be employed and set for the Project. The organizational chart of the PIU is shown in below.



Note: Dashed line colored in light blue shows PIU, and position and sections colored in light blue means these belong to PIU.

Source: Hearing from GHCL

Figure 8.2-2 Organizational Chart of the PIU at Lakhra site

The main members of the PIU and their positions are shown in Table 8.2-3

Table 8.2-3 The Position and BPS Scale of PIU

Position	BPS Scale	Num.
Chief Engineer / Project Director	BPS-20	1
Director (Finance)	BPS-19	1
Deputy Manager Finance	BPS-18	1
Assistant Manager Finance	BPS-17	2
Account Officer	BPS-16	2
Director (Technical)	BPS-19	1
Sr. Engineer Mechanical	BPS-18	1
Jr. Engineer Mechanical (Boiler, BOP, Turbine)	BPS-17	3
Sr. Engineer Electrical	BPS-18	1
Jr. Engineer Electrical	BPS-17	2
Sr. Engineer Control and Instrumentation	BPS-18	1
Jr. Engineer Control and Instrumentation	BPS-17	2
Sr. Engineer Chemical / Senior Chemist	BPS-18	1
Jr. Engineer Chemical / Junior Chemist	BPS-17	2
Sr. Engineer FGD, Coal and Ash Handling	BPS-18	1
Jr. Engineer FGD, Coal and Ash Handling	BPS-17	2
Director (Civil)	BPS-19	1
Sr. Engineer Civil	BPS-18	1
Jr. Engineer Civil	BPS-17	2
Director (Procurement)	BPS-19	1
Deputy Director Procurement	BPS-18	1
Assistant Director Procurement	BPS-17	2
Deputy Director Environment / Social Aspects	BPS-18	1
Assistant Director (Environment)	BPS-17	1
Assistant Director (Social Aspect)	BPS-17	1

Note: BPS, Basic Pay Scale (Govt. Servant Salaries)

Source: Hearing from GHCL and Modified by JICA Survey Team

All staff of PMU and PIU will be arranged thorough the public offering as the public servant of GoP from outside of GENCO and Internal personnel deployment by GENCO itself.

8.2.4 Project Executing Agency

(1) Back-ground

Although a total 26 IPP power plants were installed after enactment of the Power Policy 1994[2] and revision in 2002[3], there is no power station which utilizes coal as fuel in the private sector in Pakistan. In the public sector, the existing Lakhra Power Station is the only coal fired thermal power plant in Pakistan as mentioned in Chapter 4.

While, nine goals have been set in the National Power Policy 2013, one of which is " iii) Ensure the generation of inexpensive and affordable electricity for domestic, commercial, and industrial use by using indigenous resources such as coal (Thar coal) and hydel".

(2) Power Plant in Public Sector

The public sector to private sector ratio is one third and two third respectively in 2014. Considering the power shortage situation in Pakistan, the government and GENCO should have planned and implemented the new power plant project. However, there is no new thermal power plant installed for 17 years in the public sector since unit No.13 (Steam Turbine for Combine Cycle) of Guddu was installed in 1994.The GoP launched three major power projects under GENCO in 2008 after a long time. However the projects are considerably delayed compared to the planned period, and then, only two projects, namely the 747MW Guddu project and the 425MW Nandipur project reached the test commissioning stage as of February 2015.

(3) Power Plant in the Private Sector

On the other hand, in order to attract private investment for the energy sector, some IPPs were established and started to supply power in Pakistan by the enactment of the Power Policy of 1994.The Kot Addu Power Station[4], the oldest one in private sector, was installed in 1986. The power plant was initially installed as a public power plant owned by WAPDA and privatized in 1996 as the first private power plant. Since then, total installed capacity of IPPs has reached about 8,158 MW as of February 2015 in the private sector.

All of IPPs use RFO and gas as fuel, and they adopt sub-critical steam conditions with drum type boilers. Whereas, some IPPs have plans to install USC steam condition with one-through boiler in the future.

As for O&M of their plants, the IPPs are outsourcing the task to third parties.

[2] Policy Framework and Package of Incentives for Private Sector Power Generation Projects in Pakistan ; March 1994
[3] Policy for Power Generation Projects year 2002
[4] The Kot Addu power plant was installed and owned by WAPDA (from 1987 to 1996), and then it was privatized.

(4) The Consideration of Eligibility of USC Technology in the Public Sector

There are only a few cases of coal fired thermal power plants that adopt USC technology in the developing countries and it seems there are very few or no plants by IPPs. High quality experiences are required to obtain related skills and knowledge for reliable O&M of a coal fired thermal plant, hence, it takes a long term.

However, introduction of USC technology is recommended to overcome the current situation of power shortage and achieve one of the goals of the above-mentioned National Power Policy 2013 (by using indigenous resources), and the project should become the top runner of future projects by the public sector. The increase of coal fired thermal power projects is expected in Pakistan in the future using advanced technology of USC and indigenous coal such as Thar coal, therefore GoP is expected to take initiative to develop the power projects.

8.2.5 Recommended Organization for the New Lakhra Power Plant

Organization and management systems of other projects under GENCO were studied and compared in table 8.2-4. The studied projects are Guddu (747MW), Nandipur (425 MW) and Jamshoro (2x660MW) projects. And then, a suitable organization was considered for the Project as well. The comparison of each project is shown in Table 8.2-4

Table 8.2-4 Comparison of each Project Status

Project	Guddu 747MW	Nandipur 425MW	ADB Jamshoro 2x660MW	Lakhra 1x660MW (GENCO IV)	SPV Establishment for Lakhra (GENCO VI)
Executing Agency	PMU in GHCL	PMU in GHCL	PMU in GHCL	PMU in GHCL Recommended	SPV Establishment
In charge of the Project	GM in GPCL	GM in GPCL	GM in GPCL	GM in GPCL Recommended	GM or CEO in SPV
NEPRA License	Modification	Modification	Modification	Modification	New Petition
Other Permission	Modification	Modification	Modification	Modification	New Petition
Location	Same site	Different site	Same site	Same site	Same site
Management Organization (Old and New)	Separate (Each Chief engineer)	Separate (Each Chief engineer)	Separate (Each Chief Engineer)	Separate (Each Chief Engineer) recommended	Independent
Financial Statements	Cannot be confirmed	Cannot be confirmed	Cannot be confirmed	In-house Company (Separate) recommended	Independent
Financial Account	Cannot be confirmed	Cannot be confirmed	Cannot be confirmed	Separate recommended	Independent
PPA Generation Tariff	Not decided	Not decided	Not decided	Separate recommended	New contract
Comment		GENCO V established at commissioning stage		JST Recommended	

Source: JICA Study Team

Guddu and Nandipur projects were established and are managed by PMUs. Both projects have obtained the generation modification licence from NEPRA. Each project appointed a general manager for coordination of the project.

For Nandipur project, the PMU was established under GENCO III (Muzaffargah Power Station) although the project site is located far from Muzaffargah. Therefore, GENCO V was newly established in Nov.2014 at the commissioning stage. Through observation of the establishment of GENCO V, it can be a short cut to settle the business entity and its operation by using the license and permission of the existing GENCO III.

While, special purpose vehicles (SPVs) are established for power plant projects in some cases, and it is also one of the options for the Project. The advantage for the SPV is its clarity as an independent account, therefore SPV is allowed to determine its own budget allocation and secure the maintenance budget as it deems necessary. On the other hand, newly established SPV does not have any permission and license such as generation license from NEPRA, light of water intake and acquisition of land use, separately from GENCO IV. In addition, SPV shall sign a lease contract of land use for construction of new power plant with GENCO IV. Therefore, the new business entity of SPV will take a long time to obtain construction authorization.

As compared between establishment of SPV (GENCO VI) and PMU under GENCO IV, the JST recommended the project to be implemented by PMU in GHCL rather than the establishment of SPV. The independence of finance is still ensured by in-house company account. Detailed comparison between GENCO VI and PMU under GENCO IV are summarised in table 8.2-5.

JICA and GPCL eventually concluded MoM on related financial Issues in June 2015 when the Project would be implemented in GENCO IV.

As for securing budget for fuel and O&M, the escrow account is necessary to keep fuel cost of at least one month and maintenance cost of one year for ensuring to make the plant operation efficient and stable. Detailed financial and economic comparison is studied in Chapter 10.

Table 8.2-5 Comparison between GENCO IV and GENCO VI

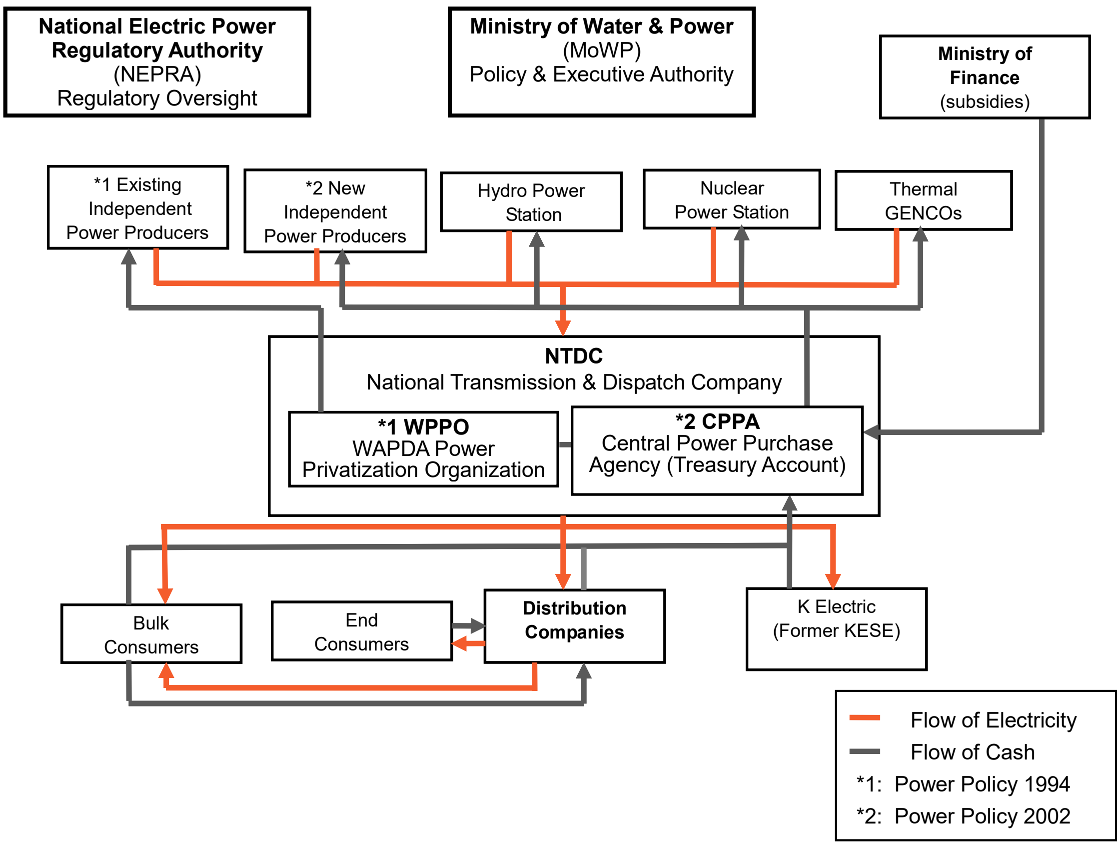
Comparison Items	GENCO IV (Modification of Existing Entity)	GENCO VI (New Entity Establishment)
1. Management Organization	Newly established organization under GENCO IV	Newly established company under GHCL
- Project Implementation Management	PMU established under GENCO IV conduct the management The staffs are hired or assigned by GHCL/GENCO IV	Newly established company conduct the management. The staffs are hired or assigned by GHCL
- Operation and Maintenance Management	O&M management organization is newly established completely separated from the old plant	O&M management organization is established in new company
2. NEPRA Generation Permission	Modification of current generation permission (for both old and new) is necessary	Obtaining new generation permission is necessary The petition of the permission shall be submitted well in advance for NEPRA to be able to thoroughly review it
3. Other Permission, if any	If the permissions other than the generation license is necessary for new plant, modification of current permission is necessary	If the permissions other than the generation license is necessary for new plant, obtaining permission is necessary
4. Financial Statements	Consolidated financial statements for two power plants is prepared	Financial statement dedicated for new plant is prepared
5. PPA & Generation Tariff	New PPA is concluded and new tariff is set for new plant separate from that of old plant	New PPA is concluded and new tariff is set for new plant
6. Financial Management Account	Separate financial management accounts for old and new power plants are prepared	Financial management account for new plant is prepared
7. Financial Independence	With monitoring cash flow and balance sheet of the GENCO IV, independence of finance is secured (It recommended that the above shall be stated in signed MOM and attached to LA)	Balance sheet and account is dedicated to new plant
8. Establishment of Escrow Account (For Fuel & O&M)	Escrow account can be opened for making sure fuel & O&M payment.	Escrow account can be opened for making sure fuel & O&M payment.
9. Pros & Cons	1) Lower risk of delay in project implementation by avoiding the establishment of a new company 2) Risk in the use of the Project's revenue for compensating the deficit of the existing Lakhra Power Station 3) GENCO IV is subjected to be privatized, if it will be realized, new Lakhra cannot be under the GENCO	1) Higher risk of delay in project implementation due to the establishment of a new company 2) More financial independence guaranteed by establishing a new company
10. Recommendation to Mitigate the Risks	Abnormal value (e.g. increase in receivables) in cash flow of existing and new Lakhra Power Plant shall be regularly (quarterly) monitored and reported to relevant stakeholders.	Deadline for establishing a new company and assignment of personnel should be made as one of the milestones for the schedule of the project implementation.

Source: JICA Survey team

For reference, power supply flow and energy charge payment flow is shown in Figure 8.2.3

Power generation is sent to the National grid (NTDC), and energy charge payment are done by Central Power Purchase Agency (CPPA) for each generation company.

The CPPA is primarily responsible for purchasing power from all generation plants located throughout Pakistan excluding the Karachi area and selling DISCOs and bulk consumers including K Electric (former KESE). It also has duties concerning the verification of Energy Purchase Price (EPP) invoices, the verification of Capacity Purchase Price Invoices and Supplementary Invoices claimed by the generators (GENCOs etc.). In addition, the CPPA is responsible to autonomous entity for Power Sector through the treasury account, in the case of object include mitigating cash shortfall risks.



Source: JICA Survey Team

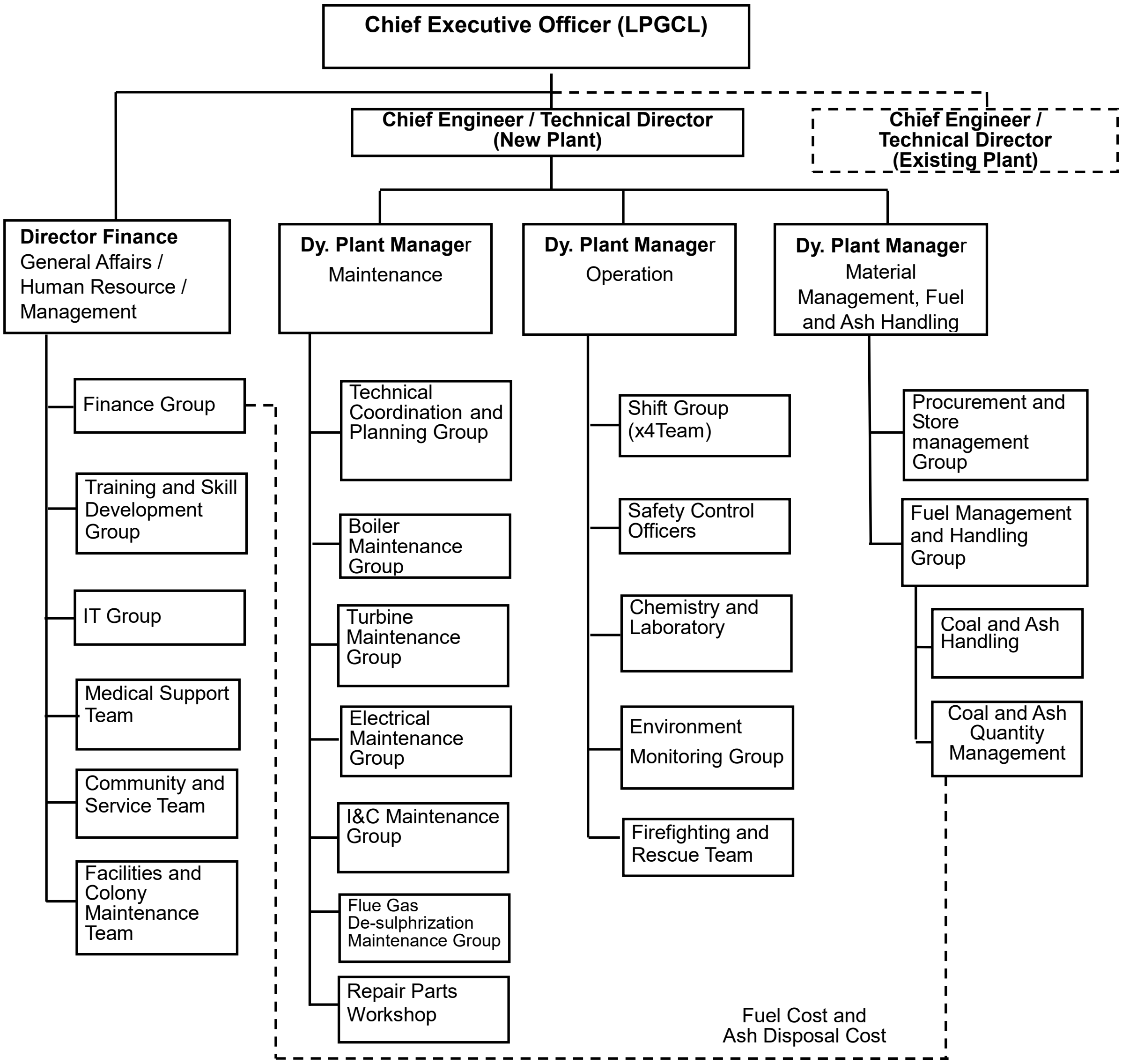
Figure 8.2.3 Power Supply Flow and Energy Charge Payment Flow

8.2.6 Organization of the Power Station for the Operation Stage

The PIU will be integrated into the organization for the power station at the operation stage after commissioning. Additional staffs for the power station will also be arranged through the public offering as the public servant of GoP from outside of GENCO and internal personnel deployment.

The organization for the power station is responsible for the operation, maintenance of all facilities for fuel handling, ash handling, environmental monitoring, and related power plant management. All of these tasks follow and comply with the government policy, and related regulations or laws will be employed and be set for power plant management.

The recommended organization of the power station is shown in Figure 8.2-4.



Source: Hearing from GHCL and Modified by JICA Survey Team

Figure 8.2-4 Organizational Chart of the New Power Station for the Operation Stage

The recommended number of staff for each section is shown in Table 8.2-6.

Table 8.2-6 Task of Each Section and Staff Number for New Power Station

Section	Position and Task	BPS Rank	Number of Staffs
Director	Station Chief Engineer / Technical Director	20	1
Finance/ General Affairs/ Human Resource/ Management / Security	Director(Finance, HR/GA)	19	2
	Deputy Manager (Finance, Training and Skill Development, Security)	18	4
	Assistant Manager (HR/GA, IT, other service)	17	3
	Finance Officer	8	4
	HR/ GA Officer	8	6
	IT Officer	8	4
	Security Inspector	15	1
	Support Staff (Medical , community service, Colony maintenance	7	10
	Security Guard	5	40
	Subtotal		**75**
Operation	Deputy Plant Manager (Resident Engineer) Operation	19	1
	Assistant Resident Engineer Operation	18	1
	Senior Shift Engineer	18	4
	Junior Shift Engineer	17	4
	Operators (Boiler x2, Turbine ,Electric, C&I, Fuel x2, Coal and Ashx4,) x 4 team	16	44
	Attendants	14	20
	Safety Control Officer	12	4
	Assistant Engineer / Chemist (Chemistry and Environment Monitoring)	18	1
	Junior Chemist	17	2
	Assistant Chemist	13	2
	Chemical Laboratory Officer (water treatment, coal analysis)	10-12	8
	Environment Monitoring officer	10-12	4
	Fire fighting Head	7	1
	Fire fighting and Rescue Team	5	16
	Subtotal		**112**
Maintenance	Deputy Plant Manager (Resident Engineer) Maintenance	19	1
	Assistant Resident Engineer maintenance	18	1
	Senior Engineer(Technical coordination & planning, boiler, turbine, electric and C & I, FGD)	18	6
	Junior Engineer(Technical coordination & planning, boiler, turbine, electric and C & I, FGD)	17	6
	Technical Coordination & Planning, Inspection Test and Record Quality Control	14	6
	Boiler Main Equipment Maintenance Staff	14	4
	Boiler Auxiliary Equipment Maintenance Staff	14	4
	Turbine Main Equipment Maintenance Staff	14	4
	Turbine Balance of Plant Staff	14	3
	Generator, Electrical Equipment staff	14	4
	C & I	14	4
	High Voltage Equipment (Transformer, transmission line)	14	3
	Fuel Gas De-sulpherization Facility	14	10
	Workshop Head	14	1
	Workshop Staff	14	15
	Helpers,	14	30
	Subtotal		**102**
Fuel Management and Ash Handling	Deputy Plant Manager (Resident Manager) Material Management, Fuel and Ash Handling	19	1
	Assistant resident Manager (Fuel, ash handling)	18	1
	Coal Handling and Management	14	10
	Ash Handling and Management	14	10
	Coal & Ash Quantity Record Management	14	4
	Subtotal		**26**
Mechanical management (Procurement)	Assistant Manager (Procurement, Store)	18	1
	Assistant Manager (Fuel Procurement)	18	1
	Procurement, Store Officer	11	6
	Helpers	5	8
	Fuel Procurement Officer	11	6
	Helpers	5	10
	Subtotal		**32**
Total			**347**

Source JICA Survey Team

8.2.7 Determination of Concept of Staff Numbers

The total number of staff was calculated at 347 as shown in table 8.2-5.

The number of staff was calculated based on the existing GENCOs' organization at other power stations with reference to 600MW class coal power stations in Japan. The new plant will adopt automatic control system for all equipment such as coal and ash handling systems and environmental abatement system. There is remarkable difference between analogue and automatic control of power plants, therefore it is necessary that staff number is accumulated considering work volume for each section with automatic control system.

The total number of staff is considered reasonable in comparison to the new Jamshoro Power Project and the Hub Power Station which adopt automatic control system as well.

8.2.8 Recruitment Planning for New Lakhra Power Station Staff

The new Lakhra Power Station will be controlled under the GHCL. Therefore the recruitment of all staffs will be according to the prescribed procedure for public servants the same as the other government officers. It is recommended that candidates for the Project will be nominated widely from GENCOs, other IPPs and engineers and technicians who are experienced and have related technical skills.

Table 8.2-7 Tasks for Recruitment and Period

Period	Event	Related event on planning and construction stage
Three years before construction start	A new power plant construction project team will start in GENCO Holdings to make the basic plan and train for environment impact assessment by ten personnel. 50 personnel (key engineers for the construction) will be recruited and will study the new plant system.	Plant planning and environment monitoring
Two years before construction start	50 personnel will be recruited and will study the new plant system. These are candidates for engineer positions in each section.	Main facilities detailed design, balance of plant and FGD planning
One year before construction start	50 personnel will be recruited and will study the new plant system. These are candidates for the operation engineers' position in each section	Coal handling and ash handling planning
Construction start	50 personnel will be recruited and will study the new plant system. These are candidates for the maintenance engineers' position in each section.	Plant construction supervising
Two years before operation	50 personnel will be recruited and will study the new plant system. They are candidates for the engineers' position in each section.	Plant operation training
One year before operation	80 to 100 personnel will be recruited and will study for the new plant system. They will be recruited as the engineers in each section.	Prepare test commissioning

Source: JICA Survey Team

8.3 Career Development and Training for the New Power Plant

8.3.1 General

There has not been any USC power plant in Pakistan so far. Therefore, Pakistan has no experience in operating the plant, while the Jamshoro Power Generation Project financed by the Asian Development Bank (ADB) will adopt USC conditions. The current experience of GENCO is limited to 3×150 MW CFBC boilers of the Lakhra coal-fired Power Plant. A USC power plant is also proposed in the Project, hence, an operation training system needs to be implemented to educate engineers and operators on such advanced and complicated technologies.

8.3.2 Difference between SC and USC-type and Subcritical-type Boilers

Modern thermal power plants operate at very high pressures greater than the critical pressure of steam. Therefore, it is necessary to understand the difference between subcritical power plants and SC and USC power plants.

SC power plants were in service since the 1980s. However, the technology did not really take off for a while due to the problem of reliability on the metallurgical aspect. The most important factor is the resistibility of used materials under SC and USC condition. Increases in operating pressure and temperatures have to go hand in hand with developments in metallurgical technology.

The following describes the main differences between subcritical units, SC and USC units:

(1) Efficiency

The main advantage in a higher pressure operation is the increase in thermodynamic efficiency of the Rankine cycle. Large subcritical thermal power plants (15 MPa to 17 MPa, and 538 ºC to 566 ºC) operate at approximately 38% plant efficiency. On the other hand, SC units (24 MPa to 26 MPa, and 566 ºC to 593 ºC) perform at approximately 42%. Increase in efficiency is principally effective on reductions of operating cost and CO_2 emissions.

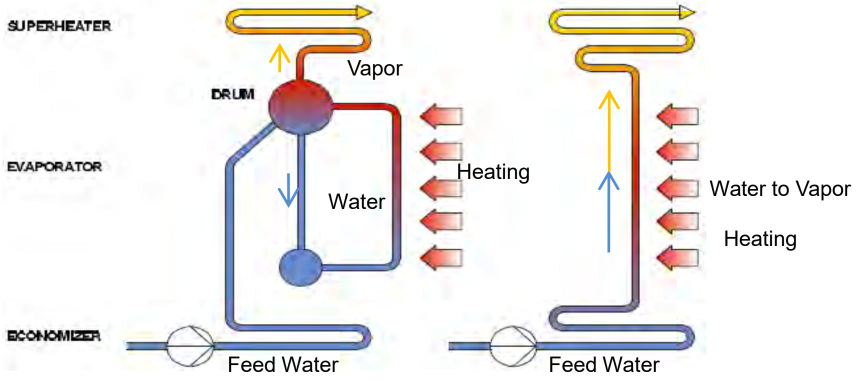
(2) Operational Flexibility

SC and USC units use once-through boiler technology. This is ideal for sliding pressure operation which has much more flexibility in load changes and controlling power grids. However, this requires more sensitive and quicker responding control systems.

(3) Evaporation Endpoint

Schematic diagrams of drum-type boiler and once-through type boiler are shown in Figure

8.3-1. In subcritical units, the drum acts as a fixed evaporation endpoint, and the furnace waterwalls act as the evaporator. On the other hand, in the once-through boiler design of SC and USC units, the evaporation endpoint is not fixed such as in a drum-type boiler for subcritical units. All feed water entering the once-through system is warmed up, evaporated, and superheated in a once-through mode. The evaporation endpoint can occur at various levels of the furnace depending on the boiler load. The percentage of superheat in SC and USC units is higher than in subcritical units. Because of this the furnace tubes act more as super heaters than waterwalls. Therefore, advanced high quality material is required for furnace tubes.



Souse: Foster Wheeler Boiler Technology

Figure 8.3-1 Difference of Drum-type Boiler and Once-through Boiler

(4) Heat Transfer Area

The difference between the temperature of a combustion gas and steam for USC units results in smaller than that for subcritical units due to larger amount of generated heat. Therefore, heat transfer area for USC units should be designed in a larger area than subcritical units.

Primary steam stream in high temperature which goes through HP turbine causes high temperature of reheat stream into IP turbine. Consequently, higher temperature is achieved in the heat transfer area and USC boilers perform in high thermodynamics efficiency.

(5) Water Treatment

SC and USC units adおpt once-through boiler, hence, high water quality is required for the boiler. Once-through boilers do not include steam drum that separates steam and water, therefore, the vapor of low quality water affects turbine blades as deposited impurities.

(6) Materials

SC and USC power plants require advanced technologies on design and materials for the boiler tubes and turbine blades. In fact, research and development of new and advanced alloy allow the plant to secure steady operation especially for boilers and tubes.

8.3.3 Additional Equipment or Facility for Using Coal

- ✓ Induced fans, primary fans
- ✓ Coal mills, coal scales
- ✓ Coal handling system (Coal conveyer, coal yard, coal stacker and reclaimer, etc.)
- ✓ Ash handling system (Clinker hopper, fly ash handling, ash pond, etc.)
- ✓ Flue gas de-sulfurization system
- ✓ Low NO_x burner system

The main difficulty is to handle solid fuel, slurry, and powder. These materials always caused erosion, corrosion, and plugging for many facilities. Careful observation and treatment are required for erosion and corrosion of curved fuel pipes and banker hoppers, and plugging of coal feeders and nozzles to excrete slurry for flue-gas desulfurization (FGD).

8.3.4 Necessity and Benefits in Using the Power Plant Simulator

Conventional paper based on schooling and training methods (OJT) can provide a lot of information, however, in reality, it does not provide periodical training to operators in reality. One of the most effective methods seems to use a full-scale, real-time, and high fidelity power plant simulator.

Whoever tries a fossil-fired power plant operation or wants to try a new plant operation faces a great challenge: the lack of qualified, well-trained and proficient operators. Especially, this is the first challenge for a USC once-trough type of boiler in Pakistan.

The coal-fired power plant consists of many related fuel supply and control equipment such as coal pulverizers, coal metric feeders, and primary fans.

A full replica simulator system covers the entire main power plant control, no matter whose control system the plant deploys. Flexible training scenarios can help operators handle the entire plant control.

Through the power plant simulator training, probationary and new operators of the new 660 MW plant can learn how to operate the 660 MW coal-fired unit using exactly the same operator interface as the real system in the short term. Even experienced operators can effectively learn how to deal with every conceivable accident or failure in reality. It is essential not only for operators of this plant but also of other plants. In addition, many power plant operators of GENCO and other projects use simulator training to learn how to operate a coal-fired power plant in the future.

The plant simulator system can virtually provide power plant operations and simulator training in every area. This simulator system would include the following:

- ✓ Control room fundamentals
- ✓ Unit trips
- ✓ Safe shutdown
- ✓ Hot restart
- ✓ Efficiency improvement
- ✓ Plant electrical malfunction training
- ✓ Blackout plant (loss of station service) training
- ✓ Multivariable control system operation (related to boiler-turbine cooperative control)[5]

These and many other comprehensive courses can be learned with or using the simulator. An example of a plant operation simulator is shown in Photo 8.3-1.

Souse: Courtesy by MHI

Photo 8.3-1 Example of a Plant Operation Simulator

8.3.5 Technical Skills Training for the New Coal-Fired Power Plant

Classroom trainings such as lectures are necessary to study the basic theory for all technical staff in order to understand USC technologies.

The recommended methods for each task are the following:

(1) Skills Training on Operation

It should be carefully considered for boilers to control main factors such water, air, and the

[5] Multivariable control system is based on theory of feed forward control. The factors for cooperative control of turbine-boiler are modified to set points with interlocking proportional integral differential (PID) controller, which results in optimum combustion.

amount of heat flow. Comprehensively, these factors contribute in the control amount of flow, pressure and temperature of main steam and re-heat steam temperature.

However, the control system of a subcritical drum boiler and Scand USC once-through boiler adopt different systems. The control system of once-through boiler needs sophisticated operating methods such as the boiler master input command signal for coordinated controls of turbine and boiler. This operation requires controlling the flow balance of water, fuel, and air loop, therefore an automatic plant control (APC) system is installed at SC and USC plants. All operators must be well-informed and well-trained with the APC system.

The Project will take a long period due to the USC 660 MW power plant, therefore, there is enough time to prepare the operating organization with the APC system in the Project site. It would be recommendable to reconstruct the personnel arrangement of other power plants and assign the engineers and operators to the Project for advanced skills training from the planning stage.

It is widely known that O&M is often outsourced as an optional plan in order to reduce operation cost particularly IPPs. However, it is recommended that since O&M technology is a key technology for power generation; therefore, it is preferable to train GENCO's engineers and operators and build up their knowledge through a sophisticated education program. The potential of coal mining in Pakistan is definitely high, especially for the Thar coalfield, which would cause installation and running of coal-fired thermal power plants throughout the nation. GENCO shall have lots of skilled operators and engineers at that stage.

In addition, there are a lot of considerable benefits as mentioned in Chapter 8.3.4 so that it is strongly recommended to install a simulator for USC coal fired thermal power plants with once-through boiler.

Besides the few specific projects involving construction of 600 MW class plants such as the Jamshoro Power Station financed by ADB and the Project in Pakistan, it was estimated that the total number of operators will be 40 (4 shifts x10 staff) for one unit, therefore it is efficient to train 120 staff for the three units before the commercial operations of the plant operation simulator.

The power plant operation simulator is generally installed as a common use facility with other plants. However, the man- machine interface system of each plant is different for each manufacturer. Therefore it is recommended to install the same interface system with actual unit type to maximize effects of training. Repeated trainings would plant confidence in the minds of engineers and operators, which bring correct judgments to operate the power plant. This is especially useful when unforeseen accidents occur.

(2) Skills Training on Maintenance of Facilities

There is no 600 MW class coal-fired power plant in Pakistan at present, therefore it is recommended that engineers who are in charge of maintenance should join the OJT from the construction stage with the EPC contractor.

Technical documents and instruction manuals are also useful to learn how to operate and maintain the plant as well. It is strongly recommended that preparation and submission of technical documents and instruction manuals be stipulated as one of the contractor's scope in the bidding documents.

1) Boiler Part

After learning the common basic theory of coal fired USC once-through boiler, it is recommended to study the detailed design (including the material composition), structures and functions through a technical document or instruction manual prepared by a manufacturer in general. Some of the technicians such as welders and fitters will be required to blush up their own skills and knowledge during the construction stage as OJT conducted by the contractor.

2) Turbine Part

The important point on turbine maintenance in a USC power plant is to secure the inlet of the turbine even in exclusive high temperature and pressure. Advanced materials are used to withstand high temperature and pressure so that engineers need to understand the metallurgical aspects.

3) Electrical Part

The power plant would generate high voltage and power, and therefore, engineers are required to be well-versed on such for safe O&M.

4) FGD, Coal Handling, and Ash Handling

Crushed and pulverized coal, and coal ash and slurry of limestone cause easy erosion and corrosion of related equipment such as FGD, belt conveyer, and hoppers. Engineers and operators should grasp the part where pulverulent bodies affect frequently.

(3) Skills Training for the Chemical Section (Water Treatment and Quality Control of Boiler Water, Fuel Analysis, and Ash Analysis)

It is recommended for chemists to study the different major subjects which include quality control of feed water and condensate de-mineralizer. Especially the water quality has great influence on the long-term performance of boiler heat conductivity and turbine efficiency due to deposition of impurities. Fuel and ash composition analyses are also important factors for the plant management. Therefore, it is recommended that the chemists should join and possess in-depth knowledge from the construction stage with the EPC contractor.

(4) Skills Training for Environmental Experts

Several coal-fired thermal power plants are currently planned in Pakistan; hence, more environmental experts are required throughout the nation. Experts are required to obtain comprehensive knowledge about environmental mitigation (air and water pollution management) and protection equipment such as FGD and ESP. Environmental monitoring should be started at the beginning of the operation.

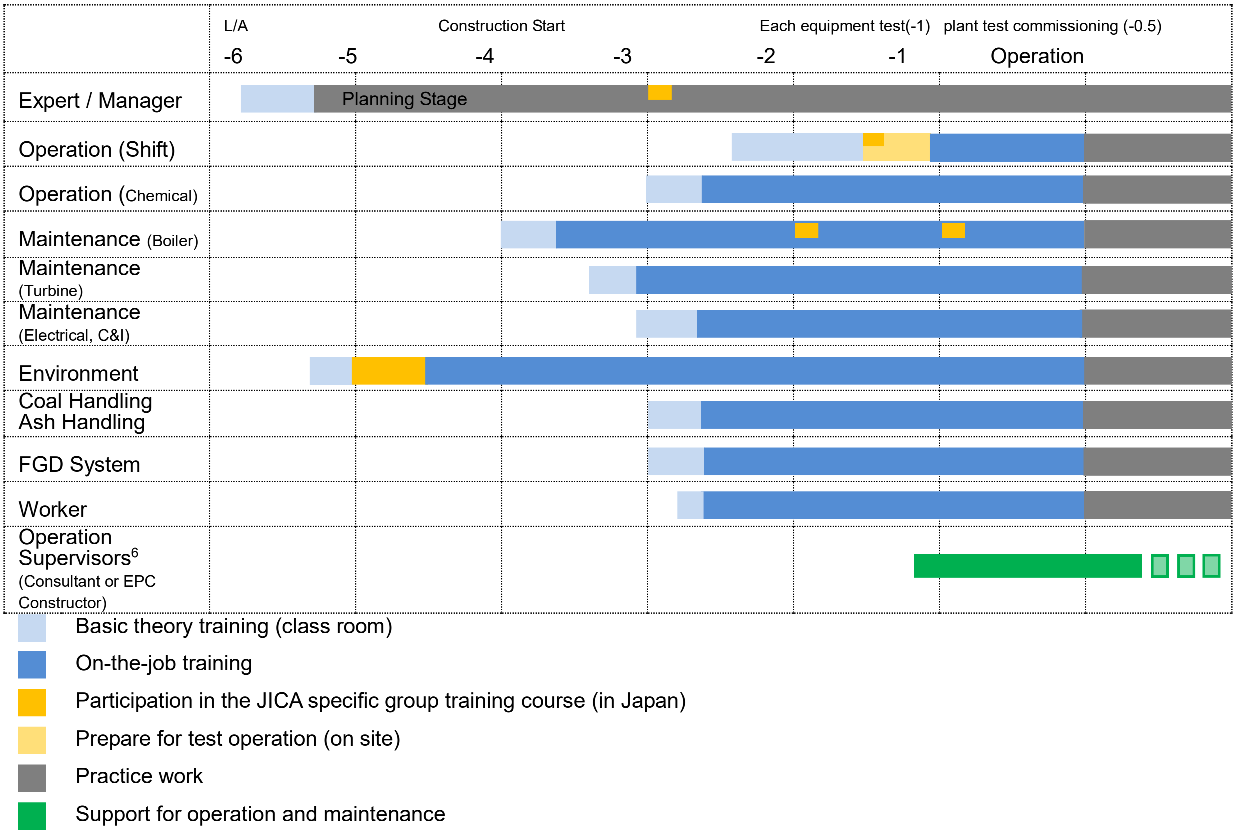
It is very useful for engineers and operators to be dispatched to the Air Pollution Source Management Course of JICA, which is a training program conducted in Japan.

(5) Worker Class Training

Workers are necessary to support all maintenance works. They should be well-trained and possess technical skills such as welding, valve maintenance, transmitter adjustment, and assembling of equipment before commercial operation.

8.3.6 Specific Plan for the Technical Skills Training Schedule

The training schedule for each section of the new Lakhra Power Station is shown in Figure 8.3-2.



Source JICA Survey Team

Figure 8.3-2 Details of the Training Schedule

As mentioned in Section 8.3.5, it is strongly recommended to start the OJT before or from the beginning of the construction stage. The project adopts USC technology therefore highly skilled (international level) engineers shall be deployed to conduct appropriate O&M works. The consultant for the implementation stage will assist GENCO to make the training curriculum and conduct training courses based on the need for international level skill. Moreover, JICA is planning to conduct "The Project for Capability Building and Strengthening of Thermal Power Generation Operation & Maintenance". It would be effective for the improvement of the ratio of "caused by O&M" in the first three years as shown in Figure 8.1-2. For more detailed suggestions, the recommendable conditions for each personnel arrangement are as follows:

(1) Managers and Environmental Experts

Personnel arrangement of managers and environmental experts are recommended to start in more than five years before commercial operation. It is recommended that long-career

[6] Operation supervisors will be posted to make sure of proficiency level for autonomous operation and maintenance for around one year. Technical transfer will be finished at the commissioning.

managers and experts are appointed as new power plant manager and experts. The construction period is expected to take 48 months, and detailed design and environmental monitoring are necessary to start in more than one year before construction. Prior to construction work at the site, the preliminary training will be mainly conducted in Japan in accordance with taking part in a JICA group training. As for environmental monitoring, some training will be conducted with monitoring works at the site. Details of the JICA group training will be explained in Clause 8.3.7.

(2) Shift Operators Including Group Leader

It is recommended to start recruiting shift operators in two and half years before commercial operation. Complexity of the plant system such as its configuration, design and protection system would take them a long time to be able to obtain comprehensive understanding of such. The operators need to obtain that knowledge and enhance their own skills before commissioning testing and commercial operation. Documentation of the operation manuals for each equipment by operators will encourage them to understand each very well, in addition, it is useful to standardize the operation methods at the power plant. Individual equipment test and commissioning test would take one year. During this term, all operators are required to be acquainted with the new plant.

(3) Boiler Maintenance Staff

It is recommended to recruit engineers from two years to four years before the commercial operation. The reason for the need of early personnel arrangement is that a once-through boiler consists of a lot of equipment, and engineers could be able to observe and find the actual property and structure of these equipments during construction work.

(4) Other Staff (Turbine, Electrician, C&I Part, Coal and Ash Handling, FGD, Chemical Section and Workers)

It is recommended to accomplish the personnel arrangement in two years before the commercial operation. This will be a good opportunity for all staff to understand the facilities' structure and operation as OJT during the construction stage.

(5) Training During Trial Operation Term

The trial run will be carried out for all individual equipments and the units at the last period of construction stage. Various troubles and failures will occurr and all of them need to be solved or improved through trial run. It will be the most effective chance to transfer the know-how and to enhance high-level skills for the new generation technology through in these experiences.

(6) Training after Commercial Operation

It is considered that basic technical transfer has been implemented by the end of the test operation period (initial stage). On the other hand, supervisors, supposedly from the EPC contractor for the power plant, are expected to be mobilized as residents for six months from the beginning of the commercial operation stage for troubleshooting (supervision stage). The training stage would shift the monitoring stage for the next six months after the supervision stage. Supervisors would monitor the operational and failure conditions periodically (i.e., once a month) and they would also check the sustainability of the power plant through annual inspection. In the monitoring stage, the supervisors do not need to be residents. Eventually, the training stage would become sustainable. Supervisors would complete their site work and resident engineers and operators would train their new colleagues by themselves.

8.3.7 Participation to the JICA Group Training in Japan

It is introduced to prepare the following JICA group training courses related to coal-fired thermal power generation:

- ✓ Thermal Power Engineering Course for Gas Turbine and Coal-Fired Steam Turbine-Improvement of Maintenance.

  Trainees are expected in this course to obtain extensive knowledge concerning general and new technology of the operation and maintenance for coal-fired thermal power plant. Therefore it is recommended for managers to participate in this course. The personnel are also expected to be trainers for OJT training after commencement of construction work at the site.

- ✓ Air Pollution Source Management

  Trainees are expected to obtain high expertise regarding air pollution control and abatement pollution technology based on long term experience for environmental pollution control in Japan. This course is recommended for environmental engineers in order to build new pollution control standards in Pakistan.

Both courses are useful and effective training for construction of the new coal-fired power plant and good promotion for new experts or leaders on coal-fired power generation.

8.4 Training Facility

8.4.1 WAPDA Engineering Academy

(1) Existing Course and Facility

The WAPDA Engineering Academy (WEA) has been established as the sole agency for imparting technical trainings to engineers and staff of WAPDA/PEPCO and the private/public sector in the fields of transmission/distribution, thermal/hydel generation, civil engineering and information technology.

The training system is defined as a standard operating procedure (SOP). The curriculum consists of two parts, i.e., training courses and promotion exams.

Each year, 12 training courses are regularly offered by the training academy to staff of power generation companies and public and private agencies. Details of the courses are shown in Table 8.4-1.

The promotion exams should be passed as requirement of all courses for participants.

Table 8.4-1 Details of Training Courses

	Name of Course	Staff Category	Duration (Weeks)	Intake Capacity	Frequency
1.	Refresher Courses (Pre-Promotion)	S.Es/Directors/R.Es/Common Services	3	25	1
2.	Refresher Courses (Pre-Promotion)	Sr. Engineers (Th. Gen)	4	15	1
3.	Sector Specific Courses (Pre-Promotion)	Junior Engineers (Th. Gen)	6	20	2
4.	Technical Induction Courses	Jr. Engineers (Th. Gen)	8	20	1
5.	Upper Technical Subordinate Staff Courses (Pre-Promotion)	Foremen/Operators to JEs	4	20	2
6.	Steam/Gas Power Plant Simulator Operation Course with Fault Analysis	Junior Engineers	4	12	1
7.	Steam/Gas Power Plant Simulator Operation Course with Fault Analysis	Operators/Attendants	5	12	1
8.	Micro Controller & PLC Course	Sr./Jr. Engineers	3	16	1
9.	Micro Controller & PLC Course	WAPDA Staff Public/Private Sector	2	16	2
10.	Process Instrumentation & Control Course	Sr./Jr. Engineers	3	16	1
11.	Process Instrumentation & Control Course	WAPDA Staff Public/Private Sector	3	16	1
12.	Internship	Engineering University Students	4	20	1

Source: Courtesy of the WAPDA Engineering Academy

The facility for thermal generation of the WEA is only a simulator for (oil-fired type) steam power plant, gas turbine and some small equipment. Therefore, this is insufficient for capacity building on the operation of coal-fired power plants.

(2) Enhancement of WEA

It is recommended for the Pakistan government to prepare training courses relating to technologies of coal-fired power plants in the future. Moreover, WEA is also expected to undergo renovation in large scale to modify and replace their facility not only for coal fired thermal power plant but also other thermal power such as gas turbine and oil thermal power plants.

The enhancement of WEA is expected in two stages;

- The first stage: Replacement of facility and the review of curriculum for common thermal power generation techniques on existing WEA
- The second stage: Establishment of the specialized coal-fired thermal technology training.

As for the second stage, the details are explained in next section.

8.4.2 Establishment of New Training Center

All the training systems in WEA were granted by GTZ (Gesellschaft für Technishe Zusammenarbeit) in 1993 to 2003. These analogue system facilities and equipment have deteriorated and have been rendered obsolete after ten years from installation.

The recent systems adopt digital system to control more sophisticated system of SC and USC plants than the analogue system of sub-C.

The existing WEA is located in the northern part of Pakistan, which is far from almost all of the planned coal power plants in the southern area. Moreover the generation capacities of the new planned plants are large in scale. The new training facilities (such as plant simulator, water treatment system, mill system, etc), are large in scale and expensive so that it will be suitable to construct the center near the new planned power plants apart from the existing WEA in consideration of the offer for use to many of engineers and technicians. It would bring out synergistic effect that technicians and engineers dispatched to power stations can be trained with both simulator and actual power plants.

For effective and practical operation and maintenance at the USC power plant, the urgent task of the new power plant is to educate high-skilled technicians such as welding technicians, valve maintenance technicians and control equipment adjustment technicians. These skills are required to secure stable operation and reliable maintenance for a long life.

8.5 Plant Maintenance Program

8.5.1 Basic Principles of Facilities Inspection Standards

The maintenance works are clarified as per their objectives; periodic maintenance work, predictive maintenance work and posterior maintenance work. The maintenance works are basically scheduled based on the facilities' inspection manuals. The maintenance concepts are described as follows:

(1) Periodical Maintenance

The periodical maintenance is designed to inspect and maintain the plant and its components at regular intervals based on calendar days and hours and the operating hours of the equipment involved. This is called “Time Based Preventive Maintenance (TBM)”. The index is operation hours of equipment.

For example, it is necessary for coal mills to be maintained and inspected every 4,000 to 8,000 operation hours for erosion by coal.

(2) Predictive Maintenance

From quantitative findings of the past trend of equipment troubles, the predictive maintenance estimates the time before the equipment reach their control or limit values, and then it stops their operation at a proper time to inspect and repair them. This is called “Condition Based Preventive Maintenance (CBM)”. The determination criteria are values or thicknesses of the materials.

For example, either the trend of reduction of durability on materials exposed in high temperature or the thickness of boiler tubes is monitored. Equipment and facilities shall be replaced in case the monitored factors are lower than the reference values.

(3) Posterior Maintenance

Posterior maintenance is defined to maintain or to repair after the equipment is damaged or failure has occurred. These equipment are able to repair or change easily without affecting the other equipment and plant operation. For example, this type of maintenance is applied the indicating instruments such as local pressure gauges, thermometers and drain valve attached to the end of the pipe line. These equipment are out of scope for periodical maintenance and predictive maintenance.

However for the equipment that have been the subject of predictive maintenance and periodical maintenance, repair or replacement is carried out immediately if damage or failure has occurred.

8.5.2 Facilities Inspection Standards

The inspection standard and period are determined by each facility or equipment. In addition, actual inspection and repair work are decided considering economic efficiency and relative importance of the facility or equipment.

8.5.3 Daily Maintenance and Inspection

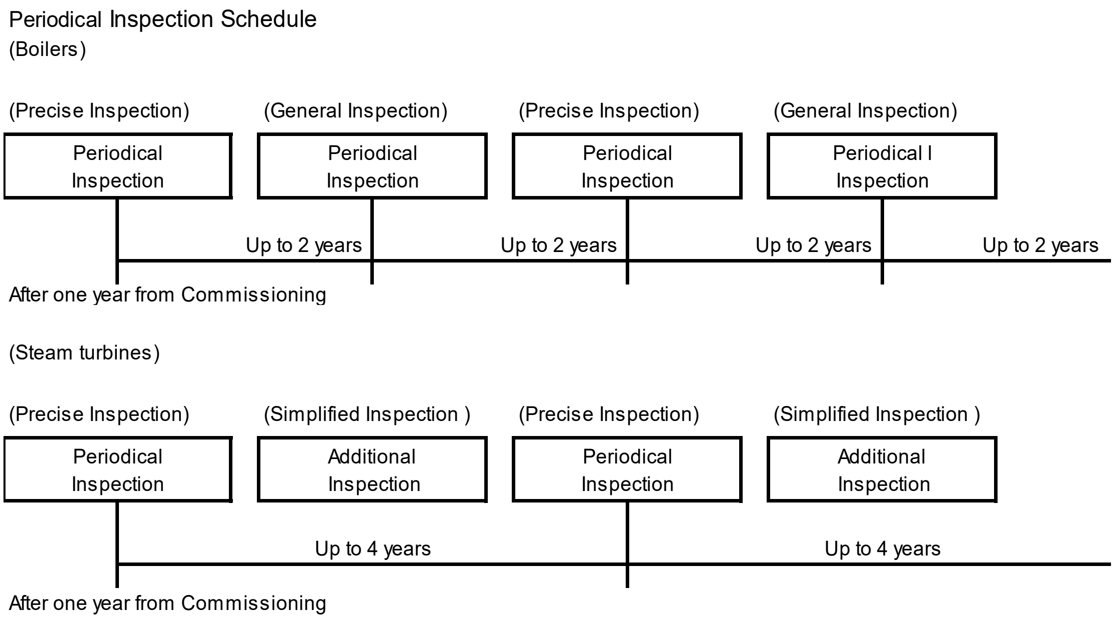
Daily maintenance works allow facilities to secure continuous and steady operation of the plant. It is necessary for all facilities to be checked up whether any defect or trouble occurs early every morning. In addition, it is also required to check important factors for understanding the condition of the facilities such as temperature noise, vibration and recoded data.

In case serious defects are found such as leakage of oil, steam and water from pipe valve, it shall immediately be maintained and repaired. If it is difficult to treat the facilities to be recovered and returned to normal condition, the trouble or defect should be mitigated, or the unit shall be shut down for repair work.

8.5.4 Periodical Inspection and Maintenance

Periodical inspection and maintenance are necessary to keep the plant in good operational condition and shall be scheduled every two years. It is recommended that the supervisors be invited to take part parts every periodical inspection and maintenance. They shall direct proper maintenance techniques for facilities.

The recommended periodical maintenance schedule is shown in Figure 8.5.1.



Source Source:JICA Survey Team

Figure 8.5.1 Recommended Maintenance Schedule Plan

Precise inspection is what is called overhaul inspection. Most of equipment is disassembled and generally inspected by non-destructive testing. The inspection is usually scheduled once every four years for turbines and boilers, and the inspection is conducted in large-scale, which commonly takes 60 days. As for the Project, inspection is recommended to take 60 days for

600 MW plant due to the number of facilities and equipment to be inspected.

General inspection (Internal inspection) for the boiler is usually scheduled in between precise inspection. In short, as shown in Figure 8.5.1, precise inspection and general inspection are conducted one after the other every two years. Boiler and others are partially disassembled and inspected in the inside. The disassembly work is done partially, therefore, the inspection takes less time than precise inspection, and it is recommended for the Project to secure 45 days to be inspected.

Simplified inspection for the turbine is scheduled at the middle of precise inspection in general, and simplified inspection is carried out usually with the general inspection of boiler. Through this inspection, the turbine is not disassembled but its blades' condition were checked out from inspection flanges and oil pressure of turbine's protection system. This inspection is for securing continuous and steady operation up to next precise inspection scheduled two years later.

As for the boiler, metal erosion and the welding condition on the boiler tubes are mainly inspected through the periodical inspections to prevent steam leakage. As for the condition of the turbine, the blades and inlet valves are examined.

In addition, it is recommended to plan intermediate inspection for two weeks. The purpose for this inspection is the checking and removal of adhered and deposited coal powder ash, slurry in FGD system.

✓ Non destructive testing (NDT): RT Radiographic Testing
MT Magnetic Particle Testing
UT Ultrasonic Testing
PT Dye Penetrate Testing etc.

8.5.5 Technical Support from Manufacturer

It is recommended that the supervisors be invited during every periodical inspection. As for maintenance and operation of USC plant, sophisticated skill and knowledge are required to check equipment conditions. Therefore, supervisors from the manufacturer are invited every inspection in case of a utility company in Japan.

Outstanding the long term maintenance is not recommended due to extra high cost. It is also not recommended from the viewpoint of building up own skills and knowledge for GENCOs' engineers and operators. On the other hand, an annual supervisory contract with the manufacturer or plant operating company is worth considering for the continuous and steady operation in case a major problem occurs.

8.5.6 Long Term Maintenance Plan

Generally speaking, the life time cycle of a thermal power plant in Pakistan is 30 years. However, some of equipment and parts should be repaired or replaced in certain periods which are less than 30 years. One of the examples is the boiler tubes. Thickness of the boiler tubes will decrease due to fly ash included in flue gas flow inside. In case the thickness of tubes gets thinner than the permissible value, leakage of steam is caused on the boiler tube, then subsequently steam pressure will be decreased, which will result in the decrease of plant efficiency. In order to prevent the decrease, the thickness shall be measured through periodical inspection every two years, and tubes shall be replaced if necessary. In addition, it is strongly recommended to monitor and analyze the measured data and then to plan the repair and replacement schedule.

For parts other than the boiler tubes, it is necessary for measurement instruments to be replaced due to deterioration of electrical parts. Turbine blades shall be replaced if the heat rate of the plant increase remarkably.

Accordingly, a long-term maintenance plan is required to allow the plant to operate for long life without unforeseen emergency shutdown.

8.6 Operation and Maintenance Cost[7]

8.6.1 Salary and Allowance

Salary and allowance of all GENCO staff are paid on the basis of the Basic Payment Scale (BPS) for public servants in Pakistan which depends on the position and experiences. Through the interview at site visits to the existing Lakhra Power Station, the total monthly basic payment and allowance are PKR 19 million, average age of employees is 45 and average wage is approximately PKR 37,000 per month. The maximum wage for BPS-20 is PKR 200,000 per month and the minimum wage for BPS-5 is PKR 15,000 per month respectively. Engineers receive more than PKR 80,000 monthly and the ratio of personnel number is around 5 %, whereas operators and the other personnel such as drivers and securities receive less than PKR 60,000 per month.

For the Project, total personnel expenditure is estimated in consideration with the salary paid for the existing Lakhra power station, price escalation and personnel allocation with BPS shown in table 8.2-3. Summary of the estimation is shown in table 8.6-1 as below.

[7] O&M cost is herein capacity charge. Energy charge (including escalable components) is described in chapter 10.

Table 8.6-1 The Summary of Personnel Expenditure for the Project

Monthly Personnel expenditure	PKR 18 million
Average monthly wage	PKR 52,000
Annual Personnel expenditure for a years	PKR 217 million

Source: JICA Survey Team

8.6.2 Annual Maintenance Cost

Maintenance cost is empirically estimated on the basis of the ratio to initial construction cost through the USC plants' operation and maintenance works, which is assumed to be 3% of the EPC cost. The figure of 3% is the sum of repair and replacement cost (1.5%) and miscellaneous cost (1.5%). The summary is shown in table 8.6-2 below.

Table 8.6-2 The Summary of Maintenance Cost

Annual cost of repair and replacement works (1.5% of EPC cost)	PKR 1,756 million
Annual cost of miscellaneous expenditure (including periodical inspection cost) (1.5% of EPC cost)	PKR 1,756 million
Annual total cost of maintenance works (3.0% of EPC cost)	PKR 3,512 million

Source: JICA Survey Team

CHAPTER 9
IMPLEMENTATION PLAN

Chapter 9 Implementation Plan

9.1 Planning of Implementation

9.1.1 Project Implementation Schedule

The planned implementation schedule of construction is shown in Figure 9.1-1. The total duration of the project is estimated for XXX months from the preparation stage of the JICA loan agreement (LA) to the completion of the commissioning tests on-site. At the time of final report submission, the period conclusion of the LA is expected in XXX, and therefore the new Lakhra Power Station may start commercial operation from XXX. The existing power station will be in operation during the construction period of the Project, and electricity and water for construction can be supplied from the equipment in the existing power station.

It usually takes XXX months to complete construction of a coal-fired thermal plan. Therefore, in order to start commercial operation under the Pakistani government, preconstruction/bidding should be completed until XXX .

"XXX" stands for "The information is masked because it includes confidential."

Figure 9.1-1 Implementation Schedule

This figure is masked because it includes confidential.

9.1.2 Project Implementation

For the purpose of construction, it is necessary to provide electricity and water. Power can be supplied by an independent generator or direct cable connection to the existing Lakhra Power Plant. According to information, the existing power plant has capability to supply for construction usage. Due to the very large electrical capacity at starting up the power plant, it is appropriate to supply electricity through a starting transformer. Therefore it is recommended to supply electricity from the existing power plant at the beginning of construction and switch over to the starting transformer after being installed. The water can be supplied by an independent water tank truck or direct pipe connection to the existing Lakhra Power Plant. According to existing power plant, the power plant has capability to supply for construction usage excluding November, December and January as dry season. Therefore, it is recommended to supply water from existing power plant basically and prepare water tank truck especially for dry season.

Local construction companies have adequate technical capabilities for contract of civil construction. In mechanical and electrical construction, equipment are procured from foreign countries, unloaded at Port Qasim, freighted inland transportation by truck and erected under supervision of expatriates.

(1) Construction for Additional Entrance Road

For access of vehicle and carrying equipment for the Project at construction stage, it is necessary to construct additional entrance road from the plant area to Indus Highway. It should be carried out at the beginning of the construction period.

It is necessary to obtain permission from the Works and Service Department of the Sindh government prior to commencement of construction for additional entrance road.

(2) Circulation Water Pipe

Circulation water pipe is installed either by underground installation or aerial installation. For example, Neurath Power Plant in Germany was constructed by aerial installation. Aerial installation requires cost for mounted structures and periodical re-paint work in order to prevent deterioration. On the other hand, underground installation requires earthworks and backfilling costs.

Both civil construction and mechanical and electrical construction schedules should be arranged in consideration of the timeline and procedure of underground installation work especially for parts of the circulation pipe which will be installed under the turbine generator building.

(3) Turbine and Generator

Basement concrete and mounted structures will be installed in sequence by the civil contractor and mechanical and electrical contractor respectively. Therefore it is recommended for both contractors to arrange the scope of work for the turbine's and generator's anchors.

Hatch, crane and roof should be prepared before carrying the turbine and generator.

The installation position of turbine generator is decided in consideration of the clearance for pulling out the rotor of the generator.

(4) Boiler

It is recommended to consider interaction of both foundation work of boiler and installation work of boiler, boiler auxiliaries and steel structure by civil contractor and mechanical and electrical contractor.

(5) Main Transformer

Main transformer will be connected with generator output and transmitted switch yard through steel structure. Installation of other structures between the switch yard and structure should be avoided.

(6) Construction Materials

In consideration of the acidic characteristic of sand covering the surrounding land of the Project site, it is recommended to adopt epoxy-coated against reinforcing steel and sulphur-resistant cement.

(7) Transportation Route between Unloading Port and Site

Bin Qasim Port is available in order to unload machine, and the transportation route is the same as the coal transportation route shown in Figure 3.3-25. The existing road condition is described in Section 3.3.2 (2).

Two gates exist on the transportation route. The First one is a toll gate on the highway that is located around N25 23' 33'', E68 15' 10''. Its present image is shown in Figure 9.1-2. No shed gate exists and the gate is in approximately 4m wide, while the second one is the toll gate on Indus Highway that is located around N25 34' 45'', E68 18' 47''. Its present image is shown in

Figure 9.1-3. Each gate has a shed with 5.5 m height and the gate is approximately 3.5 m wide.

On the other hand, the biggest part that will be transported is the iron core and copper coil of the main transformer. The image of the trailer with the aforementioned load is shown in Figure 9.1-4. The size of the load iron core and copper coil of the main transformer is assumed to be 6 m (length) x 6 m (height) x 2.8 m (width). If clearance is set at 0.3 m and vehicle height is set as 1.2 m, then the road must have a width of 3.4 m or more and height of 7.5 m or more.

Given the above therefore, the toll gate on the highway is not a problem, but it is necessary to expand the road in order to circumvent the shed.

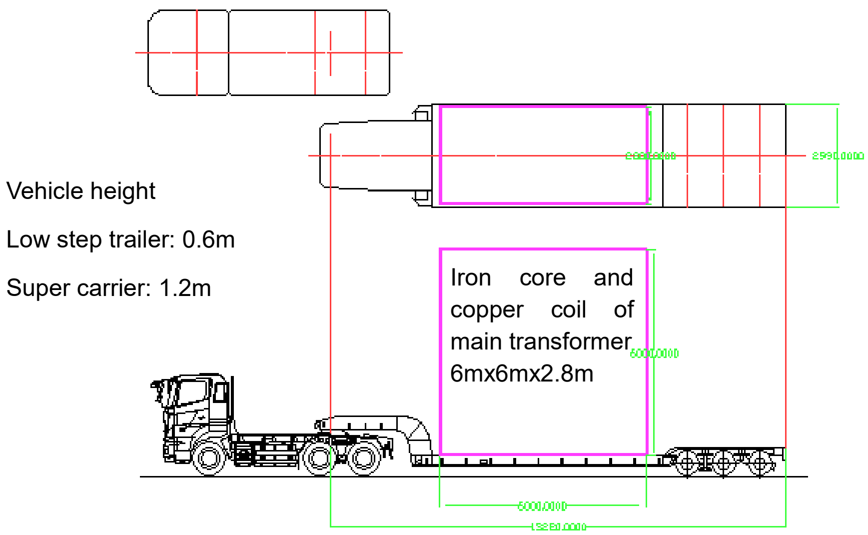
Hence, it is necessary to obtain permission from the Works and Service Department of the Sindh government prior to commencement of the construction for transportation route between the unloading port and site. Permission is likewise needed to be obtained from the department in order to carry out cure and traffic restriction in the transport of huge-scale equipment.

Source: JICA Survey Team

Figure 9.1-2 Toll Gate on Highway 1 (N25 23' 33'', E68 15' 10'')

Source: JICA Survey Team

Figure 9.1-3 Toll Gate on Highway 2 (N25 34' 45'', E68 18' 47'')



Source: JICA Survey Team

Figure 9.1-4 Image of Trailer with Load (Iron Core and Copper Coil of Main Transformer 1phase 720MVA/3)

9.1.3 Implementation Plan of Consulting Services

Based on the implementation schedule, the proposed consulting services and estimated costs were prepared in consideration of the following;

1) The tentative terms of reference (TOR) of consulting services for i) design and tender assistance and ii) construction supervision attached in Appendix 9-1 and 9-2 respectively were prepared based on the results of the feasibility study,

2) The assignment schedule for engineering staff was prepared based on the different stages of design, preconstruction and construction, and

3) Billing rates were assumed from the rates commonly used for Japanese official development assistance (ODA) projects.

The contents of the TOR of both consulting services are listed in Table 9.1-1.

Table 9.1-1 Contents of TOR of Consulting Services

Chapter 1	Background and Project Outline
Chapter 2	Objectives of Consulting Services
Chapter 3	Scope of Consulting Services
Chapter 4	Expected Time Schedule
Chapter 5	Staffing (Expertise Required)
Chapter 6	Reporting
Chapter 7	Obligation of the Employer

Source: JICA Survey Team

9.2 Estimation of Project Cost

9.2.1 Basis of Capital Cost Estimates

Capital cost estimates were developed for building one 600 MW (net) coal-fired unit (660 MW gross rated) at the Lakhra site. All costs are presented in USD by exchange rates as of July 2016. The estimation includes the EPC contractor's costs, however, it does not include financing costs. The financing cost is assumed in Chapter 10. It is assumed that all work will be performed as “turnkey” basis by an EPC contractor.

On the Project, the EPC contractor shall implement the activities below on a “turnkey” agreement;

- ✓ Detailed Design,
- ✓ Foundations,
- ✓ Steel structures,
- ✓ Procurement and Manufacturing,
- ✓ Erection,
- ✓ Commissioning and start of commercial operation,

The capital cost was estimated through reference to the “Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity” prepared by DOE. (hereinafter called “DOE’s model case”) However, the difference of specification and plant capacity between DOE’s model case and the Project is adjusted as appropriate. Foundation and civil works were estimated with information from the local construction industry.

The final project price after competitive bidding will depend on the overall market conditions at the time of bidding and the country where the major equipment will be acquired. Usually less-developed countries in term of technology can offer equipment with lower prices than developed countries, such as Japan, Western Europe and USA. However, it is strongly recommended that the equipment supplier be selected by a wider view, with consideration of not only capital cost but also high reliability. Therefore, it is recommended for the equipment supplier to satisfy the following qualifications:

1) XXX,

2) XXX,

"XXX" stands for "The information is masked because it includes confidential."

The following works and costs are not included:

- ✓ All transmission and distribution beyond the switch yard for delivery of the plant output to the transmission system,
- ✓ Switchyard
- ✓ Railway spur line,
- ✓ Land acquisition for ash ponds,
- ✓ Preparation of environment impact assessment (EIA),
- ✓ Obtaining all permits and licenses from local, provincial and federal government agencies, and
- ✓ Required working capital at start of commercial operation,

9.2.2 Estimated Construction Cost (Including Equipment)

The estimated costs for the 600 MW (net) PC-fired with USC boiler unit is shown in Table 9.2-1. The construction cost for the Project's plant is approximately USD XXX.

"XXX" stands for "The information is masked because it includes confidential."

Basically construction cost is estimated based on multiplication of the price on 580 MW (gross) from DOE's model case, adjustment coefficient to 660 MW (gross) and escalation ratio.

Budget of vehicles, office and residential buildings of the project is included in item of foundation and civil construction, respectively.

Table 9.2-1 Estimated Costs for the 600 MW (net) PC-Fired with USC Boiler Unit (Unit: USD million)

This table is masked because it includes confidential.

9.2.3 Estimated Consulting Services Fee

In line with the assumed TOR mentioned in Table 9.1-2, the required input for competent engineers for each stage is shown in Table 9.2-2.

Table 9.2-2 Input of Required Engineers

This table is masked because it includes confidential.

Based on the above assumptions of the required input of engineers, the consulting service fee during the implementation period was estimated at USD in million in total, which is comprised of USD XXX for sum of the design and preconstruction stage service fee, and USD XXX for the construction stage service fee.

"XXX" stands for "The information is masked because it includes confidential."

9.2.4 Dispute Board

The International Federation of Consulting Engineers (FIDIC, acronym for its French name Fédération Internationale Des Ingénieurs-Conseils) mandated the establishment of dispute boards in FIDIC MDB Harmonised Edition, 2010 edition. Also, JICA provided a dispute board manual in 2012.

Dispute board consists of one or three member as permanent standing organization, and they give advice and judgement through periodical site visits to prevent serious dispute troubles, i.e. arbitration, litigation.

The employer must decide the number of DB members prior to the Invitation to Tender.

In the FIDIC Contracts Guide (2000), it is suggested that a 3-person DB would typically be regarded as appropriate for a contract involving an average monthly payment certificate exceeding the equivalent of USD XXX (at year 2000 prices).

"XXX" stands for "The information is masked because it includes confidential."

9.2.5 Estimated Project Implementation Cost

Cost estimation for the project implementation includes:

- ✓ Capital cost,
- ✓ Financing cost,
- ✓ Taxes and fees, and
- ✓ Spare parts.

Capital cost is approximately USD XXX as mentioned above.

"XXX" stands for "The information is masked because it includes confidential."

Financing cost is estimated as mentioned hereinafter in the chapter of "Economic/Financial Analysis"

The spare parts cost is included in the capital cost as spare parts are supplied during the construction period. The item and number of spare parts are the same as the item and number specified in DOE's model case. The summary of the number of spare parts is shown in Table 9.2-3. In case of adoption with high quality equipment and implementation of maintenance with the recommended methodology by their manufacturer, the life cycle of facilities is expected to be at least seven to ten years without using spare parts. However, spare parts should be provided in the event of accidents until going by their expected lifetime from commencement of operation. Spare parts will remain with their own capability in the long term, if spare parts will be used. In Japan, renovation cost is generally derived from about 3% per year of construction cost, which means it will take USD XXX annually to maintain the Project plant.

"XXX" stands for "The information is masked because it includes confidential."

The project cost for the application for Lakhra Coal-fired Thermal Plant is shown in Table 9.2-4. Cost estimation for project implementation is assumed for application of Japanese Yen Loan. Price escalation was set at 2.0% for foreign cost (FC) and 6.5% for Local Cost (LC). Interest rate applied was for Japanese Yen Loan (Construction: 1.4%, Consultant: 0.01%).

The eligible cost, interest during construction and commitment charge in Table 9.2-4 correspond to the JICA-financed portion.

Table 9.2-3 Summary of Number of Spare Parts

	Spare Item	Number
Boiler and Auxiliaries	-	-
Coal & Sorbent handling and Storage	Coal Sampling System	1
	Reclaim Hopper	1
Coal & Sorbent Preparation and Feed	Limestone Weigh Feeder	1
	Limestone Ball Mill	1
	Auxiliaries	1
Ash Handling and Disposal	Clinker Grinder	1
	Pumps	1 respectively
	Air Blower	1
Stack & Duct Works	-	-
Turbine Generator and Auxiliaries	-	-
Feedwater and Condensate Water Treatment	Condensate pump (CP)	1
	Boiler Feed water Pump (BFP)	1
	Air Compressor	1
	Pumps	1 respectively
	Demineralizer	1
Circulating & Cooling Water (including Cooling Water)	Circulation Water Pump (CWP)	1
Electrical Equipment & Systems	Auxiliary Transformer	1
	Low Voltage Transformer	1
	Medium Voltage Switchgear	1
	Low Voltage Switchgear	1
Controls & Instruments	-	-
Flue Gas Clean up FGD & ESP	Pumps	1 respectively
	Belts	1
	Blower	1
Coal Discharge Pit & Belt Conveyor	Belts	1

Source: Prepared by JICA Survey Team based on “Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity”, DOE

Table 9.2-4 Project Implementation Cost (Unit: USD in Million)

This table is masked because it includes confidential.

9.3 Disbursement Schedule

The disbursement schedule is shown in Table 9.3-1. Payment for sum of 2016 and 2017will be approximately 1% of the total cost, which is composed mainly of the consultant fee for the detailed design stage and pre-bidding stage. Payment for 2018 will be about 8% of the total cost since construction will start during this year. This consists of the construction cost mainly for advance payment. Payment for 2019 will be approximately 5% of the total cost consisting of equipment and materials cost and the consultant fee for the construction stage. Payment for 2020 and 2021 will be about 24% and 44% of the total cost consisting of equipment and materials cost and the consultant fee for the construction stage, respectively. Payment for 2022 will be approximately 5% of the total cost after approval of completion of construction, while that for 2023 will be about 4% of the total cost after the warranty period is mainly completed during this year. The payment is composed of the construction cost for payment, installation cost and consultant fee for the construction stage.

Table 9.3-1 Lakhra newly 600MW (net) Power Plant Construction Cash Disbursement Schedule in %

This table is masked because it includes confidential.

9.4 Proposed Project Packages of Relevant Works

The proposed project packages include relevant works, of which executing agencies, potential financers and procurement methods and contract conditions are summarized in Table 9.4-1.

Table 9.4-1 Procurement Package

Procurement Package	Executing Agency	Financer	Procurement Method	Contract Condition
Power Plant EPC Including Water Intake	GENCO	JICA and co-financer	ICB	JICA SBD Design Build
500 kV Transmission Line	NTDC	GoP	ICB	Procurement Standard of NTDC
Railway Construction (Civil, Rail and Signal)	GENCO	Option 1 GoP	LCB or ICB	Procurement Standard of PR
		Option 2 JICA and/or co-financer	ICB	JICA SBD and/or Procurement Standard of co-financer
Procurement of locomotives and wagons	GENCO	Option 1 GoP	ICB	Procurement Standard of PR
		Option 2 JICA and/or co-financer	ICB	JICA SBD and/or Procurement Standard of co-financer

Source: JICA Survey Team

Notes:

1) JICA SBD Design Build: JICA Standard Bidding Documents Procurement of Electrical and Mechanical Plant, and for Building and Engineering Works, Designed by the Contractor.
2) Railway construction project (construction of spur line, refurbish of existing single track line, and procurement of locomotives and wagons) is necessary for transporting import coal form Qasim port to the plant.
3) Coordination is needed in GoP for assignment of executing agency of the railway construction project.
4) For the railway construction project, there are two alternatives, Option 1 & 2 are financed by GoP and JICA and/or co-financer respectively.

9.5 Steering Committee for Smooth Implementation

For smooth coordination for implementation among stakeholders, establishing steering committee is recommended for periodical coordination meetings, of which proposed members are listed in Table 9.5-1.

The committee is organized and chaired by GHCL (PMU). The initial committee will be held when the loan agreement is concluded between GOP and GOJ for making common understanding of the project and confirming tasks of each organization for the project.

Table 9.5-1 Member of Steering Committee

Organization	Tasks	Before start construction works	After start the construction works
Ministry of Water and Power			
- GENCO HCL (PMU)	Supervise GENCO Lakhra new plant	○	○
- GENCO IV (PIU)	Power Plant implementation agency	○	○
- Indus River System Authority	Allocation of water from Indus River	○	
Ministry of Railway			
- Pakistan Railway	Railway implementation agency Including preparing PC-1	○	○
Ministry of Port and Shipping			
- Port Qasim Authority	Coal un-loading facility at Port Qasim Including preparing PC-1	○	○
Government of Sindh			
- Woks and Service Dept.	Coal transportation road implementation agency	○	○
- Environmental Protection Agency	EIA review and approval agency	○	○
- Irrigation Department	Water intake approval agency	○	
- Revenue Department	Water intake land property	○	

Note: ○ Attendant of the committee

Source: JICA Survey Team

9.6 Monitoring of the Project Implementation

The method for monitoring of the project implementation to be done by the PIU and Consultant is recommended as listed in Table 9.6-1

Table 9.6-1 Monitoring Method of the Schedule and Disbursement

	Monitoring
1)	PIU and Consultant prepare indicative project schedule for bid documents
2)	Bidders submit detailed schedule referring to the schedule in the bid documents
3)	PIU and the Consultant evaluate the schedule submitted by the bidders

4)	Some adjustment on the schedule during contract negotiation, it will be finalized and attached to the contract document
5)	The EPC contractor prepare the disbursement schedule based on the contracted schedule
6)	The PIU and the Consultant review the disbursement schedule
7)	For monthly and quarterly progress meeting, the EPC contractor submit actual progress compared with the contracted schedule. If delay, they discuss how to recover the behind schedule.
8)	The PIU and the Consultant monitor that the accumulated disbursement compare with the planned one.

Source: JICA Survey Team

9.7 Permission and Clearance

For implementing the project, the required permission/clearance are listed in Table 9.7-1.

Table 9.7-1 List of Permission and Clearance for the Project

Permission and Clearance	Authority Issuing the Permission	Obliged Date
Power Plant		
PC-1	Planning Commission under Ministry of Planning and Development	Before conclusion of loan agreement between both governments
Generation License	NEPRA under MoWP	Construction of plant
Determination of Tariff	NEPRA under MoWP	Commissioning of plant
EIA	Sindh Environmental Protection Agency	JICA appraisal mission
LARAP	GENCO (Letter of Acceptance)	JICA appraisal mission
Water Intake		
Water Intake Right	Irrigation Department, GoS	Start of detailed design of the intake
Land Use Right	Revenue Department, GoS	Start of detailed design of the intake
Transmission Line		
PC-1	Planning Commission	Before conclusion of loan agreement between both governments
EIA	Sindh Environmental Protection Agency	JICA appraisal mission

Source: JICA Survey Team

Notes:

1) "Approved with condition" for EIA for construction of power plant is issued by SEPA . Obtaining unconditional approval from SEPA is necessary from now on.
2) Railway construction project (construction of spur line, refurbishment of existing single track line, and procurement of locomotives and wagons) is necessary for transporting import coal from Port Qasim to the plant.
3) Coordination is needed in GoP for assignment of executing agency of the railway construction project.
4) For the railway construction project, there are two alternatives, options 1 and 2 are financed by GoP and JICA and/or co-financer respectively.

CHAPTER 10
FINANCIAL AND ECONOMICAL ANALYSIS

Chapter 10 Financial and Economic Analyses

10.1 Objectives and Methodology of the Financial and Economic Analyses

The financial and economic analyses aim to examine the viability of the Project (Lakhra coal fired thermal power plant) by calculating the internal rate of return (IRR) and the net present value (NPV).

10.1.1 Financial Analysis

Financial analysis is conducted to evaluate the profitability of the Project from the viewpoint of the implementing organization. To obtain the financial internal rate of return (FIRR) and the financial net present value (FNPV), net benefit of the project is calculated considering 1) the benefits i.e., incremental revenue of tariff from the Project and 2) the cost based on the market price.

Financial cost excludes price contingencies, interest during construction (IDC), and other financial charges from the project cost. FIRR and FNPV are calculated based on the cash flow before interest payments.

10.1.2 Economic Analysis

Economic analysis is conducted to evaluate the viability of the Project from the viewpoint of the national economy. To obtain the economic internal rate of return (EIRR) and the economic net present value (ENPV), the benefit of the Project is calculated considering 1) the increased benefit based on the saved cost by replacing alternative energy sources (e.g., diesel generators) and 2) the economic costs.

In the EIRR and ENPV calculation, the cost of the Project is converted to economic cost in order to evaluate the actual cost for the national economy. In this regard, transfer payment within the national economy (e.g., tax) is excluded from the calculation as it is neither a benefit nor a cost for the country.

10.1.3 Methodology

The cash flow of the Project is prepared to calculate the IRR and NPV. These figures are calculated based on the following formula. The IRR is equal to the cut-off rate that results in zero NPV. For the calculation of the NPV, a predetermined discount rate is used.

$$\sum_{t=1}^{n} \left\{ (B - C)_t \div (1 + r)^t \right\} = 0$$

Where, C=cost, B=Benefit, t=*t*th year (1,2,3…n), n=project life, r=internal rate of return

For the calculation of both the IRR and NPV, two cases, namely, "with project" and "without project", are normally considered to determine the net incremental benefit and cost. However, the incremental benefit of "without project" is not taken into account in this analysis as there is no assumed significant foregone benefit due to the Project.

10.2 Assumptions Used in the Financial and Economic Analysis

This section lists and describes some of the assumptions that are used for calculating IRR and NPV based on the findings in the study.

10.2.1 Project Life, Salvage Value, and Price Base

The Project is assumed to have a useful economic life of 30 years after the completion of construction.[1] At the end of the economic life, the Project is assumed to have no salvage value. Benefits and costs are expressed in terms of 2016 constant prices in Pakistan Rupees.

10.2.2 Physical Contingency and Price Escalation

Physical contingency is defined as the monetary value of additional resources that may be needed beyond the base cost to complete the project. It is estimated as a percentage of the base cost. Physical contingency generally varies, depending on the source of the base cost. In the analysis, the physical contingency is assumed to be 5% of the base cost.

Price escalation allows for any fluctuation in the foreign exchange and commodity price, between the time of the cost estimate and loan approval. Price escalations are assumed at 1.6% and 5.8% for foreign cost and local cost, respectively.

Price escalation is excluded from the financial and economic analysis due to the uncertainty of price fluctuations in the future and the assumption on the application of the 2016 constant price.

10.2.3 Tariff

NEPRA has issued "Decision of the Authority regarding Reconsideration Request filed by Government Pakistan in the matter of Upfront Tariff for Coal Power Projects" in June 2014, by revising "Determination of NEPRA in the Matter of Upfront Tariff for the Projects on

[1] The assumption of project life for thermal plant follows the one used in "National Power System Expansion Plan 2011-2030". The upfront tariff of imported coal, local coal and Thar coal is decided up to 30th years. ADB's feasibility study report on Jamshoro coal-fired thermal power station assumes that the project life is 30 years, though it includes the construction period of five years.

Imported/Local Coal (Other than Thar Coal)" in June 2013. NEPRA has also issued "Determination of the Authority in the Matter of Thar Coal Upfront Tariff", July 9, 2014.

These documents state that the tariff of coal based generation technology consists of two types of charges: 1) energy purchase price that covers variable cost and 2) capacity purchase price that covers fixed cost. These two charges are further divided into items as shown in Table 10.2-1.

Table 10.2-1 Structure of Tariff for Coal-based Generation Technology

A. Energy Purchase Price	B. Capacity Purchase Price
1. Fuel	1. Fixed O&M (local)
2. Variable O&M (local)	2. Fixed O&M (foreign)
3. Variable O&M (foreign)	3. Insurance
4. Lime stone	4. Working capital
5. Ash disposal	5. Return on equity (ROE)
	6. Debt repayment
	7. Interest charges

Source: NEPRA, "Decision of the Authority regarding Reconsideration Request filed by Government Pakistan in the matter of Upfront Tariff for Coal Power Projects", June 26, 2014. NEPRA, "Determination of the Authority in the Matter of Thar Coal Upfront Tariff", July 9, 2014

Note: Upfront tariff for Thar coal divides the fuel cost into 1) variable fuel cost and 2) fixed fuel cost.

Based on the methodology of calculating the upfront tariff and with reference to the case of Jamshoro,[2] the expected tariff for the Project is calculated. Although the Project has to submit the petition[3] for the negotiated tariff to and obtain the approval from NEPRA in the future and the figures of the tariff in the report and in the petition may be different reflecting the changes in assumptions and the environment, Lakhra calculated tariff (base case) is to be used to forecast the revenue of the Project and calculate FIRR and FNPV.

Table 10.2-2 Comparison of Tariff

This table is masked because it includes confidential.

[2] GENCO I has submitted the petition of the negotiated tariff for Jamshoro coal fired power station to NEPRA in September, 2014 and obtained approval from NEPRA.
[3] The petition for tariff is normally submitted to NEPRA in 3-4 months before commissioning, while the petition for obtaining/modification of the generation license is submitted before the construction work starts.

The tariff for the Project is calculated based on the assumptions described in the table below. The major differences with the upfront tariff and Jamshoro's tariff are those of fuel, Railway O&M, ROE and loan payment. The tariff of Lakhra reflects the cost of the railway project into the ROE and loan payment components, though it excludes the cost of locomotives, wagons, and the rehabilitation of the line between Kotori and Budapur as these equipment and facility are not necessarily used exclusively for Lakhra power station.

Table 10.2-3 Assumptions for Calculating Lakhra Negotiated Tariff

	Assumption
1. Fuel	Calculated based on the assumption of the coal cost (90$/ton: including coal handling cost)
2. Limestone & ash	Same as Upfront tariff & Jamshoro's case
3. Variable O&M	Same as Jamshoro's case
4. Railway O&M	Calculated based on the assumption of the railway related cost
5. Fixed O&M	Same as Jamshoro's case
6. Working capital & insurance	Same as Jamshoro's case
7. ROE	Assumed as 15%
8. Loan payment	Based on principal equal payment with the grace period during construction period

Source: Prepared by the Survey Team

Note: See the appendix for more detail of tariff calculation for the Project. Fixed O&M (local) is slightly different between Lakhra and Jamshoro as the former does not include this cost in the first year of operation.

Note: See "10.2.5 Fuel" for the calculation of the tariff on fuel component.

The following table shows the detail of tariff structure and comparison with Jamshoro's negotiated tariff.

Table 10.2-4 Comparison of Tariff (Base case) with Jamshoro

This table is masked because it includes confidential.

NEPRA's determination on the tariff for import and local coal specifies the price adjustment mechanism for the changes of the cost. The tariff component such as fuel, O&M cost, and financial charges will be monitored and regularly adjusted in accordance with the change of prices and indexes (e.g. consumer price index). Therefore, it is assumed in the financial analysis that the revenue from the energy purchase price and capacity purchase price with such index mechanism offsets the cost of coal and other items used for the generation and will be adjusted in a timely manner when such costs has changed.[4]

10.2.4 Fuel

Fuel is a major component in the energy purchase price. The cost of fuel for the case of the Project is calculated as XXX Rs./kWh based on the assumptions in the table below.

"XXX" stands for "The information is masked because it includes confidential."

Table 10.2-5 Fuel component in the tariff (Unit: Rs./kWh)

This table is masked because it includes confidential.

10.2.5 Operation and Maintenance (O&M) Cost

According to NEPRA's determination on the upfront tariff of coal, "Operation and maintenance expenses" means the expenditure incurred on operation and maintenance of the project, or part thereof, and includes the expenditure on manpower, repairs, spares, consumables and overheads.

The upfront tariff of NEPRA indicates the assumptions on the unit cost of fixed and variable O&M based on the capacity of the power plant and type of financing as a guideline.

The variable and fixed O&M cost for the Project is not included in the cost in the analysis, as it is regarded as "pass through" item, which is automatically and timely adjusted.

[4] Those power companies that operate coal fired power plants may make profit or deficit depending on the time lag of the adjustment of the tariff in reality. However, it is assumed that they do not make significant profit or deficit not to influence the result of financial analysis.

Table 10.2-6 Assumption on Unit Cost of O&M for 660MW

This table is masked because it includes confidential.

For the purpose of calculating the tariff for the financial analysis, the O&M cost for the Project is same as those of Jamshoro, except the fixed O&M cost (local).[5] In addition, O&M cost of railway is calculated as the railway infrastructure for transporting coal to the plant is assumed to be owned by GENCO.

Table 10.2-7 Assumption on Unit Cost of O&M for Railway Infrastructure

This table is masked because it includes confidential.

10.2.6 Conversion Factor

The standard conversion factor (SCF) is an indicator to estimate the level of distortion in the market due to policies, duties, or subsidies of the government. The SCF is applied in the economic analysis when the local cost, which is assumed to be distorted, is to be converted into the economic cost in order to eliminate distortion.

The SCF is calculated as XXX based on the following formula, and figures from the recent terms of trade and duties.[6] This figure is nearly equal to one. It can be concluded that there is not much distortion in the prices of commodities.

SCF= [Import (CIF) + Export (FOB)] / [(Import + Import Duty) + (Export + Export Subsidy - Export Tax)]

"XXX" stands for "The information is masked because it includes confidential."

Table 10.2-8 Terms of Trade (Unit: Rs. million)

This table is masked because it includes confidential.

[5] There is a minor difference in the figures of Fixed O&M (local) between Jamshoro and the Project as the latter does not incur this cost in the first year of operation, while the former includes the cost in the same period.
[6] The standard conversion factor of 0.92 is applied in ADB's "Jamshoro Power Generation (JPG) Project Feasibility Study Report", October 31, 2013. SCF of 0.97 in this report can be regarded as reasonable figure, considering the figure of the ADB's recent report.

Regarding labor cost, it is assumed that there are no significant distortions in the wage of skilled labor. However, in the case of unskilled labor, underemployment exists in Pakistan. The average wage of workers in the informal sector is nearly half of that of the formal sector as explained in the previous study.[7] Therefore, a conversion factor of 0.5 is applied to the cost of unskilled labor when it is converted to economic cost.

Cost of unskilled labor is assumed to share 30% of local cost portion of procurement and construction. As a result of the calculation below, the conversion factor of the local cost of procurement and construction is XXX.

"XXX" stands for "The information is masked because it includes confidential."

Table 10.2-9 Calculation of Conversion Factor on Local Cost of Procurement and Construction

This table is masked because it includes confidential.

10.2.7 Cut-off Rate

The cut-off rate is used as a deciding factor whether the project is viable from the viewpoint of the implementing organization and the national economy, by comparing it with FIRR and EIRR, respectively.

In principle, the cut-off rate adopted in the financial analysis is calculated based on the concept of opportunity cost of capital.

Though the financing of the Project is not finalized yet, the nominal weighted average cost of capital (WACC) is tentatively calculated as the cut-off rate for financial analysis.

Table 10.2-10 Nominal Weighted Average Cost of Capital (WACC)

This table is masked because it includes confidential.

.

[7] See "8.2.5 Conversion Factor" in JICA, "Data Collection Survey on Thar Coal Field in Pakistan Final Report", February 2013

ADB' guideline states that "an inflation adjustment should also be applied to any interest rate and discount rate that is used to calculate an annualized value for capital costs or simply a real rate of interest. As explained in "10.2.3 Tariff" and shown in Table 10.2-1, the upfront tariff determined by NEPRA has the components of 1) return on equity (ROE) and 2) interest charge. The level of 1) ROE and 2) interest charges is nominal in that it reflects the current inflation level. Therefore, the discount rate to be used for financial analysis needs to be also nominal rate, not real rate in order to make the calculation consistent.

In this report, the cut-off rate of 5.64% is used to determine the viability of the Project in terms of the FIRR and calculate FNPV.[8]

The Asian Development Bank (ADB) used 10%-12% as the social discount rate for the economic analysis, and such rate is regarded as the social opportunity cost of capital.[9] This report applies 12% for the calculation of EIRR as the recent ADB's feasibility study on Jamshoro coal fired thermal plan uses this figure.

10.2.8 Auxiliary Consumption and Transmission and Distribution Loss

The percentage of auxiliary consumption of a coal fired thermal power plant is assumed to be 8% of the total amount of generation based on the decision on the upfront tariff of NEPRA.

From the recent figure of Electricity Marketing Data, 2.48% of transmission loss and 17.54% of distribution loss is applied to calculate the net incremental sales of electricity and benefit in the economic analysis.

Table 10.2-11 Transmission and Distribution Loss

	2012	2013	2014
Transmission loss	2.82%	3.05%	2.48%
Distribution loss	18.17%	17.64%	17.54%
T&D loss (% of net generation)	**20.99%**	**20.69%**	**20.02%**

Source: NTDC, "Power System Statistics 2013-2014, 39th Edition", "Table B: PEPCO (Public and Private)"

10.2.9 Adjustment on the Cost of Water and Coal

Coal fired thermal power plant uses water and coal for generation. As the energy price charge (variable charge) is assumed to be decided on cost-plus basis, the costs of water and coal are

[8] The treatment of nominal discount rate in this report is different from that used in ADB's feasibility study on Jamshoro Power Generation (2013). ADB's report uses 2.55% as the discount rate for calculating FNPV based on the calculation of the real weighted average cost of capital (WACC) by deducting the inflation rate from the nominal rate.

[9] ADB Economics and Development Resource Center, "Guideline for the Economic Analysis of Projects", February 1997, p.37

regarded as "pass-through" items in the financial analysis.[10] Indeed, the revised upfront tariff of imported coal and local coal and the upfront tariff of Thar coal refers to the fuel price adjustment mechanism. In the case of foreign and local coal, fuel cost will be adjusted on a monthly basis, while the cost of Thar coal will be adjusted once the competent authority has announced. The cost of water for Thar coal will be also adjusted when the government of Sindh has announced the revised water charges. Based on this assumption, both the variable costs including water and coal and the revenue of energy charge are assumed to offset each other, which results in no profit or deficit.

On the other hand, in the economic analysis, water is assumed to have no opportunity cost and is zero cost. Economic cost of Thar coal is assumed to have no opportunity cost as well based on the assumption that it can be sold to other coal power plants in the country and no overseas buyers are likely to import Thar coal.[11]

10.2.10 Cost of Insurance and Working Capital

Capacity purchase price of the upfront tariff includes the component that covers the cost of insurance and working capital respectively.

Table 10.2-12 Tariff on Cost of Working Capital and Insurance (Unit: Rs./kWh)

This table is masked because it includes confidential.

The cost of insurance (XXX Rs./kWh) and working capital (XXX Rs./kWh) in Jamshoro's proposed tariff is used for calculating the revenue from these two components.

"XXX" stands for "The information is masked because it includes confidential."

It is assumed in the financial and economic analysis that the revenue that covers the cost of working capital and insurance offsets these costs, based on the assumption that this component does not make profit or deficit.

[10] NEPRA's decision on the upfront tariff of Thar coal takes into consideration the water related costs. Water charge to be paid to the government of Sindh will be adjusted once it is announced by them. Capital cost for pumping station and pipeline will be allowed for mine mouth power plants in Thar blocks. Operation and maintenance cost for pumping station will be indexed with price index. NEPRA's upfront tariff on Thar coal decides the water cost for 660 MW with local financing of 0.5071 Rs./kWh (1st – 10th years) and 0.42 Rs./kWh (11th – 30th years).

[11] According to New Energy and Industrial Technology Development Organization (NEDO) and Institute of Energy Economics, Japan (IEEJ), "Study on the Status of Overseas Coal (FY 2009)", February 2010, p. 5 (in Japanese), due to the fact that the lignite has high water content and low heat value, the international trade of lignite is rare and the majority of lignite is utilized for power generation at the site near the lignite mines. The assumption that Thar coal does not have any opportunity cost is in line with the feasibility study of Jamshoro coal fired power plant. Jamshoro's economic analysis does not assume any opportunity cost of Thar coal.

10.3 Identification and Quantification of Financial and Economic Costs

Financial and economic costs are identified and quantified based on the estimation of project costs. Financial costs and economic costs are used for calculating FIRR/FNPV and EIRR/ENPV, respectively.

10.3.1 Financial cost

The financial cost is derived from the project cost, which is indicated in the estimation of project costs. Financial cost consists of 1) initial investment cost and 2) O&M cost.

Project cost includes procurement and construction cost, land acquisition cost, consulting services, and physical and price contingencies.[12] On the other hand, financial cost is used to estimate the performance of the Project from the viewpoint of the implementing organization, and excludes price escalation and interest during construction (IDC).

Table 10.3-1 Financial Cost of the Project upon Completion of Construction (Unit: Rs. million)

This table is masked because it includes confidential.

Table 10.3-2 Annual Allocation of Financial Cost (Unit: Rs. million)

This table is masked because it includes confidential.

10.3.2 Economic Cost

Economic cost is derived from the project cost, which is indicated in the estimation of project cost. Costs of project items in local currency are converted to economic costs by applying the corresponding conversion factors. Costs of items that are already at border price need not be adjusted.

Economic cost is used to estimate the performance of the project from the viewpoint of

[12] The cost of railway construction is included in the financial cost as railway infrastructure is assumed to be owned by GENCO, who is also the borrower for the loan of the railway project.

national economy, and excludes price escalation, duty and taxes, interest during construction, and the cost of transmission and distribution. Duty, taxes and the cost of transmission and distribution are excluded from the economic cost as they are transfer payments within the economy of a country and are not real cost to the national economy.[13]

Table 10.3-3 Economic Cost of the Project upon Completion of Construction

(Unit: Rs. million)

This table is masked because it includes confidential.

Table 10.3-4 Annual Allocation of Economic Cost (Unit: Rs. million)

This table is masked because it includes confidential.

10.4 Identification and Quantification of Financial and Economic Benefits

Financial and economic benefits are identified and quantified in this section. These benefits are derived from the incremental generation from a coal thermal power plant, which will be achieved through the implementation of the Project.

First, the financial benefits are quantified based on incremental power generation and incremental revenue by selling electricity to NTDC.

Secondly, the economic benefits are calculated based on the saved cost by replacing the alternative energy sources (e.g., uninterrupted power supply (UPS) equipment and diesel generators).

10.4.1 Financial Benefits

The financial performance of the Project is evaluated from the viewpoint of the implementing organization (i.e. GENCO).

[13] ADB's Jamshoro report treats the cost of transmission and distribution in a different manner. The report includes the cost of transmission (0.0024 US$/kWh) and the cost of distribution (0.0075 US$/kWh) in the stream of economic cost.

Financial benefit of the generation project is identified as the increased revenues from electricity sales to NTDC. If the generation project starts to operate, the implementing organization can sell more electricity and earn more revenue. Project output (i.e. generated electricity) will be calculated based on the following formula.

Generation (GWh) = Capacity (MW) x 24 hours x 365 days x Plant factor (%) /1000

The benefit is calculated until the end of the project life (30 years).[14] For financial analysis, the benefit of incremental revenue can be calculated in a particular year, by multiplying the incremental electricity generated with the tariff. The tariff consists of 1) energy purchase price (variable charge) and 2) capacity purchase price (fixed charge), as explained in Section 10.2.4.

Revenue = Generation (GWh) x Capacity purchase price + Generation (GWh) x Energy purchase price

As it is assumed that there will be no forgone benefit of agricultural products that used to be produced by the land where the coal thermal power plant will be located, which results in no opportunity cost, the gross revenue is equal to what is calculated based on the above formula.

10.4.2 Economic Benefits

In determining the economic benefit of the Project, two types of benefits are normally identified. The value of economic benefit from electricity consumption is based on the 1) induced market, which is brought about by the increased electricity consumption (i.e., incremental benefits) and 2) diverted market, which is the current energy consumption where the electricity replaces alternative energy sources such as kerosene lamps, uninterruptible power supply (UPS), and/or diesel generators (i.e., non-incremental benefits).

With a huge deficit in electricity supply and prolonged load shedding in Pakistan, the electricity produced by the Project will not increase the electricity consumption or replace the existing generation capacity, but simply act as substitute to the alternative energy source. Thus, the entire output of the Project is considered as non-incremental.

In identifying the economic benefit level, the saved cost is calculated from the viewpoint of consumers, by using the economic cost of alternative energy sources as the upper limit and the economic price of the tariff as the lower limit.

[14] U.S. Power Consul LLC's report, "Jamshoro Power Generation (JPG) Feasibility Study Report" assumes 30 years as the project life, though it includes the construction period. This report defines 30 years as the project life though it excludes the construction period. This arrangement is same as the assumption of NEPRA on the project life.

(1) Economic Price of Tariff

Electricity is the only product that will be generated from the Project. Electricity is assumed to be a non-tradable output since it is produced only for domestic economy and not exported to neighboring countries. The economic price of the retail tariff resulting to Rs.XXX/kWh is calculated using the SCF of XXX.[15]

"XXX" stands for "The information is masked because it includes confidential."

Table 10.4-1 Economic Price of Retail Tariff

This table is masked because it includes confidential.

(2) Avoided Cost of Alternative Energy

There are two major sources of energy that can be saved by the incremental supply of electricity, which is made possible by the Project. Table 10.4-2 below shows that the diesel generators are mainly used by industrial and agricultural users while the UPS is used by commercial and domestic (residential) users as alternative source of lighting and for the use of electric appliances such as television, radio and computers.

Table 10.4-2 Assumption on the Alternative Energy Sources Based on the Types of Consumers

Alternative Source	Type of Consumers
UPS	Domestic, commercial users
Diesel generator	Industrial, agricultural, others

The above assumption is justified by the average electricity consumption of each consumer category. The average electricity consumption of domestic and commercial consumers is relatively small, while that of industrial and agricultural consumers is large. Table 10.4-3 shows the current average consumption of the users in each category.

Table 10.4-3 Average Electricity Consumption per Consumer (Unit: kWh)

	Domestic	Commercial	Industrial	Agricultural
Monthly	144	152	5,609	2,181
Annual	1,726	1,820	67,309	26,177

Source: NTDC, "Power System Statistics 2013-2014, 39th Edition", "Table D-5: Electricity Consumption per Consumer"

[15] The tariff used in the calculation is not the upfront tariff, but the retail tariff to be paid by the consumers. This is because the saved cost is calculated based on how much the consumers can save by avoiding to pay the cost of the alternative energy and paying the retail tariff.

The UPS is selected as an alternative energy source instead of kerosene lamp, which is often used for calculating the saved cost, since the latter is not widely used in Pakistan.[16] Furthermore, load shedding is widespread in Pakistan, leading electricity consumers to prepare for load shedding by using the UPS.

Electricity users tend to utilize the alternative energy sources due to load shedding and unstable power supply. These are replaced as soon as uninterrupted stable power is supplied. The cost of alternative energy source, which is normally higher than the retail tariff, is regarded as the upper limit to calculate the saved cost, which is explained in the following section.

Diesel generators

Diesel generators, one of the major alternative sources of power supply, can be replaced using incremental power supply from the increased capacity of generation. The saved cost on diesel generators can be regarded as economic benefit.

More than 80% of crude oil is imported from overseas.[17] As the Government of Pakistan regulates the price of petroleum products and imposes tax and market margin, such transfer payment within a country is deducted from the prescribed price in order to calculate the true cost to the country.

Table 10.4-4 Economic Cost of Hi-Speed Diesel Oil (Unit: Rs./litter)

Prescribed Price	44.51
- Petroleum levy	(8.00)
Net Price of H.S.D. (excluding tax)	**36.51**

Source: Pakistan State Oil Company, Notification (Ref. PSO-HSD 08/2015-16), February 1, 2016

Note: Prescribed price includes dealers commission and distributors margin.

The cost of generation by a diesel generator consists of fixed and variable costs. Fixed cost (i.e., purchase cost of equipment) is excluded in the calculation as it is regarded as a sunk cost at the time of calculation.

Table 10.4-5 Variable Cost of Diesel Generation

Item	Formula	Figure	Unit
Installed capacity	A=kVA*Power Factor	9.2	kW
Power factor	Power factor = 0.8	0.8	
Load factor	Load factor = 0.5	0.5	
Net generation	B=kW*8760*Load factor	40,296	kWh/year
Economic cost of diesel oil	C=Market price-tax& margin	36.51	Rs./L
Fuel consumption	D=Web site info	2.90	L/hour

[16] According to USAID Pakistan, "Energy Sector Assessment for USAID/Pakistan", Table 9: Average Monthly Expenditure in Rupees on Energy in Pakistan Households (Winrock 2007), less than 3% of household energy related expenditure is spent on kerosene, while approximately 50% is spent on the payment of electricity bill.

[17] Adeel Ahmad, Mithilesh Kumar Jha, “Status of Petroleum Sector in Pakistan - A Review”, Oil and Gas Business, 2007

Fuel cost	E=Fuel consumption (liter per hour)*8760*Load factor*Fuel price per liter	463,750	Rs./year
Variable O&M cost	F=Fuel cost*1%	4,638	Rs./year
Total cost	**G=E+F**	**468,388**	**Rs./year**
Variable cost per kWh	**H=G/B**	**11.62**	**Rs./kWh**

Source: Prepared by JICA Survey Team

Note: The calculation is made in the case of 11kVA.

As a result of the calculation, Rs.11.62/kWh is decided as the upper limit of the economic cost of diesel generators.

UPS

The domestic and commercial customers tend to use the UPS as a back-up in case of load shedding and unstable supply. Since the economic life of UPS is relatively short, both fixed and variable costs per kWh are calculated as shown in Table 10.4-6.

Table 10.4-6 Fixed and Variable Costs of UPS

Items	Formula	Figure	Unit	Remark
Price of UPS	A=survey	14,599	Rs.	Quotation from UPS dealer
Capacity of UPS	B=survey	2,000	VA	Quotation from UPS dealer
Economic life	C=assumption	5	year	
Annualized cost	D=A/C	2,920	Rs./year	
Equivalent wattage	E=B*power factor	1,600	watt	Capacity (VA)xpower factor (0.8)
Hours of use per day	F=assumption	10	hours	
Equivalent kWh per year	G=E*F*365/1000	5,840	kWh/year	
Fixed cost per unit (kWh-Value)	**H=D/G**	**0.50**	**Rs./kWh**	
Unit price of battery	I=survey	4,818	Rs./unit	Quotation from UPS dealer
Necessary no. of battery	J=survey	3	unit/year	Quotation from UPS dealer
Cost of battery per year	K=I*J	14,453	Rs./year	
Tariff	L=assumption	10.0395	Rs./kWh	Economic cost of tariff
Efficiency	M=assumption	0.5		
Recharging cost	N=G*L/M	117,261	Rs./year	
Variable cost per unit (kWh-Value)	**O=(K+N)/G**	**22.55**	**Rs./kWh**	
Total cost of UPS	**P=H+O**	**23.05**	**Rs./kWh**	

Source: Prepared by JICA Survey Team

As a result of the calculation above, Rs.23.05/kWh is the upper limit of the economic cost of the UPS.

(3) Saved Cost

The saved cost represents the economic value of electricity consumption of the consumers. This is not equal to the retail tariff of electricity. Often, the retail tariff rate tends to be subsidized and does not adequately reflect economic benefit. In the economic analysis, economic benefits are equated with savings from using electricity for lighting, irrigation, industrial, and other works, by utilizing UPS and diesel generators as major sources of alternative energy.

It is assumed in the analysis that the difference between 1) the weighted average retail tariff and 2) what consumers are actually paying for the alternative source of energy is the saved cost as illustrated in Figure 10.4-1.

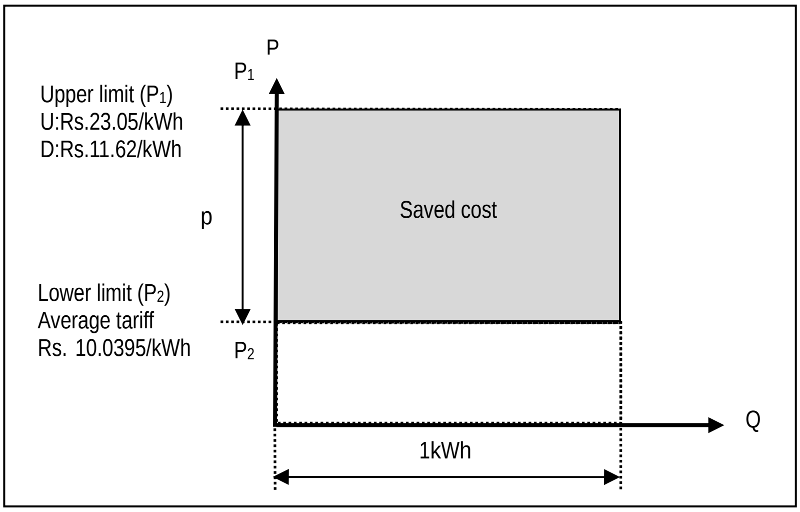


Figure 10.4-1 Saved Cost

Note: "U" represents "UPS", while "D" represents diesel generation.

Source: JICA Survey Team

Domestic consumers are assumed to be using UPS. While irrigation users are assumed to be using diesel-powered irrigation pumps as backup for their electric-powered pumps, commercial users, on the other hand, are assumed to be using mainly UPS as backup for electric lighting while very few utilize diesel generators. Moreover, industrial users are assumed to be using diesel generators, although there are some who do not own such equipment.

Table 10.4-7 Calculation of Saved Cost of Alternative Energy Sources

Tariff Category	Alternative Source	Consumption (GWh)		Economic Price (Rs./kWh) Upper Limit	Lower Limit	Difference	Weighted Saved Cost
			(a)	(b)	(c)	(d)=(b)-(c)	(e)=(a)*(d)
Domestic	UPS	33,357	47%	23.05	10.0395	13.01	6.11
Commercial	UPS	4,795	7%	23.05	10.0395	13.01	0.88
Industrial	Diesel	20,549	29%	11.62	10.0395	1.58	0.46
Agricultural	Diesel	8,130	11%	11.62	10.0395	1.58	0.18
Others	Diesel	4,271	6%	11.62	10.0395	1.58	0.10
		71,102	100%			**Total**	**7.72**

Source: Power System Statistics 2013-2014, Table D- 4: Consumption of Energy by Economic Group. Prepared by the JICA Survey Team

Based on the consumption share of each tariff category, the weighted saved cost is calculated at Rs.7.72/kWh as shown in Table 10.4-7.

10.5 Conclusion of Financial and Economic Analyses

The financial and economic IRR and NPV are calculated and presented in this section based on the assumptions, costs and benefits described so far.

10.5.1 FIRR and FNPV

(1) Base Case

Benefit and cost are compiled and calculated considering the 2016 prices in order to obtain the FIRR. Moreover, the weighted average cost of capital (WACC) (5.64%) is used as a discount rate for calculating the FNPV.

Table 10.5-1 FIRR and FNPV

This table is masked because it includes confidential.

By applying 5.64%, FNPV turns into positive and FIRR becomes higher than the cut-off rate. It can be concluded that the Project is expected to produce a reasonable profit as assumed in the calculated tariff. Therefore, the implementation of the Project can be justified from the financial perspective.

2) Sensitivity Analysis

Sensitivity analysis is conducted for the financial analysis as the actual condition may be different from those assumed for the base case. In the sensitivity analysis, the following changes in assumptions are considered; 1) tariff decrease (-10%), 2) cost increase (+10%), and 3) delay in construction (one year).

Table 10.5-2 Sensitivity Analysis for FIRR & FNPV

This table is masked because it includes confidential.

As indicated in Table 10.5-2, the FIRR and FNPV are likely to be relatively influenced by tariff decrease (-10%) and cost increase (+10%). This implies that the executing agency should pay careful attention to 1) the cost management during the construction period in order to avoid the cost overrun and to 2) the determination of the proper tariff setting. The result of the sensitivity analysis is understandable because the calculated tariff covers all of the cost and the expected return. If the level of the tariff decreases or the cost increases, it will definitely influence the certainty and level of the return to the lender and the shareholder, which is the basis for calculating the weighted average cost of capital (WACC).

If this situation occurs, the return to the equity is likely to decrease as the priority of payment of the Project will be placed on that of the receivables and other liabilities, not the dividend to the shareholders (i.e. the Pakistan Government).

3) Conclusion

As mentioned earlier, the figures can justify the implementation of the Project. As is clear from this result, it can be also concluded that the executing agency should opt for the negotiated tariff and not the upfront tariff, which is lower than the negotiated tariff, in order to ensure that the tariff is able to cover the cost and the required profit.[18]

10.5.2 EIRR and ENPV

(1) Base Case

The benefit and cost are compiled and calculated using the economic benefit and cost, in order to obtain the EIRR. Moreover, a social discount rate of 12% is used to calculate the ENPV.

Table 10.5-3 EIRR and ENPV

This table is masked because it includes confidential.

The EIRR is higher than the cut-off rate (12%), and the ENPV is positive with a significant amount of economic net present value.

(2) Sensitivity Analysis

A sensitivity analysis is conducted for economic analysis. The cost overrun of construction and delay in construction are analyzed.

[18] This conclusion is indeed in line with that in ADB's Jamshoro report. The report states, "JPCL (Jamshoro Power Company Limited) would be required to submit a tariff petition to NEPRA for determination of Project specific tariff" (page 172). Indeed, GENCO I has already submitted the petition for the negotiated tariff to NEPRA last year.

Table 10.5-4 Sensitivity Analysis for EIRR & ENPV

This table is masked because it includes confidential.

The EIRR still outweighs the cut-off rate and the ENPV is still positive in every case of sensitivity analysis.

3) Conclusion

The Project is justified from the viewpoint of the country's economy because of the higher EIRR than the cut-off rate, and the significant positive ENPV. Thus, the Project should be implemented as it contributes to the national economy's enormous savings from reducing the spending on the alternative expensive energy sources.

10.6 Risk Analysis

The Project is justified from the financial and economic viewpoint in the analysis so far. However, the analysis is based on various assumptions. Impacts of the changes in assumptions are analyzed in the sensitivity analysis. There are some other risks that may significantly influence the cash flow of the Project. Therefore, such risk factors are listed and briefly analyzed in this section with several remedial measures.

10.6.1 Delay in Receipt of Tariff Due to Accumulating Circular Debt

The new government has made an effort to address the issue of circular debt in the power sector.[19] However, the issue has not been completely solved yet. According to a recent newspaper article, the circular debt in the power sector has been rapidly increasing up to Rs. XXX at the beginning of May, 2014, out of which Rs XXX has to be paid by the government to the IPPs operating under the 1994 power policy and Rs XXX to the IPPs running under the 2002 policy.[20]

"XXX" stands for "The information is masked because it includes confidential."

If this situation has worsened, it may significantly influence the cash position of the organization in charge of operating the Project and make it difficult to make necessary payment in timely manner, even if the Project itself is making profit.

[19] According to Finance Division, Government of Pakistan "Year Book 2012-2013" (p. 34), Finance Division released Rs.342 billion in June, 2013 to PEPCO for onward payment to IPPs and other entities and Rs.138 billion were adjusted under Inter-Government Settlement in July, 2013.

[20] The Express Tribune, "Payment issue: Ministry calls on power producers for resolution", May 24, 2014

Planning Commission of Pakistan published a report on the issue of circular debt[21] and attempted to identify the root causes of the circular debt and necessary measures to be taken to reduce the debt. Various measures are recommended for the government, the regulator (NEPRA), and the corporations (mainly distribution companies) levels.

The situation of circular debt needs to be carefully monitored and managed by the initiative of the Government and other stakeholders in order to minimize the negative impact on the Project as well as the power sector.

10.6.2 Insufficient Tariff Level Required for Cost Recovery and Profit

National Electric Power Regulatory Authority (Tariff Standards and Procedure) Rules, 1998 states that “tariffs should allow licensees the recovery of any and all costs prudently incurred to meet the demonstrated needs of their customers” and “tariffs should allow licensees a rate of return which promotes continued reasonable investment in equipment and facilities for improved and efficient service”. As is clear from these statements, NEPRA allows the licensees to make full cost recovery and reasonable profit.

However, the engineering, procurement, and construction (EPC) cost assumed in the NEPRA’s upfront tariff is lower than the estimated EPC cost for the Project. If GENCO chooses the negotiated tariff, which requires a thorough review of the petition, relatively longer time for approval and public hearing, it is not clear at the time of writing this report whether the approved tariff fully allows the level of the tariff that covers the EPC cost and other costs of the Project.[22]

The result of the petition for tariff has yet to be seen in the case of the negotiated tariff.[23] In the case that the approved tariff is not satisfactory to the petitioner, the executing agency of the Project has two counter measures to deal with such situation. First, the petitioner has the right to file the motion for review based on NEPRA (Tariff Standards and Procedure) Rules, 1988, though it should specify the grounds to justify the review. Secondly, the petitioner can bring the case to the court.[24] Thus, there are two measures for the petitioner to take against unsatisfactory level of the tariff determined by NEPRA.

[21] Planning Commission of Pakistan, “The Causes and Impacts of Power Sector Circular Debt in Pakistan”, March 2013
[22] There may be another risk that the government of Pakistan does not notify the tariff determined by NEPRA, which occurred in the past, mainly for the retail tariff. However, according to GENCO, such case did not happen for the generation tariff in the past.
[23] The generation tariff petition is normally submitted to NEPRA in 3-4 months before commissioning.
[24] Both NEPRA and GENCO affirmed that these two measures are possible.

10.6.3 Operation under the Existing GENCO

Chapter 8 explains and compares two alternatives of organizational structure (the establishment of a new company as GENCO VI and the operation under GENCO IV).[25] It is suggested in Chapter 8 that the Project should be operated under GENCO IV.

Each power generation company under GENCO Holding Company produces the financial statement. If one power company operates more than one power plant, the bank account and management account will be made for each power plant to make the accounting and cash flow situation clearly separated as explained in Table 8.2-4.[26]

If the power plant newly constructed by the Project becomes a part of the existing power generation company (i.e. GENCO-IV (LPGCL): Lakhra Power Generation Company Limited), the risk may remain that the surplus money generated from the Project may be spent for the expenditure of the existing Lakhra power plant under the same company if the latter is making financial loss.

Indeed, LPGCL has been making a huge loss, though the gross loss has drastically decreased according to the income statement of 2014.

Table 10.6-1 Income Statement of GENCO IV (LPGCL) (Unit. Mil. Rs.)

This table is masked because it includes confidential.

However, there is a mechanism that supports the cash flow of the generation company under GENCO Holding Company. In principle, Central Power Purchasing Agency (CPPA) under NTDC is the single buyer of electricity from GENCO, WAPDA and IPPs and transmits electricity to distribution companies.

In theory, generation companies such as LPGCL should have the receivables of CPPA, because there is a time lag between 1) the time of transmitting electricity to CPPA and 2) the time of receiving money as the generation tariff from CPPA. However, the balance sheet of LPGCL shows an increasing amount of payable to CPPA. LPGCL requests CPPA for cash disbursement for various payments such as wage. As LPGCL has been making financial loss

[25] See “8.2.5 The Recommended Organization for the New Lakhra Power Plant” for more detail of this issue.
[26] This is also confirmed by the management of GENCO Holding Company.

and in cash shortage, the amount of payable to CPPA is larger than the receivable from CPPA at present.

Table 10.6-2 Payable to CPPA of LPGCL (Unit. Mil. Rs.)

This table is masked because it includes confidential.

Therefore, in reality, there is a support from NTDC for the cash flow of the GENCO's power generation companies, which can reduce the risk of cash shortage for the operation of the power plant to some extent.

Furthermore, the scale of the deficit of GENCO IV is insignificant compared with the expected revenue and profit of the Project. For example, the current revenue of GENCO IV is Rs. XXX, while the Project's expected revenue reaches up to Rs. XXX in the first year of operation, which is approximately XXX times larger than that of the existing Lakhra power station.

"XXX" stands for "The information is masked because it includes confidential."

As shown in the appendix, the independent and consolidated financial forecast of 1) the Project and 2) the existing Lakhra power station clearly proves the difference in the scale of the revenue and the profit is large and the impact of the deficit of the latter on the former is not significant.

The financial indicators of the return on equity (ROE) and the return on asset (ROA) declines in the second year of operation due to the starting of loan repayment. However, from Year 3 and onward, the figures of these financial indicators become stable.

Table 10.6-3 Financial Indicators of the Consolidated Financial Statements

This table is masked because it includes confidential.

The current ratio, which is a liquidity ratio that measures an ability to pay the short-term obligation, shows a relatively high and increasing trend. This is simply due to the fact that the Project makes profit and accumulates cash once it has started to generate electricity.

Having said that, some measures may need to be taken to ensure that the part of revenue will be set aside for the repayment of the loan, especially from the viewpoint of the financial institutions. First, the separate bank account (escrow account)[27] should be established to set aside the revenue that is the equivalent to the repayment of the loan, fuel and/or the O&M cost and avoid the use of this money for other expenses. In the case of Jamshoro coal-fired power plant, at least 1 month of fuel cost and 1 year of maintenance cost are obliged to be kept in the separate escrow account.[28] Same arrangement is recommended for the Project.

By practicing this arrangement, the money necessary for operating the plant (i.e., fuel and O&M) is always made available to the Project without being influenced by cash shortage, which results in the shutdown or the unstable operation of the plant. The implementation of the arrangement can avoid such situation and contribute to the better utilization of the plant.

To realize the establishment of such account, the loan agreement should include a financial covenant that obliges the executing agency to open this account for maintaining the money enough for the loan repayment.

Secondly, the loan agreement can oblige the borrower to periodically (e.g. quarterly) submit the cash flow statement of both the Project and the existing Lakhra power station in order to check any extraordinary change in figures. This arrangement will help the stakeholders identify any significant changes in the financial conditions, which may affect the timely payment of the loan.

[27] Escrow account is generally defined as a separate bank account for keeping money that is the property of others.
[28] ADB "Report and Recommendation of the President to the Board of Directors: Proposed Loans Islamic Republic of Pakistan: Jamshoro Power Generation Project, Table 4, November 2013

CHAPTER 11
ENVIRONMENTAL AND SOCIAL CONSIDERATION

Chapter 11 Environmental and Social Considerations

11.1. Outline of the Project

11.1.1 Project Components

(1) Outline

The proposed Project of power plant (1 x 660MW (gross)) include two associated projects of transmission line and railway works for imported coal transportation. In this report, environmental and social aspects of following components regarding to the power plant and transmission lines will be considered.

1) One 660 MW Coal-Fired Thermal Power Plant
- Coal storage site and coal handling facilities
- Ash disposal site and ash handling facilities
- Water supply systems
- Wastewater treatment and discharge systems
- Two (2) access roads

2) 500 kV Transmission Lines
- Four (4) transmission lines (T/Ls) between the power plant and the existing grid system

(2) Categorization of each Component

The Project requires three kinds of EIAs of 1) the power plant, 2) transmission lines and 3) railway works based on the categories designated in the national regulations (Section 11.3.2). The project responsible entities are GENCO Holding Company Limited ('GHCL'), National Transmission & Dispatch Company ('NTDC') and Pakistan Railway ('PR') respectively. Responsibilities are summarized in Table 11.1-1.

Table 11.1-1 Responsible Entities for each Component

Component		Regulatory Category	Report Prepared	Responsible Entity for EIA	Responsible Entity for Construction	Responsible Entity for Operation
Prime Project	Power Plant	EIA	EIA	GHCL	GHCL	GHCL
Associated Projects	Transmission Lines	EIA	EIA	NTDC	NTDC	NTDC
	Railway Works	EIA	EIA	GHCL	PR	PR

Source: JICA Survey Team

11.1.2 Project Location

The Prime Project site is within the estate of existing Lakhra Power Station (3 x 50MW) ('Lakhra Plant') which is an only coal fired thermal power station operated in Pakistan. Lakhra Plant is located in Manjhand Taluka[1], Jamshoro District, about 175 km northeast of Karachi and about 40

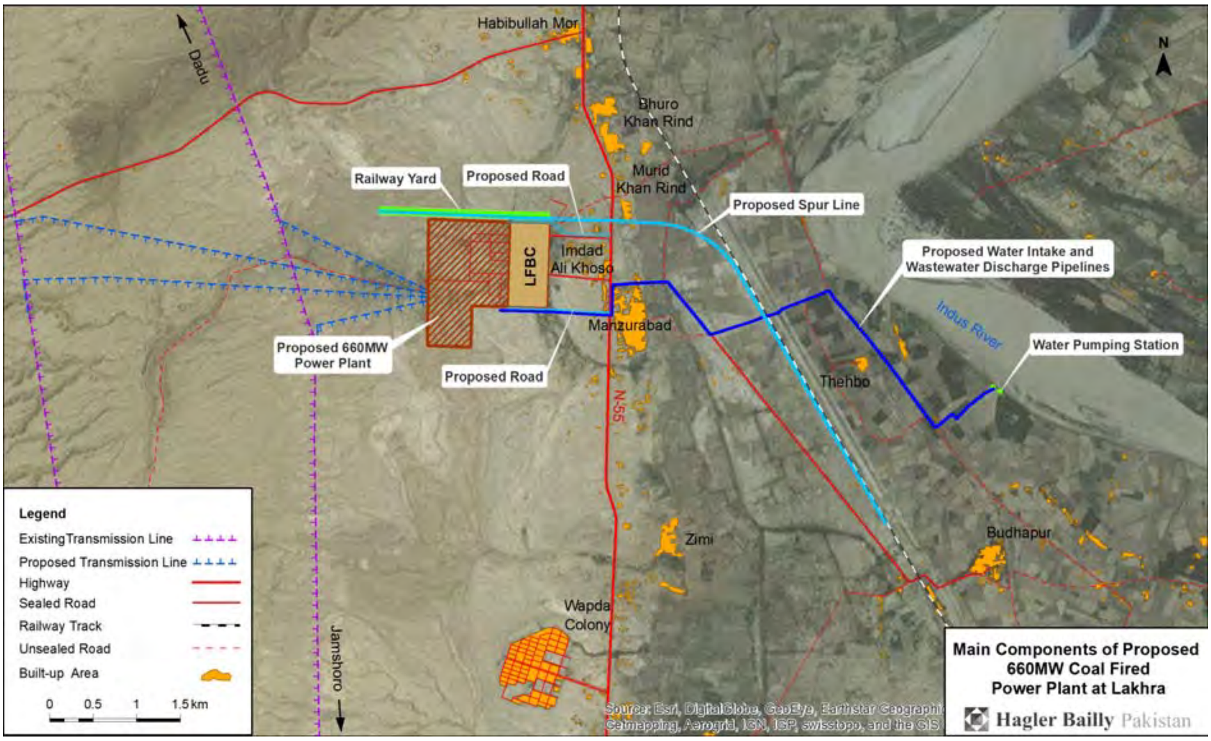
[1] A taluka is an administrative division and consists of an area of land with a city or town that serves as its headquarters, with possible additional towns, and usually a number of villages.

km northwest of Hyderabad. It is located on N-55 (Indus Highway) which is one of the main highways that connect Karachi with the rest of the country.

The Indus River flows on the east of the Plant at a distance of about 4 km. Water requirements of the existing Lakhra Plant are met through an inlet pipe connected to the Indus River.

Barren plain of limestone is spread in the western side of Lakhra Plant. The plain has sparse vegetation and coal ash from the Plant is disposed of here. The limestone is mined and used as a desulfurization material for the Plant. Existing 500kV transmission line between Jamshoro and Dadu is in approximately 1.4km from the Lakhra Plant.

Existing railway line exists in 1.3 km east from Indus Highway in parallel with the irrigation channel. The nearest station is called Budhapur St. The Unarpur St., Cadet College Petro St. and Sindh University St. are dispersed between Budhapur St. and Kotri St. located near Hyderabad. The location of the Prime Project is shown in Figure 11.1-1.



Source: Hagler Bailly Pakistan

Figure 11.1-1 Location Map of Proposed Power Plant and Main Components

11.1.3 Consideration of indivisible project

According to JICA Guidelines[1] (April 2010), in addition to the direct and immediate impacts of projects, the derivative, secondary, and cumulative impacts as well as impacts of indivisible projects will be assessed with regard to environmental and social considerations, so far as it is rational. The life cycle impact of a project period is also considered.

[1] Guidelines for Environmental and Social Considerations

11.1.4 Scope of Impacts to be Assessed

The Project implementation would potentially induce changes to the physical environment that are expected to reduce with the increased distance from the project facilities. A Study Area of five (5) kilometer around the proposed coal–fired power plant was delineated in this report. The Study Area falls within the Manjhand taluka of Jamshoro district in Sindh Province and includes 18 rural settlements and one colony. The changes to the physical environment within the Study Area would potentially impact on natural and social environment directly and indirectly.

11.1.5 Lakhra Power Station

(1) General information

The key plant features are described in Table 11.1-2.

Table 11.1-2 General Information of Existing Lakhra Power Station

Unit	*Unit No. 1*	*Unit No. 2*	*Unit No. 3*
Commissioning Date	6th June, 1995	14th October, 1995	3rd January, 1996
Current Status	Operational	Operational	Not Operational
Installed Capacity	50 MW	50 MW	50 MW
Steam Condition	535 ºC, 9.8 MPa		
Type of Boiler	Fluidized Bed Combustion, Subcritical pressure		
Manufacture Boiler/Turbine	Dongfang Electric (China)		
Cooling method	Wet type cooling tower method		
Desulfurization method	Limestone		
Fuel	Type: Lignite coal Source: Lakhra Coal Mines Consumption: 52 ton/hour Supplier: Lakhra Coal Development Company (LCDC), a public sector company		
Water supply quantity	Source: Indus River Quantity: 0.25 m^3/sec (9 cusec) Transport: Underground pipe of 0.51 m (20 inch)		
Land Area	Plant: 112.30 ha (277.5 acre) Intake area: 4.78 ha (11.80 acre) Colony: 46.13 ha (114.00 acre) **Others**: 23.88 ha (59.02 acre) **Total: 187.09 ha (462.32 acre)**		
Power Dispatch	Through two 132 kV lines to Jamshoro and one 132 kV line to Khanot operated by NTDC		

Source: Lakhra Power Station

(2) Current Operational Condition

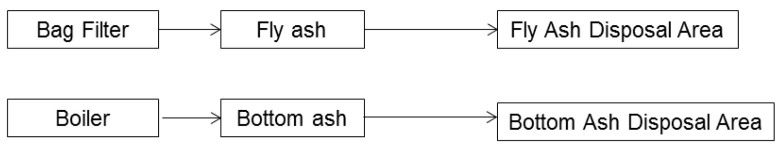
The 3 x 50 MW Lakhra Plant was an experimental power station. Fluidized Bed Combustion (FBC) is a relatively new technology for combusting low grade, high sulfur coal for power generation. In this system, the coal and limestone are suspended (fluidized) throughout the furnace by means of air entering at the bottom of furnace. FBC technology was just introduced when this plant was installed. Even the contractor did not have sufficient expertise for project of this size (50 MW), and sought assistance from Foster Wheeler & Company USA for initial designing of FBC boilers. The boilers were designed after testing of coal samples from different locations of Lakhra coal field.

The contractor faced number of problems during the guarantee period resulting in several modifications of the design. However, many problems remained mainly due to high sulfur and ash contents in the coal. Boiler Unit No. 1 and 2 have been operated, whereas Unit No. 3 has not been operated due to deterioration since March, 2007. Consequently current power generation capacity is around 30 MW. One of the key issues is the erosion of different parts of boiler. The continuous operation of boilers for longer period, i.e., beyond 50 days has not been achieved, so far, due to heavy clinker formation after burning of coal. The boilers are therefore stopped and are to be cleaned after operation of about 40 days.

(3) Ash Disposal

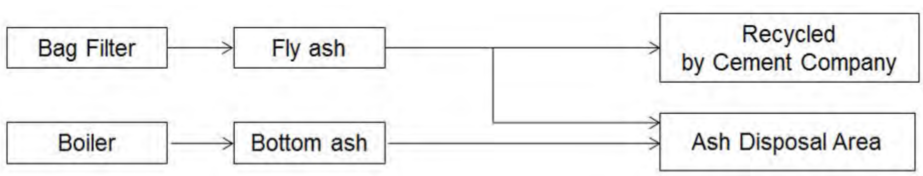
Collection, transportation and disposal of ash are operated by Lakhra Plant itself. Current ash disposal process is shown in Figure 11.1-2. Fly ash disposal site is located in about 12 km far west of Lakhra Plant as shown in Figure 11.1-4 and Photo 11.1-2. According to interviews to Lakhra Plant, the area belongs to Lakhra Coal Development Company (LCDC). On the other hand, bottom ash is dumped in barren land adjacent to the west side of Lakhra Plant as shown in Figure 11.1-4 and Photo 11.1-3. According to Lakhra Plant, some portion of the ash has been utilized as alternative materials of soil for dam construction projects.

In the community consultations, the local people raised issues and their concerns about the current practice of ash disposal. The ash illegally disposed of in hilly catchment near residential area is carried by rain water and wind and affecting their health (eye and respiration), agricultural lands and waterways (Photo 11.1-4, 11.1-5). The community concerns are provided in Section 11.6 Stakeholder Consultations and Disclosure. In this Project, to ensure appropriate treatment of ash and to avoid further conflicts regarding the ash disposal, ash pond will be designed within the power plant area. Besides, as much as possible, this Project will recycle fly ash as cement materials (Figure 11.1-3).



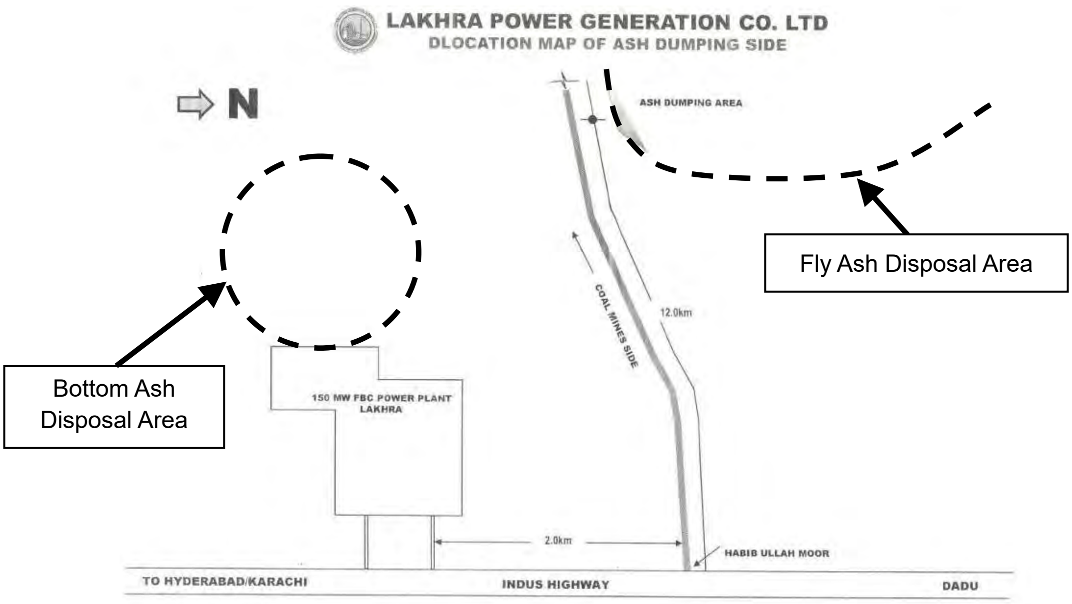
Source: JICA Survey Team

Figure 11.1-2 Ash Disposal Process of Lakhra Plant



Source: JICA Survey Team

Figure 11.1-3 Projected Ash Disposal Process of the Project



Source: Lakhra Plant

Figure 11.1-4 Ash Disposal Area of Lakhra Plant

Source: JICA Survey Team

Photo11.1-1 Truck Collecting Fly Ash

Source: JICA Survey Team

Photo11.1-2 Fly Ash Disposal Area

Source: JICA Survey Team

Photo11.1-3 Bottom Ash Disposal Area

Source: JICA Survey Team

Photo11.1-4 Ash disposed near Residential Area

Source: JICA Survey Team

Photo11.1-5 Ash disposed near Residential Area

(4) Stack Emission Measurement Result

To investigate the current emission conditions of pollutants from Lakhra Plant, following tests were performed at duct located close to bag house of Unit-2 from November 7 to 10, 2014. The operating load of plant was 32 MW.

The results of the measurement and comparison with the National Environmental Quality Standards (NEQS) and the IFC guidelines are shown in Table 11.1-3 and 11.1-4, respectively for particulate matter (PM), sulfur dioxide (SO_2) and nitrogen oxides (NO_X), whereas Table 11.1-5 provides results of analysis and NEQS for the metals.

These results indicate that all of those parameters (PM, SO_2 and NO_x) meet NEQS. However, PM and SO_2 significantly exceed the maximum values of IFC Guidelines. Regarding metals, all parameters meet NEQS.

Table 11.1-3 Results of PM, SO_2 and NO_x, and Comparison with NEQS

Pollutant	*Measured Result*	*NEQS Value*	*Units*	*Basis*
PM	393–533 (The range of values from three observations)	500	mg/Nm^3	Value at Actual O_2 and Normal Conditions
SO_2	92.8	500	Tons/day	Mass Emission
NO_x	167.3	260	ng/J of Heat Input	32 MW net Power Output and 30% Efficiency

Source: Hagler Bailly Pakistan

Table 11.1-4 Results of PM, SO_2 and NO_x, and Comparison with IFC Guidelines for Thermal Power Plants

Pollutant	*Measured Result*	*IFC Guidelines Value*	*Units*	*Basis*
PM	595 – 806 (The range of values from three observations)	50	mg/Nm^3	Value at 6% O_2,and Normal Conditions
SO_2	19,933	900-1500	mg/Nm^3	Value at 6% O_2,and Normal Conditions
NO_x	331	510	mg/Nm^3	Value at 6% O_2,and Normal Conditions

Source: Hagler Bailly Pakistan

Table 11.1-5 Results of Metal Analysis and Comparison with NEQS

	Lead	*Total Mercury*	*Cadmium*	*Arsenic*	*Copper*	*Antimony*	*Zinc*
Analysis Value (mg/Nm^3)	0.00949	0.0188	0.0024	0.0028	0.0134	0.0017	0.0855
NEQS (mg/Nm^3)	50	10	20	20	50	20	200

Source: Hagler Bailly Pakistan

11.2 Basic Situation of Environment and Society

11.2.1 Environmental Status

(1) Area of Influence

The potential impacts of the Project on its surrounding physical and biological environments include air and water quality impacts, noise generation, land transformation and changes to soil. These are expected to reduce with the increased distance from the Project facilities, affecting more the areas located closer, up to five (5) kilometers, to the Project facilities. For this, a study area of five (5) kilometers around the site was delineated, to assess the baseline conditions in the areas likely to be affected by the Project due to its proximity to the Project site (Figure 11.2-5). This is referred to as the 'Study Area' in this report.

For other impacts, such as, changes due to project water intake and water outfall, some primary data was also collected from the Indus River. Assessment of traffic was based on data collected in baseline survey.

(2) Geology

Pakistan geologically overlaps both with the Indian and the Eurasian tectonic plates. Sindh province lies on the north-western corner of the Indian plate. The Study Area lies on the southeastern fringe of the Kirthar range, a hill range that runs in the north to south direction for about 400 km along the Sindh-Balochistan provincial boundary[1]. Primary lithology in the Study Area is of sedimentary origin, consisting of limestone with occasional shale and sandstone of Laki Formation. Laki Formation is very rich in fossils of Eocene age (56-34 million years ago). Study area mostly consists of flood plain deposits. Two major active fault lines located near the Study Area are Surjam Fault, about 50 km to the southwest and the Jhimpir Fault, about 45 km to the south. Maximum recorded earthquakes on the Surjam and Jhimpir Faults were 6.1 and 5.6 on the Richter scale, respectively[2].

(3) Topography and Land Use

The elevation of the Study Area generally ranges between 20 and 45 m above mean sea level. It slopes towards the Indus River which runs along the eastern boundary of the Study Area. There are small sedimentary hills in the western and southwestern side of the Study Area that rise to an elevation of about 100 meters. The western side of the Study Area is gravel plain with very little

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1 Geology and tectonics of Pakistan, Kazmi. A. H and Jan. M. Q, 1997

2 Sindh Provincial Monsoon/Floods contingency Plan 2011 (Draft Version), provincial disaster management authority, Government of Sindh

natural vegetation cover. The eastern half of the Study Area is part of the Indus River flood plain. There are two main land uses in the Study Area other than the Lakra Plant. These are the agricultural land in the east and semi urban areas in the southeast and northeast. The Indus River floodplain has good alluvium soil and has been converted to productive farmlands. About 51% of the Study Area falls in this category of land use. The semi-urban areas are located in southeast and northeast of the Study Area. These include Manzorabad, Aliabad and some more villages. Other minor land uses include the road network, the canal network, the under-construction Right Bank Outfall Drain (RBOD) and about eight small rural settlements spread around the Study Area.

(4) Climate

Climate is the average course or condition of the weather at a place usually over a period of years as exhibited by temperature, wind velocity, and precipitation. The climate of the Study Area is broadly hot and dry summer mild winter and rainfall in monsoon.

The weather station closest to the Study Area is located at Hyderabad (25° 38' N, 68° 42' E), approximately 42 km east of the plant site. The climatic description of the Study Area presented in this section is based on the 30-year climatic data of Hyderabad. The hottest month is June in which the maximum average monthly temperature exceeds 40 ºC. The winters are mild with temperature dropping to 20 ºC in January. The Study Area receives approximately 178 mm of rain annually. Almost 65 % of the rain is concentrated in the monsoon months of July and August. Monthly temperature, rainfall and wind data are provided in Figure 11.2-1 and Figure 11.2-2. The annual and seasonal wind-roses are shown in Table 11.2-1 and Figure 11.2-3.

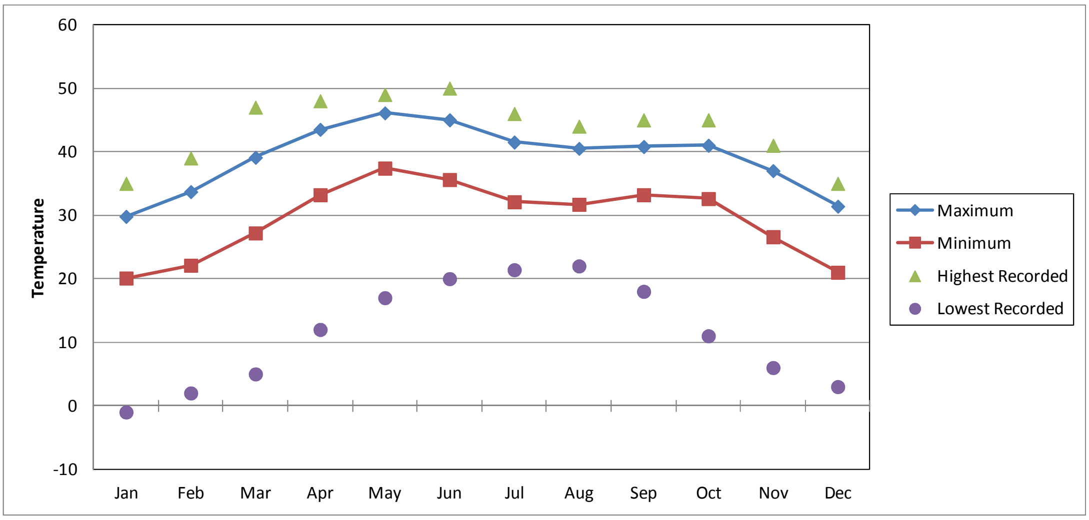
According to Koppen climate classification, the climate in the Study Area is arid desert hot climate which is broadly hot and dry summer with mild winter rainfall. Broadly speaking, there are four seasons in Pakistan. These seasons are defined on the basis of temperature and the changes associated with the southwest monsoon. The southwest monsoon is a wind system that prevails from April to October in the Indian Ocean, and is characterized by a reversal in wind direction and heavy rainfall over most of the Indian Subcontinent. Within Pakistan, considerable variation is found in temperature and monsoonal changes. Thus, the specific characteristics and duration of seasons depend on geographic location. The general characteristics of the season in the Study Area on the basis of climatic data of Hyderabad are presented below:

- Winter (December to early March): The winters have mild weather with minimum temperatures ranging between 11 to 19 ºC with January being the coldest month. Winter is mostly dry with accumulative rainfall of about 10 mm similarly relative humidity is around 50%. The Wind direction is mostly from North to South in entire winter with an average speed of 1.4 meters per second (m/s) and shift to Northeast direction in the month of March and remains there for the rests of the year.

- Summer (April to June): The summers are hot with average temperature reaching 35 ºC with June being the hottest month where temperate may cross 40 ºC. Summer is also dry with rainfall of less than 14 mm in the month of June relative humidity ranges between 50% in April to 64% in June. The wind direction is towards Northeast with average wind speed of 3 m/s.

- Monsoon (July to August): Monsoon is the characteristic feature of the subcontinent with hot average temperature reaching 36 ºC and heavy rainfall. From the historic climatic data (1961-1990) almost 65% of the rainfall occurs in this season with slightly higher rainfall in august than July. The relative humidity reaches monthly average of more than 65%. The wind direction is still towards Northeast with average wind speed of 3.6 m/sec.
- Post-Monsoon summer (September to November): In Post Monsoon temperatures starts dropping and reaches 24 ºC by November, although in month of September the recorded rainfall is of 16 mm but rest of season is mostly dry with humidity of around 50%. Wind direction is from Southwest to Northeast which changes its course towards north in the end of season.

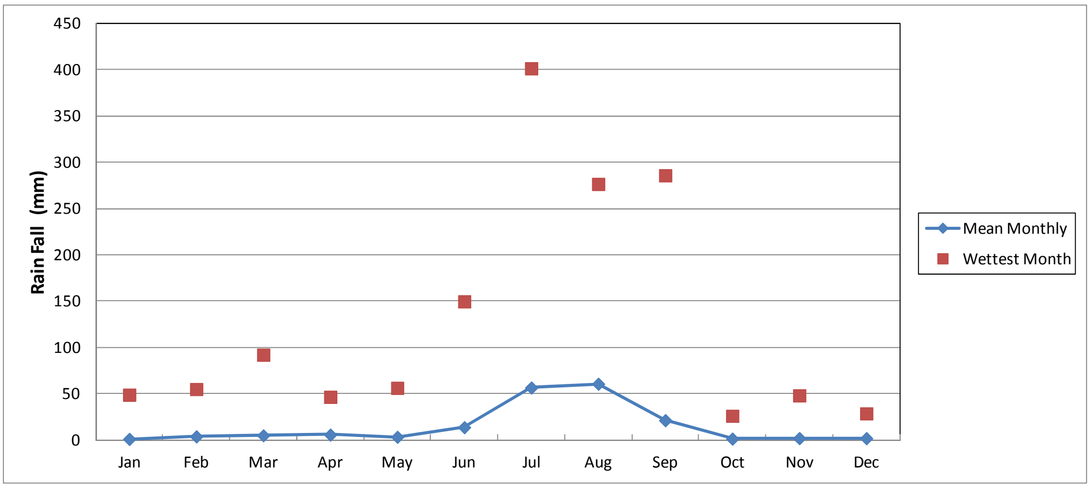
Post-Monsoon summer (September to November): In Post Monsoon temperatures starts dropping and reaches 24 ºC by November, although in month of September the recorded rainfall is of 16 mm but rest of season is mostly dry with humidity of around 50%. Wind direction is towards southwest which changes its course towards north in the end of season.



*Highest and lowest recorded temperatures are based on data collected at the Hyderabad station since it was established in 1877

Source: Pakistan Meteorological Department

Figure 11.2-1 Temperature of the Study Area



* Based on data collected at the Hyderabad station since it was established in 1877

Source: Pakistan Meteorological Department

Figure 11.2-2 Rainfall in the Study Area

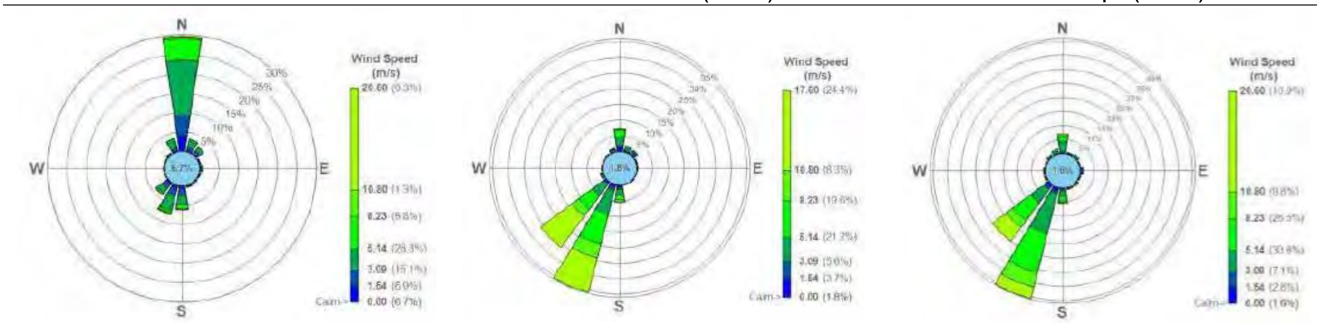
Table 11.2-1 Mean Wind of the Study Area

Month	Wind Speed(m/s)	Wind Direction
Jan	1.2	N
Feb	1.3	N
Mar	1.3	SW
Apr	2.2	SW
May	3.5	SW
Jun	3.9	SW
Jul	3.7	SW
Aug	3.6	SW
Sep	2.8	SW
Oct	1.4	SW
Nov	1.3	N
Dec	1.2	N
Year	2.3	SW

Based on data collected at the Hyderabad station between 1975 and 1979

Source: Pakistan Meteorological Department

Oct. 2010 to Feb. 2011	Mar. to Jun. (2011)	Jul. to Sep. (2011)



Source: Hagler Bailly Pakistan

Figure 11.2-3 Wind Rose for 2011

(5) Water Resources

Major water bodies in the Study Area include the Indus River and the under construction Right Bank Outfall Drain (RBOD). Groundwater is not major source of drinking water in the Study Area due to high amount of salinity in the groundwater. The water resources are briefly described below.

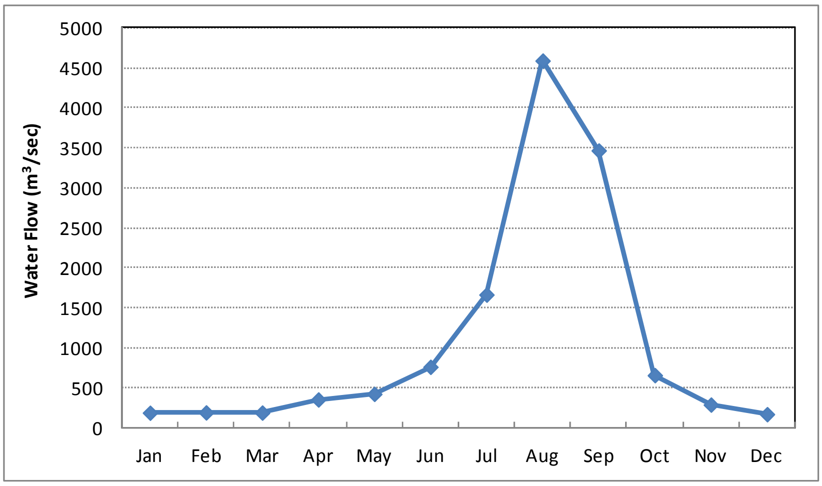
a) Surface Water Lakhra

The Indus River flows at a distance of about 4 km to the east of the plant site. The river has an average width of about 500 m during normal flow which increases to several kilometers during high floods. The width of the river at Kotri Barrage is one kilometer. Kotri Barrage, built in 1955, is used to divert water to irrigation canals and to provide protection against flood. The barrage has 44 bays and has the maximum design capacity to discharge 24,777 m^3/s. The average annual flow of Indus River at Kotri barrage is 1,085 m^3/s. The 10-year monthly averaged flow data for the Indus River recorded from 2005 season to 2014 season at the upstream of Kotri barrage is presented in Figure 11.2-4. The highest and lowest flow amount are 4,592 m^3/s in August and 177 m^3/s in December respectively.

Part of the under-construction RBOD is also located in the Study Area. The channel is designed to carry saline water from water logged farmlands on the right back of Indus River to the sea. The channel is partly excavated and various excavated sections are not connected. Rainwater and seeped water from surrounding land has accumulated in the excavated channels.

b) Groundwater

Total five groundwater extraction wells found in nearby village of Manzorabad. Depth to groundwater, known from owners, is varies from 40 to 50 meters in these wells. There is no significant groundwater resource in other villages in the Study Area found. In Manzorabad, groundwater uses restrict to washing and ablution needs due to high salinity.



Source: Irrigation & Power Department, Government of Sindh

Figure 11.2-4 Indus River Monthly Flow at Kotri Barrage


Source: JICA Survey Team
Photo11.2-1 Agricultural land


Source: JICA Survey Team
Photo11.2-2 Proposed project site


Source: JICA Survey Team
Photo11.2-3 Existing ash disposal area


Source: JICA Survey Team
Photo11.2-4 Existing intake facility


Source: JICA Survey Team
Photo11.2-5 Residential area


Source: JICA Survey Team
Photo11.2-6 Existing railway


Source: JICA Survey Team
Photo11.2-7 Residential Area (Colony)


Source: JICA Survey Team
Photo11.2-8 Mosque (Colony)

(6) Air Quality

Other than the Lakhra Plant, there are no major stationary sources of gaseous emission in the Study Area. The main non-stationary source is the N-55 (Indus Highway) that passes close to the Plant. Beyond the Study Area, the main sources of emission are:

- Jamshoro Thermal Power Station (JTPS) is 25 km south of Lakhra Plant
- Lakhra Coalfield to the west and northwest of the plant site at a distance of 10 - 25 km

Emissions from these sources consist of oxides of nitrogen (NOx), sulfur dioxide (SO2), carbon monoxide (CO) and particulate matters.

Ambient air samplings were conducted at five locations from February 14th to March 8th, 2014. These locations were selected considering their proximity to the Project site and surrounding settlements. The sampling locations are shown in Figure 11.2-5. Summary of sampling results are presented in Table 11.2-2.

Table 11.2-2 Summary of Air Sampling Analysis

Unit: μg/Nm^3

Point No.	*Sulfur Dioxide (SO_2)*	*Nitrogen Dioxide (NO)*	*Nitrogen Dioxide (NO_2)*	*Particulate Matter*	
				Less than 10 Microns (PM_{10})	*Less than 2.5 Microns ($PM_{2.5}$)*
APSTA01	6.67	5.33	1.55	139.47	55.56
APSTA02	22.67	2.84	8.56	152.14	82.64
APSTA03	7.95	0.79	18.59	210.97	112.52
APSTA04	13.96	11.61	6.26	250.00	172.41
APSTA05	[a]	8.46	10.50	153.42	55.79
Sindh Environmental Quality Standards (SEQS)					
24 hours Average	120	40	80	150	75
Annual Average	80	40	40	120	40
IFC Guidelines					
24 hours Average [c]	125 (IT-1) 50 (IT-2) 20 (GL)	[b]	[b]	150 (IT-1) 100 (IT-2) 75 (IT-3) 50 (GL)	75 (IT-1) 50 (IT-2) 37.5 (IT-3) 25 (GL)
Annual Average [c]	[b]	[b]	40 (GL)	70 (IT-1) 50 (IT-2) 30 (IT-3) 20 (GL)	35 (IT-1) 25 (IT-2) 15 (IT-3) 10 (GL)

Notes:

a Tube was installed but was found damaged later and could not be analyzed by the laboratory

b IFC has not prescribed any guidelines for these parameters for the corresponding averaging period.

c IT: Interim Target, GL: Guideline. Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines.

Source: Hagler Bailly Pakistan

The followings are the key observations on the results.

Comparison with ambient standards and guidelines

1. The observed values of all gaseous pollutants (SO_2, NO, and NO_2) are well within the corresponding maximum value set by the Sindh Environmental Quality Standard (SEQS) for ambient air quality and the ambient air quality guidelines of the International Financial

Corporation (IFC).

2. Particulate matter, both PM_{10} and $PM_{2.5}$, at most of all locations generally exceed SEQS and IFC Guidelines values.

Sulfur Dioxide (SO_2)

3. Compared to other locations, the observed values SO_2 at APSTA02 is high and exceeds the guideline value (20 µg/Nm^3) of IFC Guidelines. The sampling site is downwind of the Lakhra Plant. This may indicate contribution from the Lakhra Plant (Section 11.1.5 (4)).

Oxides of Nitrogen (NO_X)

4. The results of NO and NO_2 do not show any particular spatial pattern.

Particulate Matter

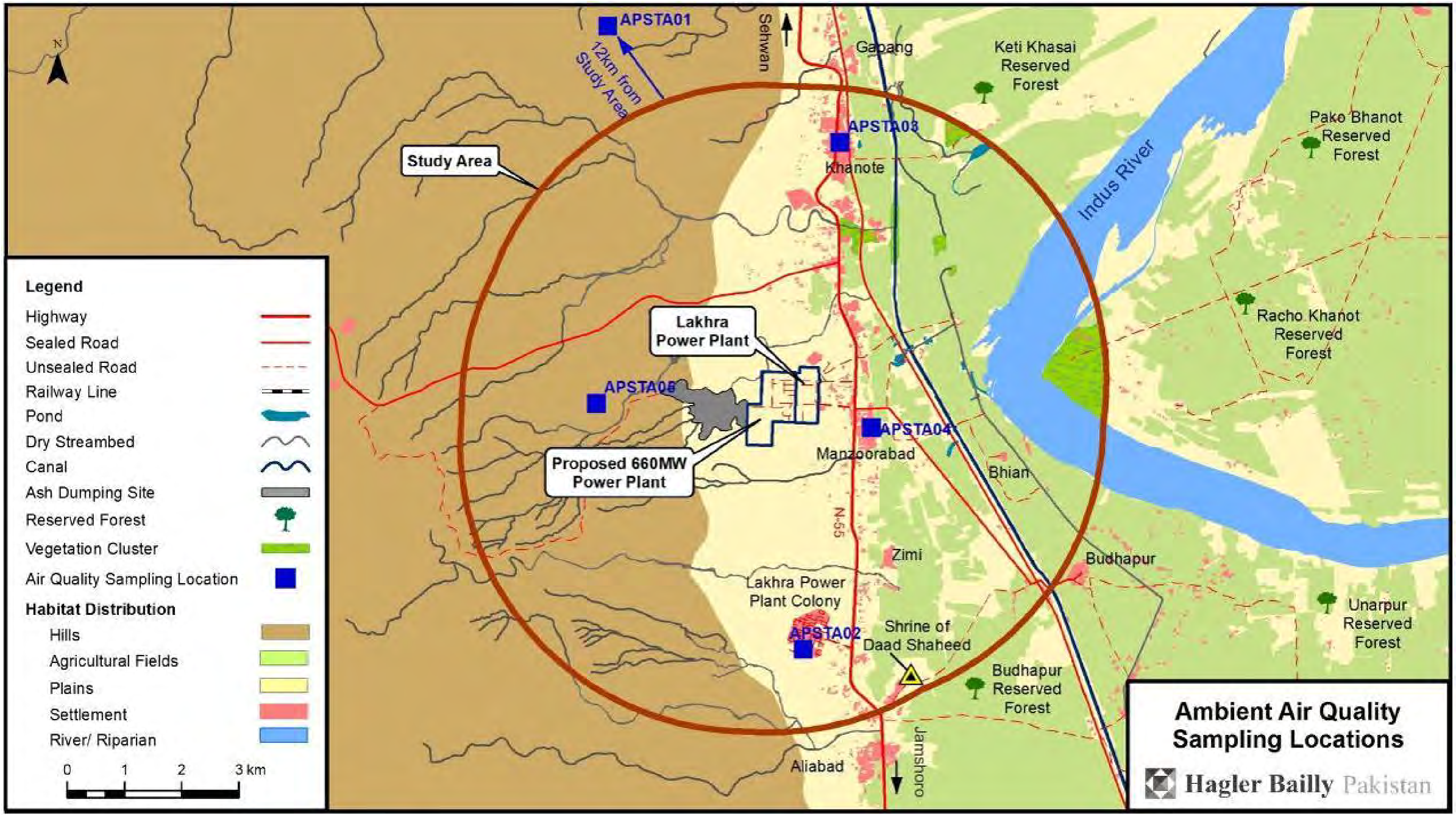
5. Main source of the PM is most likely existing Lakhra Plant, which is indicated from the result of stack emission measurement (Section 11.1.5 (4)). Other than this, the following sources are considered.

6. PM_{10} appears to be higher near the large settlements (Khanote and Manzoorabad) by about 60-100 µg/Nm^3 as compared to the other locations. This indicates contribution from local traffic particularly on unsealed roads.

7. In Pakistan, $PM_{2.5}$ appears to show similar pattern. Its levels are higher in large settlements by about 60-100 µg/Nm^3 as compared to the other locations. Cooking in the houses using biomass as fuel is also the possible source of higher levels of $PM_{2.5}$ as well as road traffic. According to the analysis conducted by World Bank, there is a trend that $PM_{2.5}$ is showing high concentration in Pakistan (e.g., Lahore: 143 µg/Nm^3, Karachi: 88 µg/Nm^3, Islamabad: 61µg/Nm^3) due to traffic and industrial gases[1].

8. For both PM_{10} and $PM_{2.5}$, other than the contribution from the anthropogenic sources, the source of the higher levels of particulate matter is natural. The desert and dry conditions in the area results in stirring up of particulate matter by wind.

[1] Cleaning Pakistan's Air, Policy Options to Address the Cost for Outdoor Air Pollution (2014)



Source: Hagler Bailly Pakistan

Figure 11.2-5 Ambient Air Quality Sampling Locations

(7) Water Quality

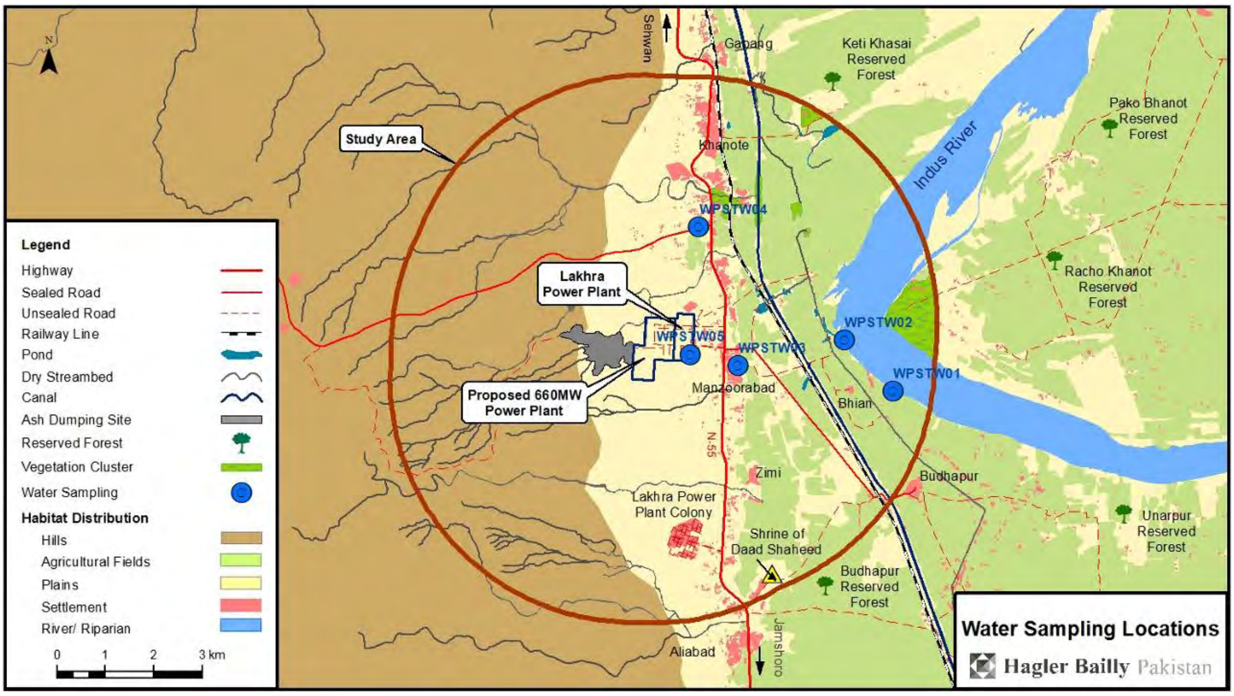
Major water bodies in the Study Area include the Indus River and the under construction RBOD. Groundwater is not major source of drinking water in the Study Area due to high amount of salinity in the groundwater.

A total of five water samples were collected from water resources in the Study Area on February 20th, 2014.

The sampling locations were chosen to cover:

- River- Upstream and downstream of Water Intake and Effluent fall point of Lakhra Plant (WPSTW01 and WPSTW02)
- Lakhra Plant effluent (WPSTW05)
- Shallow and deep wells in residential areas of the Study Area (WPSTW03, WPSTW04)

The sampling locations are shown in Figure 11.2-6.



Source: Hagler Bailly Pakistan

Figure 11.2-6 Water Quality Sampling Locations

The summary of sample analysis report is presented in Table 11.2-3 and Table 11.2-4.

Portable Water Source Samples Results Compliance with NEQS and WHO Guidelines

Samples from river and groundwater were evaluated with National Environmental Quality Standard (NEQS) for drinking water and WHO Guidelines (Table 11.2-3).

Key observations are as follows:

- Results for TDS are higher than the NEQS and WHO Guidelines for samples WPSTW03 (groundwater) and WPSTW04 (groundwater).
- Chloride in WPSTW04 was also found higher than the NEQS and WHO Guidelines.
- Results for analyzed metals are within permissible levels of NEQS in all samples.
- Other major ions in analyzed samples are within permissible levels of NEQS.

Effluent Water Source Sample Results Compliance with NEQS and IFC Guidelines

All the parameters of the sample from effluent water were found within the permissible levels of NEQS and IFC Guidelines for waste/effluent water (Table 11.2-4).

Table 11.2-3 Sample Analysis Results from Water Resources

Parameter	*Unit*	*Level of Reporting, LOR*	*NEQS Guideline Values for Drinking Water*	*WHO Guidelines For Drinking Water*	*Sample ID: WPSTW01*	*Sample ID: WPSTW02*	*Sample ID: WPSTW03*	*Sample ID: WPSTW04*
Temperature	°C	1.0	–	-	19.5	19.5	30.5	30.4
DO	mg/l	1.00	–	-	9.30	9.27	4.00	3.80
Conductivity	μS/cm	1.0	–	-	539.0	525.0	6,710.0	5,502.0
TDS	mg/l	10.0	<1000	<1000	480.0	470.0	5,070.0	4,028.0
pH		0.1	6.5 – 8.5	6.5 – 8.5	7.79	7.82	7.2	7.1
TSS	mg/l	4.0	-	-	11.67	–	–	–
Fluoride	mg/l	0.1	<1.5	1.5	<0.1	<0.1	–	<0.1
Sulfate	mg/l	10	-	-	88	–	–	–
Chloride	mg/l	5.0	<250	250	58.49	54.95	–	1,352
Color	CU	1.0	<15	<15	–	<1.0	–	<1.0
Turbidity	NTU	0	<5	<5	–	<0	–	<0
Nitrate	mg/l	0.001	<50	50	–	0.703	–	0.492
Nitrite	mg/l	0.010	<3	3	–	<0.010	–	<0.010
Residual Chlorine	mg/l	0.1	0.2 – 0.5	-	–	<0.1	–	<0.1
Total Hardness	mg/l	1.0	<500	-	–	120	–	1,308
Ammonia	mg/l	0.5	–	-	<0.5	–	–	–
Calcium	mg/l	1.0	–	-	28.22	–	–	–
Magnesium	mg/l	1.0	–	-	11.87	–	–	–
Cadmium	mg/l	0.001	0.01	0.003	<0.001	0.002	<0.001	0.002
Chromium	mg/l	0.001	<0.05	0.005	0.041	0.030	0.046	0.047
Copper	mg/l	0.001	2	2	0.054	0.036	0.097	0.136
Lead	mg/l	0.001	<0.05	0.01	0.009	0.007	0.008	0.009
Mercury	mg/l	0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001
Selenium	mg/l	0.001	0.01	0.01	<0.001	<0.001	0.003	0.005
Nickel	mg/l	0.001	<0.02	0.02	0.016	0.011	0.018	0.019
Silver	mg/l	0.001	–	-	<0.001	<0.001	0.010	0.002
Zinc	mg/l	0.001	5.0	3	0.028	0.023	0.025	0.052
Arsenic	mg/l	0.001	<0.05	0.01	<0.001	<0.001	0.009	0.006
Barium	mg/l	0.001	0.7	0.7	0.127	0.131	0.073	0.260
Iron	mg/l	0.001	–	-	0.023	0.020	0.058	0.049
Manganese	mg/l	0.001	<0.5	0.5	0.109	0.097	0.178	0.125

Parameter	Unit	Level of Reporting, LOR	NEQS Guideline Values for Drinking Water	WHO Guidelines For Drinking Water	Sample ID: WPSTW01	Sample ID: WPSTW02	Sample ID: WPSTW03	Sample ID: WPSTW04
Boron	mg/l	0.001	0.3	0.3	0.040	0.015	0.064	0.053
Sodium	mg/l	0.001	-	-	66.961	–	–	–
Potassium	mg/l	0.001	–	-	4.206	–	–	–
Phosphate	mg/l	0.001	–	-	0.019	–	–	–

Note: LOR is the minimum concentration of a substance that can be measured with the procedure adopted
In the above table dash (-) means information not available or not applicable
Source: Hagler Bailly Pakistan

Table 11.2-4 Analysis Results of Sample from Plant Effluent

Parameter	Unit	Level of Reporting, LOR	NEQS Guideline Values for Waste Water	IFC Guidelines for Effluent	Sample ID: WPSTW05
Temperature	°C	1.0	–	-	20.2
DO	mg/l	1.00	–		6.91
Conductivity	µS/cm	1.0	–		850.0
TDS	mg/l	10.0	3500	-	684
pH		0.1	6 - 9	6 – 9	7.0
TSS	mg/l	4.0	200	50	13.0
Fluoride	mg/l	0.1	10	-	<0.1
Sulfate	mg/l	10.0	600	-	231
Chloride	mg/l	5.0	1000	-	179
Ammonia	mg/l	0.5	40	-	<0.5
Calcium	mg/l	1.0	–	-	38
Magnesium	mg/l	1.0	–	-	20
Cadmium	mg/l	0.001	0.1	0.1	<0.001
Chromium	mg/l	0.001	1.0	0.5	0.037
Copper	mg/l	0.001	1.0	0.5	0.026
Lead	mg/l	0.001	0.5	0.5	0.005
Mercury	mg/l	0.001	0.01	0.005	<0.001
Selenium	mg/l	0.001	0.5	-	<0.001
Nickel	mg/l	0.001	1.0	-	0.009
Silver	mg/l	0.001	1.0	-	<0.001
Zinc	mg/l	0.001	5.0	1.0	0.012
Arsenic	mg/l	0.001	1.0	0.5	<0.001
Barium	mg/l	0.001	1.5	-	0.120
Iron	mg/l	0.001	8.0	1.0	0.020
Manganese	mg/l	0.001	1.5	-	0.057
Boron	mg/l	0.001	6.0	-	0.036
Sodium	mg/l	0.001	–	-	150.837
Potassium	mg/l	0.001	–	-	5.891
Phosphate	mg/l	0.001	–	-	0.024

Note: In the above table dash (–) means information not available or not applicable
Source: Hagler Bailly Pakistan

(8) Soil Quality

Soil samplings were conducted at four locations in the Study Area on February 20th, 2014. The

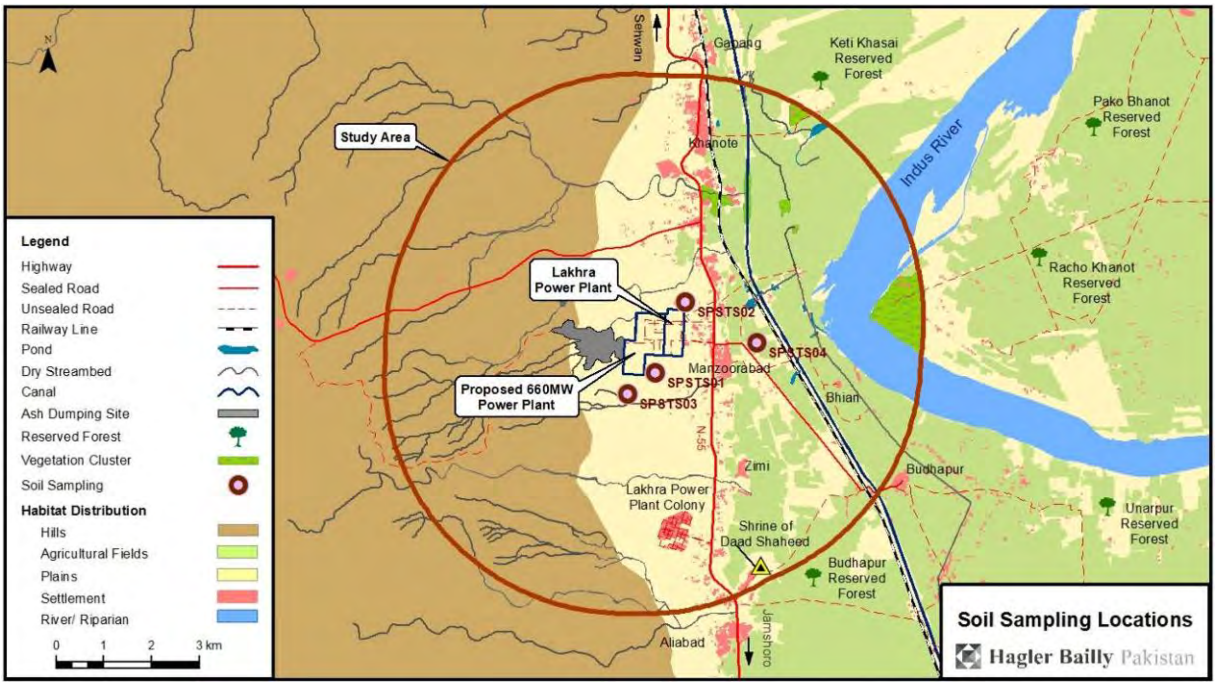
Study Area has a very shallow soil cover. The soil map of Sindh[1] categorizes the area of the Lakhra Plant and its surrounding as 'rough mountainous land' whereas the area close to Indus River is categorized as loamy and seasonal flooded soil of river plains. The dominant soil group in both areas is Calicisols[2], which are loamy soils with accumulation of secondary calcium carbonates.

The sampling locations were chosen considering wind direction of current ash disposal site. One sample was collected from agriculture land to check top soil fertility characteristics.

The sampling locations are shown in Figure 11.2-7.

There are no national standard or international guidelines for screening of soil parameters. An approach is to compare the concentration of various parameters with the three times the corresponding value of average crustal abundance (the target value).

The summary of sample analysis reports is presented in Table 11.2-5.



Source: Hagler Bailly Pakistan

Figure 11.2-7 Soil Quality Sampling Locations

Metals were analyzed in four samples from the Study Area. Key observations on the results are as follows:

- Boron was detected higher than the target value in Sample SPSTS03.
- Cadmium was detected three times higher than its average crustal abundance in Sample SPSTS01 and SPSTS02.

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1 *Soil Map of Sind 1:1,000,000*. Soil Survey of Pakistan, Lahore. 1978.

2 Calicisols is a soil with substantial accumulation of lime.

- Selenium was detected three times higher than its average crustal abundance in all samples (SPSTS01 to SPSTS04).
- Silver was detected three times higher than its average crustal abundance in Sample SPSTS04.

The higher values of above metals may have occurred due to the spread of bottom and fly ash with the wind from existing plant. No disposal mechanism is adopted at the plant for end management of bottom ash and fly ash. Currently, the bottom and fly ash from the plant is being disposed of mainly to an open barren land located west of the existing plant. During the scoping and feedback consultations, complaints were voiced on ash dumped near residences and a hilly catchment. The Section 11.6 Stakeholder Consultations and Disclosure provides the result of consultations. These concerns from scoping consultations are summarized in Table 11.6-5 and the concerns from feedback consultations are summarized in Table 11.6-6. The full record of these voices are included in the separate EIA for Power Plant Appendix 12 and 13.

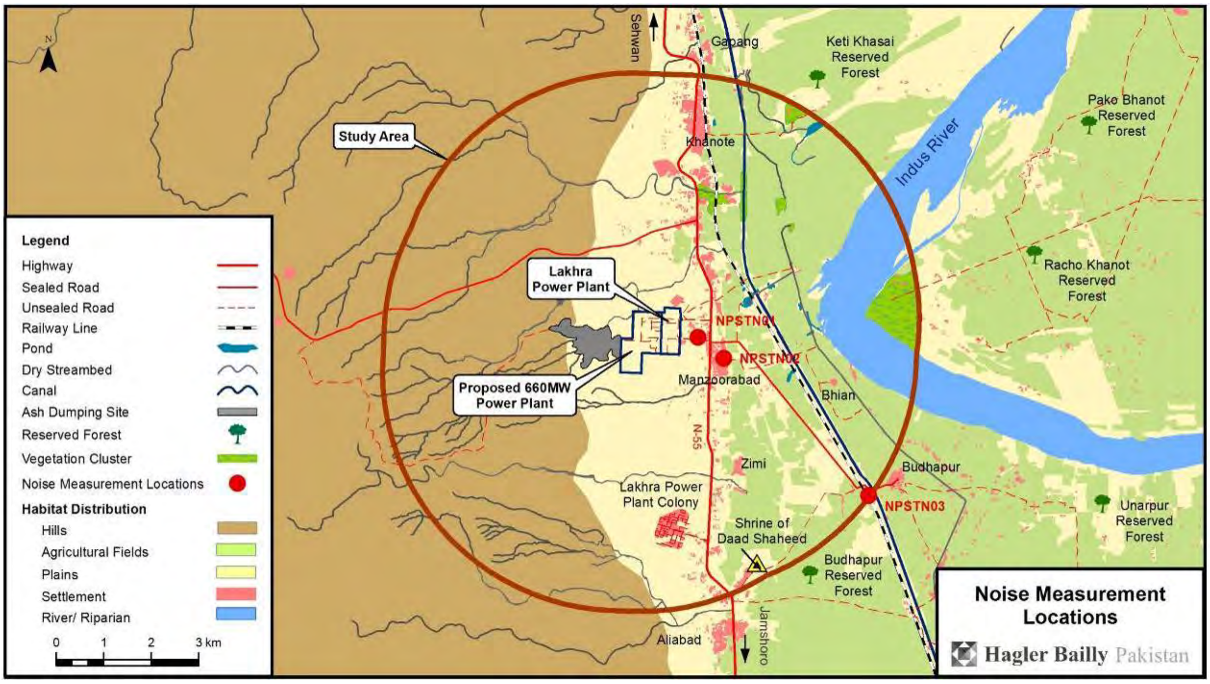
Table 11.2-5 Summary of Soil Samplings Analysis Results

Parameter	*Units*	*Level of Reporting, LOR*	*SPSTS01*	*SPSTS02*	*SPSTS03*	*SPSTS04*	*3 x Crustal Abundance*
Arsenic	mg/kg	0.001	0.964	0.810	0.429	0.720	6.3
Barium	mg/kg	0.001	116.009	97.280	76.176	107.552	1,020
Boron	mg/kg	0.001	10.564	14.338	28.529	9.358	26.1
Cadmium	mg/kg	0.001	0.725	0.501	0.230	0.057	0.45
Chromium	mg/kg	0.001	74.518	46.118	78.412	52.998	420
Copper	mg/kg	0.001	17.375	16.225	18.036	13.572	204
Iron	mg/kg	0.001	76.218	67.142	215.653	133.795	189,000
Lead	mg/kg	0.001	2.284	3.052	4.057	4.711	30
Manganese	mg/kg	0.001	328.172	465.106	551.246	618.837	3,300
Nickel	mg/kg	0.001	14.162	13.952	24.765	19.655	270
Selenium	mg/kg	0.001	3.657	1.826	1.925	4.290	0.15
Silver	mg/kg	0.001	0.094	0.195	0.147	0.725	0.24
Zinc	mg/kg	0.001	27.171	21.943	16.333	14.605	237
Mercury	mg/kg	0.001	0.072	0.019	0.048	0.037	0.201
Potassium	mg/kg	0.001	–	–	–	192.472	45,000
PO_4 (P)	mg/kg	0.001	–	–	–	9.355	–
NO_3 (N)	mg/kg	0.001	–	–	–	43.068	–
pH	–	1.0	–	–	–	8.020	–
EC	µS/cm	1.0	–	–	–	5,350	
Organic Matter	%	0.1	–	–	–	0.9	–
Organic Carbon	mg/kg	0.050	–	–	–	0.54	–

Source: Hagler Bailly Pakistan

(9) Noise and Vibration

There is no industrial source of noise within the Project vicinity other than the Lakhra Plant. To determine the baseline noise, measurements were taken at three locations in the Study Area from February 21st to 24th, 2014. The measurement locations were chosen considering nearest receptors to the plant boundary, which are shown in Figure 11.2-8.



Source: Hagler Bailly Pakistan

Figure 11.2-8 Noise Measurement Locations

General Noise Levels

A summary of results is provided in Table 11.2-6. The minimum and maximum noise levels are reported as L_{10} and L_{90}, respectively. L_{10} and L_{90} refer to percentile noise levels that are exceeded 10% and 90% of the time, respectively. A percentile score tells us what percent of other scores is less than the data point we are investigating. This means that the data averaging is made through excluding of 10% upper and lower extreme ranges of the noise data.

The noise levels in the daytime are within the guideline values. However, the nighttime values are exceeding the guideline values for point NPSTN01 and NPSTN02. This may be attributed due to the location of the measurement points nearer the highway (N-55) and existing plant.

Train Noise Level

During the noise survey near the railway track, two trains passed through the Budhapur Station. Analysis of the train noise is presented in Table 11.2-7**.**

Table 11.2-6 Summary of Noise Levels during the Survey

Measurement Point	*Noise Levels (dB A)*			
	Time	L_{10}	*Leq*	L_{90}
NPSTN01	Daytime	46.9	51.7	56.1
(350 m east of the plant, residential huts, primary school)	Nighttime	48.3	53.8	56.1
NPSTN02 (950 m east of the plant, Manzorabad settlement)	Daytime	48.3	55.4	61.4
	Nighttime	48.3	53.0	61.4
NPSTN03	Daytime	31.7	45.5	51.3
(5 km south of the plant, rail station, residential houses)	Nighttime	31.6	38.3	51.3
NEQS Ambient Quality Limits				
Daytime (06:00 - 22:00 hours)		–	55	–
Nighttime 22:00 - 06:00 hours		–	45	–
IFC Guildelines				
Daytime (07:00 - 22:00 hours)		–	55	–
Nighttime 22:00 - 07:00 hours		–	45	–

Source: Hagler Bailly Pakistan

Table 11.2-7 Train Noise Analysis

Train	*Time of Day (hours)*	*Time Taken to Pass the Station (Minutes)*	*Peak Noise Level (d BA)*	*Leq During the Passage (d BA)*	*Leq for 5 Minutes before the Passage*	*Leq for 5 Minutes after the Passage*
1	22:09	4	80.9	67.8	37.7	36.4
2	23:54	5	83.3	68.1	33.1	36.3

Source: Hagler Bailly Pakistan

(10) Ecology

The ecological baseline study was conducted from February 14th to February 16th, 2014 to determine the abundance and diversity of terrestrial and aquatic ecological resources in the Study Area during the spring season. The Study Area consists of the existing Lakhra Plant, the proposed site for the 660 MW Power Plant and a 5 km potential impact zone around them to account for an area in which the ecological resources may be impacted by the Project related activities including sound, vibrations, and air quality. A map of the Study Area and sampling locations are shown in Figure 11.2-9.

A total of twelve sampling locations were selected for terrestrial sampling of vegetation, mammals, herpeto-fauna and birds in the Study Area. In addition, fish sampling was conducted at 3 locations in the Indus River and 2 locations in the ponds in the Study Area.

Due to time constraints, seasonal surveys could not be conducted. The spring is the best time to observe flowering plants . Moreover, high abundance and diversity of other terrestrial animals can also be observed in spring. To address the seasonal aspects of ecology, a literature review was carried out referring WWF, IUNC and other available sources. In addition, information from the EIA of Jamshoro Power Generation Project (June 2012) was referred to cover the summer period.

1) Vegetation

A total of 25 plant species were observed in the Study Area. During the field survey, most of the observed plant species were common and found in more than one habitat. These included *Acacia senegal, Prosopis cineraria, Aerva javanica, Leptadenia pyrotechnica, Salvadora oleoides, Ziziphus nummularia* and *Calotropis procera.* The vegetation of the Indus River bank and mostly composed of perennial shrubs of *Tamarix dioica* and *Alhagi camelorum*.

No threatened plant was determined to be present at the Study Area.

2) Mammals

A total of 21 mammal species have been reported from the Study Area and its vicinity.[1] These include members from Family Canidae, Ericinaceidae, Felidae, Herpestidae, Hystricidae and Leporidae. Among the river mammals, a dolphin species from Family Platanistidae[2] and an otter from Family Mustellidae[3] have been reported from the Indus River mostly upstream of Kotri barrage. Small mammals reported from the Study Area include species from Family Muridae, Vespertilionidae, Sciuridae, Viverridae, Soricidae.[4]

Species observed or likely to occur are nine (9) as shown in Table 11.2-8.

a. Large Mammals

No threatened large mammals were determined to be resident on the Study Area. None of the mammal species were listed in IUCN Red List. There are some species that are included in the CITES Species List[5] and in the Pakistan Mammals National Red List 2006. However, none of the mammal species observed was endemic, their distribution is not limited to any specific site or habitat type, and their distribution is widespread.

b. Aquatic Mammals

Two aquatic mammals of the Study Area that are included in the IUCN Red List are the Smooth-coated Otter *Lutrogale perspicillata* and the Indus Blind Dolphin *Platanista minor*. The Smooth-coated Otter is listed as vulnerable in IUCN Red List 2014 and has been reported from

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1 Ghalib, SA.,Hasnain, SA. and Khan, AR. 2004. Current status of the Mammals of Sindh.J.Nat.Hist.Wildl. 3(1):16.

2 Gachal, G. S. and Slater, F. M. 2004.Barrages, Biodiversity and the Indus River Dolphin.*Pakistan J.Biol. Sci*., **7**(5):797-801.

3 Khan, W. A., Akhtar, M., Ahmad, M. S., Abid M., Ali H. and Yaqub A. Historical and Current Distribution of Smooth-coated otter(*Lutrogale perspicillatasindica*) in Sindh, Pakistan. Pakistan J. Wildl., vol. 1(1): 5-15, 2010

4 Roberts, T. J. 1997. The Mammals of Pakistan.Revised Edition, Oxford University Press, 5-Bangalore Town, Sharae Faisal, Karachi.525 pp.

5 UNEP-WCMC 7 March 2014, UNEP-WCMC Species Database: CITES-Listed Species

the vicinity of the Study Area but population recoded is low in number. The Indus Blind Dolphin is listed as endangered in the IUCN Red List and endemic to the sub-continent. However, the dolphins are not restricted to the stretch of the Study Area and population in the vicinity of the Study Area is small in number. The maximum abundance has been reported from the Indus Dolphin Game Reserve that is about 415 km upstream of the proposed Project site. The small population of the Indus Dolphin (4 – 6 individuals) have been reported from the vicinity of the Kotri barrage that is located 63 km downstream from the Project site in a survey conducted by WWF in 2006. Therefore, specimens of both these species are not restricted to this Project site and their distribution is wide spread.

c. Small Mammals

No threatened small mammals or endemic species were determined to be resident on the Study Area. None of the small mammal species observed are included in the IUCN Red List. There are some species of limited conservation concern, but their distribution is widespread.

3) Herpeto Fauna

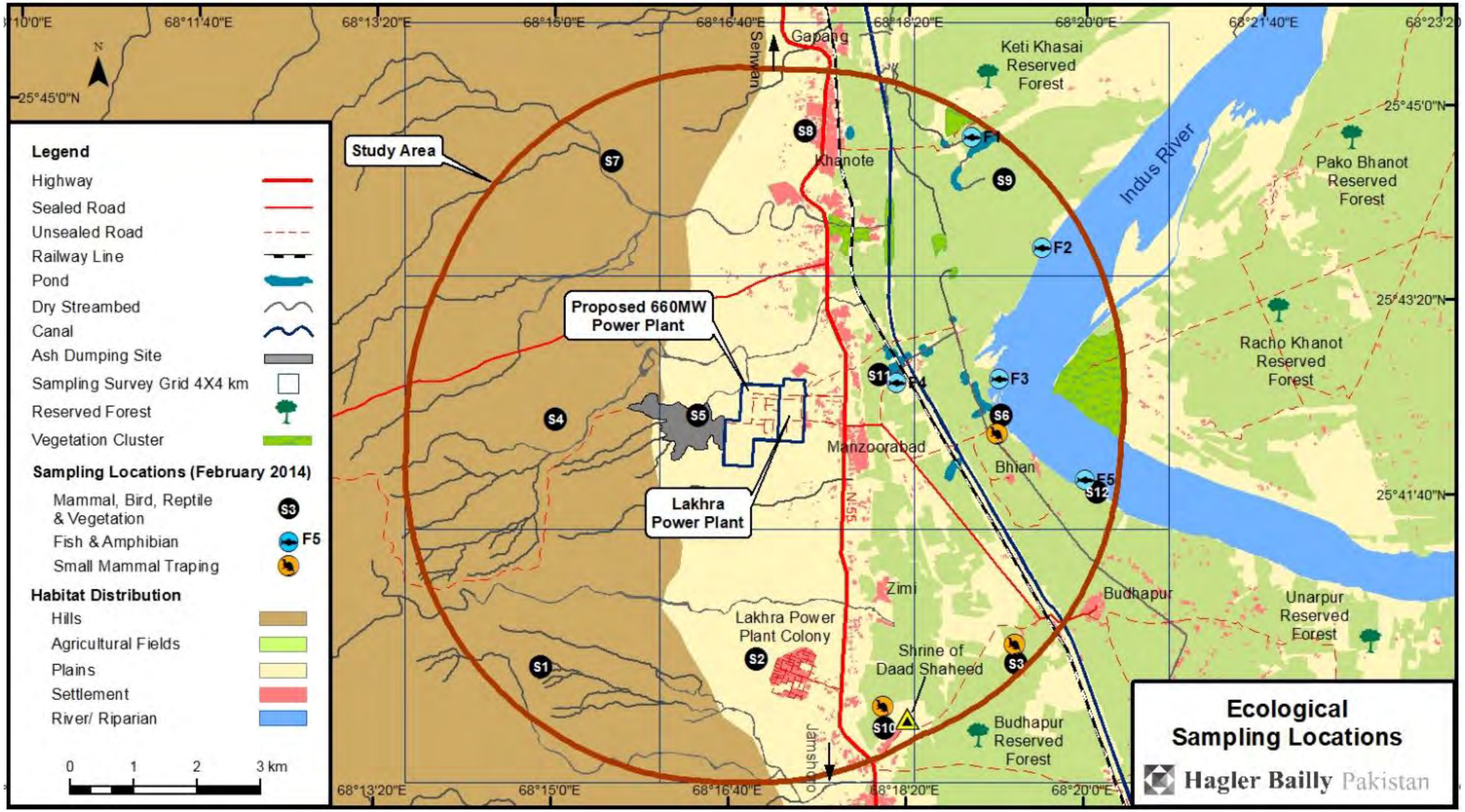
19 species are observed or likely to occur as shown in Table 11.2-9. There are some herpeto-fauna species included in the IUCN Red List. Spotted Pond Turtle (*Geoclemys hamiltonii*), Common River Turtle (*Hardella thurjii*), Indian Softshell Turtle (*Nilssonia gangetica*), Peacock Soft-shell Turtle (*Nilssonia hurum*) are listed as vulnerable and Narrow-headed Soft-shell Turtle (*Chitra indica*) are listed as endangered in the IUCN Red List. There are several CITES listed species and one endemic reptile species reported from the Study Area. However, their distribution is not limited to any specific site or habitat type, and their distribution is widespread.

4) Birds

Seven species are observed or likely to occur as shown in Table 11.2-10. Indian Skimmer (*Rynchops albicollis*) is listed as vulnerable in the IUCN Red List and some others are included in the CITES listed species. However, their distribution is not limited to any specific site or habitat type, and their distribution is widespread. No endemic bird species has been reported from the Study Area.

5) Fish Fauna

15 species are observed or likely to occur as shown in Table 11.2-11. Among the fish fauna observed in the Study Area, Common carp (*Cyprinus carpio*) is listed as vulnerable and some other species are also included in the IUCN Red List. However, these fish are not restricted to the stretch of the Indus River found in the Study Area and their distribution is widespread.



Source: Hagler Bailly Pakistan

Figure 11.2-9 Ecological Sampling Locations

Table 11.2-8 List of Mammal Species with Conservation Status Observed or Likely to Occur in the Study Area

No.	*Scientific Name*	*Common Name*	*Conservation Status*			*Sampling Points where observed*
			National Status[1]	*IUCN Status*[2]	*CITES Appendix*[3]	
	Canidae					
1.	*Canis aureus*	Asiatic Jackal	**Near Threatened**	Least Concern	III	S9, S10, S1, S5, S8, S11, S6 and S12
2.	*Vulpes bengalensis*	Bengal Fox	**Near Threatened**	Least Concern	III	S9, S10, S5, S11 and S12
3.	*Vulpes vulpes*	Common Red Fox	**Near Threatened**	Least Concern	III	Not Seen
	Felidae					
4.	*Felis chaus*	Jungle Cat	Least Concern	Least Concern	II	Not Seen
	Herpestidae					
5.	*Herpestes edwardsii*	Grey Mongoose	Least Concern	Least Concern	III	Not Seen
6.	*Herpestes javanicus*	Small Indian Mongoose	Least Concern	Least Concern	III	Not Seen
	Mustellidae					
7.	*Lutrogale perspicillata*	Smooth Coated Otter	**Near Threatened**	**Vulnerable**	II	Not Seen (S1 – S12)
	Platanistidae					
8.	*Platanista minor*	Indus Blind Dolphin	**Endangered**	**Endangered**	**I**	Not Seen (S6, S12)
	Viverridae					
9.	*Viverricula indica*	Small Indian Civet	**Near Threatened**	Least Concern	III	Not Seen

Source: Hagler Bailly Pakistan

1 Status and Red List of Pakistan Mammals. 2006. Biodiversity Programme IUCN Pakistan

2 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 7 March 2014.

3 UNEP-WCMC 7 March 2014. UNEP-WCMC Species Database: CITES-Listed Species

Table 11.2-9 List of Herpeto Fauna Species with Conservation Status Observed or Likely to Occur in the Study Area

No.	Scientific Name	Common Name	Conservation Status			Sampling Points where observed
			Endemism	IUCN Status[1]	CITES Appendix[2]	
	Boidae					
1.	*Eryx johnii*	Common Sand Boa		Not evaluated	II	Not seen
2.	*Gongylophis conicus*	Russell's Sand Boa		Not evaluated	II	Not Seen
	Colubridae					
3.	*Ptyas mucosus*	Dhaman or Rope Snake		Not evaluated	II	Not Seen
4.	*Xenochrophis piscator*	Checkered Keel Back		Not evaluated	III	Not seen
	Dicroglossidae					
5.	*Hoplobatrachus tigerinus*	Bull Frog		Least Concern	II	Not Seen
	Elapidae					
6.	*Naja naja*	Indian Cobra		Not evaluated	II	S11 and S12
	Geoemydidae					
7.	*Geoclemys hamiltonii*	Spotted Pond Turtle		**Vulnerable**	**I**	Not seen
8.	*Hardella thurjii*	Common River Turtle		**Vulnerable**	II	Not Seen
9.	*Pangshura smithii*	Brown Roofed Turtle		**Near Threatened**	II	S6
10.	*Pangshura tecta*	Indian Roofed Turtle		Least Concern	**I**	Not Seen
	Lacertidae					
11.	*Eremias cholistanica*	Cholistan Desert Lacerta	Endemic	Not evaluated		Not Seen
	Trionychidae					
12.	*Chitra indica*	Narrow-headed Soft-shell Turtle		**Endangered**	**I**	Not Seen
13.	*Lissemys punctata andersoni*	Indian Flap Shell Turtle		Least concern	II	Not Seen
14.	*Nilssonia gangetica*	Indian Softshell Turtle		**Vulnerable**	**I**	S6 and S12
15.	*Nilssonia hurum*	Peacock Soft-shell Turtle		**Vulnerable**	**I**	Not Seen
	Uromastycidae					
16.	*Saara hardwickii*	Indian Spiny-tailed Ground Lizard		Not evaluated	II	Not seen
	Varanidae					
17.	*Varanus bengalensis*	Bengal Monitor Lizard		Least concern	**I**	**S12**
18.	*Varanus griseus koniecznyi*	Indo-Pak Desert Monitor		Not evaluated	**I**	**Not Seen**
	Viperidae					
19.	*Daboia russelii*	Russel's Viper		Not evaluated	III	Not seen

Source: Hagler Bailly Pakistan

1 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 20 February 2014.

2 UNEP-WCMC. 20 February 2014. UNEP-WCMC Species Database: CITES-Listed Species

Table 11.2-10 List of Bird Species with Conservation Status Observed or Likely to Occur in the Study Area

No.	Scientific name	Common Name	IUCN Status[1]	CITES Appendix[2]	Sampling Point where observed
	Accipitridae				
1.	*Aquila rapax nipalensis*	Steppe Eagle	Least Concern	II	S5
2.	*Milvus migrans*	Black Kite	Least Concern	II	Not Seen
3.	*Elanus caeruleus*	Black-shouldered Kite	Least Concern	II	Not Seen
	Gruidae				
4.	*Grus grus*	Common Crane	Least Concern	II	Not Seen
	Motacillidae				
5.	*Motacilla alba*	White Wagtail	Least Concern	II	Not Seen
	Rynchopidae				
6.	*Rynchops albicollis*	Indian Skimmer	**Vulnerable**		Not Seen
	Sternidae				
7.	*Sterna aurantia*	River Tern	Near Threatend		S9

Source: Hagler Bailly Pakistan

Table 11.2-11 List of Fish Species with Conservation Status Observed or Likely to Occur in the Study Area

No.	Scientific Name	Common name	Max. size (cm)	Commercial value	IUCN status[3]	Sampling points where observed
	Clupeidae					
1.	*Tenualosa ilisha*	Hilsa Shad (Palla)	60	Very high	Not evaluated	F5
	Notopteridat					
2.	*Chitala chitala*	Humped featherback	120	High	**Near Threatened**	F1
	Cyprinidae/Barbinae					
3.	*Cirrhinus mrigala*	Mrigal	100	Very high	Least Concern	F1 and F3
4.	*Gibelion catla*	Catla	180	Very high	Least Concern	F4
5.	*Labeo rohita*	Rohu	200	Very high	Least Concern	F1 and F3
	Cyprinidae/ Cyprininae					
6.	*Cyprinus carpio*	Common carp	120	Very high	**Vulnerable**	F1
	Bagridae/ Bagrinae					
7.	*Mystus cavasius*	Gangetic mystus	40	High	Least Concern	F1,F2 and F5
	Sisoridae					
8.	*Bagarius bagarius*	Gangetic goonch	250	High	**Near Threatened**	F5
	Siluridae					
9.	*Ompok pabda*	Pabdah catfish	45	Low	**Near Threatened**	F1 and F4
10.	*Wallago attu*	Freshwater shark	240	Very high	**Near Threatened**	
	Schilbeidae/ Ailininae					

1 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 10 March 2014.

2 UNEP-WCMC 10 March 2014. UNEP-WCMC Species Database: CITES-Listed Species

3 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 10 March 2014.

No.	Scientific Name	Common name	Max. size (cm)	Commercial value	IUCN status[3]	Sampling points where observed
11.	*Ailia coila*	Gangeti cailia	30	Low	**Near Threatened**	F3 and F5
12.	**Schilbeidae/ Schilbeinae** *Clupisoma garua*	Garua bachcha	60	Very high	Least Concern	F3
13.	*Eutropiichthys vacha*	Batchwa vacha	40	High	Least Concern	F2 and F3
14.	**Channidae** *Channa marulia*	Great snakehead	180	Very high	Least Concern	F5
15.	**Cichlidae** *Oreochromis mossambicus*	Mozambique tilapia	39	High	**Near Threatened**	F1 and F4

Source: Hagler Bailly Pakistan

(11) Protected area

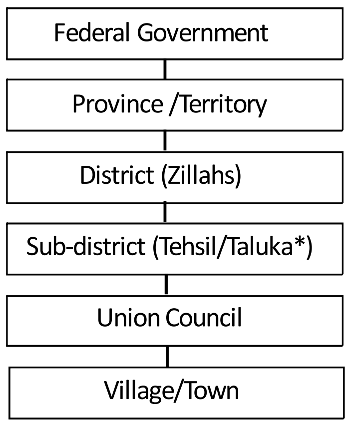
There is no wild life sanctuary, national park and game reserves in the immediate vicinity of the Study Area. There is one national park 40 km away from the Study Area and this is called the Kirthar National Park managed by Sindh Wildlife Department. The Indus Dolphin Game Reserve stretches a distance of approximately 415km upstream of the project site (170 km from the Sukkur Barrage upstream to the Guddu Barrage). However, this Game Reserve is located at least 415 km upstream of the Project site on the River Indus.

There are forest reserves called Keti Khasai and Budhapur Reserved Forests exist in about 6 to 8.5 km from the site. These forests are managed by Sindh Forest Department. According to the Forest Department, species are protected in their natural habitat and no human interference is allowed or any kind of human activity is strictly prohibited without any special permission in reserved forests. However, the field study confirmed that Budhapur Reserved Forest and Keti Khasai Reserved Forest are largely degraded and consist mostly of scrub vegetation surrounded by agricultural fields, even though the forests were designated as 'reserve'.

11.2.2 Social Environment

(1) Outline

The Pakistani administration units are constituted in following order; Federal Government, Province, District (called Zillahs), Sub-district (called Taluka or Tehsil), Union Council and, Village. The lowest governing unit is union council (Figure 11.2-10).



Source: JICA Survey Team

Figure 11.2-10 Administration Units

The Project will have potential impacts on the socioeconomic environment that fall into two categories: the direct impacts on socioeconomic environment include employment generation and, skill and technology transfer and the indirect impacts on socioeconomic environment include disturbance due to construction work, issues related to health, safety and well–being, pressure on local markets (businesses) and pressure on basic infrastructure. These impacts on socioeconomic environment covered in this section as well as the separately prepared EIA. The Project will also have direct adverse impacts such as loss of land, physical structures on land, income and livelihood, business etc. due to land acquisition. These impacts are covered in the separately prepared Land Acquisition and Resettlement Action Plan.

The direct socioeconomic impacts will affect the settlements located closer, up to five (5) kilometer to the proposed Project facilities (referred to as the Study Area). The Study Area, which is shown in Figure 11.2-11, includes 18 rural settlements and one colony. The indirect socioeconomic impacts of the Project will not only affect the immediate socioeconomic environment of the Project but also diffuse to other parts of Jamshoro district and possibly Sindh province.

(2) Methodology of Socioeconomic Baseline Survey

This report referred District Census Report, Dadu 1998[1], Development Statistics of Sindh 2011, Pakistan Social and Living Standards Measurements 2011-2012 and Pakistan Demographic and Health Survey as primary sources of provincial and district level information. However, village level information was limited in the Study Area. Therefore socioeconomic baseline survey was conducted using questionnaire at the field from April 8, 2014 to April 15, 2014 in parallel with the community consultations to collect the information specific to the Study Area Including demographics, available infrastructure and facilities, incomes and livelihoods and migration patterns.

Due to their familiarity with the area and language advantage, two persons (one male and one female) from the project area were hired to assist the survey. Residents of settlements were given advance notice about the survey and consultation.

The socioeconomic baseline survey was implemented in 16 of the total rural settlements and one residential colony, but could not be conducted in two rural settlements (Faqir Dad Khoso and Pehlwan Khoso) during the field survey period as the residents of the settlements were preoccupied. However, the residents of those two rural settlements (Faqir Dad Khoso and Pehlwan Khoso) were contacted on telephone and limited information was collected subsequently.

[1] Dadu district was bifurcated into the Jamshoro and Dadu districts in 2004 and within the Jamshoro district, Kotri taluka was further bifurcated into Kotri and Manjhand talukas, therefore information from the District Census Report (DCR) of Dadu 1998 was used where applicable.

(3) Demography

The population of Jamshoro district in 2013 is 752,741 (Table 11.2-12). About 92% of this population is rural, whereas the remaining 8% is urban.[1]

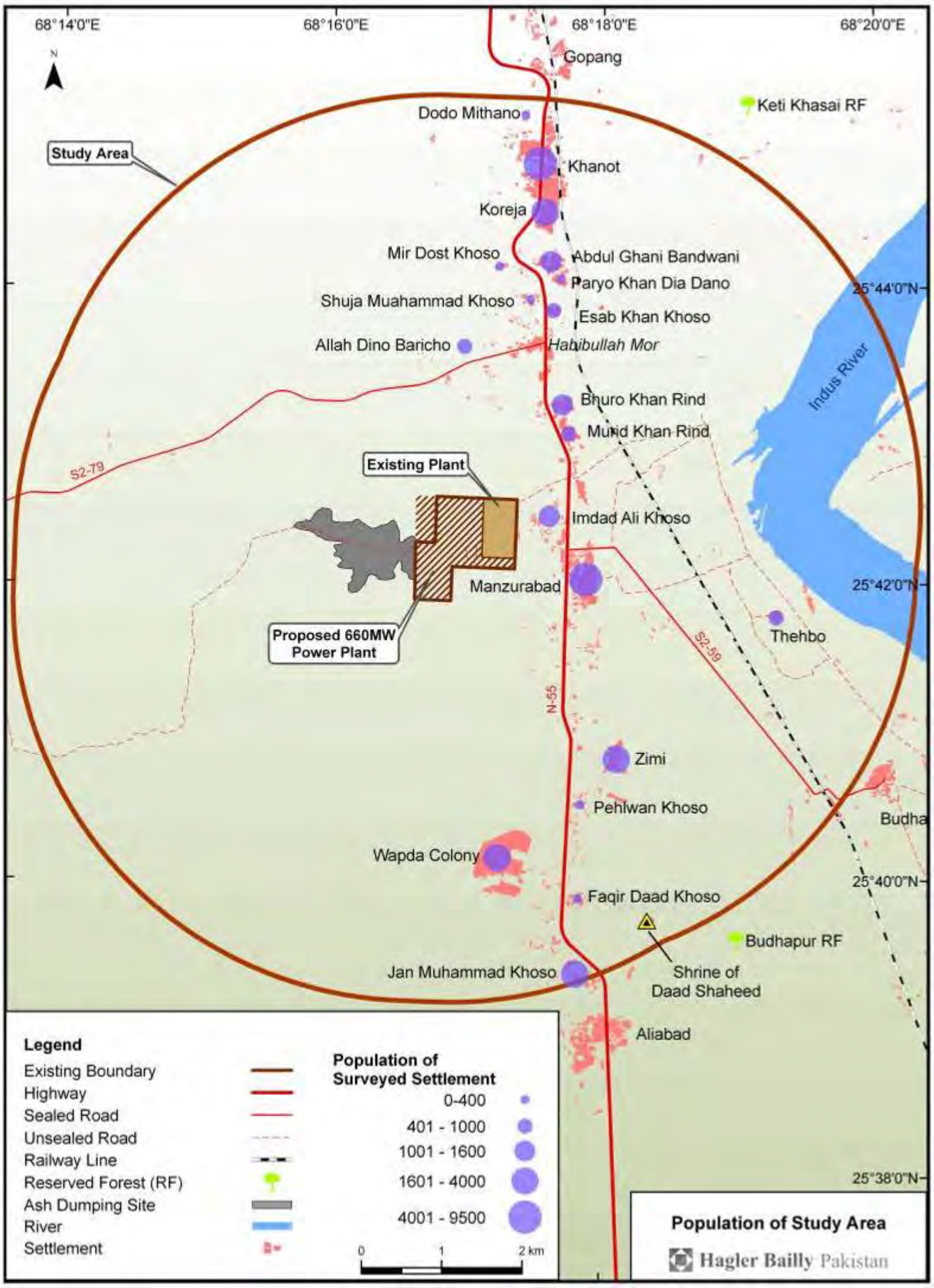
Table 11.2-12 Population of Jamshoro District

Name	*Population*
Kotori Taluka	279,104
Manjhand Taluka	118,458
Sehwan Taluka	220,498
TBK Taluka	134,681
Total in Jamshoro District	**752,741**

Source: Data obtained from Jamshoro Coordination Office

The locations of settlements in the Study Area are shown in Figure 11.2-11. In addition to the 18 rural settlements and one colony there is one commercial area, Habibullah Mor. There is no resident population in the commercial area and therefore it is not included in the settlement survey.

1 Population Census Organization, Government of Pakistan, *District Census Report, 1998*, Islamabad, April 2000



Source: Hagler Bailly Pakistan

Figure 11.2-11 Location of Settlements in the Study Area

Table 11.2-13 gives a list of the settlements in Study Area. Total population of Study Area is 38,685, which is approximately 25% of the total population of Manjhand taluka in 2014. Rural population is 37,020 persons and colony population is 1,665 persons. Population in colonies constitutes 4% (1,665 persons) of the total population of Study Area and the remaining 96% (37,020 persons) is rural.[1]

1 Socioeconomic Settlement Survey held in the Study Area from 8 April 2014 to 15 April 2014 by HBP team.

Table 11.2-13 Population of Settlements in the Study Area

Name of Settlement	*Union Council*	*Taluka*	*District*	*Total HH*	*Estimated Population of Settlement*	*HH Size*
Rural Settlements						
Manzurabad	Manzurabad	Manjhand	Jamshoro	1,150	8,500	7.4
Zimi	Manzurabad	Manjhand	Jamshoro	300	2,400	8.0
Imdad Ali Khoso	Manzurabad	Manjhand	Jamshoro	138	1,300	9.4
Shuja Muhammad Khoso	Manzurabad	Manjhand	Jamshoro	50	400	8.0
Bhuro Khan Rind	Manzurabad	Manjhand	Jamshoro	300	1,500	5.0
Jan Muhammad Khoso	Manzurabad	Manjhand	Jamshoro	500	4,000	8.0
Khanot	Manzurabad	Manjhand	Jamshoro	1,200	9,500	7.9
Thehbo	Manjhand	Manjhand	Jamshoro	200	1,000	5.0
Paryo Khan Dia Dano	Manzurabad	Manjhand	Jamshoro	40	320	8.0
Koreja	Manzurabad	Manjhand	Jamshoro	250	2,500	10.0
Allah Dino Baricho	Manzurabad	Manjhand	Jamshoro	100	800	8.0
Esab Khan Khoso	Manzurabad	Manjhand	Jamshoro	100	900	9.0
Murid Khan Rind	Manzurabad	Manjhand	Jamshoro	90	900	10.0
Abdul Ghani Bandwani	Manzurabad	Manjhand	Jamshoro	200	1,600	8.0
Dodo Mithano	Manzurabad	Manjhand	Jamshoro	50	400	8.0
Mir Dost Khoso	Manzurabad	Manjhand	Jamshoro	30	240	8.0
Faqir Dad Khoso	Manzurabad	Manjhand	Jamshoro	50	360	7.2
Pehlwan Khoso	Manzurabad	Manjhand	Jamshoro	50	400	8.0
Colony						
Wapda Colony	Manzurabad	Manjhand	Jamshoro	333	1,665	5.0
Total:				**5,131**	**38,685**	**7.5**

Note: HH abbreviates for Household.

Source: Hagler Bailly Pakistan

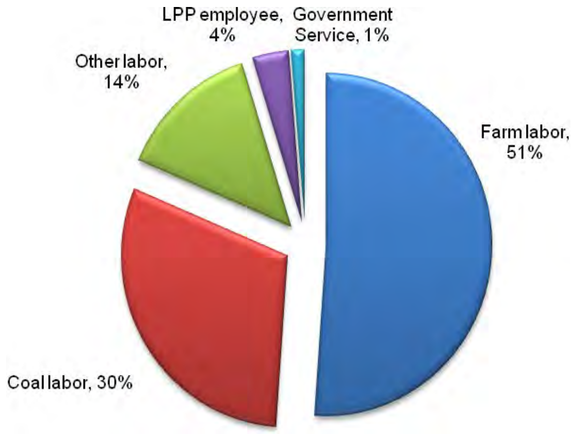
(4) Land Use

Sindh province occupies land area of 14.091 million ha (34.81 million acres). Out of this, the total geographical area of Jamshoro district is 12,350 km^2. Based on the analysis using a Google Earth satellite image, the total area of the study area is approximately 102.5 km^2. Within the study area, about 38% of the area constitutes hills, 32% is barren land,20% is cultivated, 1% is covered by the settlements/colony and the remaining 7% area includes the Indus River, flood plain and Lakhra Power.

As a result of field survey, the barren land has little natural vegetation cover (small trees, shrubs and grasses). The settlements are mainly colonized along the Indus Highway. The agricultural field is spread in the flood plain of the Indus River. In the agricultural field, livestock grazing (e.g., goats and cattle) were observed. In the Indus River, fishing activities were observed.

(5) Occupation and Income Level

Agriculture and coal labor are the two major sources of income in the Study Area. About 51% of the total surveyed population is engaged in farm labor either on their own land or as a laborer on others' land. Another 30% population is involved in coal labor with the coal mining companies working in the area. Fourteen percent population earns income through other labor works including daily wage labor, masonry, wood cutting and selling, shop ownership and shop keeping etc. Only one percent population in the area is employed in government services including teaching and driving.[1] The percentage of occupations observed in surveyed settlements of Study Area is given in Figure 11.2-12.



Note: Information for Faqir Dad Khoso and Pehlwan Khoso is not available as surveys could not be conducted in these settlements.

Source: Hagler Bailly Pakistan

Figure 11.2-12 Percentage of Occupations Observed in Study Area

The average monthly household income is Rs. 5,667 in rural area of Sindh province. Of the Sindh working population, 37.61% of total monthly income is sourced by agriculture, 27.04% by wages and salaries, 14.99% by self-employment such as grazing and other business, and 7.14% by property management (land owning).

(6) Industry

Industries including the Jamshoro, Lakhra and Kotori Power Stations, Lakhra Coal Mine and other mining (e.g., Limestone, Salika Sand, Gravels, Silt, Marbal, Sui Gas) involve manpower and sustain a part of the Jamshoro regional economy. According to the hearing during the socioeconomic survey, 58 locals of the eight settlements[2] are employed in the existing Lakhra Plant. These employees are usually laborers, drivers or security guards at the LPP.

Two government-owned companies and 20 - 25 private companies are engaged in mining in the Lakhra Coal Field, which is located approximately 16 km west of the candidate site. The largest company of coal mining is Hussain Mining Company in Lakhra, which produces coal according to customer demands, whereas Lakhra Coal Development Company (LCDC) produces about 800

1 Socioeconomic Settlement Survey held in Study Area from 8 April 2014 to 15 April 2014 by HBP team.

2 Eight settlements incclude Manzurabad, Zimi, Imdad Ali Khoso, Bhuro Khan Rind, Khanot, Paryo Khan Dia Dano, Koreja, Murid Khan Rind. Information for Faqir Dad Khoso and Pehlwan Khoso is not available as surveys could not be conducted in these settlements.

tons of coal per day and supplies only to Lakhra power plant.1 Majority of the labor working in LCDC belongs to Northern Areas (NA) of Swabi and Mangora. Labor from the NA is normally hired on contract basis for six months, during the winter season. Laborers migrate back to native areas in the summers. Only two private companies hire people from local communities.[2] In the settlements of the Study Area, 32% of the total workforce was involved in coal mining labor.

(7) Fishery

The Department of Livestock and Fisheries controls the fisheries departments of all the districts in Sindh. The district office of concerned department issues an annual license for fishing in a specific area for Rp.12,000 per person per boat. Fishing is only permitted in the allotted area which is normally within the stretch of the river or a water body within the registered district. The project site is located in the river stretch under jurisdiction of Nwabsha, Hyderabad, Jamshoro and Matiari districts office. The number of registered fishermen and boats, and annual fish production are as shown in Table 11.2-14. In general, the livelihood of fishermen strongly depends on the income from fish sales. The fishermen sell their catch in local market. Jamshoro is the main market for fish. and other small markets exist in Sehwan and Bhan areas[3].

Table 11.2-14 Inland Fish Production by Districts

Province/District	*Fish Production (Million Tones)*	*Total Numbers of Registered Fishermen*	*Total Numbers of Registered Boats*
Nawabshah/ Shaheed Benazirabad	5,175	1,100	363
Hyderbad	5,408	1,032	152
Jamshoro	11,180	2,130	597
Matiari	3,378	501	152
Total	25,141	4,763	1,264

Source: Department of Livestock and Fishery of Sindh

(8) Agriculture

Sindh's diversified economy comprises of a well–developed agricultural base supported by an effective irrigation network on the Indus. Around 14% wheat, 30% rice, 30% sugar cane, 25% cotton and 30% vegetable crops grown in Pakistan are from Sindh.4

In the Study Area, agriculture forms the major income generating activity with 51% surveyed

1 Data has been provided to HBP by the LCDC, Lakhra, on February 24, 2014.

2 Ibid.

3 Information was shared with HBP by Mr Abdul Latif, Deputy Director of Department of Livestock and Fisheries, Hyderabad.

4 Sindh Board of Investment. http://www.sbi.gos.pk/sindh–economy.php (accessed March 27, 2014).

population pursuing farm labor either on their own lands or on other agricultural land.[1] Major crops produced in Study Area and their estimated production is given in Table 11.2-15

Table 11.2-15 Major Crops and their Production in Study Area[2]

Average Production (kg/hectare)						
Summer		*Winter*				
Cotton	Sesame Seeds	Wheat	Chickpeas	Lentil	Sorghum	Cluster bean
2,700	1,000	2,300	2,100	1,500	1,900	1,900

Note: Information for Faqir Dad Khoso and Pehlwan Khoso is not available as surveys could not be conducted in these settlements.
Source: Hagler Bailly Pakistan

Nine of the 17 surveyed settlements reported that agriculture is dependent on rain and flood events. Settlement of Thehbo however, reported that land was cultivated every year as the settlement is located less than one kilometer from River Indus. In this settlement, irrigation channels bringing water from the river, have been dug to irrigate the land using the river water (Photo 11.2-9 and 11.2-10). Such irrigation channels were observed in a few other rural settlements. In some agricultural lands, where available, underground water wells have been dug to irrigate the land. Some village locals reported that storm water runoff carrying coal ash deposited near their settlements caused damage to agricultural lands.

Source: JICA Survey Team
Photo 11.2-9 Agricultural field in Koreja

Source: JICA Survey Team
Photo 11.2-10 Irrigation channel through agricultural field in Thehbo

(9) Housing

According to the 1998 District Census Report, there are 25% masonry dwellings (called "Pacca") and 75% adobe households (called "Kacha") in taluka Manjhand[3]. Burned bricks/blocks are used

1 Socioeconomic Settlement Survey held in Study Area from 8 April 2014 to 15 April 2014 by HBP team.

2 Ibid.

3 There are three general classes of housing in Pakistan: pukka (or pacca) houses, built of substantial material such as stone, brick, cement, concrete, or timber; katchi (or kacha [“ramshackle”]) houses, constructed of less-durable material (e.g., mud, bamboo, reeds, or thatch); and semi-pukka houses, which are a mix between the two. Encyclopedia Britannica, http://www.britannica.com/EBchecked/topic/438805/Pakistan/276147/Housing (accessed April 02, 2014).

for walls in 95% of housing units and wood/bamboo are used for roof in 48 % of the rural housing units and steels for roof in 32% in Sindh province[1].

(10) Infrastructure of Household

In Sindh province, statistically 90% of households use electricity for lighting in 2011-2012, whereas in rural area, the percentage of electricity connections would dramatically decrease. Majority of households use wood/charcoal or other fuel for cooking and only 11 % of households use gas for cooking (2008-2009).

(11) Water Supply and Sanitation

In Sindh province, 73% of rural population use hand pumps for drinking purposes while the rest use sources including tap water, motor pump, dug wells and water tankers. The average monthly water bill in rural Sindh is Rs 120, paid by approximately 62% of the population.[2]

The main source of drinking water in the Jamshoro district is tap water, which is used by 30% of the households. Almost 22% households have access to hand pumps and 12% through motor pumps. Remaining 21% use groundwater wells and 15% are dependent on other sources.[3]

Only 22% of rural Sindh has flush toilet facility compared to 58% overall rural average in Pakistan. About 83% of rural Sindh has no sanitation system. Open drains are provided in only 15% of the rural areas of the province. There is no garbage collection system in the rural areas of the province.[4]

(12) Health

Health services in Jamshoro district are mainly provided through basic health units (BHUs), Rural Health Centers (RHCs) and District Head Quarter Hospital (DHQ) in Jamshoro. These facilities are equipped for primary health care services and to some extent comprehensive emergency obstetric care services. [5] There are four hospitals in the district (one located in each taluka), five RHCs, 16 BHUs and six government dispensaries.[6]

(13) Education

Jamshoro district has 926 educational institutions including primary, middle, higher and higher secondary institutions. However, out of these, only 173 institutions are in rural areas and very few middle, secondary and higher secondary school facilities are for both boys and girls. About 74%

1 Pakistan Bureau of Statistics, Government of Pakistan "Pakistan Social And Living Standards Measurement Survey (Pslm) 2010-11 Provincial/District"

2 Pakistan Bureau of Statistics, Government of Pakistan. Pakistan Social and Living Standards Measurements (PSLM). Government Report, Islamabad: Pakistan Bureau of Statistics, 2013.

3 Ibid.

4 Ibid.

5 Emergency obstetric care (EmOC) refers to the care of women and newborns during pregnancy, delivery and the time after delivery

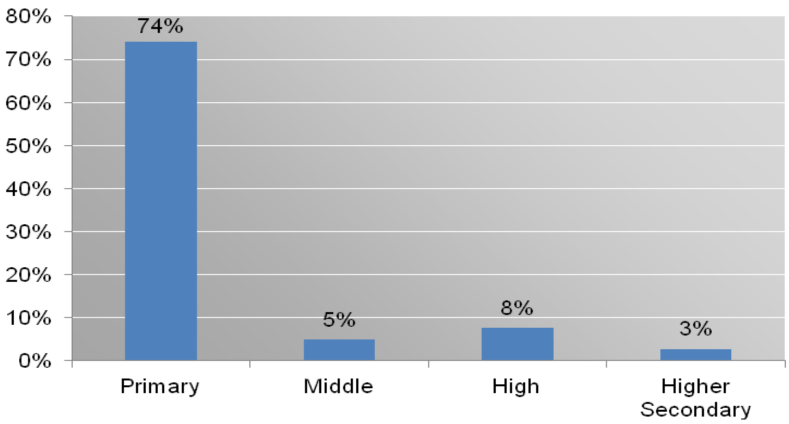
6 District Government Jamshoro. http://www.jamshoro.com.pk/. http://www.jamshoro.com.pk/Glance.htm (accessed March 27, 2014).

of the total enrolment in Jamshoro district is in Primary schools.[1] This shows a high drop-out rate of students in the entire district (Table 11.2-16). In 2011, the literacy rate in Jamshoro district was lower (44%) compared to overall literacy rate for Sindh (59%) in the same year. Of the total population, 57% male and 28% female population was reported literate.[2] In Sindh province, 58% women and 38% men have had no education while 11% women and 17% men are enrolled in higher education (Grade 11 and above).[3]

Table 11.2-16 Educational Institutions in Jamshoro District

	Primary	*Middle*	*High*	*Higher Secondary*	***Total***
Boys	553	28	25	4	**610**
Girls	284	17	11	4	**316**
Total	**837**	**45**	**36**	**8**	**926**

Source: National Institute of Population Studies (NIPS) Pakistan and ICF International. 2013.[4]



Source: National Institute of Population Studies (NIPS) Pakistan and ICF International. 2013.[5]

Figure 11.2-13 Sector-wise Percentage of Enrolment in Jamshoro District

(14) Heritage

There is no cultural heritage (protected archeological/cultural site[6]) within the Study Area. The closest heritage site is a shrine named 'Daad Shaheed' and a grave yard are located about 6 km southeast of the candidate site. The Daad Shaheed is 700 - 750 years old and it is a holy place for local people. According to the interview with the keeper of Daad Shaheed, in a particular period

1 National Education Management Information System (NEMIS) Academy of Educational Planning and Management (AEPAM). (2012). *District Education Profile 2011-12.* Islamabad: Ministry of Education, Trainings and Standards in Higher Education, Government of Pakistan.

2 Pakistan Bureau of Statistics, Government of Pakistan. *Pakistan Social and Living Standards Measurements (PSLM) 2011-12.* Government Report, Islamabad: Pakistan Bureau of Statistics, 2013.

3 Pakistan Bureau of Statistics, Government of Pakistan. *Pakistan Social and Living Standards Measurements (PSLM) 2011-12.* Government Report, Islamabad: Pakistan Bureau of Statistics, 2013.

4 *Pakistan Demographic and Health Survey 2012-13.* Islamabad, Pakistan, and Calverton, Maryland, USA: NIPS and ICF International, 2013.

5 *Pakistan Demographic and Health Survey 2012-13.* Islamabad, Pakistan, and Calverton, Maryland, USA: NIPS and ICF International, 2013.

6 Protected sites are notified under the Antiquity Act 1975 and Sindh Cultural Heritage (Preservation) Act 1994.

of a year over 3 - 5 days, approximately 2,000 people visit the Daad Shaheed. The closest major historical site is the 'Ranikot Fort' which is located at a distance of 45 km northwest of the candidate site, in Dadu district. The Ranikot Fort is tentatively listed as a cultural heritage under UNESCO. It is listed as a tentative believed to be the world's largest fort with a perimeter of about 26 km.

Source: JICA Survey Team

Photo 11.2-11 Entrance of Daad Shaheed

Source: JICA Survey Team

Photo 11.2-12 Inside of Daad Shaheed

Source: JICA Survey Team

Photo 11.2-13 Graveyard of Daad Shaheed

Source: JICA Survey Team

Photo 11.2-14 Ranikot Rort
(Source: Islamic Arts and Architecture 2014)

(15) Ethnicity and Religion

About 95% of Jamshoro district's population is Muslim. The remaining five percent comprise of Hindus, Christians, scheduled castes and others[1]. Similar to the overalls district, the population in the socioeconomic study area is predominantly Muslim, with less a one percent non-Muslim minority. No community has been legally defined as indigenous or protected by the State. The religious minority population in the area is culturally integrated with the rest of the population. According to the information available, there is no religious or social conflict that makes the minority population vulnerable.

(16) Culture and Traditions

The main languages spoken in the Jamshoro district is Sindhi and Balochi. In addition, other languages spoken include Urdu, Pubjabi, Saraiki, Pashoto, Hindko, Saraiki, Marvari and Jabli.

1 District Government Jamshoro (http://jamshoro.com.pk/Population.htm)

Sindh is known all over the world for its handicrafts and artifacts such as the *ajrak* and *topi* are famous as a gift at Eid, weddings, or on other special occasions like homecoming.

(17) Gender Role

A household usually contains two gender-based positions of authority; the first is the position of the head, the oldest, the able-bodied male member of a household. The society in rural Sindh is male-dominated. The second is the position of the senior woman, ideally the wife of the eldest resident male, who is subordinate of the household head. The male members govern household decision making process and are responsible to represent the household in the neighborhood and larger society.

(18) Child

There are about 50 million children aged between 5 and 19 years old in Pakistan[1.] While, almost 25 million children and adolescents are out of school, out of which 7 million children aged between 3 and 5 years have yet to receive primary schooling. It is reported that there were 12 million child laborers in Pakistan in 2012. Another report revealed that 5,659 cases of violence against children were reported from January to October 2012[2].

11.3 Legal and Institutional Framework

11.3.1 Legislations and Standards

Table 11.3-1 International Environmental Treaties Endorsed by Pakistan

Convention	Date of Treaty	Entry into force in Pakistan
Climate Change and the ozone layer		
1) UNFCCC on Climate Change	1992	1994
2) Kyoto Protocol to the UNFCCC	1997	2005
3) Vienna Convention for the Protection of the Ozone Layer	1985	1993
4) The Montreal Protocol on Substances that Deplete Ozone Layer and associated amendments	1987	1993
Waste and pollution		
1) Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1989	1994
2) International Convention on Oil Pollution Preparedness, Response and Co-operation	1990	1995
3) Stockholm Convention on Persistent Organic Pollutants	2001	2008
Desertification		
1) International Convention to Combat Desertification	1994	1997
Biodiversity and the protection of plants and animals		
1) Convention on Biological Diversity	1992	1994
2) Cartagena Protocol on Biosafety to the Convention on Biological Diversity	2000	2009
3) Bonn Convention on the Conservation of Migratory Species of Wild	1979	1987

1 Pakistan Bureau of Statistics, Government of Pakistan, Population Census 1998

2 Daily Times, Pakistan (2013 May 29) Report on State of Pakistan's Children 2012, United Nations Educational, Scientific and Cultural Organization (UNESCO) (2013) Financing for Global Education

Animals		
4) Memorandum of Understanding concerning Conservation Measures for the Siberian Crane	1998	1999
5) Convention on International Trade in Endangered Species of Wild Fauna and Flora	1973	1976
6) International Plant Protection Convention	1951/52	1954
7) Agreement for the Establishment of the Near East Plant Protection Organization	1993	2009
8) Plant Protection Agreement for the Asia and Pacific Region and amendments	1955 (amended 1967)	1958 (amended 1969)
9) Convention on Wetlands of International Importance especially as Waterfowl Habitat	1971 (amended 1987)	1976 (amended 1994)
Cultural heritage		
1) Convention concerning the Protection of the World Cultural and Natural Heritage	1972	1976

Source: JICA Survey Team

Governmental mitigation plan for climate change has not been developed by GOP. Besides, no financial assistance for climate change has been provided from Government of Japan to GOP as well.

11.3.2 Procedure of IEE and EIA

(1) Law on IEE and EIA Procedure

The "Sindh EPA (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations, 2014" (Sindh IEE-EIA Regulations 2014) provide the necessary details on the preparation, submission, and review of IEE and EIA. The following guidelines and standards should be referred to;

- Guidelines for the preparation and review of environmental reports;
- Guidelines for public consultation;
- Guideline for sensitive and critical areas; and,
- National Environmental Quality Standards (NEQS),1993
- Sindh Environmental Quality Standards (SEQS), 2014

(2) Categorization

Categorization of projects for IEE and EIA is one of the main components of the Sindh IEE-EIA Regulations 2014. Projects have been classified on the basis of expected degree of adverse environmental impact. Project types listed in Schedule II (Table 11.3-3) of the regulations are designated as potentially seriously damaging to the environment and require EIA, and those listed in Schedule I (Table 11.3-2) as having potentially less adverse effects and require an IEE.

Since the 660 MW power plant, 500 kV transmission lines and railway works fall under the category of Schedule II, EIAs should be prepared for each component.

Table 11.3-2 Schedule I (List of project requiring an IEE)

A. **Agriculture, Livestock and Fisheries**
   1. Poultry, livestock, stud and fish farms
   2. Projects involving repacking, formulation, cold storage and warehouse of agricultural products

B. **Energy**
   1. Hydroelectric power generation less than 50 MW
   2. Thermal power generation less than 100 MW
   3. Coal fired power plants with capacity less than 50 MW
   4. Transmission lines less than 11 kV, and grid station
   5. Waste-to energy generation projects including bio-mass less than 25 MW
   6. Solar project
   7. Wind project

C. **Oil and Gas projects**
   1. Oil and gas 2D/3D seismic survey and drilling activities
   2. Oil and gas extraction projects including exploration and production located outside the environmentally sensitive areas
   3. Construction of LPG storage facilities
   4. Construction of LPG, CNG filling station and petrol pumps

D. **Manufacturing and processing**
   1. Ceramics and glass units less than Rs. 500 million
   2. Food processing industries with total cost less than Rs. 200 million
   3. Pharmaceutical units
   4. Marble units
   5. Carpet manufacturing units
   6. Rice mills, ghee/oil mills
   7. Brick kilns
   8. Stone crushing units
   9. Man-made fibers and resin projects with total cost less than Rs. 200 million
   10. Manufacturing of apparel, textile garments unit, including dyeing, bleaching and printing, with total cost more than Rs.50 million
   11. Wood products with total cost more than Rs. 100 million
   12. Steel re-rolling mills
   13. Recycling plants

E. **Mining and mineral processing**
   1. Commercial extraction of sand, gravel, limestone, clay, sulfur and other minerals not included in Schedule II with total cost less than Rs.100 million
   2. Crushing, grinding and separation processes
   3. Smelting pants with total cost less than Rs.100 million

F. **Transport**
   1. Flyovers, underpasses and bridges having total length less than 500 meters

G. **Water management, dams, irrigation and flood protection**
   1. Dams and reservoirs with storage volume less than 25 million cubic meters of surface area less than 4 square kilometers.
   2. Small-scale irrigation systems and drainage system with total cost less than Rs.100 million

H. **Water supply and filtration**
   Water supply schemes and filtration plants with total cost less than Rs.100 million (Including projects of maintenance, up gradation, reconstruction of existing projects.)

I. **Waste disposal and treatment**
   1. Solid and non-hazardous waste with annual capacity less than 10,000 tons
   2. Waste water treatment for sewage treatment facility with total cost less than Rs. 200 million
   3. industry specific Waste water treatment facility for Industrial effluent (small scale plant)

J. **Urban development**
   1. Housing schemes less than 10 acres
   2. Multi-story buildings having residential and commercial setup on the total plot size is less than 2,000 sq. yards
   3. Hospitals with capacity of 50 beds, health care unit/laboratories with 500 OPD/day
   4. Construction of Educational, Academic institutions on land less than 10 acres

K. **Other projects**

Any other project for which filing of an IEE is required by the Agency under sub-regulation (2) of Regulation 6.

Source: Sindh EPA (Review of IEE and EIA) Regulations, 2014

Table 11.3-3 Schedule II (List of projects requiring an EIA)

A. **Energy**
1. Hydroelectric power generation over 50 MW
2. Thermal power generation over 100 MW
3. Coal power projects above 50 MW
4. Transmission lines (11 kV and above) and distribution projects
5. Nuclear power plants
6. Wind energy projects if falls under any sensitive, protected area

B. **Oil and Gas projects**
1. Petroleum refineries
2. LPG and LNG Projects (including LNG Terminals, re-gasification units) except LPG filling stations
3. Oil and gas transmission systems
4. Oil and gas gathering system, separation and storage

C. **Manufacturing and processing**
1. Cement plants
2. Chemical manufacturing industries
3. Fertilizer plants
4. Steel Mills
5. Sugar Mills and Distilleries
6. Food processing industries including beverages, dairy mild and products, slaughter houses and related activities with total cost more than Rs. 200 million
7. Industrial estates (including export processing zones)
8. Man-made fibers and resin projects with total cost of Rs.200 million and above
9. Pesticides (manufacture or formulation)
10. Petrochemicals complex
11. Synthetic resins, plastics and man-made fibers, paper and paperboard, paper pulping, plastic products, textiles (except apparel), printing and publishing, paints and dyes, oils and fats and vegetable ghee products, with total cost more than Rs. 10 million
12. Tanning and leather finishing projects
13. Battery manufacturing plant

D. **Mining and mineral processing**
1. Mining and processing of coal, gold, copper, sulfur and precious stones
2. Mining and processing of major non-ferrous metals, iron and steel rolling
3. Smelting plants with total cost of Rs.100 million and above

E. **Transport**
1. Airports
2. Federal or Provincial highways or major roads (including rehabilitation or rebuilding or reconstruction of existing roads)
3. Ports and harbor development
4. Railway works
5. Flyovers, underpasses and bridges having total length of more than 500 meter

F. **Water management, dams, irrigation and flood protection**
1. Dams and reservoirs with storage volume of 25 million cubic meters and above having surface area of 4 square kilometers and above
2. irrigation and drainage projects serving 15,000 hectares and above
3. Food Protection

G. **Water supply and filtration**
Large Water supply schemes and filtration plants

H. **Waste Disposal and treatment**
1. Handling, storage or disposal of hazardous or toxic wastes or radioactive waste (including landfill sites, incineration of hospital toxic waste)
2. Waste disposal facilities for municipal or industrial wastes, with total annual capacity of 10,000tons and above
3. Waste water treatment facility for industrial or municipal effluents

I. **Urban development and tourism**

1. Housing schemes above 10 acres
2. Residential/commercial high rise buildings/apartments from 15 stories and above
3. Land use studies and urban plans (large cities)
4. Large scale public facilities
5. Large-scale tourism development projects

J. **Environmentally Sensitive Areas**
All projects situated in environmentally sensitive areas

K. **Other projects**
1. Any other project for which filing of an EIA is required by the Agency under sub-regulation (2) of Regulation 5
2. Any other project likely to cause an adverse environmental effect

Source: Sindh EPA (Review of IEE and EIA) Regulations, 2014

(3) Environmental Impact Assessment Procedure

Regulation 9 of the IEE-EIA Regulations 2014 requires that '1) Ten paper copies and two electronic copies of an lEE or EIA shall be filed with the Federal Agency; 2) Every lEE and EIA shall be accompanied by (a) an application, in the form set out in Schedule V; (b) copy of receipt showing payment of the review fee; (c) no objection certificates from the relevant departments in case of EIA shall be the part of reports; and (d) the environmental check list as per its guidelines. Generally, decision on the EIA will be made within 4 months from submission of EIA to Sindh EPA.

The procedure of EIA is as follows (Figure 11.3-1);

a. EIA shall be submitted to and reviewed by Sindh EPA;

b. Preliminary scrutiny (within 15 working days of filing of EIA)
- Sindh EPA shall confirm that the EIA is complete for purposes of initiation of the review process; or
- Sindh EPA shall require the proponent to submit such additional information as may be specified; or
- Sindh EPA shall return the EIA to the proponent for revision, clearly listing the points further study and discussion.

c. Public participation
- Sindh EPA will place a public notice in any English or Urdu national newspaper and in a local newspaper of general circulation in the area affected by the project, informing the public about the project and where it's EIA can be assessed.
- The notice shall also set a date for public hearing which shall not be earlier than 15 days from the date of publication of the notice;

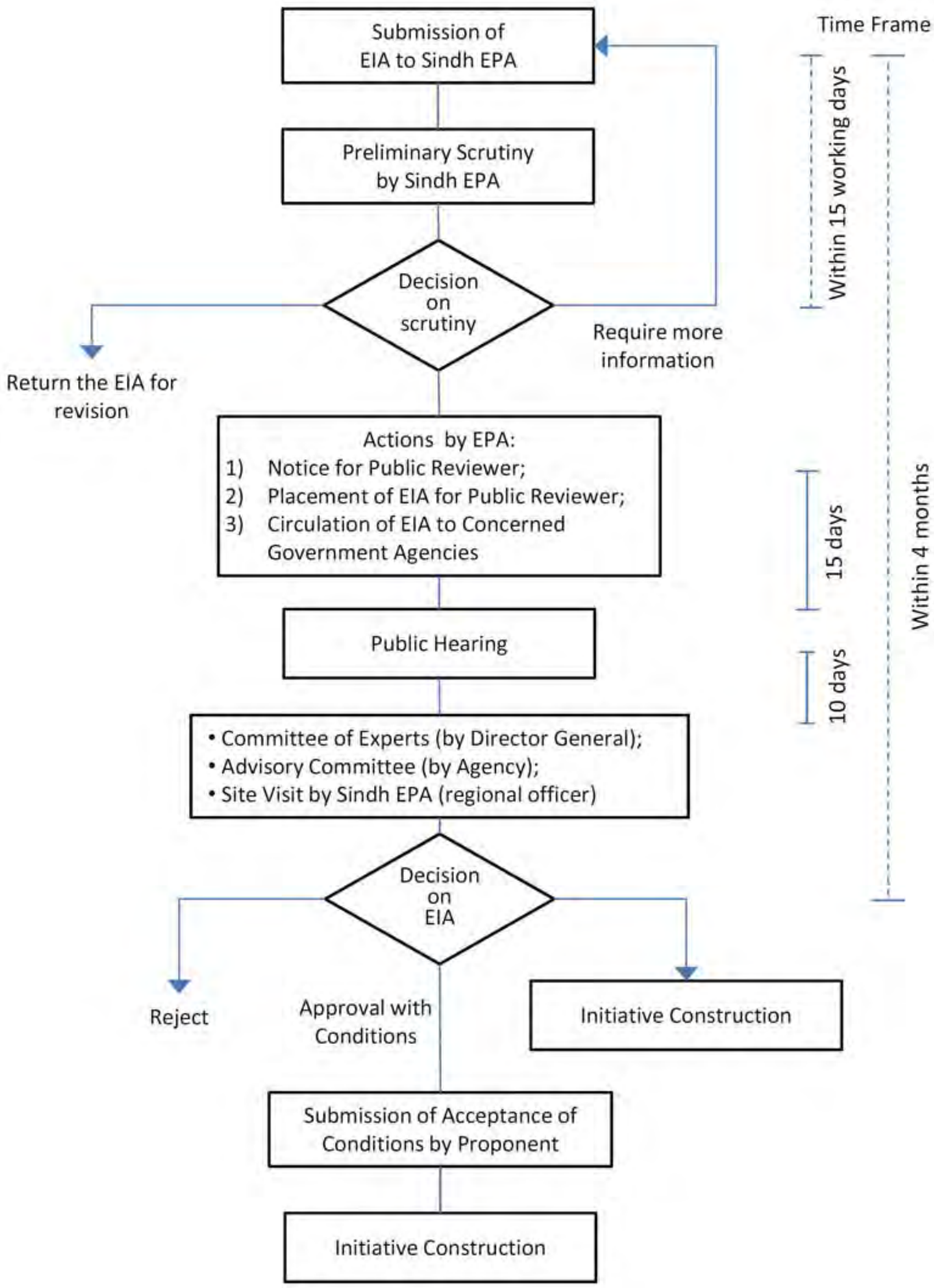
d. Review (within 4 months)
- Sindh EPA shall make every effort to carry out its review of the EIA within four (4) months of issue of confirmation of completeness of filing of EIA.
- Sindh EPA shall consult such Committee of Experts be constituted for the purpose by the

Director General, and may also solicit views of concerned Advisory Committee, if any, constituted by the Agency.

- The Director General may, where he considers it necessary, constitute a committee to inspect the site of the project and submit its report on such matters as may be specified; and,
- The review of the EIA by the Agency shall be based on quantitative and qualitative assessment of the documents and data furnished by the proponent, comments from the public and Government Agencies received and views of the committees.

e. Decision

- After the decision of EIA by Sindh EPA, if the EIA is approved with conditions, the contents will be informed to the proponent and the construction works will be initiated.



Source: Sindh IEE-EIA Regulations 2014 and Sindh EPA

Figure 11.3-1 Review and Approval Procedure of Environmental Impact Assessment

(4) Information Disclosure

Public participation required for the preparation of EIA is designated in the first clause of Section 11 of Sindh EIA-IEE Regulations 2014. The procedure of information disclosure is conducted through the following media;

- English or Urdu national newspaper and a local newspaper of general circulation in the area affected by the project; and,

- notice on which the type of project, its exact location, proponent's information (i.e., name and address) and facility where the EIA is available for inspection are described.

11.3.3 Environmental Regulations

The Sindh Environmental Protection Act 2014 ('Sindh Act 2014') is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The act is applicable to a broad range of issues and extends to air, water, industrial liquid effluent, marine, and noise pollution, as well as to the handling of hazardous wastes. The articles of Sindh Act 2014 that have a direct bearing on the proposed Project are listed below. The details are discussed in the following sections.

- Article 11 that deals with the Sindh environmental quality standards (SEQS) and its application
- Article 13 that deals with hazardous substances
- Article 14 that prohibits various acts detrimental to the environment
- Article 15 that relates to vehicular pollution
- Article 17 that establishes the requirement for environmental impact assessment

Following the promulgation of Sindh Act 2014, Sindh has notified its own ambient air quality standard. It is understood that the NEQS issued prior to Sindh Act 2014 remain in force in Sindh unless they are expressly amended, as is the case with the ambient air quality standards. As the Sindh Act 2014, does not have the provision for a national standard and PEPA 1997 is no longer applicable in Sindh, the term 'Sindh Environmental Quality Standards' is understood to include the NEQS (except ambient air quality standards) issued under PEPA 1997. However, the term NEQS is still used in this document where reference is made to older standards.

All industrial standards (ambient air quality, gaseous emission, ambient noise, and industrial effluent) are applicable to the proposed Plant.

The proposed project is legally required to comply with the NEQS for gaseous emission, ambient air quality[1], and liquid effluent. The only exception is the ambient air quality standards which Sindh EPA has notified separately. In addition, in case of co-financing project, IFC environmental guidelines should also be followed.

(1) Air Quality

Comparisons of NEQS and IFC Guidelines for gaseous emission and ambient air quality are shown in Table 11.3-4 and Table 11.3-5.

In general, IFC emission guidelines are different for degraded and non-degraded air sheds (DA and NDA respectively). The degraded air shed is defined by IFC as: *Airshed should be considered* *as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly.*[2] In this project, IFC emission guideline for NDA shall be referred based on the estimated background air quality shown in Table 11.5-3 of the Section 11.5.2. it is argued that all ambient air quality of the Project site will meet the NEQS after the rehabilitation of the existing Lakhra power plant (with the possible exception of $PM_{2.5}$).

Table 11.3-4 Comparison of NEQS and IFC Guideline Limits for Emission of Key Pollutants from Coal Fired Power Plant

Parameter	Source of Emission	NEQS	IFC Standards
NEQS for Gaseous Emissions			
Particulate matter	Boilers and furnaces: coal-fired	500 mg/Nm^3	NDA: 50 mg/Nm^3 DA: 30 mg/Nm^3
Carbon monoxide	Any	800 mg/Nm^3	-
Nitrogen Oxides	Coal-fired	1,200 mg/Nm^3	NDA: 510 mg/Nm^3 DA: 200 mg/Nm^3
NEQS for Sulfur Dioxide and Nitrogen Oxides			
Sulfur Dioxide	Power plant operating on oil and coal	100 - 500 Tons per day	NDA: 200-850 mg/Nm^3 DA: 200 mg/Nm^3
Nitrogen Oxides	Power plant operating on oil and coal	For lignite fossil coal: 260 ng/J of heat input	NDA: 510 mg/Nm^3 DA: 200 mg/Nm^3

1. For additional parameters and explanation, see complete NEQS and IFC Guidelines in Appendix 11-3.
2. A “-” in the third column indicates that IFC has not provided any guidelines for the parameter
3. NDA = Non-degraded airshed; DA = Degraded airshed
4. In respect of emissions of sulfur dioxide and nitrogen oxides, the power plants operating on oil and coal as fuel shall in addition to NEQS for gaseous emissions, comply with the standards stated in NEQS for sulfur dioxide and nitrogen dioxides.

Source: JICA Survey Team

Table 11.3-5 Comparison of SEQS and IFC Guideline Limits for Ambient Air Quality

Pollutants	Time-weighted Average	SEQS	IFC Standards *** (μg/m^3)
Sulfur Dioxide (SO_2)	Annual Average *	80 μg/m^3	- ****
	24 hours **	120 μg/m^3	125 (Interim target 1) 50 (Interim target 2) 20 (guideline)
Oxide of Nitrogen as (NO)	Annual Average *	40 μg/m^3	-
	24 hours **	40 μg/m^3	-
Oxide of Nitrogen as (NO_2)	Annual Average *	40 μg/m^3	40 (guideline)
	24 hours **	80 μg/m^3	-
Ozone (O_3)	1 hour	130 μg/m^3	-
Suspended Particulate Matter (SPM)	Annual Average *	360 μg/m^3	-
	24 hours **	500 μg/m^3	-

[1] Ambient air quality means maximum concentration of air pollution substances at ground level.

[2] This definition is provided in several places in the IFC’s EHS Guidelines. For example, Tables 6(A), 6(B), 6(C) of the Thermal Power Plant Guidelines.

Pollutants	Time-weighted Average	SEQS	IFC Standards *** ($\mu g/m^3$)
Respirable particulate Matter. PM_{10}	Annual Average *	120 $\mu g/m^3$	70 (Interim target 1) 50 (Interim target 2) 30 (Interim target 3) 20 (guideline)
	24 hours **	150 $\mu g/m^3$	150 (Interim target 1) 100 (Interim target 2) 75 (Interim target 3) 50 (guideline)
Respirable Particulate Matter. $PM_{2.5}$	Annual Average *	40 $\mu g/m^3$	35 (Interim target 1) 25 (Interim target 2) 15 (Interim target 3) 10 (guideline)
	24 hours **	75 $\mu g/m^3$	75 (Interim target 1) 50 (Interim target 2) 37.5 (Interim target 3) 25 (guideline)
	1 hour	15 $\mu g/m^3$	-
Lead (Pb)	Annual Average *	1 $\mu g/m^3$	-
	24 hours **	1.5 $\mu g/m^3$	-
Carbon Monoxide (CO)	8 hours **	5 mg/m^3	-
	1 hour	10 mg/m^3	-

* Annual arithmetic mean of minimum 104 instruments in a year taken twice a week 24 hourly at uniform interval

** 24 hourly /8 hourly values should be met 98% of the in a year. 2% of the time, it may exceed but not on two consecutive days.

*** WHO Ambient Air Quality Guidelines (IFC General EHS Guidelines, Air Emissions and Ambient Air Quality, Table 1.1.1)

**** IFC General Guidelines describes "temperature of wastewater prior to discharge does not result in an increase greater than 3 °C of ambient temperature at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use and assimilative capacity among other considerations".

Source: JICA Survey Team

(2) Water Quality

Comparison of NEQS and IFC guideline for effluents is shown in Table 11.3-6.

Table 11.3-6 Comparison of NEQS and IFC Guideline Limits for Effluents

(mg/l, unless otherwise defined)

Parameter	NEQS (Into Inland Waters)	IFC Guidelines
Temperature increase	≤ 3°C	-
pH value	6 to 9	6 to 9
Five-day bio-chemical oxygen demand (BOD) at 20°C	80	-
Chemical oxygen demand (COD)	150	-
Total suspended solids (TSS)	200	50
Total dissolved solids (TDS)	3,500	-
Grease and oil	10	10
Phenolic compounds (as phenol)	0.1	-
Chlorides (as Cl')	1,000	-
Fluorides (as F')	10	-
Cyanide total (as CN')	1.0	-
Anionic detergents (as MBAS)	20	-
Sulfates (SO_4)	600	-
Sulfides (s')	1.0	-

Parameter	NEQS (Into Inland Waters)	IFC Guidelines
Ammonia (NH_3)	40	-
Pesticides	0.15	-
Cadmium	0.1	0.1
Chromium (trivalent and hexavalent)	1.0	0.5
Copper	1.0	0.5
Lead	0.5	0.5
Mercury	0.01	0.005
Selenium	0.5	-
Nickel	1.0	-
Silver	1.0	-
Total toxic metals	2.0	-
Zinc	5.0	1.0
Arsenic	1.0	0.5
Barium	1.5	-
Iron	8.0	1.0
Manganese	1.5	-
Boron]	6.0	-
Chlorine	1.0	0.2

Notes:

1. For additional parameters and explanation, see complete NEQS and IFC Guidelines in Appendix 11-3.
2. A "-" in the third column indicates that IFC has not provided any guidelines for the parameter or they are to be established by the environmental assessment.

Source: JICA Survey Team

11.3.4 Sensitive and Critical Area

The Sindh Wildlife Protection Ordinance 1972 empowers the government to declare areas of ecological significance as protected. The law provides three different types of such areas, the national park, the wildlife sanctuary and the game reserve. Responsible authority for each classification is Sindh Forest & Wildlife Department. According to guidelines for sensitive and critical areas 1997, thirty (30) wildlife sanctuaries (532,582ha), one (1) national park (308,733ha) and eleven (11) game reserves (127,020ha) are designated.

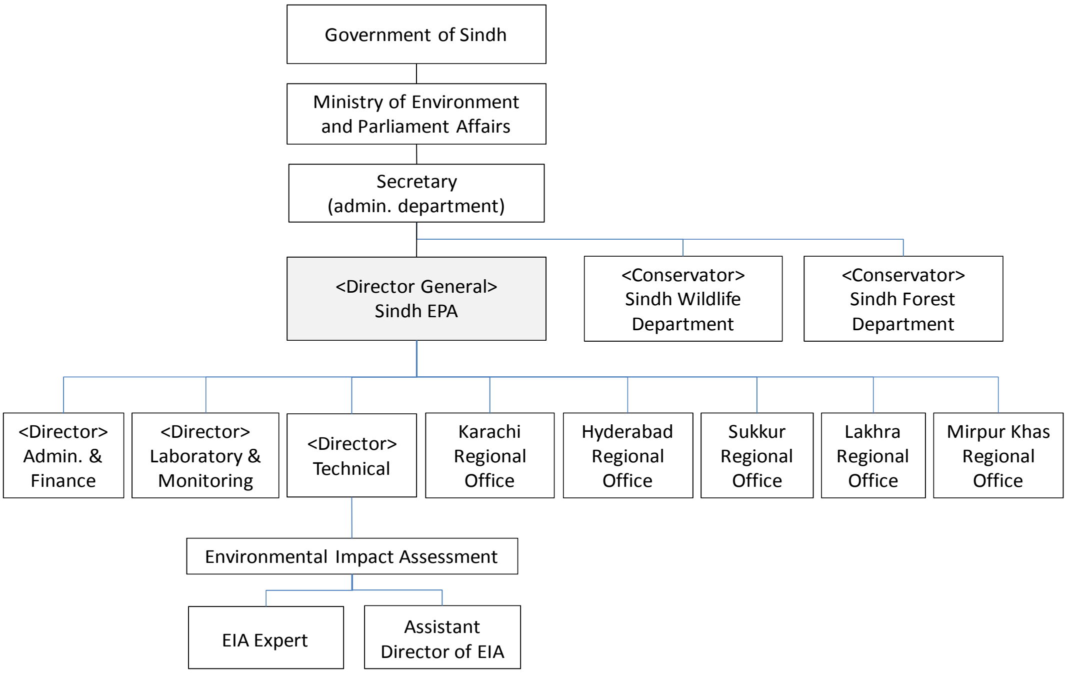
Table 11.3-7 Classification of Protected area in Sindh Province

Classification	Responsible Authority	Contents
Wildlife sanctuary	Sindh Forest & Wildlife Department	• undisturbed breeding ground • prohibited or regulated public areas • non-exploitation of forest
National park		• protection and preservation of scenery, flora and fauna in its natural state • an area of outstanding scenic merit and natural interest
Game reserves		Hunting and shooting of wild animals is not be allowed, except under a specific permit, which may specify the maximum number of animals or birds that may be killed or captured and the area and duration for which such permits shall be valid.

Source: Guidelines for sensitive and critical areas, 1997

11.3.5 Relevant Organization

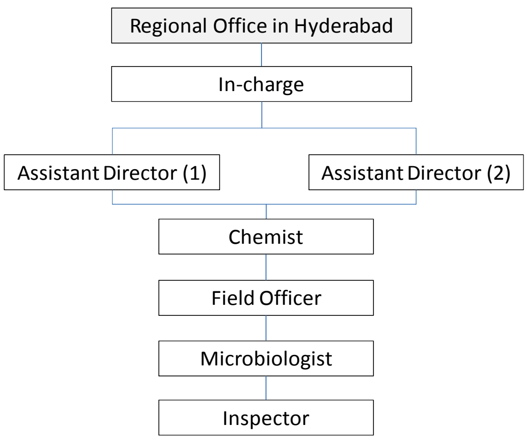
Administration on environment has been divided into federal and provincial government. International issues such as the environmental policy and regulation has been managed by Ministry of Climate Change. On the other hand, national environmental matter has been managed by provincial government. In Sindh province, Sind EPA has been responsible for the provincial matters. All of the environmental technical issues such as EIA, monitoring, enforcement of law/environmental quality standards are headed by Director General of Sindh EPA. The structures of Sindh province and Sindh EPA are shown in Figure 11.3-2.



Source : Sindh EPA

Figure 11.3-2 Structure of Sindh Province and Sindh EPA

As to project(s) in Jamshoro district, regional office in Hyderabad is responsible for the monitoring at operation stage. They sometimes conduct speculations. Its structure is shown in Figure 11.3-3.



Source : Sindh EPA

Figure 11.3-3 Structure of Regional Office in Hyderabad

11.3.6 Approval of the EIA and Other Permits

The preparation and approval of the EIA is a legal requirement. Approval of the EIA does not absolve the project proponent from requirements under other laws. Following are some of the related permits;

- ***EIA***: Approval required from Sindh EPA. The approval must be obtained prior to start of construction. The decision of the EIA is made within 4 months after submission of the EIA to Sindh EPA.
- ***Land for Intake Facility***: Approval required from Sindh Revenue Department. The approval must be obtained prior to occupying the site. It takes 9 – 15 months in general.
- ***Construction of Intake Facility***: Approval required from Irrigation & Power Department to construct intake facility in Indus River. It takes 2 – 3 months in general. The Irrigation Department will also allocate water for the plant.
- ***Effluent Discharge to the Indus River***: Approval required from Irrigation Department. It takes 2 – 3 months in general.
- ***Water Right from Indus River***: Approval required from Irrigation & Power Department. (See Chapter 7)

11.4 Discussion of Alternatives (including Non-Project Option)

<u>Site selection was conducted and the selected project site was agreed between MoWP/GENCO and JICA at the end of 2013. Following Section 11.4.4 Site Selection was basically developed based on the information collected prior to the agreement (see Chapter 3). Additional information was collected and comments from the Advisory Committee were addressed after above agreement.</u>

11.4.1 Consideration of Non-Project Option

In case that this project is not implemented, impacts shown in Table 11.4-1 are predicted.

Table 11.4-1 Predicted Impact in case of Non-Project Option

Contents	Positive Impact	Negative Impact
Power Demand	- None	- Critical power shortage corresponding to 6,100MW as of 2011 would continue in Pakistan. In order to generate power on the other locations, cheaper coal mined in Pakistan would be most likely used. Most of the domestic coals are low quality lignite with high sulfur concentration, which would have adverse impact on air quality.
Environmental Pollution	- No air pollution - No impact of water intake from the Indus River - No impact of coal dust diffusion and emissions from coal transportation	- Opportunity loss of improving ambient air quality due to rehabilitation of Lakhra Plant. (This Project will contribute towards improving the environmental conditions, particularly the air quality in and around

Contents	Positive Impact	Negative Impact
	- No underground water pollution - No waste - No noise from traffic and operation of the newly constructed power station - No odor from spontaneous ignition at coal stockpile	Lakhra. It has been agreed that GHCL will rehabilitate the emission control equipment of the existing power plant before the commission of the proposed 660 MW Power Plant.)
Natural Environment	- No need to clear plants and shrubs along the planned spur line	- None
Social Environment	- No land transformation resulting in physical[1] and economic displacement - No impact on human health induced from changes in physical environment	- No direct socioeconomic impacts. No job creation such as non-skilled workers and guards for the surrounding communities during construction and operation, and other jobs for people of Sindh in particular and people of Pakistan in general in skilled, technical and administrative categories, which contribute to towards improving the economic conditions of the communities. - No improvement of labor's health and work condition at Lakhra Plant.
Other	- No greenhouse gases (GHG) emissions	- Opportunity loss of environmentally-friendly development of Pakistan power industry: This Project adopts state of the art technology of coal fired thermal power plant (ultra-supercritical pressure), which will contribute to lower GHG emissions in comparison with sub-critical technology. - Coal fired power station using only domestic coal would also increase the amount of carbon dioxide

Source: JICA Survey Team

11.4.2 Comparison of Generation Cost

Table 11.4-2 shows the generation unit cost for each generation method in 2012. According to National Power Policy 2013, the average generation unit cost was Rs. 12/kW in 2012. If the cost for transmission line extension corresponding to Rs. 2.7/kW and losses due to fee collection and stolen power corresponding to Rs. 0.9/kW are added to above generation unit cost, the generation unit cost at the demand point becomes Rs. 15.6/kW. In 2012, average selling power unit price was Rs. 9.01/kW and moreover in 2013 the average power price would be raised up by 30% in average. So Pakistan critically needs cheaper power generation systems.

Gas price for existing gas turbine power stations is cheaper than the other fuel due to local production. But most of the gas has been allotted to household and industrial use, and vehicles. As the demand for gas excesses the supply, there is chronic shortage of gas.

Large-sized hydro power needs about ten year and furthermore the power generation in dry

[1] Physical displacement is loss or relocation of assets such as loss of land and physical structures on the land or access to them. Economic displacement is loss of income source or means of livelihood, whether or not the affected persons must move to another location, and restriction of access to legally designated parks and protected areas resulting in adverse impacts on the livelihoods of the displaced persons.

season significantly drops. So hydropower cannot be stable power generation through the year. Therefore, the coal fired thermal power plant seems to be the most appropriate power generation system which solves the critical power shortage.

Table 11.4-2 Power Generation Cost of each Generation Method

Generation Method	Cost (per kW)	Source
Coal fired thermal Power Station (P/S) (with imported coals)	Rs. 7.6	Up-front tariff 600MW class
Coal fired thermal P/S (with Thar coals)	Originally more than Rs. 7.6 but less in a few years	The Thar Coal price is likely higher than the imported coal at the beginning the development of Thar Coalfield. As the investment costs are collected and the amount of Thar coal production is increased, then the Thar Coal price is expected to be lower than the imported ones.
Gas turbine P/S (with domestic gas)	Rs. 7.9 - 8.3	NTDC Power System Statistics 2011 - 2012 Rs. 7.9 GTPS Kotri (2012) Rs. 8.3 GTPS Faisalabad (2011)
Gas turbine P/S (with imported gas)	More than Rs. 10.0	Up-front tariff Fuel cost will take Rs. 10/kWh with an estimation of gas price as 11 USD/MMBTU.
Gas & Oil (RFO) mixed thermal P/S	Rs. 12.0	National Power Policy 2013
Oil (RFO) thermal P/S	Rs. 17.0	National Power Policy 2013
Diesel (HSD) engine P/S	Rs. 23.0	National Power Policy 2013
Wind power	Rs. 15.5	Up-front tariff
Hydro power	Rs. 6.5	National Power System Expansion Plan 2011-2030 Main Report
(Reference) Photovoltaic power	Rs. 33.4	Government of Japan calculated in December 2011 (Japanese Yen 33.4).

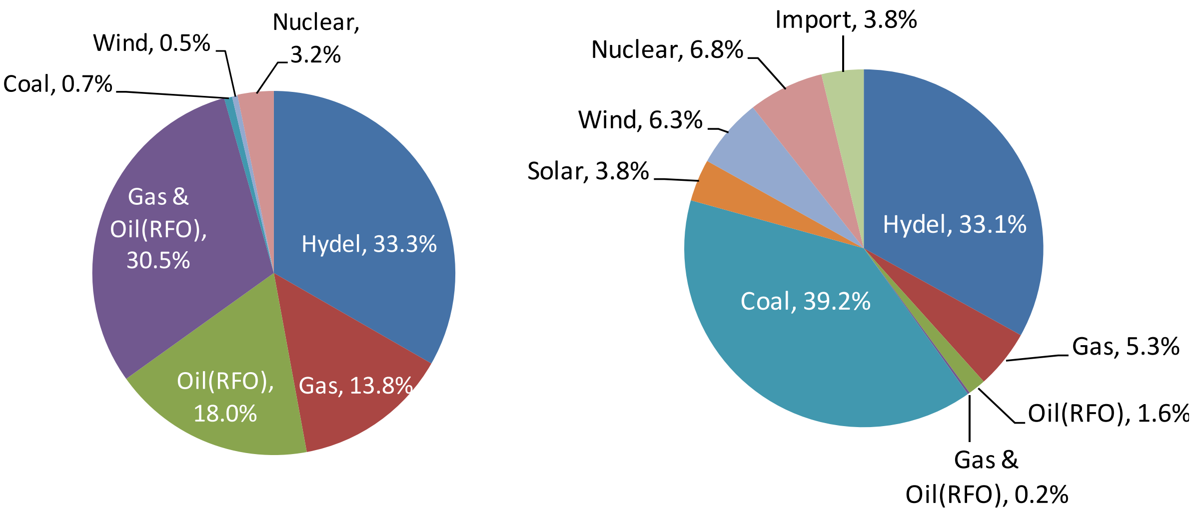
Source: JICA Survey Team

11.4.3 Renewable Energy

Figure 11.4-1 shows power source composition status as of November 2013 and the power source composition plan from 2013-14 to 2019-20 in Pakistan. This plan indicates that hydropower plant will be kept around 33%, whereas gas-fired, oil-fired and gas & oil-fired power plant will be reduced. Regarding coal-fired power plant, the number will be largely increased.

In terms of renewable energy (RE), the number of solar power (photovoltaic) and wind power station will be increased in the future. There is no plan for biomass energy including waste and solar thermal power plant in Pakistan.

Contrary to fossil fuels, greenhouse gas (GHG) emission from RE is recognized as zero. So the RE is suitable for the world trend of fossil fuel reduction. However, problems are still remained and to be solved to apply RE. Wind power and hydropower depend on location and season. Solar power depends on sunshine duration. Besides, those power plants need larger area for construction than coal-fired power plant.



Power Source Composition Status as of November 2013 (Total Installed Capacity: 20,829MW)

Power Source Composition Plan (2013-14 to 2019-20) (Total Installed Capacity: 247,608MW)

Source: NTDC

Figure 11.4-1 Power Source Composition Plan in Pakistan (NTDC)

11.4.4 Comparison of Greenhouse Gas Emissions from Power Generation

(1) GHG Emissions from Power Station using Fossil Fuel

Although small amount of GHG is produced due to the procurement of power and consumption of fossil fuel, the amount can be negligible compared to the GHG produced during project operation. Therefore as described above GHG produced from renewable energy projects such as wind, hydro and photovoltaic power generation is recognized as zero. On the other hand, power generation projects using fossil fuels produce huge amount of GHG.

GHG emissions (Carbon dioxide (CO_2) emission) (PE_y) during power plant operation is calculated by the following formula. Calculation results of CO_2 produced from fossil fuels are shown in Table 11.4-3.

According to the results, power generation using coal emits larger quantity of CO_2 than the other generation methods.

$$PE_y = FC_{i,y} \times NCV_i \times EF_{fuel,i}$$

PE_y : Annual emissions during operation (t-CO_2/year)
$FC_{i,y}$: Annual consumption amount of fossil fuel i (t/year)
NCV_i : Calorific value of fossil fuel i (GJ/t)
$EF_{fuel,i}$: Emission factor of fossil fuel i (t-CO_2/GJ)

Table 11.4-3 GHG Emissions from Power Stations using Fossil Fuel

Generation Method	Type of Fossil Fuel	*FCi,y* [1]	*NCVi* [2]	*EFfuel,i* [2]	*PEy*
		ton/year	GJ/ton	t-CO_2/GJ	t-CO_2/year
Coal fired P/S	Sub-Bituminous Coal	1,547,007	18.9	0.0961	2,809,813
Coal fired P/S	Lignite	2,044,646	14.3	0.1010	2,953,082
Gas P/S	Natural Gas	501,640	48.0	0.0561	1,350,816
Oil P/S (RFO)	Oil (RFO)	779,395	40.4	0.0774	2,437,137
Diesel engine P/S	Diesel Oil	726,691	43.3	0.0741	2,333,225

1) Equivelant quantity with 600MW

2) 2006 IPCC Guidelines for National Greenhouse Gas Inventries / JICA Survey Team (NCV of Lignite = 3,415 kcal/kg)

3) Cabinet Secretariat of Government of Japan: Plant efficiency= 42% (coal), 51% (gas), and 39% (oil (RFO) & dieseloil)

(2) GHG Emissions in case of Non-Project Option

If the Project is not implemented in Pakistan, the existing Lakhra Plant may be operated keeping current conditions (50 MW x 2). On the other hand, there is a possibility that the existing Lakhra Plant is rehabilitated up to original generation capacity (50 MW x 3). The GHG emissions calculated in cases of two scenarios are shown in Table 11.4-4. By rehabilitating the existing Lakhra Plant, the plant efficiency and operating rate are expected to be increased rather than current situation. Consequently the annual power generation and the amount of CO_2 emission would be as 2.6 times as in 2014-15.

Table 11.4-4 GHG Emissions from Power Stations using Fossil Fuel

Type of boiler	Type of coal	Phase	Operating Condition	Annual Power Generation	*FCi,y*	*NCVi* [1]	*EFfuel,i* [2]	*PEy*
				GWh/year	ton/year	GJ/ton	t-CO_2/GJ	t-CO_2/year
Sub Critical	Lignite (Lakhra coal)	2014-15	50 MW x 2	376	394,410	14.3	0.1010	569,647
		After Rehabilitation	50 MW x 3	962	1,009,798	14.3	0.1010	1,458,452

1) JICA Survey Team (NCV=3,415 kcal/kg)

2) 2006 IPCC Guidelines for National Greenhouse Gas Inventries

3) Cabinet Secretariat of Government of Japan: Auxiliary consumption rate=6.2%; Plant efficiency= 42% after rehabilitation; Operating rate= 80%
JICA Survey Team: Plant efficiency= 24% during 2014-15,

11.4.5 Site Selection

Candidate sites for the Project are shown in Table 11.4-5 and Figure 11.4-2.

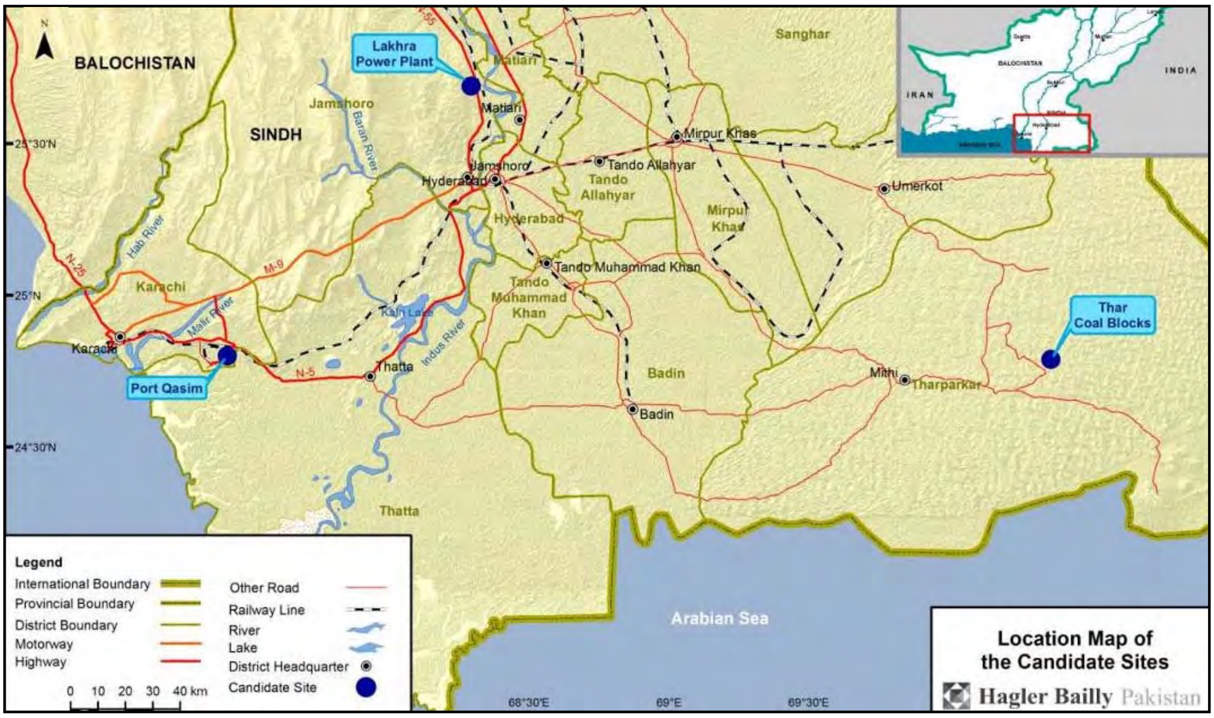
Table 11.4-5 List of Candidate Sites

	Candidate Area	Candidate Site		Size
1	Thar Coalfield Mine Mouth (Tharparker district, Sindh province)	Energy Park in Block II being developed by Sindh Engro Coal Mining Company (SECMC)		135 ha
2	Indus River (Hyderabad, Tatta Badin district, Sindh province)	a	Lakhra Power Station	77.7 ha
		b	North of Jamshoro Power Station	100 ha
3	Karachi Coastal Area (Port Qasim) (Karachi, Sindh province)	Port Qasim Industrial zone (2.5 km from the sea)		100 ha

Source: JICA Survey Team

Those sites were selected mainly based on the following criteria.

- Water availability
- Conditions of infrastructure such as road, railway for transportation of local and imported coal, and construction equipment.
- Distance to existing transmission lines
- Environmental and social conditions
- Land availability



Source: Hagler Bailly Pakistan

Figure 11.4-2 Location Map of three Candidate Sites

Current conditions at each site are presented in Table 11.4-6.

Table 11.4-6 Conditions at each Candidate Site

	Candidate Site	Water Availability	Infrastructure Conditions	Transmission Line	Environment and Social Conditions	Land Owner
1	Thar Coalfield Mine Mouth (Block II)	LBOD* is 85 km from site. Water channel and water treatment plant has been constructed from LBOD to Thar by Sindh Coal Authority.	[For Thar coal] Domestic roads are used. [For imported coal] Railway shall be constructed between Qasim and Thar.	NTDC has planned to install T/Ls from Thar to Matiari (250 km).	Agricultural land. No resident.	Private land being acquired by SECMC

	Candidate Site	Water Availability	Infrastructure Conditions	Transmission Line	Environment and Social Conditions	Land Owner
2-a	Lakhra Power Station	Indus River is 4.2 km from site.	[For Thar coal] Roads are in good conditions. (Chapter 5) [For imported coal] Railway is 2.0 km from site in good condition.	T/L is 1.7 km from site.	The site is in Lakhra Power Station. Poor vegetation. No resident.	GHCL
2-b	North of Jamshoro Power Station	Indus River is 4.0 km from site.	[For Thar coal] Same as 2-a. [For imported coal] Railway is 1.3 km from site in good condition.	T/L is 0.7 km from site.	Barren land with poor vegetation. Some structures.	Unknown, possibly private land
3	Karachi Coastal Area (Port Qasim)	Arabian Sea is 2.5 km from site.	[For Thar coal] Roads (Thar - Qasim) are in good conditions. (Chapter 5) [for imported coal] Roads in Port Qasim are in good conditions.	T/L is 35 km from site.	The site exists in Industrial zone. Poor vegetation. No resident.	Private companies

*: LBOD: Left Bank Outfall Drain

Source: JICA Survey Team

(1) Natural Environment

The assessment results for natural environment on each site are shown in Table 11.4-7.

Table 11.4-7 Comparison of Natural Environment in each Candidate Site

Site	Thar Coalfield Mine Mouth [Site 1]	Indus River		Karachi Coastal Area
		Lakhra P/S [Site 2-a]	North of Jamshoro P/S [Site 2-b]	Port Qasim [Site 3]
Habitat Classification and Distribution	Mangrove: N/A Coral reef: N/A Wetland: wetland registered under Ramsar Convention exists in 50km south	Mangroves: N/A Coral reef: N/A Wetland: exists along the Indus River	Mangrove: N/A Coral reef: N/A Wetland: exists along the Indus River	Mangrove: inhabits the bay Coral reef: N/A Wetland: exists along the seashore
Ecology (IUCN Red List)	Flora: 0 Mammal: 1 Bird: 4 Reptile: 0 Amphibian: 0 Fish: 0 (Surveys conducted in 2010 for Block II ESIA, IUCN Red List 2010)	Flora: 0 Mammal: 2 Bird: 2 Reptile: 6* Amphibian: 0 Fish: 7 (Surveys conducted in Feb. 2014 for this project, IUCN Red List 2013)	Flora: 0 Mammal: 2 Bird: 2 Reptile: 1** Amphibian: 0 Fish: 7 (Surveys conducted in June 2012 for ADB Jamshoro project, IUCN Red List 2012)	Flora: 0 Mammal: 0 Bird: 0 Reptile: 0 Amphibian: 0 Fish: 0 (Surveys conducted in 2011 for PIBT ESIA, IUCN Red List 2011)
Concern	Railway between Qasim and Thar should be constructed for transportation of imported coal.			Local people are grazing livestock at an estuary to which plant effluent may flow.

* Reptile: Turtle (Spotted Pond Turtle, Common river Turtle, Brown Roofed Turtle, Narrow-headed Soft-shell Turtle, Indian Softshell Turtle, and Peacock Soft-shell Turtle)

** Reptile: Spotted Pond Turtle

Source: JICA Survey Team

(2) Current Air Quality

Current situation of air quality at each candidate site is shown in Table 11.4-8.

Table 11.4-8 Comparison of Ambient Air Quality at each Candidate Site (Baseline)

Site	Thar Coalfield Mine Mouth [Site 1]	Indus River: Lakhra P/S [Site 2-a]	Indus River: North of Jamshoro P/S [Site 2-b]	Port Qasim [Site 3]
Current Situation	SO_2 and NO_2 meet the NEQS and IFC Guidelines. PM_{10} and $PM_{2.5}$ exceed the standards with season due to the desert conditions. (Block II Mining ESIA, 2012)	SO_2, NO and NO_2 meet NEQS and IFC Guidelines. PM_{10} and $PM_{2.5}$ exceeds SEQS and IFC Guidelines at many sampling points probably due to local traffic, cooking in houses and Lakhra P/S. (Surveys conducted in Feb. 2014)	SO_2, NO_2 and PM_{10} meet NEQS. $PM_{2.5}$ along Indus Highway exceeds the standards due to sand diffusion and traffic. (Jamshoro Final EIA, 2012)	SOx, NOx, PM_{10} and CO meet NEQS and IFC guideline limits so far. (PIBT ESIA, 2011)
Concerns	There is a tendency that PM_{10} and $PM_{2.5}$ become high from middle of May to middle of June due to strong wind which diffuses sand. If the other coal fired thermal power plants are developed in adjacent blocks, pollutants can be increased.	In Pakistan, $PM_{2.5}$ generally shows high concentration due to anthropogenic causes such as traffic and seasonal reasons (wind speed)*. Lakhra P/S may have some contribution to PM concentration.	In Pakistan, $PM_{2.5}$ generally shows high concentration due to anthropogenic causes such as traffic and seasonal reasons (wind speed)*. Jamshoro P/S might have some contribution to SO_2 concentration.	Pakistan Steel factory is about 5km west from the site, which hasn't been operational. If it's resumed, pollutants would be emitted. Construction of new coal fired power stations by IPP are planned within 5km from the site. The cumulative air pollution from them is concerned.

* Cleaning Pakistan's Air, Policy to Address the Cost of Outdoor Air Pollution (2014, World Bank)

Source: JICA Survey Team

(3) Air Pollution by Coal Transportation

The project will use <u>only imported coal</u> until the Thar coal mining begins. Once Thar coal mining begins, Thar coal will be mixed to the imported coal up to 20% on a weight basis.

Transportation means and distance are presented in Table 11.4-9. The locomotives use diesel engine though, the adverse impact on air quality is negligible compared with trucks. Air pollution is predicted in some extent due to the exhaust gas from trucks and diffusion of loaded coal from trucks to the surrounding environment along the roads.

Table 11.4-9 Transportation Vehicles and Distances

Site	Thar Coalfield Mine Mouth [Site 1]	Indus River: Lakhra P/S [Site 2-a]	Indus River: North of Jamshoro P/S [Site 2-b]	Port Qasim [Site 3]
Imported coal (distance from Port Qasim)	[Railway] Railway construction shall be required.	[Railway + Truck] Sidetracks are constructed at existing railway and transported by trucks from there to power plant. [Railway] Spur line shall be constructed from existing railway to	[Railway + Truck] Sidetracks are constructed at existing railway and transported by trucks from there to power plant. [Railway] Spur line shall be constructed from	[Truck] Existing roads will be used.

Site	Thar Coalfield Mine Mouth [Site 1]	Indus River		Port Qasim [Site 3]
		Lakhra P/S [Site 2-a]	North of Jamshoro P/S [Site 2-b]	
	(401km)	power plant (4 km). (196km)	existing railway to power plant (2 km). (167km)	(10km)
Thar coal (distance from Thar coalfield)	[Truck] Domestic roads will be used. (Conveyer in future) (20km)	[Truck] Existing roads will be used. (310km)	[Truck] Existing roads will be used. (280km)	[Truck] Existing roads will be used. (380km)

Source: JICA Survey Team

(4) Result from Environmental Aspect

Impacts on natural environment and human health based on the above considerations are evaluated in Table 11.4-11. Evaluation method is calculated comprehensively based on the scores described in Table 11.4-10.

Table 11.4-10 Scores for Evaluation

Score	Impact on Natural Environment and Human Health	Current Situation of Air Quality
0	Non-predicted	Baseline values meet SEQS and the possibility of exceeding SEQS after commissioning of the power station is very low.
-1	Negligible	Baseline values meet SEQS. However, the values might excess the SEQS after commissioning of the power station unless any mitigation measure is taken.
-2	Though some impacts are predicted, it is not irreversible.	Baseline values have already exceeded SEQS. Some measures can mitigate the excess.
-3	Irreversible impacts are predicted.	Baseline values have already exceeded SEQS. No measures can mitigate the excess.

Source: JICA Survey Team

The evaluation is based on the following conditions;

- The power plant will use imported coal (80%) and Thar coal (20%); and
- Imported coal will be transported by railway except Port Qasim site.

1) Thar Coalfield Mine Mouth

As Thar coalfield mine mouth site is located in sandy dune, the baseline of PM is expected to be high. However, this is not as a result of this project implementation. The impact on natural environment and human health is not significant. As described above, belt conveyor would be installed for transporting Thar coal at Block II in the future, so that the impact derived from truck transportation would be limited.

2) Indus River

In case that the Lakhra Power Station is continuously operated by keeping current generation capacity, cumulative air pollution shall be taken into consideration. Some mitigation measures shall be taken to the Lakhra Power Station by GHCL prior to the Project implementation.

In case a once-through cooling system is applied, thermal discharge would be disposed to the Indus River, which may has impact on aquatic organisms. However, due to limited conditions of water resources in the river, this Project will adopt a natural draft cooling tower that requires less water resources than above once-through cooling system.

3) Karachi Coastal area

In case a sea water circulation cooling system is adopted, thermal discharge would have significant impact on the aquatic organisms and mangroves. However, the type of cooling system has been still under consideration. Cumulative impacts of the other plants such as Pakistan steel and new IPP coal fired power plant to be constructed are concerned.

As a result, [Site 2-b] obtained highest score from environmental aspects. However there is no big difference in scores.

Table 11.4-11 Evaluation Results from Environmental Aspects

Site		Thar Coalfield Mine Mouth [Site 1]		Indus River: Lakhra P/S [Site 2-a]		Indus River: North of Jamshoro P/S [Site 2-b]		Karachi Coastal Area: Port Qasim [Site 3]	
Natural Environment	Habitat Classification and Distribution	N/A	0	N/A	0	N/A	0	Significant impact on mangroves	-3
	Ecology	Negligible	-1	Negligible	-1	Negligible	-1	Some impacts on aquatic organism	-2
Current Air Quality	SOx	Low	0	Low	0	Low	0	Low	0
	NOx	Low	0	Low	0	Low	0	Low	0
	PM_{10}	Exceeds with season	-2	Exceeds	-2	Low	-1	Low	0
	$PM_{2.5}$	Exceeds with season	-2	Exceeds	-2	Exceeds with season	-2	Cumulative impact of the other plants	-1
Coal Transportation	Truck	Negligible	-1	Some impacts	-2	Some impacts	-2	Some impacts	-2
	Railway	Impact during construction	-2	Negligible	-1	Negligible	-1	—	0
Total Assessment			-8		-8	Appropriate	-7		-8

Source: JICA Survey Team

(5) Social Environment

1) Baseline of Social Environment

The present condition of land use and distribution of residences were examined based on the result of site investigations and analysis of Google Earth satellite image dated on 2013 May 25th, and then necessity of involuntary resettlement were compared and assessed among the four (4) candidate sites (Table 11.4-12). Residential facilities are not found in the candidate sites in Lakhra and the Port Qasim Industrial Zone as these two areas are owned by government or private companies. The candidate site in Thar area is used for agriculture and grazing purposes with no residential facilities. Within the candidate site in Jamshoro, four (4) obstacles were found on the satellite image.

Table 11.4-12 Social Environmental Condition of the Candidate Sites

Site		Thar Coalfield Mine Mouth [Site 1]	Indus River		Karachi Coastal area
			Lakhra P/S [Site 2-a]	North of Jamshoro P/S [Site 2-b]	Port Qasim [Site 3]
Land use	Power Station	Agriculture, Grazing, Green Field, Undeveloped Land (Plain Land) and Road	Open Space in the existing Lahkra Power Station (used for waste stock)	Undeveloped Land (Plain Land), Green Field, Residential Area	Undeveloped industrial land, Green Field (used for Grazing)
	Study Area		Undeveloped Land (Plain Land), Agriculture, Grazing, Green Field, Water Area, Road and Rail	Undeveloped Land (Plain Land), Green Field, Agriculture, Grazing, Residential Area, Water Area, Road and Rail	Industry, Grazing, Green Field, Road and Rail, Residential Area, Water Area, Recreation
Land Owner	Power Station	Private or Government	GHCL and Government	Private or Government	Port Qasim Authority (PQA) or Private companies
	Study Area		Private or Government		Port Qasim Authority (PQA) or Private companies
Land Acquisition	Power Station	Required	N/A	Required	Required (from PQA or private companies)
	Study Area	N/A	Required for associated facilities	Required for associated facilities	N/A
Physical Relocation (Loss of Structure)	Power Station	Required (Agricultural Structure)	N/A	Required (Residential Structures[1])	N/A
	Study Area	N/A	N/A	N/A	N/A
Economical Relocation (Income Loss)	Power Station	Loss of agricultural land, crops, grazing land, livestock and trees	N/A (No economic activities)	Loss of agricultural land, crops, grazing land, livestock, and trees	N/A (No economic activities yet)
	Study Area	N/A	Loss of agricultural land, crops, grazing land	Loss of agricultural land, crops, grazing land, livestock, and trees	N/A
Water Use (Commercial Fishing)	-	N/A	There are commercial fishing activities along Indus River	There are commercial fishing activities along Indus River.	No commercial fishing activities in creeks of Port Qasim area

*1 Estimated based on Google Earth (Satellite image taken on 2013 May 25)

Source: JICA Survey Team

2) Result from Social Aspect

As a result of the above consideration in social aspects, the potential impacts (pros and cons) are analyzed and assessed in comparison among four (4) candidate sites.

Table 11.4-13 Scores for Evaluation

Scoring	Criteria for Assessment
-1	Negative impact is expected
0	No impact or negligible impact is expected
+1	Positive impact is expected

Source: JICA Survey Team

The result of social assessment is shown in Table 11.4-14. The Karachi coastal area is expected to have least negative impacts both in Planning/Construction stage and Operation stage.

- [Site 1] Thar Area: Planning/Construction Stage -16 / Operation Stage - 4
- [Site 2-a] Lakhra: Planning/Construction Stage -16 / Operation Stage - 5
- [Site 2-b] Jamshoro: Planning/Construction Stage -17 / Operation Stage - 5
- [Site 3] Karachi coastal area Planning/Construction Stage -11 / Operation Stage - 2

The land use of all candidate sites are undeveloped (plain) land, agricultural land and grazing land.

Firstly, the Karachi coastal area site is located within the industrial area therefore, the least social impacts are expected.

Secondly, in the Thar area, the candidate site land is only used for agriculture and grazing. Therefore, land-based income and peoples' livelihood is negatively affected due to land acquisition.

Thirdly, the Lakhra candidate site is owned by GHCL and so that involuntary resettlement is not involved for power station. However, land acquisition is most likely required for construction of associated facilities and adverse impacts on living and livelihood is expected to some extent.

At last, the Jamshoro candidate site is expected to involve land acquisition and possibly physical relocation by construction of power station as well as other associated facilities.

From the above analysis, the Karachi coastal area is assessed to be most realistic, followed by Thar area and Lakhra site.

Table 11.4-14 Scoping of Candidate Site from Social Environmental Aspects

Site	Thar Coalfield Mine Mouth [Site 1]				Along Indus River								Karachi Coastal Area			
					Lakhra P/S [Site 2-a]				North of Jamshoro P/S [Site 2-b]				Port Qasim Industrial Zone [Site 3]			
	Planning/ Construction		Operation		Planning/ Construction		Operation		Planning/ Construction		Operation		Planning/ Construction		Operation	
Resettlement	・Loss of land [-1] ・Loss of structure [-1] ・Loss of income[-1]	-3	・None	0	・Loss of land[-1] ・Loss of income[-1]	-2	・None	0	・Loss of land [-1] ・Loss of structure [-1] ・Loss of income [-1]	-3	・None	0	・Loss of land[-1]	-1	・None	0
People below the Poverty Line	・Impact on living and livelihood [-1]	-1	・Impact on living and livelihood [-1]	-1	・Impact on living and livelihood [-1]	-1	・Impact on living and livelihood [-1]	-1	・Impact on living and livelihood [-1]	-1	・Impact on living and livelihood [-1]	-1	・None	0	・None	0
Ethnic Minorities & Indigenous People	・None	0	・None	0	・None	0	・None	0	・None	0	・None	0	・None	0	・None	0
Living and Livelihood / Regional Economy	・Changes in living and livelihood [-1] ・Job creation in construction works [+1]	-1	・Changes in living and livelihood [-1] ・Changes in patterns of job opportunities [+1]	0	・Changes in living and livelihood [-1] ・Job creation in construction works [+1] ・Impact on commercial fishing [-1]	-1	・Changes in living and livelihood [-1] ・Changes in patterns of job opportunities [+1]	0	・Changes in living and livelihood [-1] ・Job creation in construction works [+1] ・Impact on commercial fishing [-1]	-1	・Changes in living and livelihood [-1] ・Changes in patterns of job opportunities [+1]	0	・Job creation in construction works [+1]	+1	・None	0
Land and Resources	・Impact on land and resources use [-1] ・Disturbance to movement [-1]	-2	・Changes in patterns of land and resources use [-1]	-1	・Impact on land and resources use [-1] ・Disturbance to movement [-1]	-2	・Changes in patterns of land and resources use [-1]	-1	・Impact on land and resources use [-1] ・Disturbance to movement [-1]	-2	・Changes in patterns of land and resources use [-1]	-1	・Impact on land and resources use [-1] ・Disturbance to movement [-1]	-2	・Changes in patterns of land and resources use [-1]	-1

Site	Thar Coalfield Mine Mouth [Site 1]				Along Indus River								Karachi Coastal Area			
					Lakhra P/S [Site 2-a]				North of Jamshoro P/S [Site 2-b]				Port Qasim Industrial Zone [Site 3]			
	Planning/ Construction		Operation		Planning/ Construction		Operation		Planning/ Construction		Operation		Planning/ Construction		Operation	
Water Use	・Degradation in underground water quality [-1]	-1	・Degradation in underground water quality [-1]	-1	・Degradation in surface and underground water quality [-1] ・Impact on fishery field [-1]	-2	・Degradation in surface and underground water quality [-1]	-1	・Degradation in surface and underground water quality [-1] ・Impact on fishery field [-1]	-2	・Degradation in surface and underground water quality [-1]	-1	・Degradation in marine and underground water quality [-1]	-1	・Degradation in marine and underground water quality [-1]	-1
Infrastructure and Social Services	・Disturbance to traffic [-1]	-1	None	0	・Disturbance to traffic [-1]	-1	・Increase in traffic from coal transportation [-1]	-1	・Disturbance to traffic [-1]	-1	・Increase in traffic from coal transportation [-1]	-1	・Disturbance to traffic [-1]	-1	None	0
Social Capita and Social Institutions	・Changes in social relations, perception and attitude among stakeholders [-1]	-1	・None	0	・Changes in social relations, perception and attitude among stakeholders [-1]	-1	・None	0	・Changes in social relations, perception and attitude among stakeholders [-1]	-1	・None	0	・Changes in social relations, perception and attitude among stakeholders [-1]	-1	・None	0
Social Conflict	・Conflicts among stakeholders from difference in project interests, benefits and impacts. [-1]	-1	・None	0	・Conflicts among stakeholders from difference in project interests, benefits and impacts. [-1]	-1	・None	0	・Conflicts among stakeholders from difference in project interests, benefits and impacts. [-1]	-1	・None	0	・Conflicts among stakeholders from difference in project interests, benefits and impacts. [-1]	-1	・None	0
Heritage	・Disturbance to grave yard in noise and vibration[-1]	-1	・None	0	・None	0	・None	0	・None	0	・None	0	・Disturbance to grave yard in noise and vibration[-1]	-1	・None	0

Site	Thar Coalfield Mine Mouth [Site 1]				Along Indus River								Karachi Coastal Area			
					Lakhra P/S [Site 2-a]				North of Jamshoro P/S [Site 2-b]				Port Qasim Industrial Zone [Site 3]			
	Planning/ Construction		Operation		Planning/ Construction		Operation		Planning/ Construction		Operation		Planning/ Construction		Operation	
Landscape	･Changes in topography due to land preparation [-1]	-1	･Changes in harmonization of landscape due to construction of facility [-1]	-1	･Changes in topography due to land preparation [-1]	-1	･Changes in harmonization of landscape due to construction of facility [-1]	-1	･Changes in topography due to land preparation [-1]	-1	･Changes in harmonization of landscape due to construction of facility [-1]	-1	･None	0	･None	0
Gender	･Changes in gender role as a result of degradation in living standard [-1]	-1	･None	0	･Changes in gender role as a result of degradation in living standard [-1]	-1	･None	0	･Changes in gender role as a result of degradation in living standard [-1]	-1	･None	0	･Changes in gender role as a result of degradation in living standard [-1]	-1	･None	0
Child Right	･None	0	･None	0	･Worsen the situation of child labor and school attendance as a result of degradation in standard of living [-1]	-1	･None	0	･Worsen the situation of child labor and school attendance as a result of degradation in standard of living [-1]	-1	･None	0	･Worsen the situation of child labor and school attendance as a result of degradation in standard of living [-1]	-1	･None	0
Infectious (HIV/AIDS) diseases	･Increase risks in respiratory and infectious disease due to influx of workers[-1]	-1	･None	0	･Increase risks in respiratory and infectious disease due to influx of workers[-1]	-1	･None	0	･Increase risks in respiratory and infectious disease due to influx of workers[-1]	-1	･None	0	･Increase risks in respiratory and infectious disease due to influx of workers[-1]	-1	･None	0
Working Conditions	･Increase risks of accident [-1]	-1	･None	0	･Increase risks of accident [-1]	-1	･None	0	･Increase risks of accident [-1]	-1	･None	0	･Increase risks of accident [-1]	-1	･None	0
Sub-total Assessment		-16		-4		-16		-5		-17		-5		-11		-2
Total Assessment				-20				-21				-22	Appropriate			-13

Source: JICA Survey Team

(6) Consideration on Technical Aspect

Table 11.4-15 shows the consideration result for each candidate site from technical aspect.

Table 11.4-15 Comparison of each Candidate Site from Technical Aspect

Content		Thar Coalfield Mine Mouth [Site 1]	Indus River		Karachi Coastal Area
			Lakhra P/S [Site 2-a]	North of Jamshoro P/S [Site 2-b]	Port Qasim Industrial Zone [Site 3]
Conditions of Location		Possible for construction	Possible for construction	Possible for construction	Possible for construction
Condenser Cooling System		Cooling Tower (natural draft type)	Cooling Tower (natural draft type)	Cooling Tower (natural draft type)	Sea Water Cooling System
Intake		Water is taken from LBOD. Water supply pipeline has been constructed by the Government of Sindh between LBOD and Thar via RO water treatment facility at Nabisar (approx. 85km). Underground water is also available in Block II.	Water is taken from the Indus River. Water supply pipeline shall be constructed from the intake point to the site (approx. 4.2km).	Water is taken from the Indus River. Water supply pipeline shall be constructed from the intake point to the site (approx. 4.0km).	Seawater is taken from the sea. Water supply pipeline to the site and RO water treatment facility shall be installed.
Discharge		No thermal discharge. Effluent water will be treated and mostly reused in greening etc.	No thermal discharge. Effluent will be treated and drained off through water pipeline to the Indus River.	No thermal discharge. Effluent will be treated and drained off through water pipeline to the Indus River.	Construction of discharge pipeline will face to technical difficulties in installing the pipeline more than 16 km, given that the NEQS requires the outlet for thermal discharge to be installed at least 10 miles (approx. 16 km) away from mangrove.
Connection to Existing Transmission Lines		Transmission line will be constructed between Thar and Matiari by NTDC (approx. 250km).	Transmission line from the site to existing transmission line shall be constructed by NTDC (toward the west from the site, approx. 1.7km).	Transmission line from the site to existing transmission line shall be constructed by NTDC (toward the west from the site, approx. 0.7km).	Transmission line from the site to NKI (NTDC-KESC Interconnection) S.S. (approx. 60km)
Coal Transportation	Thar Coal	By truck using domestic roads.	The rehabilitation works of existing road and construction works of bypass have already been started between Badin and Thar Coalfield. Some bypasses have been constructed due to existence of towns along the road.		The rehabilitation works of existing road and construction works of bypass have already been started between Badin and Thar Coalfield. Some bypasses have been constructed due to existence of towns along the road.

	Imported Coal	Imported coal would be transported by train. Railway shall be constructed between Port Qasim and Thar (401km).	[Railway + Truck] Railway sidetracks shall be constructed along with the existing railway. [Railway] Spur line shall be constructed from existing railway to power plant. Rehabilitation work of existing track might be required in some extent.	Coals would be unloaded at the Port Qasim and transported by trucks (approx. 10km).

Source: JICA Survey Team

Based on the above table, each candidate site was evaluated with below scores.

Table 11.4-16 Score for Evaluation

Score	Criteria
0	No technical problem is predicted.
-1	Though technical problems are observed, the solution is comparatively easy.
-2	There are technical problems which needs high technical measures for the solution.
-3	There are technical problems which cannot be solved even with high technical measures.

Source: JICA Survey Team

1) Thar Coalfield Mine Mouth

Thar coalfield mine mouth requires the construction of railway between Thar and Port Qasim, which shall be proceeded by Pakistan Railway under the Ministry of Railway.

2) Port Qasim

Port Qasim area sustains large mangrove forest. So [Site 3-b] accompanies reclamation work in size of 50 ha, which requires removal of large mangrove forests. There are no major issues in technical aspects in any candidate site.

Results of evaluation are shown in Table 11.4-17. [Site 2-a] and [Site 2-b] gained high score.

Table 11.4-17 Evaluation Results from Technical Aspects

Content	Thar Coalfield Mine Mouth [Site 1]		Indus River				Karachi Coastal Area	
			Lakhra P/S [Site 2-a]		North of Jamshoro P/S [Site 2-b]		Port Qasim Industrial Zone [Site 3]	
Conditions of Location	No problem	0	No problem	0	No problem	0	No problem	0
Intake	Secured water supply	-1	No problem	0	No problem	0	No problem	0
Discharge	No problem	0	No problem	0	No problem	0	Mangrove should be removed for the outlet construction.	-2
Connection to existing Transmissi on Lines	No problem	0	No problem	0	No problem	0	T/L (60km) should be laid along the seashore in order to avoid the city.	-1
Coal Transport ation — Thar Coal	No problem	0	Preventive measure for spontaneous ignition and dust control are needed.	-1	Preventive measure for spontaneous ignition and dust control are needed.	-1	Preventive measure for spontaneous ignition and dust control are needed.	-1

	Imported Coal	Railway shall be constructed (401km). Preventive measure for spontaneous ignition and dust control are needed.	-2	Railway sidetracks shall be constructed along the existing railway. Preventive measure for spontaneous ignition and dust control are needed.	-1	Railway sidetracks shall be constructed along the existing railway. Preventive measure for spontaneous ignition and dust control are needed.	-1	No problem	0
Total Score			**-3**	**Appropriate**	**-2**	**Appropriate**	**-2**		**-4**

Source: JICA Survey Team

(7) Consideration on Economic Aspect

A comparison of total costs is provided in Table 11.4-18. As to Alternative 2, 3, 6 and 7, as the cost for spur line is higher than that for side track, those initial costs are conservatively estimated for spur line.

As a result, Alternative 6 is the most economical in terms of initial cost.

On the other hand, as for the total cost including running cost, in case coalfield development progresses on schedule and is not delayed, Alternative 1 is the most economical.

On the other hand, if coalfield development is delayed for 15 years or more, Alternative 1 will be the most expensive in the contrary.

Table 11.4-18 Comparison of Total Cost

Unit: Rs million

	Alternative 1 Thar Thar Coal 100%	Alternative 2 Lakhra Thar Coal 100%	Alternative 3 Jamshoro Thar Coal 100%	Alternative 4 Karachi Thar Coal 100%	Alternative 5 Thar Mix (80% Bitu)	Alternative 6 Lakhra Mix (80% Bitu)	Alternative 7 Jamshoro Mix (80% Bitu)	Alternative 8 Karachi Mix (80% Bitu)
Scenario 1 (0)*1								
- Initial	154,631	162,426	163,329	167,815	159,897	118,536	119,439	123,521
- Operation	316,962	355,862	355,836	348,975	517,870	517,335	516,172	482,161
Total	**471,593**	**518,288**	**519,166**	**516,790**	**677,768**	**635,871**	**635,611**	**605,682**
Scenario 2 (5)*2								
- Initial	154,631	162,426	163,329	167,815	159,897	118,536	119,439	123,521
- Operation	378,498	390,577	388,438	372,646	551,696	520,531	519,562	484,347
Total	**533,129**	**553,004**	**551,767**	**540,461**	**711,593**	**639,068**	**639,001**	**607,868**
Scenario 3 (10)*3								
- Initial	154,631	162,426	163,329	167,815	159,897	118,536	119,439	123,521
- Operation	440,034	425,318	421,039	394,083	556,920	523,727	522,952	486,532
Total	**594,665**	**587,744**	**584,368**	**561,897**	**716,818**	**642,264**	**642,391**	**610,053**
Scenario 4 (15)*4								
- Initial	154,631	162,426	163,329	167,815	159,897	118,536	119,439	123,521

- Operation	501,569	460,059	453,641	415,519	562,145	526,923	526,342	488,718
Total	**656,201**	**622,485**	**616,970**	**583,333**	**722,042**	**645,460**	**645,781**	**612,239**

Source: JICA Survey Team

<NOTE> *1 Mining operation will commence on schedule.
*2 Mining operation will be delayed for 5 years.
*3 Mining operation will be delayed for 10 years.
*4 Mining operation will be delayed for 15 years.

(8) Result of Site Selection Evaluation

Evaluation results from environmental, social, technical and economic aspects are presented in Table 11.4-19. Total evaluation should be made taking into consideration the risk of delay of the Thar mining operation and critical impacts on each site. From comprehensive point of view, Site 2-a, Lakhra Power Station site, is evaluated to be the most appropriate location for the project.

Table 11.4-19 Comparison of each Candidate Site

Content	Thar Coalfield Mine Mouth [Site 1]	Indus River		Karachi Coastal Area
		Lakhra P/S [Site 2-a]	North of Jamshoro P/S [Site 2-b]	Port Qasim [Site 3-a]
Environmental	PM exceeds SEQS. [-8]	PM exceeds SEQS. [-8]	PM exceeds SEQS. [-7]	Impact on mangroves and aquatic organisms by thermal discharge [-8]
			Appropriate	
Social	No involuntary resettlement. Land acquisition will be needed to a large extent. Impact on agriculture and grazing is negligible. [-20]	No involuntary resettlement. Land acquisition for sidetracks will be needed in some extent. Impact on commercial fishing activities shall be considered. [-21]	Involuntary resettlement will be involved to some extent. Land acquisition will be needed to a large extent. Impact on commercial fishing activities shall be considered. [-22]	Land shall be acquired from Port Qasim Authority. No involuntary resettlement. No impact on commercial fishing in Arabian sea. [-13]
				Appropriate
Technical	Railway construction (401km) [-3]	No major problem [-2]	No major problem [-2]	Mangrove removal Construction of thermal discharge outlet [-4]
		Appropriate	**Appropriate**	
Economic	[Thar Coal 100%] If no delay, the total cost including initial and operation cost is the lowest. [0]	[Thar Coal 100%] The total cost is higher than Site1 and Site 3. [-2]		[Thar Coal 100%] Initial cost is highest but operation cost is lower than Site 2. [-1]
	Appropriate (No delay)			**Appropriate (in case of delay)**
	[Mix Combustion] Initial investment	[Mix Combustion] Initial investment cost is the lowest.		[Mix Combustion] Total cost including

	cost is the highest. [-2]	[-1]		initial investment cost and operation cost is the lowest. [0]
				Appropriate
Score	-31 (Thar 100%) -33 (Mix)	-33 (Thar 100%) -32 (Mix)	-33 (Thar 100%) -32 (Mix)	-26 (Thar 100%) -25 (Mix)
Critical Risk	Delay of mining operation	Nothing in particular	Involuntary resettlement	Mangrove and thermal discharge
Total Evaluation		**Appropriate**		

Source: JICA Survey Team

11.4.5 Greenhouse Gas Emission (Comparison of Boiler Types)

The emission of greenhouse gases from each boiler type (i.e., Subcritical, Supercritical and Ultra Supercritical pressure boiler) were calculated for coal fired thermal power plant with 660MW capacity.

Carbon dioxide (CO_2) emission (PE_y) during power plant operation was calculated by the following formula.

$PE_y = FC_{i,y} \times NCV_i \times EF_{fuel,i}$

PE_y : Annual emissions during operation (t-CO_2/year)
$FC_{i,y}$: Annual consumption amount of fossil fuel i (t/year)
NCV_i : Calorific value of fossil fuel i (GJ/t)
$EF_{fuel,i}$: Emission factor of fossil fuel i (t-CO_2/GJ)

(1) Comparison of Carbon Dioxide Emission among Type of Boiler

Calculation result of CO_2 emissions in case of 100% imported coal is shown in Table 11.4-20. Compared with Subcritical boiler, CO_2 emission from Supercritical and Ultra Supercritical boilers would be reduced by 8.1% and 11.3% respectively.

Table 11.4-20 Carbon Dioxide Emission for each Boiler Type (single burning)

	Parameter	*FCi,y* 1)	*NCVi* 2)	*EFfuel,i* 2)	*PEy*
Type of boiler	Type of coal	ton/year	GJ/ton	t-CO_2/GJ	t-CO_2/year
Subcritical	Imported coal (Sibbituminous)	1,683,910	18.9	0.0961	3,058,469
Supercritical		1,547,007	18.9	0.0961	2,809,813
Ultra Supercritical		1,494,360	18.9	0.0961	2,714,191

1) Equivelant quantity with 600MW (net)
2) 2006 IPCC Guidelines for National Greenhouse Gas Inventries

Source: JICA Survey Team

(2) Economical Aspect on Boiler Type

The construction cost for coal fired thermal power plant (660MW) with cooling tower system was calculated. The result shows that the cost for Ultra Super Critical boiler would be increased by 5.9% (approx. USD XXX) and 7.3% (approx. USD XXX) compared with Super

Critical and Sub Critical boiler respectively.

This project will adopt the Ultra Supercritical boiler due to higher generation efficiency and less CO_2 emission rather than the other boiler types.

"XXX" stands for "The information is masked because it includes confidential."

11.5 Environmental and Social Considerations on each Component

11.5.1 Preconditions

- As concluded in Section 11.4, the location at Lakhra Power Station is selected as the most appropriate project site. Hereafter the environmental and social considerations are discussed for the selected site.
- As described in Section 11.1.1, the Project consists of three associated projects, the power plant, transmission lines, and railway works. A separate report for pre-feasibility study[1] was prepared by JICA in which the environmental and social considerations for railway works were described.
- 100% imported coal (sub-bituminous coal) would be used for the Project when Thar coal (lignite coal) is not available. The imported coal would be transported by railway from Port Qasim and Thar coal might be transported by truck. Hereafter the environmental and social impacts due to the Project is described in case 100 % imported coal is used.
- After Thar coal becomes available, bended coal with 80 % imported coal and 20 % Thar coal would be used. The impacts in case of using blended coal are described in separate clause (Section 11.5.2, (9)).

11.5.2 Power Plant

The power plant comprises following associated facilities:

- Coal storage site and coal handling facilities
- Ash disposal site and ash handling facilities
- Water supply system
- Wastewater treatment and discharge systems
- Two access roads

(1) Scoping

According to the JICA Guidelines (April 2010), the predicted environmental impacts are assessed by referring to the results of first and second site works as shown in Table 11.5-1.

[1] Preparatory Survey on Lakhra Coal Fired Thermal Power Plant Construction Project in Pakistan, Pre-feasibility Study on Coal Transportation between Qasim and Lakhra by Railway, 2015 (JICA)

Table 11.5-1 Result of Scoping (Power Station)

No.	Item	Assessment: Pre/Construction Phase	Assessment: Operation Phase	Assessment Reason
Pollution Control				
1	Air Quality	B-	A-	**[Construction Phase]** Soil dust might emit from civil works of land clearance. Soil dust and emissions of particulate matter (PM) and sulfur dioxides (SO_2) might emit from trucks transporting equipment and heavy machines. **[Operation Phase]** The operation of power plant might emit SO_2, PM and nitrogen oxides (NO_X). Coal dust might be generated during transporting coal. Coal dust might emit from coal piles. Spontaneous ignition is predicted at coal piles. Coal ash might emit from coal ash.
2	Water Quality	B-	B-	**[Construction Phase]** Effluent of concrete and water with oil might percolate into underground water. Domestic effluent from base camps might percolate into underground water. **[Operation Phase]** Cooling tower discharge would be drained into the Indus River. Effluents from associated equipment (regular and irregular effluents), domestic water from administration office and water with oil can percolate into underground water. Storm water from ash pond might include arsenic and heavy metals, which might pollute the underground water. Leachate from ash pond may contaminate the groundwater.
3	Soil Quality	B-	B-	**[Construction Phase]** The leakage of lubricant oil and fuel oil from construction vehicles and machines might pollute soil. **[Operation Phase]** The leakage of lubricant oil and fuel oil used in the power plant might pollute soil. Leachate from ash pond may contaminate the soil under the facility.
4	Wastes	B-	B-	**[Construction Phase]** Solid wastes and hazardous wastes might be generated from base camps and construction sites. **[Operation Phase]** Solid wastes and hazardous wastes might be generated from administration building, accommodations and canteen. Coal ash and by-product gypsum from flue gas desulfurization will be generated from the power plant.
5	Noise and Vibration	B-	A-	**[Construction Phase]** Noise and vibration might be generated from large-sized vehicle traffic on access roads and construction sites. Noise and vibration might be generated from heavy machines during excavation works and equipment setting. **[Operation Phase]** Noise and vibration might be generated from each unit such as boiler and power generator, etc.
6	Subsidence	D	D	**[Construction & Operation Phase]** No subsidence will occur due to no use of underground water.
7	Odor	B-	B-	**[Construction Phase]** Odor might be generated from kitchen wastes at base camps and septic tanks. **[Operation Phase]** Odor might be generated from kitchen waste at administration building and canteen and manure treatment systems. Irritating smell might be generated from the spontaneous ignition of coal and ash.
8	Sediment	B-	B-	**[Construction Phase]** Sediment in the Indus River might be

No.	Item	Assessment		Assessment Reason
		Pre/Construction Phase	Operation Phase	
	Quality (bottom of Indus River)			damaged due to civil works of intake and outlet facilities. **[Operation Phase]** Some impacts on sediment are predicted due to disposal of cooling tower discharge into the Indus River.
Natural Environment				
9	Protected Areas	C-	C-	**[Construction & Operation Phase]** Keti Khasai Reserved Forest in 6km northeast and Budhapur Reserved Forest in 6km southwest from the project site exist. Site investigation will be done in the third site works.
10	Ecosystem	C-	C-	**[Construction & Operation Phase]** Two species of mammals, two species of birds, six species of reptile and seven species of fish listed in the IUCN Red List 2013 have been reported. Further site investigations will be done especially for aquatic organisms such as Indus River blind dolphin. **[Operation Phase]** Taking water may possibly cause suction of fish species.
11	Hydrology	B-	B-	**[Construction Phase]** Temporary impacts on the hydrology are predicted due to construction of intake water and effluent discharge facility in the Indus River. **[Operation Phase]** Impact by intake water and effluent discharge may adversely impact on the Indus River.
12	Topography and Geology	B-	D	**[Construction Phase]** Excavation and land clearance for ash pond being acquired may have adverse impact on topography. **[Operation Phase]** No impact would be predicted.
Social Environment				
13	Resettlement	B-	B-	**[Pre Construction Phase]** Land acquisition is required for ash pond, access road, water pump station and temporary for water pipelines and some of the land are private owned land. **[Operation Phase]** Land would be permanently acquired and impacts on that economical activities in some extent.
14	People below the Poverty Line	C-/C+	C-/C+	**[Pre Construction Phase]** A further study is required to reveal if people below poverty line are included in the affected people **[Construction and Operation Phase]** Job creation and provision of job training would impact positively. **[Operation Phase]** Loss of income may cause adverse impact on people's living.
15	Ethnic, Minorities and Indigenous People	C-	C-	**[Pre/ Construction & Operation Phase]** People other than Muslim (such as Hindi, Christian and other minor groups) may be more vulnerable to project impacts compared with the major religious group.
16	Living and Livelihood	C-/C+	C-/C+	**[Pre Construction Phase]** A further study is required to find out the state of fishery activities in the Indus River and whether intake/discharge of riverine water result in any adverse impacts on fishery products, fishing area and, fisherman's income. **[Construction Phase]** Temporary increase in traffic may disturb existing traffic and may lead to adverse impact on regional economic activities. **[Construction and Operation Phase**] Job creation and provision of

No.	Item	Assessment: Pre/Construction Phase	Assessment: Operation Phase	Assessment Reason
				job training would impact positively. **[Operation Phase]** Intake/discharge of water from/to the Indus River may cause adverse impact on income source of fishermen without appropriate mitigation measures.
17	Use of Land and Resources	C-	C-	**[Construction and Operation]** Intake/discharge of water from/to the Indus River may cause adverse impact on use of aquatic resources (such as water, water area, fishery products) without appropriate mitigation measures.
18	Water Use	C-	C-	**[Construction]** Some quantity of water intake and, discharge of rain water contaminating particulate matter, oil and sediment from construction site may negatively impact on water use (for the purpose of drinking, rice production and fishing). **[Operation]** Large quantity of water may be required for cooling systems and domestic use, and some quantity of effluent may be discharged into surface water (e.g. Indus River, drainage).
19	Infrastructure and Social Services	B-	D	**[Construction Phase]** Temporary increase in traffic may disturb existing traffic and may lead to adverse impact on regional economic activities.
20	Social Capita, Institutions and Conflicts	C-	D	**[Pre Construction Phase]** Differences in acceptance of the project and income gap among stakeholders may change social relation, deepen hierarchies and, create conflicts.
21	Unevenness of Project Benefits and Impact	C-	C-	Unevenness of the project benefit and impacts may deepen economic inequality amongst communities.
22	Heritage	C-	D	**[Construction Phase]** Possibility of sound and vibration impacts on the Syed Daad Shaheed Graveyard and Shrine, that are located 6 km south-east from the candidate site, is expected.
23	Landscape	D	D	No large scale earth works are involved None
24	Gender	C-	C-	**[Construction Phase]** Difference in benefits of temporary job opportunities between men and women will be arisen. **[Construction and Operation Phase]** Women's work load may be caused by degradation of income source and livelihood standard.
25	Child Right	C-	C-	**[Construction Phase]** Temporal job opportunities in construction work may result in an increase in number of child labors. **[Construction and Operation Phase]** Degradation of income source and livelihood standard may worsen the situation of child labor and school attendance.
26	Infectious Diseases	B-	D	**[Construction Phase]** Influx of workers may increase risks in respiratory and infectious disease.
27	Working Condition and Accident	B-	B-	**[Construction Phase]** Risks of accident, spread of infectious diseases may be increased. **[Operation Phase]** Accident could be occurred in work environment. Possibility of spontaneous combustion at the coal yard are expected.
28	Transboundary Waste Treatment and Climate	B-	A-	**[Construction & Operation Phase]** No transboundary waste treatment would be predicted. **[Construction Phase]** Temporary carbon dioxides (CO_2) emissions from vehicle and heavy machinery are predicted.

No.	Item	Assessment: Pre/Construction Phase	Assessment: Operation Phase	Assessment Reason
	Change			**[Operation Phase]** Certain amount of CO_2 will be generated.

A+/-: Significant positive/negative impact is expected
B+/-: Positive/negative impact is expected to some extent
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected
Source: JICA Survey Team

(2) TOR for Environmental and Social Consideration Survey for Power Plant

In order to prepare the draft Environmental Impact Assessment ('draft EIA') and the draft Land Acquisition and Resettlement Plan ('draft LARAP'), following regulations/guidelines/policies shall be referred to.

- Draft EIA
  - Sindh EPA (Review of IEE and EIA) Regulations, 2014
  - JICA Guidelines (April 2010)
  - World Bank Safeguard Policy OP 4.01 Annex B
- Draft LARAP
  - Land Acquisition Act (LAA), 1894
  - JICA Guidelines (April 2010)
  - World Bank Safeguard Policy OP 4.12 Annex A (Resettlement Plan)
  - Involuntary Resettlement Sourcebook Planning and implementation in Development Projects

TOR for the power plant is shown in Table 11.5-2.

Table 11.5-2 Terms of Reference (Power Plant)

Environmental Item	Survey Item	Survey Method
Air Quality	(1) Confirmation of environmental standards (SEQS, IFC, etc.) (2) Current condition of air quality (3) Confirmation of location of residence, school, and hospital, etc. around the project site. (4) Impact during construction	(1) Collection of air quality standards and exhaust standards (2) Collection of meteorological data such as temperature, humidity and wind speed, etc. Measurement of air pollution substances such as SOx, NOx and PM. (3) Site investigation (4) Confirmation of construction method
Water Quality	(1) Confirmation of environmental standards (NEQS, IFC, etc.)	(1) Collection of standards for drinking and effluent water quality

Environmental Item	Survey Item	Survey Method
	(2) Confirmation of surface (e.g., Indus River, pond) and groundwater quality	(2) Measurement of surface and groundwater quality
Soil Quality	(1) Oil leakage prevention measures during construction and operation	(1) Measurement of groundwater quality (turbidity, BOD, heavy metals, etc.)
Wastes	(1) Environmental standards (2) Type and treatment method of construction wastes (3) Domestic waste during construction (4) Wastes during operation (ash, waste oil, etc.)	(1) Collection of waste-related law, guidelines (2) Hearing with the project proponent (3) Hearing with the project proponent (4) Confirmation of construction method
Noise and Vibration	(1) Confirmation of environmental standards (NEQS, IFC, etc.) (2) Distance between the site and residential area, school and hospital, etc. (3) Impact during construction (4) Current conditions of noise and vibration	(1) Collection of standards for noise and vibration (2) Confirmation of the location of residential areas, school, hospital, etc. at each site (3) Confirmation of construction method (4) Measurement of noise (baseline)
Odor	(1) Odor generation source	(1) Hearing with project proponent
Sediment Quality (bottom of Indus River)	(1) Location and structure of water intake and effluent outlet equipment (2) Impact scale	(1) Site investigation (2) Confirmation of construction method and equipment's specification
Protected Areas	(1) Confirmation of Reserved Forest adjacent to the site	(1) Site investigation (2) Associated report collection
Ecosystem	(1) Current conditions of mammals, birds (migratory birds etc.) and reptiles including precious species	(1) Confirmation of related data, and ecological survey
Involuntary Resettlement (Land Acquisition)	(1) Land and assets to be relocated (2) Affected people (economically or physically) (3) Renters, business, workers, employees, people without allocation (squatters and encroachers) (4) Replacement cost for land and assets (farm land, urban land, houses and other structures) (5) Supplementary measure for loss of assets	- Analysis of legal frameworks - Collection of reference material - Analysis on satellite image - Population census survey - Collection of land record and assets inventory - Socioeconomic survey (interviews, public meeting, group discussion, site investigation)
People below poverty line	(1) Presence of fishery activities in the Indus River (2) Presence of people below poverty line in the affected fishermen	- Collection of reference material - Socioeconomic survey - Income and livelihood survey - Interview to local fishery association and local governments
Ethnic Minorities & Indigenous People	(1) Baseline information on ethnic, minorities and indigenous people, the social relations and vulnerability.	- Collection of reference material - Socioeconomic survey - Interview to local community
Living and Livelihood /	(1) Baseline information on livelihoods and standards of living	- Collection of reference material - Socioeconomic survey

Environmental Item	Survey Item	Survey Method
Regional Economy	of which affected people	- Income and livelihood survey - Site investigation and interview to affected people, labor's association, local government and NGO etc.
Land and Resources	(1) Baseline information on land use (2) Baseline information on Aquatic resources	- Collection of reference material - Analysis on satellite image - Analysis of land use map - Site investigation and interview
Water Use	(1) Baseline information on use of river and underground water (for different purposes i.e. drinking and irrigation	- Collection of reference material - Analysis of water management record - Interviews to local government - Site investigation
Infrastructure and Social Services	(1) Transporting route of construction materials and equipment (2) Transporting route of coal (3) Location of social infrastructures (school, hospital and other services)	- Analysis on satellite image - Analysis of land use map - Site investigation to understand geographic relations of roads and infrastructures and - Interviews to local government
Gender and Child	(1) Baseline information of women's role and work state (especially in family of fishermen) (2) Baseline information of child labor and school attendance (especially in family of fishermen)	- Socioeconomic survey - Income and livelihood survey - Site investigation and interview to affected people, fishermen, labor's association, local government and NGO etc.
Infectious (HIV/AIDS) diseases	(1) Infection rate of diseases such as respiratory diseases and HIV/AIDS in the local community (2) Local NGOs conduct activities regarding infectious disease	- Collection of reference materials - Interviews to local government, medical facilities, NGOs etc.
Working Conditions and Accident	(1) Time, route and area of public movement (2) Potential hazards to workers at construction and operation stage (3) Potential health risk to workers (4) Baseline information of forces labor	- Collection of reference material (similar projects' EIA) - Analysis of satellite image - Analysis of land use map - Requirements and guideline of occupational health and safety in Pakistan - Environmental, Health and Safety Guidelines (EHS Guidelines) are - Interview with local government, NGOs, labors association etc.
Stakeholder consultation	(1) Stakeholder's states and the relations (2) Concerns and comments on project (3) Baseline information	- Stakeholder meetings - Public consultations - Focus group interviews - Individual interviews

Source: JICA Survey Team

(3) Prediction of Environmental Impact for Power Plant

1) Air Quality

(a) Emission from Existing Lakhra Plant

The existing plant with no control measures is adding substantial amount of pollutants to the ambient air causing the pollutant concentration levels to exceed both the SEQS as well as the IFC guideline limits. If the existing plant is allowed to run in its present condition, the concentration SO_2, PM_{10} and $PM_{2.5}$ in the ambient air will exceed the limits prescribed by SEQS as well as IFC guidelines.

(b) Emission from Proposed Project

The operation of power plant will emit SO_2, PM and NOx if no appropriate mitigation measure is applied to the plant.

(c) Coal Dust Dispersion during Operation Phase

At the coal unloading site and coal piles at the site, coal dust might be generated and be dispersed to vicinity areas by wind. Spontaneous ignition might occur at coal stock piles due to oxidation reaction.

(d) Coal Ash Dispersion during Operation Phase

The fly ash will be transported from ESP to ash pond in dry condition by truck if no recycle process is conducted. The bottom ash will be transported from boiler and FGD to the ash pond by truck in dry condition as well. Since those disposed ash is stocked in open space, ash dust may be dispersed by strong wind especially in dry season.

2) Water Quality

(a) Extraction of water from the River

Water will be extracted from the Indus River and used for cooling in the proposed Project. The proposed power plant requires 0.50 m^3/s water from the River Indus when operating at full capacity. Of this, an estimated quantity of 0.01 m^3/s will be returned to the river. The net extraction of water by the proposed power plant is therefore estimated at 0.49 m^3/s at full capacity. As detailed in Chapter 5, river flow upstream of Kotri barrage[1] varies from a monthly average level of 4,592 m^3/s in August, to a monthly average level of 177 m^3/s in December. Water extracted by the power plant will therefore be 0.28% of the minimum monthly average flow of the river. Minimum daily flows in the drought periods can drop to as low as 14% of the minimum monthly average flows. In these conditions, the water extracted by the plant as a percent of the river flow will increase to about 2.0%. This level of change of flow will not cause any significant change in the geomorphology and the hydraulic parameters of relevance to the river ecology such as the depth of water, the width of the river, and the area wetted by it.

(b) Quality of Effluent Discharge into the River

[1] Data provided by Irrigation & Power Department, Government of Sindh for the period 2005-2014

As discussed in Section 11.2.1, a sample from effluent water was assessed for compliance with NEQS and IFC Guidelines, and all the analyzed parameters were found within the permissible levels of the standards. As described in Chapter 7, the proposed 660 MW power plant will discharge cooling tower effluent/ blowdown and the other waste water generated into the river after treated. Effluent flow with the proposed 660 MW power plant will increase by only 0.1 m^3/s. The additional effluent from the Project will be controlled to meet the NEQS and IFC Guidelines (Table 11.3-6).

(c) Quality of the Groundwater around the Ash Pond

Leachate from ash pond may contaminate the groundwater through soil.

3) Soil Quality

As well as the above description of quality of groundwater, leachate from ash pond may contaminate the soil under the facility. In order to investigate the quality of soil, groundwater quality should be monitored regularly around the ash pond.

According to the soil quality analysis (Section 11.2.1, (8) Soil Quality), the concentration of Boron, Cadmium, Selenium and Silver indicated higher level compared with their average crustal abundance in some sampling sites. The higher values may have occurred due to the spread of bottom and fly ash with wind from existing Lakhra Plant.

Apart from this project, the mitigation measures for the soil contamination are proposed in (8) of Section 11.5.2.

4) Wastes

Municipal solid waste, industrial and hazardous wastes will be generated during construction and operation period. Besides coal ash and by-product gypsum (bottom ash) will be generated during operation period.

5) Noise and Vibration

The noise during the construction phase greatly depends on the stage of construction work and equipment used at the site. The construction activities can be divided into the following phases:

- site clearing and preparation,
- excavation and pile driving,
- foundations and concrete placement,
- erection of metal structures,
- delivery of equipment and materials to the site,
- installation of mechanical and electrical equipment, and
- steam blowing and commissioning.

The source of noise during operation and maintenance phase includes:

- coal delivery, unloading and handling,
- operation of equipment within the turbine generator building and outside,
- steam blowing and purging,
- electric power transmission to the switchyard, and
- shutting down of components and switching to other equipment,

A settlement, Manzoorabad, exists in the vicinity of the power plant. The noise measured at two points, NPSTN01 (350 m east of the plant, residential huts, primary school) and NPSTN02 (950 m east of the plant, Manzoorabad settlement) in night exceed the NEQS and IFC Guidelines by almost 10 dB. This may be attributed due to the location near the highway (N-55) and the existing plant.

IFC Guidelines[1] requires that noise impacts should not exceed daytime (0700 – 2200 hours) levels (55 dBA) and night-time (2200 -0700 hours) levels (45 dBA), or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site. This Project will be designed not to increase the noise level more than 3 dB at the nearest receptor (see Table 11.2-6).

6) Ecological Impact

Impact on Aquatic Habitat

For the proposed power plant, 0.5 m^3/s of fresh water will be required, over and above an average of 0.06 m^3/s being consumed by the existing unit at present. The Project will therefore increase the water intake from the river to about 0.6 m^3/s. As discussed above, there will be minor impact on the hydraulic parameters and consequentially the aquatic fauna due to change in the quantity of water extracted.

Without any mitigation measures, the Project has potential impact on water quality of the river though, as long as the effluent water is treated to meet the NEQS and IFC Guidelines limits before returning to the river, the river ecology will not be at risk.

There is a risk that fish species may be sucked through inlet of water during operation phase without mitigation measures.

Impact on Aquatic Fauna

The Spotted Pond Turtle (*Geoclemys hamiltonii*), Common River Turtle (*Hardella thurjii*), Indian Softshell Turtle (*Nilssonia gangetica*), Peacock Soft-shell Turtle (*Nilssonia hurum*), and Smooth-coated Otter (*Lutrogale perspicillata)* are listed as vulnerable, and Narrow-headed Soft-shell Turtle (*Chitra indica*) and Indus Blind Dolphin (*Platanista minorare*) are listed as endangered in IUCN Red List 2014. Since the distribution of these species are not restricted to the Study Area, the Project is not directly impact on their survival. However, the Project shall

1 IFC General EHS Guidelines: Environmental Noise Management

pay attention to observation of these species as well as nests of these turtles during construction period.

Impact on Protected Area

As described in (11) of Section 11.2.1, though the candidate site is not located in any protected area, Keti Khasai, Budhapur and Racho Khanot Reserved Forests are in about 6 to 8.5 km from the site. According to the air quality modeling analysis shown in Table 11.5-4 and Appendix 11-6, ground level pollutant concentrations of SO_2, NOx, PM_{10} and $PM_{2.5}$ at 5 km area (boundary of Study Area) meet the SEQS ambient air quality level. Besides, no direct adverse impact on those reserved forests due to the proposed project is predicted in terms of water quality and noise. Therefore, those reserved forests outside the Study Area are not likely to be impacted by Project activities.

Impact on Terrestrial Fauna

Birds and mammals are not expected to be attracted to the ash pond due to existing levels of disturbance and restricted ground access. Transport of additional coal and supplies for construction of the Project will increase traffic volumes and can result in land disturbance and habitat fragmentation of animals. However, since existing road networks will be used to accommodate the additional traffic volumes, this impact is not likely to be significant considering that the area is already heavily disturbed.

(4) Impact Assessment for Power Plant

The result of the environmental and social impact assessment is presented in Table 11.5-3.

Table 11.5-3 Result of Environmental and Social Impact Assessment (Power Plant)

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
Pollution Control						
1	Air Quality	B-	A-	A-	A-	**[Pre/Construction Phase]** According to the result of ambient air sampling analysis (Table 11.2-2), the concentration of PM10 and PM2.5 is already exceed the SEQS. Soil dust is generated by civil works of land clearance. Exhaust gas from vehicles is generated. However, as most of the activity is conducted within the existing Lakhra Plant, the risk is low. **[Operation Phase]** The operation of power plant will emit SO_2, PM and NO_x. Coal dust might emit from coal piles. Spontaneous ignition is predicted. Coal ash might be dispersed from ash pond.
2	Water Quality	B-	B-	B-	B-	**[Construction Phase]** Oil-contaminated water, fuel used for heavy machines, domestic water at construction site and base camps can be leaked into underground water. Civil works of intake and outlet facilities will bring about some impacts on river water quality. **[Operation Phase]** Effluent from associated equipment of power plant, domestic water from administration office and waste water with oil will be generated, which might contaminate the Indus River and percolate into underground water without any mitigation measures. Leachate from ash pond may contaminate underground water.
3	Soil Quality	B-	B-	B-	B-	**[Construction Phase]** The leakage of lubricant oil and fuel oil from construction vehicles and machines can pollute soil. **[Construction Phase]** The leakage of lubricant oil and fuel oil from construction vehicles and machines can pollute soil.
4	Wastes	B-	B-	B-	B-	**[Construction Phase]** Municipal solid waste, industrial and hazardous waste will be generated. **[Operation Phase]** <u>Municipal solid waste, industrial and hazardous wastes</u> will be generated. <u>Coal ash and by-product gypsum</u> will be generated.
5	Noise and Vibration	B-	A-	B-	B-	**[Construction Phase]** Noise and vibration are generated from large-sized vehicle traffic on access roads and construction sites, and

No.	Item	Assessment of Scoping: Pre/Construction Phase	Assessment of Scoping: Operation Phase	Assessment of Survey Result: Pre/Construction Phase	Assessment of Survey Result: Operation Phase	Results
						from heavy machines during excavation works and equipment setting. **[Operation Phase]** Noise and vibration will be generated from units such as boiler and power generator, etc.
6	Subsidence	D	D	N/A	N/A	No use of underground water
7	Odor	B-	B-	B-	B-	**[Construction Phase]** Odor may be generated from solid and liquid waste, and septic tanks of base camp. **[Operation Phase]** Spontaneous ignition of coal and ash might occur.
8	Sediment Quality (bottom of Indus River)	B-	B-	B-	D	**[Construction Phase]** Civil works of intake and outlet facilities may impact on sediment quality. **[Operation Phase]** No significant impact on sediment quality is predicted due to small quantity of effluent water.
Natural Environment						
9	Protected Areas	C-	C-	N/A	N/A	**[Construction & Operation Phase]** Project site is not located within any protected area. The selected project site is located and kept distance of 6-8 km from the closest reserved forests. Therefore, there is no significant impact as long as the project is designed to meet the environmental quality standards.
10	Ecosystem	C-	C-	B-	B-	**[Construction Phase]** Construction activities may disturb both terrestrial and aquatic animal habitats. Construction of intake and effluent discharge facilities may temporally impact on the aquatic habitat due to installation of steel piles and temporal degradation in water quality. **[Operation Phase]** Inlet of the intake water may possibly suck fish species. Without any treatment of waste water, there is potential impact on aquatic ecosystem due to water discharge. Monitoring on fish species will be preferably implemented taking into account the impact on fishery.
11	Hydrology	B-	B-	B-	D	**[Construction Phase]** Some impact is predicted due to the construction of intake water facility, which installs steel piles in the river. **[Operation Phase]** No significant impact is predicted.

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
12	Topography and Geology	B-	D	D	D	**[Construction & Operation Phase]** No large-sized topographical and geological changes occur.
Social Environment						
13	Involuntary Resettlement (Land Acquisition)	B-	B-	B-	B-	**[Pre-construction/Construction/Operation Phase]** 46.25 acres of land will be acquired for two access roads, water pumping station and path to pumping station, water pipelines (temporary acquisition) and ash pond. Project will affect 0.87 acres of uncultivated private land of three households (18 people). There will be no other impacts on assets and livelihood. Compensation for the loss of land on replacement value basis and other support will be provided to restore/improve livelihood of affected people.
14	People below the Poverty Line	C-/C+	C-/C+	D	D	**[Pre-construction/Construction/Operation Phase]** Project affected people do not include people below national poverty line[1].
15	Ethnic, Minorities and Indigenous People	C-	C-	D	D	**[Pre-construction, Construction and Operation Phase]** There is no significant impact since group of people such as Hindi, Christian and other minor groups are harmonized with the major religious group, Muslim people.
16	Living and Livelihood	C-/C+	C-/C+	B+	B+	**[Pre-construction and Construction Phase]** Project may change local economic structure. Project would employ about 3,000 people and give priority to local people, provide job skill training and capacity building activities as part of social augmentation. Project will also use services from local vendors for regular business and every goods at labor camp site. **[Operation Phase]** Changes are expected in local economic structure. Project would expedite new job and business opportunities by recruiting unskilled labors from the adjacent communities and using services from local vendors for regular business and every goods.
17	Use of Land	C-	C-	B-	D	**[Pre-construction/Construction Phase]**

[1] The Pakistan national poverty line is US$ 1.25 per person per day (that is PKR 3,703 at exchanging rate US$ 1 = PKR 98.75 on 4th August 2014).

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
	and Resources					Movement of local people, their livestock and traffic will be disturbed from land acquisition, construction activities and influx of workers. **[Operation Phase]** No impact on the existing traffic and movement of local people as coal will be transported by rail which is designed with bridge structure. Railway will not disturb movement of local people and traffic.
18	Water Use	C-	C-	B-	D	**[Construction Phase]** Storm water runoff from construction site may temporally impact on quality of irrigation water from Indus River that is used in some settlements located less than one kilometer from Indus River; underground water that is used through wells, dug wells and hand pumps in some settlements in Study Area. Construction works of intake and discharge facilities may temporally affect water quality of Indus River. **[Operation Phase]** There is no significant impact on water use as water flow of the river is secured and waste water will be treated appropriately before discharged.
19	Infrastructure and Social Services	B-	B-	B-	D	**[Construction Phase]** Construction activities and influx of labors may affect availability and capacity of existing social infrastructures and social services such as transportation, schools and health facilities. **[Operation Phase]** Coal will be transported by railway, so that there would be no increase in the volume of traffic.
20	Social Capita, Institutions and Conflicts	C-	D	B-	D	**[Pre Construction / Construction Phase]** Differences in acceptance of the project among local communities and changes of cultural value and norms between the local communities and incoming labors may cause social conflicts.
21	Unevenness of Project Benefits and Impact	C-	C-	B-	B-	**[Construction / Operation Phase]** Inappropriate compensation and supports may cause unevenness among project beneficiaries. Income gaps between the project employed workers and the other locals may cause unevenness of the project benefit.
22	Heritage	C-	D	D	D	**[Pre Construction / Construction / Operation Phase]** There is no heritage site within the Study Area.
23	Landscape	D	D	D	D	**[Pre Construction / Construction / Operation Phase]** No large scale earth works are involved.
24	Gender	C-	C-	B-	B+	**[Construction Phase]** Influx of migratory labor during construction works may increase impact on female daily activities, privacy, and

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
						possibility of abuse of local female. As measures, the labors will be educated, the local community will be consulted and monitored. **[Operation Phase]** Women's work load may be eased if community water utilities are provided by the executing agency as part of the social augmentation.
25	Child Right	C-	C-	D	B+	**[Construction Phase]** It will be made sure that children will not be employed in the project. **[Operation Phase]** Improvement in local economy, social infrastructures such as water utilities, schools and health facilities as part of social augmentation may positively impact on social environment for children.
26	Infectious Diseases	B-	D	B-	D	**[Construction Phase]** Influx of workers may increase risks in respiratory and infectious diseases. The project will implement periodic medical check and health education for the workers.
27	Working Condition and Accident	B-	B-	B-	B-	**[Construction / Operation Phase]** Projects are exposed to the risks of accident and occupational health and safety hazards. Mitigation measures are proposed to control these risks.
Other						
28	Transboundary Waste Treatment and Climate Change	C-	C-	D	B-	**[Construction Phase]** Transboudary of waste is not predicted. **[Operation Phase]** The power plant generates 2.7 – 2.8 million ton-CO_2/year.

A+/-: Significant positive/negative impact is expected

B+/-: Positive/negative impact is expected to some extent

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

D: No impact is expected

Source: JICA Survey Team

(5) Environmental Management Plan (mitigation measures) for Power Plant

1) Mitigation Measures

(a) Air Quality

Proposed Project

Emission of SO_2, NOx, PM_{10} and $PM_{2.5}$ will be controlled to meet ambient air quality in SEQS and IFC Guidelines.

Air Quality Modeling for Existing Lakhra Plant and Proposed Project

USEPA regulatory model AERMOD was used to simulate criteria pollutants from major sources in the project area and predict air quality for SO_2, NO_2, PM_{10} and $PM_{2.5}$. The list and location map of sensitive receptors such as health, educational and religious facilities are given in Appendix 11-5.

Table 11.5-4 summarizes the estimated background air quality, predicted increment due to the Project and predicted ambient air quality after the proposed project commissioning and the rehabilitation of existing LFPS is taken place.

In general, IFC emission guidelines are different for degraded and non-degraded air sheds. The degraded air shed is defined by IFC as: *Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly*.

As Sindh Province has established provincial ambient air quality standards (SEQS) which, although not identical to those of the WHO, are comparable and even more stringent in certain cases, the decision of degraded or non-degraded airshed shall be based solely on the provincial criteria. Based on the results shown in Table 11.5-4 it is argued that the airshed after the rehabilitation of the existing plant shall be considered as non-degraded as all ambient air quality standards (with the possible exception of $PM_{2.5}$) will be met.

IFC recommends that facilities in degraded airsheds should minimize incremental impacts by meeting IFC guidelines. Further, it suggest that "*facilities or projects located within poor quality airsheds should ensure that any increase in pollution levels is as small as feasible, and amounts to a fraction of the applicable short-term and annual average air quality guidelines or standards …*"

The airshed of the existing LFPS will be classified as degraded under the present conditions as it does not meet SEQS with respect to SO_2. The rehabilitation of emission controls on the existing LFPS stacks will result in reducing the emission of SO_2, PM_{10}, and $PM_{2.5}$. This will result in cleaning the air to the extent that the concentration of SO_2 and PM_{10} will be well within the ambient air quality standards, and that of $PM_{2.5}$ will be substantially reduced. This would result in re-classifying the airshed as non-degraded.

Concentration levels in ambient air were predicted for SO_2, NO_2, PM_{10} and $PM_{2.5}$ for the simulations. Contour maps for the increment in pollutants concentration caused by the proposed Project are given in Appendix 11-6 (Figure 1 - Figure 8). The contour maps for the predicted ambient air quality after the proposed plant is commissioned and Lakhra Plant is rehabilitated are given in Appendix 11-6 (Figure 9 - Figure 16).

Table 11.5-4 Air Quality Modeling Results (µg/m³)

	Period	SEQS	IFC Guide-lines	Estimated Background	Predicted Increment due to Proposed Plant (660 MW)	Predicted Ambient Air Quality After Proposed Plant Commissioning and LFPS Rehabilitation[1]
SO_2	Maximum 24–hr	–	125 (IT-1) 50 (IT-2) 20 (GL)	10.8	7.1	120.5
	24–hr (98th %le)	120	–		6.7	87.8
	Annual	80	–		1.8	38.2
NO_2	Maximum 24–hr	–	–	21.1	6.1	86.5
	24–hr (98th %le)	80	–		5.8	67.2
	Annual	40	40 (GL)		1.5	37.4
PM_{10}	Maximum 24–hr	–	150 (IT-1) 100 (IT-2) 75 (IT-3) 50 (GL)	69.1	1.5	75.9
	24–hr (98th %le)	150	–		1.4	73.8
	Annual	120	70 (IT-1) 50 (IT-2) 30 (IT-3) 20 (GL)		0.4	69.1
$PM_{2.5}$	Maximum 24–hr		75 (IT-1) 50 (IT-2) 37.5 (IT-3) 25 (GL)	43.1	0.7	46.5
	24–hr (98th %le)	75	–		0.7	45.5
	Annual	40 or back-ground plus 9	35 (IT-1) 25 (IT-2) 15 (IT-3) 10 (GL)		0.2	43.9

Note: IT: Interim Target, GL: Guideline. Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines.

Source: Hagler Bailly Pakistan

1 Includes emission from the Proposed Plant, the existing plant with 150 MW capacity after rehabilitation and the background concentration of the pollutants.

The results show that the predicted increment caused by the proposed Project is very small in comparison to the background and baseline levels.
For the existing plant to comply with the SEQS, it will be necessary to rehabilitate the existing pollutant control system.

With rehabilitated control measures on the existing plant, the proposed 660 MW plant meets all the limits prescribed by SEQS as well as IFC guidelines. (The concentration of SO_2 exceeds the Interim Terget 2 level of IFC guidelines. The concentrations of PM_{10} exceed the Interim Target 3 (Max. 24-hr) and Interim Target 2 (Annual). The concentration of $PM_{2.5}$ exceeds Interim Target 3 (Max. 24-hr) and Interim Target 1 (Annual).) The annual average limit for $PM_{2.5}$ is 40 μg/m³ or 'background plus 9 μg/m³'. The increment from the 660 MW plant, however, is very small, 0.2 μg/m³ in comparison to the background concentration of 43.1 μg/m³ on annual average basis.

Coal Ash Dispersion during Operation Phase

Coal ash diffusion from ash pond is mitigated by water sprinkling and dikes with 5 m height around it. Greenbelt would be installed around the ash pond to reduce the dispersion. Spontaneous ignition will be avoided by appropriate management (periodic inspection, limiting the coal stock height, compaction of coal stock, and water sprinkling).
Fly ash will be recycled by cement companies as much as possible. The fly ash should be transported by dedicated cars for powder and granular material in order to avoid ash dust dispersion.
On the other hand, fly ash, bottom ash and by-product gypsum not recycled will be disposed of at ash pond. Those ashes will be solidified gradually by absorbing water so that the dispersion will be controlled naturally.

(b) Water Quality

Quality of Effluent Discharge into the River

All of the effluents including rainfall runoff from ash pond and coal piles will be routed to the wastewater treatment facility for treatment and discharged to the river. (Figure 7.3-42)

Quality of Groundwater and Soil around Ash Pond

HDPE membrane would be applied under the ash pond to avoid the leachate from percolating into groundwater.

(c) Soil Quality

HDPE membrane would be applied under the ash pond to avoid the leachate from percolating into groundwater.

(d) Wastes

Wastes generated during Construction and Operation Period

Wastes generated during construction and operation period will be stored by each type of wastes, collected and treated appropriately by local licensed firms.

Ash Recycling

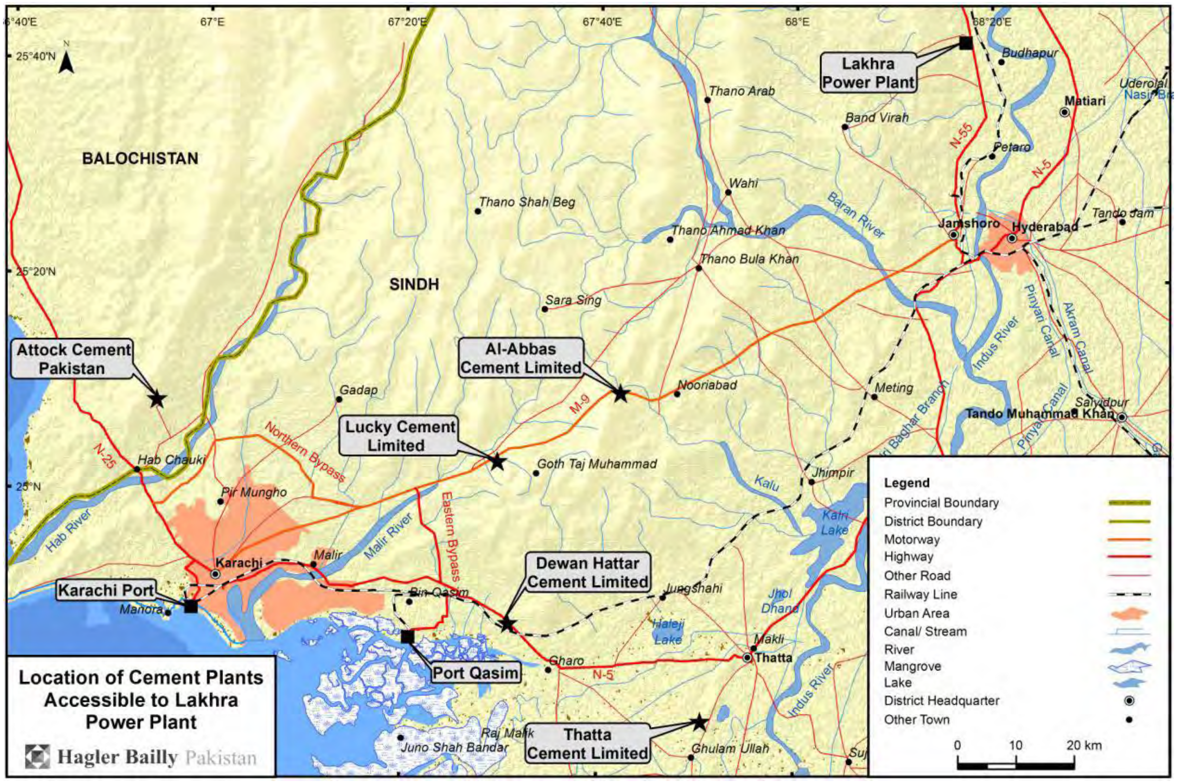
Fly ash will be recycled by cement companies as much as possible.

The proposed power plant will be equipped with a pressurized pneumatic fly ash handling system. The system is designed to remove fly ash collected in the ESP, economizer hoppers, and air-heater hoppers and convey it to the fly ash storage silo. All the fly ash will be temporarily stored in ash silos. However, later it will be either transported in its dry form to cement companies for recycling or will be disposed of in the ash ponds. Dedicated trucks will be used to transport ash from the silos to the cement companies. Gypsum will initially be stored in silos. Gypsum that cannot be recycled will also be transferred to the ash pond for storage.

The major portion of ash re-utilization is carried out in the cement manufacturing industry due to the presence of cement manufacturing plants in the region. For this purpose, the following cement manufacturing plants are considered:

- Al-Abbas Cement Limited
- Attock Cement Pakistan
- Dewan Cement Limited
- Lucky Cement Limited
- Thatta Cement Limited

The above listed cement plants are shown in Figure 11.5-1.



Source: Hagler Bailly Pakistan

Figure 11.5-1 Location of Cement Plants Accessible to Project Site

(e) Noise and Vibration

Insulation measures such as building, sound absorber, green belt and insulation wall are applied to main transformer, circulation pumps, turbines, and boilers, etc.

Noise will be measured and monitored around the periphery of the site to assure that permissible limits have not been exceeded. Alarms system will be employed to alert the main control room when any of the detectors indicate excessive noise levels. The detectors will be installed at critical receptor areas, such as hospital, school and residential areas. These detectors will be checked and calibrated periodically by plant personnel.

(f) Ecosystem

In principle the Project will be designed to meet the requirement of NEQS/SEQS in order to avoid the impact on the surrounding ecosystem and to minimize the adverse impact on those endangered/vulnerable species reported in the region.

In case, any endangered or vulnerable species (including their nests and eggs) are observed during construction period, it is recommended to contact the local ecological experts from IUCN, WWF, universities and research institutions etc. and get their advice on appropriate measures.

The inlet of the intake water pipeline will be screened as to avoid suction of fish species.

2) Institutional Framework for implementation of EMP

Figure 11.5-2 and Figure 11.5-3 present the structure of the project organization during construction and operation phase respectively.

Project Implementation Unit ('PIU') acts as a contract manager for the EPC contract. It will ensure appropriate reporting to financiers, and will manage the project implementation consultants ('PIC'). The PIU plays a most important role to carry out the project construction successfully, which leads the implementation of the project at the construction site and has decisive influence on the quality and productivity of the workforce. Table 11.5-5 shows the positions of the PIU.

The Project management Unit ('PMU') is to be established at GHCL to manage the implementation of the projects financed by international agencies. PMU will provide overall direction and management to the project to ensure the project is delivered on schedule and in accordance with the budget and specifications. The PMU will also ensure that environmental and social safeguard requirements be satisfied at all projects being executed under the umbrella of GHCL. In addition, the PMU is also responsible for the coordination of the training program for all the projects. Table 11.5-6 shows the PMU structure. The PMU also includes supporting staffs as needed for better supervision, coordination and workload management. The PMU staffs shall have appropriate relevant academic qualifications, with experience working in their specialty area.

Table 11.5-5 Project Implementation Unit structure

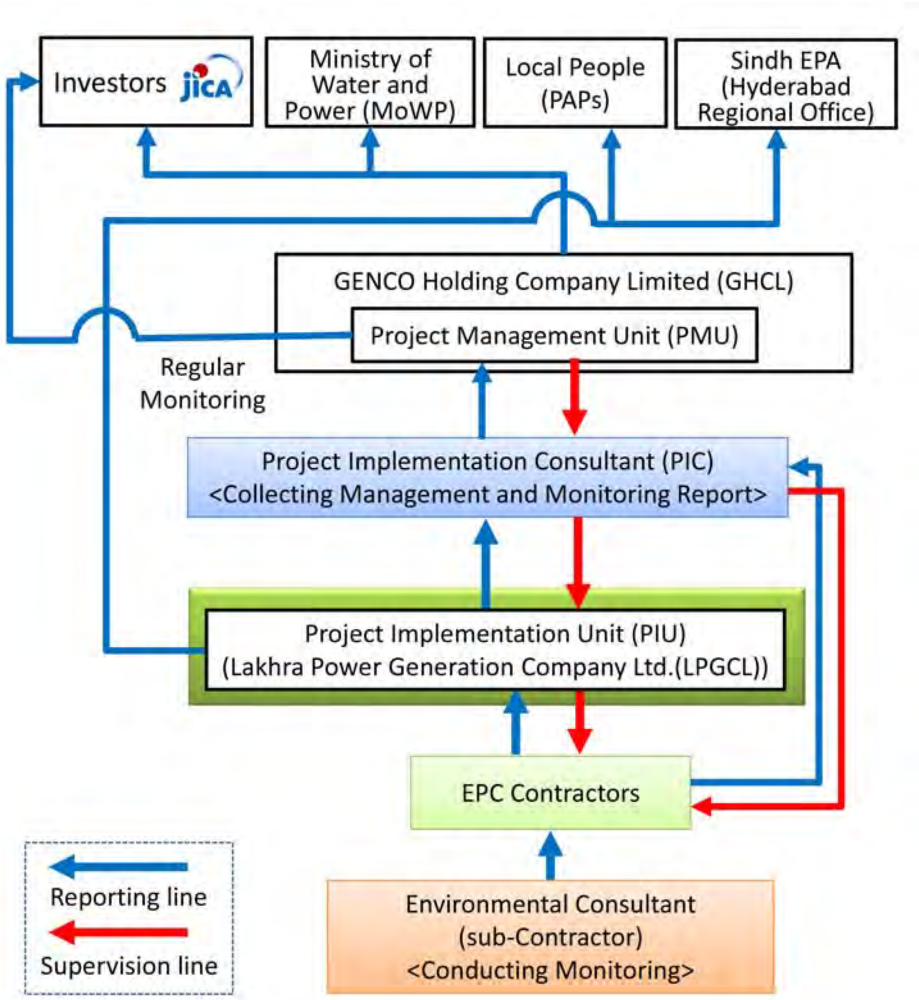
<table>
<tr><td rowspan="5">Chief Engineer/PD (BPS-20) in charge of PIU</td><td>Finance Manager (BPS-19)</td><td>01 Nos. Deputy Manager Finance. (BPS-18)
02 Nos. Assistant manager Finance (BPS-17)
02 Nos. Accounts Officer (BPS-16)</td></tr>
<tr><td>Director Technical (BPS-19)</td><td>01 No. Sr. Engineer Mechanical (BPS-18)
02 Nos. Jr. Engineer Mechanical (BPS-17)
01 No. Sr. Engineer Mechanical (BPS-17)
02 Nos. Jr. Engineer Electrical (BPS-17)
01 No. Sr. Engineer Control and Instrumentation (BPS-18)
02 Nos. Jr. Engineer Control and Instrumentation (BPS-17)
01 No. Sr. Engineer Chemical/Senior Chemist (BPS-18)
02 Nos. Jr. Engineer Chemical/Junior Chemist (BPS-17)</td></tr>
<tr><td>Director Civil (BOS-19)</td><td>01 No. Sr. Engineer Civil (BPS-18)
02 Nos. Jr. Engineer Civil (BPS-17)</td></tr>
<tr><td>Director Procurement (BPS-19)</td><td>01 No. Deputy Director Procurement (BPS-18)
02 Nos. Assistant Director Procurement (BPS-17)</td></tr>
<tr><td>Deputy Director Environment/Social Aspects (BPS-18)</td><td>01 No. Assistant Director (Environment) (BPS-17)
01 No. Assistant Director (Social Aspects) (BPS-17)</td></tr>
</table>

Source: GENCO

Table 11.5-6 Project Management Unit Structure with all Projects at GHCL Level

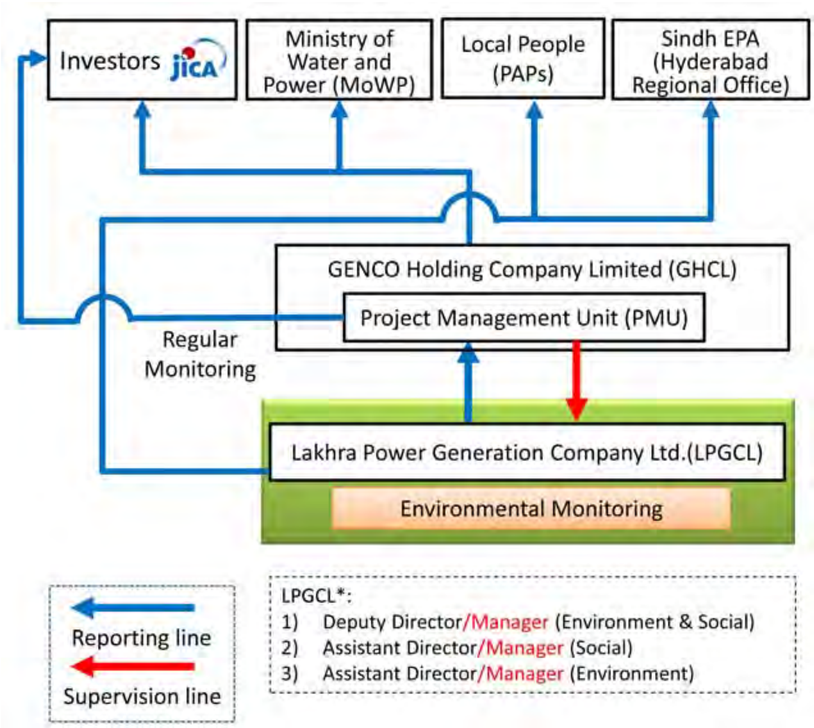
<table>
<tr><td rowspan="3">GM (D&D) Overall in charge of PMU</td><td>02 No. Director Technical (BPS-19)</td><td>02 Deputy Director (BPS-18)
02 Assistant Directors (BPS-17)</td></tr>
<tr><td>02 No. Director (Monitoring & Evaluations) (BPS-19)</td><td>02 Deputy Director (BPS-18)
02 Assistant Director</td></tr>
<tr><td>Director (Environment) (BPS-19)</td><td>Deputy Director (Environment) (BPS-18)
Assistant Director (Environment) (BPS-17)</td></tr>
</table>

Source: GENCO



Source: GENCO

Figure 11.5-2 Project Organization (Construction Phase)



LPGCL*: 1) Deputy Director/Manager (Environment & Social), 2) Assistant Director/Manager (Social), 3) Assistant Director/Manager (Environment)

Source: GENCO

Figure 11.5-3 Project Organization (Operation Phase)

Environmental Management Plan for construction and operation phase is shown in Table 11.5-7.

Table 11.5-7 Environmental Mitigation and Management Plan (Power Plant)

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
A. Design phase					
Project disclosure	Stakeholder concern	・Submit EIA to Sindh EPA and obtain approval.	LPGCL	GHCL	Rs. 200,000 (GENCO pays.)
Land Acquisition	Effects of resettlement on livelihood	・The Land Acquisition and Resettlement Plan (LARAP) will be implemented. ・In case of any change in the area of the land, the LARAP will be updated before any acquisition of land. ・Coordination of activities with relevant regulatory government departments such as the DC and the Revenue Department.	LPGCL	PIC/GHCL	Cost is included in LARAP
Stack emissions	SO_2, NO_x and PM emissions from the stack	・Ensure that the following equipment are included in the project design in order to ensure compliance with the World Bank Group EHS Guidelines on Thermal Power Plants, 2008, national standards and international best practices: ESP (High efficiency 99.7%) to limit the total PM emissions to 30 mg/Nm^3 FGD (High efficiency 80%) using lime slurry to limit SO_2 emissions Low NO_x burners to minimize the NO_x generation ・A stack height of 210 m. The equipment type and details may be changed as long as the objectives are met. Any such change will require approval of JICA/investor(s).	PIC	GHCL/LPGCL	Cost is included in the EPC contract.

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
Ash pond	Dust and leachate are potential sources of contamination	・About 73 acres of land are allocated for the ash disposal with the capacity of over 5 years of ash and gypsum waste for the 660 MW project. ・The fly ash will be collected from silos and recycled as much as possible or disposed of at the ash pond. Bottom ash will be collected and disposed of at the ash pond. Water will be sprinkled on the ash pond for avoiding ash dispersion. ・The ash pond will be provided with trenches to collect the storm water during rainy days. Greenbelt will be provided enveloping the ash pond to arrest the fugitive dust emissions. Ash pond will also be provided with clay or High Density Polyethylene (HDPE) liner. The design will allow phased expansion of the ash pond to store ash. ・The storm water coming from the ash pond will be treated at the effluent treatment facility and will be discharged into Indus River.	Design consultant	GHCL/LPGCL	Cost is included in the EPC contract.
Plant wastewater	Discharge of untreated waste water will pollute the surface water and expose river ecology to thermal stress	・Ensure that the following measures are included in the project design in order to ensure compliance with the World Bank Group EHS Guidelines, 2008, national standards and international best practices: ・Cooling tower blow down will be extracted from the outlet of the cooling tower instead of the present practice of drawing it from the inlet sump of the cooling tower/condenser outlet ・Replacement of the pipeline originally designed to carry the effluent from the plant to the river and restoration of the system for collection of effluent water and its routing to the effluent pipeline	PIC	GHCL/LPGCL	Cost is included in the EPC contract.
Wastewater from construction site and base camp	Leakage into underground water	・Sanitation facilities (temporary lavatories) are installed at construction site.	PIC	GHCL/LPGCL	Cost is included in the EPC contract.
Fire prevention	Fire hazards and impact on community	・A hazard and operability study (HAZOP) will be undertaken. In the study, the power plant process will be systematically assessed to identify risks to personnel, equipment, or community. The firefighting system and the emergency response plan will be developed on the basis of the HAZOP study.	EPC Contractor	PIC/LPGCL/ GHCL	Cost is included in the EPC contract.
B. Construction phase					

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
Construction management	Construction activities although temporary can potentially have adverse impact on the environment.	・Ensure that a detailed Construction Management Plan (CMP) based on the skeleton plan is developed. ・Ensure that the CMP is implemented	EPC Contractor	PIC	N/A
Environment					
Air quality	Ambient air quality (soil dust, exhaust gas from vehicles)	・Water sprinkling is implemented at construction area ・To ensure that appropriate maintenance is conducted for vehicles	EPC Contractor	PIC	N/A
Water quality	Leakage into underground water	・Before disposing of the waste water, coagulation or oil separation process is applied. ・Chemicals are kept in the specific storage with roof and wall. ・Trainings for cleaning method of chemicals are implemented for labors in case of chemical leakage accidents.	EPC Contractor	PIC	N/A
	River water pollution during civil works	・ The waste water from sanitary facilities (temporary lavatories) is collected by licensed company. ・To adopt the construction method with less impact on the river water.	EPC Contractor	PIC	N/A
Soil quality	Soil contamination by oil	・Lubricant/fuel oil is dealt appropriately. ・Training for oil management is conducted for labors by EPC Contractor in advance.	EPC Contractor	PIC	N/A
Disposal of replaced construction related spare parts and fluids (oil filters, engine oil, tires, *etc*.)	Generates wastes such as iron, copper, electronics and oil	・Appropriate waste storage facilities are designed and constructed for each type of waste. ・Training for handling and managing hazardous wastes is implemented to all labors in advance. ・Waste collection and disposal agreement with licensed company is made. ・Wastes are collected at least once a week. ・Ensure that the waste is disposed as per the waste management plan.	EPC Contractor	LPGCL	Rs. 100/ton

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
Noise and vibration	Noise	・To disclose the construction plan and duration to residents ・Vehicles do not enter the construction sites during night time (22:00 - 6:00) ・O&M and fix are regularly conducted to construction machines and vehicles ・Civil works with big noise and vibration are implemented during daytime (6:00 - 22:00) ・Excavation and piling works are implemented during daytime (6:00 - 22:00) ・Where big noise is emitted, insulation wall is constructed or silencer is installed on construction machine	EPC Contractor	PIC	Cost is included in the EPC contract.
Odor	Odor from kitchen waste and septic tanks	・Kitchen waste is segregated at waste storage facility. ・Septic tanks are inspected regularly and kept in good condition by adding chlorine appropriately.	EPC Contractor	PIC	N/A
Sediment quality	Impact on sediment quality during civil works	・To adopt the construction method for water intake and effluent discharge facility, which has less impact on the sediment quality ・To adopt the outlet method for effluent discharge facility, which has less impact on the sediment quality	EPC Contractor	PIC	N/A
Ecosystem	Water pollution during construction phase	・To adopt the construction method for water intake and effluent discharge facility, which brings about less impact on the sediment quality	EPC Contractor	PIC	Cost is included in the EPC contract.
	Reptile nesting	・To take care of the nest of turtles during their hibernation). If their nest was found near the site, PIC shall get professional advice from ecological expert.	EPC Contractor	PIC	N/A
Socio-economics					
Involuntary resettlement and land acquisition	Changes in income source patterns	・LARAP will be implemented. ・Progress of effectiveness of LARAP implementation will be monitored.	PIU/LPGCL	PIC/GHCL	Cost is under investigation
Living and livelihood	Changes in income sources and local economic structure	・LARAP will be implemented. ・Progress and effectiveness of LARAP implementation will be monitored. ・Establishment of grievance system. ・Job creation as construction workers and give priority to locals including PAPs. ・Provision of job skill training and capacity building activities. ・Using local services and local venders.	PIU/LPGCL	PIC/GHCL	N/A
Use of land resources	Loss of land based economic production/	・Same EMP as [Living and Livelihood]	PIU/LPGCL	PIC/GHCL	N/A

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
	Disturbance of movement of local people and their livestock	･Specific timings for construction work will be planned to avoid disturbance to the local communities and their mobility during business hours. ･Mobility of the contractor's staff through the nearby residential areas will be controlled and prohibited, where possible	EPC Contractor	PIC	N/A
Water use	Disturbance of water use for everyday use, agriculture and fishing due to temporary degradation of water quality.	･Same EMP as [Water Quality] ･Consultations/explanation to the locals ･Monitoring of the local community. ･Implementation of grievance system.	EPC Contractor	PIC/GHCL	N/A
Infrastructure and social services	Availability and capacity of existing infrastructure and services	･Upgrade, repair and/or develop social infrastructures and services, if necessary. ･Develop camp site that facilitates required infrastructures, if necessary ･Traffic of construction vehicles during business hours shall be avoided. ･Installation of traffic signs, driving safety education, speed restriction, check/maintain vehicle equipment (brake, klaxon) if necessary.	EPC Contractor	PIC	N/A
Social capita, Institutions and Conflicts	Social conflicts	･Consultations/explanation to the locals ･Education of employees about local cultural value, norms and common resources. ･Maintain liaison between incoming workers and local communities. Mobility of the contractor's staff through the nearby residential areas will be controlled and prohibited, where possible. ･Monitoring of the local community. ･Establishment of grievance system.	EPC Contractor	PIC/GHCL	Cost is under investigation
Unevenness of Project Benefits and Impact	Income gaps between project beneficiaries	･Implement fair compensation ･Proposal of social augmentation ･Consultations/explanation to the locals. ･Monitoring of the local community. ･Establishment of grievance system.	EPC Contractor	PIC/GHCL	N/A
Gender	Influx of workers may increase impact on female daily activities, privacy and possibility of abuse.	･Education of employees ･Establishment of grievance system. ･Local community will be consulted and monitored	EPC Contractor	PIC/GHCL	

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
Infectious diseases	Influx of workers may increase risks in respiratory and infectious disease.	･Implementation of periodic health check and education for workers ･Monitoring of the local community.	EPC Contractor	PIC/GHCL	
Working condition and accident	Risks of accident, occupational health and safety hazards, spread of infectious diseases	･Development of occupational health and safety management plan ･Implementation of periodic health check and education for workers ･Restriction of long-time exposure to noise for workers. ･Application of personal protective gears ･Construction of temporary first aid station at the working site with nurse. ･Establishment of cooperative relationship with the local medical facilities.	PIU/LPGCL/EPC Contractor	PIC/GHCL	Cost included in EPC Contract
C. Operation phase					
Environment					
Air quality					
Fugitive emissions from coal storage areas	Dust emissions	･Dust extraction/suppression system will be provided at transfer points of conveyor system and ventilation system to supply fresh air; ･Roof extraction fans will be provided in essential areas like crusher house and boiler bunker floors. ･Conveyor belt will be enclosed to prevent dust generation; ･Provision of water sprinkling system at material handling and storage yard; ･Asphalting of the roads within the plant area; and ･Developing of Greenbelt or wind break wall around the plant to arrest the fugitive emissions.	LPGCL	GHCL	Cost is included in EPC contract.
	Fire hazards from auto generated combustion	･Self–generated combustion of coal stock prevented by limiting the coal stock height to design limit of 15 meters, and compaction of coal stock to avoid the air passage.	LPGCL	GHCL	Cost is included in EPC contract.

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
Fugitive emissions from fuel		・Provision and periodic inspections of mechanical seals in pumps; ・Preventive maintenance of valves, flanges, joints, roof vents of storage tanks; and ・Submerged filling of liquid fuel storage tanks.	LPGCL	GHCL	
Stack emission	Changes in ambient air quality due to stack emissions	・Regular monitoring of ambient air quality is recommended and presented in the Environmental Monitoring Plan. ・Installation of continuous emission monitoring system (CEMS) equipment on the new stack for coal-fired boilers.	LPGCL	GHCL	Cost is included in EPC contract. Ambient Air Quality Mobile Monitoring Station: USD 50,000 CEMS at stack: USD 160,000
Water and effluent waste					
Wastewater from plant	Pollution of receiving water bodies	・Complete treatment of wastewater including the cooling tower blowdown. ・Use of infiltration and runoff control measures such as compacted soils, protective liners, and sedimentation controls for runoff from coal piles; treatment of low–volume wastewater streams that are typically collected in the boiler and turbine room sumps in conventional oil–water separators before discharge; treatment of acidic low–volume wastewater streams, such as those associated with the regeneration of makeup demineralizer and deep–bed condensate polishing systems, by chemical neutralization in–situ before discharge; pretreatment of cooling tower makeup water, installation of automated bleed/feed controllers, and use of inert construction materials to reduce chemical treatment requirements for cooling towers; and elimination of metals such as chromium and zinc from chemical additives used to control scaling and corrosion in cooling towers. ・Regular monitoring of water is recommended and presented in the Environmental Monitoring Plan.	LPGCL	GHCL	Cost is included in EPC contract. Monitoring: USD 20,000

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
Storm Water	Typically storm water runoff contains suspended sediments, metals, petroleum hydrocarbons, coliform, etc.	・Rainfall runoff from the coal pile will contain mainly suspended solids. This runoff will be routed to the wastewater treatment facility for treatment and re-use for sprinkling, if possible, or discharged. ・Storm water will be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge. ・Surface runoff from process areas or potential sources of contamination will be prevented. ・Oil water separators and grease traps will be installed and maintained as appropriate at refueling facilities, workshops, parking areas, fuel storage and containment areas. ・Adequate storm drains will be constructed along the boundary of the plant area and within the plant area to drain off the storm water during monsoon period. ・Limestone and gypsum storage areas will be covered so that there will be no contaminated runoff.	LPGCL	GHCL	Cost is included in EPC contract.
Ground water	Contamination of groundwater due to leachate from ash pond	・HDPE is applied to the bottom of ash pond	LPGCL	GHCL	Cost is included in EPC contract.
Treated waste water from Housing Colony	Land degradation due to open drainage of water	・Regulation of the use of effluent water for agriculture and provision of outlets to farmers under agreements for water use with permission from the Irrigation Department;	LPGCL	GHCL	Cost is included in EPC contract.
Waste					
Wastes	Health hazard by inappropriate disposal of municipal, industrial and hazardous waste	・Municipal and industrial wastes are segregated by labours before the collection. ・Training for handling the hazardous waste is implemented to all labors in advance. ・Licensed company is selected by bid every year.	LPGCL	GHCL	Rs. 100 /ton (municipal, industrial, hazardous waste)
Fly ash	Dust	・Fly ash is recycled by cement companies as much as possible. ・Water sprinkling is implemented in order to avoid dust diffusion.	LPGCL	GHCL	N/A

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
Sludge from FGD	Water pollution	・The sludge from the FGD will be treated to separate the gypsum which can be potentially sold in the market and water. The water will be treated by first separating the solid material and then through the plant treatment system. ・The gypsum, if it cannot be marketed, will be disposed in the ash pond.	LPGCL	GHCL	N/A
Noise					
Noise	Noise from equipment	・The occupational noise exposure to the workers in the form of 8 – hourly time weighted average will be maintained well within the 60 dB (A)). Acoustic enclosures will be provided wherever required to control the noise level below 60 dB (A). Anywhere not possible technically to meet the required noise levels, personal protection equipment will be provided to the workers. ・The operation noise of the plant will comply with IFC +3 noise level standards which restricts the noise to 3 decibel increase in the existing background noise level prevailing in the nearby communities. For this purpose, noise mufflers will be employed around the noisy machinery to reduce their impact on the ambient noise level.	LPGCL	GHCL	Cost is included in the EPC contract. Monitoring: USD 10,000
Odor					
Odor	Kitchen waste, septic tanks	・Kitchen waste is segregated at waste storage facility. ・Septic tanks are inspected regularly and kept in good condition by assing chlorine.	LPGCL	GHCL	N/A
	Spontaneous ignition of coal, ash	・Water is sprinkled on coal and ash in order to avoid spontaneous ignition.	LPGCL	GHCL	N/A
Ecosystem					
Ecosystem	Suction of aquatic organism	・To install the intake screen to avoid suction of fishes.	EPC Contractor	PIC	Cost is included in the EPC contract.
Socio-economics					
Health and Safety					

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
Boilers	Higher exposure to electric and magnetic fields	· Identification of potential exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities; · Training of workers in the identification of occupational Electromagnetic Fields (EMF) levels and hazards; · Establishment and identification of safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting access to properly trained workers; · Implementation of action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the International Commission on Non–Ionizing Radiation Protection (ICNIRP), the Institute of Electrical and Electronics Engineers (IEEE). Personal exposure monitoring equipment will be set to warn of exposure levels that are below occupational exposure reference levels (e.g., 50 percent). Action plans to address occupational exposure may include limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, or the use of shielding materials.	LPGCL	GHCL	Cost is included in the EPC contract.
	Heat Exposure	· Regular inspection and maintenance of pressure vessels and piping; · Provision of adequate ventilation in work areas to reduce heat and humidity; · Reducing the time required for work in elevated temperature environments and ensuring access to drinking water; · Shielding surfaces where workers come in close contact with hot equipment, including generating equipment, pipes etc; · Use of warning signs near high temperature surfaces and personal protective equipment (PPE) as appropriate, including insulated gloves and shoes.	LPGCL	GHCL	Cost is included in the EPC contract.
Living and livelihood	Positive impact on local economic structure	· Project would expedite new job and business opportunities by recruiting unskilled labors from the adjacent communities · Using services from local vendors for regular business and every goods.	PIU/LPGCL	PIC/GHCL	

Items	Potential impact	Environmental Mitigation and Management Plan	Prepared/ Implemented by	Reviewed/ Approved/ Supervised by	Cost
Working condition and accident	Working condition	・ Development of occupational health and safety management plan ・ Implementation of periodic health check and education for workers ・ Restriction of long-time exposure to noise for workers. ・ Application of personal protective gear ・ Installation of first aid station/kits at the working site ・ Installation of traffic signs, driving safety education, speed restriction, check/maintain vehicle equipment (brake, klaxon). ・ Development of gas-leakage prevention management plan. ・ Installation of gas-leakage alarm system, stationary fire prevention system, fire hydrant, fire extinguisher, fire escape exit, fire alarm, fireproof compartment, emergency exit, etc. ・ Installation of automatic control system. ・ Same EMP as [Use of Land Resource]	EPC Contractor	PIC	Cost is included in the EPC contract.
	Fire hazards from spontaneous combustion of coal and ash	・ Self-generated combustion of coal stock prevented by limiting the coal stock height to design limit of 15 meters, and compaction of coal stock to avoid the air passage. ・ Water is sprinkled on coal and ash in order to avoid spontaneous ignition.	LPGCL	GHCL	Cost is included in the EPC contract
Other					
Transboundary waste treatment and climate change	Carbon dioxides emissions	・ High efficient power generation technology, USC, is adopted, which generates less CO_2 than subcritical and supercritical pressure type of boiler.	GHCL	-	-

Source: JICA Survey Team

(6) Environmental Monitoring Plan for Power Plant

The detail of the Environmental Monitoring Plan during construction and operation phase is shown in Table 11.5-8.

Rules for the environmental monitoring are designated in NEQS (Self-Monitoring and Reporting by Industry) rules, 2001, in which priority parameters for monitoring of liquid effluents and gaseous emissions are provided according to the type of industries. This project is categorized in “Thermal Power Plants (Coal and Oil based)” in the NEQS.

According to the air quality monitoring, maximum ground level pollutant concentrations are expected in northeastern area of the projected power plant, located along N-55 about 1 km from the site as shown in Appendix 11-6. Therefore this area should be considered as one of the monitoring points of the ambient air quality during construction and operation phases.

Sample of Monitoring Form is shown in Appendix 11-4. Implementing agency shall submit the monitoring report to JICA by using this form.

Table 11.5-8 Environmental Monitoring Plan (Power Plant)

Item	Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Agency	
					Implementation	supervision
A. Construction Phase						
General	Handling and storage of parts and equipment at plant	Work Sites	・Visual inspection	Daily	EPC Contractor	PIC/LPGCH/ GHCL
	Top soil	Construction areas	・Top soil of 0.5 m depth will be excavated and stored properly	Beginning of earth filling works	EPC Contractor	PIC/LPGCH/ GHCL
	Erosion	Construction areas and material storage sites	・Visual inspection of erosion prevention measures and occurrence of erosion	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
	Hydrocarbon and chemical storage	Construction camps	・Visual Inspection of storage facilities	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
	Local roads	Approach Roads	・Visual inspection to ensure local roads are not damaged	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
	Traffic safety	Haul Roads	・Visual inspection to see whether proper traffic signs are placed and flagmen for traffic management are engaged	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
Air quality [1]	PM, NO_2, SO_2, CO	Suggested locations are: ・locations where the impact of power plants, road traffic, and other sources are minimal; ・locations near the N-55; ・locations near maximum ground level concentration (GLC); and ・sensitive receptors (e.g. plant housing colony).	・Fixed air quality monitoring station (two) and mobile air quality monitoring station (one).	Suggested frequency is continuously at two locations (fixed station) and once in a month at other locations for one day.	EPC Contractor through External contractor or arrangements with educational or government agencies	PIC/LPGCH/ GHCL
	Dust, smoke	Construction sites	・Visual inspection to ensure good standard equipment is in use and dust suppression measures	Daily	EPC Contractor	PIC/LPGCH/ GHCL

Item	Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Agency	
					Implementation	supervision
			(spraying of waters) are in place.			
		Material storage sites	・Visual inspection to ensure dust suppression work plan is being implemented	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
Water quality	Drinking water and sanitation	In construction sites and construction camps	・Ensure the construction workers are provided with safe water and sanitation facilities in the site	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
	River water pollution by effluent	Construction sites along the Indus river	・Ensure the construction workers are provided with sanitation facilities (temporary lavatories) in the site	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
Waste management	Municipal waste, industrial waste, hazardous waste	Construction camps and construction sites	・Visual inspection that solid waste is disposed at designated site	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
Noise and vibration	Noise	・Construction site ・Boundary area of the power plant, ・Nearest residence or primary school	・Visual inspection to ensure good standard equipment are in use	Weekly	EPC Contractor through a nationally recognized laboratory	PIC/LPGCH/ GHCL
			・Hourly, day and night time noise levels (dB) monitoring using noise meters	Quarterly	EPC Contractor through a nationally recognized laboratory	PIC/LPGCH/ GHCL
Odor	Kitchen waste	Waste storage facility	・Visual inspection that those wastes are disposed of at designated sites	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
	Septic tank	Lavatory	・Visual inspection that the lavatories are properly managed.	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
Socio-economics	Cultural and archeological sites	At all work sties	・Visual observation for chance finding	Daily	EPC Contractor	PIC/LPGCH/ GHCL
	Reinstatement of work sites	All work sites	・Visual Inspection	After completion of all works	EPC Contractor	PIC/LPGCH/ GHCL
	Safety of workers	At work sites	・Usage of Personal Protective equipment	Monthly	EPC Contractor	PIC/LPGCH/ GHCL
	Infectious Diseases	Construction site	・The number of reported infections	Regular health checks	EPC Contractor	PIC/LPGCH/ GHCL
	Accidents and safety	Construction site	・The numbers, contents, and processing results of diseases,	Every day	EPC Contractor	PIC/LPGCH/ GHCL

Item	Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Agency	
					Implementation	supervision
			accident if occurred			
	Gender	Project site	・Status of the Grievance Redress Mechanisms (GRM) establishment, ・The number of grievance	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
B. Operation Phase						
Air quality [1]	Stack emissions	Prior to pre–treatment in ESP and FGD and at the exit of the stack	・For the new stack for coal-fired boilers, continuous monitoring using on–line equipment during operation phase (SO_2, NOx, CO, PM_{10} and $PM_{2.5}$) and exit gas temperature and velocity. ・Monthly monitoring as per the SMART [2] rules through third-party contractor.	Continuous monitoring	LPGCL	GHCL
	Ambient air quality	Near sensitive sites and settlements	・24 hours air quality monitoring of PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO	Continuously at two locations (fixed station) and once every month at other locations for one day	PGCL through nationally recognized laboratory/with mobile lab to be owned by LPGCL for air quality monitoring	GHCL
Water quality	Waste water drained into the river	At the point where effluent leaves within the plant boundary	**[normal plant conditions]** ・SMART [2] parameters (flow, temperature, pH, TSS, oil & grease) and TDS for a 24 hour composite sample	Monthly	LPGCL	GHCL
			・Heavy metals (Zn, Pb, Ni, Fe, Hg, Cu, Co, Cr, As, CD) for a 24 hour composite sample - in order to meet the regulatory requirement and IFC Guidelines	Quarterly	LPGCL	GHCL
			[start-up and upset conditions] ・SMART [2] parameters (flow, temperature, pH, TSS)	Hourly	LPGCL	GHCL
	Groundwater	Around ash pond	・Parameters (NEQS Guidelines for Drinking Water)	Monthly	LPGCL	GHCL

Item	Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Agency	
					Implementation	supervision
Waste	Municipal waste, industrial waste, hazardous waste	Waste storage facility at power plant	・Visual inspection that each waste is disposed of at designated site ・Evidenced documents (invoice, payment receipt, manifesto, etc.)	Monthly	LPGCL	GHCL
	Ash	Department/person in charge of ash management	・Evidenced documents (delivery record, etc.) ・Agreement between cement company	Monthly	LPGCL	GHCL
Noise and vibration	Noise	・Boundary area of the power plant, ・Nearest residence or primary school	Hourly, day and night noise levels (dB) monitoring using noise meters	Quarterly	LPGCL	GHCL
Odor	Solid and liquid waste	Waste storage facility	・Visual inspection that those wastes are disposed of at designated sites	Monthly	LPGCL	GHCL
	Septic tank	Lavatory	・Visual inspection that the lavatories are properly managed.	Monthly	LPGCL	GHCL
	Spontaneous ignition of coal	Coal yard	・Visual inspection	Continuous	LPGCL	GHCL
	Spontaneous ignition of ash	Ash pond	・Visual inspection	Continuous	LPGCL	GHCL
Ecosystem	Fish Fauna	At three locations: upstream of Project, point of effluent discharge and downstream of Project	・Sampling surveys to determine abundance (catch per unit effort) and diversity of fish at selected locations	Annually in November	LPGCL	GHCL
Social Environments	Grievances on Land Acquisition, Resettlement, Living and Livelihood, Use of Land, Water and Social Infrastructure, Social conflicts, Unevenness of Project Benefits	NA	・The numbers, contents, and processing results of grievances	Everyday	Public Complaints Unit (PCU), Grievance Redress Committee (GRC), Grievance Focal Points (GFPs)	GHCL
	Gender	Project site	・Status of the Grievance Redress Mechanisms establishment, the	Monthly	Public Complaints Unit	GHCL

Item	Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Agency	
					Implementation	supervision
			number of grievance		(PCU), Grievance Redress Committee (GRC), Grievance Focal Points (GFPs)	
	Report on Working Condition and Accident	NA	・The numbers, contents, and processing results of diseases, accident if occurred	Everyday	EPC Contractor	GHCL

1. Gaseous emissions: metal analysis of all gaseous emission would be carried out once in two years.
2. NEQS (self-Monitoring and Reporting (SMART) by Industry) Rules, 2001

Source: JICA Survey Team

(7) Total Budget Estimates

Cost estimates are prepared for all the mitigation and monitoring measures proposed in the EMP. The details of the cost estimates and the budget during construction stage and first three years of operation stage for the mitigation and monitoring measures are given in Table 11.5-9. The cost estimates for control measures and some of the mitigation measures that were already part of Engineers estimate are not included in the EMP.

The cost estimates also includes the budget for environmental monitoring, consultants for EMP implementation, institutional strengthening and capacity building of power plant staff and environmental enhancement/compensation measures.

The total budget for EMP implementation is estimated to be about US$ 866 thousand.

Table 11.5-9 Environmental Monitoring Plan (Power Plant)

	Item	Unit	Unit Cost US$	Quantity	Total Cost US$
A	**Environmental Monitoring (Design, Construction, and Operation Periods) – 6 years**				
1	Air quality monitoring fixed station	Station	80,000	2	160,000
2	Air quality monitoring mobile station	Station	50,000	1	50,000
3	Air quality monitoring recurring cost (6 years)				428,000
4	Monitoring of SMART parameters in effluent water @ monthly monitoring over 6 years)	Site	50	72	3,600
5	Heavy metals monitoring in effluent water (@ Quarterly over 6 years)	Site	70	24	1,680
6	Groundwater quality monitoring (5 sites@ 3 yearly over 6 years)	Site	500	30	15,000
7	Noise monitoring (5 sites@ 4 yearly over 6 years)	Site	25	120	3,000
8	Equipment for monitoring noise and dust				7,400
	Sub Total (A)				**668,680**
B	**Social Augmentation Plan Implementation**				**122,320**
C	**Training Cost**				**75,000**
	Grand Total (A+B+C)				**866,000**

(8) Suggestion of Mitigation Measures to existing Lakhra Plant

1) Air Quality

As indicated by the baseline ambient air quality sampling test (Section 11.2.1 (6)) and stack emission measurement test (Section 11.1.5 (4)), the existing Lakhra Plant apparently contributes to the high concentration of particulate matters (PM_{10} and $PM_{2.5}$) and SO_2 ambient air quality. To ensure that those parameters would meet the SEQS as well as IFC Guidelines, JICA requested

GHCL to take appropriate mitigation measures to the existing Lakhra Plant by the time the construction work starts. Measures shown in Table 11.5-10 were proposed from JICA. GHCL agreed to the suggestion in Minutes of Meetings on November 26, 2014.

Table 11.5-10 Mitigation Measures for Existing Lakhra Plant

Parameter	Possible measures
Particulate Matter	• Rehabilitation of existing bag filter • Newly installation of bag filter • Installation of Electrostatic Precipitator (ESP)
SO_2	• Flue Gas Desulfurization System (FGD) • Procurement of pure limestone (purity rate: more than 99%) and appropriate operation management

Source: JICA Survey Team

2) Ash Disposal

As described in Section 11.1.5, coal ash from the existing Lakhra Plant is disposed of at the designated ash disposed areas. According to some residents living near the existing Lakhra Plant, however, the ash sometimes is disposed of near residential sites. According to stakeholder consultations, residents of Koreja village located in 3km north of the existing Lakhra Plant raised issues in deterioration of their agricultural land and health problems such as eye irritation and respiratory problems due to the disposed ash. There are no official medical records that support the causal relationship between ash from the existing Lakhra Plant and these claims on health problems though, some residents are not in favor of the Project.

To address this complaint on ash dumping, JICA requested GHCL to take mitigation measures. JICA suggested GHCL that LPGCL shall dispose of the ash at designated area located in the west of the existing Lakhra Plant, not in the vicinity of residential areas. GHCL agreed to the suggestion in Minutes of Meetings on November 26, 2014.

Though apart from this Project, an appropriate ash disposal area should be prepared to prevent the air pollution and soil/water pollution due to the ash in near future. Possible mitigation measures are as follows;

- ✓ High Density Polyethylene (HDPE) liner under the facility
- ✓ Installation of wall or net around the facility to prevent ash dust from dispersing to surrounding area
- ✓ Sprinkler system to wet and solidify the ash.

(9) Environmental and Social Impacts in case Blended Coal Is Used

As described in Section 11.5.1., after Thar coal becomes available, bended coal with 80 %

imported coal and 20 % Thar coal would be used for the proposed project. The blending ratio of Thar coal would be at most 20 % due to the specifications of the power plant as shown in Chapter 7.

Expected adverse impacts on environment and social due to the use of Thar coal are described below.

1) Transportation Route of Thar Coal

Thar coal will be transported from Thar coalfield to Lakhra by truck. Four route options were evaluated during this survey.

(a) Candidate Routes

Route alternatives of the transportation from Thar coalfield by trucks are shown in Table 11.5-11.

Table 11.5-11 Transport Route Option

Route Option	*Route*	*Major towns*	*Length*	*No of roads intersection*	*No of water bodies*	*Settlement density **	*Average width ***
1	Islamkot-Mithi-Digri-Mirpur Khas-Hyderabad-Jamshoro	Islamkot, Mithi, Naukot, Jhudo, Tando Jan Mohammad, Digri, Mirwah, Gorchani, Mirpur Khas, Tando Allahyar, Tando Jam, Hyderabad, Jamshoro	304 km	99	21	13.8%	3.32 m
2	Islamkot-Mithi-Digri-Matli-Hyerabad-Jamshoro	Islamkot, Mithi, Naukot, Jhudo, Tando Jan Mohammad, Digri, Tando Ghulam Ali, Matli, Tando Muhammad Khan, Hyderabad, Jamshoro	262 km	98	54	14.5%	2.84 m
3	Islamkot-Mithi-Badin-Matli-Hyderabad-Jamshoro	Islamkot, Mithi, Shadi Large, Khoski, Nindo, Badin, Piro, Lashari, Talhar, Matli, Tando Muhammad Khan, Hyderabad, Jamshoro	307 km	89	28	11.5%	2.82 m
4	Islamkot-Mithi-Badin-Thatta-Jamshoro	Islamkot, Mithi, Shadi Large, Khoski, Nindo, Badin, Golarchi, Sujawal, Thatta, Piro Lashari, Talhar, Kotri, Jamshoro	359 km	94	82	7.9%	3.59 m

* estimated percentage of area covered by settlements and structures within 200 m of the route

** weighted average width of different segments of the route

Source: JICA Survey Team

(b) Result of Traffic Survey

Physical Aspect

As described in Section 5.4 (Transportation of Thar Coal by Truck), Route 3 is assessed as the most appropriate route out of four candidates (Figure 11.5-4).

Environmental and Social Aspect

According to the physical assessment, Route 2 needs the most expensive rehabilitation cost and Route 4 needs long running time due to the longest distance. Regarding Route 1 and 3, environmental and social surveys, i.e. sensitive receptors, populated townships, water bodies, etc., were conducted in March 2014.

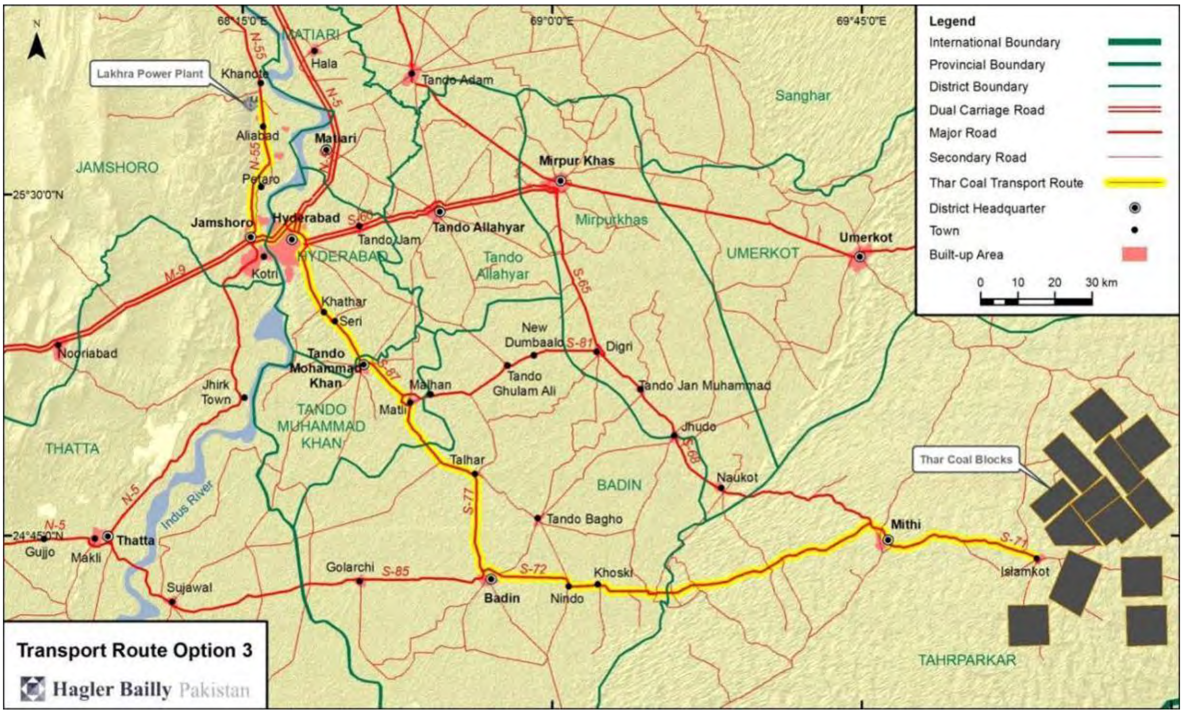
- Transport Route Option 1

  Total length is 304 km. The route passes through 13 towns. Several of the towns on the route have bypass-roads constructed to deter passage of heavy traffic through the towns. The bypasses are not fully utilized and through traffic still pass through the towns. On the route, most of the road line is consisted of single carriageway.

- Transport Route Option 2

  Total length is about 307 km. The route passes through 12 major towns. Several of the towns on the route have bypass-roads constructed to deter passage of heavy traffic through the towns. The bypasses are not fully utilized and through traffic still pass through the towns. On the route, most of the road line is consisted of single carriageway.

The result of traffic survey is shown in Table 11.5-12. This result indicates that Route 1 includes more buildings such as settlements, educational facilities, health facilities and mosques, etc. As a result, Route 3 is evaluated as the most appropriate route from environmental and social point of view.



Source: Hagler Bailly Pakistan

Figure 11.5-4 Recommended Route for Thar Coal Transportation (Route 3 is colored by yellow.)

Table 11.5-12 Summary of Transport Route Receptors

Segment		Length (km)	Route		Receptors						
From	to		Option 1	Option 3	Settlement	Educational Facilities	Health Facilities	Mosques	Water Bodies	Playgrounds	Shrine
Lakhra Power Plant (N-55)	Jamshoro Stop on N-5	37	☒	☒	8	7	1	5	0	0	0
Jamshoro Stop (on N-5)	Hala Turning (on N-5)	15	☒	☒	1	0	0	2	5	0	0
Hala Turning (on N-5)	Fateh Roundabout	8	☒	☒	0	2	1	4	1	0	0
Fateh Roundabout	Mirpur Khas	66	☒	☐	7	5	2	7	6	1	3
Mirpur Khas	Degri	41	☒	☐	10	2	0	5	3	0	1
Degri	Naukot	47	☒	☐	6	5	2	6	4		1
Mithi	Thar Coal Blocks	60	☒	☒	1	1	0	2	0	0	0
Fateh Roundabout	Matli	53	☐	☒	7	5	0	5	4	0	1
Matli	Badin	50	☐	☒	4	0	0	2	6	0	3
Badin	Mithi	104	☐	☒	4	1	0	4	12	0	0
Naukot	Mithi	50	☒	☐	4	1	0	4	2	0	0
Summary											
Route Option 1	-	**324**	-	-	**37**	**23**	**6**	**35**	**21**	**1**	**5**
Route Option 3	-	**327**	-	-	**25**	**16**	**2**	**24**	**28**	**0**	**4**

Source: Hagler Bailly Pakistan

2) Environmental and Social Impact due to Coal Transportation

Aspects resulting from transportation of Thar coal to the Project site are:

- Incremental increase in the existing traffic on the road will affect the daily commuters
- Traffic interference may cause nuisance and safety hazards

- Emission and noise level will affect the air quality and cause nuisance to communities living alongside the route selected for transportation
- Degradation of the existing roads

Currently Lakhra coal is transported from Lakhra coalfield to the Lakhra Plant using N-55. As the route where trucks transports Lakhra coal and route where trucks would transport Thar coal are not duplicated, when it comes to traffic baseline, the number of trucks transporting Lakhra coal is not considered.
In Table 11.5-13, the existing traffic and the projected traffic on N-55 is presented.

Table 11.5-13 Daily Road Traffic on N-55

Current Traffic (2013)	
Light vehicles	7,594
Heavy vehicles	1,804
Total	9,398
Projected traffic (2015)[1]	
Light vehicles	8,809
Heavy vehicles	2,093
Total	10,901

Source: Hagler Bailly Pakistan

Thar coal will be transported by trucks. GHCL will work with the Sindh Coal Authority (SCA) to undertake appropriate actions such as rehabilitation, bypass constructions, etc. to enable the heavy trucks to move smoothly taking into account environmental and social aspects.

According to Table 5.5-2, the number of trucks (60 ton type trailers) used for the transportation of Thar coal is calculated to be 1,820 vehicles per day. Traffic impact on N-55 associated with transportation of Thar coal will be minor as the incremental traffic volume would be one fifth of the levels indicated in Table 11.5-13.

On the other hand, there is possibility that coal dust would drop from the trucks due to wind and vibration and be dispersed along roads during transportation. Though the impact of dispersed coal on human health is occasionally raised in the world, especially in case of rail transportation (e.g. Australia), the impact is expected to be minor because the dispersion is limited to short distance from roads due to the size of dropped coal dust. In order to mitigate the environmental impact, loaded coal should be covered with plastic sheets made of polyester.

[1] Pakistan Economic Survey, 2008-2009, a 7.7% annual growth applied based on last 10 years average growth of Pakistan countrywide traffic from 1992-2009

As Thar coal is lignite coal, there is a possibility that spontaneous combustion would occurs due to oxidation action and friction of coal during coal transportation. Running time required for coal transportation in case of Route 3 is calculated to be 8.7 hours (Table 5.5-1). In order to avoid spontaneous combustion, covering application to loaded coal with sheets would be effective, by which oxidation action may be reduced.

3) Comparison of CO_2 Emission between Single and Mix Burning

Calculation results of CO_2 emissions in case of single burning with imported coal and mix burning with 80% imported coal and 20% Thar coal are shown in Table 11.5-14 and Table 11.5-15 respectively. Those results show that CO_2 emissions from mix burning would be increased by 3.1% compared with single burning.

Table 11.5-14 CO_2 Emission for each Boiler Type (single burning)

	Parameter	*FCi,y* 1)	*NCVi* 2)	*EFfuel,i* 2)	*PEy*
Type of boiler	Type of coal	ton/year	GJ/ton	t-CO_2/GJ	t-CO_2/year
Subcritical	Imported coal (Sibbituminous)	1,683,910	18.9	0.0961	3,058,469
Supercritical		1,547,007	18.9	0.0961	2,809,813
Ultra Supercritical		1,494,360	18.9	0.0961	2,714,191

1) Equivelant quantity with 600MW (net)

2) 2006 IPCC Guidelines for National Greenhouse Gas Inventries

Source: JICA Survey Team

Table 11.5-15 CO_2 Emission for each Boiler Type (mix burning)

	Parameter	*FCi,y* 1)	*NCVi* 2)	*EFfuel,i* 2)	*PEy*
Type of boiler	Type of coal	ton/year	GJ/ton	t-CO_2/GJ	t-CO_2/year
Subcritical	Thar coal (Lignite)	334,534	11.9	0.1010	402,076
	Imported coal (Sibbituminous)	1,515,519	18.9	0.0961	2,752,622
	Total	1,850,053			**3,154,698**
Supercritical	Thar coal (Lignite)	307,336	11.9	0.1010	369,387
	Imported coal (Sibbituminous)	1,392,306	18.9	0.0961	2,528,831
	Total	1,699,642			**2,898,218**
Ultra Supercritical	Thar coal (Lignite)	296,877	11.9	0.1010	356,816
	Imported coal (Sibbituminous)	1,344,924	18.9	0.0961	2,442,772
	Total	1,641,801			**2,799,588**

1) Equivelant quantity with 600MW (net)

2) 2006 IPCC Guidelines for National Greenhouse Gas Inventries

Source: JICA Survey Team

4) Comparison of Air Pollutant Emission between Single and Mix Burning

Table 11.5-16 shows the comparison of air pollution emissions generated from the power plant between scenario 1 (mix burning) and scenario 2 (single burning). According to the air modeling, the maximum ground concentrations of sulfur dioxide and nitrogen dioxide from scenario 1 are estimated to be slightly larger than scenario 2. Regarding PM_{10} and $PM_{2.5}$, the concentrations have no difference between those scenarios. Detail modeling results are presented in Appendix 11-6.

Table 11.5-16 Air Quality Modeling Results (μg/m³) for Scenario 1 and 2

Pollutant	Period	SEQS	IFC Guidelines	Estimated Background	Predicted Increment due to Proposed Plant (660 MW)	
					Scenario 1 80% Imported Coal; 20% Thar Coal	Scenario 2 100% Imported Coal
SO_2	Maximum 24–hr	–	125	10.8	7.7	7.1
	24–hr (98th %le)	120	–		7.3	6.7
	Annual	80	–		1.9	1.8
NO_2	Maximum 24–hr	–	200	21.1	6.2	6.1
	24–hr (98th %le)	80	–		5.8	5.8
	Annual	40	40		1.5	1.5
PM_{10}	Maximum 24–hr	–	150	69.1	1.5	1.5
	24–hr (98th %le)	150	–		1.5	1.4
	Annual	120	70		0.4	0.4
$PM_{2.5}$	Maximum 24–hr		75	43.1	0.7	0.7
	24–hr (98th %le)	75	–		0.7	0.7
	Annual	40 or background plus 9	35		0.2	0.2

11.5.3 Transmission Line

Four transmission lines will be connected to existing two 500 kV transmission lines of which two lines are located in 1.2 km and the others in 4.2 km east from the site.

(1) Scoping for Transmission Line

According to the JICA Guidelines (April 2010), the predicted environmental impacts are assessed by referring to the results of first and second site works as shown in Table 11.5-17.

Table 11.5-17 Result of Scoping (Transmission Line)

No.	Item	Assessment: Pre/Construction Phase	Assessment: Operation Phase	Assessment Reason
Pollution Control				
1	Air Quality	B-	D	**[Construction Phase]** Temporary dust may be generated as a result of construction activities. Besides, exhaust emissions (CO, SOx, NOx and PM_{10}) are generated from stand-by diesel generator, material transport vehicles and construction machinery /earth moving equipment. **[Operation Phase]** No adverse impact is expected.
2	Water Quality	B-	C-	**[Construction Phase]** Site erosion and landslides due to the construction activities including installation of towers, construction of new access roads and clearing of tower basis leads to the contamination of surface and ground water. **[Operation Phase]** Spills of oil and chemicals during operation and maintenance might impact on ground water.
3	Soil Quality	B-	B-	**[Construction Phase]** Generated wastes such as waste concrete, steel scrap, wooden scaffolding, empty cement bags, excavated soil, wood remains etc. would cause negative impact on the surroundings. **[Operation Phase]** During operation and maintenance activities, spills of oil and chemicals may occur.
4	Wastes	B-	D	**[Construction Phase]** Solid wastes and hazardous wastes might be generated from base camps and construction sites. **[Operation Phase]** No waste would be generated.
5	Noise and Vibration	B-	D	**[Construction Phase]** Noise may be generated from heavy machinery, vehicles and construction activities including excavation. **[Operation Phase]** No noise would be generated.
6	Subsidence	D	D	**[Construction & Operation Phase]** No subsidence would occur.
7	Odor	B-	D	**[Construction Phase]** Odor might be generated from temporary construction camps due to solid and liquid wastes. **[Operation Phase]** No odor would be generated.
Natural Environment				
8	Protected Areas	D	D	**[Construction & Operation Phase]** There is no protected area within the ROW.
9	Ecosystem	C-	C-	**[Construction & Operation Phase]** Further site investigations shall be done.

No.	Item	Assessment		Assessment Reason
		Pre/Construction Phase	Operation Phase	
10	Hydrology	D	D	**[Construction & Operation Phase]** As there is no major water body, no adverse impact is expected.
11	Topography and Geology	D	D	**[Construction & Operation Phase]** No large-scale topographical and geological change is predicted
Social Environment				
12	Resettlement (Land acquisition)	C-	C-	**[Pre/Construction Phase]** Physical and economical relocation might be expected due to temporary land acquisition. **[Operation Phase]** Land that falls under ROW are accessible and no need of permanent land acquisition.
13	People below the Poverty Line	C-/C+	C-/C+	**[Pre/Construction and Operation Phase]** Income of the people below poverty line may be affected due to land acquisition without appropriate mitigation measures. Job creation and provision of job training would impact positively.
14	Ethnic, Minorities and Indigenous People	C-	C-	**[Pre/Construction and Operation Phase]** Investigation is required to identify whether people other than Muslim such as Hindi, Christian and other minor groups of people are more vulnerable to project impacts compared with the major religious group.
15	Living and Livelihood	C-/C+	C-/C+	**[Pre/Construction Phase]** Temporary land acquisition for tower construction, contractor's camp, access roads etc. will adversely affect living and livelihood of land owners. **[Construction Phase]** Loss of crops, cropping seasons and trees within the ROW will adversely affect income of the owner. Job creation and provision of job training would impact positively. **[Pre/Construction and Operation Phase]** Economic inequality/ income gap may occur between the project workers and other people in communities.
16	Use of Land and Resources	C-	C-	**[Pre Construction Phase]** Loss of crops and trees within the ROW. **[Construction Phase]** The general mobility of locals and their livestock in and around TL will be temporary affected in specific locations. Loss of cropping seasons within the ROW. **[Operation Phase]** Restriction of agricultural use within the land under the towers. Restriction of plantation of trees (e.g. orchards) above certain height. The value of land may vary in the long term basis due to the erection of towers and the TL passing.
17	Water Use	C-	D	**[Construction Phase]** Temporary contamination of surface and ground water due to construction activities (clearing and grabbing, excavation, filling, laying down concrete foundation for towers and camps, use of fuel and lubricants etc.) may affect water use (for the purpose of drinking, agriculture and fishing).
18	Infrastructure and Social Services	B-	D	**[Construction Phase]** Stringing across the existing roads may temporary disturb traffic.

No.	Item	Assessment		Assessment Reason
		Pre/Construction Phase	Operation Phase	
19	Social Capita, Institutions and Conflicts	C-	D	**[Pre Construction Phase]** Differences in acceptance of the project and income gap among stakeholders may change social relation, deepen hierarchies and, create conflicts.
20	Heritage	C-	D	**[Construction Phase]** Syed Daad Shaheed Shrine might be impacted in terms of sound, vibration and traffic disturbance.
21	Landscape	B-	B-	**[Construction Phase]** Temporary restriction in use of land in and around ROW of TL. **[Operation Phase]** Landscape along ROW will be changed due to having towers and lines
22	Gender and Child Issue	C-	C-	**[Construction Phase]** Difference in benefits of temporary job opportunities between men and women will be arisen. **[Construction and Operation Phase]** Gender issues such as any un-ethical activities, disturbance in routine movement, increase in work load may be caused.
23	Child Right	C-	C-	**[Construction Phase]** Temporal job opportunities in construction work may result in an increase in number of child labors. **[Construction and Operation Phase]** Degradation of income source and livelihood standard may worsen the situation of child labor and school drop-out.
24	Infectious Diseases	B-	D	**[Construction Phase]** Influx of workers may increase risks in respiratory and infectious disease.
25	Working Condition and Accident	B-	B-	**[Construction Phase]** Risks of accident, spread of infectious diseases may be increased. **[Operation Phase]** Accident could be occurred in work environment.
26	Transboundary Waste Treatment and Climate Change	B-	D	**[Construction Phase]** Temporary emissions of CO_2 from trucks and heavy machines are expected. **[Construction and Construction Phase]** No transboundary of waste would occur.

A+/-: Significant positive/negative impact is expected

B+/-: Positive/negative impact is expected to some extent

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

D: No impact is expected

Source: JICA Survey Team

(2) TOR for Environmental and Social Consideration Survey for Transmission Line

TOR for environmental and social consideration survey is shown in Table 11.5-18.

Table 11.5-18 Terms of Reference (Transmission Line)

Environmental Item	Survey Item	Survey Method
Consideration of alternatives	(1) Route of transmission lines and location of steel towers	(1) Data collection of residential area, affected facilities (school, hospital, etc.), wetland, pond and river, road (e.g. Indus Highway), protected area
Air Quality	(1) Confirmation of environmental standards (NEQS, IFC, etc.) (2) Current condition of air quality (3) Confirmation of location of residence, school and hospital, etc. around the ROW. (4) Adverse impact during construction	(1) Collection of air quality standards (2) Measurement of current air quality (baseline) (3) Site investigation (4) Prediction of adverse impact
Water Quality	(1) Confirmation of water body.	- Site investigation and hearing with relevant organization.
Wastes	(1) Type of wastes generated from construction site and camps	- Collection of existing EIA for construction of transmission lines
Noise and Vibration	(1) Confirmation of environmental standards (NEQS, IFC, etc.) (2) Distance between the site and residential area, school and hospital, etc. (3) Impact during construction (4) Current situation of noise	(1) Collection of standards for noise and vibration (2) Site investigation (3) Confirmation of construction method (4) Measurement of current noise (baseline)
Odor	(1) Waste treatment method	- Collection of existing EIA for construction of transmission lines
Ecosystem	(1) Current condition of ecosystem	- Collection of existing EIA and conducting ecological survey (baseline)
Involuntary Resettlement	(1) Land and assets to be relocated Affected people (economically or physically) (2) Renters, businesses, workers, employees, people without allocation (squatters and encroachers) (3) Replacement cost for land and assets (farm land, urban land, houses and other structures) (4) Supplementary measure for loss of assets	- Analysis of legal frameworks - Collection of reference material - Analysis on satellite image - Population census survey - Collection of land record and assets inventory - Socioeconomic survey (Interviews, public meeting, group discussion, site investigation)
People below poverty line	(1) Presence and state of people below poverty line in the affected people	- Collection of reference material - Collection of land record - Socioeconomic survey - Population census survey - Income and livelihood survey - Interviews, public meeting, group discussion, site investigation
Ethnic Minorities & Indigenous	(1) Baseline information on ethnic, minorities and indigenous people, the social relations and vulnerability.	- Collection of reference material - Socioeconomic survey - Interview to local community

Environmental Item	Survey Item	Survey Method
People		
Living and Livelihood / Regional Economy	(1) Baseline information on livelihoods and standards of living of which affected people	- Collection of reference material - Socioeconomic survey - Income and livelihood survey - Site investigation and interview to affected people, labor's association, local government and NGO etc.
Land and Resources	(1) Baseline information on land use (2) Baseline information on local resources	- Collection of reference material - Analysis on satellite image - Analysis of land use map - Site investigation and interview
Water Use	(1) Baseline information on use of surface and underground water (for different purposes i.e. drinking and irrigation	- Collection of reference material - Analysis of water management record - Interviews to local government - Site investigation
Infrastructure and Social Services	(1) Transporting route of construction materials and equipment (2) Transporting route of coal (3) Location of social infrastructures (school, hospital and other services)	- Analysis on satellite image - Analysis of land use map - Site investigation to understand geographic relations of roads and infrastructures and - Interviews to local government
Gender and Child	(1) Baseline information of women's role and work state (especially in family of fishermen) (2) Baseline information of child labor and school drop-out (especially in family of fishermen)	- Socioeconomic survey - Income and livelihood survey - Site investigation and interview to affected people, fishermen, labor's association, local government and NGO etc.
Infectious (HIV/AIDS) diseases	(1) Infection rate of diseases such as respiratory diseases and HIV/AIDS in the local community (2) Local NGOs conduct activities regarding infectious disease	- Collection of reference materials - Interviews to local government, medical facilities, NGOs etc.
Working Conditions	(1) Potential hazards to workers at construction and operation phase (2) Potential health risk to workers (3) Baseline information of forces labor	- Requirements and guideline of occupational health and safety in Pakistan - Environmental, Health and Safety Guidelines (EHS Guidelines) are - Collection of reference material (similar projects' EIA) - Interview with local government, NGOs, labors association etc.
Accident	(1) Potential hazards to workers at construction and operation phase (2) Time, route and area of public movement	- Analysis of satellite image - Analysis of land use map - Collection of reference material (similar projects' EIA) - Interviews
Stakeholder consultation	(1) Stakeholder's states and the relations (2) Concerns and comments on project Baseline information	- Stakeholder meetings - Public consultations - Focus group interviews - Individual interviews
Climate Change	(1) CO_2 emissions from trucks and heavy machines	- Confirmation of construction method

Source: JICA Survey Team

(3) Prediction of Environmental Impact for Transmission Line

1) Air Quality

Air quality degradation from construction activities is expected but it is lasts only during construction period.

2) Water Quality

Water quality degradation from construction activities is negligible.

3) Waste

Waste will only be generated from construction activity.

4) Noise and Vibration

Noise and vibration impacts will occur in construction period while machinery usage and vehicular movement. However as there is no house near the ROW, no impact is predicted. Electromagnetic Interference will also be an issue during operation of T/Ls. No settlements are present near the proposed ROW of T/Ls, therefore the impact of Electromagnetic Interference is negligible

5) Ecosystem

Impact on migratory bird flyways is expected. The birds during migration fly at elevation between 800 and 2,000 m. On the other hand the maximum height of the towers of T/Ls is less than 40 m. The T/Ls will therefore not cause any obstruction for the flight of migratory birds.

(4) Impact Assessment for Transmission Line

Table 11.5-19 Result of Environmental and Social Impact Assessment (Transmission Line)

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction	Operation	Pre/Construction	Operation	
Pollution Control						
1	Air Quality	B-	D	D	D	**[Construction Phase]** - Temporary dust generated from construction will be negligible. - Exhaust emissions generated from stand-by diesel generator, vehicle, construction machinery, etc. will be negligible. **[Operation Phase]** - No specific air pollution is expected.
2	Water Quality	B-	C-	D	D	**[Construction Phase]** - No negative impact on water quality is expected. Because transmission routes are selected avoiding any step sloping land, and any slopes would be reinforced with concrete or other means to minimize soil runoff and turbid water generation. **[Operation Phase]** - No negative impact is expected. Because the oil and chemicals would be stored at designated sites and treated appropriately.
3	Soil Quality	B-	B-	D	D	**[Construction Phase]** - No negative impact on soil quality is expected. Because generated wastes would be stored at designated sites. **[Operation Phase]** - No negative impact is expected. Because the oil and chemicals would be stored at designated sites and treated appropriately.
4	Wastes	B-	D	B-	D	**[Construction Phase]** - Solid wastes and hazardous wastes might be generated from base camps and construction sites. **[Operation Phase]** - No waste would be generated.
5	Noise and Vibration	B-	D	D	D	**[Construction Phase]** - Noise may be generated from heavy machinery, haulage of construction materials and tower materials to and around construction sites, and site construction activities including concrete mixing, excavation and blasting. But there is no house near the ROW, no impact would be predicted.

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction	Operation	Pre/Construction	Operation	
						[Operation Phase] - No noise and vibration would be generated.
6	Subsidence	D	D	D	D	**[Construction & Operation Phase]** - No subsidence would occur.
7	Odor	B-	D	D	D	**[Construction & Operation Phase]** - No odor would be expected by appropriately disposing of solid and liquid wastes at designated sites and being collected by licensed company regularly.
Natural Environment						
8	Protected Areas	D	D	D	D	**[Construction & Operation Phase]** - ROW does not pass through any protected areas including National Parks and no impact will result in displacement of wildlife and loss of habitat.
9	Ecosystem	C-	C-	D	B-	**[Construction Phase]** - No negative impact on ecosystem is expected. Transmission line route was selected so as to avoid any protected areas. **[Operation Phase]** - Birds striking the lines and other impacts are expected to be least significant.
10	Hydrology	D	D	D	D	**[Construction & Operation Phase]** - As there is no major water body, no adverse impact is expected.
11	Topography and Geology	D	D	D	D	**[Construction & Operation Phase]** - No large-scale topographical and geological change is expected.
Social Environment						
12	Resettlement (Land Acquisition)	C-	C-	D	D	**[Pre-construction Phase]** - The concerned land is non-productive and unoccupied barren waste land. As a result of the land survey by this study team with the help of the Revenue Staff, the land under ROW and footings of towers are determined to be unregistered. Under Pakistani land laws, any unregistered land falls under the ownership of the provincial government. In any case, the towers will be installed without any formal land acquisition and no compensation will be paid based on existing practice of NTDC.
13	People below the Poverty Line	C-/C+	C-/C+	D	D	**[Pre-construction/Construction/Operation Phase]** - No practical land use such as agriculture and housing are observed therefore, project will not affect living and livelihood of people.

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction	Operation	Pre/Construction	Operation	
14	Ethnic, Minorities and Indigenous People	C-	C-	D	D	**[Pre-construction and Operation Phase]** - No ethnic minority groups or indigenous people were identified along the transmission line route.
15	Living and Livelihood	C-/C+	C-/C+	B+	D	**[Pre-construction/Construction/Operation Phase]** - No practical land use such as agriculture and housing are observed therefore, project will not affect living and livelihood of people. **[Construction Phase]** - Employing as many local residents as possible, and using the services and products offered by the local community.
16	Use of Land and Resources	C-	C-	D	D	**[Pre-construction Phase]** - Project site is a barren wasteland consisting of natural condition outlying spurs of the Kirthar Range. - No practical land use is observed in project site.
17	Water Use	C-	D	D	D	**[Pre-construction/Construction/Operation Phase]** - Transmission line route was selected so as to avoid any steep sloping land. - Erosion control will be applied to minimize soil runoff and turbid water generation.
18	Infrastructure and Social Services	B-	D	B-	A+	**[Construction Phase]** - The proposed T/Ls will be connected to the existing ones; therefore, there is a chance of power outage. - Since the volume of construction traffic will be small, no significant impact is anticipated on existing traffic. **[Operation Phase]** - The proposed transmission lines will increase the capacity of the existing power of the system.
19	Social Capita, Institutions and Conflicts	C-	D	D	D	**[Pre-construction/Construction/Operation Phase]** - No specific impact is predicted concerning local decision making institutions.
20	Heritage	C-	D	D	D	**[Pre-construction/Construction/Operation Phase]** - There is no heritage in the project alignment. **[Operation Phase]** - No specific impact is predicted concerning cultural heritage.

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction	Operation	Pre/Construction	Operation	
21	Landscape	B-	B-	D	D	**[Construction and Operation Phase]** - Transmission line route was selected so as to avoid any protected and scenic areas to the maximum extent.
22	Gender	C-	C-	D	D	**[Pre-construction/Construction/Operation Phase]** - No specific negative impact is expected.
23	Child Right	C-	C-	D	D	**[Pre-construction/Construction/Operation Phase]** - No specific negative impact is expected.
24	Infectious Diseases	B-	D	B-	D	**[Construction Phase]** - Local people will be recruited for simple unskilled works as much as possible. - There is a low risk of infectious diseases being transmitted by incoming external workers by implementing medical checkups for external workers at pre-employment and periodically. **[Operation Phase]** - No specific negative impacts are expected.
25	Working Condition and Accident	B-	B-	B-	B-	**[Construction Phase]** - The construction of civil works poses an inherent risk of injury to workers from accidents and hazardous working environments. **[Operation Phase]** - There is a risk of accidents with handling elevated high tension (EHT) lines. Operation and maintenance (O&M) of elevated high tension (EHT) lines can pose an inherent risk to workers. O&M is currently undertaken by
Others						
26	Transboundary of Waste Treatment and Climate Change	B-	D	D	D	- No specific negative impact is expected.

A+/-: Significant positive/negative impact is expected

B+/-: Positive/negative impact is expected to some extent

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

D: No impact is expected

Source: JICA Survey Team

(5) Environmental Management Plan (mitigation measures) for Transmission Line

1) Mitigation Measures

(a) Air Quality

Dust suppression system and maintenance controls of vehicles will be applied. The aspect has been addressed in the EMP.

(b) Water Quality

Erosion controls will be applied. The aspect has been addressed in the EMP.

(c) Wastes

Waste management practices are proposed. The aspect has been addressed in the EMP.

(d) Noise and Vibration

Noise attenuation controls will be applied. The aspect has been addressed in the EMP.

(e) Ecosystem

As the possibility of bird striking should be considered, birds monitoring should be conducted. In case the bird striking is confirmed during monitoring period, appropriate mitigation measures to reduce the accident should be discussed and implemented by NTDC during operation period. The aspect has been addressed in the EMP.

2) Institutional Framework for Implementation of EMP

This section describes the responsibilities required for the implementation of EMP in conjunction with the NTDC, Environmental and Social Unit (ESU), Independent Monitoring Consultants (IMC), Construction Supervision Consultant (CSC) and Contractors.

Executing Agency (EA) is NTDC.

Implementation Agency (IA) is NTDC PMU. The IA will be assisted by Construction Supervision Consultant (CSC) during construction and CSC will be responsible for field surveys, engineering studies, design, and preparation of engineering drawings. JICA will monitor the overall planning, design, construction stages of the project and nominate a consultant who will report directly to JICA. Sindh EPA will act as the overall regulatory body for environmental control. The specific roles of key officials are described henceforth.

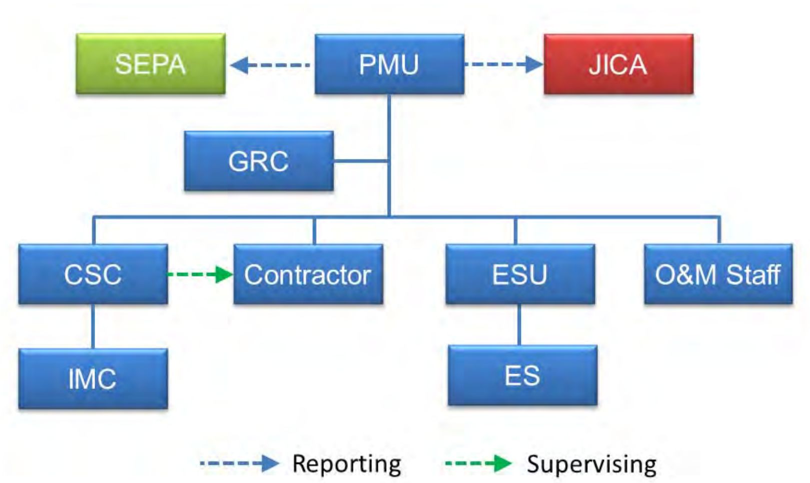
Environment Specialist (ES): NTDC PMU will appoint an environment specialist (ES) to monitor the implementation of environmental management measures required for the Project. ES will commence monitoring of the Project and prepare environmental monitoring reports with the aid of CSC, every month (during construction) and post-project reports (during operation), to be delivered to JICA.

Independent Monitoring Consultants (IMC): Independent Monitoring Consultants (IMC) will be part of CSC and will assist ES. IMC will be responsible for day-to-day environmental monitoring and will report directly to ES.

Grievance Redress Mechanism: Field level grievance will be addressed through a local

Grievance Redress Committee (GRC) to be formally constituted by the proponent. The GRC will consist of a specially recruited grievance officer nominated by PMU. The grievance officer will place a complaint register at an accessible location (Union Council office, mosque, or at camp site) for respective community so that anyone can register their complaint in this register and on weekly basis, it will be checked by the GRC. The complaint would be solved by GRC, PMU, or the highest level Project Director.

The organizational setup of the management plan is shown in Figure 11.5-5.



Source: Environmental Management Consultant

Figure 11.5-5 Organizational setup of the Management Plan

Environmental Management Plan for pre-construction (design), construction and operation phases is shown in Table 11.5-20.

Table 11.5-20 Environmental Mitigation and Management Plan (Transmission Line)

Items	Potential impact	Environmental Mitigation and Management Plan	Implementing organization	Supervising organization	Cost
A. Design phase					
Social Impacts	To ensure community involvement to minimize social impacts	- Disclose project detail to neighboring community	NTDC CSC	NTDC PMU	N/A
Hydrological Impacts	Hydrological and drainage impacts	- Design of adequate major and minor culverts facilities for drainage. - Existing open wells in the ROW will be capped - Temporary Construction Camps should not be located within 100 m of any domestic or public water sources	NTDC ESU with the Design Consultant	NTDC PMU	N/A
Waste disposal	Ensure adequate disposal options for all waste including transformer oil, residually contaminated soils, and scrap metal.	- Create waste management policy and plan to identify sufficient locations for and storage of waste generated from construction camps oils and disposal of residually contaminated soils and scrap metal “cradle to grave”. - Designate disposal sites in the contract and cost unit disposal rates accordingly. - Location is approved by Sindh EPA and NTDC	NTDC ESU with Sindh EPA	NTDC PMU	N/A
Temporary drainage and erosion control	Include mitigation in preliminary designs for erosion control and temporary drainage.	- Identify locations where drainage crossing ROW may be affected by works. - Include protection works in contract as a payment milestone(s). - Locations are identified in the EIA/EMP or as required / approved by Sindh EPA	NTDC ESU with the Design Consultant	NTDC PMU	N/A
Contract clauses	Ensure requirements and recommendations of environmental assessment are included in the contracts.	- Include EMP Matrix in tender documentation and make contractors responsible to implement mitigation measures by reference to EIA/EIA in contract. - Include preparation of EMP review and method statement WM plan, TD and EC Plan in contract as a payment milestone(s). - Require environmental accident checklist and a list of controlled chemicals / substances to be included in the contractor’s work method statement and tender documentation.	NTDC ESU with the Design Consultant	NTDC PMU	N/A
B. Construction phase					
Hydrology and drainage aspects	To ensure the proper implementation of any requirements mentioned in EPA conditions of approval letter in	- Streams, river and drains within and adjacent to construction sites should be kept free from any debris - Spoil disposal pits should be in suitable depressions not adjacent to waterways - Natural water courses should be maintained to the maximum extent possible - Debris and vegetation clogging culverts should be regularly cleared	Contract or supervised by EPC Contractor or to actively supervise and enforce.	NTDC PMU	Cost is included in the EPC contract.

Items	Potential impact	Environmental Mitigation and Management Plan	Implementing organization	Supervising organization	Cost
	relation to Hydrology of the project.	- Consideration of weather conditions when particular construction activities are undertaken. - Limitations on excavation depths in use of recharge areas for material exploitation or spoil disposal.			
Orientation for Contractor, and Workers	To ensure that the CSC contractor and workers understand and have the capacity to ensure the environmental requirements and implementation of mitigation measures.	- NTDC ESU environmental specialist to monitor and progress all environmental statutory and recommended obligations. - Conduct special briefing for managers and / or on- site training for the contractors and workers on the environmental requirement of the project. Record attendance and achievement test for contractors site agents. - Agreement on critical areas to be considered and necessary mitigation measures, among all parties who are involved in project activities. - Continuous progress review and refresher sessions to be followed.	NTDC ESU, EPC Contractor and the CSC and record details.	NTDC PMU	Cost is included in the EPC contract.
Air quality	Minimize dust effectively and avoid complaints due to the airborne particulate matter released to the atmosphere.	- Control all dusty materials at source. - All heavy equipment and machinery shall be fitted in full compliance with the national regulations. - Stockpiled soil and sand shall be slightly wetted before loading, particularly in windy conditions. - Fuel-efficient and well-maintained haulage trucks shall be employed to minimize exhaust emissions. - Vehicles transporting soil, sand and other construction materials shall be covered. Limitations to speeds of such vehicles necessary. Transport through densely populated area should be avoided. - Spraying of bare areas with water. - Concrete plants to be controlled in line with statutory requirements should not be close to sensitive receptors.	EPC Contractor	NTDC PMU	Cost is included in the EPC contract.
Construction Waste Disposal	Minimize the impacts from the disposal of construction waste.	- Waste management plan to be submitted to the CSC and approved by NTDC ESU one month prior to starting of works. WMP shall estimate the amounts and types of construction waste to be generated by the project. - Investigating whether the waste can be reused in the project or by other interested parties without any residual environmental impact. - Identifying potential safe disposal sites close to the project, or those designated sites in the contract. - Investigating the environmental conditions of the disposal sites and recommendation of most suitable and safest sites. - Piling up of loose material should be done in segregated areas to arrest washing out of soil. Debris shall not be left where it may be carried by water to the water bodies.	CSC and NTDC ESU should supervise and take action to ensure that EPC contractor’s complete relevant activities according to EIA / EMP requirements & NEQS.	NTDC PMU	Cost is included in the EPC contract.

Items	Potential impact	Environmental Mitigation and Management Plan	Implementing organization	Supervising organization	Cost
		- Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national regulations. - Oily wastes must not be burned. Disposal location to be agreed with local authorities/EPA. - Machinery should be properly maintained to minimize oil spill during the construction. - Machinery should be maintained in a dedicated area over drip trays to avoid soil contamination from residual oil spill during maintenance.			
Worker Camp Operation and Location (if required)	To ensure that the operation of work camps does not adversely affect the surrounding environment.	- Identify location of work camps in consultation with local authorities. The location shall be subject to approval by the NTDC. If possible, camps shall not be located near water bodies. - Water and sanitary facilities (at least pit latrines) shall be provided for employees. Worker camp and latrine sites to be backfilled and marked upon vacation of the sites. - Solid waste and sewage shall be managed according to the national and local regulations. - The Contractor shall organize and maintain a waste separation, collection and transport system. - The Contractor shall document that all liquid and solid hazardous and non-hazardous waste are separated, collected and disposed of according to the given requirements and regulations. - At the conclusion of the project, all debris and waste shall be removed. All temporary structures, including office buildings, shelters and toilets shall be removed. - Exposed areas shall be planted with suitable vegetation. - NTDC and Construction Supervising Consultant shall inspect and report that the camp has been vacated and restored to pre-project conditions.	EPC Contractor	NTDC PMU	Cost is included in the EPC contract.
Safety Precautions for the Workers	To ensure safety of workers	- Providing induction safety training for all staff adequate warning signs in health and safety matters, and require the workers to use the provided safety equipment. - Providing workers with skull guard or hard hat and hard toe shoes.	Contractor and CSC	NTDC PMU	Cost is included in the EPC contract.
Social Impacts	To ensure minimum impacts from construction labor force on public health.	- Potential for spread of vector borne and communicable diseases from labors shall be avoided (worker awareness orientation and appropriate sanitation should be maintained). - Complaints of the people on construction nuisance / any damage caused will be considered and responded to promptly.	Contractor and the CSC	NTDC PMU	Cost is included in the EPC contract.
Existing Social Infrastructure and Services	Temporal electric outage during connection between	- Compliance of the technical protocol, notification to the local residents and institutions	Contractor and the CSC	NTDC PMU	Cost is included in the EPC contract.

Items	Potential impact	Environmental Mitigation and Management Plan	Implementing organization	Supervising organization	Cost
	existing TLs and new ones				
Infectious Diseases	Impacts of the influx of labor farce and staff on infectious diseases.	- Instructions on construction workers about infectious diseases and their preventions by the Consultant before the construction starts.	Contractor and the CSC	NTDC PMU	Cost is included in the EPC contract.
A. Operation phase					
Oils, Fuel Spills and Dangerous Goods	Minimize Oil, fuel spillage.	- Chemicals and oils should be stored in secure designated areas with permanent impermeable bunds at distance of at least 100 m from any water course. - Transformer oil will be supplied in drums from an imported source and tap tanks will be topped up as necessary at the above noted secure designated areas. - Refueling of machinery, equipment and vehicles should be undertaken at distance of at least 100 m from any water course. - Any major work including oil changing and engine maintenance with the potential for oil to be spilled will be done in designated areas at distance of at least 100 m from any water course and with containment to prevent any oil spills washing away. - Contaminated residues and waste oily residues should be disposed at an appropriate site approved by the relevant local environmental authority.	NTDC O&M Staff	NTDC PMU	N/A
TL and Substation Operation and Maintenance	Mitigate any inherent Health and Safety risk to O&M staff.	- O&M of elevated high tension (EHT) lines and substations will be undertaken by adequately trained, certified and experienced NTDC staff or contractors. - All relevant Government health and safety laws will be complied with. - In addition, an operation phase Occupational Health and Safety (OHS) plan will be developed.	NTDC O&M Staff	NTDC PMU	N/A
Human Exposure to Electromagnetic Fields (EMF)	Mitigate the impact of EMF.	- Overall no significant adverse EMF impacts are predicted during Project operation - During design the ROW alignment was selected so as to avoid settlements and sensitive receptors. - Operation phase EMF monitoring will be undertaken. Average and peak exposure levels should remain below the ICNIRP recommendation for general public exposure.	NTDC O&M Staff	NTDC PMU	N/A
Electrocution and Induced Currents	Mitigate the risk of direct contact with high-voltage electricity or from contact with tools,	- Warning signs will be posted at towers along the ROW. - Substations will be fenced with gates, locks and security personnel - Anti-climbing features will be installed on towers. - Conducting objects (e.g. fences or other metallic structures) installed near power lines will be grounded to prevent shock.	NTDC O&M Staff	NTDC PMU	N/A

Items	Potential impact	Environmental Mitigation and Management Plan	Implementing organization	Supervising organization	Cost
	vehicles, ladders, or other devices.				
Wind, Fire and Earthquake Hazards	To ensure that the safety of project operations.	- Transmission towers have been design as per relevant national building codes which include earthquake resistance and loading requirements related to wind conditions. - Transmission support structures such as tower foundations have also been designed to withstand different combinations of loading conditions including extreme winds that generally exceed earthquake loads. - The fire hazards risk will be minimized through the use of tall towers and wide ROWs. - System protection features designed to safeguard the public and line equipment will minimize fire hazards due to fallen conductors. The protection systems will consist of TL relays and circuit breakers that are designed to rapidly detect faults and cut-off power to avoid shocks and fire hazards. - Regular maintenance of the protection system including conductors and circuit breakers will be undertaken.	NTDC O&M Staff	NTDC PMU	N/A
Impact on migratory bird flyways	To reduce the impact on migratory birds and impact on their flyways.	- Birds Monitoring	NTDC ESU	NTDC PMU	USD 72,000

Note:

LAC = Local Authority Council. TD = Temporary drainage. EC = Erosion control. WM = waste management. CSC = Construction supervision consultant or equivalent. TXL = Transmission line. GSS = Grid substation. NEQS = National Environmental Quality Standards CSC = Construction supervision consultant. ESU = Environmental and Social Unit

Source: Environmental Management Consultant

(6) Monitoring Plan for Transmission Line

The monitoring plan was designed based on the project cycle. During the pre-construction period, the monitoring activities will focus on (i) checking the contractor's bidding documents, particularly to ensure that all necessary environmental requirements have been included; and (ii) checking that the contract documents' references to environmental mitigation measures requirements have been incorporated as part of contractor's assignment and making sure that any advance works are carried out in good time. Where detailed design is required (e.g. for power distribution lines and avoidance of other resources) the inclusion and checking of designs must be carried out. During the construction period, the monitoring activities will focus on ensuring that environmental mitigation measures are implemented, and to guide any remedial action to address unexpected impacts. Monitoring activities during project operation will focus on recording environmental performance and proposing remedial actions to address unexpected impacts.

Rules for the environmental monitoring are designated in NEQS (Self-Monitoring and Reporting by Industry) rules, 2001, in which priority parameters for monitoring of liquid effluents and gaseous emissions are provided according to the type of industries. This project is categorized in "Transmission Lines (11 kW and above) and distribution projects" in the NEQS.

The detail of the Monitoring Plan during pre-construction (design stage), construction and operation phases is shown in Table 11.5-21.

Sample of Monitoring Form is shown in Appendix 11-4. Implementing agency shall submit the monitoring report to JICA by using this form

Table 11.5-21 Environmental Monitoring Plan (Transmission Line)

Item	Parameter	Location	Means of Monitoring	Monitoring Frequency	Implementing Organization	Supervising Organization
A. Design Phase						
Environmental and Social Consideration to be ensured by Contractors	Project bidding documents	-	Review the documents if EIA and EMP is included.	-	ESU through PMU.	NTDC PMU
	Selection process and final alignment of T/Ls	-	Monitor the process and its environmental compliance with EMP	-	ESU with the assistance of IMC	NTDC PMU
	Detail design	-	Monitor the designs if they ensure relevant standards and mitigation measures proposed in EMP	-	ESU with the assistance of PMU	NTDC PMU
	Implementation of detail environmental guidelines for construction works	-	Monitor the procurement management, works and closing operation	-	ESU with the assistance of CSC	NTDC PMU
	Construction materials and waste management	-	Review the list of materials used and waste disposed	-	ESU with the assistance of CSC	NTDC PMU
B. Construction Phase						
Waste management	Municipal waste, industrial waste and hazardous waste	Construction sites	Visual observation	During routine monitoring	CSC	NTDC PMU
Existing Social Infrastructure and Services	Occurrence and recovery of outages	Local residents and institutions such as clinics and schools	Confirming residents or institutions	Continuously during the process of connecting the proposed and the existing transmission lines	CSC	NTDC PMU
Infectious Diseases	Implementation status of mitigation measures proposed in the EMP, the reported number of infections	Project site, camp sites	Reporting from EPC contractor	Biannually	CSC	NTDC PMU

Accidents and Safety	Implementation status of mitigation measures proposed in the EMP, occurrence of accidents and health issues	Project site		Everyday	CSC	NTDC PMU
C. Operation Phase						
Maintenance	Implementation status of O&M	T/L Corridor		Maintenance timing	NTDC ESU	NTDC PMU
Birds monitoring	Bird Fauna	T/L Corridor	Counting the bird's body	June - August	NTDC ESU	NTDC PMU

Note:

Complete record of sampling and analysis should be maintained and documented.

PMU = Project Monitoring Unit,

Source: Environmental Management Consultant

(7) Total Budget Estimates

Cost estimates are prepared for all the mitigation and monitoring measures proposed in the EMP. The details of the cost estimates and the budget during construction stage and first two years of operation stage for the mitigation and monitoring measures are given in Table 11.5-22. The cost estimates for control measures and some of the mitigation measures that were already part of Engineers estimate are not included in the EMP.

The cost estimates include the budget for environmental monitoring and independent monitoring consultant for EMP implementation during the project phases.

The total budget for EMP implementation is estimated to be about US$ 84 thousand.

Table 11.5-22 Summary of Costs for Environmental Management and Monitoring (Transmission Line)

	Item	Unit	Unit Cost US$	Quantity	Total Cost US$
1	Waste Management	Site	1,000	12	12,000
2	Birds Monitoring	Site	12,000	06	72,000
	Total (1 + 2)				**84,000**

Source: Environmental Management Consultant

11.6 Stakeholder Consultations and Disclosure

Stakeholder consultations were conducted for project affected groups including both institutional and community stakeholders during EIA process.

11.6.1 Objectives of Stakeholder Consultations

The objectives of the stakeholder consultations during the EIA process are;

- To provide an overview of the Project description to the communities;
- To gather data and information on concerns of the stakeholders about their socioeconomic and biophysical environment, as well as about the dependence on their environment;
- To ensure involvement of the stakeholders in the Project planning and EIA processes and land acquisition procedures;
- To seek input from the stakeholders on the planned project activities to increase positive project outcomes and avoid or effectively mitigate negative Project impacts.

The views, interests and concerns of stakeholders will be taken into account in the following:

- Planning, design and implementation of the Project;
- During the assessment of the potential impacts of the Project and the identification of appropriate mitigation measures;
- Decisions by the regulatory authorities on whether to approve the Project and determination of corresponding conditions of approval.

11.6.2 Regulations for Stakeholder Consultations

The Project will adhere to the applicable national laws and international guidelines for the EIA process. In accordance, the legal framework for stakeholder consultations is explained below.

(1) National Regulations

Pakistan Environmental Protection Ordinance (1997) mandates public consultation implementation as a part of EIA process. *Environmental Impact Assessment Law (2000)* issues a set of guidelines of general applicability and sectoral guidelines indicating specific assessment requirements. This includes *Guidelines for Public Consultation,1997*.

(2) International Standards

The World Bank (WB), International Finance Corporation (IFC) and Japan International Cooperation Agency (JICA) direct community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them[1 2 1 2 3].

[1] WB. 1999. Operation Principle(OP)/Bank Policy(BP) 4.01, Environmental Assessment

[2] IFC. 2012. Performance Standards (PS) 1, Assessment and Management of Environmental and Social Risks

11.6.3 Stakeholder Identification and Analysis

At scoping stage, stakeholders were identified as groups and individuals that can be affected by the Project activities or that can influence the outcome of the project.

All groups and individuals that fall within the Study Area were identified as stakeholders that can be affected by the Project activities and were consulted through representatives during the scoping phase.

Groups and individuals that hold interest in the Project and can influence the outcome of the Project (latter part of the definition of stakeholders) include:

- Government and regulatory authorities directly or indirectly connected to or overseeing, the activities of the Project;
- Non–governmental organizations working in areas that can be affected by the Project;
- Academia that can be interested in transfer of skill and knowledge aspect of the Project;

The stakeholders were identified on the basis of the most recent information and understanding of the Project and its surrounding environment. Given the varying roles and educational backgrounds, stakeholders were divided into the following target groups for consultations:

- Institutional stakeholders;
- Communities.

11.6.4 Consultation Material

The main document distributed to stakeholders during the consultations was the Background Information Document (BID). The BID contained information on the Project and the EIA process. The BIDs were developed for both Scoping Consultation and Feedback Consultation. The BID was made available to stakeholders in both Sindhi and English, to accommodate their language preference.

11.6.5 Consultation with Institutional Stakeholders

(1) Scoping Consultations with Institutional Stakeholders

Scoping consultation meetings were scheduled with the institutional stakeholders during February and March 2014 as shown in Table 11.6-1. An overview of the Project description, description of the EIA process, a list of the possible environmental and social impacts were

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and Impacts

[1] WB. 2007. Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets

[2] WB. 1996. Participation Sourcebook

[3] JICA. 2010. Guidelines for Environmental and Social Considerations

explained to stakeholders. Stakeholders were given the opportunity to raise queries or concerns regarding the Project. Queries were responded to and concerns were documented for consideration in the EIA.

Table 11.6-1 List of Institutional during Scoping Consultation

Institutions Invited	*Date Consulted*
World Wildlife Fund (WWF), Islamabad	Feb 19, 2014
Pakistan Museum of Natural History (PMNH), Islamabad	Feb 19, 2014
International Union for Conservation of Nature (IUCN), Islamabad	Feb 19, 2014
Lakhra Coal Development Company (LCDC), Lakhra	Feb 24, 2014
Sindh Wildlife Department (SWD), Hyderabad	Feb 25, 2014
Deputy Commissioner (DC), Jamshoro	Feb 25, 2014
Sindh Forest Department, Hyderabad	Feb 25, 2014
Mehran University, Jamshoro	Feb 26, 2014
Department of Livestock and Fisheries, Hyderabad	Feb 26, 2014
Liaqat University of Health and Medical Sciences (LUMHS), Jamshoro	Feb 26, 2014
Lakhra Coal Development Company Limited (LCDC), Karachi	Feb 28, 2014
International Union for Conservation of Nature (IUCN), Karachi	Mar 04, 2014

Source: JICA Survey Team

(2) Feedback Consultations with Institutional Stakeholders

The feedback consultation meetings were scheduled with the institutional stakeholders on Sep 08, 2014 and targeted the same institutions that were consulted earlier in the scoping consultation. The consultations with IUCN, Karachi, Forest Department, Hyderabad, and WWF, Islamabad could not be conducted due to their official commitments. The responses of issues raised during scoping phase consultation were provided to them in writing. List of institutional stakeholders consulted are as shown in Table 11.6-2.

Table 11.6-2: List of Institutions Consulted during Feedback Consultation

Institutions Invited	*Date Consulted*
Sindh Wildlife Department (SWD), Hyderabad	Sep 8, 2014
Liaqat University of Health and Medical Sciences (LUMHS), Jamshoro	Sep 8, 2014
Sindh Forest Department, Hyderabad	Sep 8, 2014
Mehran University, Jamshoro	Sep 8, 2014
Department of Livestock and Fisheries, Hyderabad	Sep 8, 2014
Additional Deputy Commissioner (ADC), Jamshoro	Sep 8, 2014

Source: JICA Survey Team

11.6.6 Consultation with Community Stakeholders

(1) Scoping Consultations with Community Stakeholders

Total eighteen (18) rural communities located within the Study Area and a residential colony for WAPDA staff were identified. In addition, there was a commercial area, namely Habibullah Mor, situated about 2.5 km of north of Lakhra Power Plant.

Stakeholders were explained about the consultation process, its objectives, overview of the Project and EIA in Urdu and Sindhi, depending on their language preference. Stakeholders were given the opportunity to raise queries or concerns regarding the Project. Queries were responded to and concerns were documented.

At scoping stage, the communities were consulted during April 2014. The list of communities consulted along with the geographical coordinates of the consultation locations and dates when the consultations took place are shown in Table 11.6-3.

Table 11.6-3 List of Communities Consulted during Scoping Stage
(in Chronological Order with the Geographical Coordinates of the Consultation Locations)

Location	*Union Council*	*Taluka*	*District*	*Coordinates*		*Consulted Date*
Manzurabad	Manzurabad	Manjhand	Jamshoro	25 42 07.0 N	68 17 51.9 E	Apr 9, 2014
Zimi	Manzurabad	Manjhand	Jamshoro	25 40 49.0 N	68 18 06.8 E	Apr 9, 2014
Imdad Ali Khoso	Manzurabad	Manjhand	Jamshoro	25 42 17.1 N	68 17 36.1 E	Apr 10, 2014
Shuja Muhammad Khoso	Manzurabad	Manjhand	Jamshoro	25 43 49.9 N	68 17 13.3 E	Apr 10, 2014
Bhuro Khan Rind	Manzurabad	Manjhand	Jamshoro	25 43 49.9 N	68 17 27.9 E	Apr 10, 2014
Jan Muhammad Khoso	Manzurabad	Manjhand	Jamshoro	25 39 26.8 N	68 17 46.9 E	Apr 11, 2014
Khanot	Manzurabad	Manjhand	Jamshoro	25 44 40.4 N	68 17 39.4 E	Apr 11, 2014
Paryo Khan Dia Dano	Manzurabad	Manjhand	Jamshoro	25 44 05.9 N	68 17 40.9 E	Apr 12, 2014
Koreja	Manzurabad	Manjhand	Jamshoro	25 44 33.6 N	68 17 35.7 E	Apr 12, 2014
Thehbo	Manjhand	Manjhand	Jamshoro	25 41 46.7 N	68 19 14.5 E	Apr 12, 2014
Allah Dino Baricho	Manzurabad	Manjhand	Jamshoro	25 43 36.3 N	68 17 27.0 E	Apr 13, 2014
Esab Khan Khoso	Manzurabad	Manjhand	Jamshoro	25 43 47.3 N	68 17 35.4 E	Apr 13, 2014
Murid Khan Rind	Manzurabad	Manjhand	Jamshoro	25 42 54.1 N	68 17 46.5 E	Apr 14, 2014
Abdul Ghani Bandwani	Manzurabad	Manjhand	Jamshoro	25 44 09.2 N	68 17 29.2 E	Apr 14, 2014
Dodo Mithano	Manzurabad	Manjhand	Jamshoro	25 45 06.5 N	68 17 30.2 E	Apr 14, 2014
Wapda Colony	Manzurabad	Manjhand	Jamshoro	25 40 04.7 N	68 17 14.9 E	Apr 15, 2014
Mir Dost Khoso	Manzurabad	Manjhand	Jamshoro	25 44 07.7 N	68 17 20.3 E	Apr 15, 2014
Traders (Habibullah Mor)	Manzurabad	Manjhand	Jamshoro	25 43 35.6 N	68 17 30.7 E	Apr 15, 2014

Source: JICA Survey Team

(2) Feedback Consultations with Community Stakeholders

The feedback consultation primarily targeted the same community that was consulted earlier in the scoping consultation, including eighteen (18) rural communities located within the Study Area, Habibullah Mor, a commercial area, WAPDA residential colony. Residents of the settlement of Faqir Dad Khoso could not be consulted as the notable of the settlement failed to attend any of the mutually planned consultation sessions. Community stakeholders were provided an update of the Project design and results on how their concerns raised under scoping consultation have been addressed under the EIA. The list of communities consulted are shown in Table 11.6-4.

Table 11.6-4 List of Communities Consulted during Scoping Stage

Location	*Union Council*	*Taluka*	*District*	*Coordinates*		*Consulted Date*
Imdad Ali Khoso	Manzurabad	Manjhand	Jamshoro	25 42 17.1 N	68 17 36.1 E	Sep 5, 2014
Manzurabad	Manzurabad	Manjhand	Jamshoro	25 42 07.0 N	68 17 51.9 E	Sep 5, 2014
Zimi	Manzurabad	Manjhand	Jamshoro	25 40 49.0 N	68 18 06.8 E	Sep 5, 2014
Esab Khan Khoso	Manzurabad	Manjhand	Jamshoro	25 43 47.3 N	68 17 35.4 E	Sep 6, 2014
Bhuro Khan Rind	Manzurabad	Manjhand	Jamshoro	25 43 49.9 N	68 17 27.9 E	Sep 6, 2014
Shuja Muhammad Khoso	Manzurabad	Manjhand	Jamshoro	25 43 49.9 N	68 17 13.3 E	Sep 6, 2014
Allah Dino Baricho	Manzurabad	Manjhand	Jamshoro	25 43 36.3 N	68 17 27.0 E	Sep 6, 2014
Koreja	Manzurabad	Manjhand	Jamshoro	25 44 33.6 N	68 17 35.7 E	Sep 6, 2014
Murid Khan Rind	Manzurabad	Manjhand	Jamshoro	25 42 54.1 N	68 17 46.5 E	Sep 6, 2014
Khanot	Manzurabad	Manjhand	Jamshoro	25 44 40.4 N	68 17 39.4 E	Sep 6, 2014
Thehbo	Manjhand	Manjhand	Jamshoro	25 41 46.7 N	68 19 14.5 E	Sep 6, 2014
Dato Khoso	Manzurabad	Manjhand	Jamshoro	25 40 33.9 N	68 19 33.5 E	Sep 6, 2014
Abdul Ghani Bandwani	Manzurabad	Manjhand	Jamshoro	25 44 09.2 N	68 17 29.2 E	Sep 7, 2014
Pehlwan Khoso	Manzurabad	Manjhand	Jamshoro	25 40 30.3 N	68 17 50.8 E	Sep 7, 2014
Mir Dost Khoso	Manzurabad	Manjhand	Jamshoro	25 44 07.7 N	68 17 20.3 E	Sep 7, 2014
Jan Muhammad Khoso	Manzurabad	Manjhand	Jamshoro	25 39 26.8 N	68 17 46.9 E	Sep 7, 2014
Dodo Mithano	Manzurabad	Manjhand	Jamshoro	25 45 06.5 N	68 17 30.2 E	Sep 7, 2014
Paryo Khan Dia Dano	Manzurabad	Manjhand	Jamshoro	25 44 05.9 N	68 17 40.9 E	Sep 7, 2014
Wapda Colony	Manzurabad	Manjhand	Jamshoro	25 40 04.7 N	68 17 14.9 E	Sep 7, 2014
Traders (Habibullah Mor)	Manzurabad	Manjhand	Jamshoro	25 43 35.6 N	68 17 30.7 E	Sep 7, 2014

Source: JICA Survey Team

11.6.7 Opinions Expressed during Consultations

(1) Scoping Consultation

The key concerns emerged from consultations were summarized in Table 11.6-5. The detailed log of consultations is provided in EIA of Power Plant

Table 11.6-5 Key Concerns from Scoping Consultations

	Issues raised by Stakeholders	*Addressed in the EIA*
Ecosystem	• Any change in the environment may result in a loss of biodiversity of the area. Measures should be taken to avoid any loss of flora and fauna in the area.	• Mitigation measures and management measures are addressed to the potential environmental impacts of each component. The construction management plan are also developed to minimize the impacts of construction activities. (EIA Chapter 9)
Water Intake	• Large amount of water intake from the Indus River will affect water availability in the Indus River especially be critical in the low flow season (in the month of December) .	• Amount of water intake has been planned to secure the water flow during the dry season. (The amount of water taken from the river is approximately 0.5 m^3/s. The lowest water flow amount is 177 m^3/sec in December. The intake amount corresponds to approx. 0.3 % of total flow amount.).
Water Discharge	• The wastewater discharge and thermal discharge from power plant will cause environmental changes in the Indus River and be critical for aquatic life. Wastewater discharge will also damage agricultural field near the power plant. • Wastewater discharge will harm the quality of the Indus River and create problems for aquatic life and may adversely affect the livelihood of fishermen. • Water discharge during construction stage should also be carefully treated. Community is dependent on Indus River water for water uses. • The discharge water from the existing LFPS is not treated and polluting water quality.	• All effluent from the power plant (cooling tower blow down, storm water, etc.) is treated by effluent treatment facility in order to meet the NEQS. • Domestic water from the colony is initially treated at septic tank and then treated by the effluent treatment facility. • Oil-contaminated water is treated by oil-separate tank. Separated water is treated by the effluent treatment facility. Separated oil is collected and kept for recycle or proper treatment by licensed company. • Sludge is regularly collected and disposed of by licensed company.(EIA Chapter 9) • The construction management plan includes mitigation measures for water discharge from the construction site such as installation of temporary drainage to avoid water and soil contamination. • The environmental monitoring plan is also proposed for operation stage. (EIA Chapter 9)

	Issues raised by Stakeholders	Addressed in the EIA
	• Any water discharge from coal yard and ash pond shall be treated properly.	• The ash pond will be lined with a layer of HDPE membrane or clay liner in order to avoid water seepages to the ground. • Storm water from coal yard and ash pond will be treated at effluent treatment facility and recycled for greening or sprinkling on coal and ash. • Groundwater samples will be collected from the monitoring wells at ash pond and at the communities within one kilometer from the ash pond to monitor the water quality. (EIA Chapter 9)
Stack Emissions	• Air emissions from the plant could adversely affect the communities, agricultural fields in the surrounding areas and, water quality of the Indus River. • The inhabitants of the village suffer from numerous diseases such as respiratory illnesses and eyes problems due to the air emissions from existing LFPS.	• Appropriate equipment's (ESP for total PM emissions/FGD using lime slurry for SO_2 and dry low NOx burners for NO_2) are installed to comply with the NEQS and EHS Guidelines on Thermal Power Plants, 2008, of the World Bank Group. • A stack height of 210 m will be part of design. The equipment type and details may be changed as long as the objectives are met. Any such change will require approval of JICA/investor(s). • The emissions with CEMS (Continuous Emission Monitoring System) and the ambient air quality at vicinity of the project will be monitored. In case the quality exceeds the national standards, countermeasures such as control of power generation shall be conducted.

	Issues raised by Stakeholders	*Addressed in the EIA*
Ash Disposal	• • To save fuel, the truck drivers of the existing LFPS dump the ash near the settlements instead of allotted ash dump site. • In the rainy days, the water comes with the ash, dumped near the settlements and ruined the agricultural fields. Resultantly, agricultural fields gradually lose fertility. • Ash trucks transporting ash from LFPS to dumping site are not covered properly, which causes spread of ash and health problems in local area. • Ash is thrown immediately adjacent to settlement which causes health hazards especially among children. • The ash should be dumped at the allocated site and water should be sprinkled on the dumped ash.	• The problem mentioned is associated with the existing power plant. The issue has been brought to the attention of GHCL and LPGCL for addressing the concern of the community. • In this Project, the ash pond will be newly installed and applied appropriate mitigation measures as state above [Water Discharge]. • In this Project, all the bottom and fly ash will be temporarily stored in ash silos. However, later it will be either transported to cement companies or will be disposed in the ash ponds.
Other Concerns	• The project should provide job opportunities to local people and internship opportunities to the university students.	• The Project will create additional job opportunities and employ the local resident as many as possible. • About 3,000 people are expected to be employed during construction period and, 347 staff positions will be created at the power plant during operation period. • The Project will prioritize to choose the local services and products wherever possible such as laundry, catering, venders, daily goods etc.
	• The project proponent should provide the facility of drinkable water for the community.	• The concerns are addressed in Social Augmentation Program.
	• Unemployment, lack of education and medical facilities and water shortage were identified as the main issues in the community and project proponent should provide sources.	• The concerns are addressed in Social Augmentation Program.

Source: JICA Survey Team

(2) Feedback Consultation

The key concerns emerged from the feedback consultations were summarized in Table 11.6-6. The detailed log of feedback consultations is provided in EIA of Power Plant.

Table 11.6-6 Key Concerns from Feedback Consultations

	Response of Stakeholders	*Post-Feedback Consultation Changes to EIA*
Ecosystem	• The community of Koreja settlement will not support the new power plant project at any cost as the pollutants discharge of existing power plant in Indus River is impacting an adverse effect on fish breeding and decreasing fish population. • Any change in the environment may result in a loss of biodiversity of the area. Measures should be taken to avoid any loss of flora and fauna in the area.	• This issue is related to the existing plant. As discussed in EIA Chapter 7 the impact of the proposed Project on aquatic fauna will be insignificant. The issue has been brought to the attention of GHCL and LPGCL for addressing the concern of the community.
Water Intake	• Sindh Wildlife Department, Hyderabad and communities demanded that the intake amount of water from Indus River should be minimum as local communities use water of Indus River for their domestic use.	• As discussed in Section 11.5.2, the proposed power plant requires 0.50 m^3/s water from the River Indus when operating at full capacity. Water extracted by the power plant will be 0.28% of the minimum monthly average flow of the river. Water use for the project has been optimized in the design keeping in view the value of water for existing uses and the need for power generation.
Water Discharge	• The communities and Liaquat University of Medical Sciences (LUMHS), Jamshoro suggested that the treated wastewater should be provided to the communities for their agricultural fields. • Sindh Wildlife Department, Hyderabad suggested that there should be audit and monitoring of the proposed mitigation measures for discharged wastewater on yearly basis. • The community of Koreja settlement will not support the new power plant project as the pollutants discharge of existing power plant in Indus River is having an adverse effect on fish breeding and is decreasing fish population. • The communities were happy and appreciated the proposed mitigation plans to minimize the negative impacts of discharged water.	• Only 0.01 m^3/s of treated effluent will be returned to the river where it will be diluted. This effluent will not be suitable for irrigation use in view of its quality. • Monitoring of environmental components (including fish) and mitigation measures during implementation and operation stages is a key component of the EMP to safeguard the protection of environment (EIA Chapter 9). • The problems mentioned are associated with the existing power plant. The need for rehabilitation of the existing Power Plant has been highlighted in the EIA. The issue has been brought to the attention of GHCL and LPGCL for addressing the concern of the community. The effluent from the Plant is treated at effluent treatment facility to meet NEQS.
Stack Emissions	• Sindh Wildlife Department, Hyderabad suggested that there should be audit and monitoring of the	• Monitoring of environmental components and mitigation measures during implementation and operation stages is a

	Response of Stakeholders	*Post-Feedback Consultation Changes to EIA*
	proposed mitigation measures for air emissions on yearly basis on yearly basis. • The community of Koreja settlement is not in a favor of coal power plant as they are already facing health problems due to the air emissions and ash from existing power plant. Flora and fauna are affected by the release of the pollutant air emissions from the existing power plant. • The communities as well as LUMHS expect appropriate equipment (ESP for total PM emissions/FGD using lime slurry for SO_2/ SCR and dry low NOx burners for NO_2) are installed in the existing power plant before the construction of new power plant. • The communities were happy and appreciated the proposed mitigation plans to minimize the negative impacts of air emission.	key component of the EMP to safeguard the protection of environment (EIA Chapter 9). • The need for rehabilitation of the existing power plant has been highlighted in the EIA in order to reduce the pollutants such as PM10 and PM2.5 to improve the air quality in the vicinity of the plant (EIA Chapter 8). • The need for rehabilitation of the existing power plant has been highlighted in the EIA in order to reduce the pollutants such as PM10 and PM2.5 to improve the air quality in the vicinity of the plant (EIA Chapter 8).
Ash Disposal	• The ash from the existing power plant is dumped near the settlements. In the rainy days, the ash is washed into the nearby agricultural fields. Resultantly, agricultural fields gradually lose fertility.	• The problem mentioned is associated with the existing power plant. In the proposed Project, all the bottom and fly ash will be temporarily stored in ash silos. However, later it will be either transported to cement companies or will be disposed using ash ponds. Trucks will be used to transport the ash from the source to the silos as well as from silos to the cement companies (EIA Chapter 8). • The issue has been brought to the attention of GHCL and LPGCL for addressing the concern of the community.
Other Concerns	• The communities appreciated the proposed augmentation plan and hope that with the construction of new power plant will provide employment and improved health care facilities. • The community demanded the renovation of existing school building and improving their education by providing an educated teacher. • The communities raised issue of quality education, unavailability of schools, especially in case of women. • In the past, community influential or notable people and poor people of the	• The Social Augmentation Program proposes construction/rehabilitation of drinking water supply scheme, rehabilitation of primary health care clinic in Manzurabad and BHU in Khanot, and provision of training and capacity building activities (EIA Chapter 9).

	Response of Stakeholders	*Post-Feedback Consultation Changes to EIA*
	village were ignored. There should be monitoring officer for monitoring and evaluation of the social augmentation program. • The community member mentioned the needs of gas and drinking water facility. • Both male and female community members expressed interests to employment through the Project. • Female members wish to get skill training.	

Source: JICA Survey Team

11.6.8 Future Consultations

(1) Consultation during EIA Process

As a requirement during EIA process, one or more public hearings to be held to assess public opinion on the environmental impacts of the Project. After receipt of the EIA report, SEPA will advertise the public hearings in newspapers. But in general practice, advertisements are usually placed in two national newspapers and also in local newspapers. The public hearings will be held at least 30 days after the public notice. Copies of the EIA report and a non-technical summary have to be made accessible to the public during the notification period.

(2) Consultation beyond the EIA Process

The Project management will continue community engagement activities throughout the life of the plant including:

- Ongoing reporting of the implementation progress of the environmental and social management measures and recording of comments on the effectiveness of these measures;
- Updating communities about new project developments and recording comments on these; and,
- Ongoing operation of the grievance mechanism.

11.7 Land Acquisition and Resettlement Action Plan

A Land Acquisition and Resettlement Action Plan (LARAP) is prepared for land acquisition and resettlement for construction of power plant and other associated facilities. The LARAP is to guide the executing agencies to prepare, implement and monitor the land acquisition and resettlement.

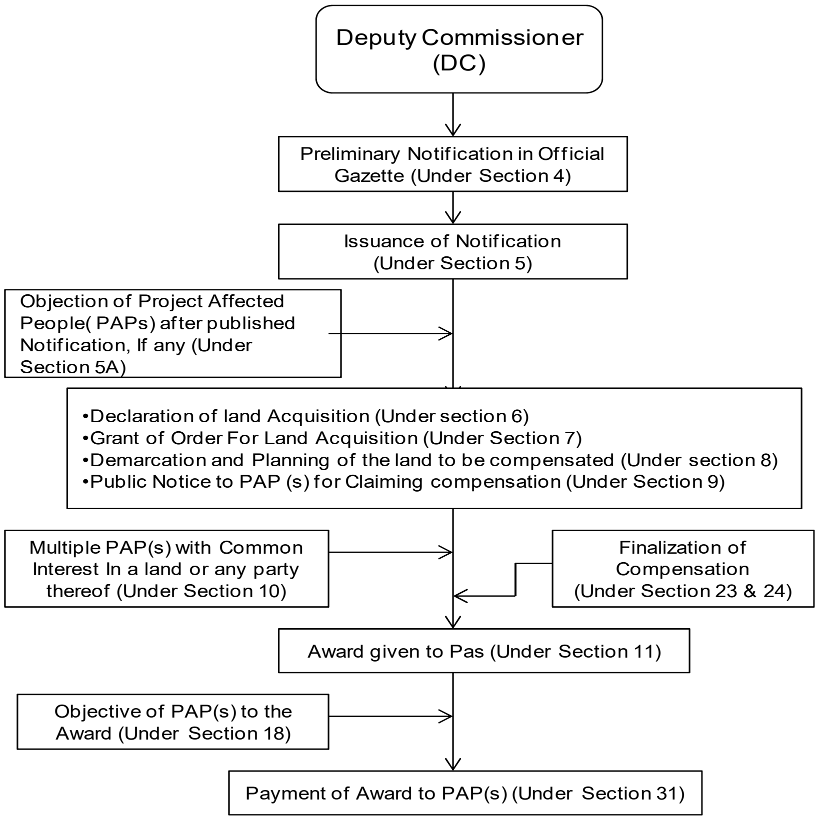
11.7.1 Analysis of Legal Framework and Concerning Land Acquisition

(1) Land Acquisition Act (LAA) 1894

The Pakistan law governing land acquisition is the LAA of 1894 and successive amendments. The LAA regulates the land acquisition process and enables the provincial government to acquire private land for public purposes. Land acquisition is a provincial responsibility and provinces have also their own province specific implementation rules like Punjab and Sindh Land Acquisition Rules, 1983.

The LAA and its Implementation Rules require that, following an impact identification and valuation exercise, land and crops are compensated in cash at the current market rate to titled landowners. The LAA mandates that land valuation is to be based on the last three years average registered land-sale rates. However, in several recent cases, the median rate over the past one year, or even the current rates, have been applied with an added 15% Compulsory Acquisition Surcharge (CAS) according to the provision of the law. The PAPs, if not satisfied, can go to the Court of Law to contest the compensation award.

The flow of the land acquisition activities according to LAA are summarized in Figure 11.7-1 and each section are briefly described in Table 11.7-1.



Source: JICA Survey Team

Figure 11.7-1 Schematic diagram of LAA, 1984 procedure

Table 11.7-1 Brief description of activities in each section of LAA.

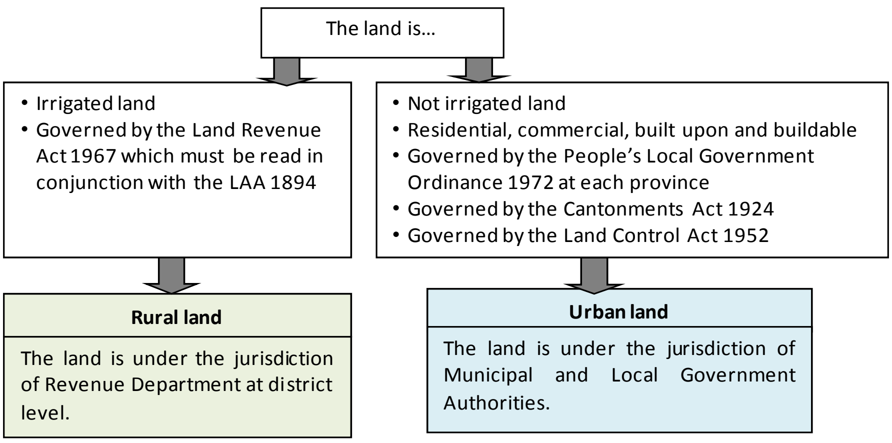
Preliminary Investigation :
・ Section 4, refers to the publication of preliminary notification and power for conducting survey. ・ Section 5 relates to the formal notification of land for a public purpose and 5(a) covers the need for inquiry.
Declaration of Intended Acquisition:
・ Section 6 refers to the government makes a more formal declaration of intent to acquire land. ・ Section 7 indicates that the Land Commissioner shall direct the Land Acquisition Collector (LAC) to take order for the acquisition of land. ・ Section 8, Land to be marked out, measured and planned, the LAC shall thereupon cause the land (unless it has been already marked out under Section 4) to be marked out. LAC shall also cause it to be measured and if no plan has been made thereof, a plan to be made of the same. ・ Section 9, allows the LAC to give notice to all PAPs that the government intends to take possession of the land. If they have any claims for compensation then these claims are to be made to him at an appointed time. ・ Section10 delegates power to the LAC to record statements of PAPs in the land to be acquired or any part thereof as co-proprietor, sub-proprietor, mortgagee and tenant or otherwise;
Enquiry into Measurement, Value and claims and Award by the Deputy Commissioner :
・ Section 11, enables the Collector to make inquiries into the measurements, value and claim and issue the final "award". The award includes the land's marked area and the valuation of compensation and the LAC has made an award under Section 11, LAC will then take possession and the land shall thereupon vest absolutely in the government, free from all encumbrances. ・ Section 12, DC makes a decision on the final award. ・ Section 12 A, if there are any, DC correct and adjust any mistake in the final award. ・ Section 13, Adjournment of enquiry. ・ Section 14, power to summon and enforce attendance of witness. ・ Section 15, matters to be considered and neglected.

Taking Possession:
· Section 16, power to take possession · Section 17, Special powers in case of urgency. Emergency land acquisition, which will not be applied in this Project for the acquisition of land.
Reference to Court & Procedure Thereupon
· The Section 18, reveals that in case of dissatisfaction with the award, PAPs may request the LAC to refer the case onward to the court for a decision; · Section 19, Statement of the court · Section 20, Service of Notice · Section 21, Restrictions of Scope & proceedings · Section 22 and 22A Proceedings to be in open court and cross Objections · Section 23, refers to the award of compensation for the owners for acquired land is determined at its market value plus 15% in view of the compulsory nature of the acquisition for public purposes; · Section 24 Matters to be neglected in determining compensation · Section 25 Rules as to amount of compensation · Section 26 Forms of Award · Section 27 Costs · Section-28 relates to the determination of compensation values and interest premium for land acquisition;
Appointment of Compensation
· Section 29 Particulars of apportionment to be specified · Section 30 Dispute as to apportionment
Payments
· Section 31, provides that the LAC can, instead of awarding cash compensation in respect of any land, make any arrangement with a person having an interest in such land, including the grant of other lands in exchange;
Others
· Section 35, refers to the temporary occupation of arable or waste land subject to the provision of Part VII of the Act. The provincial government may direct the Collector to procure the occupation and use of the same for such term as it shall think fit, not exceeding three years from the commencement of such occupation, and · Section 36, provides the information relating to the power to enter and take possession and compensation on restoration. On the payment of such compensation, or on executing such agreement or on making a reference under Section 35, the Collector may enter upon and take possession of the land and use or permit the use thereof in accordance with the terms of the said notice.

Source: JICA Survey Team

(2) Regulation on Land Classification

In Pakistan, the land is classified (i) "urban" or "rural" lands and, (ii) residential/commercial or agricultural lands depending on its jurisdiction as described in Figure 11.7-2.



Source: JICA Survey Team

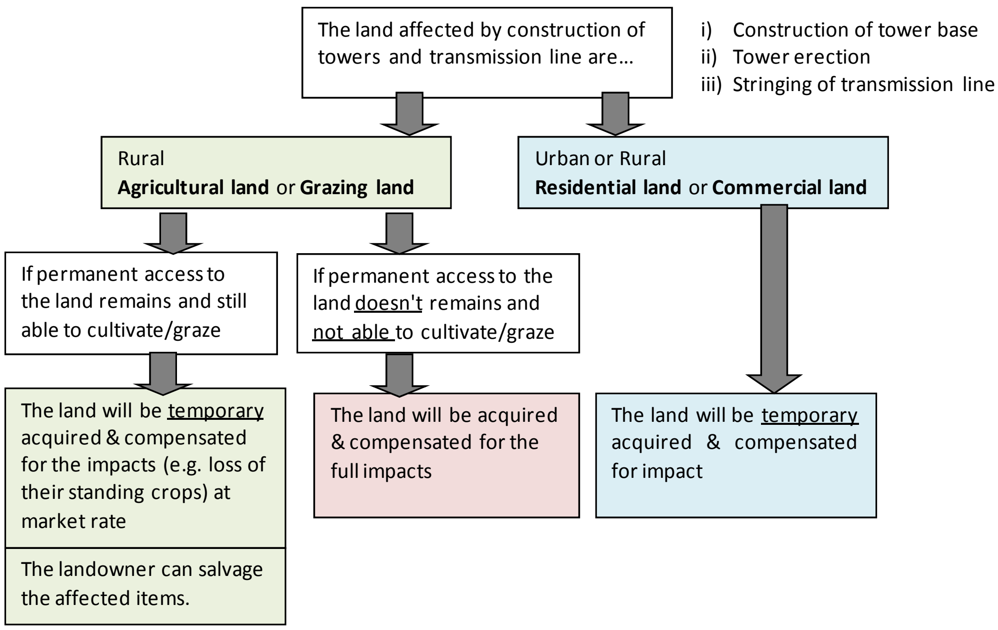
Figure 11.7-2 Land Classification (Urban versus Rural)

In general, either the Land Revenue Act or the People's Local Government Ordinances determines the classification of land. However there are some cases where both applies and other cases where different legislation altogether can indicate jurisdiction and classification over land.

In this study, during the field survey, the project proponent(s) work with the *Patwari* (registrar or keeper of land records) of the Revenue Department of the Jamshoro district to identify the classification as well as land ownership of the land within the project are, "area of interest", herein after referred to as AOI) as an initial step in preparation of the Land Acquisition and Resettlement Action Plan. In the AOI in this project is most likely classified as rural land that falls under the jurisdiction of revenue department at districts level. The land is governed by the Land Revenue Act, 1967 which must be read in conjunction with the LAA, 1894.

(3) Telegraph Act (TA), 1885

In case of impacts caused by poles and Towers for public facilities and Transmission Lines (T/Ls), the land acquisition is not regulated by the LAA but instead by the Telegraph Act, 1885 (amended in 1975). The TA Section 16 provides that the proponent has to provide compensation for the damages to crops, irrigation facilities, land quality or land income etc. during the three (3) major phases (construction of tower bases; tower erection; and stringing) depending on land classification and its damage (See Figure 11.7-3).



Source: JICA Survey Team

Figure 11.7-3 Category of compensation depend on Land Classification (Agricultural/Grazing versus Residential/Commercial)

(4) Analysis of Gaps between Pakistan Laws and JICA Guideline (April 2010)

There are gaps between LAA and JICA Guidelines (April 2010) and World Bank (WB) Safeguard Policy. To establish equal and appropriate land acquisition and resettlement system, the Pakistan government proposed "Draft National Resettlement Policy (NRP), 2002" and "Draft Project Implementation and Resettlement of Affected Persons Ordinance 2001. However, they were not approved by the cabinet of Parliament so that not applicable to practice use at present. As described above, there are legal frameworks for public consultation for EIA implementation though; there are none for land acquisition and resettlement.

The differences between the Pakistani legal frameworks and JICA Guideline (April 2010) on land acquisition and resettlement are analyzed in LARAP that is prepared separately.

11.7.2 Necessity of Land Acquisition and Resettlement

(1) Power Plant

The power plant project will require 46.25 acres of additional land for various components, including two access roads, water pumping station and path to pumping station, water pipelines (temporary acquisition) and ash pond (Table 11.7-2). The Project will affect 0.87 acres of uncultivated private land of three households (18 people). However, there is no physical relocation of household, no impacts on their assets and livelihood. Overall attitude of the affected people is that the project is necessary in the current situation of power supply and demand. They are willing to give their lands at fair price.

Table 11.7-2 Land Acquisition Requirements by Project Components

No	*Project Component*	*Required Land (Acres)*	*AHs*	*APs*
1	Northern Access Road	3.95	-	-
2	Southern Access Road	1.99	-	-
3	Water Pumping Station	0.11	1	9
4	Path to Pumping Station	0.76	3	18
5	Water Pipeline (Temporary acquisition)	3.29	-	-
6	Ash Pond	36.15	-	-
Total		**46.25**	**3**	**18***

Source: Resettlement Field Survey June–July 2014

*Some of the AHs and APs are being affected by more than one component therefore total does not match with the sum of the columns.

(2) Transmission Line

According to the “National Transmission and Dispatch Company Safety Considerations" issued by the Design Directorate of NTDC, the Right of Way (RoW) is proposed to be a corridor of 30m on either side of the center line. According to the current Pakistani Law and NTDC's practice, the land under the T/Ls and footing of towers are usually not acquired permanently unless the presence of the tower hinders access to the cultivated or residential land underneath it.

During this Study, the field investigation has revealed that the land within the proposed RoW is uninhabited and non-productive barren stony wastelands. It was further confirmed through stakeholder consultations that no one has the ownership of the land concerned. As such, it is concluded that the land within the proposed RoW will not be acquired in the implementation of this Project.

(3) Land Acquisition and Resettlement Action Plan

In this project for power plant, it is expected that less than 200 people are displaced. Therefore, the impacts are considered as "minor" according to 'World Bank Safeguard Policy OP 4.12'. The LARAP for power plant was developed in this preparatory study that was equivalent to "Abbreviated Resettlement" with the following contents (Appendix 11-7).

1) Scope of Land Acquisition and Resettlement
2) Legal Framework
3) Socio-economic Information and Profile of Affected People
4) Social Impacts
5) Entitlement, Assistance and Benefits
6) Information Disclosure, Consultation and Participation
7) Relocation of Housing, Livelihood Restoration and Rehabilitation
8) Grievance Redress Mechanism
9) Land Acquisition and Resettlement Budget
10) Institutional Arrangements for Implementation
11) Implementation Schedule
12) Monitoring and Reporting

CHAPTER 12
REVIEW FOR THE F/S ON THAR- MATIARI TRANSMISSION LINE

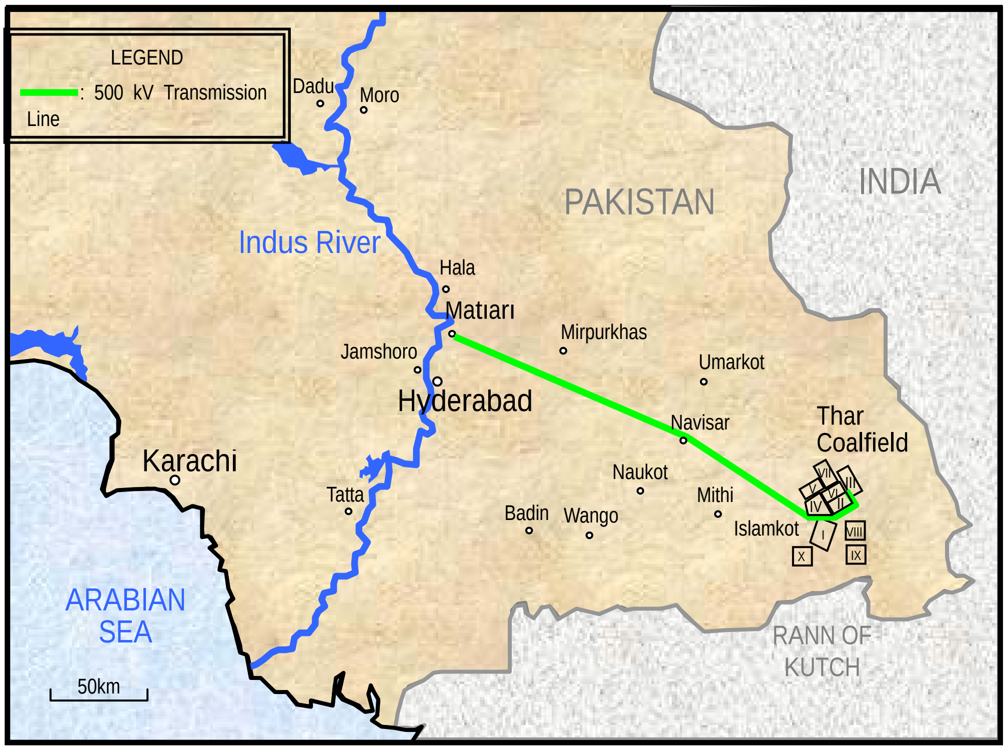
Chapter 12 Review of the Feasibility Study of the Thar – Matiari Transmission Line

12.1 Objective of the Survey

12.1.1 General

The feasibility study (F/S) of the 500 kV transmission line between the Thar coalfield and Matiari had already been carried out under the National Transmission & Despatch Company (NTDC). PC-1 for the 500 kV transmission line has already been approved on 28 August 2012. The project cost is estimated at around Rs XXX. A route map of the 500 kV transmission line between Thar and Matiari is shown in Figure 12.1-1, and a list of major items for the above project are shown in Table 12.1-1.

"XXX" stands for "The information is masked because it includes confidential."



Source: JICA Survey Team

Figure 12.1-1 Route Map of the 500 kV Transmission Line Between Thar and Matiari

Table 12.1-1 List of Major Equipment for the 500 kV Transmission Line Between Thar and Matiari

No.	Description	Unit	Qty.
1	Tower	Nos.	694

2	Conductor (Araucaria)	km	6,300
3	Shield Wire	km	263
4	OPGW	km	263
5	Insulator 82 kN	Nos.	20,056
6	Insulator 160 kN	Nos.	290,996
7	Conductor accessories, hardware and grounding sets, etc.	Lot	1

Source: PC-1 for Interconnection of Thar Coal-based 1,200 MW Power Plant with NTDC

Table 12.1-2 List of Major Equipment for the Extension of 500 kV Matiari Switching Station

No.	Description	Unit	Qty.
1	Circuit Breaker	Sets	5
2	Bus Isolator (DS)	Sets	8
3	Line Isolator (DS with Earthing Switch)	Sets	2
4	CT	Nos.	15
5	CVT	Nos.	6
6	Lightning Arrestor	Nos.	13
7	Shunt Reactor (3 x 37 MVAR)	Nos.	2
8	Spare Shunt Reactor (1 x 37 MVAR)	Nos.	1

Source: PC-1 for Interconnection of Thar Coal-based 1,200 MW Power Plant with NTDC

12.1.2 Objective of the Survey

In the case of Thar coalfield being identified as a suitable site for the Project, the F/S is reviewed in accordance with the planning of the power station under the Project.

Other than Thar being identified as a suitable site for the Project the power station will be constructed in the Thar coalfield, in addition, transmission line between Thar and Matiari is absolutely needed. Therefore, the development status for each developer will be confirmed. Consequently, the F/S is reviewed in consideration of the connection with the power station.

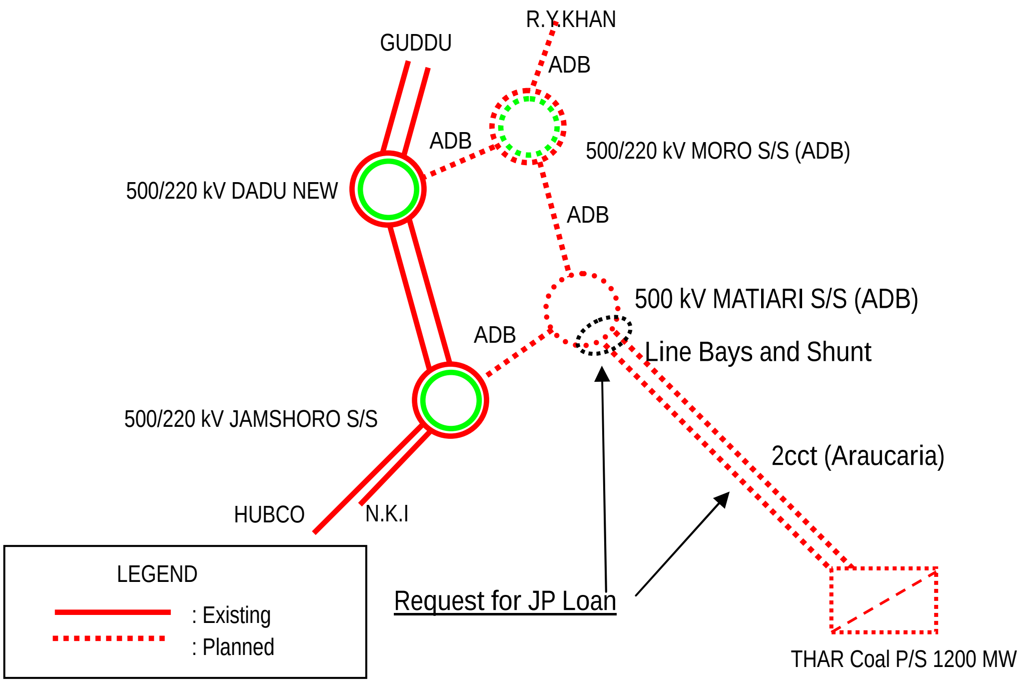
As for the Matiari Switching Station, basic design of an expansion bay for the connection with Thar will be carried out.

12.2 Review of the F/S

12.2.1 Expansion Plan and Current Status of the 500 kV Network Surrounding Sindh

The expansion plan of the 500 kV network system surrounding Sindh is shown in Figure 12.2-1. The expansion plan of the 500 kV network from the Matiari Switching Station, including the Matiari Switching Station itself, will be carried out utilizing funds from the Asian Development Bank (ADB). According to the tentative schedule of PC-1, their network will be completed in June 2016.

However, according to the latest information from NTDC, since the expansion plan of the 500 kV system for the surrounding Sindh is connected with the Thar Power Station, their expansion plan was stopped due to lack of progress in the development of the Thar coalfield at present.



Source: NTDC

Figure 12.2.1 Expansion of the 500 kV Network System Surrounding Sindh from 2016 to 2017

12.2.2 Development Plan of Power Stations in the Thar Coalfield

On the other hand, according to the latest information from TCEB and developers, there is a power generation plan of 3,120 MW in total in the Thar area until 2020, as shown in Table 12.2-1. In case that mining is started and its amount increases, there is a high possibility to construct additional power stations in the Thar area, since mine mouth generation is suitable due to lignite coal.

In addition, the construction site of the coal-fired thermal power station financed by JICA is selected in the existing Lakhra Power Station and not in the Thar coalfield as mentioned in Chapter 3.

Table 12.2-1 Development Plan of Power Stations in the Thar Area, as of November 2013

Name of Block	Name of Developer	Capacity	Operation Year
Block II	Thar Power (Phase 1)	300 MW	2017
Block II	Thar Power (Phase 1)	300 MW	2018
Block II	Thar Power (Phase 2)	600 MW	2019
Block VI	Oracle	600 MW	2017
Block I	SSRL Lease Holder	660 MW	2017
Block I	SSRL Lease Holder	660 MW	2019
Total		3,120 MW	

Source: TCEB

12.2.3 Applicability of Low Loss Conductor

Since AAAC of Araucaria is selected as conductor for the 500kV transmission line between Thar and Matiari in original plan, applicability of low loss conductor compared with AAAC is considered as follows.

There is a paucity of influence of strong wind in Pakistan, AAAC is mainly used at coastal area. However, since AAAC is weak to the wind pressure load in Japan, ACSR is normally used in Japan. In addition, it is feature that AAAC is light and loss is low compared with ACSR.

(1) Low Loss Conductor

Low electrical power loss thermal resistant aluminum alloy conductor steel reinforced/aluminum-clad steel reinforced (LL-TACSR/AS) is applied for this Project as an alternative besides the AAAC of Araucaria, which was the selected conductor in the F/S. Comparison between the AAAC and LL-TACSR/AS is shown in Table 12.2-2.

Table 12.2-2 Comparison Between AAAC and LL-TACSR/AS

Description		AAAC "Araucaria" 820 mm^2	LL-TACSR/AS 430 mm^2	LL-TACSR/AS 550 mm^2	**LL-TACSR/AS 750 mm^2**
Overall Diameter (mm)		37.3	25.2	28.62	32.9
Sectional Area AL / Core (mm^2)		821.1	429.1 / 29.09	550.4 / 40.08	751.2/33.00
Nominal Weight (kg/km)		2269.5	1,399	1,814	2,310
Min. Breaking Load (kN)		242.24	106.9	140.5	159.9
DC Resistance at 20 degrees (ohm/km)		0.0406	0.0677	0.0526	0.0387
Allowable Continuous Operation Temp.		75	150	150	150
Applicable N-1 System (Transmission Capacity)	Ambient Temp. at 40 degrees	Up to 2,700 MW	Up to 4,100 MW	Up to 4,900 MW	Up to 5,800 MW
	Ambient Temp. at 52.5 degrees	-	Up to 2,300 MW	Up to 2,700 MW	Up to 3,200 MW
Conductor Price (USD/m)		6.2	8.3	10.1	13.1

Source: JICA Survey Team

(2) Applicability of Low Loss Conductor

1) Transmission Line Loss

In order to reduce transmission line loss, a low loss conductor is generally applied in cases in other countries. However, resistance to the AAAC of the existing conductor is low.

A comparison of transmission line losses is shown in Table 12.2-3. The loss due to the Araucaria AAAC and resistance are low, thus resistance of the conductor is not much different compared with LL-TACSR. Although it is possible to realize loss reduction, the advantage for the reduction of transmission line loss is not a large value.

In the result, since the initial cost of LL-TACSR is high as shown in Table 12.2-5, the amount of balance for the initial cost of LL-TACSR and Araucaria could not be collected from the electricity tariff for the transmission line loss.

Table 12.2-3 Comparison of Transmission Line Loss

Transmission Capacity	Transmission Line Loss			
	AAAC "Araucaria"		LL-TACSR/AS 750 mm^2	
	(kWh/year)	%	(kWh/year)	%
1,200 MW	40,427,891	0.64	38,989,849	0.62

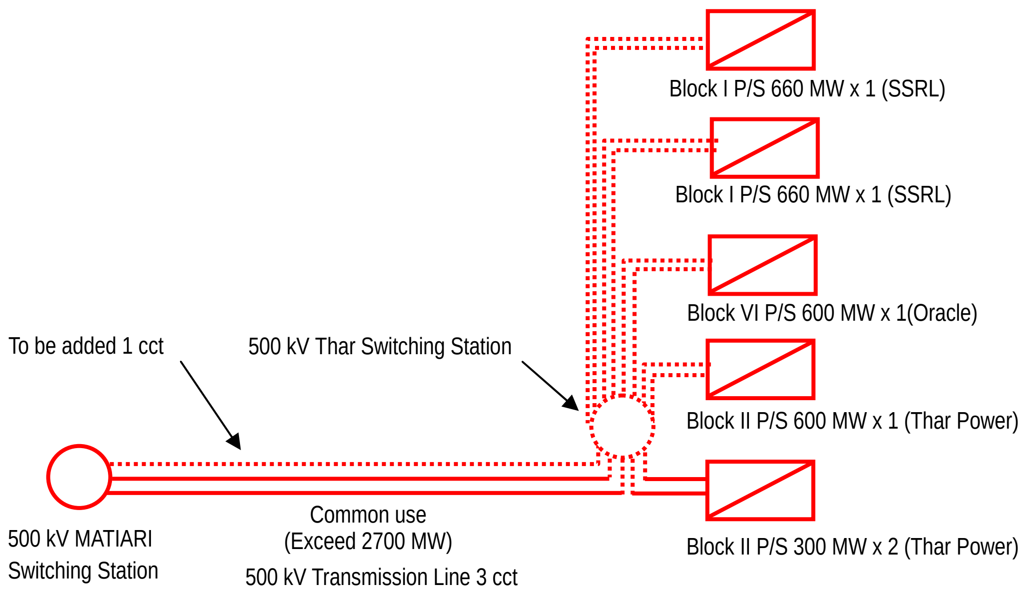
Note: Calculation basis follows below conditions.
No. of Circuits: 2, Power Factor: 0.9, Load Factor: 0.6

Source: Prepared by the JICA Survey Team

2) Thermal Capacity

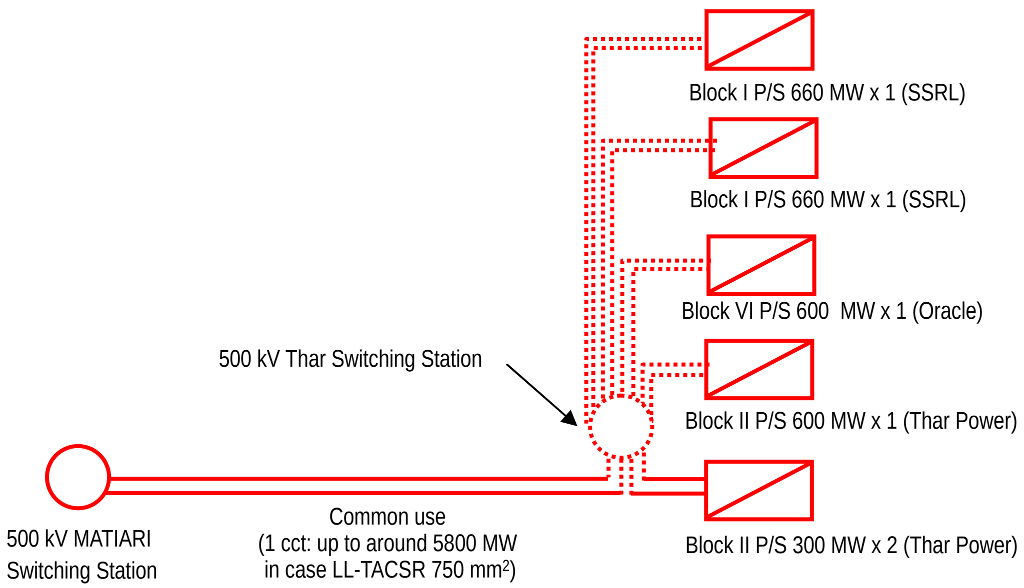
In terms of thermal capacity, when the generation power exceeded 2,700 MW, as for the adopted conductor in the F/S, it cannot be operated for the N-1 system, and it is necessary to construct new transmission lines.

Particularly, LL-TASCR/AS is beneficial from the viewpoint of increasing the transmission capacity of the Project. Although the initial cost will be higher than Araucaria, it has economical advantage considering the future expansion plan shown in Table 12.2-4.



Source: JICA Survey Team

Figure 12.2-2 Operation Method of 500 kV Transmission Line (Original Plan of Araucaria)



Source: JICA Survey Team

Figure 12.2-3 Operation Method of 500 kV Transmission Line (In Case of LL-TACSR/AS 750 mm^2)

Table 12.2-4 Comparison of Construction Cost in Consideration of Future Expansion

This figure is masked because it includes confidential.

3) Power System Analysis

Based on the results of the power system analysis for stability, since the transmission line between Thar and Matiari covers a long distance of approximately 250 km, only 1,200 MW per single circuit can be transmitted regardless of the kind of conductor.

In consequence, the availability of transmission capacity depends on the stability; therefore the advantage of large transmission capacity in terms of thermal capacity is lost.

4) Conclusion

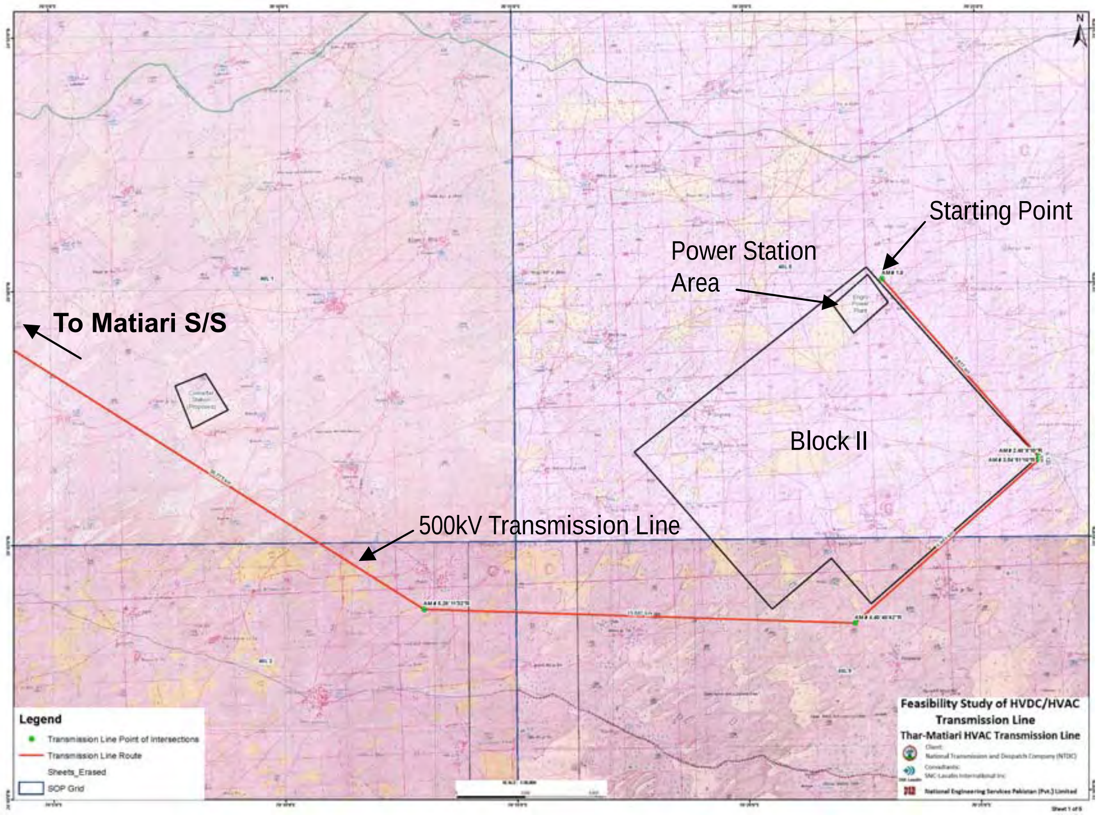
As mentioned above, there is no cost advantage for the adoption of LL conductor in this case.

Accordingly, power stations are planned in the Thar area as mentioned in Section 12.2.2, and when the construction of power plant is completed, the number of circuits between Thar and Matiari may be increased, in addition, main transmission line between north and south to be reinforced.

12.2.4 Starting Point of Transmission Line in Thar

The starting point of the 500 kV transmission line at the Thar side will be located near the power station at first. In the F/S of the transmission line between Thar and Matiari, the starting point at the Thar side was planned in the power station in Block II as shown in Figure 12.2-4.

The construction plan for the power station in Block II is the latest situation. In addition, the location of the power station of Block II is not changed. Consequently, the starting point is the same as in the F/S.



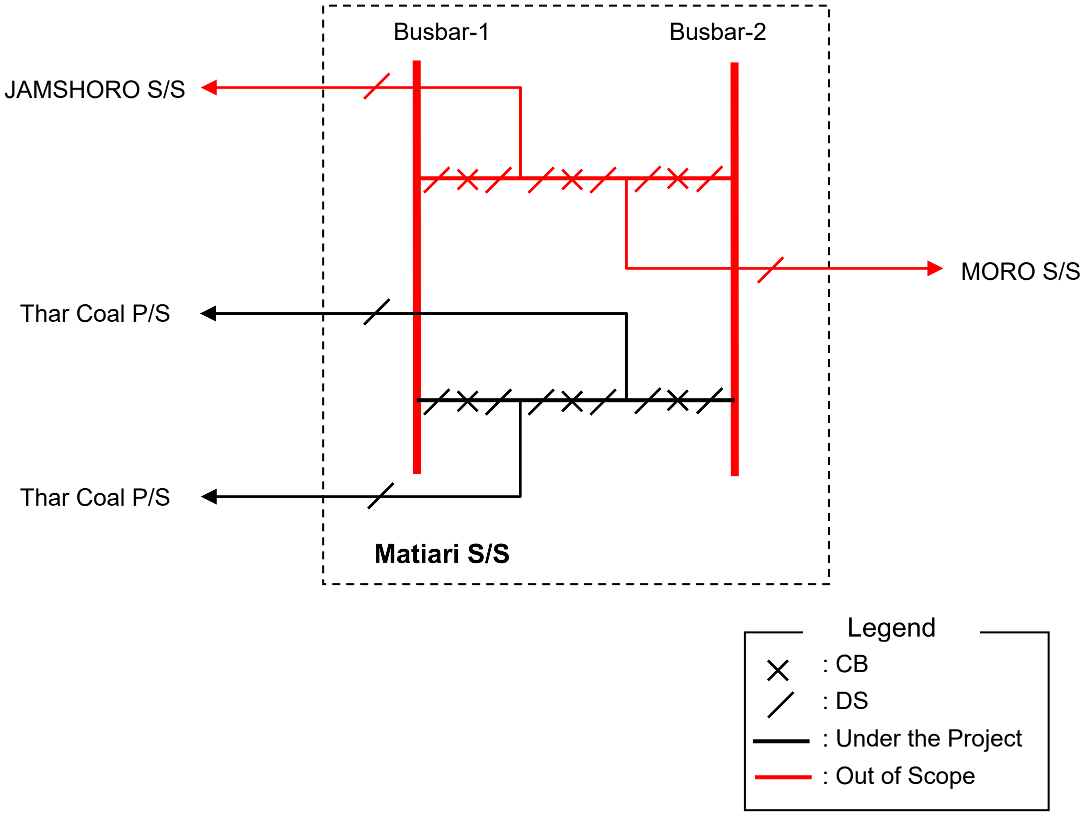
Source: Prepared by the JICA Survey Team based on the F/S by NTDC

Figure 12.2-4 Starting Point of the 500 kV Transmission Line

12.2.5 Conceptual Design of Matiari Switching Station

(1) General

The diagram of the 500 kV network at the Matiari Switching Station is shown in Figure 12.2.5. Since the 500 kV Matiari Switching Station is constructed under another project, the two expansion bays for connecting to the transmission line from Thar are constructed under the Project.

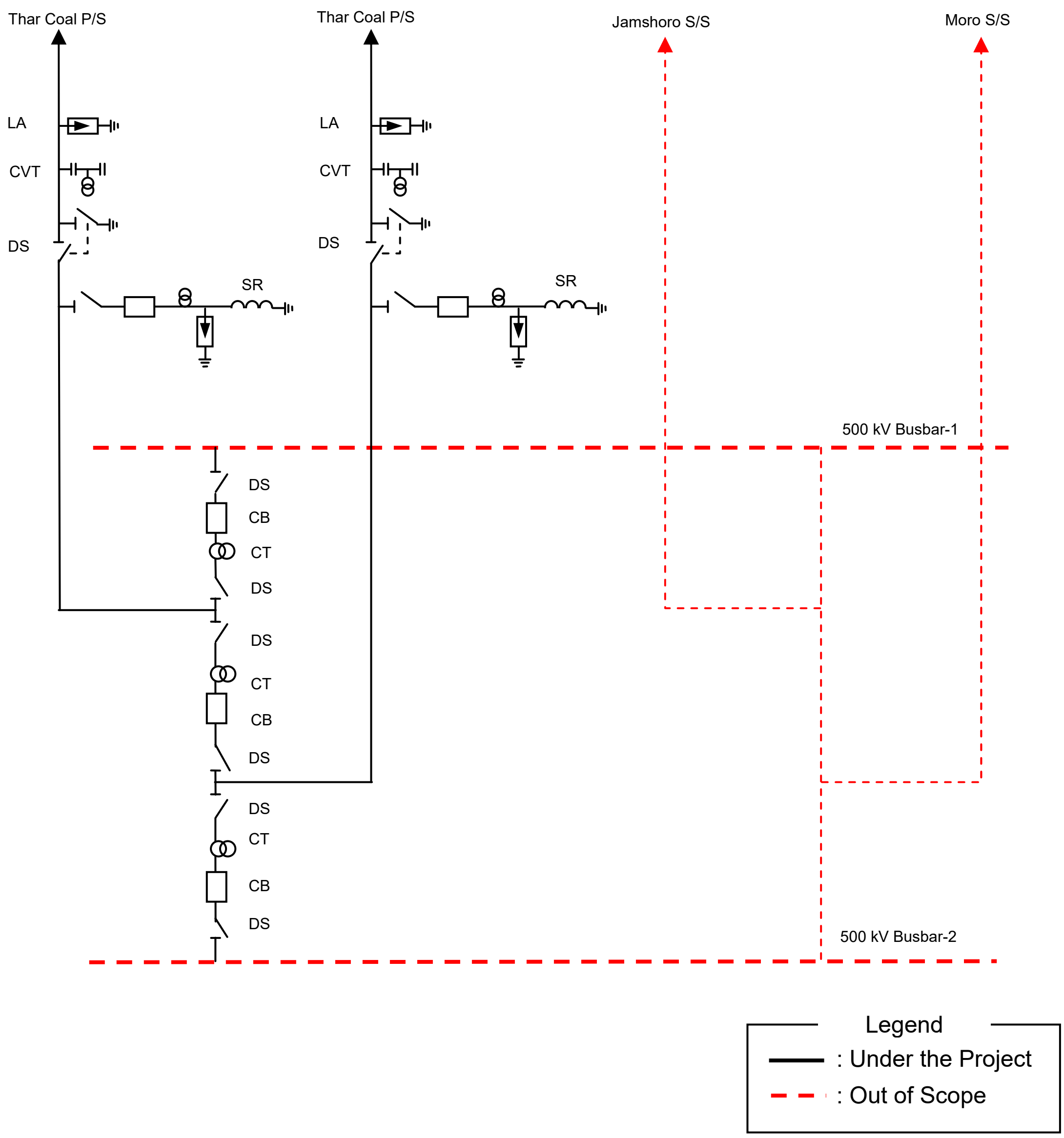


Source: JICA Survey Team

Figure 12.2-5 Diagram of the 500 kV Network at the Matiari Switching Station

The busbar system at Matiari Switching Station will be of breaker-and-a-half scheme based on standards of NTDC. In order to connect to the 500 kV transmission line bays, three breakers are installed between busbar-1 and busbar-2. Then two 500 kV transmission line bays with 3 x 37 MVA shunt reactors are installed for connecting to the transmission lines to the Thar coal P/S.

The single line diagram of the 500 kV Matiari Switching Station is shown in Figure 12.2-6.



Source: JICA Survey Team

Figure 12.2-6 Single Line Diagram of the 500 kV Matiari Switching Station

(2) Specifications and Quantities of Major Equipment

The specifications of equipment applied are in accordance with the standards of NTDC. General electrical requirements for 500 kV equipment and specifications of 500 kV switchgear are as follows:

1) General Electrical Requirements for 500 kV Equipment

i)	Nominal system voltage	500 kV
ii)	Rated voltage (rms value) (Highest voltage for equipment)	550 kV
iii)	Rated frequency	50 Hz
iv)	Rated lightning impulse withstand voltage (peak value) - For other equipment	1,550 kV
v)	Switching impulse withstand voltage, dry and wet (peak value) - For other equipment: phase-earth	1,175 kV
vi)	Rated current	3,150 A
vii)	Rated short-duration withstand current (3 s)	63 kA

2) Specifications of 500 kV Switchgear

All main facilities installed under the Project should be of outdoor type. Major specifications of the equipment are as follows:

a)	Circuit Breakers	- Single pole, SF6 gas type - Rated voltage: 550 kV - Rated normal current: 3,150 A - Short-circuit breaking current: 63 kA - Operation sequence: O-0.3s-CO-3min-CO - Rated short-duration power-frequency withstand voltage (rms): Phase to earth and between phase: 620 kV Across open breaker: 800 kV - Rated lightning impulse withstand voltage (peak): 1,550 kV
b)	Disconnecting Switches (DS)	- Single pole, Vertical break type - Rated voltage: 550 kV - Rated continuous current: 3,150 A - Rated short-duration withstand current: 63 kA - Rated short-duration power-frequency withstand voltage (rms): Phase to earth and between phase: 620 kV Across open breaker: 800 kV - Rated lightning impulse withstand voltage (peak): 1,550 kV 220 V DC motorized and manual operation
c)	DS with Earthing Switch	-Same as item b)
d)	Current Transformers	- Rated voltage: 550 kV - 3000-2400-2000-1250-750/1A, 5P20 & cl. 0.2, 30 VA
e)	Current Voltage Transformers	- Capacitive Type -Voltage ratio: 500 /√3 kV, 110 /√3 V, 110 /√3 V -Accuracy and burden; secondary (measurement): 0.2, 100 VA tertiary (protection): 3P, 100 VA -Coupling capacitance: ≧6,900 pF

f)	Surge Arresters	- Station type metal oxide arresters with surge counter - Arrester rated voltage (rms): 420 kV - Rated discharge current: 20 kA
g)	Shunt Reactors	-Single phase, oil immersed type - Cooling: ONAN - System nominal voltage: 500 kV /√3 kV - Reactor rated voltage: 550 /√3 kV - Maximum operating voltage : 575 /√3 kV - Rated lightning impulse withstand voltage (peak): Line End :1,550 kV, Neutral End: 325 kV - Rated switching impulse withstand voltage (peak): Line End :1,300 kV, Neutral End: 280 kV - Nominal power rating at rated voltage: 37 MVAR - Rated power rating at rated voltage: 44.77 MVAR

3) Quantities of Major Equipment

With reference to the single line diagram, the quantities of main facilities of each substation required for the Project are shown in Table 12.2-5.

Table 12.2-5 Quantities of Major Equipment

No.	Major Equipment	Quantity
a)	Circuit breakers	5 sets
b)	Disconnecting switches	8 sets
c)	DS with earthing switch	2 sets
d)	Current transformers	5 sets
e)	Current voltage transformers	2 sets
f)	Surge arresters	4 sets
g)	Shunt reactors (3 x 37 MVAR)	2 sets
h)	Spare shunt reactor (1 x 37 MVAR)	1 set

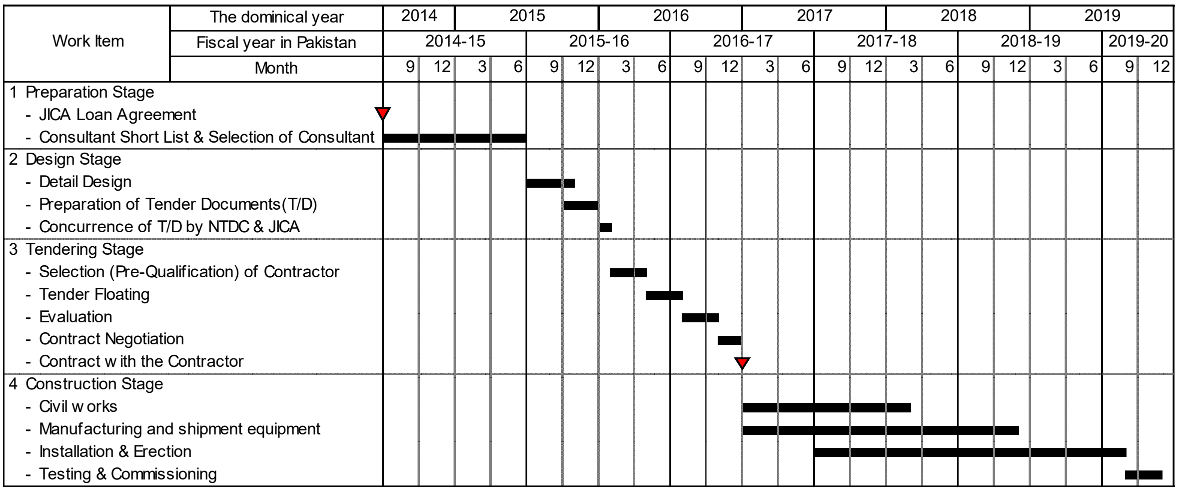
Source: JICA Survey Team

12.2.6 Implementation Schedule

The tentative implementation schedule for the construction of the 500 kV transmission line is shown in Figure 12.2-7. In case that the transmission line is constructed using Japanese yen loan, the JICA loan agreement will be signed in June 2014, and the transmission line between Thar and the Matiari Switching Station will be completed in December 2019.

On the other hand, commercial operation of the power station (300 MW) in Block II will be in 2017 at the earliest, as shown in Table 12.2-1.

Therefore, it is necessary to ascertain the validity of the construction of the power station.



Source: Final Report for the Data Collection Survey on Thar Coal Field in Pakistan

Figure 12.2-7 Implementation Schedule in Case of Funding by Japanese Yen Loan

12.2.7 Project Cost

The Project costs for the application of Araucaria in the existing plan, and LL-TACSR are shown in Table 12.2-5. The Project implementation cost is revised based on PC-1, on the assumption of application of Japanese yen loan. Price escalation was considered from the time of PC-1, thus, the construction cost is approximately Rs XXX per km for AAAC, and is Rs XXX per km for LL-TACSR. It is judged that the Project cost is appropriate.

"XXX" stands for "The information is masked because it includes confidential."

In addition, the eligible cost, interest during construction, and commitment charge in Table 12.2-6 correspond to the JICA-financed portion.

Table 12.2-6 Project Implementation Cost

This table is masked because it includes confidential.

12.3 Financial and Economic Analysis

The review of the F/S of the Thar-Matiari transmission line in terms of financial and economic analysis is to be conducted by comparing the results (internal rate of return (IRR) and net present value (NPV)) of PC-1 and JICA's previous study,[1] as this will make it easier to judge whether the results of each analysis is appropriate or not. If there is a significant gap between the results of these two studies, it can be concluded that either of the results are likely to be inappropriate.

There are many differences in the assumptions used in the financial and economic analysis of PC-1 and JICA's study. As it is difficult to use the same assumptions and recalculate IRR and NPV, the results alone are simply compared in this section.

The financial costs of both studies are compared in Table 12.3-1 and Table 12.3-2.[2] The financial cost of JICA's study is based on the cost using LL-TACSR, and is significantly higher than that of PC-1, which assumes the use of the Araucaria conductor.[3]

Table 12.3-1 Financial Cost of PC-1 (Unit: Rs million)

This table is masked because it includes confidential.

Table 12.3-2 Financial Cost of JICA's Study (Unit: Rs million)

This table is masked because it includes confidential.

The results of the financial and economic analysis of these studies are shown in tables below, though it may be unlikely to completely match the figures of both calculations due to the differences in assumptions, which in turn resulted in the different IRR and NPV results.

[1] JICA, "Data Collection Survey on Thar Coal Field In Pakistan Final Report", February 2013
[2] The figures of the cost of JICA's study are slightly different from that of the Final Report due to the change in the price escalation.
[3] See 5.1 Transmission Line, Chapter 5 of "Data Collection Survey on Thar Coal Field In Pakistan Final Report" for the difference between two types of transmission line.

Despite that, it is worthwhile mentioning the implication of the results of the financial internal rate of return (FIRR) and financial net present value (FNPV). It is clear from the results of both calculations that the FIRR is unable to meet the cutoff rate, and the NPV turns out to be negative. In other words, from the viewpoint of the executing agency (i.e., NTDC), the business is not profitable and may produce financial loss even in the accounting term.

Table 12.3-3 FIRR and FNPV of PC-1

This table is masked because it
includes confidential.

Table 12.3-4 FIRR and FNPV of JICA's Study

This table is masked because it
includes confidential.

The results of the economic internal rate of return (EIRR) and economic net present value (ENPV) in both studies are similar, though the differences in figures exist as well as in the financial analysis. The Project can produce significant economic return for the national economy, which is much higher than the cutoff rate, and justifies the implementation of the Project to bring about significant benefit to the country.

Table 12.3-5 EIRR and ENPV of PC-1

This table is masked because it
includes confidential.

Table 12.3-6 EIRR and ENPV of JICA's Study

This table is masked because it
includes confidential.

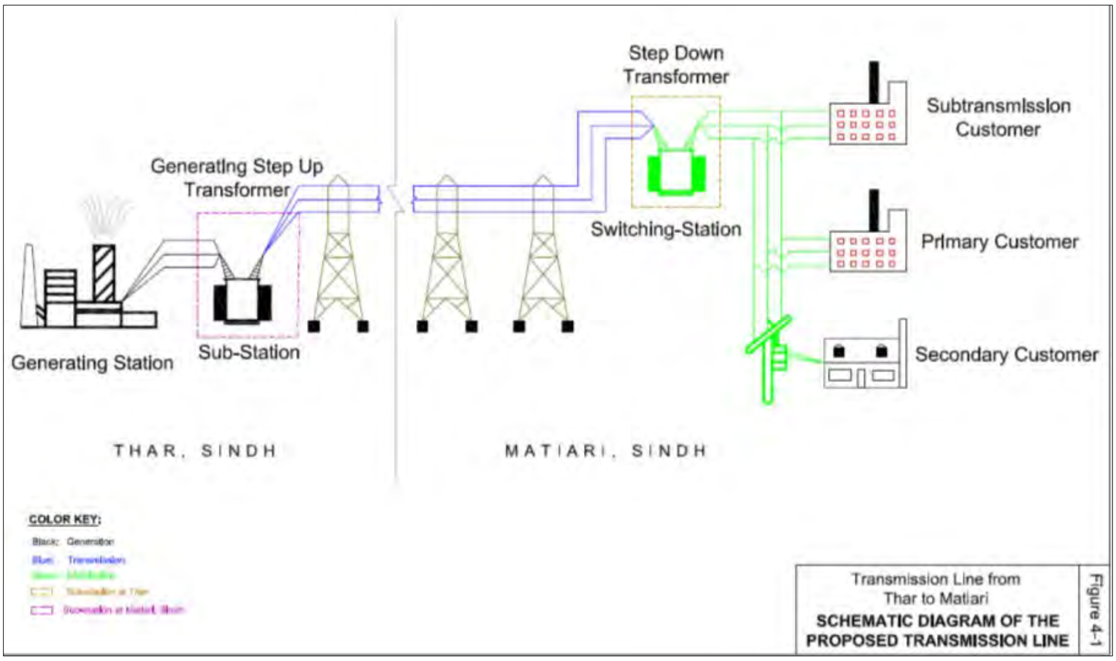
It can be concluded that the implementation of the Project can be justified because of its significant benefit to the national economy and that the conclusion based on the results of financial and economic analyses of both studies are not contradictory to each other.

12.4 Environmental and Social Considerations

12.4.1 Project Components

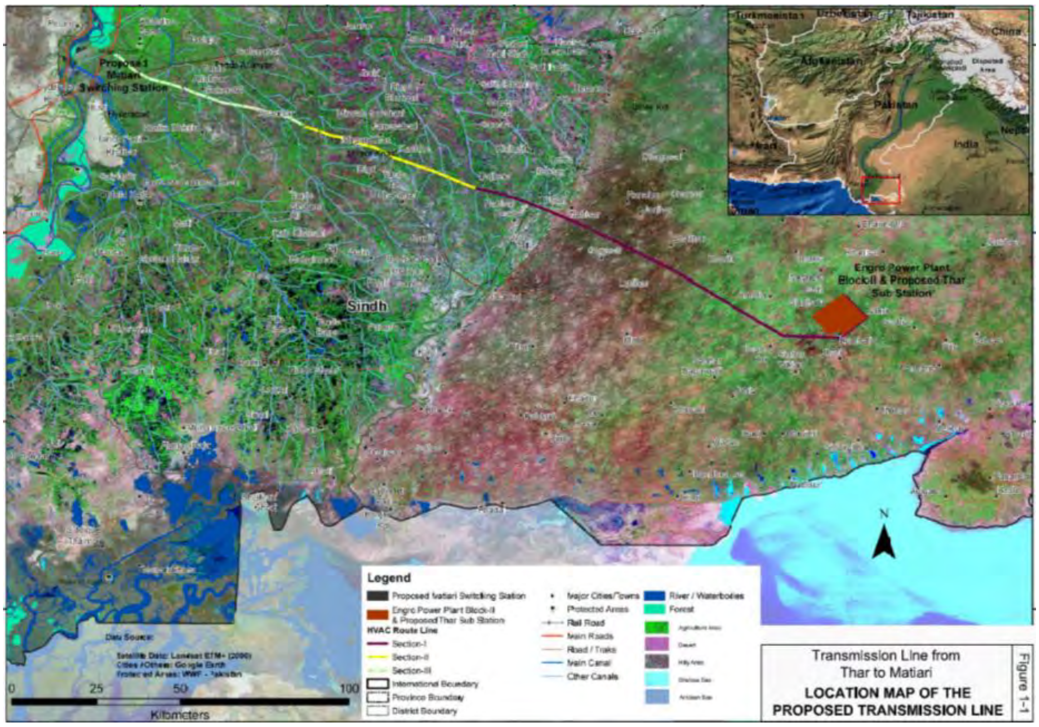
The Project components of the transmission line (T/L) between Thar and Matiari are as follows: (1) transmission line and (2) substation and switching station, which are described in the environmental impact assessment (EIA) for the transmission line between Thar and Matiari (EIA for the T/L).

A schematic diagram of the T/L is shown in Figure 12.4-1, and the location map of the T/L is shown in Figure 12.4-2.



Source: EIA for Transmission Line between Thar and Matiari

Figure 12.4-1 Schematic Diagram of the Transmission Line



Source: EIA for Transmission Line between Thar and Matiari

Figure 12.4-2 Location Map of the Proposed Transmission Line

12.4.2 Natural Environment

The T/L consists of three sections (Sections I, II, and III) as shown in Table 12.4-1. Based on the classification of "terrestrial ecoregions" proposed by the World Wildlife Fund's (WWF's) Wildfinder, the T/L will pass through two main ecoregions of deserts and xeric shrublands, and the Northwestern thorn scrub forests.

Table 12.4-1 Each Section of the Transmission Line

Section Name	Section	
Section I	Tharparkar District - Umerkot District	AM #1 - 12
Section II	Mirpurkhas District - Badin District	AM #12 - 20
Section III	Tando Allahyar District - Hyderabad District	AM #20 - 31

Source: EIA for Transmission Line between Thar and Matiari

(1) Flora and Fauna

The major flora species found in the pass area, i.e., Umerkot, Rahim yar Khan, and Bahawalpur districts, are kandi (*Prosopis cineraria*), khabbar (*Salvadora oleoides*), aak (*Calatropis procera*), booi (*Aerva javanica*), neem (*Azadirachta indica*), and kikar (*Acacia nitolica*), etc. Species ordinarily found in the plains, i.e., Khairpur, Sukkur, Ghotki, Bahawalnagar, Pakpatan, Okara and Kasur districts, are sufaida (*Eucalptus camaldulensis*), bair (*Zizyphus jajuba*), shesham (*Dalbergia sisso*), mango (*Mangifera indica*), and date okara palm (*Phoenix dactylifera*).

Major mammals found in the corridor of impact (COI) are rabbit (*Lepus nigricollis*), jackal (*Canis aureus*), and pig (*Suss crofa*). Domestic animals include cows, buffaloes, sheep, goats, cats, and camels. Reptiles include snakes and small-sized lizards which are also commonly seen in the area. Porcupine (*Hystrix indica*), squirrel (*Funambulus layardi*), and mouse (*Mus musculus*) are the basic rodents found in the area. Toad (*Bufo bufo*) and frog (*Rana tigrina*) are the basic amphibians in the area. Important resident bird species/avifauna found in the area are house sparrow (*Passer* species), and common crow (*Corvus splendons*).

(2) Game Reserves, National Parks, and Wildlife Sanctuaries

According to the EIA for the T/L, a minimum strip of 100 m (50 m on either side from the centerline) was delineated as the right-of-way (ROW) in which direct impacts of the proposed T/L are anticipated as a result of its implementation. However, for indirect impacts related to physical, ecological, and social domains, the COI of 500 m on each side of the center line of the T/L was considered as the project corridor or COI.

Based on data from the Forest Department of related states, the proposed T/L will not pass through or cross any protected area, i.e., game reserves, national parks and wildlife sanctuaries.

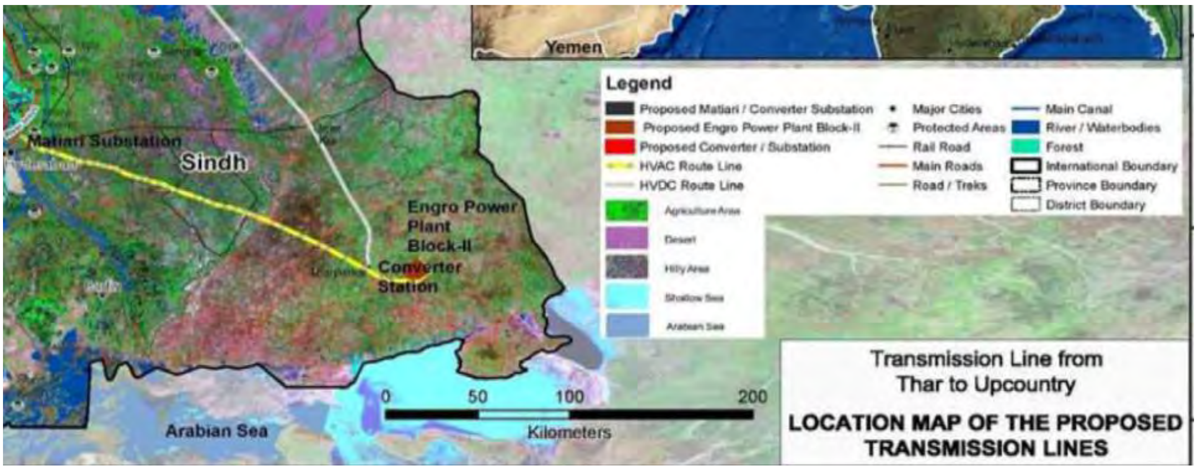


Figure 12.4-3 Protected Areas in Sindh and Punjab Provinces

Source: Draft F/S of the T/L

(3) Ecologically Important Habitat and Religious, Archaeological and Historical Sites

Religious, archaeological and historical sites along the COI are given in Table 12.4-2

Table 12.4-2 Religious, Archaeological, and Historical Sites

Category	Section-I	Sections-II & III
Religious Facility	Shrines, mosques, graveyards and temples exist in COI.	82 religious facilities (mosques, shrines and graveyards) exist.
Historical Facility	None	None

Source: EIA for the Transmission Line between Thar and Matiari

12.4.3 Socioeconomic Environment

(1) Land Use

The T/L crosses through Sindh and Punjab provinces. Most of the land of Tharparkar District in Sindh are desertic and consist of barren tracts of sand dunes covered with thorny bushes. On the other hand, the main land use in Punjab Province is agricultural and irrigated areas.

In the COI, the main water sources are groundwater, and surface water. The Sutlej River will be the only river to be crossed by the proposed T/L.

(2) Agriculture

There are only two main crops being cultivated in the COI, i.e., wheat in *Rabi* season (spring harvest), and basmati rice (paddy) in Kharif season (autumn harvest). In addition to these two crops, fodder is cultivated in the COI in both seasons.

12.4.4 Policy, Legal and Administrative Framework

(1) Policy and National Plan on the Environment

The National Power System Expansion Plan 2011-2030 aims to construct new power stations in the Thar coalfield to increase power generation up to 40,000 MW. The policies regarding this plan are enumerated below.

- National Conservation Strategy, 1992
- National Environmental Policy, 2005
- Poverty Reduction Strategy Paper, 2003
- National Forest Policy Pakistan, 2001
- Pakistan Labour Policy, 2010

(2) Legislation

Legislations regarding the proposed T/L project are listed below.

- The Pakistan Environmental Protection Act (PEPA), 1997
- Pak EPA Regulations, 2000

- Guidelines for the Preparation and Review of Environmental Reports, Pakistan Environmental Protection Agency, 1997
- Guidelines for Public Consultation, Pakistan Environmental Protection Agency, May 1997
- Sectorial Guidelines: Pakistan Environmental Assessment Procedures, Pakistan Environmental Protection Agency, October 1997
- Guidelines for Critical and Sensitive Areas, 1997
- Guidelines for Public Consultation
- National Environmental Quality Standards (NEQS), 2000
- The Land Acquisition Act (LAA), 1894
- The Telegraph Act, 1910
- Pakistan Penal Code, 1860
- Affected Persons Ordinance, 2001
- Electricity Act, 1910
- The West Pakistan Water and Power Act, 1958
- The Forest Act, 1927
- Provincial Wildlife (Protection, Preservation, Conservation and Management) Acts, Ordinances and Rules (Act 1972)
- Sind Wildlife Protection Ordinance, 1972
- The Cutting of Trees (Prohibition) Act, 1975
- Protection of Trees and Brushwood Act, 1949
- Provincial Local Government Ordinance, 2001
- Antiquities Act, 1934
- Sindh Cultural heritage (Preservation) Act, 1994
- Explosive Act, 1884
- ADB Safeguard Policy Statement (SPS), 2009
- Convention on Biological Diversity, 1994
- The Convention on Conservation of Migratory Species of Wild Animals, 1979
- The Rio Declaration, 1992
- Convention on Wetlands (Ramsar Convention), 1971
- NTDC Safety Considerations
- Punjab Plantation and Maintenance of Trees Act, 1974
- Factories Act, 1934
- The Punjab Wild Life (Protection, Preservation, Conservation and Management) Act, 1974

(3) Environmental Impact Assessment and its Procedure

The Pak-EPA (Review of IEE and EIA) Regulations, 2000, Schedule-II states that an EIA is required for T/L with capacity of 11 kV or above. Also, the Pakistan Environmental Protection Act (PEPA), 1997 and Pak-EPA require an EIA for each grid station, substation and converter (switching) station. In the EIA for the T/L, these stations are included in the EIA as associated equipment. The EIA procedure is shown in Figure 12.4-4

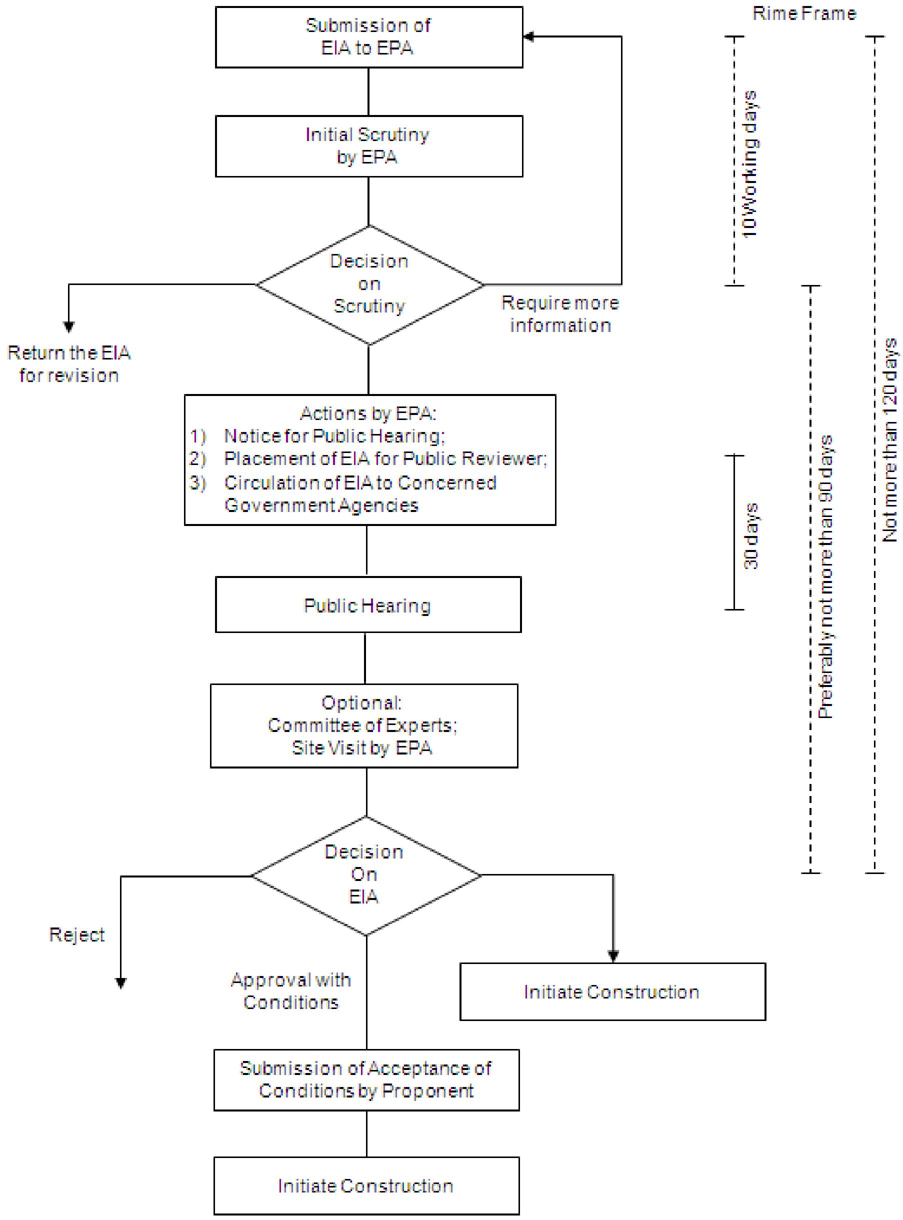


Figure 12.4-4 EIA Review and Approval Procedure

Source: Jamshoro Final EIA

(4) Associated Organizations

The responsible organizations for the implementation and administration of the T/L project is NTDC. Regarding environmental and social considerations, the Environmental Protection Agency of Sindh (SEPA) and the EPA of Punjab are the responsible authorities.

The provincial agriculture, forest, wildlife and fisheries departments as well as the provincial governments of Sindh and Punjab are other related organizations.
Regarding non-governmental organizations (NGOs), the National Rural Support Program (NRSP) and the Punjab Rural Support Program (PRSP) can be associated.

12.4.5 Analysis of Alternatives

In the EIA for the T/L, some alternatives of the T/L project were considered using the following four kinds of aspects:

- No project option (NPO);
- Technical and economic evaluation;
- Route alignment; and
- Design.

(1) No Project Option (NPO)

The T/L project is a cost effective option to dispatch bulk electricity produced from Thar coal to major electricity supply centers of Pakistan. If NPO is exercised, cheap electricity produced from Thar coal could not be supplied to the consumers, which may worsen the shortage of electricity in Pakistan and will cause losses to the national economy. In light of the above situation, NPO is not acceptable.

(2) Technical and Economic Evaluation of Transmission Alternatives

Based on the system conditions in 2030, and taking into account the generation and demand situation, the following two transmission alternatives were considered:

- Alternative 1: Mix of 500 kV HVAC and ± 600 kV HVDC; and
- Alternative 2: Mix of 500 kV HVAC and 765 kV HVAC.

As a result of technical and preliminary cost evaluation of transmission alternatives, Alternative 2 was considered to be superior.

(3) Study of T/L Potential Route Corridors

The EIA for the T/L developed the Route Alignment Criteria based on the technical as well as critical environmental and social considerations including resettlement parameters in order to minimize the impacts as much as possible, as follows:

- Avoid densely populated areas/towns;
- Avoid indigenous or tribal settlements;
- Avoid cultural, religious, and historical buildings;
- Minimize disturbance to the natural habitats of flora and fauna;
- Avoid major birds migratory routes;
- Avoid wildlife sanctuaries, national parks and game reserves;
- Avoid potentially security vulnerable areas;
- Appropriate distance from the sensitive receptors (for instance, minimum 500 m);

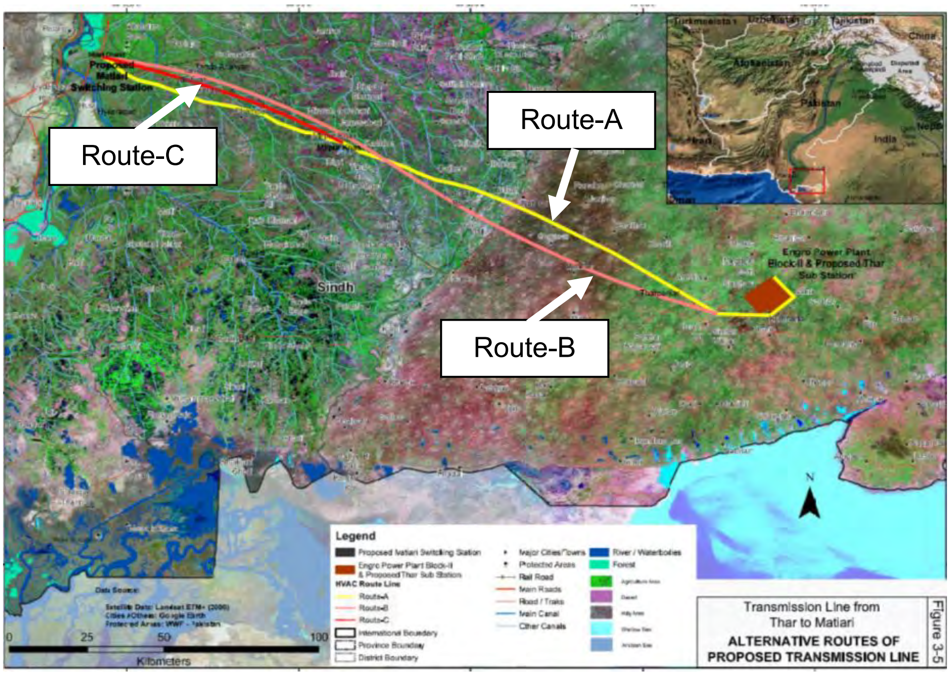
- Avoid crossing large water bodies like lakes, rivers or streams; and
- Avoid crossing airports, railway tracks, and other similar structures and facilities.

In the EIA for the T/L, three routes (Routes A, B, and C) are compared as shown in Table 12.4-3. Figure 12.4-5 shows the details of the routes. As a result, Route-C was selected due to its minimal impact and the length of the T/L would be about 233.37 km.

Table 12.4-3 Summary of the T/L Route Options

Sr. No.	Parameter	Option A	Option B	Option C
1	Settlements	>45	<28	<23
2	Wildlife sanctuaries, national parks and game reserves	2	1	1
3	Forests	1	1	0
4	Airports, railway tracks and other similar structures	>45	<20	<10
5	Large water bodies like lakes, rivers or streams	NA	NA	NA
6	Infrastructure such as roads, and railway crossings	>25	<20	<18

Source: EIA for the Transmission Line between Thar and Matiari



Source: EIA for the Transmission Line between Thar and Matiari

Figure 12.4-5 Alternative Routes of the Transmission Line

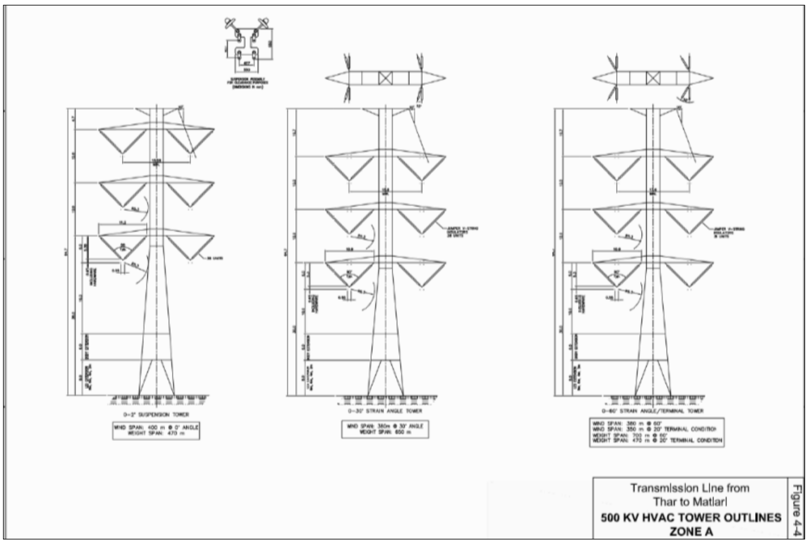
(4) Design Evaluation of Transmission Alternatives

Specifications for the T/L, steel towers, substations, and switching stations were considered according to each setting condition.

All the towers will be self-supporting type, lattice steel structures, and fabricated from galvanized structural steel shapes. All towers will be equipped with danger plates, number plates, and anti-climbing devices. Tower spotting will be done considering the following factors:

- Selection of proper tower type and positioning at optimum location;
- Achievement of economical tower heights with safe clearance from ground and nearby objects;
- Assurance of compliance with design load criteria;
- Location of towers to minimize risk of foundations being damaged by flood, erosion, shifting of sands, etc.;
- Providing a minimum clearance of 20 m from the outer conductor to the nearest conductor of another power line, existing or planned;
- Avoiding interference with or obstruction to any roadway or track being regularly used by wheeled vehicles, animals, or pedestrians;
- In areas of shifting sands, extra ground clearance will be ensured so that movement of the sand dunes will not reduce conductor ground clearance below the minimum safe value; and,
- The requirements of the relevant authorities regarding distance of towers from the roadways and railways have been fulfilled.

NTDC will provide the final route of the T/L along with the plan and profile drawings to the contractor. The contractor will carry out tower staking in the field.



Source: EIA for the Transmission Line between Thar and Matiari

Figure 12.4-6 Outline of Tower

12.4.6 Impacts of the Transmission Line and Mitigation Measures

The COI has been defined as 500 m distance from the center line of the proposed T/L on either side.

Predicted impacts as a result of the installment of the T/L and switching station, and the mitigation measures described in the EIA for the T/L are provided in Appendix 12.1

12.4.7 Environmental Checklist

Based on the mitigation measures described in Subsection 12.4.8, a checklist was prepared for the T/L and switching station in accordance with the JICA Guidelines (2010), which is provided in Appendix 12.1.

12.4.8 Appropriateness of Environmental and Social Considerations on Transmission Line Project

As a conclusion, the environmental and social considerations for the T/L project have been properly carried out so that significant adverse impacts on the natural and social environment would be predicted. It is necessary to monitor and check the progress of resettlement, land acquisition, and appropriate implementation of compensation for the T/L project.

12.4.9 Items Judged to be Inadequate for Environmental and Social Considerations

In the T/L project, there is no specific item that would be insufficient for environmental and social considerations.

CHAPTER 13
CONCLUSION AND RECOMMENDATION

Chapter 13 Conclusion and Recommendation

13.1 Conclusion

13.1.1 Outline of the Project

Having explained in previous chapters in the report, the outline of the project is summarized in Table 13.1-1. In those chapters two coal options, namely option-1 mixing of 80% imported coal and 20% Thar coal (indigenous) and option-2 100% imported coal were studied.

For the project option-2, 100% utilizing imported coal, will be applied at the beginning, since development of Thar coal mining seems to be uncertain at present. Therefore, after Thar coal is actually available, the indigenous coal will be utilized up to 20% to imported coal.

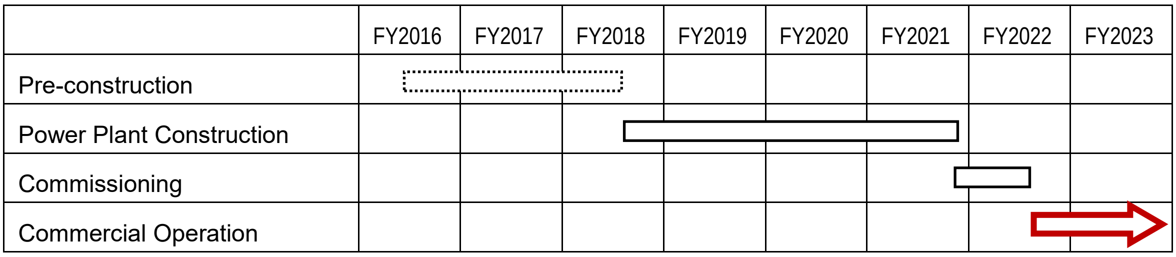
Table 13.1-1 Outline of the Project

Coal Fired Thermal Power Plant with USC technology		
1)	Unit Capacity (Net)	600 MW
2)	Maximum Capacity	660 MW
3)	Main Steam Pressure/Temperature	24.1 MPa/ 593^{o}C
4)	Reheat Stream Pressure/Temperature	4.2 MPa/ 593^{o}C
5)	Unit Efficiency (Gross, LHV)	42.5% with 100% imported coal
6)	Cooling system	NDCT (Natural Draft Cooling Tower)
7)	Source of Flesh Water	Intake from Indus river approx. 6.5km with 700mm diameter steel pipes.
8)	Pollution Abatement	PM emission: ESP 99.7% SOx emission: FGD 80% NOx emission: DeNox Burner
9)	Design Characteristics of Imported Sub-bituminous Coal	Heat value: 5,000 kcal/kg Moisture: 22.4 % Ash: 8.06% Volatile Matter: 35.77% Fixed Carbon: 33.77% HGI: 50
10)	Main Transformer	Capacity 720 MVA Voltage 22 or 24 primary/ 500kV second. Cooling OFAF
11)	Switching Station	Voltage: 500kV Bus system: One and half CB (Circuit Breaker)
Transmission Line		
1)	Voltage:	500kV
2)	Connection	2cct π-connection from existing Jamshoro and Dadu transmission line (1.65km to 1 cct and 4.6km to 1 cct

		from switch yard)

13.1.2 Schedule of the Project

The overall schedule of the project is shown in Figure 13.1-1 of which detailed schedule is shown in Chapter 9. Pre-construction, loan agreement, procurement of the Consultant, preparation bid document, procurement of EPC contractor, will be last to later in FY2018. The power plant construction will start subsequently and last 48 months including commissioning. The commercial operation will start in FY 2022 (April in 2023)



Note: FY (Fiscal Year) starts 1st July and ends 30th June

Source: JICA Survey Team

Figure 13.1-1 Project implementation Schedule

13.2 Recommendation

To facilitate successful implementation of the project design and construction, it is recommended that the following items be taken up on priority.

1) To facilitate implementation of the project, preparation of coal procurement should be done, medium or long term coal supply contract and alternative coal mine for minimizing the risk should be secured, and coal specifications for boiler design and performance testing recommended to be defined prior to completion of bidding documents for the EPC contractor.

2) To confirm the development of coal unloading port, and conclude Minutes of Discussion with for unloading 2 mtpa of coal for the project.

3) To have close communication with Pakistan Railway who will carry out rehabilitation of existing railway and newly construct new line for transporting imported coal between Port Qasim and New plant.

4) Investigate ash utilization by cement plants and other business entities for commercial applicants.

5) Setup a Project Management Unit in GHCL and Project Implementation Unit in GENCO IV.

6) Prepare EPC contract PQ documents and evaluation criteria of PQ.

7) Procurement of the Consultant (international and national) for assisting project implementation.

8) GHCL copes with following issues related to the existing Lakhra Plant;

   - Ash generated from the Lakhra Plant should be transported to and disposed of at designated ash disposal sites, and,

   - As a precondition for the implementation of the proposed project, to implement actions for reducing sulfur dioxide emission and to rehabilitate the existing precipitator (bag filters) should be conducted to meet NEQS/SEQS and IFC Guidelines.

13.3 Operational and Effect Indicator

13.3-1 Operational Indicator

Operational indicators for evaluating operational condition of the plant, namely the plant is operating properly, quantitatively is set as listed in Table 13.3-1.

Table 13.3-1 Operational Indicator

	Name of indicator	Indicator	Target	
Basic	Maximum Output (MW)	Same as left	Designed maximum output of the Plant 660MW	
Basic	Plant Load Factor (%)	Annual generated power /（Rated output kW x 8,760）x 100	80%	
Supplemental	Availability Factor (%)	(Annual Operating Hours / 8,760)×100	85%	
Supplemental	Auxiliary Power ratio (%)	(annual auxiliary power/annual generated power at generator)x 100%	6.5%	
Basic	Gross Thermal Efficiency (%)	(Annual generated power×860)/(annual consumed coal ×coal calorific value)×100	42.5% when 100% imported coal	
Basic	Outage Hours by Cause (hours/year)	Same as left	Human error	0 hours
			Machine trouble	360 hours
			Planned outage	960 hours
Supplemental	Outage Times by Cause (times/year)	Same as left	Human error	0 time
			Machine trouble	3 times
			Planned outage	1time

Source: JICA Survey Team referring to “Japan ODA Loan Reference of Operational and Effect Indicators July 2014”

13.3.2 Effect Indicator

Effect indicators for evaluating effect of the plant for beneficially or for the region quantitatively are set as listed in Table 13.3-2.

Table 13.3-2 Effect Indicator

	Name of indicator	Indicator	Target
Basic	Maximum Output （MW）	Same as left	Designed maximum output of the Plant 660MW
Basic	Net Electric Energy Production (GWh/year)	Same as left	4,200GWh/year

Source: JICA Survey Team referring to “Japan ODA Loan Reference of Operational and Effect Indicators July 2014”