No.

Republic of Uzbekistan

Supplemental Study to enhance the collaboration with NEDO on Tashkent Heat Supply Power Plant Modernization Project

Final Report
（Summary）

November 2009

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Services Co., LTD

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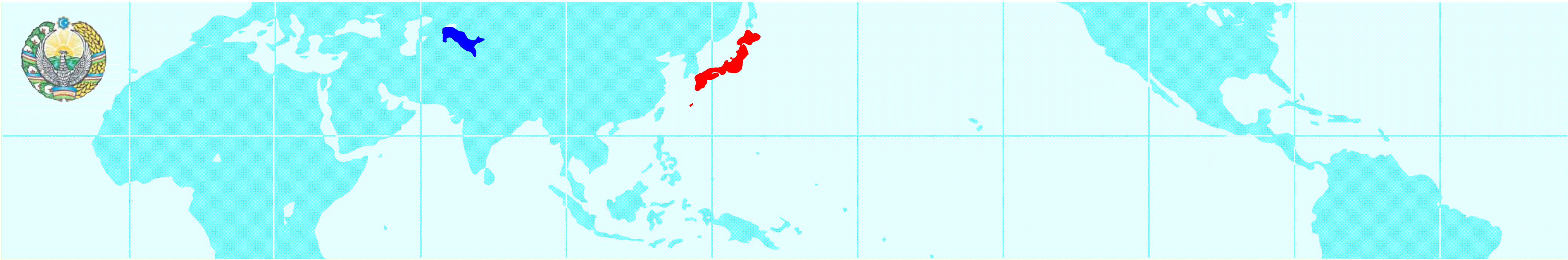

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Chapter 1 Layout Design

Chapter 1 Layout Design

1.1 Common Facilities with NEDO Project (1/3)

The Study Team determined the basic course of common facilities by evaluating merit and demerit.

(1)110kV Switchyard
(2)Main Building
(3)Central Control Room
(4)Piping

Chapter 1 Layout Design

1.1 Common Facilities with NEDO Project (2/3)

	Merit	Demerit	Conclusion
110kV Switchyard	Each GTCS can transmit the power through two lines which increases the reliability. Uniform management of the facilities.	During the construction of NEDO plant (Scope of Uzbekenergo) it is required to design the faculty taking into account the connection of JICA facilities.	**Construct as common facilities.** During the construction of NEDO plant, bus should be installed.
Main Building	Cost saving by introducing common overhead crane. Space saving. Maintainability by common maintenance space.	Remove of wall of the building should be required. There is a possibility that common overhead crane is not applied because the GTG type of JICA plant has not determined yet.	**Construct as common facilities.**

Chapter 1 Layout Design

1.1 Common Facilities with NEDO Project (3/3)

	Merit	Demerit	Conclusion
Central Control Room	Labor cost reduction by reducing the number of the operator. Uniform management of the plant.	Affecting the area of the NEDO building. Cabling work is required in the area of operating NEDO plant during the construction of JICA facilities.	**Construct as common facilities.** The Space for the operating consol for JICA plant is required in the central control room of NEDO plant.
Piping	Piping work is required only once.	There is a possibility that common piping is not applied because the water / steam condition of JICA plant has not determined yet.	Eash piping will be installed separately; however common piping rack will be installed.

Chapter 1 Layout Design

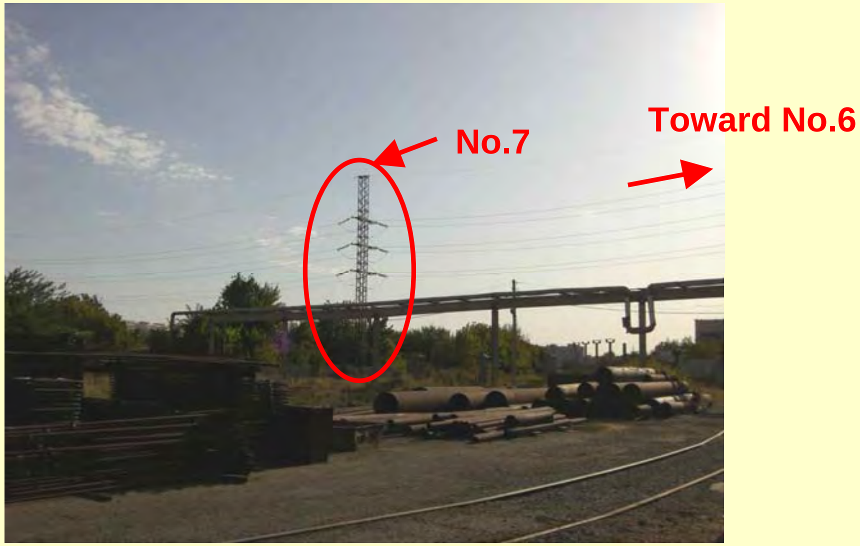
1.2.1 Overview of 110kV Existing Transmission Line

- Section: Tashkent CHP Plant - 220/110kV Yuksak Substation
    - T-branch off to textile industry complex supply line (double circuit, length: 0.55km) at tower No.13 and No.14 (2.66km from Tashkent CHP Plant)
- Length: 4.22km
- Number of circuit: 2 (Л-5-Ю-1, Л-5-Ю-2)
- Number of tower: 36units
- Conductor: AC-185 (replaced in 2005)

1.2.2 Conditions of Circumference of Expected Branch Span b/w Junction Tower and New Switching Station (1)

- Existing 110kV transmission line section b/w No.6 and No.7 (span length = 68m)
- Tower No.6: п г с 110-18 а - Т (Suspension type)
- Tower No.7: А у с 110-26 а - Т (Tension type)

Tower No.6



Tower No.7

1.2.2 Conditions of Circumference of Expected Branch Span b/w Junction Tower and New Switching Station (2)

- Distribution line (North-South) : 9m from conductor of Л-5-Ю-2 toward east
  - Ground height of distribution line: About 7m (visual estimation)
  - Ground height of distribution pole: About 8 – 9m (visual estimation)
- Steam pipeline (North-South) : 11m from conductor of Л-5-Ю-2 toward east
  - Ground height: About 7.3m

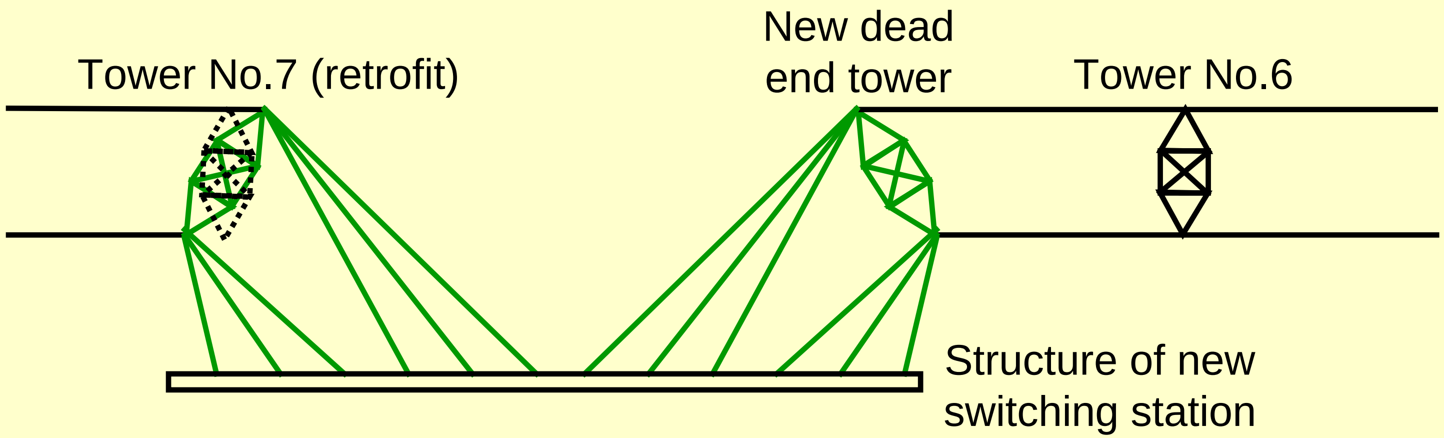
Distribution line

Steam pipeline

1.2.3 Selection of Connection Method (1)

- Plan A: π -Junction

  Build a new dead-end tower into the section b/w No.6-No.7, connecting existing 110kV line to the new switching station through the dead end tower and tower No.7.



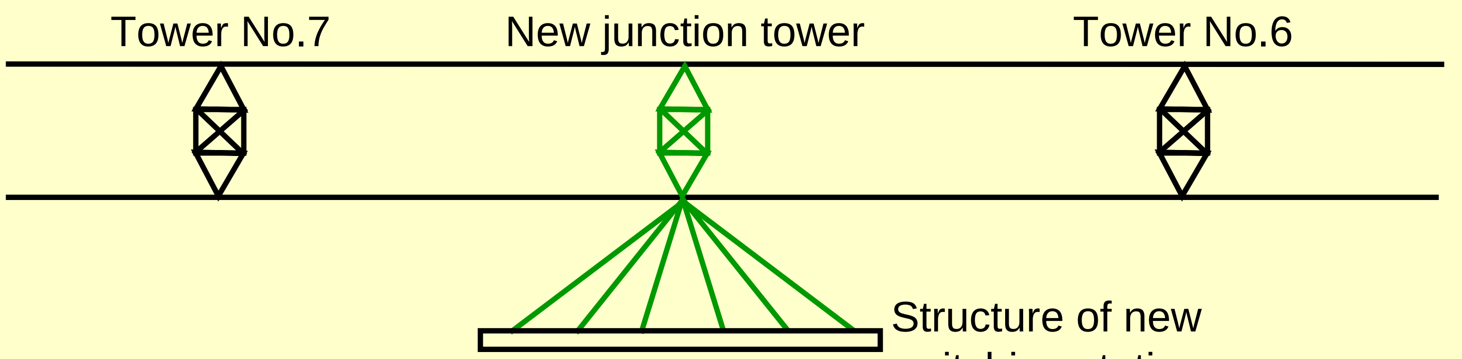
- ➢ Advantage: High reliability
- ➢ Disadvantage:
  - ✓ Cross-arm and dead-end retrofit design or rebuilding of tower No.7 may be necessary.
  - ✓ Number of feeder bays double compared with that of T-junction.

Construction cost may become higher than that of T-junction method

1.2.3 Selection of Connection Method (2)

- Plan B: T-Junction

  Build a new junction tower into the section b/w No.6-No.7, connecting existing 110kV line to the new switching station through the junction tower.



- Advantage
  - ✓ No need to divide the section b/w No.6-No.7
  - ✓ Number of feeder bays is half compared with that of π-junction

Reduction in construction cost may be possible.

- Disadvantage
  - ✓ The circuits constitute "multi-terminal transmission line", consideration on selection of appropriate protection relays to maintain reliability is necessary.

1.2.3 Selection of Connection Method (3)

- Confirmation on selection of proper connection method b/w plan A and B
  - Comments of SAESP
    - ✓ Division of the transmission line b/w No.6-No.7 is not acceptable.
    - ✓ T-Junction method is widely applied as standard.

Plan B: T-Junction method was adopted.

Standard T-junction tower

1.2.4 Consideration of the Branch Span between Junction Tower and New Switching Station (1)

- Design Standard
  - Regulations on Electrical Devices (PUE) and Uzbek-Standard (GOST)
- Climate Condition
  - Ambient Temperature

✓ Highest temperature	45℃
✓ Lowest temperature	-30℃
✓ Average annual temperature	15℃
✓ Temperature in case of glazed frost	-5℃

  - Wind Pressure

✓ Maximum normative wind velocity pressure	490Pa
✓ Installation condition	60Pa

1.2.4 Consideration of the Branch Span between Junction Tower and New Switching Station (2)

- Climate Condition (cont.)
  - Load Condition
    1. Highest temperature, no wind and no glazed frost
    2. Lowest temperature, no wind and no glazed frost
    3. Average annual temperature, no wind and no glazed frost
    4. Conductors are covered with glazed frost (thickness: 10mm, density: 0.9g/cm^3), temperature –5^{o}C, no wind
    5. Maximum normative wind velocity pressure q_{max}, temperature –5^{o}C, no glazed frost
    6. Conductors are covered with glazed frost (thickness: 10mm, density: 0.9g/cm^3), temperature –5^{o}C, wind velocity pressure 0.25 q_{max}
    7. During conductor installation (temperature -15^{o}C, wind pressure 6.25kgf/m^2, no glazed frost
    8. Maximum conductor temperature (assumed 100^{o}C), no wind, no glazed frost)

1.2.4 Consideration of the Branch Span between Junction Tower and New Switching Station (3)

- Design Condition

  Referred to the design condition of the existing 110kV transmission line to be connected to the project.

  - Conductor
    - 2 types, AC-150/24 and AC-185/24, were considered.
  - Overhead ground wire
    - Assumed that earthing at the new switching station was sufficient to comply with the norms of earthing, PUE Chapter 1.7satisfied, thus no overhead ground wire were considered.
  - Safety factor of conductor
    - Tension in the severest condition was assumed 45% of ultimate tensile strength of the conductor.
  - Insulator
    - ПСД70Е type (same type as that used for existing 110kV transmission line)
    - Single string, 9units per string (same as that used for existing 110kV transmission line)
    - Length: 1.792m, weight: 47.3kg（same as that used for No.7 ）
  - Tower
    - у с 110-8 type (standard double-circuit junction tower)

1.2.4 Consideration of the Branch Span between Junction Tower and New Switching Station (4)

- Design Condition (cont.)
  - Ground height and clearance b/w pipeline（PUE 2.5.169 Table 2.5.24）
    - ✓ Minimum conductor ground height: 7m
    - ✓ Clearance b/w steam pipeline: 4m
- Items to be considered for the Branch Span

[Maximum allowable tension]

- ✓ Maximum allowable tension taking into consideration tension increase during stringing works and conductor safety factor

Conductor Type	Span Length	
	30m	20m
AC-150	3,100N	2,100N
AC-185	2,900N	2,100N

- ✓ For span length of 20m, tension increase by changing conductor length is more significant than that for span length of 30m
  - Severer conductor tension control is required during stringing works.

Recommended span length: 30m

1.2.4 Consideration of the Branch Span between Junction Tower and New Switching Station (5)

- Items to be considered for the Branch Span (cont.)

[Conductor ground height and clearance b/w existing structures]

- ✓ Ground height and clearance b/w steam pipeline in case of maximum conductor sag condition
- ✓ Maximum conductor sag condition: Conductor temp. 100°C, no wind, no glazed frost
- ✓ Height of conductor supporting point at switching station gantry was assumed to be equal to that of bottom arm of the junction tower (10.5m).

	Conductor ground height		Clearance b/w pipeline	
Span length	30m	20m	30m	20m
AC-150	9.63m	10.00m	2.37m	2.70m
	(0.87m)	(0.50m)	(0.83m)	(0.50m)
AC-185	9.71m	9.93m	2.45m	2.63m
	(0.79m)	(0.57m)	(0.75m)	(0.57m)

***Number in parenthesis: sag of onductor**

- ☐ **Conductor height: more than 7m (PUE 2.5.169 Table 2.5.24) was secured.**
- ☐ **Clearance b/w steam pipeline: less than required length (4m) by 1.37～1.63m**
  - ✓ Countermeasures such as change of pipeline height and/or height of switching station gantory to secure required clearance are necessary.
- ☐ **Change locations and/or heights of distribution line and polies.**

1.2.4 Consideration of the Branch Span between Junction Tower and New Switching Station (6)

- Items to be considered for the Branch Span (cont.)

  [Clearance b/w phase conductors]

  - For the sag up to 3m, minimum allowable horizontal distance b/w conductors is 3m.
    - （PUE 2.5.52 Table 2.5.9 "Minimum Allowed Distance between the Conductors of High Voltage Line with Suspended Insulators and Horizontal Location of Conductors"）
  - For vertical distance of 4m, shift of conductors of neighboring horizontal levels are 0m.
    - （PUE 2.5.53 Table 2.5.11 "Minimum Shift of Conductors of Neighboring Horizontal Levels at Suspension Towers in Area II (with Moderate Conductors Galloping" ）
  - **Maximum conductor sag of the target span is below 1m and conductor vertical distance of junction tower is 4m → Satisfied required conditions.**

- Layout of Junction Tower
  - ✓ Preferred location of the tower: Close to the center of the span b/w No.6 and No.7
  - ✓ Condition may not change so much if the shift of the tower location is within about ±several meters and the angle b/w existing line and junction tower to gantry is close to 90 degrees.
  - ✓ Necessary to consider land use situation under branch line for detailed design.

Chapter 1 Layout Design

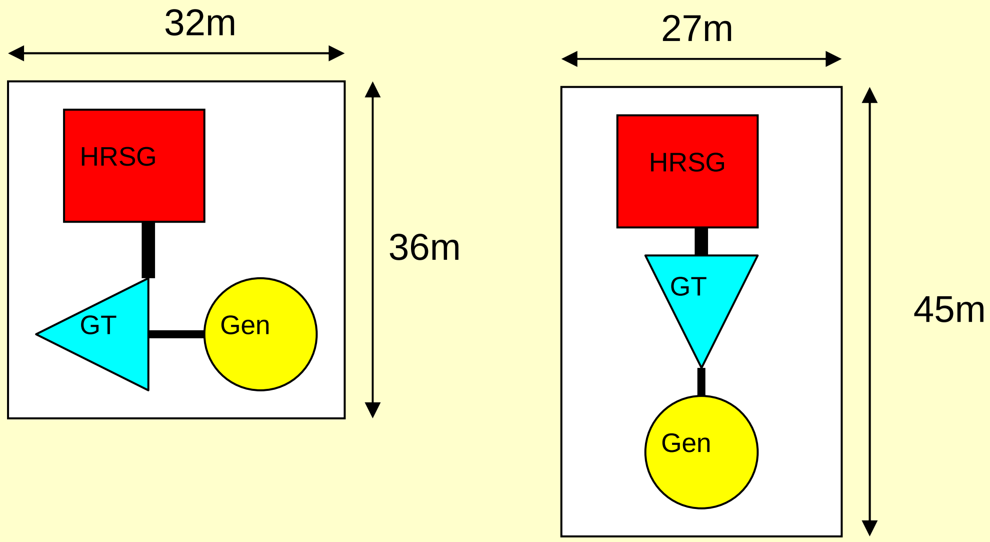
1.3 *Overall Layout Design*

1.3.1 Basic Design of 110kV Switchyard

- A combined SF6 gas insulated switch will be installed which has well cost performance and compact design feature.
- Air insulated type bus system will be installed taking into account the connection of the JICA GTCS.

  (Bus will be installed by Uzbekenergo, Circuit breaker etc. will be installed as JICA Project.)
- The interval of each phase bus is designed as 2m.
- 2 bays are required for connection with the transmission line in case of T- Junction.
- 3 bays are required for connection with each generator, one bay is required for the junction for both bus.

1.3.2 Layout of Main Equipments



Hot-end Drive **Cold-end Drive**

Note）HRSG: Heat Recovery Steam Generator
GT: Gas Turbine
Gen: Generator

Noted length shows that of the main building in case the GT is same as the candidate GT of NEDO Project (H-25).

Figure. GTCS Schematic layout for Hot-end Drive and Cold-end Drive Configuration

Chapter 1 Layout Design

1.3.3 Examination of Overall Layout Design (1/2)

In the pre-FS submitted to Government of Uzbekistan, Uzbekenergo is made a preliminary layout drawing on assumption that JICA GTCS would be the twice of NEDO GTCS.

The Study Team made a revised layout drawing which is taken consideration of the result of common facilities with NEDO GTCS, space for drawing into transmission line and the specification of 110kV switchyard.

Major revised items are;

(1) Keeping 30m space between transmission line and switchyard

(2) Adding T-junction tower and feeder line to switchyard

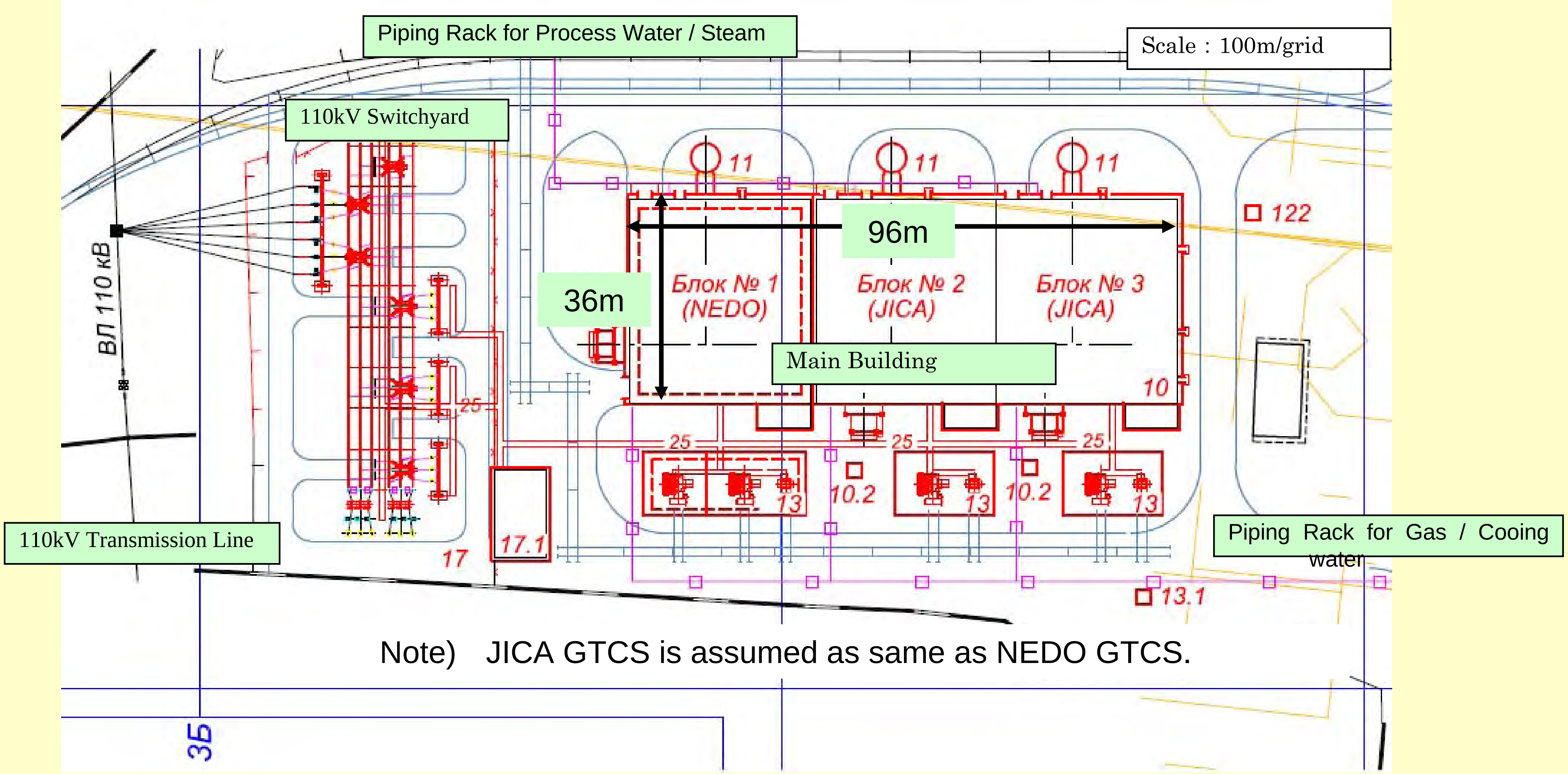
(3) Reduction of the number of gantry and feeder bays

(4) Re-routing of piping

The final layout will be determined through detailed design of the building and equipment layout during the implementation of NEDO Project.

Chapter 1 Layout Design

1.3.3 Examination of Overall Layout Design(2/2)



Note) JICA GTCS is assumed as same as NEDO GTCS.

Saving the space by introducing common main building, it is concluded that installing both three 25MW class GTCS and a 110kV switchyard in the candidate site is possible.

Chapter 1 Layout Design

1.3.4 Examination of Alternative Arrangement

Applying cold-end type for JICA plant,

East – West 86m (=32m + 27m x 2) ⇨ 10m reduction
South – North 45m（JICA GTCS） ⇨ 9m increase

Even in case of hot-end type, there is not enough room for the space of south – north direction.

For applying cold-end type, the Main Building and the piping lack for fuel gas and cooling water should be arranged south as much as possible.

Chapter 2 Considerations for an Optimum Plant System

2.1 Particulars of the Existing Plant

2.1.1 Specifications of the existing facilities (mechanical facilities)

2.1.2 Specifications of the existing facilities (electrical facilities)

2.1.3 Interface between the new facilities and the existing facilities

2.2 Operation Statuses of the Existing Plant

2.2.1 Amounts of power, heat supplied by hot water, and heat supplied by steam

2.2.2 Operation statuses of the Existing Plant

2.3 GT Cogeneration System Study

2.3.1 Study Conditions

2.3.2 Study Results

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system

2.4.2 Basic specifications of the electric facilities

Chapter 2 Considerations for an Optimum Plant System

2.1 Particulars of the Existing Plant

2.1.1 Specifications of the existing facilities (mechanical facilities)

Table 2-1-1 Specifications of the main existing facilities (1/2)

Item	Unit	Steam Boiler					Total
		K-1	K-2	K-3	K-4	K-5	
Capacity rating	t/h	60.0	60.0	70.0	75.0	150.0	415.0
Steam pressure (outlet of superheater)	MPag (kg/cm^2g)	3.14 (30.8)	3.14 (30.8)	3.43 (33.6)	3.53 (34.6)	3.33 (32.7)	
Steam temperature (outlet of superheater)	℃	425	425	425	420	420	

Item	Unit	Hot Water Boiler							Total
		K-6	K-7	K-8	K-9	K-10	K-11	K-12	
Capacity rating	Gcal/h	50	100	100	100	100	100	100	650
Hot water pressure (at boiler outlet)	MPag (kg/cm^2g)	2.5 (24.5)	2.0 (19.6)	2.5 (24.5)	2.5 (24.5)	2.5 (24.5)	2.5 (24.5)	2.5 (24.5)	
Hot water temperature (at boiler outlet)	℃	150	150	150	150	150	150	150	

Item	Steam Turbine
Capacity rating	22,500kW
Steam condition at turbine inlet	2.75MPag(27.0kg/cm^2g)、400℃
Extraction steam condition	9kg/cm^2g、320℃
In-house utility steam condition	7kg/cm^2g、270℃
Maximum steam flow (at turbine inlet)	350t/h
Maximum steam extraction	300t/h
Vacuum in condenser	0.05ata

(source) Answer of Tashkent Heat and Power Supply Plant

Chapter 2 Considerations for an Optimum Plant System

2.1 Particulars of the Existing Plant

2.1.1 Specifications of the existing facilities (mechanical facilities)

Table 2-1-2 Specifications of the main existing facilities (2/2)

Item	(Eq NO.1) Condenser	(Eq NO.2) Condensate Pump	(Eq NO.3) Low Pressure Feed Water Heater	(Eq NO.4) Deaerator
Quantity	1	2	1	4
Spec	・Cooling Water Flow:3,500m3/h ・Cooling Surface:2,000m2	・Capacity:125t/h×2 (Total:250t/h) ・Total Pressure:5.5kg/cm2	・Condensate Water Flow:50～130t/h ・Condensate Water Temperature at Heater Inlet:40～45℃ ・Condensate Water Temperature at Heater Outlet:45～80℃	・Type of Configuration: Pressurization type ・Pressure at Deaerator:0.22kg/cm2
Item	(Eq NO.5) Steam Boiler Feed Water Pump	(Eq NO.6) Water Treatment	(Eq NO.7) Low Pressure Feed Water Heater	(Eq NO.8) Low Pressure Forwarding Pump
Quantity	7	3	1	6
Spec	・Capacity:100t/h×3 150t/h×4 (Total:900t/h) ・Total Pressure:53kg/cm2	・For Hot Water Boilers 1,250t/h×1、2,000t/h×1 ・For Steam Water Boilers 180t/h×1	・Feed Water Flow:1,500～3,200t/h ・Feed Water Temperature at Heater Inlet:25～40℃ ・Feed Water Temperature at Heater Outlet:<95℃	・Capacity: 720t/h×4 1,250t/h×1 1,260t/h×1 (Total:5,390t/h) ・Total Pressure:5kg/cm2
Item	(Eq NO.9) High Pressure Feed Water Heater	(Eq NO.10) Deaerator	(Eq NO.11) High Pressure Forwarding Pump	(Eq NO.12) Hot Water Boiler Feed Water Pump
Quantity	5	4	6	14
Spec		・Type of Configuration:Vacuum type ・Pressure at Deaerator:−0.65～−0.75kg/cm2	・Capacity: 720t/h×3 800t/h×1 1,250t/h×1 1,260t/h×1 (Total:5,470t/h) ・Discharge Pressure:6.4～10kg/cm2	・Capacity:1,000t/h×14 (Total:14,000t/h) ・Total Pressure:12～17kg/cm2

(source) Answer of Tashkent Heat and Power Supply Plant

Chapter 2 Considerations for an Optimum Plant System

2.1 Particulars of the Existing Plant

2.1.1 Specifications of the existing facilities (mechanical facilities)

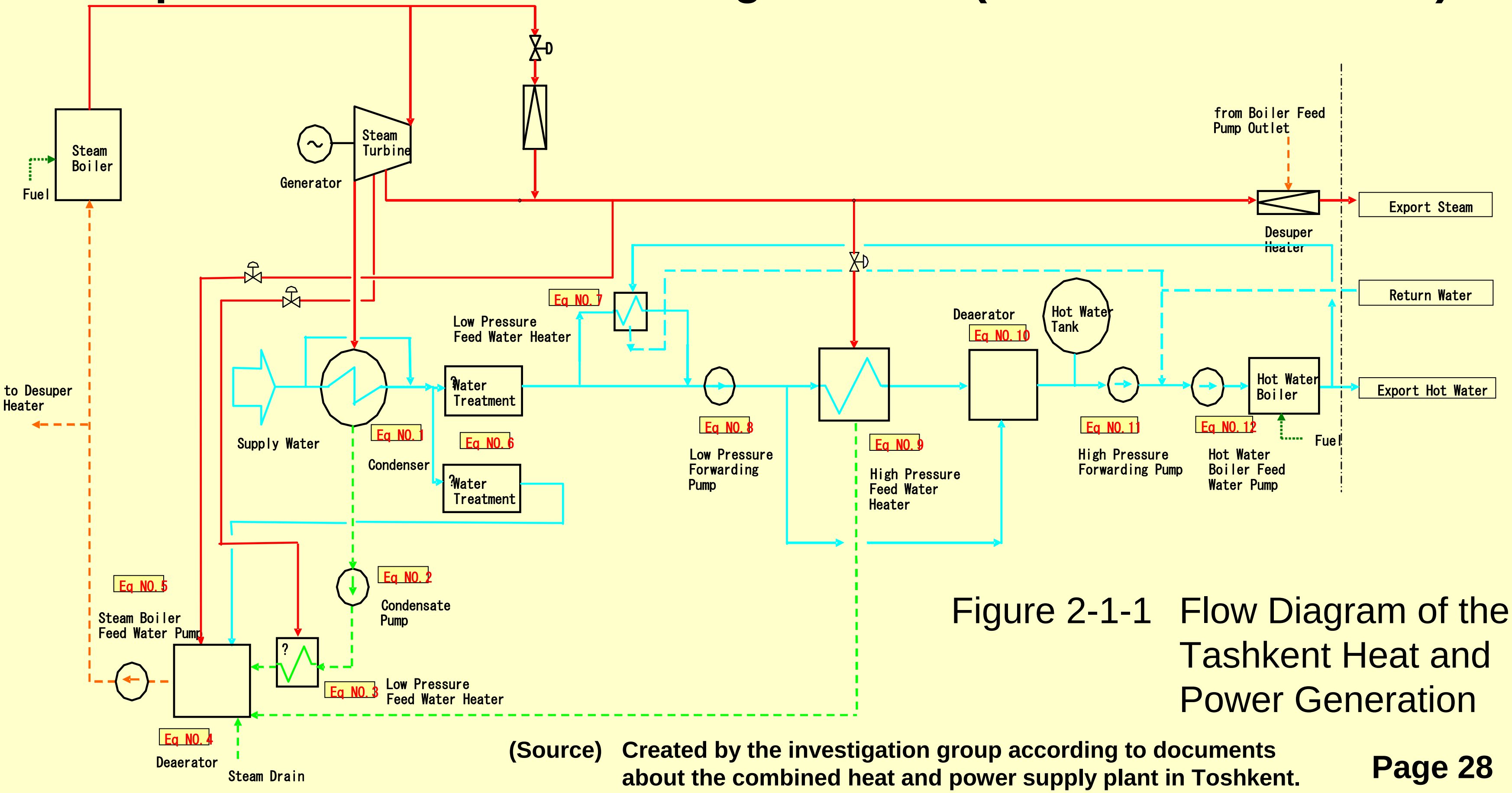


Figure 2-1-1 Flow Diagram of the Tashkent Heat and Power Generation

(Source) Created by the investigation group according to documents about the combined heat and power supply plant in Toshkent.

Chapter 2 Considerations for an Optimum Plant System

2.1 Particulars of the Existing Plant

2.1.2 Specifications of the existing facilities (electrical facilities)

- Generally, deterioration is in progress and reliability has largely been reduced. However, the taken-over technology is sufficiently reflected in the maintenance of deteriorated facilities.
- Relays important for facility protection are old electromagnetic traveling contacts, telephone relays, and the like, so reliability has reduced from the viewpoint of quick response and reliable protection.
- The power generator is an air-cooled power generator with a capacity of 25,000 kVA and a voltage of 6.3 kV, which was manufactured by Kharkiv in the Soviet Union in 1953. The rotor and stator coils have been rewound several times.
- Old-fashioned circuit breakers are used for the 6.3-kV high-voltage and low-voltage auxiliary machines. Some of these circuit breakers use a blade-type switch with a fuse.
- Power is boosted by two step-up transformers, each of which has a capacity of 31,500 kVA, from the bus at an existing substation, and a linkage with the YUKSAK substation is established with two 110-kV transmission lines.
- There is only one new system, which was manufactured in Russia and introduced as a facility for converting main power generation data with a converter and sending the converted data to a different room where the converted data can be monitored on a CRT.

2.1 Particulars of the Existing Plant

2.1.3 Interface between the new facilities and the existing facilities

(1) Feed water

Quality of feed water to the existing steam boiler and values stipulated in the JIS

Item		Unit	Minimum	Maximum	See the field indicating "10 MPa or lower" in Table 4 (feed water to exhaust heat recovery boilers and boiler water quality) indicated in JIS B 8233
Type of makeup water		-			Ion exchanged water
Feed water (at the steam boiler inlet)	pH (at 25°C)	-	8.5	9.5	8.5-9.7
	Hardness	mg/l as $CaCO_3$	-	-	Not detected
	Oil and fat	mg/l	0.13	0.2	As low as possible
	Dissolved oxygen	μg/l	10	20	7 or less
	Iron ion	μg/l as Fe	35	90	30 or less
	Copper ion	μg/l as Cu	5	15	20 or less
	Hydrazine	μg/l as N_2H_4	-	-	10 or more

(Source) Answer from the combined heat and power supply plant in Toshkent

Note: Although the values of the dissolved oxygen and iron ion at present are slightly high, the feed water quality generally satisfies the values stipulated in the JIS. There is no problem with the amount of feed water because the existing boiler is stopped and a new boiler is operated as an alternative.

2.1 Particulars of the Existing Plant

2.1.3 Interface between the new facilities and the existing facilities

(2) Bearing cooling water

- Water used for cooling bearings is supplied from the Sara river adjacent to the power plant. Dust included in the water is removed through a filter, after which the water cools the bearings of units and is discharged to the Sara river without being treated.
- There are four existing bearing cooling water pumps (two pumps have a capacity of 290 tons/hour each, and the other two pumps have a capacity of 2,020 tons/hour each.)
- The two 2,020-ton/h pumps have been used for the Textile factory, but they are not used at present.
- The two 290-ton/h pumps are used at present (one is active, and the other is on standby).
- The amount of water required to cool the bearings in the new facilities is about 700 tons/hour (with three GTs).
- The amount of water used to cool the bearings in the existing facilities is about 150 to 200 tons/hour.

Note: The capacity of the existing pumps to supply cooling water is insufficient. Additional bearing cooling water pumps need to be used or an air-cooling method needs to be implemented.

Chapter 2 Considerations for an Optimum Plant System

2.1 Particulars of the Existing Plant

2.1.3 Interface between the new facilities and the existing facilities

(3) Drainage

- There is no drainage treatment facility at present. Drainage and other wastes generated at the times of unit startup and stop are discharged to the Sara river adjacent to the power plant, without being treated.

Note: The amount of drainage from the new facilities is almost the same as that from the existing facilities, so it is assumed that the drainage can be discharged without being treated.

2.2 Operation Statuses of the Existing Plant

2.2.1 Amounts of power, heat supplied by hot water, and heat supplied by steam

Records in 2008 are as follows.

- The amounts of power, heat supplied by hot water, and heat supplied by steam are large in the winter and small in the summer.
- The amount of heat supplied by hot water makes up 90% of the total amount of energy supplied. The amount in the winter (71.8 Gcal/hour) is five times larger than the amount in the summer (368.8 Gcal/hour), indicating the largest seasonal difference.
- The amount of power generation in the summer is 16.6 MW and that in the winter is 23.1 MW. During winter operation, the rated output (22.5 MW) is always exceeded.
- The amount of heat supplied by steam is smaller than the amount of heat supplied by hot water, just making up about 2% of the total amount.

	Average in summer (minimum to maximum)	Average in winter (minimum to maximum)	Yearly total
Generated power	16.6 (16.4 ~16.7) MW	23.1 (22.8 ~ 23.3) MW	162.1 × 10^3 GWh
Amount of heat supplied by hot water	71.8 (67.6 ~76.1) Gcal/h	368.8 (322.3 ~ 403.9) Gcal/h	1623.0 × 10^3 Gcal
Amount of heat supplied by steam	1.7 (0.8 ~ 3.4) Gcal/h	6.0 (16.4 ~ 16.7) Gcal/h	28.6 × 10^3 Gcal
Amount of power and heat supplied	87.8 (84.4 ~91.3) Gcal/h	394.7 (341.9 ~ 424.0) Gcal/h	1651.8 × 10^3 Gcal

Chapter 2 Considerations for an Optimum Plant System

2.2 Operation Statuses of the Existing Plant

2.2.2 Operation statuses of the existing facilities

- The energy demand at the existing combined heat and power supply plant is satisfied with five steam boilers and seven hot-water boilers.
- Steam (30 k) from the steam boilers is mainly supplied as steam (28 k) to drive the steam turbine power generator.
- Extraction steam of the steam turbine (8 to 13 k) is used as steam used to heat supplied water (tap water) in the hot-water system and as steam used at factories. The exhaust gas from the steam turbines is used to preheat supplied hot-water in the condenser.
- The hot-water boilers heat both the supplied water in the hot-water system and hot water returned from Toshkent City and then supply the heated water to Toshkent City.
- The steam boilers are continuously operated throughout the year, except that it stops for a week in April and another week in September, a total of 14 days.
- The hot-water boilers are operated for only five or six months from November to March, during which heating facilities in Toshkent City operate, and stop for six or seven months from April to October.

2.3 GT Cogeneration System Study (1/9)

2.3.1 Study Conditions

(1) **Ambient**

Temperature	15 °C
Pressure	96.3 kPa
Humidity	60 %

(2) **Fuel**

Type	Natural gas
Low heating value	11,376 kcal/kg

(3) **Heat Energy Output**

HP steam	30 kg/cm^2 ab ×400 °C
IP steam	10 kg/cm^2 ab ×280 °C
LP steam	3 kg/cm^2 ab ×150 °C
Hot water	70 °C

Chapter 2 Considerations for an Optimum Plant System

2.3 GT Cogeneration System Study (2/9)

2.3.1 Study Conditions

(4)	Feed Water Temperature	
	for Steam production	105 ºC / 70 ºC
	for Hot water production	15 ºC
(5)	Gas Turbine Type	Latest H25
	Power output	31.0 MW (27.5 MW)
	Thermal efficiency	34.8 % (33.8 %)
	Air flow	93.9 kg/s (88.0 kg/s)
	Exhaust gas temperature	564 ºC (555 ºC)
	NOx control type	DLN combustion (W/I)

Bracketed figures are for old H25. Performance values are cited from GT World Specification Handbook.

Chapter 2 Considerations for an Optimum Plant System

2.3 GT Cogeneration System Study (3/9)

2.3.1 Study Conditions

(6) Candidate HRSG System

Among many candidate HRSG systems, the following 8 system were chosen as they could be considered to be reasonably integrated with the existing STCS.

No.	Type of HRSG	Type of Recovery Heat				FW Temp (^oC) Steam/HW	Deaerator
		HP Steam	IP Steam	LP Steam	HW		
1	HP Stm w/o Dea	○				105/ -	
2	HP Stm w Dea	○				70/ -	○
3	IP Stm w/o Dea		○			105/ -	
4	IP Stm w Dea		○			70/ -	○
5	HP/IP Stm w Dea	○	○			70/ -	○
6	IP/LP Stm w Dea		○	○		70/ -	○
7	HP Stm/HW	○			○	105/15	
8	HW				○	- /15	

2.3 GT Cogeneration System Study (4/9)

2.3.2 Study Results

(1) Performance Values

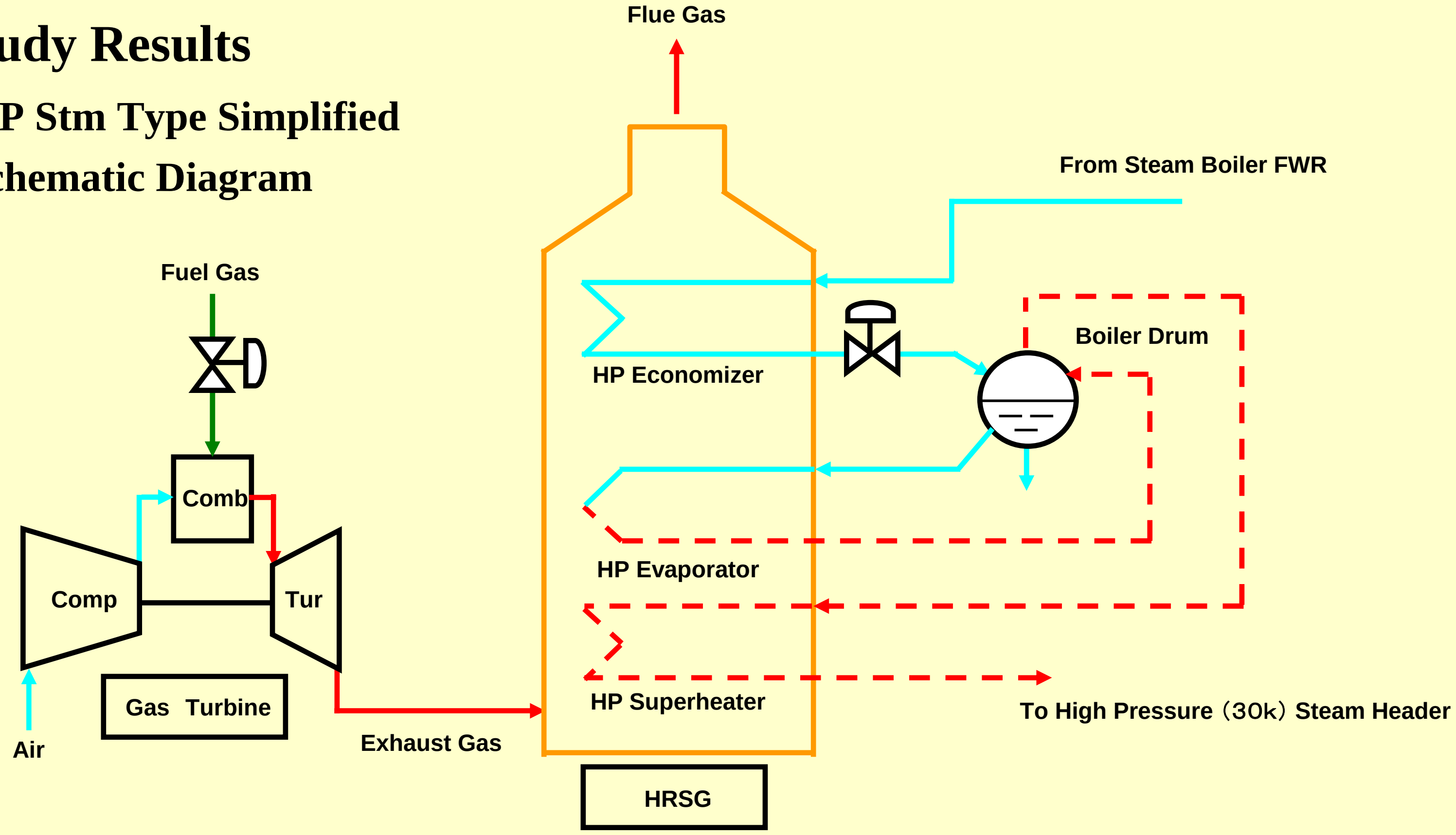
Calculation results of typical 3 GT cogeneration systems out of 8 systems are shown here. In addition, performances of existing STCS are shown for comparison. Their simple schematic diagrams are depicted on following slides.

Type of Cogeneration System	Existing STCS	New GTCS		
		HP Stm Type	IP Stm Type	HW Type
Type of Produced Heat	H/IP Steam / Hot Water	HP Steam	I Steam	Hot Water
Power Output (MW)	20.7	58.2	58.2	58.2
Total Recovered Heat (Gcal/hr)	428.0	66.8	73.0	81.2
HRSG Flue Gas Temp (^oC)	90-110	177	140	90
HRSG Heat Transfer Surface Area (m^2)	-	8,326	8,044	4,470
Plant Thermal Efficiency (%)	87.6	80.3	84.5	90.1

2.3 GT Cogeneration System Study (5/9)

2.3.2 Study Results

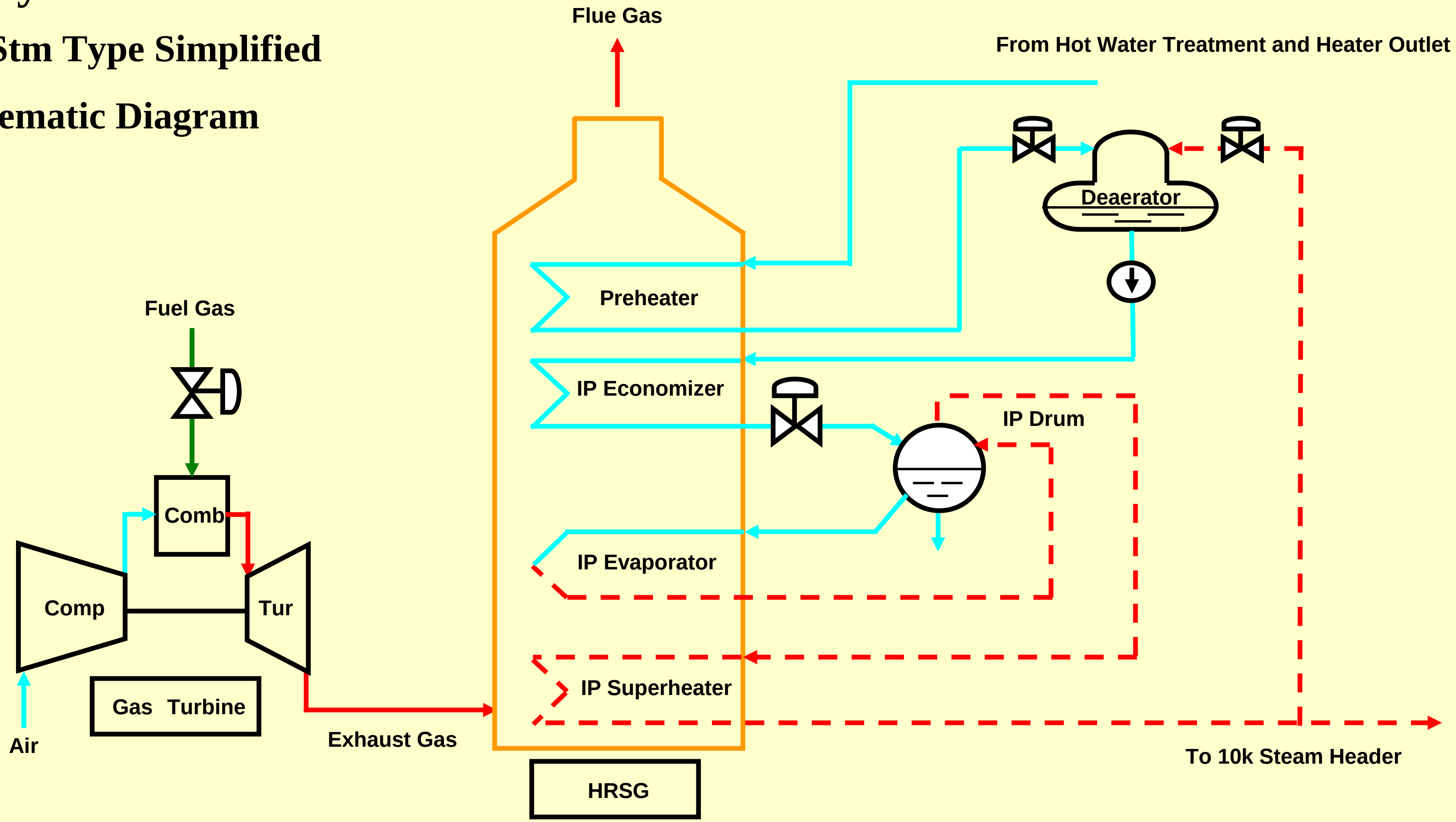
(2) HP Stm Type Simplified Schematic Diagram



2.3 GT Cogeneration System Study (6/9)

2.3.2 Study Results

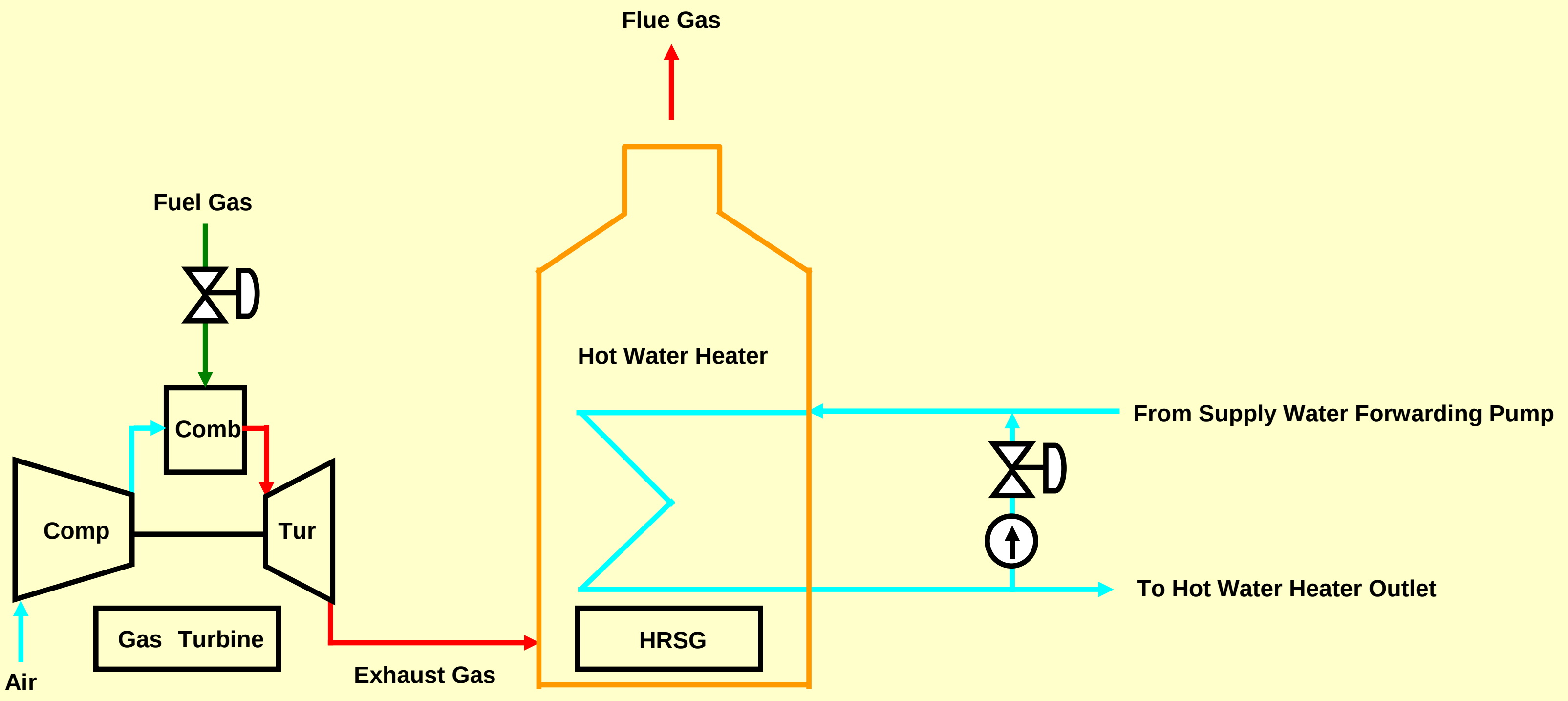
(3) IP Stm Type Simplified Schematic Diagram



2.3 GT Cogeneration System Study (7/9)

2.3.2 Study Results

(4) HW Type Simplified Schematic Diagram



2.3 GT Cogeneration System Study (8/9)

2.3.2 Study Results

(5) Study Results Summary

1) Plant thermal efficiency of GT cogeneration system is widely changeable (80%~90%) due to type of HRSG.
2) Plant thermal efficiency of GT cogeneration system, of which HRSG heat transfer surface area (HTSA)* is larger, is not always larger.
3) HRSG HTSA of HP Stm type system is largest, while its plant thermal efficiency is lowest.
4) HRSG HTSA of HW type system is lowest, while its plant thermal efficiency is highest.
5) HRSG HTSA of IP Stm type system is smaller than HP Stm type system, while its plant thermal efficiency is far higher than HP Stm type system.

* HRSG HTSA is dominant factor for HRSG cost.

2.3 GT Cogeneration System Study (9/9)

2.3.2 Study Results

(6) Study Conclusion

As the results, it can be found that performance of GT cogeneration system can be widely governed by type of HRSG system.

Heat balances of three (3) types of total systems where existing system and three (3) GT cogeneration systems of HP Stm, IP/LP Stm and HW types are combined are to be calculated. And they must be examined from viewpoints of performance, operability, flexibility and maintainability for optimization of total system.

Chapter 2 Considerations for an Optimum Plant System

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (1/11)

In a gas turbine cogeneration system (GTCS), which will be newly installed, heat exhausted from the gas turbine is collected and used in the existing combined heat and power supply plant, enabling highly efficient power generation. Now, the economic efficiency is compared and evaluated in three cases of heat recovery systems in which high pressure steam, intermediate pressure steam, and hot water are used by the GTCS combined with the existing system.

(1) Study Conditions

a) General conditions

- The amounts of power generated, heat supplied by hot water, and heat supplied by steam remain unchanged before and after the GTCS is introduced.
- With the NEDO GTCS, only one H-25 gas turbine (2007 model) is assumed. With the JICA GTCS, two of the newest H-25 gas turbines are assumed because the time of delivery differs.
- The number of days during which the Existing Plant operate for one year is 351 to allow non-operation for 14 days in the summer. The GTCS is the same as in the Existing Plant for both NEDO and JICA. The operation hours in winter and summer are determined by dividing 351 days so that the amount of energy supplied in a year, which is obtained from the calculation result of the thermal heat balance of the existing plant, matches the record in 2008.
- The plant heat balance calculation is considered separately for the summer season (during which the hot-water boilers are stopped) and the winter season (during which the hot-water boilers are operated), in view of a difference in the amount of energy supplied during the seasons.
- The ambient temperature in summer is fixed at 25°C, and that in winter is fixed at 5°C. The atmospheric pressure and humidity are respectively fixed at 96.3 kPa and 60% throughout the year.
- Natural gases are used as fuels for both the existing boilers and the newly installed GTCS.
- The amount of power generated by the new GTCS is adjusted by lowering the loads of aging facilities in other power plants or stopping these facilities, and the total amount of power generated in Uzbekistan does not change before or after the introduction of the GTCS.
- Economical evaluation is calculated by converting the total amounts of fuel used in one year in Uzbekistan before and after the introduction of the GTCS to present values.

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (2/11)

(1) Study Conditions

b) Yearly amounts of power generated, heat supplied by hot water, and heat supplied by steam

The records in 2008, shown in the table below, are assumed as the amounts of power generated, heat supplied by hot water, and heat supplied by steam in the Existing Plant.

Yearly amount of power generated	139.4×10^3 Gcal/year (162.1 GWh/year)
Yearly amount of heat supplied by hot-water	1623.0×10^3 Gcal/year
Yearly amount of heat supplied by steam	28.6×10^3 Gcal/year
Yearly total amount of energy supplied	1791.0×10^3 Gcal/year

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (3/11)

(1) Study Conditions

c) Amount of heat supplied by the combined heat and power supply plant in Toshkent

The amount of heat supplied by the combined heat and power supply plant in Toshkent remains unchanged before and after the introduction of the GTCS. The amounts of heat supplied in the summer and winter are indicated in the table below.

Heat supplied	Unit	Summer	Winter
Steam	Gcal/h	1.7	9.1
Hot water	Gcal/h	73.4	389.9
Total	Gcal/h	75.1	399.0

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (4/11)

(1) Study Conditions

d) Gas turbine performance

The table below shows performance when two 25-MW gas turbines are introduced.

Model × quantity	Unit	Hitachi H-25 (newest model) × 2	
		Winter	Summer
Ambient temperature	°C	5.0	25.0
Ambient humidity	%	60	
Atmospheric pressure	mbar	963	
Power generator output	MW	30.7	27.3
Fuel heat input	Gcal/h	75.6	70.2
Exhaust gas temperature	°C	561	573
Air flow rate	t/h	324.6	305.2
Exhaust gas flow rate	t/h	331.2	311.3

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (5/11)

(1) Study Conditions

e) Heat Recovery Steam Generator (HRSG) performance

The table below indicates the performances of each HRSG in the winter and summer.

Type of HRSG	-	High Pressure Steam	Intermediate Pressure Steam	Hot water	High Pressure Steam	Intermediate Pressure Steam	Hot water
Season	-	Winter			Summer		
Ambient temperature/ ambient humidity/pressure	-	5°C/60%/96.3 kPa			25°C/60%/96.3 kPa		
Flue gas flow rate	t/h	331.2			311.3		
Flue gas temperature (inlet)	°C	561			573		
Flue gas temperature (outlet)	°C	177	140	90	176	139	90
Amount of heat recovered	Gcal/h	34.0	36.9	41.2	33.2	36.0	39.8

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (6/11)

(1) Study Conditions

f) Economical evaluation condition

- Natural gas price: 40 USD/Gcal
  The unit price of the natural gas that is supplied from Gazprom in Russia to Europe, which is 326 US$/1000 m^3 (40.0 US$/Gcal) in 2008, is used.
- Conditions in present value evaluation
  - Business period: 25 years
  - Discount rate: 12%
  - Present value factor: 7.84

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (7/11)

(2) Heat balance calculation result

a) Generated power in the Tashkent combined heat and power supply plant

		Before introduction of the GTCS		After introduction of the GTCS (high-pressure steam type)		After introduction of the GTCS (intermediate-pressure steam type)	
		Summer	Winter	Summer	Winter	Summer	Winter
Generated gross power							
• Existing steam turbine	MW	16.41	20.72	16.41	20.72	8.80	20.72
• NEDO-GTCS	MW	-	-	25.38	28.69	25.38	28.69
• JICA-GTCS	MW	-	-	52.69	61.47	42.91	61.48
• Total generated power	MW	16.41	20.72	94.48	110.88	77.09	110.89
	MW	Base	Base	**+78.1**	+90.2	**+60.7**	+90.2
Generated net power	MW	Base	Base	**+69.5**	+85.7	**+54.0**	+80.2
JICA-GTCS load ratio (*)	%	-	-	96.4	100	78.5	100

(*) Reduction in the heat supply in the summary is controlled and adjusted by lowering the load ratio of the JICA-GTCS. When the intermediate pressure steam type is used, the amount of heat received by the Existing Plant is small; the load ratio is 78.5%, which is significantly lower when compared with 96.4% in the case in which the high pressure steam type is used.

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (8/11)

(2) Heat balance calculation result

b) Fuel consumption in the Tashkent combined heat and power supply plant

Fuel consumption	Unit	Before introduction of the GTCS		After introduction of the GTCS (high-pressure steam type)		After introduction of the GTCS (Intermediate-pressure steam type)	
		Summer	Winter	Summer	Winter	Summer	Winter
Existing steam boiler	Gcal/h	103.38	221.32	0.0	110.1	0.0	108.0
Existing hot-water boiler	Gcal/h	-	254.63	0.0	254.6	-	254.6
NEDO-GTCS	Gcal/h	-	-	71.7	77.5	71.7	77.5
JICA-GTCS	Gcal/h	-	-	135.4	151.2	108.8	151.2
Total fuel consumption	Gcal/h	103.4	475.9	207.1	593.4	180.4	591.2
	Gcal/h	Base	Base	**+103.7**	**+117.5**	**+77.1**	**+115.3**

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (9/11)

(2) Heat balance calculation result

c) Generated net power and fuel consumption in other power plants

Due to an increase in power generation, which is a result of the GTCS introduced in the Tashkent combined heat and power supply plant, the amount of generated power and fuel required for generating the power can be saved in the other power plants in Uzbekistan.

Other power plants	Unit	Before introduction of the GTCS		After introduction of the GTCS (high-pressure steam type)		After introduction of the GTCS (Intermediate-pressure steam type)	
	-	Summer	Winter	Summer	Winter	Summer	Winter
Power at the transmission terminal	MW	base	base	-69.5	-80.2	-54.0	-80.2
Fuel consumption	Gcal/h	base	base	-194.0	-224.1	-150.8	-224.1

Note: Reduction of net power at the transmission end is an increase in the transmitted power, which is brought by the Tashkent combined heat and power supply plant. The fuel consumption was calculated on the basis of the actual efficiency (30.8%) at the transmission end in 2008 at the power plant in Uzbekistan.

d) Fuel consumption reduction resulting from the introduction of the GTCS

When the total amounts of heat and power supplied in Uzbekistan remain unchanged, the fuel consumption is reduced by introducing the GTCS as shown below.

	Unit	Before introduction of the GTCS		After introduction of the GTCS (high-pressure steam type)		After introduction of the GTCS (Intermediate-pressure steam type)	
	-	Summer	Winter	Summer	Winter	Summer	Winter
Fuel consumption	Gcal/h	base	base	-103.1	-121.7	-70.6	-123.9

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (10/11)

(3) Present value of fuel consumption reduction achieved by the GTCS

When the fuel consumption reduction achieved by introducing the GTCS is evaluated as the present value, it is found that a reduction of 255 million dollars is obtained for the GTCS of the high-pressure steam type with respect to the current state, and a reduction of 230 million dollars is obtained for the GTCS of the intermediate-pressure steam type. The GTCS of the high-pressure steam type is more advantageous than the GTCS of the intermediate-pressure steam type by 25 million dollars.

	Unit	Before introduction of the GTCS		After introduction of the GTCS (high-pressure steam type)		After introduction of the GTCS (medium-pressure steam type)	
	-	Summer	Winter	Summer	Winter	Summer	Winter
Fuel consumption	Gcal/h	base	base	-90.3	-106.6	-73.7	-108.8
Operation days per year (*)	Day/year	219	132	219	132	219	132
Amount of fuel used per year	10^3 Gcal/year	base	base	-475	-338	-387	-345
	10^3 Gcal/year	base		-812		-732	
Unit price of natural gas	USD/Gcal	40		40		40	
Fuel cost per year	million USD/year	base		-32.5		-29.3	
Present value factor (**)	-	7.84		7.84		7.84	
Present value of fuel cost	million USD	Base (+210)		**-255 (base)**		**-230 (+25)**	

(*) The annual operation days for the Existing Plant are set to 351 under the assumption that the Existing Plant stops for seven days in April and another seven days in September. The annual operation days for the GTCS are assumed to be the same as of the Existing Plant for both NEDO and JICA. The operation days in summer and winter are determined so that the annual total heat output (Gcal/year) matches the record in 2008.

(**) The present value factor is set to 7.84 under the condition that the business period is 25 years and the discount rate is 12%.

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system (11/11)

(4) Comparative result of the economic potential of the heat collection method by the GTCS

- When the GTCS is introduced, the amount of natural gas consumed at the other existing thermal power plants with a low efficiency can be reduced. In evaluation of the fuel cost for 25 years according to the present value method, a reduction of 255 million USD is achieved for the high-pressure steam type, and a reduction of 230 million USD for the intermediate-pressure steam type. Therefore, the GTCS of the high-pressure steam type can further reduce the fuel cost by 25 million USD in 25 years, when compared with the GTCS of intermediate-pressure steam type.
- The construction cost of heat recovery steam generators of the high-pressure steam type is about 10 million USD, so a construction cost reduction achieved by the use of the intermediate-pressure steam type or hot-water type is at most several hundred million USD.
- The construction cost reduction achieved by the use of the intermediate-pressure steam type or hot-water type is obviously smaller than the 25 million USD fuel cost reduction, so the high-pressure steam type is more economical.
- From a technical viewpoint, the GTCS of the high-pressure steam type has a simple facility structure and is superior in operation and ease of maintenance and repair when compared with the intermediate-pressure steam type and hot-water type, because:
  - i) No deaerator dedicated to the GTCS is required.
  - ii) No water recirculation pump is required.
  - iii) No feed water pump is required.

(5) Conclusion

As the total system utilizing the existing steam turbine, t The optimum GTCS used in the Tashkent combined heat and power supply plant is of the high-pressure steam type.

2.4 Considerations for an Optimum Plant System

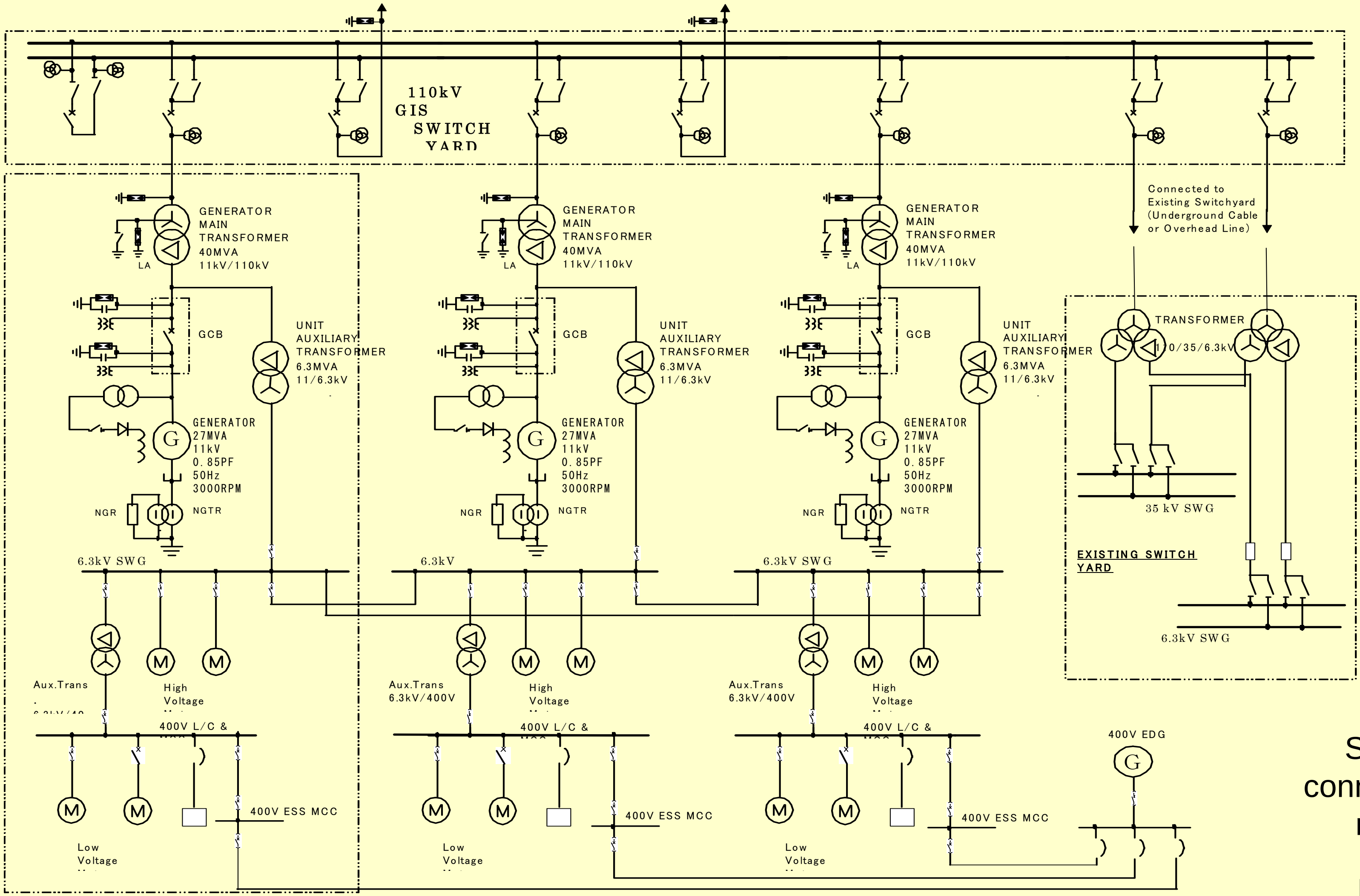
2.4.2 Basic specifications of the electric facilities

(1) Basic items

- The exciting unit of the power generator is of the brushless static type.
- The cable-buried trench type is used for connecting the new plant and the secondary side of the main transformer to the switch yard in the plant.
- Although the voltage at the terminal of the power generator is 6.3 kV in the existing facility, the voltage in the optimum plant system is 11 kV. An in-plant transformer is installed and in-plant power is supplied.
- A gas-insulated circuit breaker is installed as the high-voltage circuit breaker in the switching station.
- An automatic power generating synchronous system is introduced in the central operation room.
- The newest control system in which CRT operations are possible is introduced with sufficient consideration given to control characteristics and ease of operation in the entire combined heat and power supply plant.
- An emergency diesel power generation facility is installed to allow for accidents and outages in the entire combined heat and power supply plant.
- For all communication facilities added or modified in the power plant, the basic design must be considered.

(See the single-wire connection diagram of the power supply in the new plant shown on the next page.)

Chapter 2 Considerations for an Optimum Plant System



Single-wire connection in the new plant

2.4 Considerations for an Optimum Plant System

2.4.2 Basic specifications of the electric facilities

(2) Power generator and exciting unit

An air-cooled type power generator is used, which has a capacity of 27 MVA × 2, a frequency of 50 Hz, a power factor of 0.8, and a terminal voltage of 11 kV. A brushless thyristor exciting unit, which has a simple structure, is used as the exciting unit. The exciting system is superior in precision, stability, and response. The units in the exciting system are compact and lightweight, resulting in a low cost and easy maintenance.

(3) Transformers

- Main transformer

  The space in the power plant is a very small. Basically, the units are placed closely to one another on the south side of the power generation plant building. Isolated phase buses are used for connection between the power generator and the main transformer and among in-plant transformers, so leading on the secondary side must be considered for appropriate placement.

  In consideration that the power plant is an urban combined heat and power supply plant, fire prevention walls that can be detached during maintenance are generally provided for oil-immersed transformers. In addition, sound insulating walls, oil retaining walls, and the like are installed depending on the situation.

- In the combined heat and power supply plant in Toshkent, insulating oil in the transformers is sampled at regular intervals and undergoes gas analysis to check for insulation deterioration. Recently, continuously monitoring systems have become widespread, that monitor the operation states of transformers in real time. In these systems, a continuous gas-in-oil analysis measurement system for diagnosing deterioration can detect even very small abnormalities in devices at an early stage. So, these systems are used.

2.4 Considerations for an Optimum Plant System

2.4.2 Basic specifications of the electric facilities

(4) Isolated phase buses

In general, cable connection is dominant in the main circuit on the primary side from the power generator outlet to the main transformer in old plants manufactured by the Soviet Union. Isolated phase buses, which have superior mechanical and electrical characteristics, are used in view of a voltage of 11 kV, carrying current, and short-circuit current. When costs are taken into consideration, cables may be used for connection to the main circuit on the primary side. To assure reliability and safety for facilities for a long period of time, however, the use of isolated phase buses is recommended.

(5) High-pressure switchgear, PC, and CC circuit breaker

The power supply in the power plant consists of a high-pressure 6-kV metal clad distribution board (popularly called an MC) or a low-pressure 400-V power center (PC) (also called a load center (LC)), depending on the voltage class, and control center (CC). The closed distribution board consists of devices constituting the main circuit, control circuit parts, and other parts such as bus supporting insulators, doors, and shutters; the device constituting the main circuit includes circuit breakers, protection relays, transformers for instruments, and buses; the control circuit parts include meters, lamps, auxiliary relays, and switches.

(6) High-voltage electric motors

Three-phase induction motors are mainly used in the combined heat and power supply plant in Toshkent. These motors are classified into high-voltage electric motors (6.3 kV) and low-voltage electric motors (400 and 220V), depending on the voltage. Various types of, for example, installation (upright and sideway) and windings (cage and winding) are available depending on the application. In general, windings of the cage type are used with the exception that windings of the winding type are used in cranes running on ceilings, which require special performance in speed adjustment and starting torque characteristics. Electric motors need to be protected against (1) overload, (2) short-circuits, and (3) earth faults.

2.4 Considerations for an Optimum Plant System

2.4.2 Basic specifications of the electric facilities

(7) Protection relays for power generators and transformers

Each protection relay is required to have improved performance so that devices and the power system are protected so as to quickly respond to plant protection. Therefore, with the new plant facility, static protection relays that use semiconductors and need a largely reduced installation space are employed and a system having sufficient reliability and characteristic performance will be introduced in the relay room.

(8) DC UPS system

The UPS system is used for general control. It is an important facility because when an accident by which all power supplies in the plant are turned off occurs during an operation, the units must be stopped in a safe manner and backup power must be supplied. The AC power supply for the charger is connected to the control center, which receives power from an emergency power generator. The basic components of the UPS are a converter, an inverter, a battery, and an uninterruptible switch. The charger is duplicated in case it fails or stops during inspection. Even if one of the chargers stops, it is still possible to charge the battery.

(9) Emergency diesel power generator

The following must be considered in case all power in the combined heat and power supply plant in Toshkent is turned off due to an accident in the system or in power supply to the plant:

1. Stop the units in a safe manner.
2. Ensure a power supply used for security during an outage.
3. Determine the capacity of a power generator used to prepare for early start after resupply of power by calculating the total load of the target loads. Also determine the engine capacity on the basis of the load capacity.

2.4 Considerations for an Optimum Plant System

2.4.2 Basic specifications of the electric facilities

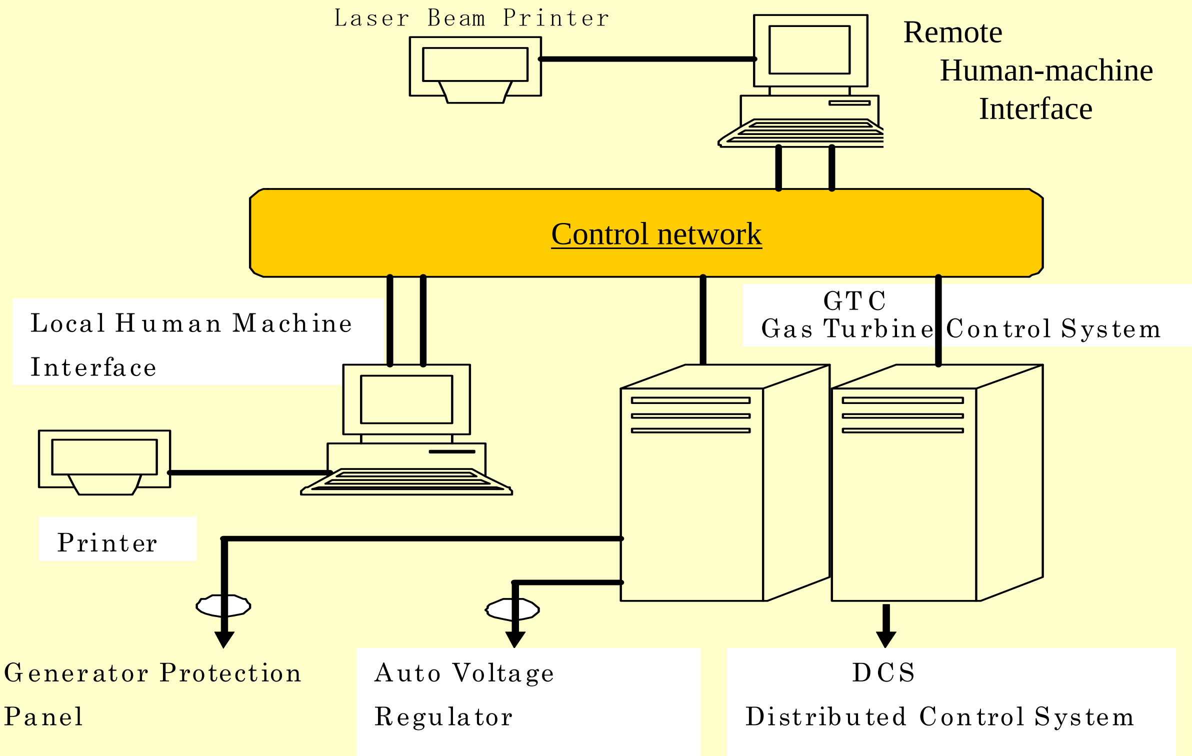
(10) Control system in the combined heat and power supply plant

- Stable power supply, high efficiency, high operability, environmental protection, and other performance over a wide range are required for the control plant in the power generation plant. For this reason, man-machine communication enabling more advanced operation management is required for plant monitoring and operation. A digital instrumentation system that meets these requirements will be introduced in the new facilities in the combined heat and power supply plant in Toshkent.
- The basic concept for the control system in the new plant is to introduce the newest information control technology with high maintainability, operability, and reliability in order to achieve preventive maintenance and stable supply of power, steam, and hot water and to streamline cabling and the control units with minimum costs considered in order to increase the economic efficiency.
- In the basic system configuration, digital control units having superior functions for self-diagnosis, online maintenance, redundancy, and the like are distributed, these units are efficiently controlled with a computer placed at the top, and plant information is compiled into information necessary for operation management so that the entire combined heat and power supply plant in Toshkent can be managed in a centralized manner at the central operator monitoring desk.

(See the diagram on the next page, which indicates the structure of the basic control system in the combined heat and power supply plant in Toshkent.)

Chapter 2 Considerations for an Optimum Plant System

Structure of the basic control system in the combined heat and power supply plant in Toshkent.



2.4 Considerations for an Optimum Plant System

2.4.2 Basic specifications of the electric facilities

(11) Communication facilities

- A communication facility to be installed is a facility for transmitting information used for system protection, system operation, and facility maintenance among the power plant, substations, Uzbekenergo, the power supply commanding station, and other business offices. Another communication facility to be installed is a paging system for communication by telephones among departments in the plant, in-plant public addressing between the field in the plant and the central operation room, and for communication with the field.
- The communication system is updated to use optical fiber cables as communication lines among Uzbekenergo, the combined heat and power supply plant in Toshkent, and the YUKSAK substation so that power supply is reliably commanded and thereby technical reliability is improved.
- A recommended electric communication system in the future is a modern facility with high system reliability in which a wired facility is based on communication cables and wireless multiplexed facilities being used together.

(12) Lighting facilities

The control centers in the plant supply the main power for lighting. The common control center supplies power for emergency lamp power supplies, airplane warning lamps, passage lamps (low-pressure sodium lamps) in the plant, and office buildings, as well as devices, facilities, and passage work lamps at each field. Some lighting facilities are automatically turned on and off. To save power, it is considered that other lighting facilities receive power from solar power supplies. Since the plant is relatively close to the Toshkent international airport, installation of airplane warning lamps is important.

Chapter 3 Power System Analysis

3.1 Fundamental Technical Standards

3.2 Study Cases

3.3 Analysis model

3.4 Analysis tool

3.5 Power Flow and Voltage Analysis

- 3.5.1 Assumptions
- 3.5.2 Analysis results

3.6 Fault Current Analysis

- 3.6.1 Analysis results

3.7 Conclusion & Recommendations

Chapter 3 Power System Analysis

Objectives

- Influence on the transmission and substation facilities caused by installation of 3 GTCS units (including NEDO project) was studied in terms of power flow, voltage, and fault current.

3.1 Fundamental Technical Standards

- Power Flow
  - In case of N-1 contingency condition, the power system shall return to normal resume within 20minutes after emergency resume.
  - In case of N-1 contingency condition, the maximum allowable current of the remaining circuits for the section with more than 2 circuits shall be within 120% of that, which is determined by ambient temperature, in normal operation condition.
- Voltage
  - Normal Operation Condition
    - ✓ System voltage±10%(substation bus), System voltage± 5%(generator bus)
  - Abnormal Operation Condition
    - ✓ System voltage+10% (transformer), System voltage± 15%（switch gear）

3.1 Fundamental Technical Standards (cont.)

- Fault Current
  - Maximum Allowable Fault Current: 40kA (220kV), 30kA (110kV)
- Reliability
  - N-1 Criteria
- Transmission lines, Transformers, and Generators
  - Transmission Capacity **(*Ambient temperature: 40 ^{o}C)**

Conductor Type	Allowable Current * (Normal operation)	Allowable Current * (Emergency)	Rated Capacity (Normal operation)	Rated Capacity (Emergency)
AC-150	364A	436A	69MVA	83MVA
AC-185	417A	499A	79MVA	95MVA

  - Transmission line, transformer, generator impedance
    - ✓ Data provided by SAESP
- Frequency
  - Normal Operation Condition: 50±0.2Hz
  - Abnormal Operation Condition: 50±0.4Hz

3.2 Study Cases

- Year 2012
  - System data up to 2012, expected operation start year of NEDO project, was provided by SAESP
- 4 phases: Summer/winter and peak/off peak

3.3 Analysis Model

- 110kV transmission system
  - Section 1: Tashkent CHP Plant - 220/110kV Yuksak substation: 4.2km
  - Section 2: T-junction-Textile industrial complex substation: 0.55km
  - Section 3: T-junction-New switching station of Tashkent CHP Plant: 40m
- Single-machine infinite bus system was assumed for the system behind 110kV bus of Yuksak substation (Swing bus: Yuksak substation 110kV bus)

3.4 Analysis Tool

- PSS/E (Power System Simulator for Engineering) ver.31
  - Siemens Power Technologies International (Siemens PTI(U.S.A))

3.5 Power Flow and Voltage Analysis

- 3.5.1 Assumptions
  - Load (for airport) connected to 35kV bus at Tashkent CHP Plant was assumed to be 50% of the peak load in light load condition.
  - In summer/winter peak load conditions, voltage of Yuksak substation 110kV bus were set to be equal to those of power flow analysis result provided by SAESP.
  - In light load conditions, voltage of Yuksak substation 110kV bus were set to the highest allowable voltage of 121kV (1.10pu).
  - N-1 fault cases were selected from the viewpoint of significance of influence on the power flow of the remaining circuit as follows:
    - ✓ Single circuit fault of the section b/w T-Junction – New switching station bus
    - ✓ Single circuit fault of the section b/w T-Junction – T-Junction to textile industrial complex

3.5 Power Flow and Voltage Analysis

- 3.5.2 Analysis Results
  - Summer/Winter Peak Load Conditions
    - ✓ In both normal operation condition and N-1 contingency conditions, no overloading or voltage violation occurred.
  - Summer/Winter Light Load Conditions
    - ✓ No overloading of transmission line occurred.
    - ✓ Voltage violation (exceed 1.10pu) occurred at 110kV buses of textile industrial complex substation, existing Tashkent CHP Plant, and new switching stations.
    - ✓ Three generators of GTCS became leading phase operation despite control of terminal voltage up to the maximum limit (1.05pu)

3.6 Fault Current Analysis

3 phase short-circuit current and 1 line-to-ground fault current were calculated.

- 3.6.1 Analysis Results
  - ✓ 3 phase short-circuit currents and 1 line-to-ground fault currents at 110kV buses were below maximum allowable fault current 30kA.

Substation/ Power plant	3 phase short-circuit fault current (A)		Difference (A)	1 line-to-ground fault current (A)		Difference (A)
	Without GTCS	With GTCS		Without GTCS	With GTCS	
Yuksak	20,282	23,392	3,110	20,427	23,384	2,957
Textile	16,403	19,366	2,963	14,303	16,937	2,634
Tashkent CHP Plant (existing)	13,692	19,112	5,420	11,437	17,438	6,001
New switching station	N/A	20,005	N/A	N/A	18,275	N/A

3.7 Conclusion & Recommendations

- Conductor AC-185 has sufficient transmission capacity for the section b/w T-Junction and new switching station
- Summer/winter light load condition (assume 110kV bus voltage at Yuksak substation will rise up to 1.10pu)
  - ✓ Output restriction of GTCS should be considered.
  - ✓ Further study on generator operation among NEDO project and the project in question should be considered.
  - ✓ Reactive power control by installation of shunt reactors and/or transformer tap adjustment for maintaining proper voltage range should be considered.

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Chapter 4 Assisting survey for EIA Preparation

4.1 Current Situation of the Air /Water Quality and Noise Level

4.1.1 Current situation of the air quality

Uzgidromet:Uzbek Hydrometeorological Institution is conducting the actual

survey under the State Natural Protection Committee on monitoring regarding the air quality in the environment in Republic of Uzbekistan

According to the survey conducted in the nearest monitoring station of TashTEZ from 2006 to 2008 NO2 emitted by the project is from 0.05 to 0.06 mg/m33 in average value and the maximum concentration for each year is from 0.24 to 0.37mg/m3.

The maximum value for each year all exceed the MAC in Uzbekistan which is 0.085mg/m3 and the maximum value by 3.4.

The annual average value exceeds the standard value 0.04 mg/m3 set by WHO which is quoted as the international standard (2006)for the IFC, Environmental, Health and Safety General Guidelines. It is assumed that the contamination level of NO2 in the vicinity of Tashkent CHP to be high.

4.1.2 Current situation of Water Quality

Water quality monitoring is regularly conducted at 2 outlets of the Tashkent CHP and 2 points upstream and downstream of the river flowing into the CHP site.

According to the results of measurements in 2008 at Tashkent CHP, the water of the rivers receiving effluent is turbid, significantly contaminated with nitrogen and phosphorus, with higher concentration than in the effluent.

Hence, concentrations of pollutants after discharge from Tashkent CHP is lower downstream compared to upstream, due to dilution.

4.1.3 Current situation of Noise

It was confirmed that no noise measurement has been conducted in and around Tashkent CHP site. The noise level in daytime was measured in four locations within the proposed site for installing new gas turbines, using simplified noise meter at the time of site investigation.

The measurement result shows that the noise level in the proposed site is generally 45 to 57dB(A), except in the north side where the existing facility operates. This value is largely satisfactory, meeting the norm for residential area in Uzbekistan.

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4.2 Prediction of Ambient Air Quality and Noise Level

4.2.1 Result of estimated ambient air quality

The impact of emission from the installation of the 2 gas turbines and the NEDO unit is under consideration. To attain an improved future air quality compared to the present, demolition of the existing steam boilers (no.2-4) is proposed as a basic plan.

The contribution concentration of the contaminant is estimated using dispersion simulation model :

・The contribution concentration of the existing unit in operation

・The contribution concentration of the 3 newly installed units in operation

・The contribution concentration of the future units (existing facility except Boilers No.2-4 + 3 new boilers) in operation

According to the estimated value of nitrogen dioxide emission, the contribution concentration is 0.060mg/m3（0.71MAC）for the existing facility, 0.010 mg/m3（0.12MAC）for the newly installed facility, and 0.043 mg/m3（0.51MAC）for the future installation of the facility.

The demolition of the existing boilers No.2-4 contributes to the improved ambient air quality.

However, since this estimation is calculated using the data obtained through internet, certain inaccuracy exists such as the gas emission speed being set much lower compared to general gas turbine. The simulation should be re-implemented in future based on the data reflecting the actual conditions.

The re-implementation of the simulation requires a formal letter of requirement from JICA to TashTEZ. The provision of existing data on emission from JICA Team is requested by TEP.

4.2.2 Result of estimated Noise Level

The noise level of the 2 new turbines of the project and the one of NEDO project is estimated using simulation model.

According to the simulation, the noise level in the residential area is under 30dB(A), which is well below the normative value and hence, the acoustic impact is within a negligible level.

However, similar to air quality, since this estimation is calculated using the data obtained through internet, certain inaccuracy exists such as the noise from the gas compressor to be installed adjacent to the apartment located south of the CHP not being considered. The simulation should be re-implemented in future based on the data reflecting the actual conditions.

The re-implementation of the simulation requires a formal letter of requirement from JICA to TashTEZ. The provision of existing data on noise levels from JICA Team is requested by TEP.

4.3 Selection of the items to be stated in the EIA

The envisaged preparation of Environmental Impact Statement (EIS) proved unnecessary, since the draft EIS had been submitted to the State committee for environmental protection (Goskomprirody) in July 2, 2009, and approved in 25 August, 2009 with no requirement for additional survey or simulation.

The EIS including the environmental impact of NEDO project was reviewed , and approved on condition that the existing boilers No.2-4 be demolished. The initial condition of demolishing only No.2 and 3 was finally altered to the demolition of Boilers No.2-4 for EIS submission. Hence, the EIA procedure in planning phase is completed.

The following table shows the contents of the EIS agreed with Goskomprirody at in-situ survey in September. The EIS contents will be examined of the compliance with JICA guideline, JBIC guideline and checklist, IFC guideline and of facility planning and emission data, with consequent addition or correction including the aforementioned additional estimation, mitigation options, or monitoring, as appropriate, to prepare the revised EIS. The legal handling of the approval of the revised EIS will be discussed and confirmed at the next survey.

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The table below shows the contents of the EIS. Regarding the business characteristics and environmental impact of the project, the basic aspects such as ambient air quality and acoustic impact are described, whereas certain items required in JBIC checklist, such as mitigation during construction phase and monitoring plan during construction and operation phase, are not included. It must be confirmed that all those contents be added to the revised EIS, and a formal letter should be submitted from JICA to TashTEZ requiring the additional data including the additional estimation of ambient air and noise, prior to the next survey.

Index	Main contents
Introduction	・Project background and need
Chapter1 Natural environment characteristic of the project site	・Physical and geographical and climate conditions/ environmental impact existing sources/surface water/soils and underground water/soils and underground water/vegetation/acoustical action/level of health of population/current environmental conditions evaluation
Chapter 2 Social and economic aspects	・reliable and uninterruptible power and heat supply/training of qualified personnel
Chapter 3 Project decision environmental analysis	・power generation unit/fire defense system/exhaust gas （exhaust gas・temperature・speed・NOx concentration)/fuel consumption amount/water use
Chapter 4 Design decision alternative variant analysis	・present state of solar power generation/fuel consumption・environmental pollution・reduction of GHG
Chapter 5 Environmental impact assessment	・ambient air quality/water quality/noise level
Chapter 6 Possible emergency situations environmental consequences assessment	・reduction of accident risks by automatic control system
Chapter 7 Assessment of impact types determined by extraction of natural resources from environment	・land use/water use/gas usage volume
Chapter 8Adverse environmental impact reduction measures and recommendations	・reduction of impact on ambient air quality/no alteration of impact on water quality/accident risk reduction using automatic control system
Conclusion and recommendation	・reduction of environmental impact compared to the present state

4.4 Mitigation Measures and Monitoring Plan in the Construction /Operation Phase

4.4.1 Mitigation measures in construction and operation phase

1）Mitigation measures in construction phase

TashTEZ should be responsible for implementing mitigation measures through understanding of the project characteristics and promoting the acknowledge of construction enterprise. The director of the plant should organize a body in charge of the implementation.

During construction with significant inflow of workers and vehicles, the explanation of the construction work, schedule, and safety measures to the residents of the surrounded area is essential, as well as the flexible mitigation measures as needed based on the opinion of the residents.

The main environmental impact during construction phase includes:

・Increasing number of workers and construction vehicles:

・Dispersion of sand and dust, gas emission from construction vehicles and equipments:

・Noise from construction vehicles/ equipments

The mitigation measures will be planned through consultation with the construction enterprise. The schedule will be formed for reporting the implementation status using documented report, to ensure the appropriate performance of mitigation and consideration of further countermeasures.

Major mitigation measures ” recommended plan” during construction phase are described below.

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Items	Potential impact	Environmental mitigation measure plan
Inflow of workers, installation of construction equipment	Safety, accident prevention, land traffic	・Avoidance of vehicles during commuting time to school ・Lessen speed in school route and residential area ・Checkup of traffic rules, installation of traffic signs, safety driving education ・Implementation of safety program (traffic signs, speed limit, lighting of trucks, loading limit, equipment checkup(brake, horn)
	Noise generation	・Prohibition of vehicle traffic at night
	Gas emission from vehicles, Scattering of sand and dust particles	・Periodic checkup and maintenance of vehicles ・Periodic check of the concentration of vehicle emissions based on laws and regulations ・Stop the engine when idling ・Anti-dispersion covering , periodic vehicle wash ・Periodic wash of surrounding road
Excavation and operation of construction equipments	Gas emission and scattering of sand and dust from machines	・Periodic watering of deposited sand
	Noise generation	・Operation only in daytime in principle ・Use of low-noise equipment (muffler, silencer)
	Occupational health and safety	・Establish safety management plan and regulation ・Regulation on worker’s long exposure to noise ・Use of PPE (personal protective equipment)
	Generation of construction waste	・Waste management program including minimization, reuse and recycling of waste ・Restriction of discharging contaminant ・appropriate separation of waste, deposition to the designated disposal site

2）Mitigation measures in operation phase

TashTEZ holds responsibility to plan / conduct environmental management plan as a mitigation measure and to formulate necessary organization within the plant.

It will also act as an organization for handling/dealing complaints from the residents in the vicinity of the plant during operation. Necessary measures will be taken after understanding the opinions from the residents.

Its basic policy is to coordinate with the local community with emphasis on the sufficient explanation of the environmental management plan and such at the plant. Special tour of the plant facilities for residents and school children in the future is regarded as useful opportunity.

The main environmental impacts during the operation are as follows:

-Generation of exhaust gas

-Generation of noise from the equipment in service

Environmental managers must control and manage the above stated organization in order to reliably implement the environmental management plan. The managers must also report to the head of CHP on plan / implemented content of the environmental monitoring which is to be mentioned later as well as the environmental management plan at all stages including the construction and during the operation. The head of the CHP will hold all the responsibilities in the end.

The environmental managers must train the staff members on environmental management before the start of the operation and also conduct training during the operation to make sure everything is going well.

Other jobs conducted by the managers are to deal with the residents in the vicinity and to report with responsibilities to the related institutions such as Environmental and Natural Protection Committee on issues such as the environmental management, environmental monitoring as well as how the trainings are going.

The main mitigation measures" recommended plan" during operation are listed in the table on the following page.

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Items	Potential impact	Environmental mitigation measure plan
Power generation	Generation of exhaust gas	-Use of natural gas -Suppression of Co, SPM by perfect combustion -Use of high stack -Fast exhaust gas speed -Placement of stacks with consideration on weather condition/buildings and such - Installation of continuous monitor for exhaust gas - Introduction of low NOx combustion appliances
	Generation of noise/vibration	-Installation of soundproof wall and planting trees /woods in the surroundings of the plant -Introduction of low noise equipments and installation of soundproof cover -Introduction of low vibration equipments and solid substructure - Regular maintenance -Use of hearing protective device such as earplugs / earmuffs to protect the workers from high acoustic noise caused by turbines and generation equipment
	Safety/Accident	-Preparing management plan for protection of gas leak and create protection equipment as part of leaking risk management plan -Installation of fixed fire-prevention equipment, hydrant, fire extinguisher, escape exit from fire, fire alarm, fire protection facilities and space, emergency exit -Planning safety regulations

4.4.2 Monitoring plan against impact during construction/operation

Monitoring plan" recommended plan" against impact during construction/operation is listed in the following table.

Classification	Item	Parameter	Place/Frequency
Under construction	Air quality	SPM, NOx (NO,NO_2)	Existing place for monitoring and its frequency
	noise	Noise level	Boundary and residential area in the vicinity of Tashkent CHP(at the time when the amount of construction work to be the maximum)
During operation	Exhaust gas	NOx (NO,NO_2)	Gas duct(continuous monitoring)
	Air quality	NOx (NO,NO_2)	Existing place for monitoring and its frequency
	noise	Noise level	Boundary and residential area in the vicinity of Tashkent CHP(about twice a year)

4.5 Schedule of EIA Implementation

Meetings to explain to the local residents is planned to be held in the future while the content and outlining schedule of the meetings were already discussed and confirmed.

The schedule for conducting the meetings will take all together about one month and will start by informing the residents when and where the meetings are to be held and then informing/inspecting the content of EIS. After the meetings, collecting /confirming opinions given by the residents will be conducted and will be reported to the related institutions and the residents.

There is a need to conduct the meetings at this point since it is necessary to explain the residents on the content of the revised EIS mentioned earlier.

Revision on EIS, content of the additional simulation, the ways to hold the meetings as well as consultation/coordination of the schedule will be conducted at the future site survey.

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The plan on the content and the schedule of the meetings at this point is shown in the chart below.

The survey team can not attend the meetings due to the tight schedule, however, in case when JICA to be able to participate in the meetings, it will be informed to TashTEZ through e-mail and such.

Classification	Content of implementation	Required days	Schedule
1	Content of revised EIS, consultation/settlement of additional simulation (at the time of site survey)	5days	2009 End of October
2	Making report on revised EIS, Going through Procedures for revision of EIS in Uzbekistan	1.5month	2009 November
3	Holding meetings to explain to the local government, local residents and community association	1 week	From mid December 2009 to mid January 2010
4	Making abridged edition of EIA report and distributing to persons concerned, inspection of EIA report at the plant/ community association	1 week	
5	Holding meetings for explaining the Environmental Impact Assessment	–	
6	Implementing questionnaires to the local residents and collection of results/analysis	1 week	
7	Report to the related institutions	1 week	

4.6 Draft EIA Report

The content assumed at this point for revised EIS is to list the mitigation measures mentioned earlier by separating period of construction and operation on environmental mitigation measures described in EIS chapter 8.

Also there is a plan to list the content of the monitoring plan mentioned earlier by adding a new chapter on the environmental monitoring plan as chapter 9.

Revised content of EIS at the site survey will be consulted /coordinated with TashTEZ, TEP and the State Natural Protection Committee in the future to settle the policy.