No.

Republic of Uzbekistan

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

Final Report
（Main Report）

November 2009

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Services Co., LTD

ECC
JR
09-019

Preface

Japanese Government determined to conduct the Supplemental Study to enhance the collaboration with NEDO on Tashkent Heat Supply Power Plant Modernization Project on request from Republic of Uzbekistan and Japan International Corporation Agency (collectively called as JICA hereafter) performed the Study.

JICA dispatched the study team to the site, which is headed by Mr. Kenji MIKATA of Tokyo Electric Power Services Company, Limited, one time during August 2009 to November 2009.

The study team conducted the site survey as well as the discussion with the related authorities of Uzbekistan Government and SJSC Uzbekenergo and has completed the study report through study works in Japan.

JICA wishes that this report will be contributable for promotion of the project and helpful for more development of the friendship between both countries.

In conclusion, JICA extends heartfelt thanks to related authorities and persons who cooperatively supported for this Study.

November, 2009

Yoshihisa UEDA
Vice-President
Japan International Cooperation Agency

November, 2009

Mr. Yoshihisa UEDA
Vice-President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

The Study Team is pleased to transmit the report on Supplemental Study to enhance the collaboration with NEDO on Tashkent Heat Supply Power Plant Modernization Project. The Study Team has performed this study pursuant to the contract with JICA during August 2009 to November 2009.

Based on the former study "Preparatory Survey on Tashkent Heat Supply Power Plant Modernization Project", the Study Team implemented Layout Design, Considerations for an Optimum Plant System, Power System Analysis to enhance the collaboration with NEDO, and additionally, carried out Survey on assisting the preparation of EIA. By introduction of the gas turbine cogeneration system into the Tashkent Heat Supply Power Plant, it is definitely expected that the energy conversion efficiency will be elevated and that the operational reliability of the plant and the impact on environment will be improved due to introduction of such system. In turn, the introduction of the system will contribute to the further economical development of Uzbekistan.

The Study Team strongly wishes that Republic of Uzbekistan will employ in priority the conclusion of the report completed through this examination.

Taking this opportunity, the Study Team extends heartfelt thanks to JICA and Ministry of Foreign Affairs, which cooperatively supported for this study. In addition, the Study Team extends heartfelt thanks to the related authorities of Uzbekistan Government, SJSC Uzbekenergo and other related authorities.

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

Table of Contents

Purpose and Scope of the Study

Chapter 1 Layout Design

Chapter 2 Considerations for an Optimum Plant System

Chapter 3 Power System Analysis

Chapter 4 Survey on assisting the preparation of EIA

Abbreviation

BOP	Balance of Plant
CCPP	Combined Cycle Power Plant
CHP	Combined Heat and Power
CPI	Consumer Price Index
DCS	Distribution Control System
EIA	Environmental Impact Assessment
EPC	Engineering, Procurement and Construction
F/S	Feasibility Study
GT	Gas Turbine
GTCS	Gas Turbine Co-generation System
HRSG	Heat Recovery Steam Generator
IFC	International Finance Corporation
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
MAC	Maximum Allowable Concentration
NEDO	New Energy and Industrial Technology Development Organization
ODA	Official Development Assistance
Pre-FS	Pre Feasibility Study
SAESP	SREDAZENERGOSETPROJECT
TEP	Teploelektroproekt
TashTEZ	Tashkent Heat and Power Supply Plant

Units

Prefixes

μ	:	micro- $= 10^{-6}$
m	:	milli- $= 10^{-3}$
c	:	centi- $= 10^{-2}$
d	:	deci- $= 10^{-1}$
da	:	deca- = 10
h	:	hecto- $= 10^{2}$
k	:	kilo- $= 10^{3}$
M	:	mega- $= 10^{6}$
G	:	giga- $= 10^{9}$

Units of Length

m	:	meter
mm	:	millimeter
cm	:	centimeter
km	:	kilometer
in	:	inch
ft	:	feet
yd	:	yard

Units of Area

cm^2	:	square centimeter
m^2	:	square meter
km^2	:	square kilometer
ft^2	:	square feet (foot)
yd^2	:	square yard
ha	:	hectare

Units of Volume

m^3	:	cubic meter
l	:	liter
kl	:	kiloliter

Units of Mass

g	:	gram
kg	:	kilogram
t	:	ton (metric)
lb	:	pound

Units of Density

kg/m^3	:	kilogram per cubic meter

t/m^3	:	ton per cubic meter
mg/m^3N	:	milligram per normal cubic meter
g/m^3N	:	gram per normal cubic meter
ppm	:	parts per million
μg/scm	:	microgram per standard cubic meter

Units of Pressure

kg/cm^2	:	kilogram per square centimeter (gauge)
lb/in^2	:	pound per square inch
mmHg	:	millimeter of mercury
mmHg abs	:	millimeter of mercury absolute
mAq	:	meter of aqueous
lb/in^2, psi	:	pounds per square inches
atm	:	atmosphere
Pa	:	Pascal
bara	:	bar absolute

Units of Energy

kcal	:	kilocalorie
Mcal	:	megacalorie
MJ	:	mega joule
TJ	:	tera joule
kWh	:	kilowatt-hour
MWh	:	megawatt-hour
GWh	:	gigawatt-hour
Btu	:	British thermal unit

Units of Heating Value

kcal/kg	:	kilocalorie per kilogram
kJ/kg	:	kilojoule per kilogram
Btu/lb	:	British thermal unit per pound

Units of Heat Flux

$kcal/m^2h$	:	kilocalorie per square meter hour
Btu/ft^2H	:	British thermal unit per square feet hour

Units of Temperature

deg	:	degree
°	:	degree
C	:	Celsius or Centigrade
°C	:	degree Celsius or Centigrade
F	:	Fahrenheit
°F	:	degree Fahrenheit

Units of Electricity

W	:	watt
kW	:	kilowatt
A	:	ampere
kA	:	kiloampere
V	:	volt
kV	:	kilovolt
kVA	:	kilovolt ampere
MVA	:	megavolt ampere
Mvar	:	megavar (mega volt-ampere-reactive)
kHz	:	kilohertz

Units of Time

s	:	second
min	:	minute
h	:	hour
d	:	day
y	:	year

Units of Flow Rate

t/h	:	ton per hour
t/d	:	ton per day
t/y	:	ton per year
m^3/s	:	cubic meter per second
m^3/min	:	cubic meter per minute
m^3/h	:	cubic meter per hour
m^3/d	:	cubic meter per day
lb/h	:	pound per hour
m^3N/s	:	cubic meter per second at normal condition
m^3N/h	:	cubic meter per hour at normal condition

Units of Conductivity

μS/cm	:	microSiemens per centimeter

Units of Sound Power Level

dB	:	deci-bell

Units of Currency

Sum	:	Uzbekistan Sum
US$	:	US Dollar
¥	:	Japanese Yen

List of Tables

List of Figures

Purpose and Scope of the Study

The Purpose of this “Supplemental Study to enhance the collaboration with NEDO on Tashkent Heat Supply Power Plant Modernization Project” (hereinafter referred as “the Study) is as follows.

i. To study the layout of GTCS for JICA ODA Project on Tashkent Heat Supply Power Plant and overall layout of the Plant collaborated with NEDO Project and to confirm the optimized operation of total plant by confirmation of power network analysis and heat balance for the both projects.

ii. To assist the development of EIA report for the Project in accordance with “JBIC guidelines for confirmation of environmental and social considerations, April 2002” and the relevant laws in Uzbekistan.

   a. To confirm the current condition of air, water quality and noise etc.
   b. To simulate the influence by model calculation and dada correction for the calculation.
   c. Mitigation for negative effects during construction and operation phase.

The Scope of the Study is as follows.

Chapter 1 Layout design
Tashkent Heat Supply Power Plant Modernization Project is planned to install three 25MW class gas turbine cogeneration system (the "GTCS") in the candidate site (east- west 200m, south-north 79m) by both NEDO project and ODA project and to connect the existing 110kV transmission line passing near west boundary of the site.
Meanwhile, NEDO project site is planned to install in the west part of site. In this study 110kV transmission line connection method and switching station installation space will be evaluated and the collaboration with NEDO project will be enhanced.
In addition, the common facilities with NEDO facilities such as main building, the central control room and piping etc. will be evaluated to promote the efficient operation of the entire plant.

Chapter 2 Considerations for an Optimum Plant System

GTCS produces steam from the supplied water from existing facilities and the steam is used for power generation and for heating of hot water. Thus GTCS shall function as planned by integrated with the existing facilities. Therefore, at first, the Study Team shall investigate the current effective capacity and operational condition of the connected existing facilities. Then, the Study Team shall evaluate an optimized plant system with the existing facilities by examination of heat balance.

Chapter 3 Power System Analysis

Influence on the transmission and substation facilities caused by installation of three GTCS units (including NEDO project) is studied by power system analysis.

The Study Team shall create the system model considering installation of three GTCS units using the system data of the buses of upper level voltage connected to the existing 110kV transmission line which passes nearby new 110kV switching station and existing 110kV transmission lines connected to the buses.

Power flow, voltage, and fault current analyses (three-phase short-circuit and one-line-to-ground fault) will be conducted to check transmission capacity and CB short-circuit capacity of the existing transmission line and substation.

Chapter 4 Assisting survey for EIA Preparation

The Study Team shall assist the development of EIA report for the Project in accordance with "JBIC guidelines for confirmation of environmental and social considerations, April 2002" and the relevant laws in Uzbekistan. At first The Study Team shall confirm the current condition of air, water quality and noise etc. And the Study Team shall simulate the influence by model calculation and dada correction for the calculation. Mitigation for negative effects during construction and operation phase shall be evaluated and the contents and schedule for public consultation shall be confirmed with the relevant counterparts.

Chapter 1 Layout Design

Table of Contents

Chapter 1 Layout Design

1.1 Facilities for common use with NEDO facilities

As part of the modernization project using the gas turbine cogeneration facilities (hereinafter referred to as "GTCS") of the Tashkent Heat and Power Supply Plant, basic research for promotion of joint implementation and others, "Tashkent Heat and Power Supply Plant Modernization Project" was implemented by the NEDO (New Energy and Industrial Technology Development Organization (hereinafter referred to as "NEDO") in fiscal year 2000. An application was filed for the granting of yen credits on this project in 2004. In 2006, the State Joint-Stock Company "Uzbekenergo" implemented the "Preliminary Feasibility Study of Investment Project of Construction of Gas Turbine Unit at Tashkent Heat and Power Supply Plant (May 2006)", and determined the installation of three 25 MW-class GTCS facilities, each having a power generation capacity of 80 MW and a heat generation capacity of 100 Gcal/h.
With further materializations of the project by NEDO after that, a "Feasibility Survey on the Energy-saving Model Project of the Heat and Power Supply Plant" was conducted in fiscal year 2007. Further in fiscal year 2008, a "Feasibility Study on the High-efficient Gas Turbine Cogeneration Model Project for Heat and Power Supply Plant (Uzbekistan)" was conducted. In a model project (hereinafter referred to as "NEDO project") for installation of one 25 MW-class GTCS, a Basic Agreement was concluded between the Government of the Republic of Uzbekistan (hereinafter referred to as "Uzbekistan") and NEDO in July 2009. This was followed by signing of the Exhibit to Basic Agreement between the Uzbekenergo and the Tohoku Electric Power Co., Inc. in August 2009, marking the start of the Project.
In the meantime, the Japan International Cooperation Agency (hereinafter referred to as "JICA") conducted the "Preliminary Survey on the Tashkent Heat and Power Supply Plant Modernization Project, Uzbekistan (June 2009)" (hereinafter referred to as "Phase I Survey"). Against the above-mentioned background, a study is being made on the feasibility of installing two 25 MW-class GTCSs (power generation capacity of 50 MW and heat generation capacity of 70 Gcal/h) at the site adjacent to the projected NEDO site as part of the yen credit-based project. Further, the Uzbekenergo has worked out the "Preliminary Technical-Economical Assessment/Pre-Feasibility Study of Investment Project ‘Updating/Reengineering of Tashkent Heat and Power Supply Plant with Construction of Two Gas Turbine Installations’ (hereinafter referred to as "Pre-FS")" for the yen credit-based project, and application is currently being filed to the Government for approval.

According to the current program, a total of three 25 MW-class GTCSs will be installed by both projects. The planned construction site (Figure 1-1-1) is measured as small as 200 meters in the east-west direction and 79 meters in the north-south direction. To ensure smooth implementation of the yen credit-based project, it is necessary work out the optimum layout with reference to the preceding NEDO project. In the Phase I Survey, installation of a 110 kV-switchyard at the western end of the planned construction site was proposed, and the items requiring coordination with the NEDO project were extracted in a preliminary study. In this Study, a specific study was made on the facilities for common use with the NEDO facilities and the layout was worked out.

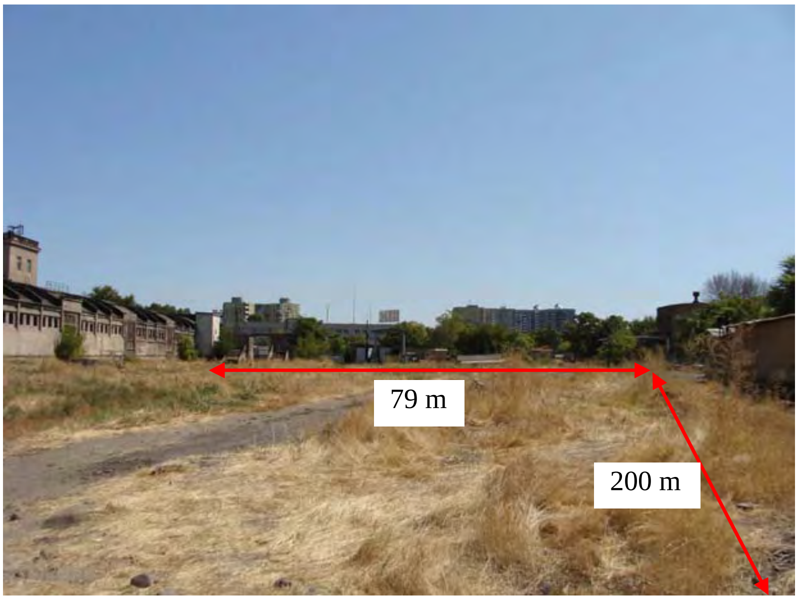


Figure 1-1-1 Planned Construction Site for NEDO project and JICA project (a view from east to west)

In the initial phase of designing a power plant, when two or more facilities are to be installed in the future, it is a common practice to find out ways for achieving a strategic arrangement of a boiler/turbine building, switchyard, central conrol room, cooling water intake, service water/waste water treatment facilities, fuel supply facilities, piping racks, electric culvert, fire extinguishing facilities, illumination facilities, roads and others which are to be used as common facilities.

It is also necessary to study which of the existing facilities should be used when there are any additional installation plans, or whether or not the capacity and specifications of the relevant facilities can be operated smoothly when an additional installation has been implemented. Further, if there are interface points for fuel, water feed, coolant, and drainage, the conditions for supply must be verified, similarly to the case of a new installation program.

From the former viewpoint, the following will discuss the facilities for common use with the preceding NEDO facilities. The former case will be examined in Chapter 2.

In this study, a 110 kV switchyard, boiler/turbine building, central operation room and various forms of piping were extracted as the facilities for which the common use with the NEDO facilities should be examined. Their advantages and disadvantages were studied. The result of this study is illustrated in Table 1-1-1 showing the policy on the common use with the NEDO facilities.

Table 1-1-1 Policy on comon use with NEDO facilities

	Advantages of common use	**Disadvantages of common use**	**Policy**
110 kV switchyard	The two-circuit transmission is enabled for each of the GTCSs with the result that supply reliability is enhanced. Centralized management can be achieved by common use of the facilities.	When NEDO facilities are constructed (under the charge of Uzbekenergo), facilities must be designed with consideration given to connection with the JICA facilities.	**Common facilities should be implemented.** The relevant site is located at the western end of the planned construction site. When NEDO facilities are constructed, the buses for connection with the JICA facilities should be provided. (When the JICA facilities are constructed, such facilities as circuit breakers will be added.)
Boiler/turbine building	The facilities cost can be reduced by sharing use of an overhead traveling crane. The building installation space can be used more effectively. Workability is enhanced by sharing use of the maintenance space in the building.	There is a need for building penetration work. Depending on the GT type of the JICA facilities, the overhead traveling crane cannot be commonly used, with the result that merely the buildings are connected with each other.	**Common facilities should be implemented.**
Central operation room	The personnel costs can be cut down by common use of the operators. Centralized management of the operation and monitoring can be achieved.	There will be a slight expansion in the building area for NEDO facilities. When the JICA facilities are constructed, there will be a need for cable laying work in the NEDO facilities currently under operation.	**Common facilities should be implemented.** Means are provided so that the JICA facilities operation console can also be installed inside the NEDO facilities central operation room. (An increase of about 20 cubic meters).
Various forms of piping and cable trenches	Installation can be completed in one construction process by common use of the fuel gas piping, water supply and steam feed piping and others.	Since the specifications of the JICA facilities are not always the same as the NEDO facilities, there mignt be consistent in the conditions of each fluid.	Eash piping will be installed separately; however **common piping rack will be installed.**

1.2 Connection of GTCS to Existing 110kV Transmission Line

In this section, the way to connect the Gas Turbine Cogeneration System (hereinafter GTCS) to the existing 110kV transmission line that passes near the west-end of the GTCS site is described.

1.2.1 Overview of Existing 110kV Transmission Line

The existing transmission line, which passes near the west-end of the GTCS site, is a double-circuit overhead transmission line with 36 steel towers. The transmission line starts from Tashkent CHP Plant and end at 220/110kV Yuksak substation. The length of the line is 4.22km. The steel towers of the line were originally designed by SEP, a distribution line design company of Uzbekistan, based on Regurations on Electrica Devices (PUE), however, the contractor of the transmission line, Makhsuselektrtarmokkurilish, modified the design. The circuits are named, looking at the line to the direction of Yuksak substation side, from right to left, Л-5-Ю-1 and Л-5-Ю-2, respectively. The 110kV transmission line branches off to the textile industrial complex supply line (double-circuit) at the tower No. 13 and 14, which are located 2.66km away from Tashkent CHP Plant. Applied conductor type is AC-185, which was replaced from AC-150 or AC-240 in 2005.[1]

1.2.2 Conditions of Circumfarence of Expected Branch Span between Junction Tower and New Switchyard

The location of the expected branch span from the existing 110kV transmission line to the planned new switchyard is from the span between tower No.6 and No.7, runs from north-south direction and whose span length is 68m, of the line to the east direction. The tower No.6 is п г с 110-18- а Т type suspension tower and located inside the adjacent factory site (Figure 1-2-1). The tower No.7 is А у с 110-26 а - Т type tension tower and located about 10m to the border of the neighboring factory site, which is located in south of the tower (Figure 1-2-2). About 11m east from the conductor of Л-5-Ю-2 line, a steam pipeline for textile factories (height: about 7.3m, diameter of the pipe: 150mm) is installed on the concrete support structures in north-south direction (Figure 1-2-3). About 2m west from the pipeline, a distribution line runs in the same direction and the ground height of the concrete poles of the distribution line is roughly 8 to 9m by eye measurement (Figure 1-2-4). The steam pipeline and distribution line is considered to become obstacles for stringing works between the existing 110kV line and the new switchyard.

[1] Preliminary Technical-Economic Assessment /Pre - feasibility study of the investment project "Updating / Reengineering of TashHPP with Construction of Two Gas-turbine Installations", Volume I, Explanatory Note 6.4.3 Capacity output circuit

Figure 1-2-1 Tower No.6

Figure 1-2-2 Tower No.7

Figure 1-2-3 Steam pipeline

Figure 1-2-4 Distribution line

1.2.3 Selection of Connection Method

As possible ways of connection between the existing 110kV transmission line and the new switchyard, the following two methods were proposed.

A) Disconnect the conductors between tower No. 6 and No.7. Construct a new dead-end tower into the section between tower No.6 and No.7 and branch off two circuits of the existing line to the gantry of the new switchyard through the dead-end tower from both Tashkent CHP Plant side and Yuksak substation side. (Double-circuit π–Junction Method: Figure 1-2-5)

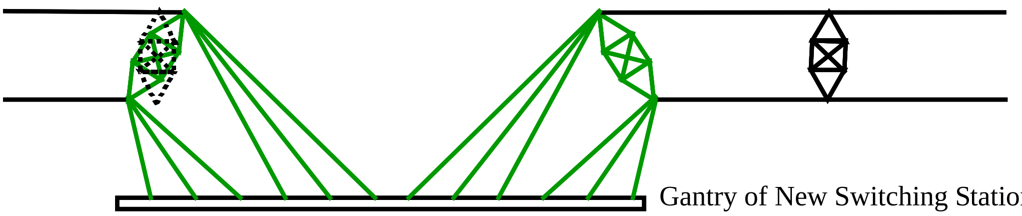


Figure 1-2-5 Double-circuit π–Junction Method

B) Construct a new junction tower into the section between tower No.6 and No.7. Branch off two circuits of the existing line to the gantry of the new switchyard through the junction tower.（Double-circuit T-Junction Method: Figure 1-2-6）

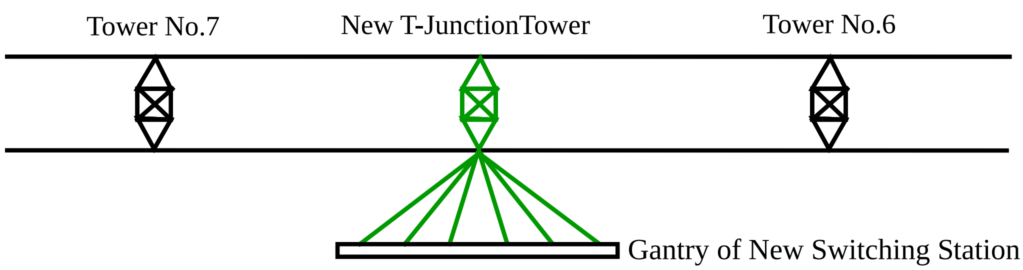


Figure 1-2-6 Double-circuit T-Junction Method

A) Double-circuit π–junction method has an advantage in terms of reliability; however, there are some disadvantages as follows:

- For the branch off span, it may be necessary for the tower to be reinforced or replaced with a dead-end type tower to endure the tension load due to heavy horizontal angle at tower No.7.
- Construction cost may become comparatively higher than that for T-junction method since necessary number of bays for incoming and outgoing transmission line doubles compared with that for the T-junction method.

B) Double-circuit T-junction method has advantages as follows:

- By stringing the new conductors between the T-junction tower and the gantry of the new switchyard, existing transmission line can be utilized without dividing the route.
- Construction cost may become lower than that for π-junction method since the necessary number of bays for incoming transmission line is one half of that for π-junction method.

However, the transmission line that constitutes T-junction configuration becomes multi-terminal transmission line, and it is necessary to select appropriate protection relay system to maintain same reliability as that of the existing transmission line.

Based on the suggestions on application of the abovementioned two connection methods made by the Central Asia Power Network Design Company (SAESP), which is responsible for design of transmission lines of 110kV to 500kV voltage classes, the T-junction method was rejected in that utilizing the existing transmission line without dividing the route was preferred and standard tower for T-junction are widely applied for branch off spans. Therefore, B) Double-circuit T-junction method was adopted as the way of connecting the existing transmission line to the gantry of the new switchyard (Figure 1-2-7).

Figure 1-2-7 Example of typically used T-junction Tower

1.2.4 Consideration of the Branch Span between Junction Tower and New Switchyard

(1) Design Standard

For the design of the branch span of this project, both the Regulations on Electrical Devices (PUE) and Uzbek-Standard (GOST) were referred to.

(2) Climate Condition

The climate conditions applied to the design were as follows:

[Ambient Temperature]

Maximum air temperature	45℃
Minimum air temperature	-30℃
Annual mean air temperature	15℃
Temperature in case of glazed frost	-5℃

[Wind Pressure]

Maximum normative wind velocity pressure	490Pa (wind velocity: 28m/sec)
Conductor installation condition	60Pa (wind velocity: 10m/sec)

[Load Condition]

8 conditions, which consist of normal opearation, conductor installation, and maximum air temperature conditions were considered. The case from 1) to 6) are based on the conditions of PUE 2.5.34, and the case 7) is based on the condition of PUE 2.5.36.

1) Maximum air temperature, no wind, no glazed frost
2) Minimum air temperature, no wind, no glazed frost
3) Annual mean temperature, no wind, 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°C, no glazed frost
6) Conductors are covered with glazed frost (thickness: 10mm, density: 0.9g/cm^3), temperature –5°C, wind velocity pressure 0.25 q_{max}
7) During conductor installation (temperature -15°C, wind pressure 6.25kgf/m^2, no glazed frost
8) Maximum conductor temperature (assumed 100°C), no wind, no glazed frost)

[Icing Level]
Level 2

(3) Design Condition

As the design condition for the branch off span in question, the design condition of the existing 110kV transmission line to be connected to the project was referred to.

[Conductor]
Both AC-150/24, which was formerly applied to the existing 110kV transmission line until 2005, and AC-185/24, which is presently applied to the existing line, were considered.

The properties of each conductor type are shown in Table 1-2-1.

Table 1-2-1 Proterties of Conductors

Type	Conductor	
	AC-150/24	AC-185/24
Component of stranded wires	Al：26/2.70mm St：7/2.10mm	Al：24/3.15mm St：7/2.10mm
Total area of aluminum wires	149.0mm^2	187.0mm^2
Overall diameter	17.1mm	18.9mm
Weight	0.599kg/m	0.705kg/m
Ultimate tensile strength	52,279N	58,075N
Modulus of elasticity	75,500MPa	111,800MPa
Coefficient of linear expansion	19.8×10^{-6}/°C	15.5×10^{-6}/°C
DC resistance at 20°C	0.19798W/km	0.15701W/km

(Source) GOST 839-80 (provided by SAESP)

[Ground Wire]
For the branch off span in question, earthing at the new switchyard was assumed to be sufficient to comply with the norms of earthing, PUE Chapter 1.7satisfied, thus no overhead ground wire were considered.

[Allowable Tension]
In PUE Table 2.5.7 “Allowable tension of conductors and cables for overhead line (more than 1kV)”, the allowable tensions in the case of conductor installation were provided as Table 1-2-2. Therefore, the tension in the severest condition was assumed 45% of the ultimate tensile strength of the conductor.

Table 1-2-2 Allowable Tension

Type	Allowable Tension in case of installation (% of Ultimate Tensile Strength)	
	Maximum load at the minimum air temperature (-30°C)	Maximum load at the annual mean temperature (15°C)
AC-150	45	30
AC-185		

(Source) PUE Table 2.5.7 (provided by SAESP)

[Insulator]

ПСД70Е type, which comforms to GOST6439-93, same type as that used for existing 110kV transmission line, was applied. The expected junction tower loacaiton is in the span between tower No.6 and 7 and the climate and air contamination conditions are considered same as those for those towers. Therefore, the insulator strings used for the junction tower was assumed single string. Similarly, the number of insulator discs per string was assumed 9. The insulator size is shown in Table 1-2-3.

Table 1-2-3 Insulator Size

Type	Height	Diameter	Rated Ultimate Strength
ПСД70Е	146mm	270mm	70kN

The length and weight of the insulator strings were assumed the same as those applied to the tension tower No.7.

- Length of insulator string: 1.792m
- Weight of insulator string: 47.3kg

[Tower]

Among the PUE standard tower types, a double-circuit junction tower for 110kV transmission lines (у с 110-8), which could be applied under the climate condition in question, was selected. Design data of у с 110-8 type tower is shown in Table 1-2-4. The applicable conductor types range from AC150/24 to AC240/32. Therefore, the tower type is applicable for the conductor type AC185/24, which is used to the existing transmission line. The maximum allowable span length is up to 40m [2].

[2] Based on the interview with SAESP Transmission Engineer

Table 1-2-4 Design Condition of Tower Type у с 110-8

Climate Condition	Icing Level		I-IV	I	II	III	IV
	Wind Level		III				
Conductor	Type		AC150/24	AC240/32			
	Allowable Tensile Stress (kgf/mm^2)	δ г	13.0	12.2			
		δ -	13.0	12.2			
		δ э	8.7	8.1			
Maximum Horizontal Angle	Angle Tower		*)				
	Dead-end Tower		N/A				

(Source) Provided by SAESP

*) Conductors for branch off span shall be strung at straight section of the route or from the outer horizontal angle side of the tower. Branch off from inner horizontal angle side of the tower shall be allowed only based on the tower member stress calculation conductor tension check results.

[Conductor Ground Height and Clearance between existing Structures]

According to PUE 2.5.169 Table 2.5.24 “Minimum Distance from High Voltage Lines to Overhead and Surface Pipelines and Cableways“, the minimum ground height for 110kV transmission line is specified 7m. Thus the required distance of 7m shall be secured between the bottom arm conductor and ground surface under the condition that conductor temperature rises up to the maximum allowable temperature, under which the sag of the conductor becomes largest.

As mentioned above, the steam pileline to textile factory and the distribution line parallel the existing 110kV transmission line inside the project site. According to PUE Table 2.5.24, the minimum required distance between 110kV transmission line and structures is specified 4m. Therefore, the required distance of 4m shall be secured between the bottom arm conductor and ground surface under the condition that conductor temperature rises up to the maximum allowable temperature, under which the sag of the conductor becomes largest.

(4) Consideration of the Branch Span between Junction Tower and New Switchyard

The following items were confirmed for the branch off span in question.

- Maximum allowable tension load between junction tower and new switchyard
- Conductor ground height and clearance between existing structures
- Clearance between phase conductors

[Maximum Allowable Tension Load between Junction Tower and New Switchyard]

The maximum applicable span length for the branch off span between the junction tower and the new switchyard gantry is 40m taking into consideration the application condition of the standard steel tower. Due to restriction of the project site, the length of the branch off span is required to be as short as possible. For a short-length span, increase in the tension load during conductor stringing works due to change in the conductor length is significant; therefore it is necessary to consider that conductor tension load will not exceed the maximum allowable tension of the conductor and the mechanical strength of the steel members of th gantry, taking into account the allowance. Hence the maximum allowable tensions were determined by span length of 20m and 30m to satisfy with the abovementioned conditions. Length of the conductor was assumed to be decreased by 100mm in stringing works. Table 1-2-5 shows the results of the calculation.

Table 1-2-5 Maximum Allowable Tension

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

The conducor tension would significantly change for the span length of 20m compared with that for the span length of 30m, thus more rigorous tension control would be necessary. Under the circumstance, 30m span length is recommended rather than that of 20m if the site area limitation would not be a problem.

[Conductor Ground Height and Clearance between Existing Structures]

The ground heights and distances between the conductor and pipeline for 2 conductor types (AC-150 and AC-185) were calculated under the maximum conductor sag condition. Where, the maximum conductor sag condition was assumed as follows:

- No wind, no glazed frost, conductor temperature: 100^{o}C

The height of conductor supporting point at switchyard gantry was assumed to be equal to that of bottom arm of the junction tower, 10.5m. The calculation results are shown in Table 1-2-6 and Figure 1-2-8, respectively.

Table 1-2-6 Conductor Ground Height and Clearance between Conductor and Pipeline

Span Length	Conductor Ground Height		Clearance b/w Conductor and Pipeline	
	30m	20m	30m	20m
AC-150	9.63m (0.87m)	10.00m (0.50m)	2.37m (0.83m)	2.70m (0.50m)
AC-185	9.71m (0.79m)	9.93m (0.57m)	2.45m (0.75m)	2.63m (0.57m)

* Values in parentheses: conductor sag

The vaules in Table 1-2-6 shows that the required ground height of 7m are secured but that the clearance between conductor and pipeline fell below the required distance of 4m by 1.37 to 1.63m for all cases considered. Hence it is necessary to take such countermeasures as change of pipeline height and/or height of switchyard gantry in order to secure the requred clearance. The ground heights of the distribution line, which runs parallel to the pipeline, and its supporting poles were seen as about the same or higher than the height of the pipeline by rough measurement by eye. Thus it is considered to be necessary to confirm the exact location and clearance between the bottom phase conductor in the detailed design stage and to change the position of such obstacles if necessary.

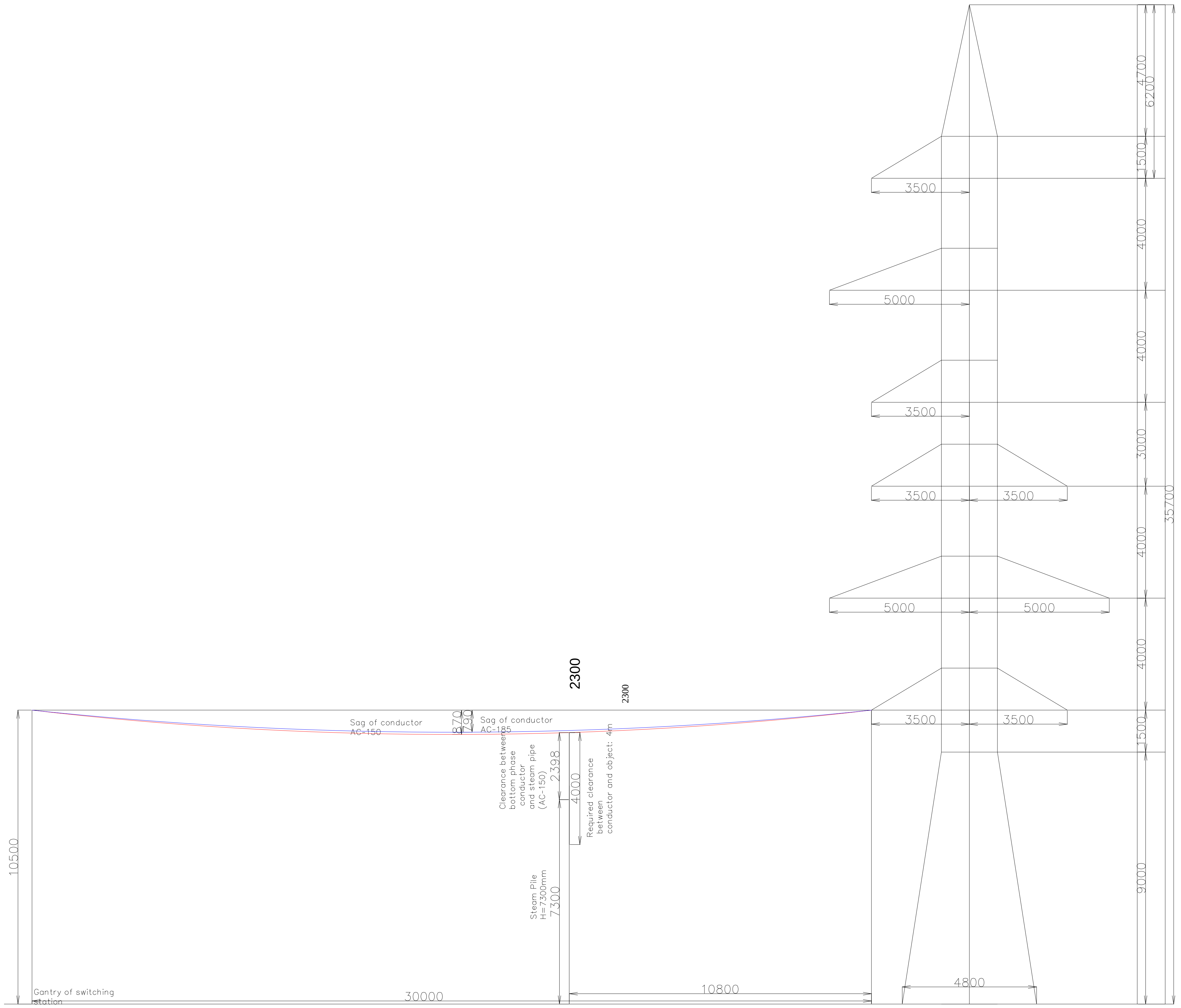


Figure 1-2-8 Ground Height of Conductor and Clearance between Bottom Phase Conductor and Pipeline

[Clearance between Phase Conductors]

For the branch off span in question, the conductor arrangement changes from a vertical arrangement at the junction tower to a horizontal arrangement at the switchyard gantry. Therefore, it is necessary for each phase conductor to secure the required insulation distance each other. According to PUE Section 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”, the required minimum horizontal distance between each phase conductor for 110kV transmission lines with 3m sag is stated 3m. Also, the required offset of the conductor for 110kV transmission lines whose each phase conductor is vertically arranged with the distance of 4m is stated 0m in PUE Section 2.5.53 Table 2.5.11 ” Minimum Shift of Conductors of Neighbouring Horizontal Levels at Suspension Towers in Area II (with Moderate Conductors Galloping)”. As mentioned above, the maximum sag of the conductor in the span in question is below 1m and the vertical distance between phase conductors at the junction tower is 4m, thus it is considered that the proposed conductor arrangement by using the junction tower satisfies with the required conditions.

(5) Layout of Junction Tower

The ground plan taking into consideration aforementioned conditions is shown in Figure 1-2-9. The span length between the junction tower and the new switchyard gantry is 30m, and the horizontal distance between the supporting points of each phase conductors was set to 3m. The preferable location of the junction tower is the middle of the span between tower No.6 and No.7, however, the condition would not drastically change even though the location of the junction tower is shifted about several meters toward tower No.7 provided that the angle between the span tower No.6 - No.7 and the branch off span is close to 90 degrees since the relative position would not change so much. However, it should be noted that the conductor tension control becomes difficult if the location of the junction tower become too close to either tower No.6 or No.7 since the shorter the span length, the more the conductor tension change significantly. Besides, it is necessary to confirm the land use condition should be confirmed to avoid interference with the railway for freight transport under the transmission line in detailed design stage.

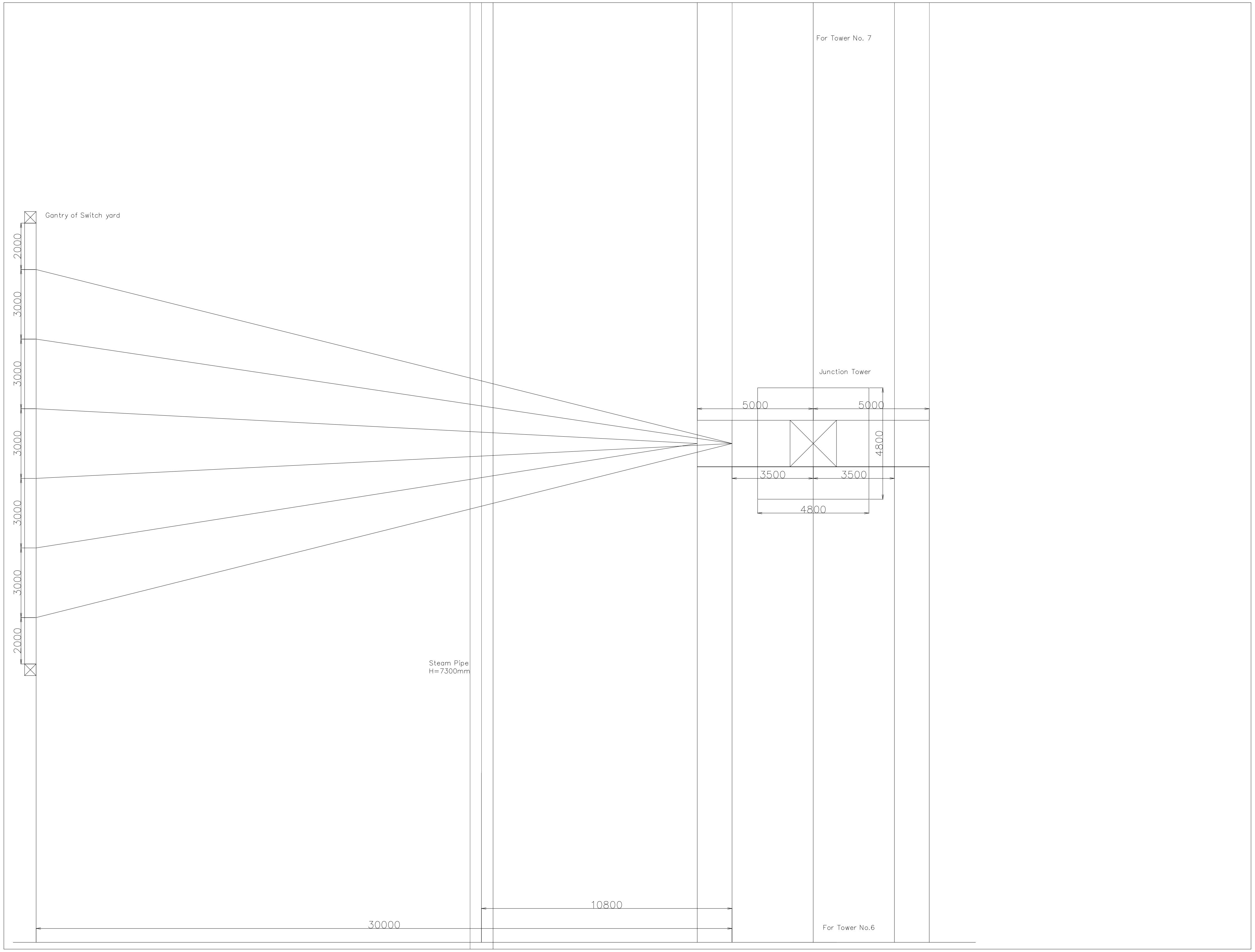


Figure 1-2-9 Ground Plan between Junction Tower and New Switching Station Gantry

1.3 Overall layout plan

1.3.1 110 kV switchyard construction plan

(1) Connection of transmission line with the switchyard

Generally, there are two methods for the connection between the power plant and power system. One is the unit system connection, where the generator is directly connected with the transmission line power system. The other is the bus system connection where the generator is connected to the transmission system via the bus of the switchyard. In the Tashkent Heat and Power Supply Plant, the bus system will be selected because the power generation capacity of the plant is comparatively small.

As illustrated in the single-wire connection diagram (Figure 2-4-9), the bus of the newly installed switchyard is connected using a 110 kV two-circuit transmission line in the section with a total length of about
4.2 km between the power plant and YUKSAK substation. The boundary point between the transmission section and power plant section is a gantry connecting two circuits of the transmission line.

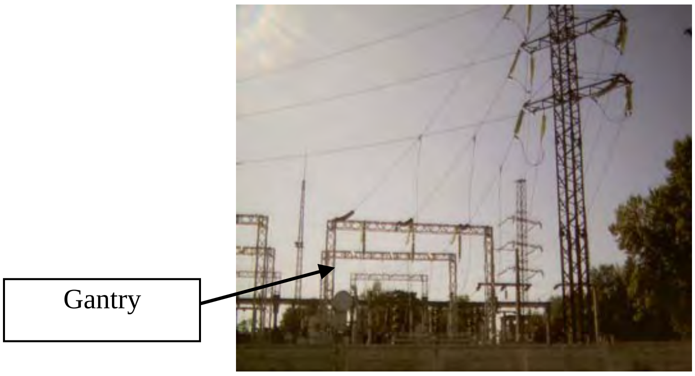


Figure 1-3-1 Connection point between the existing transmission line and switchyard

The total length of the transmission line between the Tashkent Heat and Power Supply Plant and YUKUSAK substation is not very great, but a transposition is used. The transposition provides a way for correcting imbalance in the inductance and electrostatic capacitance in each phase of the aerial transmission line in the AC transmission. This method is adopted for the transmission line of the Tashkent Heat and Power Supply Plant. Generally, in the three-phase AC transmission there is a phase shift by 120 degrees each, and the sum of all the phases comes to zero (0). In the aerial transmission, a difference in the position of the aerial transmission line, if any, will cause a difference in the working reactance and electrostatic capacitance between phases or with reference to the ground, depending of the place. This will cause a shift in the power factor. Thus, during power transmission, the voltage and current shifts of each phase are corrected by twisting the transmission line, and residual voltage is prevented from occurring at the neutral point of the three-phase star connection line or at the neutral point of the transformer, thereby ensuring efficient power transmission. Thus, for the transmission line of this power plant, the transposition is used to minimize the power loss due to transmission. Since the method also reduces induction to communication lines and the occurrence of coronas, this method is used as the most simplified method for loss reduction, particularly for the transmission line of an urban type power plant such as the Tashkent Heat and Power Supply Plant. Thus, as verified at the gantry point of the switchyard, phases are arranged in the order of B, A, and C phases (S, R, and T phases) for the #1L out of two circuits of the transmission line, as viewed from the top of the steel tower.

(2) Basic configuration of switchyard

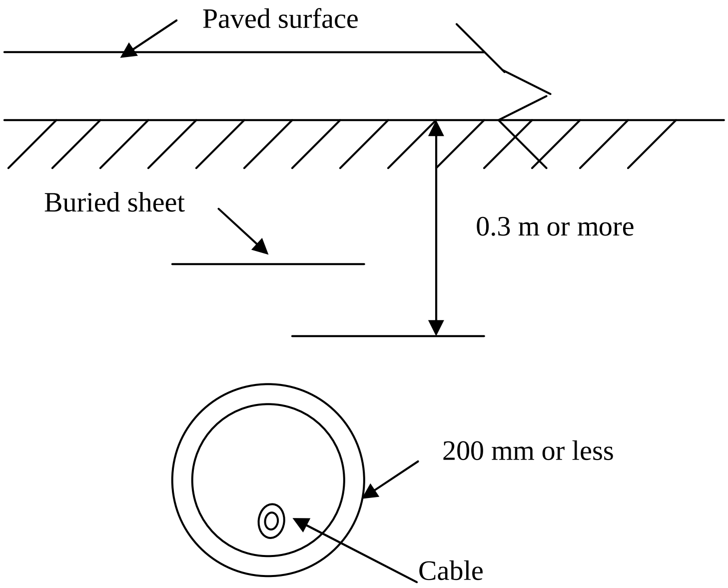
To meet the requirements for high reliability, safety, economy, space saving, and incombustibility in recent years, the switchyard of the power plant mainly uses gas insulated switches (GIS) where the circuit breaker, disconnecting switch, grounding switch, bus and all other components are sealed in SF6 gas (sulfur hexafluoride gas). The GIS can also be used for effective management of the operation and maintenance of the power plant. There are different types and specifications according to each manufacturer, and sufficient consideration must be given to ensure the dimensions and arrangement so that these components can be accommodated in the limited space of the switchyard. The site within the premises of the Tashkent Heat and Power Supply Plant is particularly limited in space. A study must be made with consideration given to installation of a gas insulated switch (GIS). At the present moment, the following points should be noted when working out a plan for installation of the main circuit breaker at the switchyard of the Tashkent Heat and Power Supply Plant.

- ✓ A hybrid SF6 gas circuit breaker characterized by excellent economy and a compact design will be adopted in the switchyard.
- ✓ The bus portion will use a normal cable instead of gas-filled equipment so as to give consideration to subsequent connections from the JICA facilities. The bus portion will be placed under the charge of Uzbekenergo, and the equipment such as a circuit breaker will be purchased at the responsibility of JICA.
- ✓ The interphase distance of the bus is assumed to be 2 meters for design purposes.
- ✓ Since a two-circuit T lead-in system is adopted, two bays are planned on the transmission side. Three bays are planned for the generator and one bay is for the bus connection. With consideration given to the position of the branched steel tower as discussed in 1.2.1 and the distance between the main transformer and gantry on the station side, three bays for generators are located to the south of the switchyard, and two bays for power transmission are positioned to the north of these three bays. Further, one bay for bus connections is placed at the north end.

(3) Connection between the power plant and switchyard

As a result of discussion with Uzbekenergo, it has been determined that the power line from the 110 kV power source on the secondary side of the main transformer in the newly installed GTCS is connected to the switchyard 35 meters in the north-south direction installed to the west inside the power plant premises, using an underground embedded cable trench. In determining the underground cable embedding method, sufficient consideration will be given to minimize the load on the high-voltage cable. Further, sufficient consideration is given to the curved portion in particular, because there is concern about the possibility of the space being restricted in the north-south direction of the building by the size of the plant and the planned cable installation site is anticipated to be small, the distance from the main transformer to the electric room of the switchyard is about 40 meters for the newly installed GTCS Unit 1, 75 meters for GTCS Unit 2, and 110 meters for GTCS Unit 3.

The cable trench will be installed according to the high voltage cable embodiment standards and technical standards stipulated in the PUE (Regulations of Electrical Installation Designing) of the Uzbekenergo. The technical standards for the method of underground installation of the power cable are standardized, and installation work must be performed in conformance to the standards. For reference purposes, the following shows various phases of underground installation methods adopted in Japan. It is recommended that the Tashkent Heat and Power Supply Plant should install the high- and low-voltage cables with reference to the following description. The power cable can be installed underground according to the conduit laying method and direct laying method. The direct laying method is used to lay such low-voltage cables as the control cable, communications cable, and illumination cable. However, sufficient care should be taken in regards to the pressure of vehicles and others.



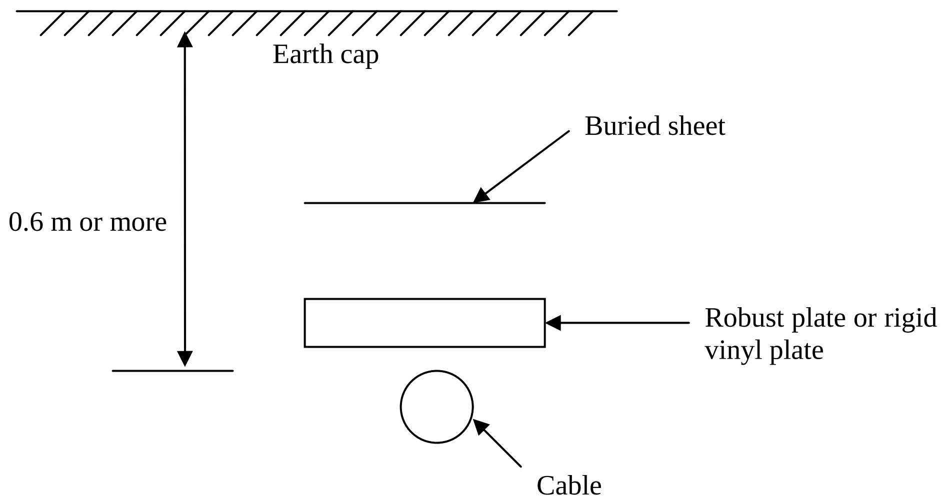
Materials:

Steel pipe made of carbon steel provided with a corrosion proof treatment such as winding of a corrosion proof tape or lining, power conduit made of thick steel, polyethylene-clad steel pipe, synthetic resin coated steel pipe for cable protection, centrifugal force reinforced concrete pipe, rigid vinyl conduit, rigid vinyl chloride VP

* A buried sheet is installed at approximately a mid-position between the conduit and ground surface.

Figure 1-3-2 An example of cable installation according to the conduit laying method

Not subjected to the pressure of a vehicle or other heavy objects
(for laying an illumination cable and others)



Subjected to the pressure of a vehicle and other heavy objects

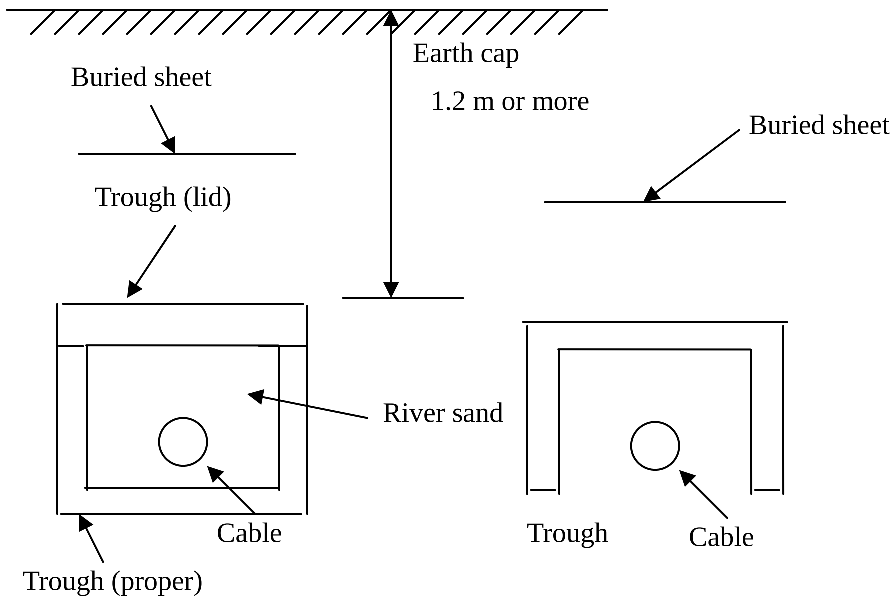


Figure 1-3-3 An example of cable installation according to the direct laying method

(4) Electric room for the 110 kV switchyard

An electric room for the 110 kV switchyard will be constructed adjacent to the switchyard installed in the west within the premises of the power plant. The room will accommodate a high-pressure auxiliary equipment circuit breaker (metal clad switch gear), control center, DC battery power source, relay panel, and others.

If they cannot be accommodated due to the limited space, they will be installed separately in the buildings on the plant side. Further, since there is a distance between the facilities of the plant proper, consideration must be given to maneuverability and measures against possible accidents at the time of installation.

1.3.2 Study of the overall layout

In the Pre-FS for which the application is being filed to the Government by the Uzbekenergo, the original plan of the layout is worked out on the assumption that the JICA facilities are two facilities of the same as NEDO facilities. Installation of the common 110 kV switchyard at the west end of the site has been already incorporated in this plan. To the east of that location, a turbine/boiler building is planned for common use in the NEDO facilities and JICA facilities. (Unit 1 (NEDO), Unit 2 (JICA), and Unit 3 (JICA) are arranged in that order as viewed from the west). According to the construction standards and regulation II-89-80 stipulating the disaster prevention road for factories, "General Design Drawing for Factories and Others", the disaster prevention road is required to be 12 meters away from the walls at the entrance and exit of the building, 8 meters away from other walls, and 1.5 meters away from the boundary fences of the premises. Thus, when the required road width is assumed as 6 meters, the common use of the building permits the distance to be reduced 12 m + 6 m + 12 m = 30 meters in the east-west direction.
In conformity to the principle of common use given in Table 1-1-1, this study provides a revised

version of the above-mentioned original layout plan, created by verification and review of the transmission line extension space, specifications for the 110 kV switchyard facilities and others. (See Figure 1-3-4 and Figure 1-3-5).

The following describes the major revisions of the original layout plan:

(1) Transmission line lead-in space of 30 meters
From the result of discussions in 1.2.1 (3), the span length between the new T-junction tower and the gantry of the newly installed switchyard is set at 30 meters. This is followed by the overall ten-meter shift of the facilities to the east from the original layout plan.

(2) Changes in the number of switchyard gantries and the number of bays caused by T-junction method

(3) Addition of T-junction tower and lead-in cable
The position of the T-junction tower and the bay on the transmission side was determined based on the discussions of 1.2.1 (5) and 1.3.1 (2).

(4) Changes to the piping route resulting from changes in the building position
Changes have been made to ensure that the piping rack laid at the time of construction of the NEDO facilities does not interfere with the construction of the JICA facilities.

It can be concluded that space can be saved by the common use of the turbine/boiler building, and three 25 MW-class GTCSs and the 110 kV switchyard can be comfortably installed in the planned construction site. In the future, the final layout will be determined subsequent to detailed designs of the building/equipment arrangement when both projects are implemented.

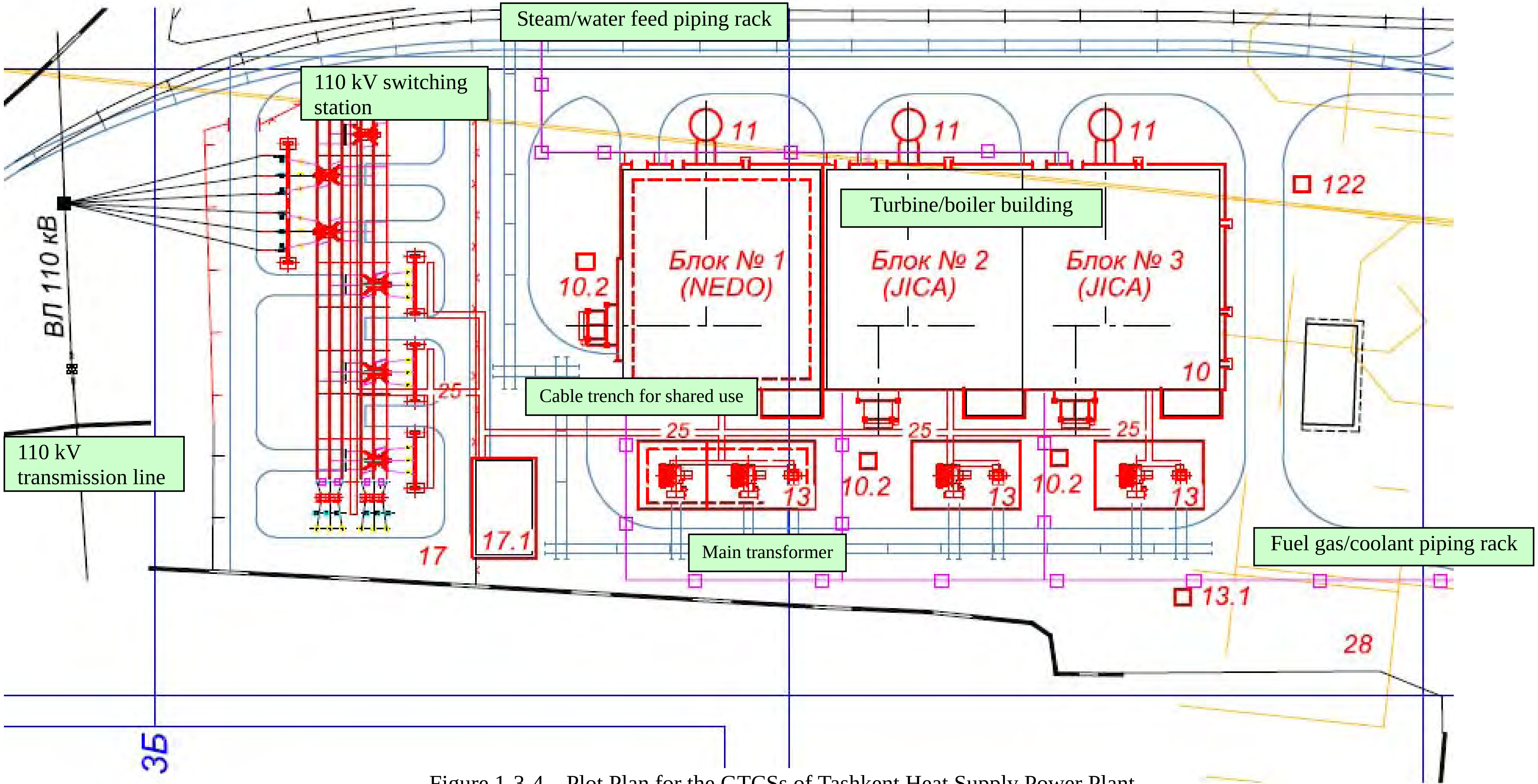
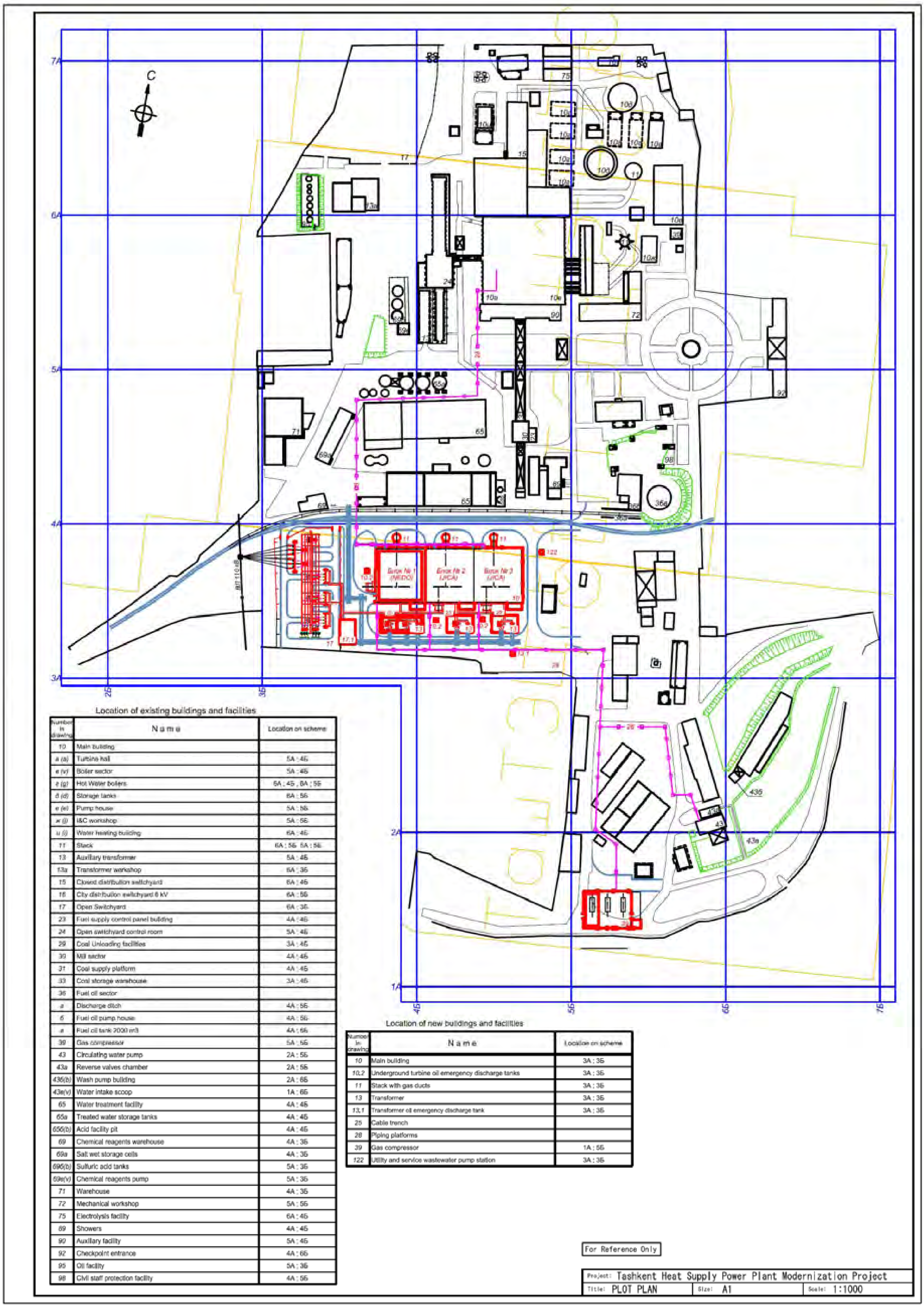


Figure 1-3-4 Plot Plan for the GTCSs of Tashkent Heat Supply Power Plant

Scale: 100 m/box



Location of existing buildings and facilities

Number in drawing	Name	Location on scheme
10	Main building	
a (a)	Turbine hall	5A : 4Б
в (v)	Boiler sector	5A : 4Б
г (g)	Hot Water boilers	5A : 4Б , 6A : 5Б
д (d)	Storage tanks	6A : 5Б
е (e)	Pump house	5A : 5Б
ж (j)	I&C workshop	5A : 5Б
и (i)	Water heating building	6A : 4Б
11	Stack	6A : 5Б 5A : 5Б
13	Auxiliary transformer	5A : 4Б
13a	Transformer workshop	6A : 3Б
15	Closed distribution switchyard	6A : 4Б
16	City distribution switchyard 6 kV	6A : 5Б
17	Open Switchyard	6A : 3Б
23	Fuel supply control panel building	4A : 4Б
24	Open switchyard control room	5A : 4Б
29	Coal Unloading facilities	3A : 4Б
30	Mill sector	4A : 4Б
31	Coal supply platform	4A : 4Б
33	Coal storage warehouse	3A : 4Б
36	Fuel oil sector	
a	Discharge ditch	4A : 5Б
б	Fuel oil pump house	4A : 5Б
в	Fuel oil tank 2000 m3	4A : 6Б
39	Gas compressor	5A : 5Б
43	Circulating water pump	2A : 5Б
43a	Reverse valves chamber	2A : 5Б
43б(b)	Wash pump building	2A : 6Б
43в(v)	Water intake scoop	1A : 6Б
65	Water treatment facility	4A : 4Б
65a	Treated water storage tanks	4A : 4Б
65б(b)	Acid facility pit	4A : 4Б
69	Chemical reagents warehouse	4A : 3Б
69a	Salt wet storage cells	4A : 3Б
69б(b)	Sulfuric acid tanks	5A : 3Б
69в(v)	Chemical reagents pump	5A : 3Б
71	Warehouse	4A : 3Б
72	Mechanical workshop	5A : 5Б
75	Electrolysis facility	6A : 4Б
89	Showers	4A : 4Б
90	Auxiliary facility	5A : 4Б
92	Checkpoint entrance	4A : 6Б
95	Oil facility	5A : 3Б
98	Civil staff protection facility	4A : 5Б

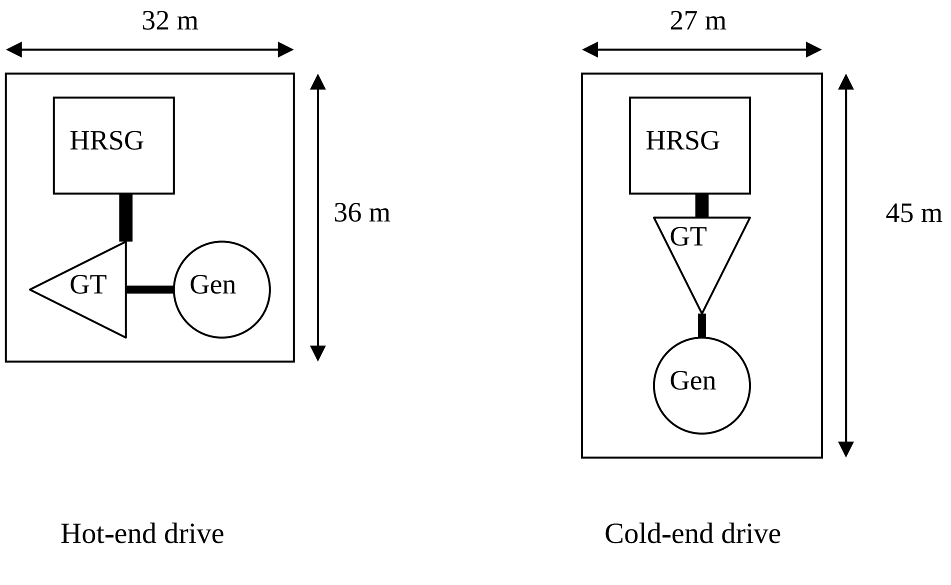
Location of new buildings and facilities

Number in drawing	Name	Location on scheme
10	Main building	3A : 3Б
10.2	Underground turbine oil emergency discharge tanks	3A : 3Б
11	Stack with gas ducts	3A : 3Б
13	Transformer	3A : 3Б
13.1	Transformer oil emergency discharge tank	3A : 3Б
25	Cable trench	
28	Piping platforms	
39	Gas compressor	1A : 5Б
122	Utility and service wastewater pump station	3A : 3Б

Figure 1-3-5 Plot Plan for the Tashkent Heat Supply Power Plant

1.3.3 Study of the alternative plan

The gas turbine generator used in the combined cycle power generation facilities and GT cogeneration facilities can be arranged in two drives -- a hot-end drive where the generator is connected to the gas turbine exhaust side and a cold-end drive where the generator is connected to the suction side. The adoption of the hot-end drive is being studied for the NEDO facilities GTCS. The exhaust duct, HRSG and smokestack are installed on the side of the turbine generator shaft (in the east-west direction). Thus, while restrictions are imposed on the dimensions in the north-south direction, there is an increase in length in the east-west direction. Figure 1-3-6 gives an example illustrating the approximate dimensions of the building for both drives when the GT (H-25 by Hitachi Limited) is adopted for the NEDO Project. If the same hot-end drive as that of the NEDO facilities GTCS is to be adopted for the JICA facilities GTCS, the dimensions of the building for the three GTCSs including the NEDO facilities is 96 meters in the east-west direction
(= 32 m × 3) and 36 meters in the north-south direction. By contrast, when the cold-end type is adopted, the dimensions are 86 meters (= 32 m + 27 m × 2) in the east-west direction and 45 meters (for JICA facilities) in the north-south direction. This signifies a reduction of ten meters in the east-west direction, and an increase of about nine meters in the north-south direction. As discussed above, according to the construction standards and regulation II-89-80, "General Design Drawing for Factories and Others", the disaster prevention road must be constructed by observing the regulation on the offset distance from the building. As shown in Figure 1-3-4, there is not much margin of safety in the space in the north-south direction in the case of the hot-end drive as well.
Thus, when the cold-end drive is to be used, it is better to arrange the southern wall of the boiler/turbine building in line to keep better landscape the NEDO facilities building and fuel gas/coolant piping rack should be placed as close as possible to the southern end.



Notes: HRSG: Heat Recovery Steam Generator
GT: Gas Turbine
Gen: Generator
The dimensions described indicate the approximate building dimensions when the GT (H-25) is adopted for the NEDO Project.

Figure 1-3-6 Approximate GTCS layout according to the hot-end and cold-end drive

Chapter 2 Considerations for an Optimum Plant System

Table of Contents

Chapter 2 Considerations for an Optimum Plant System

The heat recovery system of the new Gas Turbine Cogeneration System (GTCS) is planned to produce steam using the feed water from the existing heat and power supply system, and the steam is returned and utilized for electricity generation and heat supply in the existing plant. Therefore, the new GTCS and the existing plant are required to be organically connected with each other in order to demonstrate their expected function and performance.

For the first place, the design particular and the actual operating condition of each existing facility are investigated. In the nexet place, some types of heat recovery systems which are considered suitable for the new GTCS are independently studied and compared. Finally, the most suitable system as a combination of the existing system and the new heat recovery system is examined based on analysis of their heat balance diagrams including NEDO system.

In this chapter,the results of investigation and examination are presented and the heat recovery system most suitable to and the other facilities recommendable for JICA project are proposed.

2.1 Particulars of the Existing Plant

To check for plant heat balance, the current state of the existing power generation plant was investigated to confirm the capacities of the main existing facilities and their operation states.

2.1.1 Specifications of the existing facilities (mechanical facilities)

The specifications of the main existing facilities in Tashkent Heat and Power Supply Plant are indicated below.

(1) Steam Boiler

Steam boilers have been added in succession since the first boiler was installed in 1939. In 1955, the fifth and latest boiler was installed. The steam boilers are simply serviced every two years and fully serviced every four years, maintaining their functions. Table 2-1-1 indicates the main specifications of the steam boilers.

Table 2-1-1 Main specifications of the steam boilers

Unit No.	-	K-1	K-2	K-3	K-4	K-5
Boiler type	-	Front firing, water-cooled furnace, natural circulation (indoor installation)				
Draft system	-	Balanced draft				
Fuel	-	Natural gas or heavy oil	Natural gas or heavy oil	Natural gas	Natural gas	Natural gas or heavy oil
Capacity rating	t/h	60	60	70	75	150
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)	°C	425	425	425	420	420
Feed water temperature	°C	105	105	105	105	105
Time at which operation started	Year	1939	1939	1948	1954	1955

(source) Answer of Tashkent Heat and Power Supply Plant

(2) Steam turbine

The steam turbine was constructed and started operation in 1954 at the same time as the fourth boiler was constructed. The operation of the steam turbine has continued until today. The steam turbine is serviced every year, maintaining its functions. Table 2-1-2 indicates the main specifications of the steam turbine power generator.

Table 2-1-2 Main specifications of the steam turbine power generator

Type	Single-casing axial steam extraction and condensing turbine
Q'ty	1
Capacity rating	22,500 kW
Steam condition at turbine inlet	2.75 MPag(27.0 kg/cm^{2}g), 400°C
Extraction steam condition	9 kg/cm^{2}g, 320°C
In-house utility steam condition	7 kg/cm^{2}g, 270°C
Maximum steam flow (at turbine inlet)	350 t/h
Maximum steam extraction	300 t/h
Vacuum in condenser	0.05 ata

(source) Answer of Tashkent Heat and Power Supply Plant

(3) Hot Water Boiler

The sixth hot-water boiler with a capacity of 50 Gcal/hour was installed in 1963 in Tashkent Heat and Power Supply Plant to supply hot water used for space heating and other purposes for living. During a period from this installation until the twelfth hot-water boiler with a capacity of 100 Gcal/hour was installed in 1969, a total of seven hot-water boilers with a total capacity of 650 Gcal/hour were constructed. As with the steam boilers, the hot water boilers undergo a simplified inspection every two years and a full inspection every four years, maintaining their functions. Table 2-1-3 indicates the main specifications of the hot-water boilers.

Table 2-1-3 Specifications of the hot-water boilers

Unit No.	-	K-6	K-7	K-8	K-9	K-10	K-11	K-12
Boiler type	-	Front firing, water-cooled furnace, once-through (indoor installation)						
Draft system	-	Balanced draft						
Fuel	-	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas or heavy oil	Natural gas or heavy oil	Natural gas or heavy oil
Capacity rating	Gcal/h	50	100	100	100	100	100	100
Hot water pressure (outlet of superheater)	MPag (kg/cm^{2}g)	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 (outlet of superheater)	°C	150	150	150	150	150	150	150
Temperature at the hot-water inlet (at the boiler inlet)	°C	70	70	70	70	70	70	70
Time at which operation started	Year	1963	1965	1965	1966	1967	1968	1969

(source) Answer of Tashkent Heat and Power Supply Plant

(4) Condenser

Steam used in the steam turbine is led to the condenser, where heat is exchanged between the steam and feed water supplied to the hot-water boiler. Tap water is used as the feed water supplied to the hot-water boiler. Table 2-1-4 indicates the main specifications of the condenser.

Table 2-1-4 Specifications of the condenser

Item	Unit	-
Type	-	25-КЦС-6 (Cooling Surface, Moving Type)
Manufacturer	-	Leningrad Metal Plant
Type of cooling water	-	Tap water
Flow rate of cooling water at the inlet of the condenser	m^3/h	3,500
Pressure of cooling water at the inlet of the condenser	kg/cm^2g	0.8
Temperature of cooling water at the inlet of the condenser	°C	7.9
Pressure of cooling water at the outlet of the condenser	kg/cm^2g	0.7
Temperature of cooling water at the outlet of the condenser	°C	27.6
Cooling area	m^2	2,000
Number of tubes	pieces	4,420
Tube size (length × diameter × thickness)	mm	6,050 × 24.0 × 1.0
Tube material	-	Brass L-68
Degree of vacuum	kPa	0.05

(source) Answer of Tashkent Heat and Power Supply Plant

(5) Condensate pump

Table 2-1-5 indicates the main specifications of the condensate pump

Table 2-1-5 Specifications of the condensate pumps

Item	Unit	No. 1	No. 2
Capacity	t/h	125	125
Total pressure	kg/cm^2g	5.5	5.5
Intake pressure	kg/cm^2g	-0.5	-0.5
Discharge pressure	kg/cm^2g	4.5	4.5
Water temperature	°C	47	47

(source) Answer of Tashkent Heat and Power Supply Plant

(6) Low-pressure feed water heater for a steam boiler

Table 2-1-6 indicates the main specifications of the low-pressure feed water heater for a steam boiler.

Table 2-1-6 Specifications of the low-pressure feed water heater for a steam boiler

Item	Unit	-
Flow rate at the heater inlet (condensate)	t/h	50~130
Pressure at the heater inlet (condensate)	kg/cm^2g	5.0~5.5
Pressure at the heater outlet (condensate)	kg/cm^2g	4.5~5.0
Pressure at the heater inlet (steam)	kg/cm^2g	-0.3
Pressure at the heater outlet (steam)	kg/cm^2g	-0.6~-0.92
Temperature at the heater inlet (condensate)	°C	40~45
Temperature at the heater outlet (condensate)	°C	45~80
Temperature at the heater inlet (steam)	°C	90~100
Temperature at the heater outlet (steam)	°C	45~50

(source) Answer of Tashkent Heat and Power Supply Plant

(7) Deaerator for a steam boiler

Table 2-1-7 indicates the main specifications of the deaerator for a steam boiler.

Table 2-1-7 Specifications of the deaerator for a steam boiler

Item	Unit	No. 1	No. 2	No. 3	No. 4
Type	-	Pressurized	Pressurized	Pressurized	Pressurized
Flow rate at the deaerator inlet (makeup water)	t/h	20	20	20	20
Flow rate at the deaerator outlet (feed water)	t/h	150	150	150	150
Pressure at the deaerator outlet (feed water)	kg/cm^2g	0.5	0.5	0.5	0.5
Temperature at the deaerator inlet (drain)	°C	117	117	117	117
Pressure in the deaerator	kg/cm^2g	0.22	0.22	0.22	0.22

(source) Answer of Tashkent Heat and Power Supply Plant

(8) Feed water pump for a steam boiler

Table 2-1-8 indicates the main specifications of the feed water pump for a steam boiler.

Table 2-1-8 Specifications of the feed water pump for a steam boiler

Item	Unit	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Capacity	t/h	100	100	150	100	150	150	150
Total pressure	kg/cm^2g	53	53	53	53	53	53	53
Intake pressure	kg/cm^2g	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Discharge pressure	kg/cm^2g	48	48	48	48	48	48	48
Water temperature	°C	105~108	105~108	105~108	105~108	105~108	105~108	105~108

(source) Answer of Tashkent Heat and Power Supply Plant

(9) Water treatment unit

Three water treatment units are installed. Two of these units are used for the hot-water boilers, and the remaining one is used for the steam boilers. Table 2-1-9 indicates the main specifications of the water treatment units.

Table 2-1-9 Specifications of the water treatment units

Item		Unit	No. 3	No. 4	No. 5
Capacity		t/h	1,250	2,000	180
Water quality at the water treatment unit outlet	pH (at 25°C)	-	6.5~7.5	6.5~7.5	6.5~8.5
	Iron ion	μg/l as Fe	26~133	26~133	11~70
	Total dissolved solid	mg/l	96~110	96~110	100~118
	Chloride ion	mg/l as Cl^-	3.96~7.3	3.96~7.3	3.73~9.65
	Sulfite ion	mg/l as SO_3^{2-}	21~37.03	21~37.03	19.13~43.8
	Alkali	mg/kg	0.68~0.8	0.68~0.8	0.65~0.9
	Total organic carbon	mg/kg	2.2~5.5	2.2~5.5	1.1~2.2
	Suspended substances	mg/kg	0.5	0.5	-

(source) Answer of Tashkent Heat and Power Supply Plant

(10) Low-pressure feed water heater for a hot-water boiler

The low-pressure feed water heater for a hot-water boiler is a standby facility. It is used when the steam turbine is stopped for, for example, maintenance, during which the feed water for the hot-water boiler is not heated by the condenser. The low-pressure feed water heater is operated to supply heat to the feed water to compensate for insufficient heat to ensure the necessary temperature at the inlet of the hot-water boiler deaerator located downstream of the system. Table 2-1-10 indicates the main specifications of the low-pressure feed water heater for a hot-water boiler.

Table 2-1-10 Specifications of the low-pressure feed water heater for a hot-water boiler

Item	Unit	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Flow rate at the heater inlet (feed water)	t/h	1,500~ 3,200	1,500~ 3,200	1,500~ 3,200	1,500~ 3,200	1,500~ 3,200	1,500~ 3,200
Flow rate at the heater inlet (heated water)	t/h	1,000	1,000	1,000	1,000	1,000	1,000
Pressure at the heater inlet (feed water)	kg/cm^{2}g	1~4	1~4	1~4	1~4	1~4	1~4
Pressure at the heater inlet (heated water)	kg/cm^{2}g	4~10	4~10	4~10	4~10	4~10	4~10
Pressure at the heater outlet (feed water)	kg/cm^{2}g	1~4	1~4	1~4	1~4	1~4	1~4
Pressure at the heater outlet (heated water)	kg/cm^{2}g	2~8	2~8	2~8	2~8	2~8	2~8
Temperature at the heater inlet (feed water)	°C	25~40	25~40	25~40	25~40	25~40	25~40
Temperature at the heater inlet (heated water)	°C	63~80	63~80	63~80	63~80	63~80	63~80
Temperature at the heater outlet (feed water)	°C	<95	<95	<95	<95	<95	<95
Temperature at the heater outlet (heated water)	°C	40~55	40~55	40~55	40~55	40~55	40~55

(source) Answer of Tashkent Heat and Power Supply Plant

(11) Low-pressure forwarding pump for a hot-water boiler

Table 2-1-11 indicates the main specifications of the low-pressure forwarding pump for a hot-water boiler.

Table 2-1-11 Specifications of the low-pressure forwarding pump for a hot-water boiler

Item	Unit	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Capacity	t/h	1,260	720	720	720	1,250	720
Total pressure	kg/cm^{2}g	5	5	5	5	5	5
Intake pressure	kg/cm^{2}g	0.8~4	0.8~4	0.8~4	0.8~4	0.8~4	0.8~4
Discharge pressure	kg/cm^{2}g	6.4	8.9	8.9	8.9	7.0	8.9
Water temperature	°C	25~40	25~40	25~40	25~40	25~40	25~40

(source) Answer of Tashkent Heat and Power Supply Plant

(12) High-pressure feed water heater for a hot-water boiler

Table 2-1-12 indicates the main specifications of the high-pressure feed water heater for a hot-water boiler.

Table 2-1-12 Specifications of the high-pressure feed water heater for a hot-water boiler

Item	Unit	No. 3	No. 4	No. 5	No. 9	No. 10
Pressure (steam)	kg/cm^2g	13	7	3	14	14
Pressure (feed water)	kg/cm^2g	14	15	23	23	23
Temperature (steam)	°C	350	400	400	400	400
Temperature (feed water)	°C	150	150	120	150	150
Capacity (steam)	m^3	-	4.3	7.44	8.342	8.342
Capacity (feed water)	m^3	-	1.96	1.95	3.017	3.017
Flow rate (feed water)	t/h	1,000	400	725	1,800	1,800

(source) Answer of Tashkent Heat and Power Supply Plant

(13) Deaerator for a hot-water boiler

Table 2-1-13 indicates the main specifications of the deaerator for a hot-water boiler.

Table 2-1-13 Specifications of the deaerator for a hot-water boiler

Item	Unit	No. 1	No. 2	No. 3	No. 4
Type	-	Vacuum	Vacuum	Vacuum	Vacuum
Flow rate at the deaerator inlet (feed water)	t/h	640	640	640	640
Flow rate at the deaerator inlet (cooling water)	t/h	160	160	160	160
Flow rate at the deaerator outlet (feed water)	t/h	800	800	800	800
Pressure at the deaerator inlet (feed water)	kg/cm^2g	1.9	1.9	1.9	1.9
Pressure at the deaerator inlet (cooling water)	kg/cm^2g	2.1	2.1	2.1	2.1
Temperature at the deaerator inlet (feed water)	°C	75	75	75	75
Temperature at the deaerator inlet (cooling water)	°C	42	42	42	42
Temperature at the deaerator outlet (feed water)	°C	68	68	68	68
Pressure in the deaerator	kg/cm^2g	-0.65~-0.75	-0.65~-0.75	-0.65~-0.75	-0.65~-0.75

(source) Answer of Tashkent Heat and Power Supply Plant

(14) High-pressure forwarding pump for a hot-water boiler

Table 2-1-14 indicates the main specifications of the high-pressure forwarding pump for a hot-water boiler.

Table 2-1-14 Specifications of the high-pressure forwarding pump for a hot-water boiler

Item	Unit	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Capacity	t/h	720	1,250	720	800	1,260	720
Total pressure	kg/cm^{2}g	-	-	-	-	-	-
Intake pressure	kg/cm^{2}g	0.5	0.5	0.5	0.5	0.5	0.5
Discharge pressure	kg/cm^{2}g	9.0	7.0	9.0	10.0	6.4	9.0
Water temperature	°C	65	65	65	65	65	65

(source) Answer of Tashkent Heat and Power Supply Plant

(15) Feed water pump for a hot-water boiler

Table 2-1-15 indicates the main specifications of the feed water pump for a hot-water boiler.

Table 2-1-15 Specifications of the feed water pump for a hot-water boiler

Item	Unit	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Capacity	t/h	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total pressure	kg/cm^{2}g	12~17	12~17	12~17	12~17	12~17	12~17	12~17
Intake pressure	kg/cm^{2}g	2~4	2~4	2~4	2~4	2~4	2~4	2~4
Discharge pressure	kg/cm^{2}g	20	20	20	20	20	20	20
Water temperature	°C	50~60	50~60	50~60	50~60	50~60	50~60	50~60

Item	Unit	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13	No. 14
Capacity	t/h	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total pressure	kg/cm^{2}g	12~17	12~17	12~17	12~17	12~17	12~17	12~17
Intake pressure	kg/cm^{2}g	2~4	2~4	2~4	2~4	2~4	2~4	2~4
Discharge pressure	kg/cm^{2}g	20	20	20	20	20	20	20
Water temperature	°C	50~60	50~60	50~60	50~60	50~60	50~60	50~60

(source) Answer of Tashkent Heat and Power Supply Plant

(16) System

Figure 2-1-1 shows a schematic diagram of the combined heat and power supply plant at present in Tashkent.

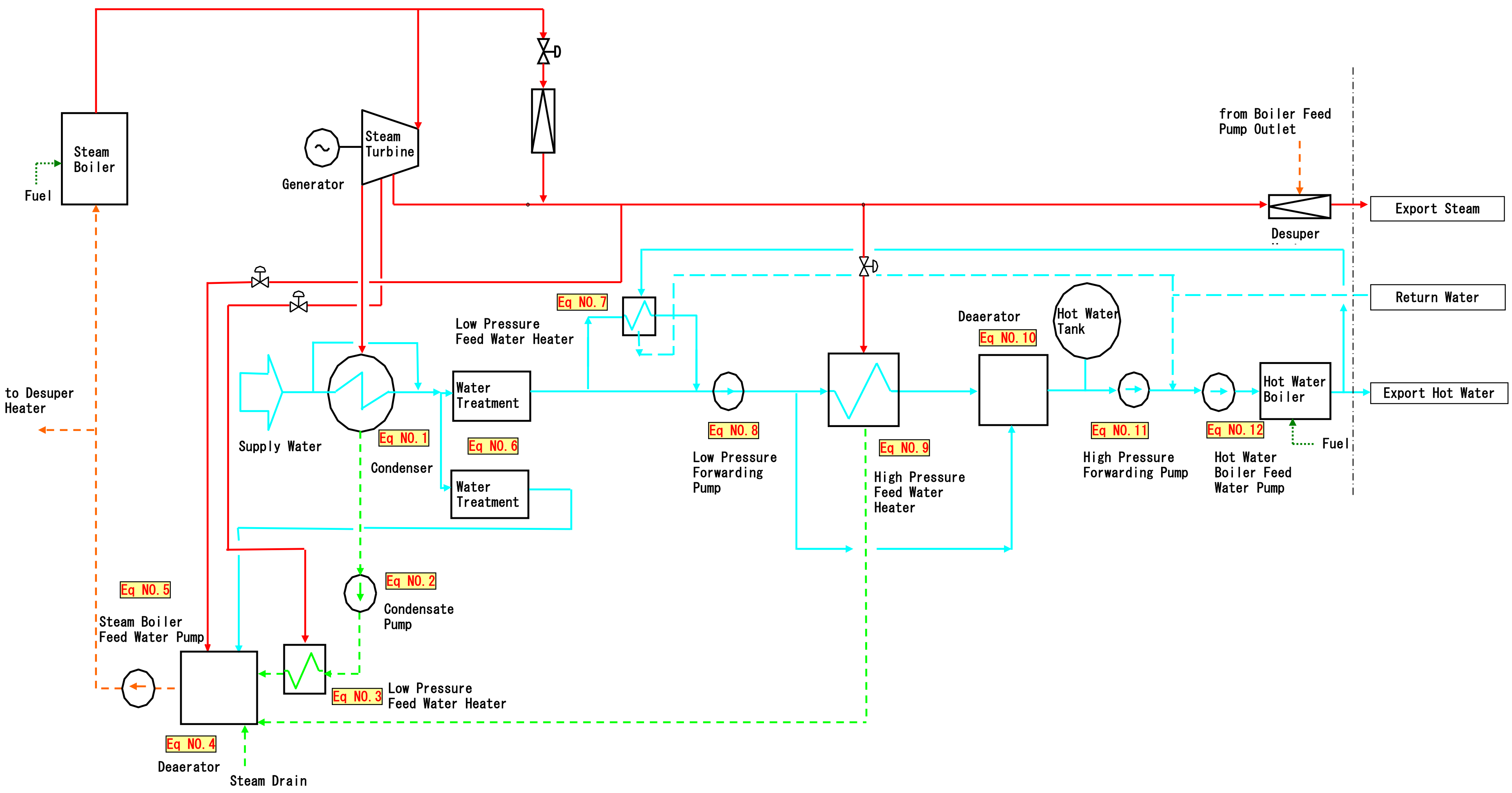


Figure 2-1-1 Flow Diagram of the Tashkent Heat and Power Supply Plant

2.1.2 Specifications of the existing facilities (electrical facilities)

Forty to seventy years have passed since the existing facilities in Tashkent Heat and Power Supply Plant started to operate. All facilities have significantly deteriorated. However, the taken-over technology developed in the Soviet age is sufficiently reflected in the maintenance of deteriorated facilities. All electrical facilities are old-fashioned facilities manufactured in the Soviet era. In general, their reliability has been significantly lowered. In addition to high-pressure and low-pressure electrical facilities, even meters and operation switches disposed in the central operation room are old-fashioned components that cannot be seen today and their deterioration is significant (Figure 2-1-2). Particularly, as for protection relays, old-fashioned relay panels of the travelling contact type and plunger type are disposed behind the upright panel in the control room. The 6.3-kV circuit breakers are old-fashioned air circuit breakers. Some of the circuit breakers for low-pressure auxiliary machines are blade-type switches.

Figure 2-1-2 Meters related to electricity

Figure 2-1-3 Central operation room

(1) Power generator

The power generator is a two-pole air-cooled power generator with a capacity of 25,000 kVA, which was manufactured by Kharkiv in the Soviet Union in 1953. The rotor and stator coils have been rewound several times. (Figure 2-1-4)

Specifications of the power generator in the existing facility

- Rated voltage: 6.3 kV ± 5%
- Insulation class: B
- Length: 16.5 m
- Rated current: 2290A, rotor current: 320A, 50 Hz, power factor: 0.8
- Rotational speed: 3000 rpm
- Power generator terminal voltage: 6.3 kV

(2) Step-up transformer

The generated electric output is transmitted by two step-up transformers from the 6.3-kV bus in the existing substation to the YUKSAK substation through two 110-kV transmission lines. The output is also transmitted to two lines of a 35-kV bus and 110-kV bus through the tertiary windings of a set-up transformer. (Figure 2-1-5)

Specifications of the transformer in the existing facility

- Manufactured in 1958 in the Soviet Union (oil-filled, forcibly cooled), 6.3 kV or 110 kV
- Capacity: 31500 kVA × 2, wire connection Yo/Yo/△, 50 Hz

(3) Data monitoring system

There is only one new system, which was manufactured in Russia and introduced as a facility for converting main power generation data by use of a converter and sending the converted data to the data control room where the converted data can be monitored on a CRT. However, data cannot be copied. (Figure 2-1-6)

(4) Power generator synchronization testing unit

In operation during power generator synchronization testing, the operator manually operates the frequency, voltage, and phase in parallel operation with the power generators. In the new combined heat and power plant in Tashkent, it is desired to introduce an automatic circuit breaker synchronizer, which is the dominant synchronizer in recent years.

Figure 2-1-4 Power generator

Figure 2-1-5 Step-up transformer

Figure 2-1-6 Data monitoring system

2.1.3 Interface between the new facilities and the existing facilities

(1) Feed water

The water quality of the existing steam boiler that will be interfaced was checked at the inlet to determine whether application to the new facility is possible. Table 2-1-16 compares the quality of feed water to the existing steam boiler with the values stipulated in the JIS.

Table 2-1-16 Comparison between the quality of feed water to the existing steam boiler with the 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
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 of Tashkent Heat and Power Supply Plant

Although the values of the dissolved oxygen and iron ion at present are slightly high. However, it is unquestionable for the existing boiler in the water quality because it is operated without trouble.

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) Bearing cooling water

Water used for cooling bearings is supplied from the adjacent Sara river. 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.) Of these, the two 290-t/h pumps are used at present (one is active, and the other is on standby). The two 2,020-t/h pumps have been used to supply cooling water to the Textile factory, but water is not supplied at present, so these pumps are not used. The amount of water used to cool the bearings in the existing facilities is about 150 to 200 tons/hour. The amount of water required to cool the bearings in the new facilities is about 700 tons/hour (with three GTs). Therefore, 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 employed.

(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, as in the case of the bearing cooling water described above and rain water. The drainage of existing facilities satisfies waste water regulations now. Since the amount of drainage from the new facilities is almost the same as that from the existing facilities, it is assumed that the drainage can be discharged without being treated.

(4) Fuel gas

As desicribed in the report by NEDO “International Model Project for Increasing Efficiency of Energy Consumption, High Efficiency Gas Turbine Cogeneration Model Project (Uzbekistan), Feasibility Study (March 2009)”, low fuel gas pressure (1.5kg/m^2) is one of the technical problem for the implementation of the NEDO Project. Thus the new exclusive gas pipeline for Tashkent Heat and Power Supply Plant between Kuylyuk gas station and Yuzhny gas station (5.6km) was planned and approved to solve such technical problem. The construction of such pipeline has started and will be completed within this year. After the completion, the gas pressure will be increased to 3kg/m^2.

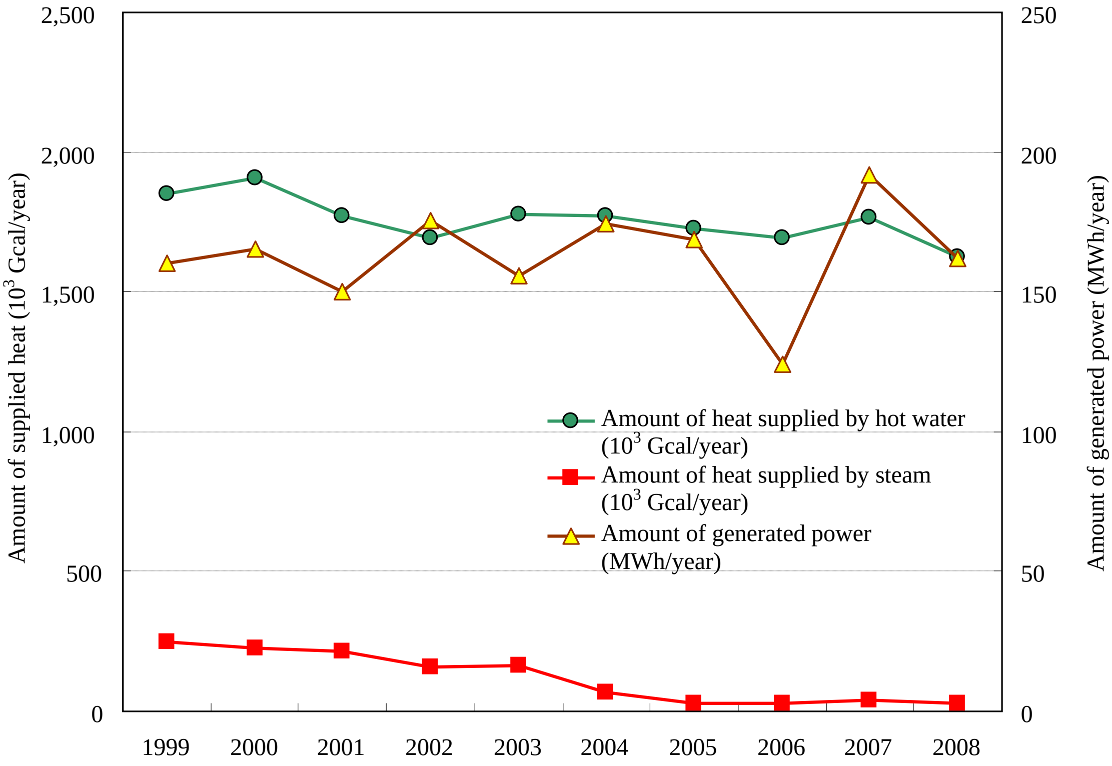
2.2 Operation Statuses of the Existing Plant

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

(1) Power generated as well as the amounts of power generated, amount of power, amount of heat supplied by hot water, and amount of heat supplied by steam over the past decade

Figure 2-2-1 indicates records of the amounts of power generated, heat supplied by hot water, and heat supplied by steam over the past decade. In addition to these records, Table 2-2-1 indicates records of the power generated.

- The maximum generated power was larger than the rated output, which is 22.5 MW, in all years. The existing facilities were operated in the range of 22.9 to 24.2 MW. The minimum generated power ranged from 9.0 to 17.7 MW.
- The amount of generated power ranged from 150 to 175 GWh, with the exception that it dropped to 124.4 MWh in 2006. There was no noticeable change.
- As with the generated power, the amount of heat supplied by hot water did not largely change during the past decade. It ranged from 1620 to 1910 × 10^3 Gcal.
- Unlike the above two cases, the amount of heat supplied by steam largely dropped from 245.7 × 10^3 Gcal in 1999 to 28.6 × 10^3 Gcal in 2008.
- In the records for 2008, the heat supplied by hot water was 1623 × 10^3 Gcal, the amount of generated power was 162 GWh (1394 × 10^3 Gcal), the amount of heat supplied by steam was 29 × 10^3 Gcal, totaling 1791 × 10^3 Gcal. The amount of heat supplied by hot water occupied most of the total, taking 90.6%. The amount of generated power occupied 7.8% and the amount of heat supplied by steam occupied 1.6%.



(source) Tashkent Heat and Power Supply Plant

Figure 2-2-1 Amounts of power generated, heat supplied by hot water, and heat supplied by steam over the past decade

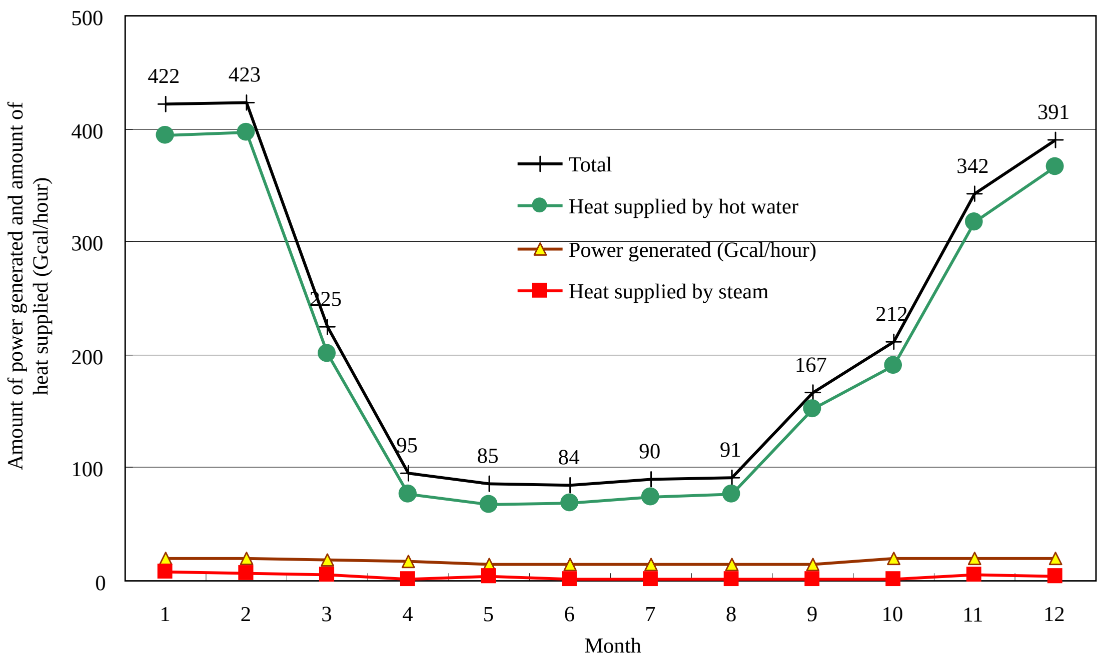
Table 2-2-1 Power generated as well as the amounts of power generated, amount of power, amount of heat supplied by hot water, and amount of heat supplied by steam over the past decade

Year	Power (MW)		Amount of generated power (GWh)	Amount of heat supplied by hot water (10^3 Gcal)	Amount of heat supplied by steam (10^3 Gcal)
	Maximum	Minimum			
1999	23.0	9.0	160.386	1,853.6	245.7
2000	23.0	13.5	165.600	1,908.2	224.6
2001	23.8	14.8	150.070	1,772.0	216.2
2002	23.8	13.8	175.494	1,695.3	159.4
2003	22.8	15.5	155.839	1,777.2	163.2
2004	22.9	15.5	174.483	1,773.5	65.9
2005	24.2	16.0	168.599	1,729.3	31.0
2006	23.7	15.6	124.361	1,693.0	29.7
2007	23.7	17.7	191.849	1,769.1	36.7
2008	23.9	14.4	162.082	1,623.0	28.6

(source) Tashkent Heat and Power Supply Plant

(2) Amounts of power generated, heat supplied by hot water, and heat supplied by steam in each month

Table 2-2-2 indicates records of the amounts of power generated, heat supplied by hot water, and heat supplied by steam for each month in 2008. Figure 2-2-2 indicates the amount of heat per hour (Gcal/hour), which is calculated by dividing the amount of power generated and the amount of heat supplied in each month in Table 2-2-2 by the calendar time in each month (the number of days multiplied by 24 hours).
In April to August during which the hot-water boilers stop, the steam boilers alone supply the steam to factries, the steam for power generation and the steam for hot water heating, and the total of heat supplied is 90 to 100 Gcal/hour. In each of January and February during which the amount of heat supplied is maximized, the sum of the amount of heat supplied by the hot-water boilers and that supplied by the steam boilers reaches 420 Gcal/hour, which is more than 4 times the amount of heat in the summer.



(Source) Created on the basis of the answer from Tashkent Heat and Power Supply Plant
Figure 2-2-2 Amounts of power generated, heat supplied by hot water, and heat supplied by steam in each month in 2008

(3) Power generated and the amounts of heat supplied by hot water and steam in summer and winter

Table 2-2-2 indicates the averages and changes (from minimum values to maximum values) of the power generated and the amounts of heat supplied by hot water and steam in the summer (in this report, five months from April to August) and winter (also in this report, four months from November to February), which were calculated from the operating records in 2008.

The average amount of heat supplied by hot water was 368.8 Gcal/hour in winter and 71.8 Gcal/hour in summer; the average in summer is significantly lower than the average in winter.

The monthly power generated was 23.1 MW in the winter on average, and 16.6 MW on average in the summer. During operation in winter, the rated output (22.5 MW) was always exceeded.

As with the power generated and the amount of heat supplied by hot water, the amount of heat supplied by steam tended to increase in winter and decrease in summer. However, the amount of heat supplied by steam occupied only 1% to 2% of the total amount of power generated and heat supplied.

Table 2-2-2 Power generated and amounts of heat supplied by hot water and steam in summer and winter (2008)

	Summer (April to August)		Winter (November to February)	
	Average	(minimum to maximum)	Average	(minimum to maximum)
Generated power	16.6 MW	(16.4 ~ 16.7)	23.1 MW	(22.8 ~ 23.3)
Amount of heat supplied by hot water	71.8 Gcal/h	(67.6 ~ 76.1)	368.8 Gcal/h	(322.3 ~ 403.9)
Amount of heat supplied by steam	1.7 Gcal/h	(0.8 ~ 3.4)	6.0 Gcal/h	(16.4 ~ 16.7)
Amount of power and heat supplied	87.8 Gcal/h	(84.4 ~ 91.3)	394.7 Gcal/h	(341.9 ~ 424.0)

2.2.2 Operation statuses of the existing plant

(1) Operation status of steam boilers and hot-water boilers

The demand of energy produced by power, hot water, and steam supplied by the existing heat and power supply plant is satisfied by steam and hot water generated by five steam boilers and seven hot-water boilers.

Steam (30 kg/cm^{2}g) generated from the steam boilers is mainly supplied as steam (28 kg/cm^{2}g) to drive the steam turbine power generator. Extraction steam of the steam turbine (8 to 13 kg/cm^{2}g) is consumed by the hot-water heater as steam to heat makeup water (tap water) in the hot-water system. The extraction steam is also supplied to adjacent factories as industrial steam. The exhaust steam from the steam turbines is used, in the condenser, to preheat the makeup water for the hot-water system.

The hot-water boilers play a role to heat the mixture of the makeup water for the hot-water system and the hot water returned from Tashkent City. The water heated by the hot-water boilers is then supplied to Tashkent City.

The steam boilers are continuously operated throughout the year, except that they stop for a week in April and another week in September, a total of 14 days, during which the steam turbines are inspected.

The hot-water boilers are mainly operated for only four months from November to February, during which the heating facilities in Tashkent City operate, and completely stop for four months from April to August. In March and a period from September to October, each of which is a transitional period between summer and winter, the hot-water boilers are operated under lower loads than in winter.

The operation status of the steam boilers and hot-water boilers are described in detail in (2) and (3) below.

(2) Amount of steam generated, amount of heat supplied by hot water, and amount of energy consumed in the steam boilers

Table 2-2-3 indicates the amount of steam generated by, the amount of feed water supplied to, and the amount of fuel consumed by the steam boilers in each month in 2008.

Figure 2-2-3 indicates the amount of feed water per hour (tons/hour) and the amount of heat per hour (Gcal/hour), which are calculated by dividing the amount of steam (tons), the amount of heat (Gcal), and the amount of energy consumption (Gcal) in each month in Table 2-2-3 by the calendar time in each month (the number of days multiplied by 24 hours).

Table 2-2-3 Amount of steam generated by, amount of feed water supplied to, and the amount of fuel consumed by the steam boilers in each month in 2008

Month	Amount of steam	Steam temperature	Steam pressure	Amount of feed water	Feed water temperature	Fuel consumption	Heat generated by fuel	Boiler efficiency
-	t	°C	kg/cm^2g	t	°C	$1000\ m^3$	$kcal/m^3$	%
January	221,405	409.9	30.6	224,969	104.6	19,889	8,279	90.5
February	206,461	410.0	30.5	210,093	106.1	18,592	8,271	89.9
March	151,496	410	30.0	154,606	107.0	13,411	8,273	91.0
April	108,650	409.9	28.1	110,673	106.0	9,533	8,195	92.1
May	99,410	408.0	28.0	101,504	105.0	8,832	8,190	92.0
June	94,063	408.0	28.0	96,071	105.0	8,287	8,304	92.0
July	104,611	405.7	28.3	106,659	105.5	9,127	8,299	91.6
August	105,659	404.3	28.15	107,779	105.0	9,377	8,202	92.45
September	73,722	404.0	30.0	75,222	104.0	6,556	8,302	91.0
October	122,972	404.3	32.0	125,390	104.5	11,055	8,127	91.2
November	176,483	405.4	32.0	179,902	106.4	15,876	8,132	91.1
December	192,630	406.0	32.0	196,228	106.0	17,265	8,135	92.0
Total	1,657,562	407.2	29.7	1,689,096	105.6	147,799	72,416.8	90.8

(source) Tashkent Heat and Power Supply Plant

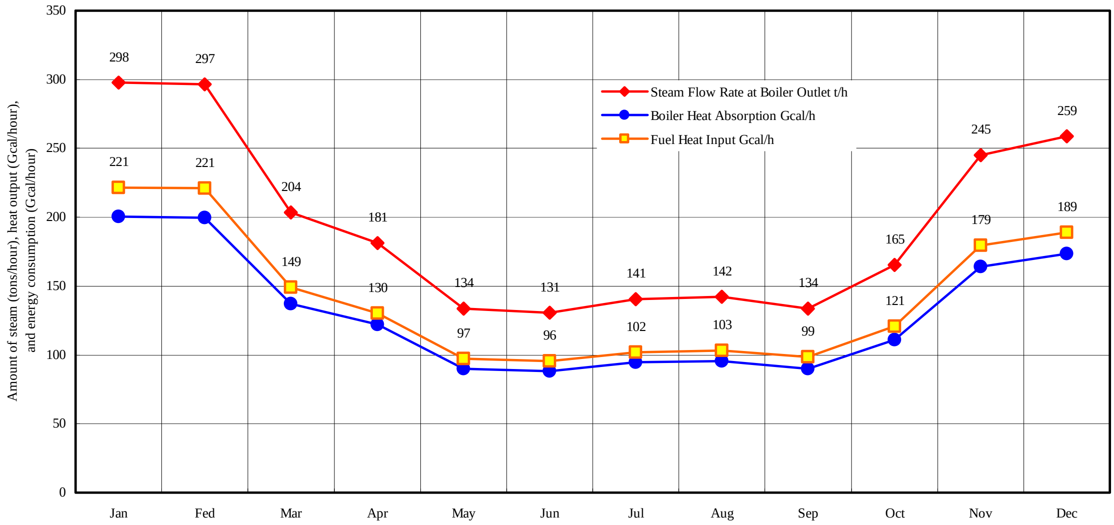


Figure 2-2-3 Operation status of the steam boilers in each month in 2008.

(3) Amount of heat generated by hot water and amount of energy consumed in the hot-water boilers

Table 2-2-4 indicates the amount of heat generated by and the amount of fuel consumed by the hot-water boilers in each month in 2008.

Figure 2-2-4 indicates the amount of feed water per hour (tons/hour) and the amount of heat per hour (Gcal/hour), which are calculated by dividing the amount of heat output (Gcal) and the amount of energy consumption (Gcal) in each month in Table 2-2-4 by the calendar time in each month (the number of days multiplied by 24 hours).

Table 2-2-4 Amount of steam generated by, amount of feed water supplied to, and the amount of fuel consumed by the hot-water boilers in each month in 2008

	Amount of hot water at the outlet	Temperature of hot water at the outlet	Pressure of hot water at the outlet	Amount of hot water at the inlet	Temperature of hot water at the inlet	Amount of natural gas consumed	Heat generated by natural gas
-	t	°C	kg/cm^2g	t	°C	$1000\ m^3$	$kcal/m^3$
January	6,448,362	83.3	10.6	6,448,362	56.2	22,883	8,279
February	5,578,992	88.5	11.4	5,578,992	58.5	21,564	8,271
March	2,089,510	85.0	11.1	2,089,510	55.3	9,397	8,273
April	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-
September	331,211	75.1	11.6	331,211	53.9	954	8,302
October	795,803	84.8	8.4	795,803	68.8	1,815	6,095
November	5,334,871	86.9	12.7	5,334,871	62.0	18,047	8,132
December	5,626,125	93.1	12.6	5,626,125	62.5	22,882	8,135
Total	26,204,874			26,204,874		97,540	41,090

(source) Tashkent Heat and Power Supply Plant

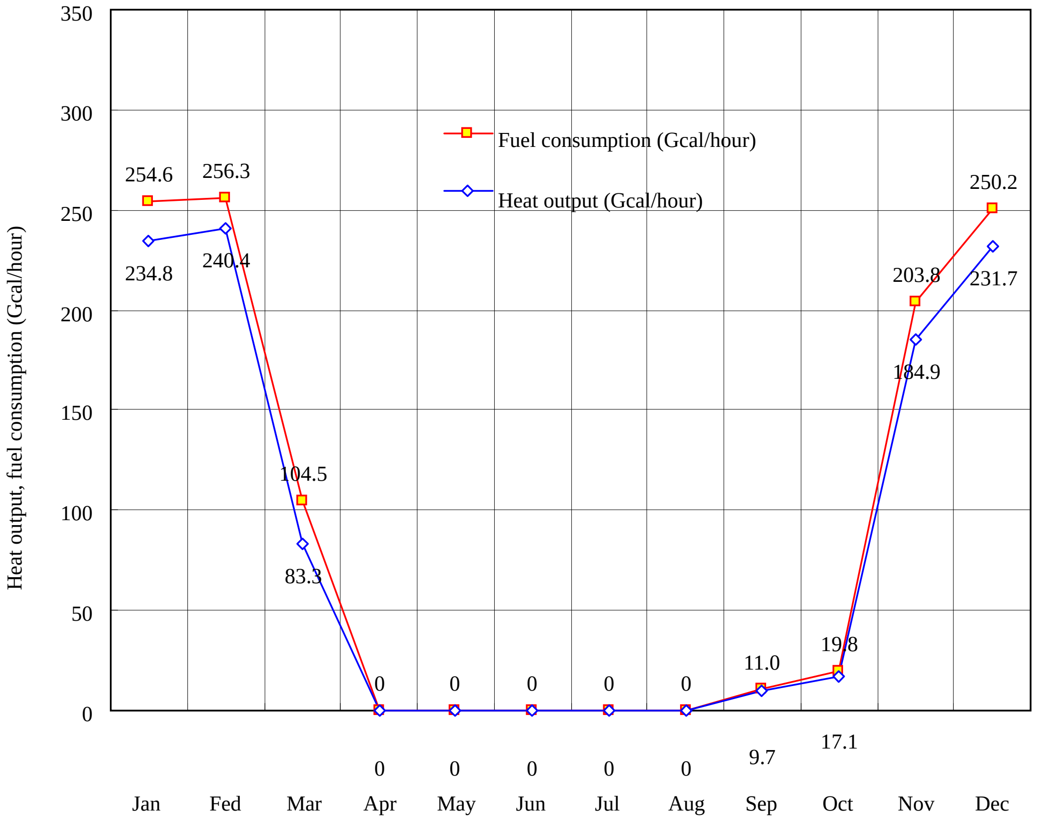


Figure 2-2-4 Amount of heat output and amount of energy consumption by the hot-water boilers in each month in 2008

2.3 Study of GT Cogeneration System

2.3.1 Preface

The cogeneration system is defined as a system to produce two (2) more kinds of secondary energies from one (1) kind of primary energy. The cogeneration system to be studied in this report is the gas turbine cogeneration system (hereinafter to be collectively called as GTCS), which produce the electrical energy by a gas turbine/generator as well as the heat energies of steam and hot water by using the exhaust gas energy from the gas turbine by inputing the natural gas as the primary energy.

The plant performance of the GTCS is widely changeable depending upon the type of heat energy to be recovered by the heat recovery steam generator (hereinafter to be collectively called as HRSG) utilizing the exhaust gas energy from the gas turbine and the type of HRSG system.

In this report, the performance of the GTSC was studied by changing the type of heat energy to be recovered and the type of HRSG system of the GTCS consisting of two (2) 25MW class gasturbine/generators and two (2) HRSGs to cope with them. The GTCS to be introduced is to be integrated with the existing steam turbine cogeneration system (hereinafter to be collectively called as GTCS). Therefore, the specific conditions of the heats to be recovered are to be met them of the heats used for the existing STCS.

2.3.2 Study Conditions

The plant performance of the GTCS is also susceptible to ambient conditions where the plant is located, the type, composition and heating value of fuel gas and the performance figures of the gas turbine/generator. For the purpose, those conditions are specified as follows.

(1) Ambient conditions

The following conditions are specified as the ambient conditions of the project site.

Dry bulb temperature	15 ^{o}C
Relative humidity	60 %
Barometric pressure	93.6 kPa

(2) Fuel

Type	Natual gas

Compostion

Component	Mole Fraction (%)
CH_4	93.9
C_2H_6	3.2
G_3H_8	0.4
n-C_4H_{10}	0.1
n-C_5H_{12}	0.1
O_2	1.0
N_2	0.9
CO_2	0.4
TOTAL	100.0

Sulfides are not to be inclusive.

Low heating value 8,670 kcal/m^{3}N (0 ^{o}C, 101.3 kPa)

(3) Specifications of recovery heat

High pressure steam	30 kg/cm^2 ab × 400 ^{o}C (for driving of steam turbine)
Intermediate pressure steam	10 kg/cm^2 ab × 280 ^{o}C (for industrial steam)
Low pressure steam	3 kg/cm^2 ab × 150 ^{o}C (for heating of hot water)
Hot water	70 ^{o}C

(4) Feed water temperature

High pressure steam	105 ^{o}C (for case without deaerator) and 70 ^{o}C (for case with deaerator)
Intermediate pressure steam	105 ^{o}C (for case without deaerator) and 70 ^{o}C (for case with deaerator)
Low pressure steam	70 ^{o}C (with deaerator)
Hot water	15 ^{o}C

(5) Performance specifications of Gas Turbine

The performance of the GTCS is to be studied for the latest H 25 gas turbine which is the same model to the 25 MW class gas turbine which to be employed for NEDO project in advance to JICA project. The table 2-3-1of the next page shows performance figures on ISO conditions by natural gas of the standard type 25 MW class gas turbines on present production line of their manufacturers. The performance figures are cited from 2009 Gas Turbine Handbook Specifications.

(6) HRSG system

The GTSC is studied for such conditions that four (4) types of heat energies as described in above paragraph (3) are recovered by HRSG. Therefore, many types of HRSG systems can be considered depending which type heat energy is recovered or how many heat energies are simultaneously recovered. Besides, the HRSG system configuration is different depending how the feed water is supplied to GTSC from the existing STSC system.

Table 2-3-1 25MW Class Industrial Heavy Duty Type Gas Turbine Performance

Manufacturer	BHE	Hitach		Mitsubishi	SMS	SMS
Model No	PG5371(PA)	H-25 (Old)	H-25 (Latest)	MF-221	STG-600	STG-700
Power Output （MW)	26.3	27.5	31.0	30.0	24.8	29.1
Thermal Efficiency (%	28.5	33.8	34.8	32.0	34.2	36.0
Fuel Consumption (m^3N/h)	9,150	8,070	8,840	9,300	7,190	8,020
Air Flow Rate (ton/h)	441	317	338	389	290	328
Exhaust Gas Temp (℃	487	555	564	533	543	518

(Source) Gas Turbine World Handbook 2009

Conditions	Dry bulb temp	15 °C
	Relative humidity	60 %
	Barometric pressure	101.3 kPa
	Fuel Natural gas	

In consideration of the configuration of the HRSG, the deaerator is not equipped on the HRSG side in case that the feed water branches from the outlet of the deaerator for the existing steam boilers. However, the deaerator is equipped in case that the feed water is taken at the inlet of the existing steam boiler deaerators or at the outlet of the existing hot water heaters.

In consideration of such circumferential conditionds, eight (8) types of HRSG systems are studied as they can be reasonably integrated with the existing STCS system. Table 2-3-2 shows the configurations of them. The simplified schematic flow diagrams of them are depicted on the successive pages.

Table 2-3-2 Configuration of HRSG System

No.	HRSG Type	Type of Recovery Heat				FW Temp (°C) Steam/HW	Deaerator
		HP Steam	IP Steam	LP Steam	Hot Water		
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	

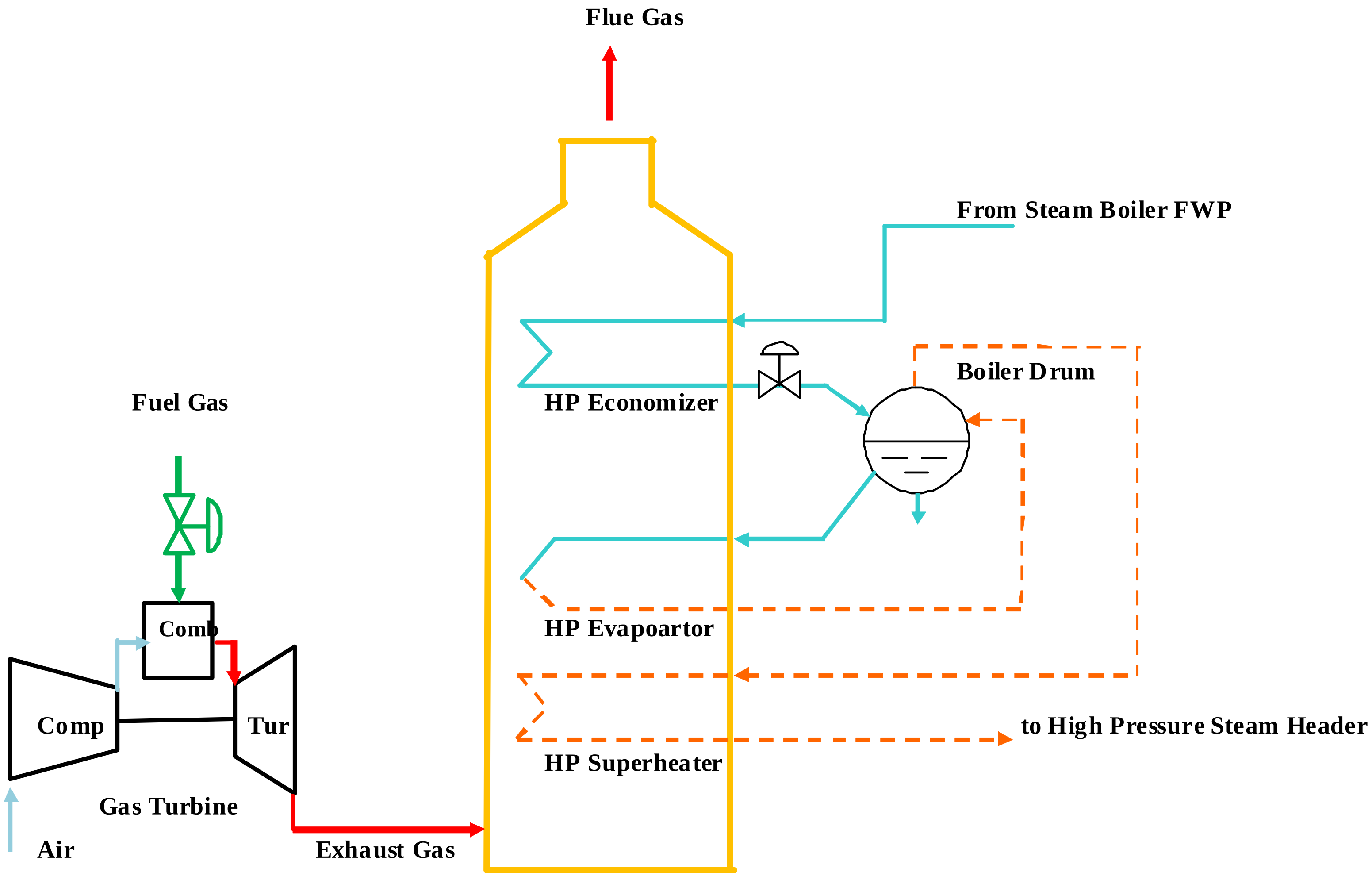


Figure 2-3-1 Simplified Schematic Flow Diagram of HP Steam Recovery HRSG System GTCS without Deaerator

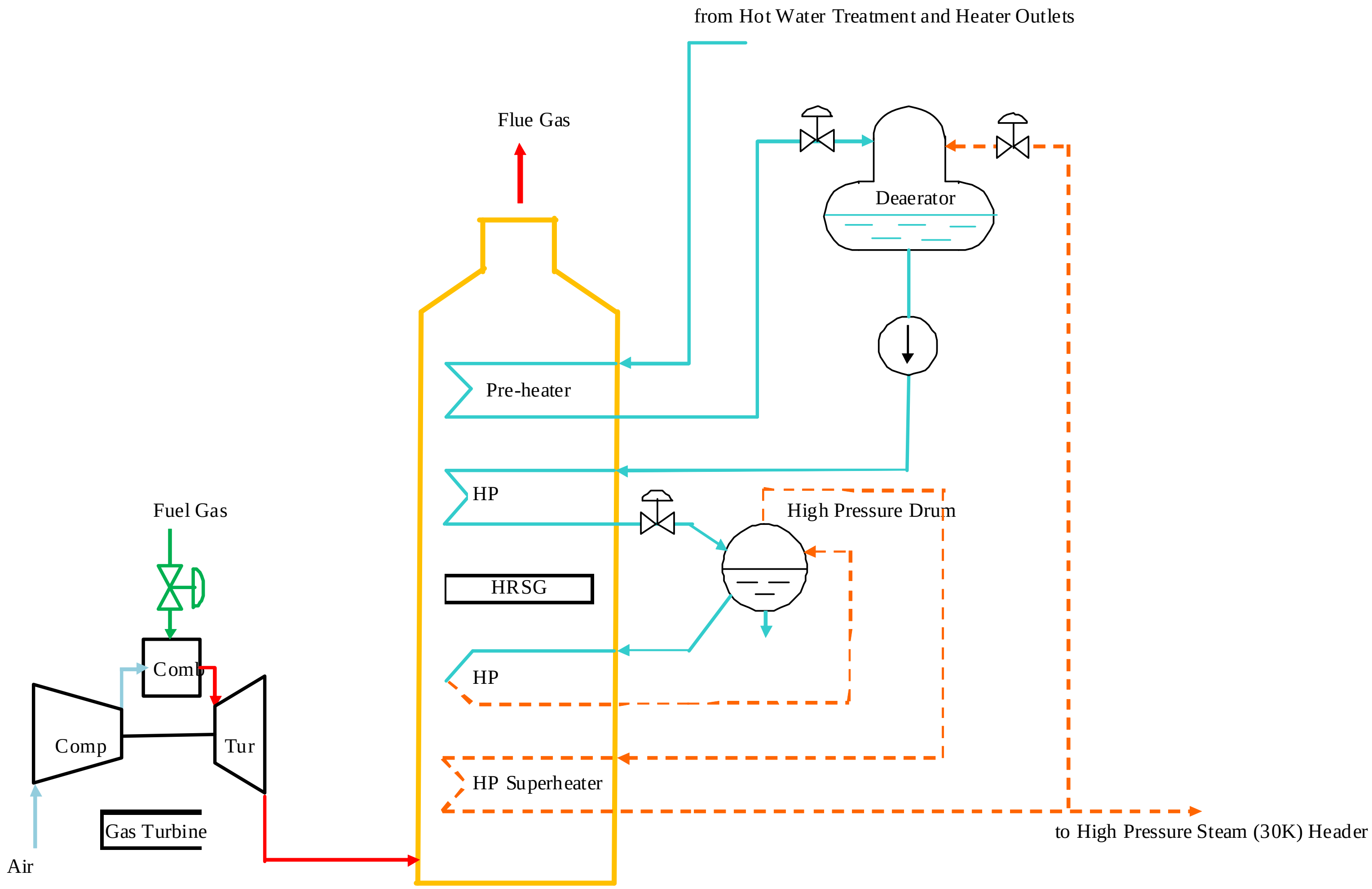


Figure 2-3-2 Simplified Schematic Flow Diagram of HP Steam Recovery HRSG System GTCS with Deaerator

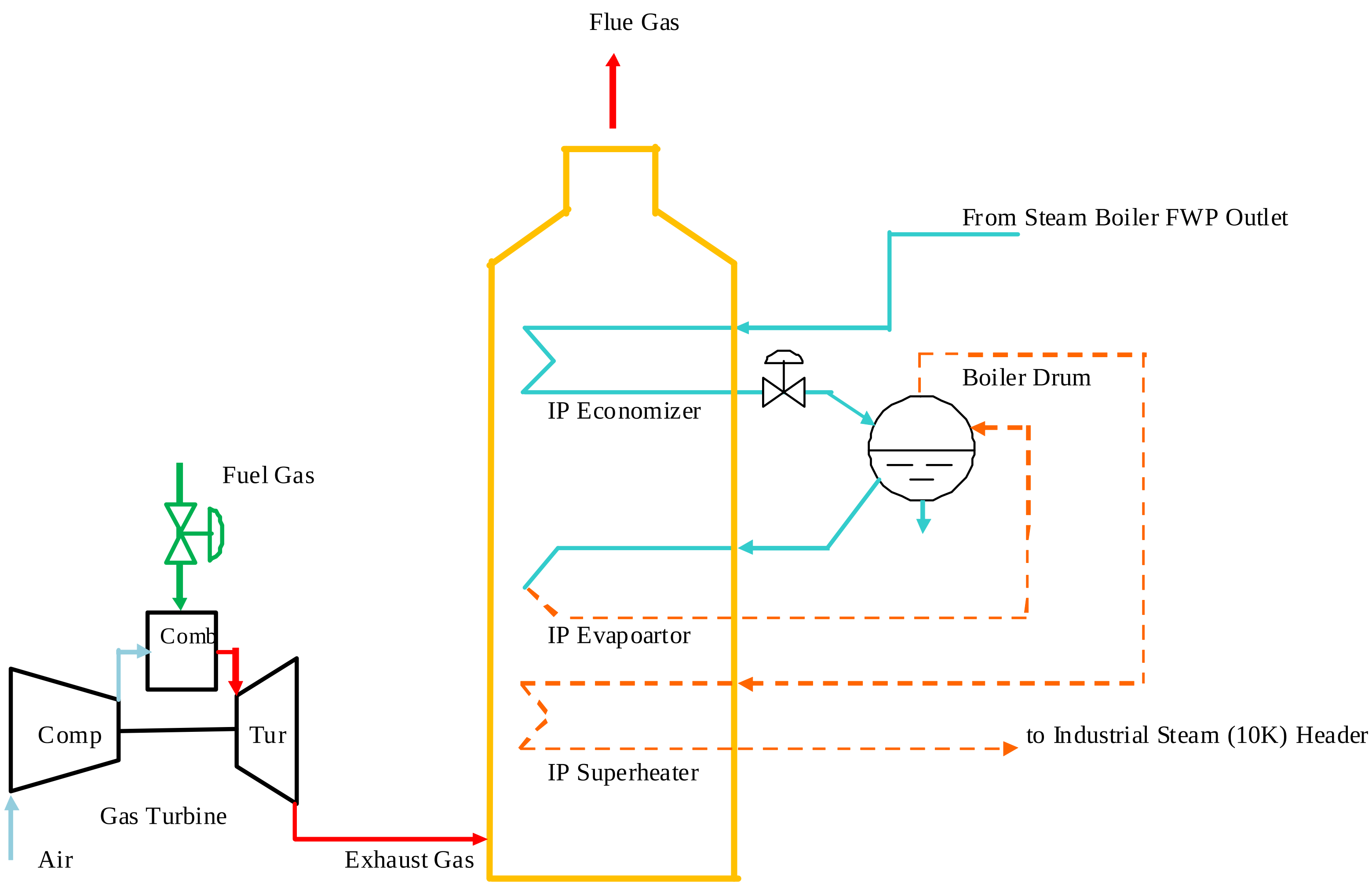


Figure 2-3-3 Simplified Schematic Flow Diagram of IP Steam Recovery HRSG System GTCS without Deaerator

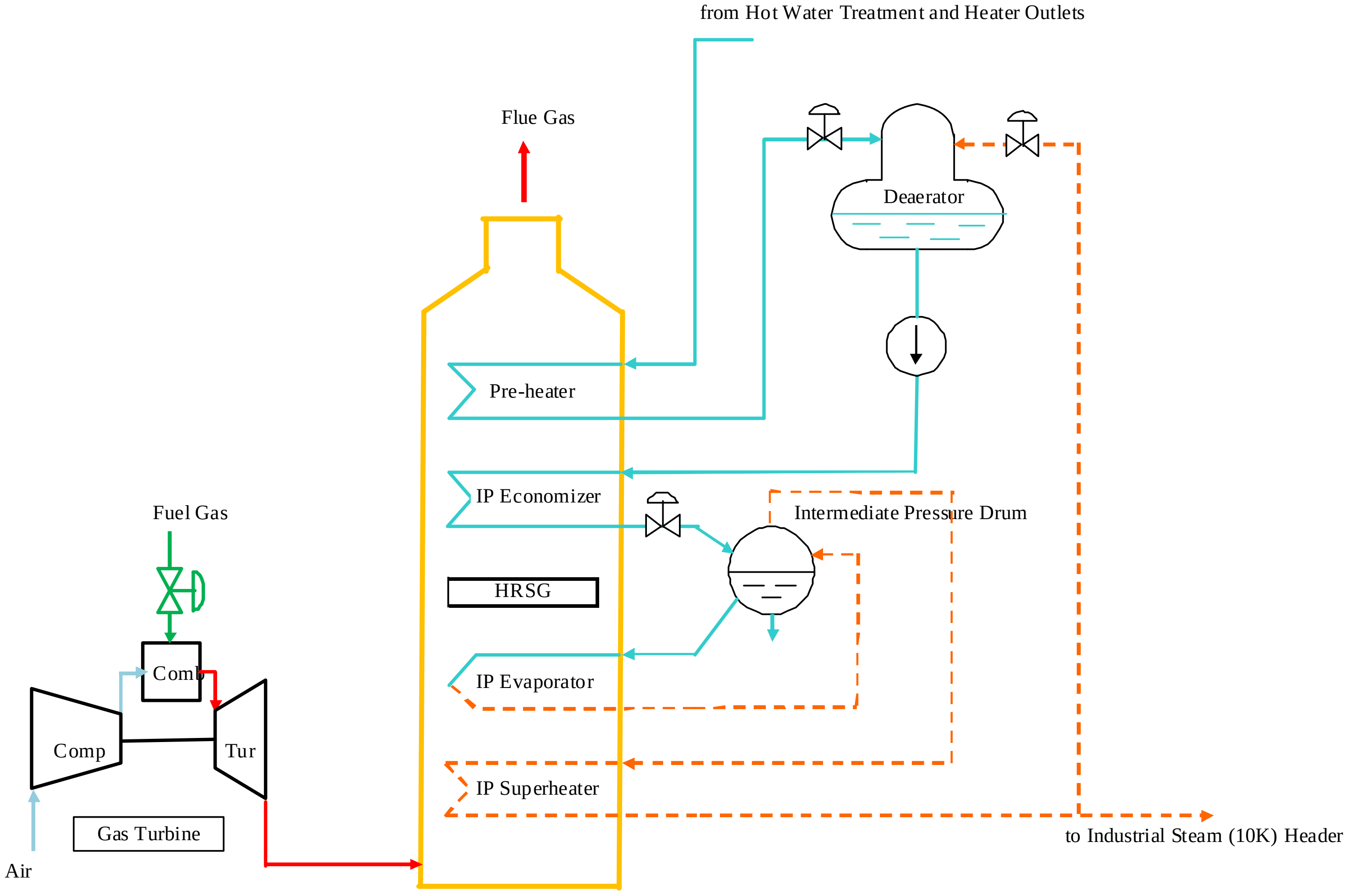


Figure 2-3-4 Simplified Schematic Flow Diagram of IP Steam Recovery HRSG System GTCS with Deaerator

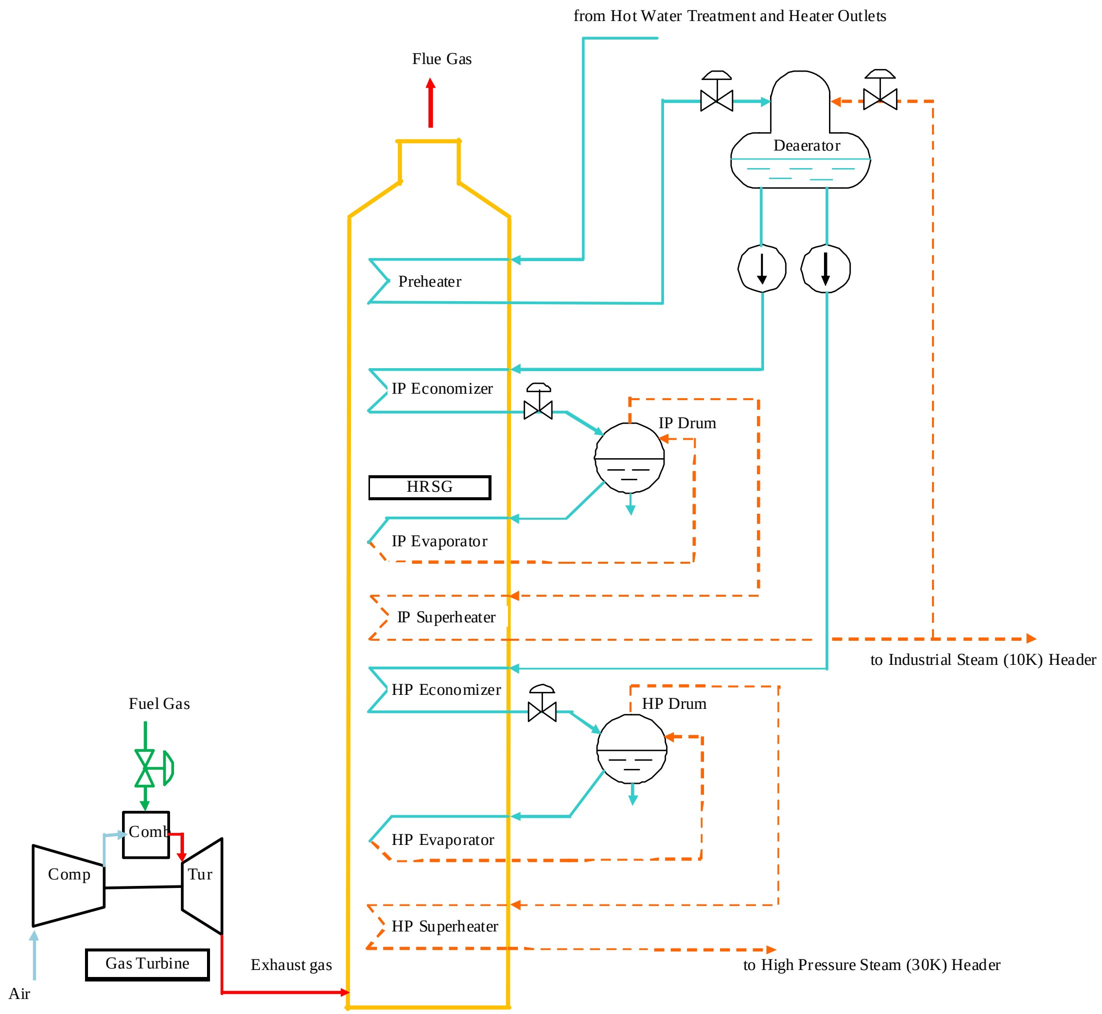


Figure 2-3-5 Simplified Schematic Flow Diagram of HP/IP Steam Recovery HRSG System GTCS with Deaerator

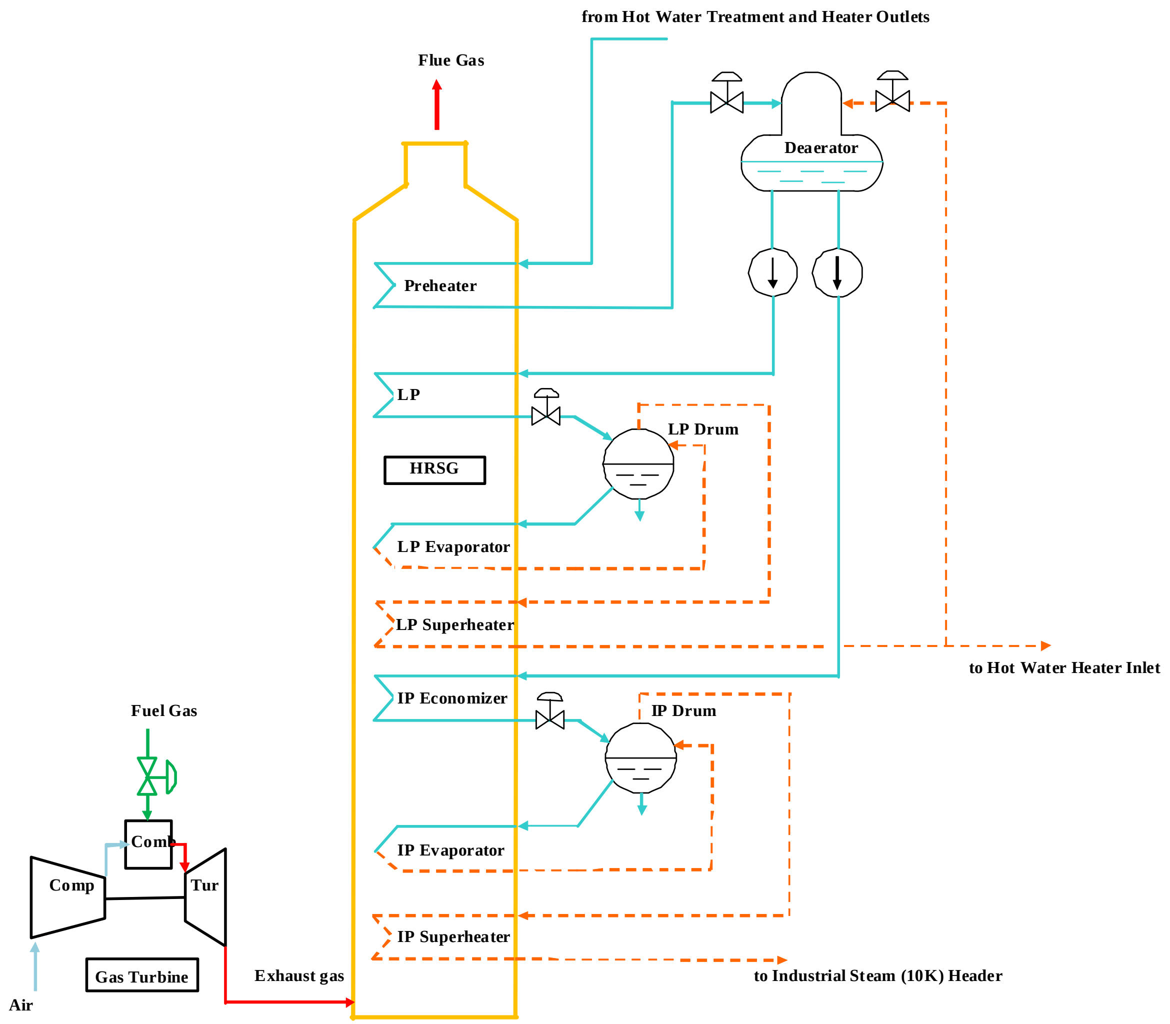


Figure 2-3-6 Simplified Schematic Flow Diagram of IP/LP Steam Recovery HRSG System GTCS with Deaerator

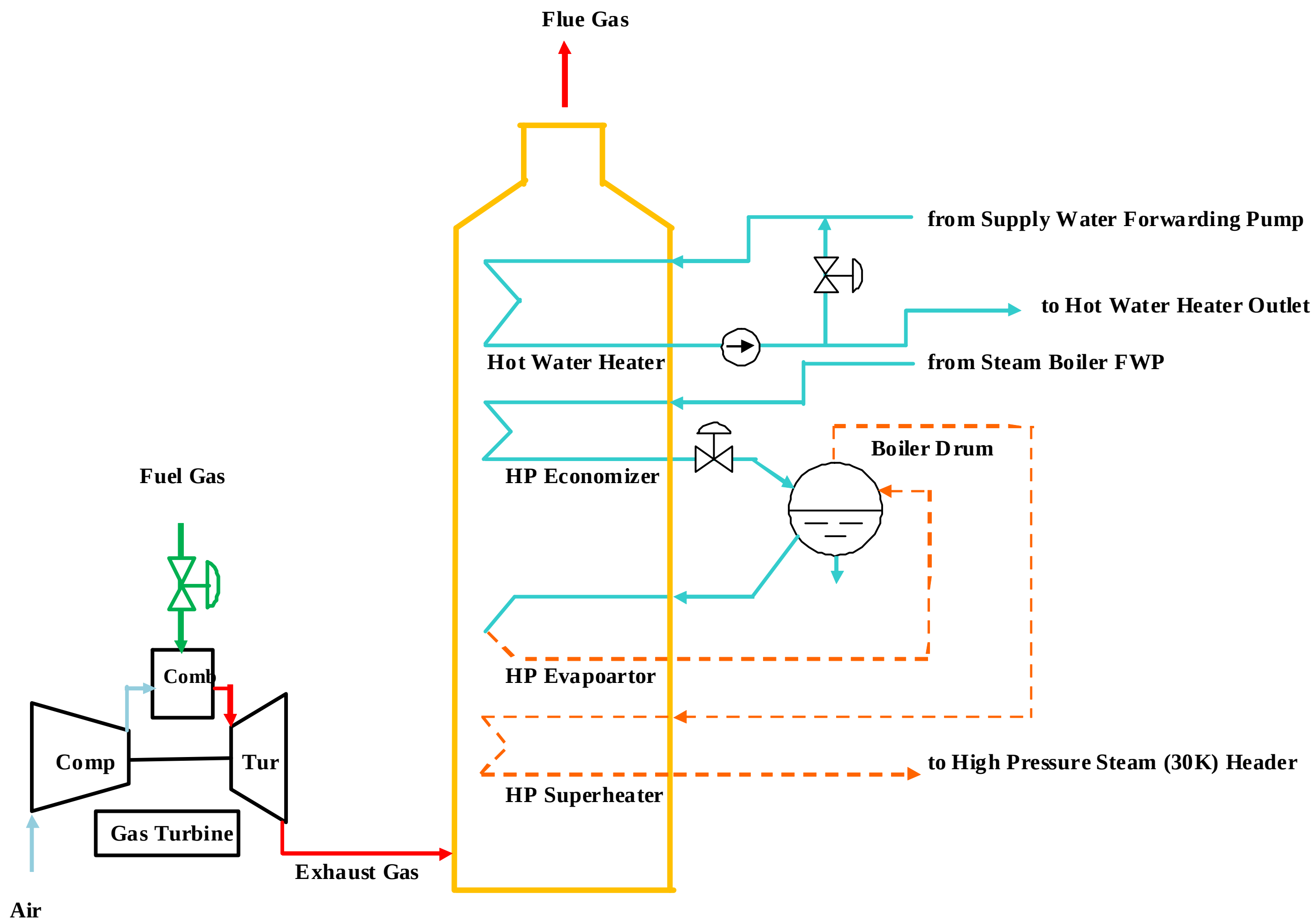


Figure 2-3-7 Simplified Schematic Flow Diagram of HP Steam/Hot Water Recovery HRSG System GTCS without Deaerator

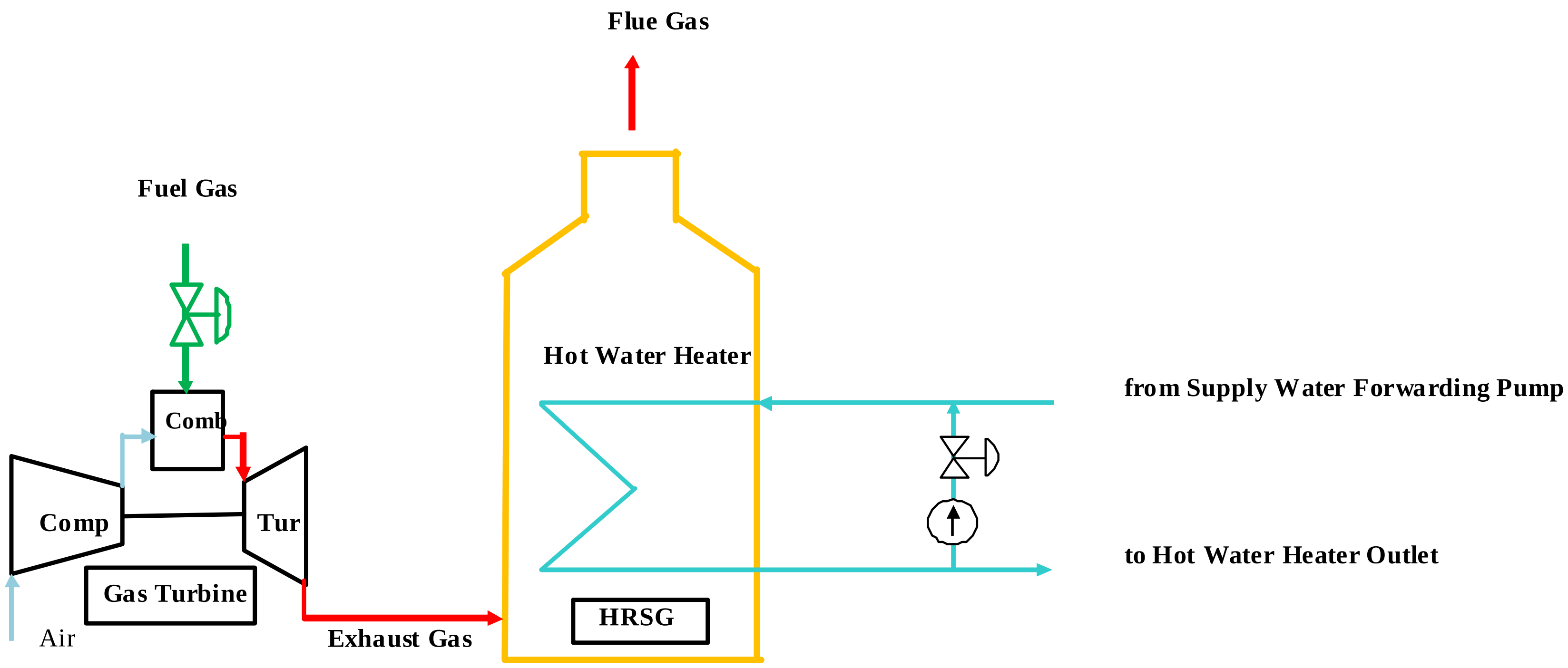


Figure 2-3-8 Simplified Schematic Flow Diagram of Hot Water Recovery HRSG System GTCS without Deaerator

(7) GTCS Performance Evaluation Method

As for the evaluation method of the cogeneration system, the plant thermal efficiency (hereinafter to be collectively called as PTE), which is defined as the ratio in percentage of the total energy output of power and heat to the fuel heat input expressed by the formula as shown below, is commonly employed.

$$\text{Plant Thermal Efficiency (\%)} = \frac{\text{Power Output} + \text{Heat Output}}{\text{Fuel Heat Input}} \times 100$$

Such formula as defined above stands for the economy of the plant provided that the output energy is a single energy or that the sales values (US$/kWh) of the output energies are equal even if the output energy consists of plural energies. However, in case that the output energy consists of plural energies and any difference happens among the sales values of them, it is not said at all that the said formula stands for the economy of the plant.

For the purpose, the Study Team proposes the plant thermal efficiency based on the new concept (hereinafter to be refered as "Modified Plant Thernal Efficiency"), which is directly linked to the economy of the plant with two (2) kinds of output energies of power and heat.

The proccrss to derive the Modified Plant Thermal Efficiency (hereinafter to be collectively called as MPTE) is described below.

The economy of the plant is directly related to the ratio of sales values of the outputs of heat and power to the fuel input cost. The ratio can be transformed as shown below to attain to the formula of MPTE.

$$\frac{\text{Sales Value of Outputs}}{\text{Fuel Input Cost}}$$

$$= \frac{\text{Sales Value of Power Output} + \text{Sales Value of Heat Output}}{\text{Fuel Input Cost}}$$

$$= \frac{\text{Power Sales Unit Price} \times \text{Power Output} + \text{Heat Sales Unit Price} \times \text{Heat Output}}{\text{Fuel Heat Consumption} \times \text{Fuel Unit Cost}}$$

$$= \frac{\text{Power Sales Unit Price} \times \left(\text{Power Output} + \text{Heat Output} \times \dfrac{\text{Heat Sales Unit Price}}{\text{Power Sales Unit Price}}\right)}{\text{Fuel Heat Consumption} \times \text{Fuel Unit Cost}}$$

Where, power sales unit price, heat sales unit price and fuel unit cost are constant values. Therefore, the ratio of sales values of output energies to the fuel input cost is proportional to $\dfrac{\text{Power Output} + \text{Heat Output} \times \dfrac{\text{Heat Sales Unit Price}}{\text{Power Sales Unit Price}}}{\text{Fuel Heat Consumption}}$. The expression in percentage of this ratio is called as MPTE to be expressed by the formula shown below.

$$\text{MPTE (\%)} = \frac{\text{Power Output} + \text{Heat Output} \times \dfrac{\text{Heat Sales Unit Price}}{\text{Power Sales Unit Price}}}{\text{Fuel Heat Consumption}} \times 100$$

Thus it is understandable that the MPTE stands for the performance evaluation index directly linked to the economy of the plant. From this formula, it is clear that the MPTE is equal to the PTE commonly used for performance evaluation if the power sales unit price is equal to the heat sales unit price.

2.3.3 Study Results

Based on the said study preconditions, heat balance calculations were performed for eight (8) types of GTSCs where the latest H 25 gas turbine is combined with eight (8) types of HRSG systems, and performance figures (power output, heat output, generation efficiency, PTE, MPTE, HRSG exit gas temperature, HRSG heating surface and etc.) are obtained for eight (8) types of GTCSs. The minimum temperature difference between the gas side and steam/water side is assumed to be 15^{o}C for heat balance calculation of the HRSG. The HRSG cost is almost determined by its heating surface. Heating surfaces of eight (8) types of HRSGs are calculated for estimation of relative cost differences among them.
For calculation of MPTE, the power and heat sales unit prices are necessary and the following sales unit prices are assumed.

Power sales unit price ＝0.04 US$/kWh
Heat sales unit price ＝7.3 US$/Gcal = 0.0063 US$/kWh

Table 2-3-3 in the next page shows performance figures of eight (8) types of GTCSs based on heat balance calculation results of them. The performance figures on winter season of the existing STCS are also provided in accordance with the NEDO Report (Feasibility Study of Heat and Power High Efficient Gas Turbine Cogeneration Model Project) dated March 2009.

Table 2-3-3 Performance Figures of GTCS

Plant	Existing STCS	JICA GTCS							
Type of HRSG System	-	HP Steam w/o Dea	HP Steam w Dea	IP Steam w/o Dea	IP Steam w Dea	HP/IP Steam w Dea	IP/LP Steam w Dea	HP Steam Hot Water	Hot Water
Power Output (MW)	20.7	58.2	58.2	58.2	58.2	58.2	58.2	58.2	58.2
Heat Output (Gcal/hr)	889.8	77.4	75.8	82.8	80.8	76.4	81.4	96.4	103.6
Feed Water Heat Input (Gcal/hr)	29.0	10.6	6.9	12.1	7.9	7.2	8.1	15.3	22.4
Retun Water Heat Input (Gcal/hr)	461.8	-	-	-	-	-	-	-	-
Fuel Heat Input (Gcal/hr)	476.0	145.5	145.5	145.5	145.5	145.5	145.5	145.5	145.5
HRSG Exsit Gas Temp (^{o}C)	90-110	177	166	154	140	163	138	90	90
HRSG Heating Surface (m^2)	-	8,326	8,554	7,678	8,044	6,493	5,765	7,739	4,470
Power Efficiency (%)	3.7	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4
PTE (%)	87.6	80.3	81.8	83.0	84.5	82.0	84.8	90.2	90.2
MPTE (%)	16.9	41.6	41.9	42.0	42.3	41.9	42.3	43.2	43.2

Heat Balances of eight (8) GTCS are attached on the successive pages.

2.3.4 Summary of Study Results

The big difference (80 %~90 %) happens to the PTE of GTCS depending upon the type of HRSG, while the difference of the MPTE is not so big.

It is not always said that the PTE or MPTE of the GTSC with HRSG system, of which heating surface is large, is high.

The heating surface of the HRSG system which produces only high pressure steam is largest, while the PTE or MPTE of the GTSC with such HRSG system is lowest.

The heating surface of the HRSG system which produces only hot water is smallest (some 50% of HRSG system producing only high pressure steam), while the PTE or MPTE of the GTSC with such a HRSG system is highest.

As can be seen from this table, there is no difference with the PTE between the existing STCS and GTCS depending upon the type of HRSG system, while there is a crucial difference with the MPTE. There is no difference with the total output of power and heat against the fuel heat input between the existing STCS and GTCS. However, there is a big difference with the ratio of the power output to the heat output. In other words, the GTCS can produce more power of which sales unit price is far more valuable than the heat. Consequently, the MPTE of the GTCS is far higher than the existing STCS. This is the reason why the GT cogeneration system, which is a new concept system, is superior to the ST cogeneration system in terms of economy.
Therefore, by using the superior characteristic of GTCS that is the high ratio of power output to heat output, this project enables high efficiency power generation without changing the current amount of heat supply, which ties to the reduction of fuel consumption in the other power stations.

2.3.5 Conclusion of Study Results

From the study results, it can be seen that there is a large difference with the plant thermal efficienct of the GT cogeneration system depending upon the type of HRSG system. However, there is not so large difference with the modified plant thermal efficiency which is evaluated by the energy sales worth.

In terms of the cost of the GTCS, the GTSC with the hot water recovery type HRSG is considered to be advantageous because of less heating surface of the HRSG.

In case of JICA project, the GTCS has to be integrated with the existing STCS. Therefore, the type of GTSC to be introduced to this project has to be finally dertermined by the optimization study for the total system of the existing STCS and the GTCS.

For the purpose, the heat balance calculation is conducted in the next paragraph for three (3) cases of the total systems where the exsisting STCS is integrated with (3) types of GTCSs which are equipped with HP Stm w/o Dea, IP Stm w Dea and HW types HRSGs respectively.

The final decision of the GTCS to be integrated is determined from the comparison study from the view points of performance, operation flexibility, operability and maintenability of the total system in consideration of the heat balance calculation results.

PERFORMANCE		
GT Gross Power Output	kW	29,104
Heat Output by Steam		
HP Steam 30 kg/cm^2 a	Gcal/hr	38.7
IP Steam 10 kg/cm^2 a	Gcal/hr	-
LP Steam 3 kg/cm^2 a	Gcal/hr	-
Total Heat Output	Gcal/hr	38.72
Heat Input by Feed Water	Gcal/hr	5.31
Heat Input by Fuel	Gcal/hr	72.76
Gross Power Efficiency	%	34.4
Gross Thermal Efficiency	%	80.3
OPERATING CONDITION		
Ambient Temperature	°C	15.0
Ambient Pressure	kPa	96.30
Relative Humidity	%	60.0
Type of Fuel	-	Natural Gas
LHV	kcal/kg	11,376

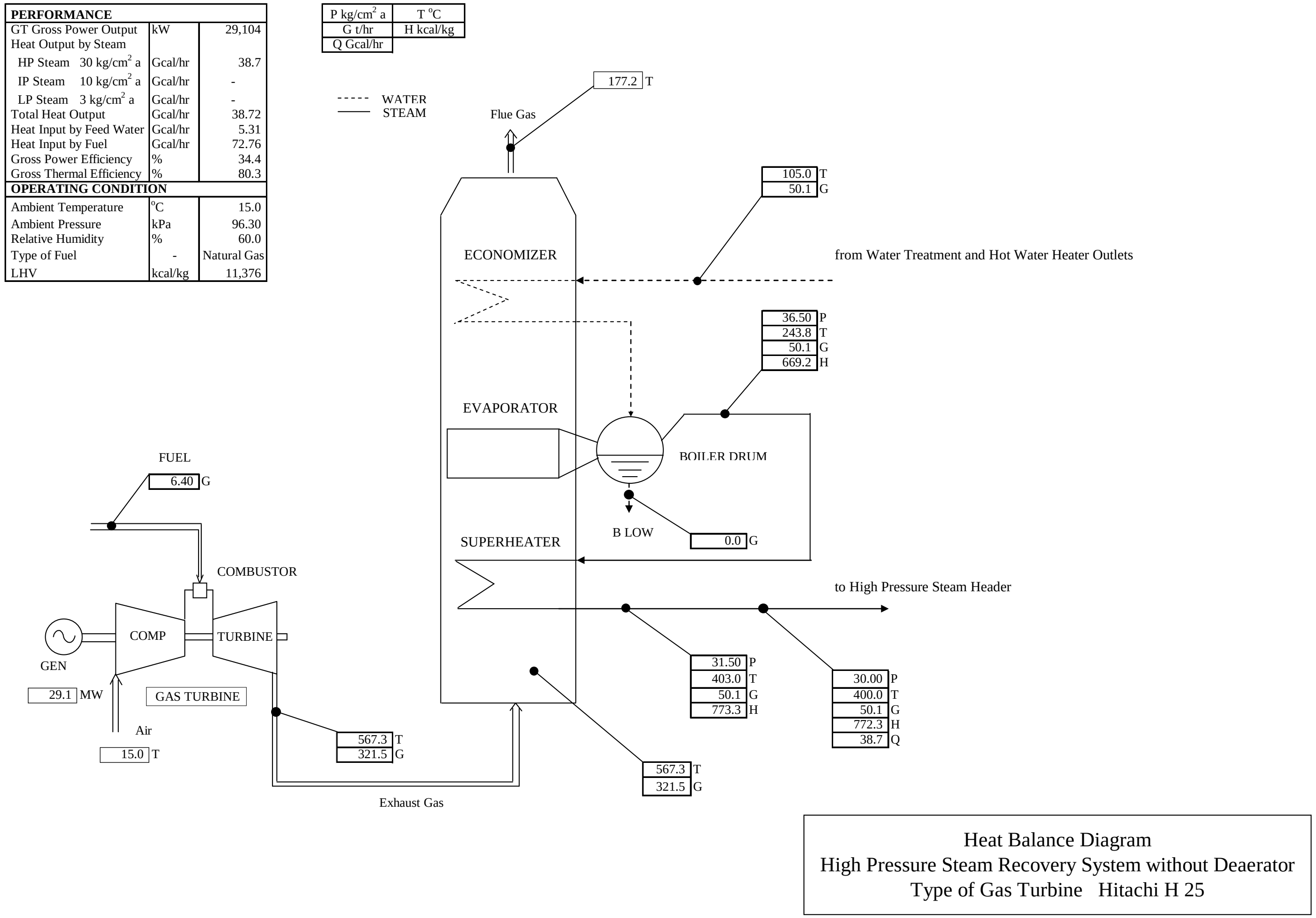
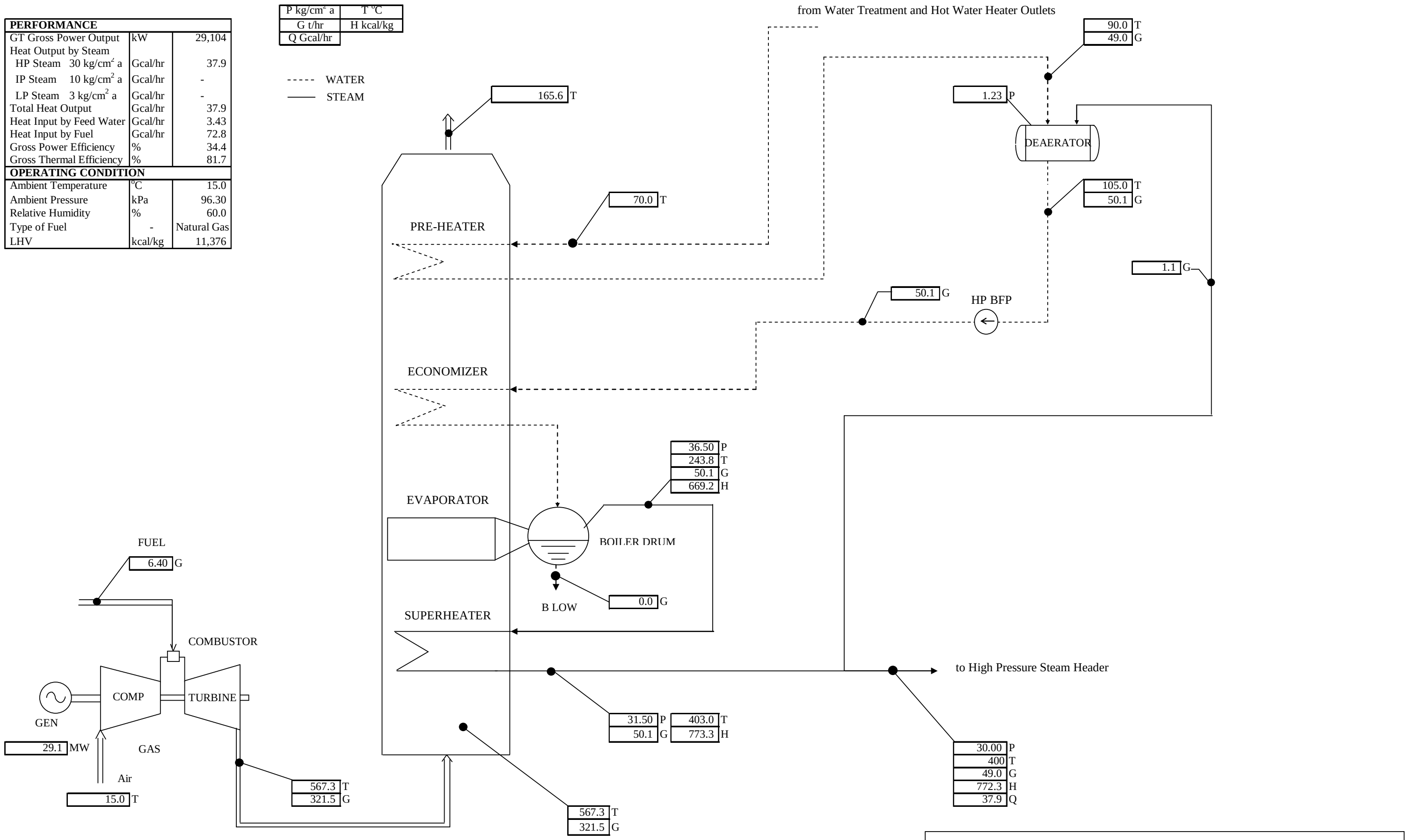


Figure 2-3-9 Heat Balance Diagram of GTCS with HP Steam Recovery Type HRSG System without Deaerator

PERFORMANCE		
GT Gross Power Output	kW	29,104
Heat Output by Steam		
HP Steam 30 kg/cm² a	Gcal/hr	37.9
IP Steam 10 kg/cm² a	Gcal/hr	-
LP Steam 3 kg/cm² a	Gcal/hr	-
Total Heat Output	Gcal/hr	37.9
Heat Input by Feed Water	Gcal/hr	3.43
Heat Input by Fuel	Gcal/hr	72.8
Gross Power Efficiency	%	34.4
Gross Thermal Efficiency	%	81.7
OPERATING CONDITION		
Ambient Temperature	°C	15.0
Ambient Pressure	kPa	96.30
Relative Humidity	%	60.0
Type of Fuel	-	Natural Gas
LHV	kcal/kg	11,376



Heat Balance Diagram
High Pressure Steam Recovery System with Deaerator
Type of Gas Turbine Hitachi H 25

Figure 2-3-10 Heat Balance Diagram of GTCS with HP Steam Recovery Type HRSG System with Deaerator

PERFORMANCE		
GT Gross Power Output	kW	29,104
Heat Output by Steam		
HP Steam 30 kg/cm^2 a	Gcal/hr	41.4
IP Steam 10 kg/cm^2 a	Gcal/hr	-
LP Steam 3 kg/cm^2 a	Gcal/hr	-
Total Heat Output	Gcal/hr	41.4
Heat Input by Feed Water	Gcal/hr	6.07
Heat Input by Fuel	Gcal/hr	72.8
Gross Power Efficiency	%	34.4
Gross Thermal Efficiency	%	83.0
OPERATING CONDITION		
Ambient Temperature	°C	15.0
Ambient Pressure	kPa	96.30
Relative Humidity	%	60.0
Type of Fuel	-	Natural Gas
LHV	kcal/kg	11,376

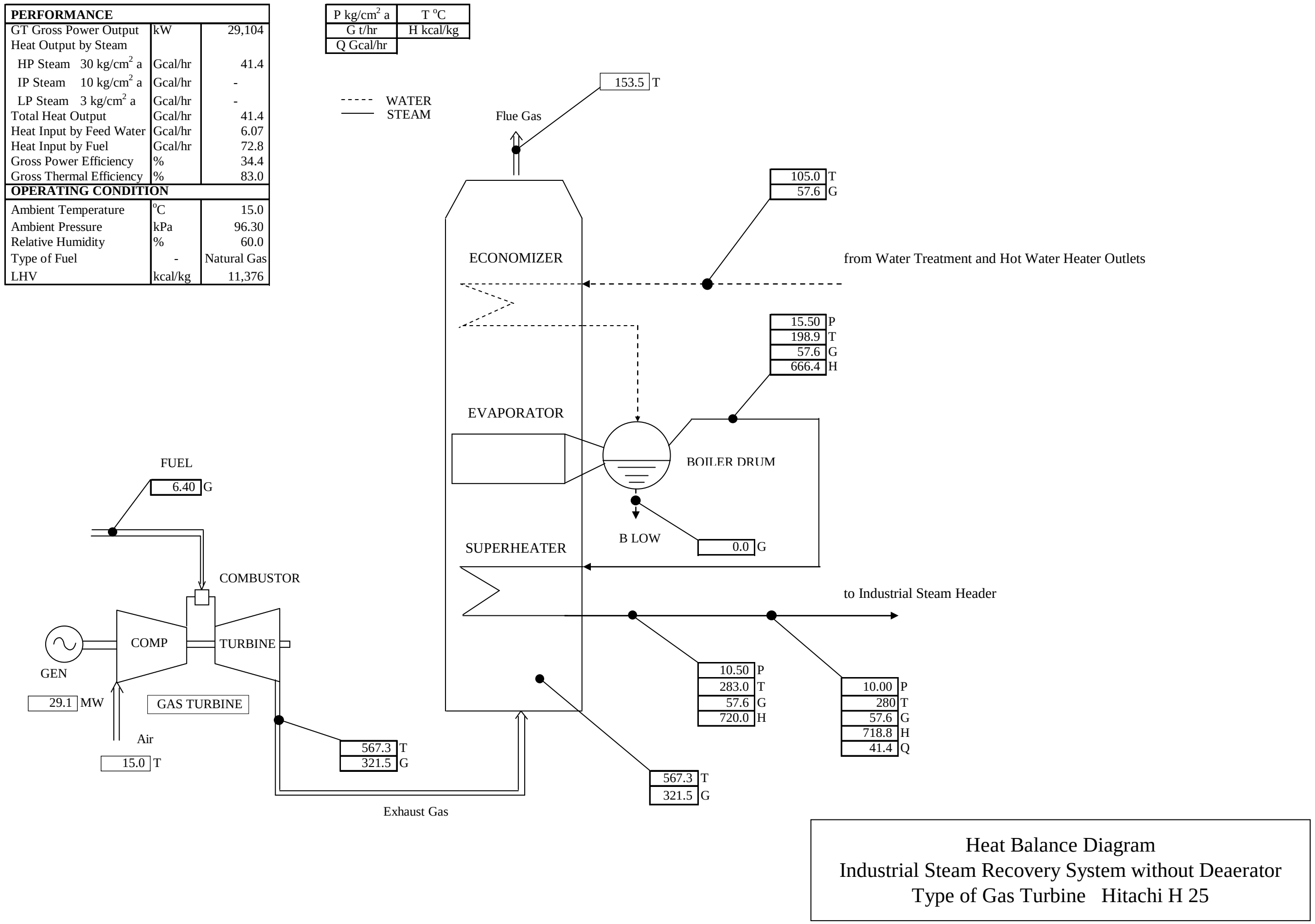


Figure 2-3-11 Heat Balance Diagram of GTCS with IP Steam Recovery Type HRSG System without Deaerator

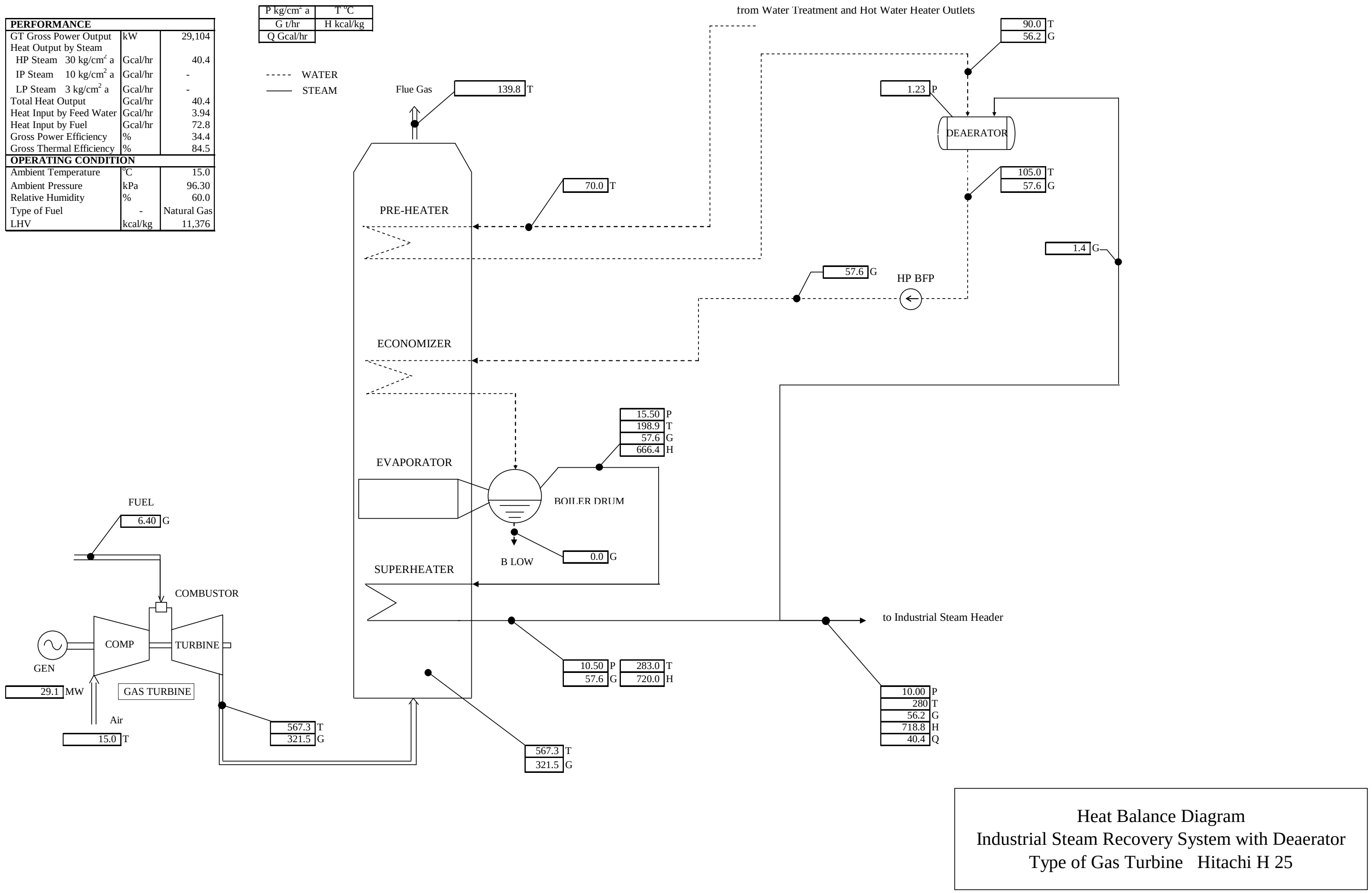


Figure 2-3-12 Heat Balance Diagram of GTCS with IP Steam Recovery Type HRSG System with Deaerator

PERFORMANCE		
GT Gross Power Outp	kW	29,104
Heat Output by Steam		
HP Steam 30 kg/cm² a	Gcal/hr	19.0
IP Steam 10 kg/cm² a	Gcal/hr	19.2
LP Steam 3 kg/cm² a	Gcal/hr	-
Total Heat Output	Gcal/hr	38.2
Heat Input by Feed Water	Gcal/hr	3.59
Heat Input by Fuel	Gcal/hr	72.8
Gross Power Efficiency	%	34.4
Gross Thermal Efficiency	%	81.9
OPERATING CONDITION		
Ambient Temperature	°C	15.0
Ambient Pressure	kPa	96.30
Relative Humidity	%	60.0
Type of Fuel	-	Natural Gas
LHV	kcal/kg	11,376

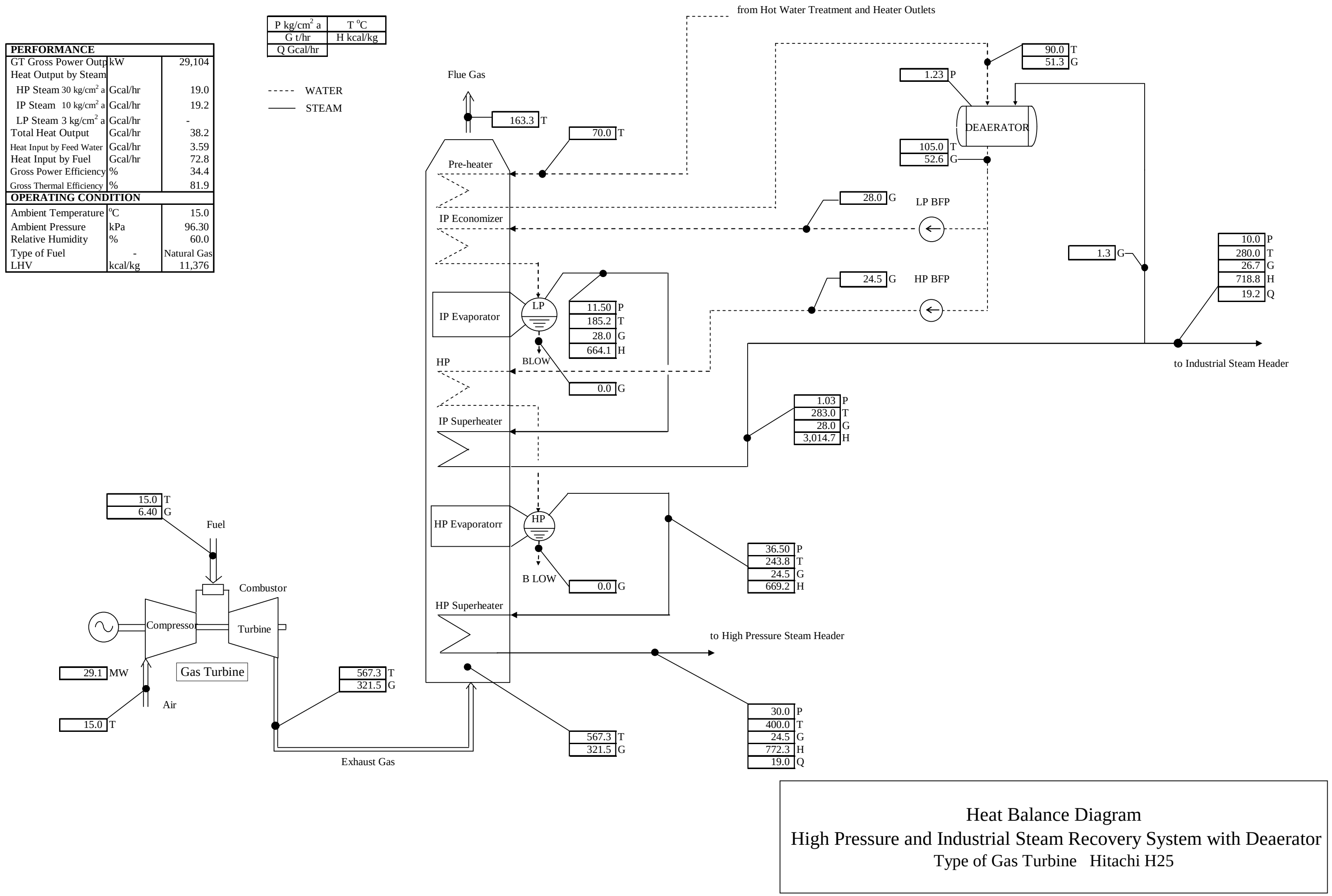
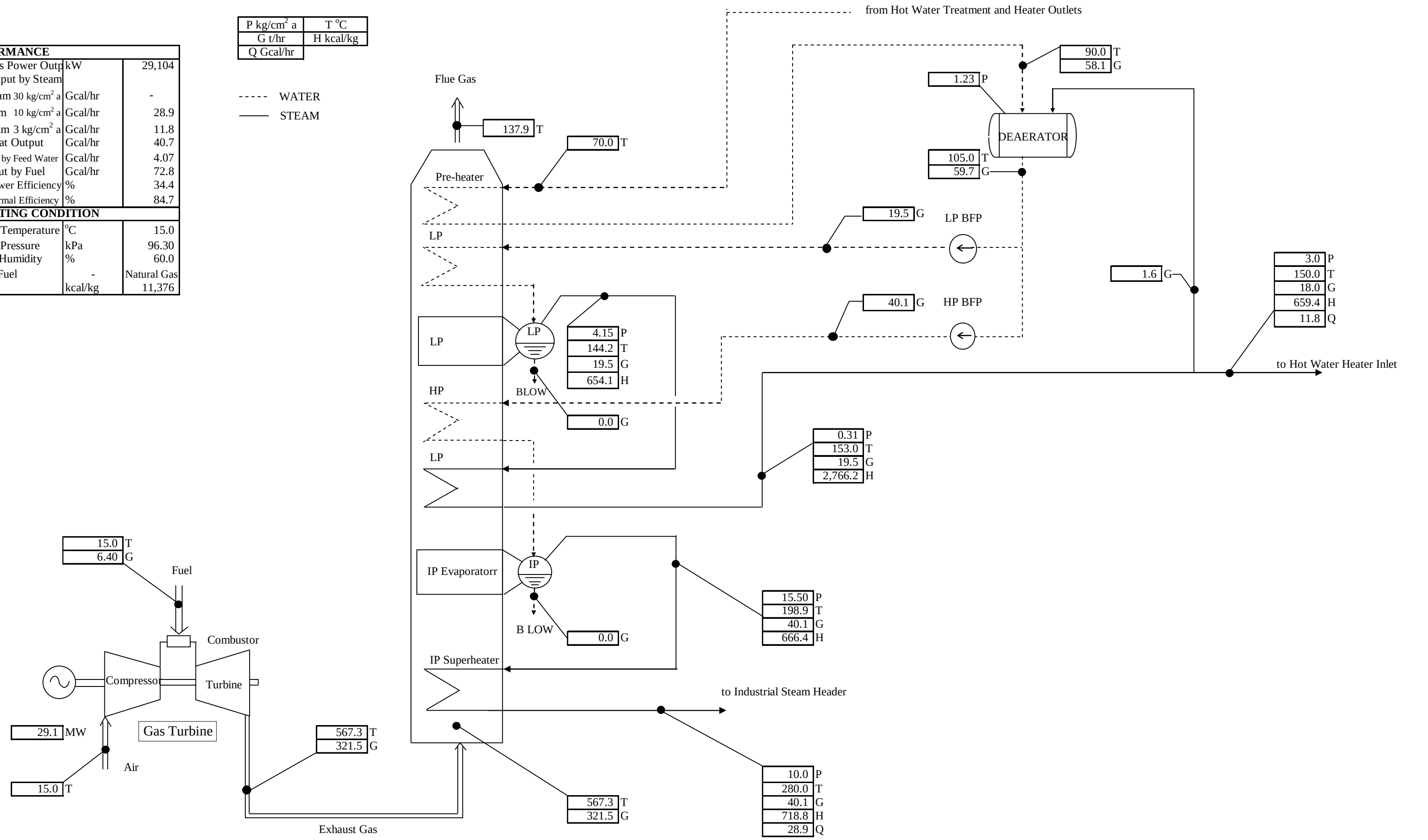


Figure 2-3-13 Heat Balance Diagram of GTCS with HP/IP Steam Recovery Type HRSG System with Deaerator

PERFORMANCE		
GT Gross Power Outp	kW	29,104
Heat Output by Steam		
HP Steam 30 kg/cm² a	Gcal/hr	-
IP Steam 10 kg/cm² a	Gcal/hr	28.9
LP Steam 3 kg/cm² a	Gcal/hr	11.8
Total Heat Output	Gcal/hr	40.7
Heat Input by Feed Water	Gcal/hr	4.07
Heat Input by Fuel	Gcal/hr	72.8
Gross Power Efficiency	%	34.4
Gross Thermal Efficiency	%	84.7
OPERATING CONDITION		
Ambient Temperature	°C	15.0
Ambient Pressure	kPa	96.30
Relative Humidity	%	60.0
Type of Fuel	-	Natural Gas
LHV	kcal/kg	11,376



Heat Balance Diagram
Industrial and Low Pressure Steam Recovery System with Deaerator
Type of Gas Turbine Hitachi H25

Figure 2-3-14 Heat Balance Diagram of GTCS with IP/LP Steam Recovery Type HRSG System with Deaerator

PERFORMANCE		
GT Gross Power Output	kW	29,104
Heat Output by Steam		
HP Steam 30 kg/cm² a	Gcal/hr	35.1
IP Steam 10 kg/cm² a	Gcal/hr	-
LP Steam 3 kg/cm² a	Gcal/hr	-
Heat Output by Hot Water	Gcal/hr	13.1
Total Heat Output	Gcal/hr	48.1
Heat Input by Feed Water	Gcal/hr	7.6
Heat Input by Fuel	Gcal/hr	72.8
Gross Power Efficiency	%	34.4
Gross Thermal Efficiency	%	90.1
OPERATING CONDITION		
Ambient Temperature	°C	15.0
Ambient Pressure	kPa	96.30
Relative Humidity	%	60.0
Type of Fuel	-	Natural Gas
LHV	kcal/kg	11,376

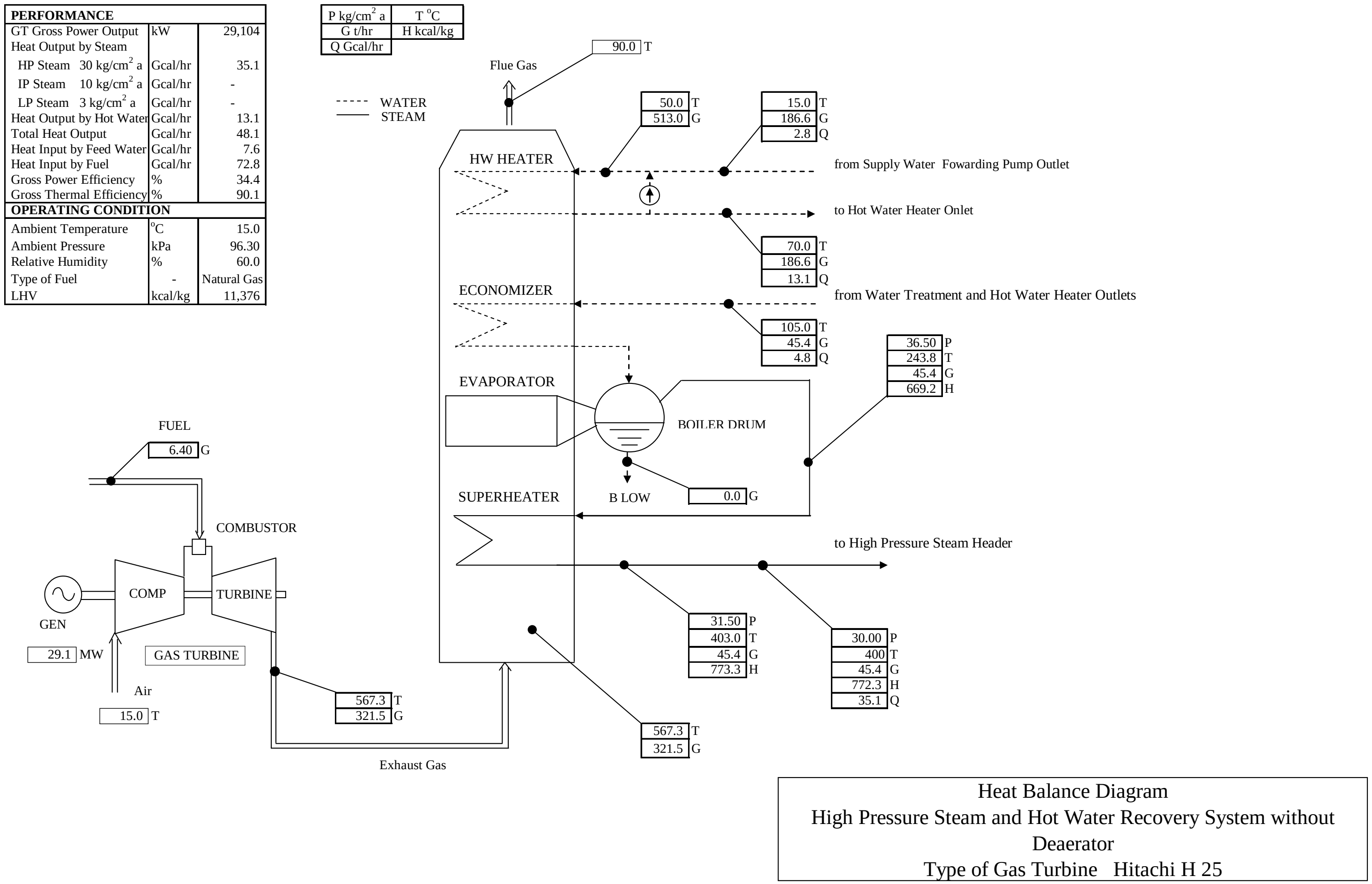
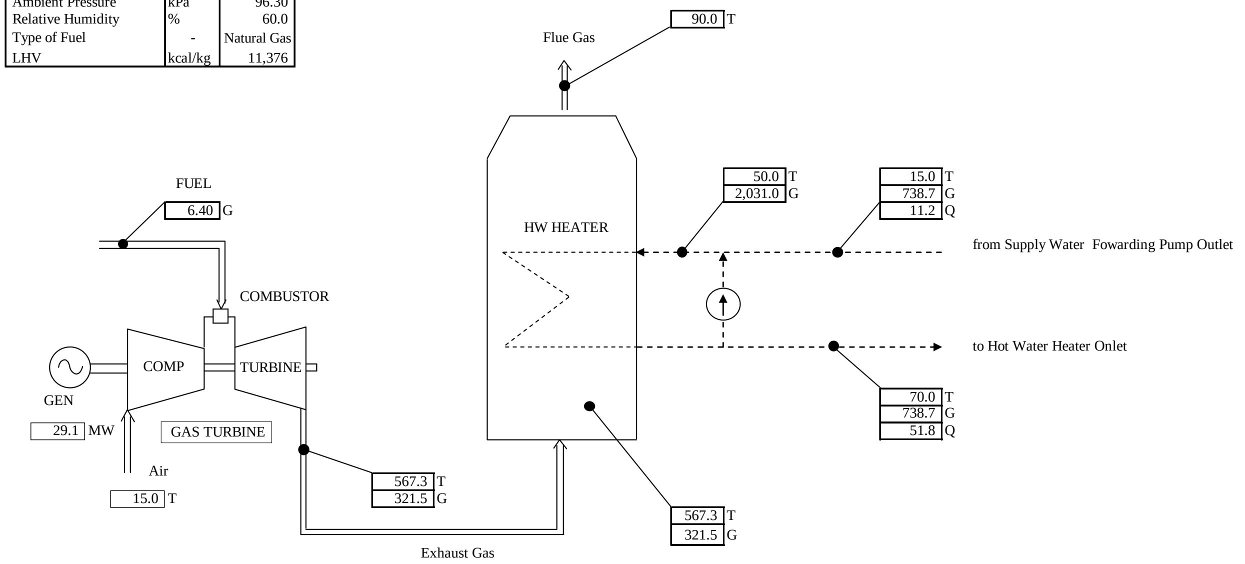


Figure 2-3-15 Heat Balance Diagram of GTCS with HP Steam/Hot Water Recovery Type HRSG System without Deaerator

PERFORMANCE		
GT Gross Power Output	kW	29,104
Heat Output by Steam		
HP Steam 30 kg/cm^2 a	Gcal/hr	-
IP Steam 10 kg/cm^2 a	Gcal/hr	-
LP Steam 3 kg/cm^2 a	Gcal/hr	-
Heat Output by Hot Water	Gcal/hr	51.8
Total Heat Output	Gcal/hr	51.8
Heat Input by Feed Water	Gcal/hr	11.20
Heat Input by Fuel	Gcal/hr	72.8
Gross Power Efficiency	%	34.4
Gross Thermal Efficiency	%	90.1
OPERATING CONDITION		
Ambient Temperature	^oC	15.0
Ambient Pressure	kPa	96.30
Relative Humidity	%	60.0
Type of Fuel	-	Natural Gas
LHV	kcal/kg	11,376

P kg/cm^2 a	T ^oC
G t/hr	H kcal/kg
Q Gcal/hr	

----- WATER
—— STEAM



Heat Balance Diagram
Hot Water Recovery System without Deaerator
Type of Gas Turbine Hitachi H 25

Figure 2-3-16 Heat Balance Diagram of GTCS with Hot Water Recovery Type HRSG System without Deaerator

2.4 Considerations for an Optimum Plant System

2.4.1 Considerations for an optimum GTCS system

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 Heat and Power Supply Plant, enabling highly efficient power generation.

Now, economic efficiency is compared and evaluated in three cases in which steam under high pressure, steam under intermediate-pressure, and hot water are used by 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 for reasons that their amounts have shown no significant fluctuation in the past 10 years, and there are no concrete plan for increasing them in the future.
- 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.

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

When there is an economical evaluation, the yearly amounts of power generated, heat supplied by hot water, and heat supplied by steam in the existing facilities are assumed to be equivalent to the records in 2008 indicated in Table 2-4-1.

Table 2-4-1 Yearly amounts of power generated, heat supplied by hot water, and heat supplied by steam (records in 2008)

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

c) Amount of heat supplied by Tashkent Heat and Power Supply Plant
The amount of heat supplied by Tashkent Heat and Power Supply Plant remains unchanged before and after the introduction of GTCS. As for the amounts of heat supplied in the summer and winter, the NEDO report in March 2009 is quoted as indicated in the table below.

Table 2-4-2 Amounts of heat supplied by steam and hot water

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

d) Gas turbine performance
Table 2-4-3 indicates the performance of the 25-MW class gas turbine Hitachi H-25 (newest model) in summer and winter, which is assumed from the performance described in "Gas Turbine World 2009". The table also indicates the performance of H-25 (2007 model) for NEDO project, which is quated from the NEDO report in March 2009.

Table 2-4-3 Gas turbine performance

Project	-	This Project		NEDO Project	
Model × quantity	-	Hitachi H-25 (newest model) × 2		Hitachi H-25 (2007 model) × 1	
Season	-	Winter	Summer	Winter	Summer
Ambient temperature	°C	5.0	25.0	5.0	25.0
Ambient humidity	%	60		60	
Atmospheric pressure	mbar	963		963	
Power generator output	MW	30.7	27.3	28.69	25.38
Fuel heat input	Gcal/h	75.6	70.2	77.49	71.68
Exhaust gas temperature	°C	561	573	552	563
Air flow rate	t/h	324.6	305.2	309.8	291.3
Exhaust gas flow rate	t/h	331.2	311.3	323.9	304.5

e) Heat Recovery Steam Generator (HRSG) performance
Methods of collecting heat exhausted from the gas turbine are compared and evaluated in three cases in which high pressure steam, intermediate-pressure steam, and hot water are used. Table 2-4-4 indicates the performance of the each type of heat recovery steam generator in winter and summer. The table also indicates the performance of HRSG for NEDO project, which is quated from the NEDO report in March 2009.

Table 2-4-4 Heat Recovery Steam Generator (HRSG) performance

Project	-	This Project						NEDO Project	
Season	-	Winter			Summer			Winter	Summer
Ambient temperature	°C	5			25			5	25
Flue gas flow rate	t/h	331.2			311.3			323.9	304.5
Flue gas temperature (inlet)	°C	561			573			552	563
Type of HRSG	-	HP Steam	IP Steam	Hot water	HP Steam	IP Steam	Hot water	HP Steam	
Flue gas temperature (outlet)	°C	177	140	90	176	139	90	180	180
Amount of heat recovered	Gcal/h	34.0	36.9	41.2	33.2	36.0	39.8	32.0	31.4

f) Economical evaluation condition
Table 2-4-5 indicates the price (purchase unit price) of the natural gas and the present value factor used in economical evaluation.

Table 2-4-5 Natural gas price and present value factor

Purchase unit price of natural gas (*)	40 USD/Gcal
Conditions in present value evaluation	
- Business period	25 years
- Discount rate	12%
- Present value factor	7.84

(*) The purchase unit price of natural gas is determined according to the price standard of the natural gas in 2008 that is supplied from Gazprom in Russia to Europe, which is 326 US$/1000 m^3 (40.0 US$/Gcal).

(2) Heat balance calculation result
The report by NEDO in March 2009 was quoted to determine the plant heat balance of Tashkent Heat and Power Supply Plant in the summer and winter before the introduction of GTCS. The plant heat balance after the introduction of GTCS was calculated on the basis of the plant heat balance before the introduction of GTCS.
The plant heat balance is detailed in Figures 2-4-1 to 2-4-8 at the end of this item.
Calculation results of the main performance values are indicated below.

a) Generated power in Tashkent Heat and Power Supply Plant

Table 2-4-6 Generated power in Tashkent Heat and Power Supply Plant

Item		Before introduction of GTCS		After introduction of GTCS					
				High-pressure steam type		Intermediate-pressure steam type		Hot-water type	
Season		Summer	Winter	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	8.32	20.72
• NEDO-GTCS	MW	-	-	25.38	28.69	25.38	28.69	25.38	28.69
• JICA-GTCS	MW	-	-	52.69	61.47	42.91	61.48	40.55	61.47
• Total generated power	MW	16.41	20.72	94.48	110.88	77.09	110.89	74.25	110.88
	MW	Base	Base	+78.1	+90.2	+60.7	+90.2	+57.8	+90.1
Generated net power	MW	Base	Base	+69.5	+85.7	+54.0	+80.2	+51.5	+80.2
JICA-GTCS load ratio (*)	%	-	-	96.4	100	78.5	100	74.2	100

(*) Reduction in heat supply in the summer is compensated by lowering the load ratio of the JICA-GTCS. When the intermediate-pressure steam type or hot-water type is used, the amount of heat received by the existing facilities is small. Therefore, the load ratios for the intermediate-pressure steam type and hot-water type are respectively 78.5% and 74.2%, which are significantly low when compared with 96.4% for the high-pressure steam type.

b) Fuel consumption in Tashkent Heat and Power Supply Plant

Table 2-4-7 Fuel consumption in Tashkent Heat and Power Supply Plant

Fuel consumption	Unit	Before introduction of GTCS		After introduction of GTCS					
				High-pressure steam type		Intermediate-pressure steam type		Hot-water type	
Season	-	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Existing steam boiler	Gcal/h	103.4	221.3	0.0	110.1	0.0	108.0	0.0	108.0
Existing hot-water boiler	Gcal/h	-	254.6	-	254.6	-	254.6	-	254.6
NEDO-GTCS	Gcal/h	-	-	71.7	77.5	71.7	77.5	71.7	77.5
JICA-GTCS	Gcal/h	-	-	135.4	151.2	108.8	151.2	104.2	151.2
Total	Gcal/h	103.4	475.9	207.1	593.4	180.4	591.2	175.9	591.2
	Gcal/h	Base	Base	+103.7	+117.5	+77.1	+115.3	+72.6	+115.3

c) Generated net power and fuel consumption in other power plants
Due to an increase in power generation, which is a result of GTCS introduced in Tashkent 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.

Table 2-4-8 Generated net power and fuel consumption in other power plants

Other power plants	Unit	Before introduction of GTCS		After introduction of GTCS					
				High-pressure steam type		Intermediate-pressure steam type		Hot-water type	
		Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Power at the transmission terminal	MW	base	base	-69.5	-80.2	-54.0	-80.2	-51.5	-80.2
Fuel consumption	Gcal/h	base	base	-194.0	-224.1	-150.8	-224.1	-143.7	-224.1

Note: Reduction of net power at the transmission end is an increase in the transmitted power, which is brought by Tashkent 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 GTCS
When the total amounts of heat and power supplied in Uzbekistan remain unchanged, the fuel consumption is reduced by introducing GTCS as shown below.

Table 2-4-9 Fuel consumption reduction resulting from introduction of GTCS

	Unit	Before introduction of GTCS		After introduction of GTCS					
				High-pressure steam type		Intermediate-pressure steam type		Hot-water type	
		Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Fuel consumption	Gcal/h	base	base	-103.1	-121.7	-70.6	-123.9	-71.2	-108.8

(3) Present value of fuel consumption reduction achieved by GTCS
When the fuel consumption reduction achieved by introducing GTCS is evaluated as the present value, it is found that a reduction of 255 million dollars is obtained for GTCS of the high-pressure steam type with respect to the current state, a reduction of 230 million dollars is obtained for GTCS of the intermediate-pressure steam type, and a reduction of 225 million dollars is obtained for GTCS of the hot-water type. GTCS of the high-pressure steam type is more advantageous than GTCS of the intermediate-pressure steam type by 25 million dollars and GTCS of the hot-water type by 30 million dollars.

Table 2-4-10 Present value of fuel consumption reduction achieved by GTCS

Present value for fuel consumption reduction	Unit	Before introduction of GTCS		After introduction of GTCS					
				High-pressure steam type		Intermediate-pressure steam type		Hot-water type	
		Summer	Winter	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	219	132	219	132	219	132	219	132
Amount of fuel used per year	10^3 Gcal	base	base	-475	-338	-387	-345	-374	-345
	10^3 Gcal	base		-812		-732		-719	
Unit price of natural gas	USD/Gcal	40		40		40		40	
Fuel cost per year	million USD	base		-32.5		-29.3		-28.7	
Present value factor (**)	-	7.84		7.84		7.84		7.84	
Present value of fuel cost	million USD	base		-255		-230		-225	
	million USD	+255		base		+25		+30	

(*) 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 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%.

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

When GTCS is introduced, the amount of natural gas consumed at 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 brought by the introduction of GTCS of the high-pressure steam type, a reduction of 230 million USD by the introduction of GTCS of the intermediate-pressure steam type, and a reduction of 225 million USD by the introduction of GTCS of the hot-water type.

When economic efficiency is compared similarly among GTCSs of all types, the reduction in fuel cost by the high-pressure steam type is 25 million USD more than the reduction by the intermediate-pressure steam type and 30 million USD more than the reduction by the hot-water type. The construction cost of an exhaust gas boiler 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. Therefore, the construction cost reduction achieved by the use of the intermediate-pressure steam type or hot-water type is significantly less than the 25 million and 30 million USD fuel cost reduction, so the high-pressure steam type is evaluated as being more economical.

From the technical viewpoint, 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 GTCS is required.
ii) No makeup water facility is required.
iii) No feed water pump or boiler cycling water pump (for the hot-water type) is required.
iv) Since the existing facilities and the new GTCS are spaced apart by 100 m or more, the high-pressure steam type using small-sized connecting pipes is advantageous.
v) There is no restriction on the power generated by the existing steam turbine power generator.

(5) Conclusion

As the total system utilizing the existing steam turbine, the optimum GTCS used in Tashkent Heat and Power Supply Plant is of the high-pressure steam type.

(Attached materials)

The plant heat balance diagrams after and before the introduction of the GTCS, which were used for the economical evaluation are attached below.

Plant heat balance diagrams

(Figure 2-4-1) Before introduction of GTCS (summer)
(Figure 2-4-2) Before introduction of GTCS (winter)
(Figure 2-4-3) After introduction of GTCS of high-pressure steam type (summer)
(Figure 2-4-4) After introduction of GTCS of high-pressure steam type (winter)
(Figure 2-4-5) After introduction of GTCS of intermediate-pressure steam type (summer)
(Figure 2-4-6) After introduction of GTCS of intermediate-pressure steam type (winter)
(Figure 2-4-7) After introduction of GTCS of hot-water type (summer)
(Figure 2-4-8) After introduction of GTCS of hot-water type (winter)

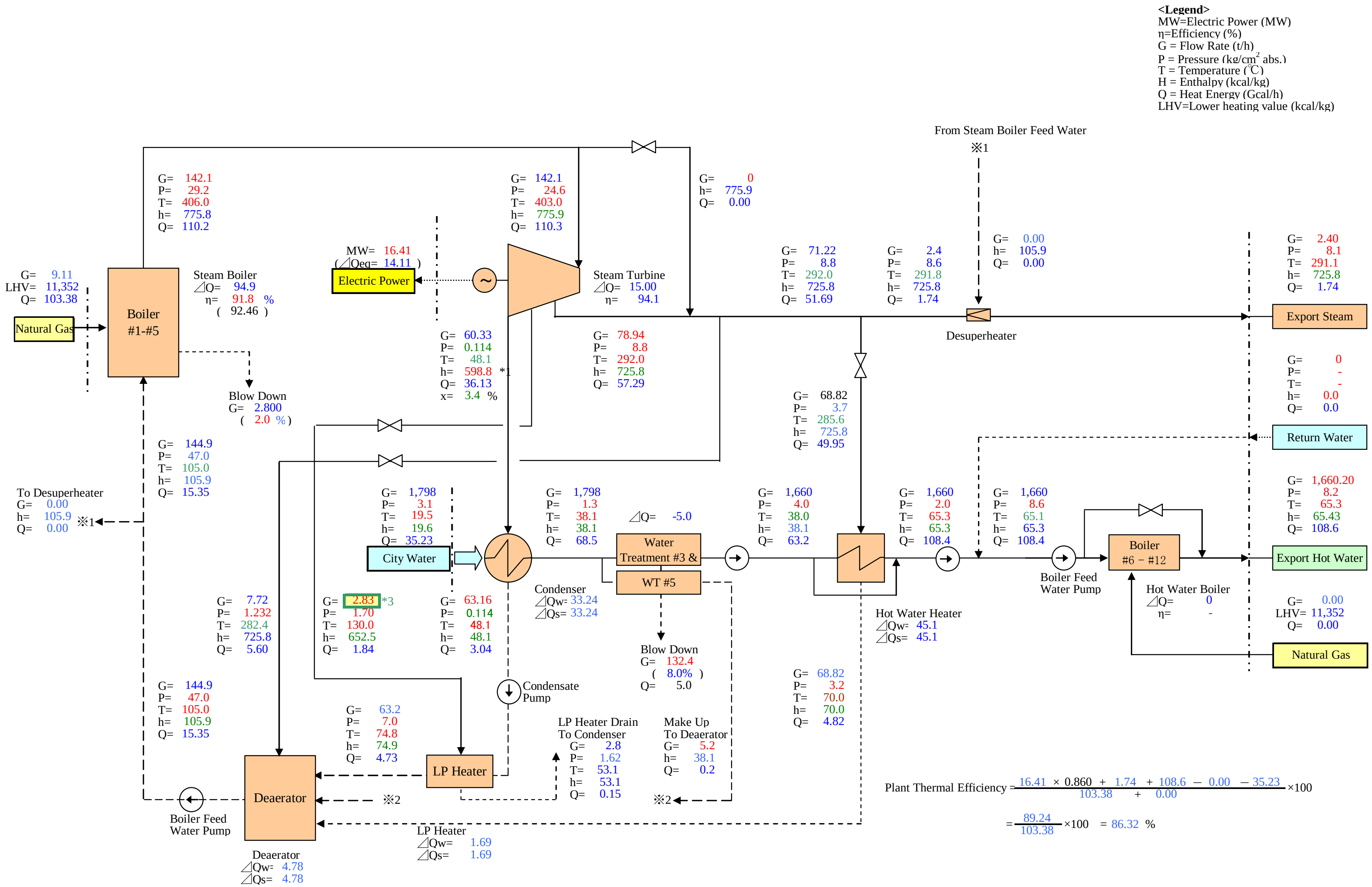


Figure 2-4-1 Before introduction of GTCS (summer)

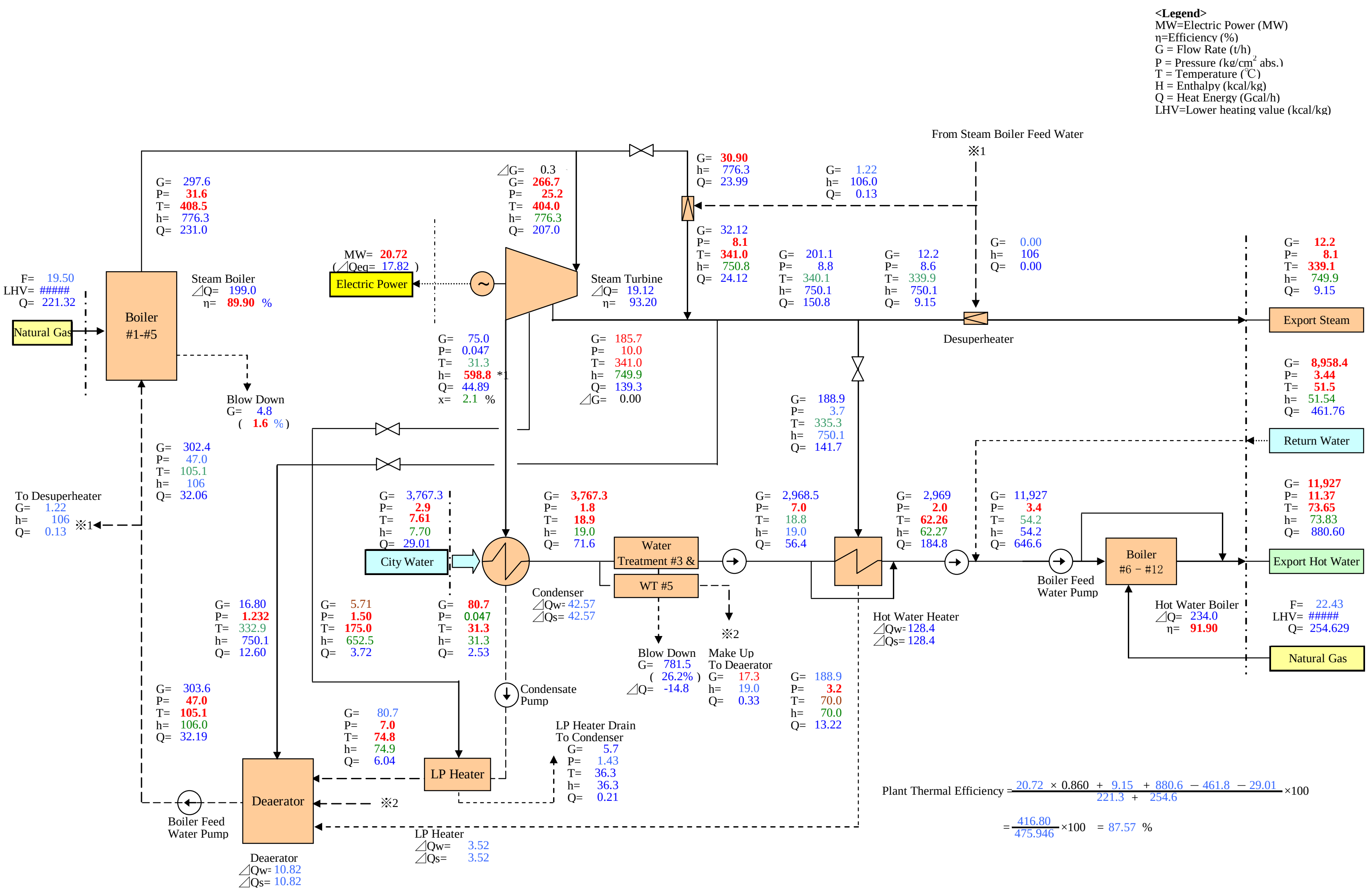


Figure 2-4-2 Before introduction of GTCS (winter)

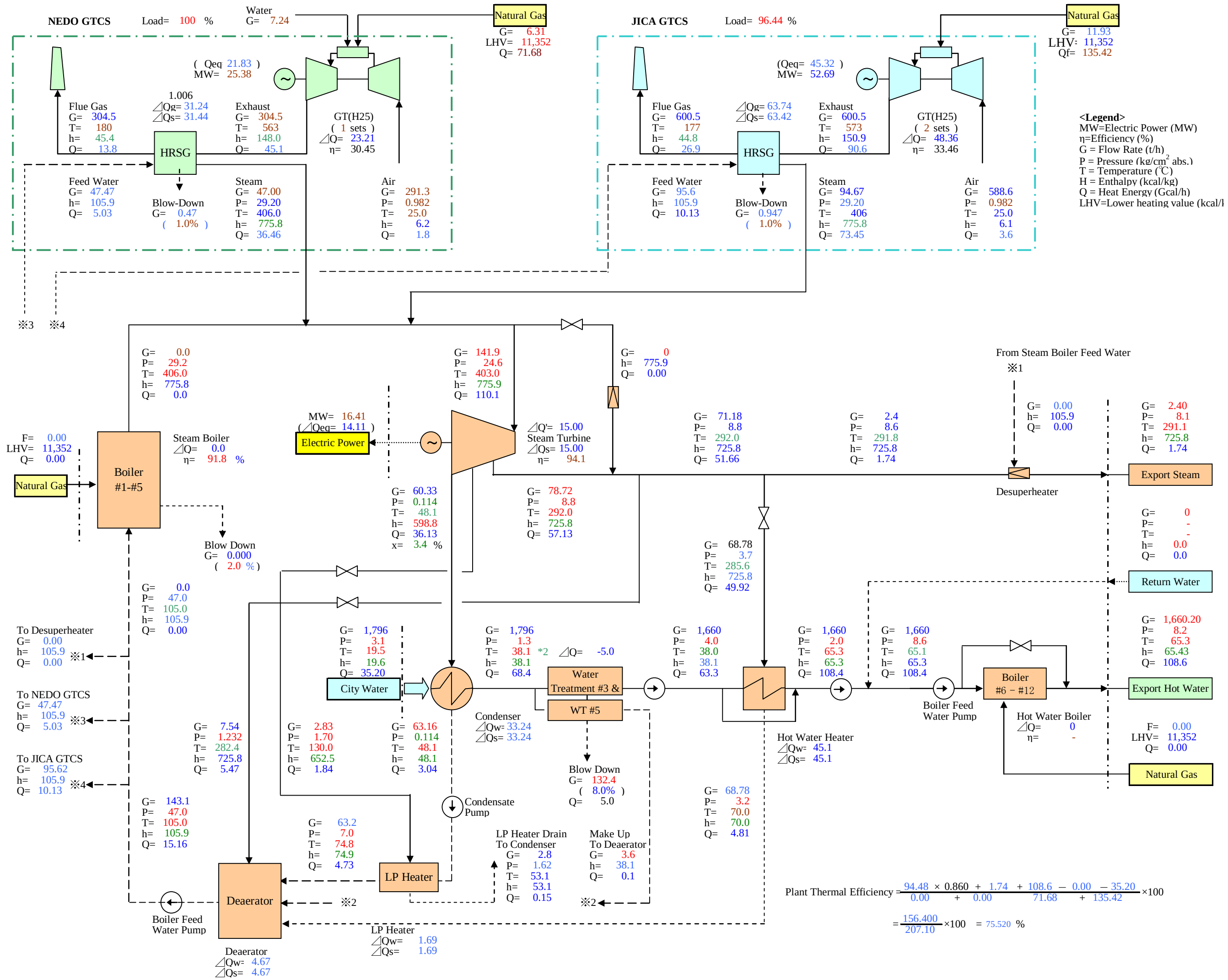


Figure 2-4-3 After introduction of GTCS of high-pressure steam type (summer)

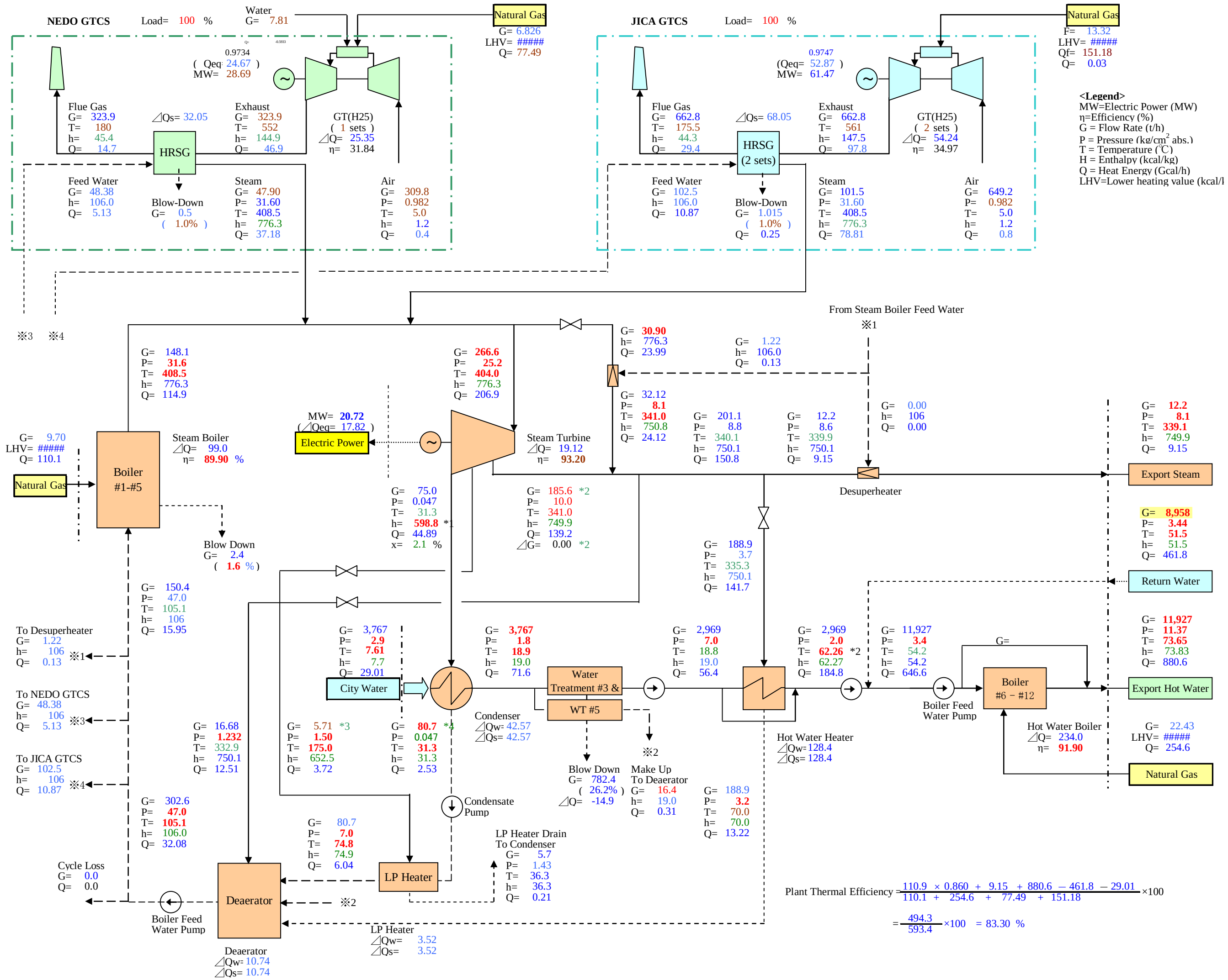


Figure 2-4-4 After introduction of GTCS of high-pressure steam type (winter)

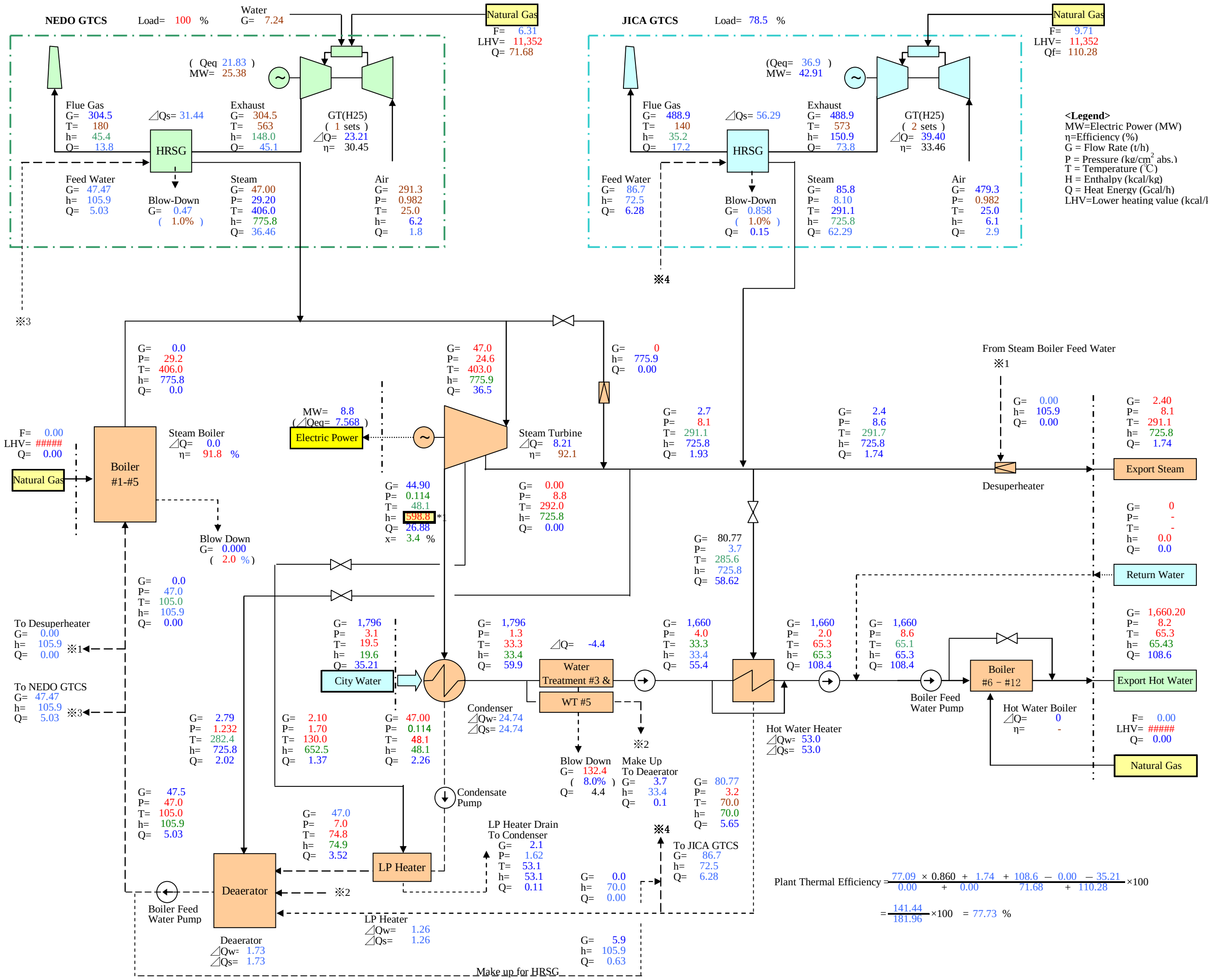


Figure 2-4-5 After introduction of GTCS of intermediate-pressure steam type (summer)

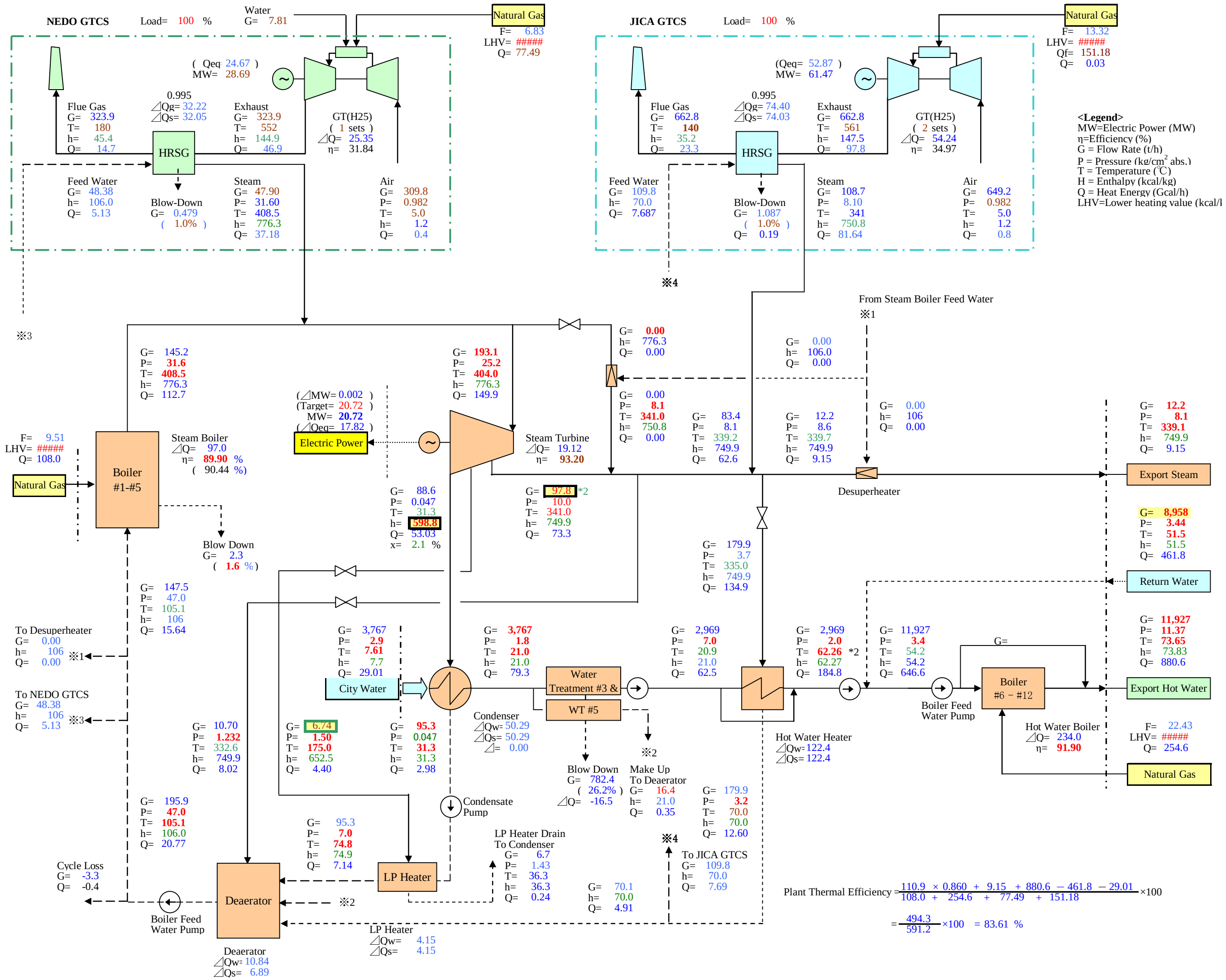


Figure 2-4-6 After introduction of GTCS of intermediate-pressure steam type (winter)

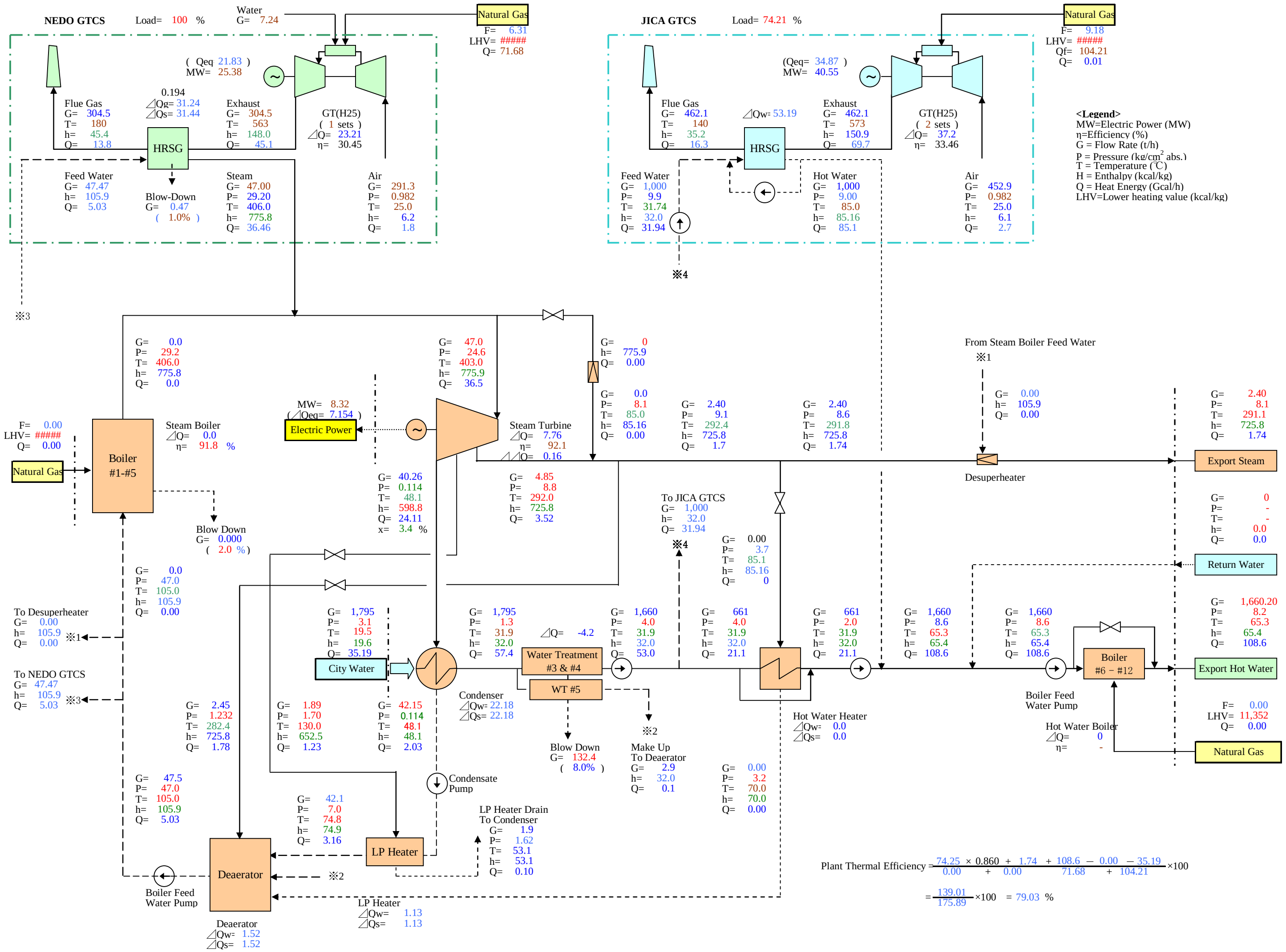


Figure 2-4-7 After introduction of GTCS of hot-water type (summer)

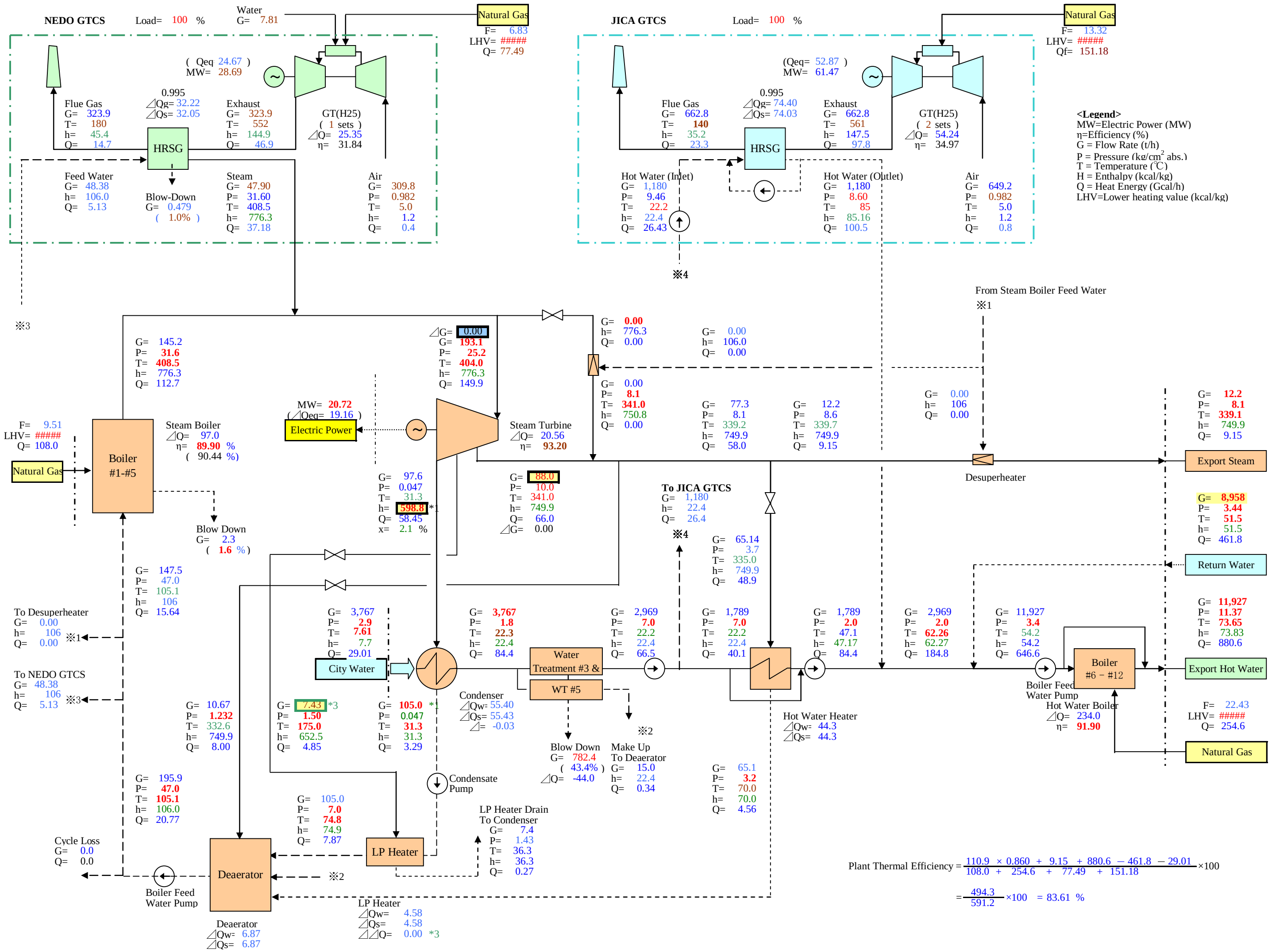


Figure 2-4-8 After introduction of GTCS of hot-water type (winter)

2.4.2 Basic specifications of the electric facilities

(1) Basic items

Figure 2-4-9 is a draft one-line diagram representing a new installation plan for Tashkent Heat and Power Supply Plant. The JICA plant may include different specifications of the equipment and facilities of the manufacturer according to the international bid. The capacity of the station auxiliary equipment and others also differs according to the plant type. Thus, the specifications of the electrical equipment in the new facilities cannot be determined in the current phase. However, from the plan of the Uzbekenergo Electrical Energy Board, the approximate capacity of the plant facilities was estimated and the specifications of the major electrical facilities were set on a tentative basis. The basic design of the facilities shall conform to the International Standards and Regulations of Electrical Installation Designing (PUE) of the Republic of Uzbekistan in principle. The following describes the confirmation items on the major basic system method for a new power plant construction project:

- Review the planned specifications on the newly installed transformer worked out by TEP.
- The generator excitation equipment is of a brushless stationary type.
- Install a new emergency diesel generator.
  A request was made to report the major points for determining the capacity.
- An underground cable trench is adopted for connection between the secondary side of the plant Step-up transformer and the switch yard. Sufficient precautions must be taken of the cable curvature and standard underground installation method.
- The existing generator terminal voltage is 6.3 kV. This is changed to 11 kV. Unlike the existing facilities, a station transformer is installed to supply a station power source.
- A request was made to submit a report on the method for calculating the percentage impedance of the transformer.
- A hybrid SF6 gas circuit breaker will be adopted in the switching station.
- The generator automatic synchronization system in the center operation room will be designed to be capable of parallel operation.
- Sufficient consideration must be given to the control characteristics and maneuverability of the entire Heat and Power Supply Plant, and a state-of-the-art control system capable of CRT operation will be introduced.
- The facilities will be designed and modified when consideration is given to the basic design of the communication facilities as a whole.
- Sufficient consideration must be given to the equipment layout of the plant facilities to be introduced.

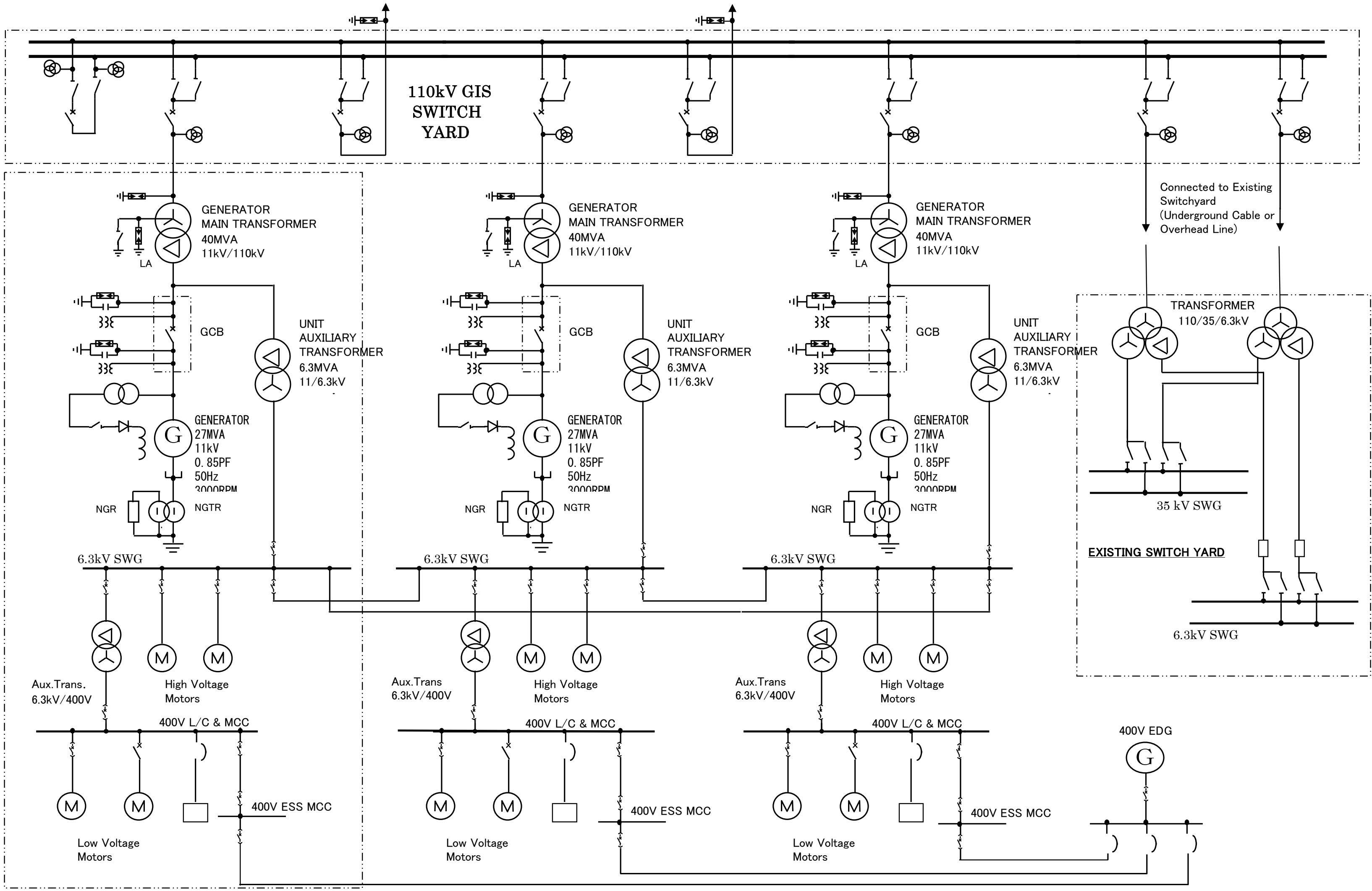


Figure 2-4-9 One-line diagram representing the new design of Tashkent Heat and Power Supply Plant (Draft)

(2) Power generator

The one-line diagram shows the plant facilities plan which is almost the same as that for Unit 1 of the NEDO model project plant in the current phase. As discussed above, the JICA plant may include different specifications depending on the manufacturer taking part in the bid. However, a study has been made on two 27 MVA air-cooled generators having a power factor of 0.8 at 50 Hz on the assumption that Units 2 and 3 of Tashkent Heat and Power Supply Plant have about the same specifications as those of Unit 1. The capacity of the single generator unit is determined by such conditions as specifications of the entire plant facilities, transmission line capacity, and the layout plan.

(3) Power generator and exciting unit

The stationary excitation method of the excitation equipment composed of the excitation transformer connected to the main circuit of the generator, or excitation current transformer and semiconductor transducer can be broadly classified into two types -- a self-excitation method and a thyristor excitation method.

Brushless thyristor excitation equipment of a simple structure will be adopted.

This excitation system uses a thyristor to establish the generator voltage. In the excitation power source of this equipment, the generator bus is provided with an excitation transformer and the voltage is supplied to the thyristor to perform operation. The control section uses a stable element such as an IC and is characterized by excellent precision, stability, and readiness. Stable operation is ensured despite a possible reduction in generator voltage (resulting from system failure and others). Further, the equipment is designed in a compact and lightweight structure, and the maintenance is easy and less costly. Thus, this equipment is adopted.

Further, excitation is provided to a synchronous machine characterized by lower cost and longer service life by improved arrangement of the field circuit without installing the field circuit breaker for cutting off the DC large current. Thus, Tashkent Heat and Power Supply Plant is equipped with a thyristor rectifier for exciting the generator field winding, a power source other than the synchronous machine output circuit connected to the AC input terminal of the thyristor rectifier via the excitation transformer and excitation AC circuit breaker, a discharge resistor connected in series between the field winding and thyristor rectifier, and a discharge resistance short-circuiting switch connected in parallel to the discharge resistance to open or close the discharge resistor terminal. When the generator is shut down normally, the excitation AC circuit breaker is opened. At the same time, a plurality of thyristor arms is fired simultaneously. This operation ensures that the energy stored in the field winding is discharged through the thyristor arm. When the synchronous machine has been brought to an emergency stop, the excitation AC circuit breaker is opened. At the same time, a plurality of thyristor arms is fired simultaneously. Further, when the discharge resistance short-circuiting switch has been opened, the energy stored in the field winding is discharged through the discharge resistor and thyristor arms.

(4) Transformers

The transformers as important components of Tashkent Heat and Power Supply Plant include a main transformer, station transformer, and a high- and low-voltage station power transformer. The following describes the specifications on the main transformer and station transformer based on the requirements of the Uzbekenergo Electrical Energy Board.

A. Main transformer

Since the on-premises site of Tashkent Heat and Power Supply Plant is very limited in space, it is essential to pay particular attention to the arrangement of transformers. In principle, all units should be installed on the southern side of the power plant building.

Since isolated-phase buses are used for connection between the generator and main transformer and between station transformers, appropriate arrangement must be ensured with consideration given to the outgoing cable on the secondary side. This Plant is an urban type Heat and Power Supply Plant, and therefore, the oil-immersed transformer is generally provided with a fire wall. Further, depending on the situation, installation of a sound barrier or oil retaining wall must be considered

The capacity of the main transformer for Unit2 and 3 will be determined as follows: (See the available data).

- Main transformer capacity = generator capacity
- Main transformer capacity = generator capacity - station transformer capacity
- Main transformer capacity of newly installed units 2 and 3: 27 MVA × 2 transformers
- It should be noted that the power loss of the isolated-phase bus (IPB) will not be taken into account because it is very small.

B. Oil-immersed gas on-line surveillance system

By the very nature, the transformer requires various forms of management to be performed to ensure reliability. Thus, in the basic design phase, it is necessary to study the methods for transformer management. The service life of the oil-immersed transformer is affected by the deterioration of the insulating oil. This makes it necessary to check the insulation for integrity at the time of periodic inspection for the sake of proper transformer management. In the inspection, the insulating oil is sampled to check the water contents, dielectric breakdown voltage, specific volume resistance, and the status of oxidation in numerical terms. Thus, the degree of deterioration must be determined. In Tashkent Heat and Power Supply Plant, the insulating oil of the transformer is sampled on a periodic basis and gas analysis is performed to determine the level of insulation deterioration. In recent years, however, there has been widespread use of the continuous oil-immersed gas analysis/measurement system capable of monitoring the transformer operation status on a real-time basis. This system has been determined to be adopted, as a result of consultation. Using the amount of oxygen dissolved in the insulating oil and percentage of the constituent, this system detects the presence or absence of the occurrence of an internal trouble, and diagnoses a failure and deterioration of the insulating paper. This system has come into the most widespread use in recent years. A small amount of the insulating oil of the oil-immersed equipment such as a transformer is sampled without interrupting the power supply, and gas contained in the oil is analyzed. From the type and amount of gas, a failure of the winding and core is correctly determined, whereby a possible plant blackout and equipment damage can be avoided. The following advantages are obtained by installation of the continuous surveillance system in the new facility plant:

- Insulating oil can be sampled during plant operation without the facilities being shut down.
- Surveillance is made to monitor a change in the concentration of the hydrocarbon-based gas of hydrogen and carbon monoxide in the step-up transformer insulating oil. The gas causing a failure is analyzed and detected to determine the level of caution and precaution.
- Insulation deterioration is diagnosed by the gas analysis method. The slightest sign of failure of the equipment is detected at an earlier stage.

Gas analysis of transformer insulating oil

(a) Measuring the acid value
The level of deterioration of insulating oil is determined. (If the transformer is heated, oil will be oxidized). If the oil is highly oxidized, deteriorated substances will be segregated in the oil. The deteriorated deposits interrupt discharge of heat and deteriorate the winding insulation.

(b) Dielectric breakdown test
If oil is mixed with "water and dust", the dielectric strength of the oil will be reduced. The water and dust will be absorbed by the insulator (insulating paper) of the winding, with the result that the dielectric strength of the winding will be reduced. The dielectric breakdown voltage is measured to determine this.

(c) Gas analysis
The trace gases in the oil of the newly installed step-up main transformer of Tashkent Heat and Power Supply Plant are analyzed to determine the partial overheat, partial discharge, and insulation deterioration in the transformer. If there is partial overheat or discharge, the oil will be degenerated, and trace gases will be produced. These gases will be dispersed in oil. Thus, a step is taken to check the changes in the type and amount of the gas in the oil of the main transformer of this power plant and to monitor the status of the insulation deterioration on a continuous basis.

C. Selecting the station transformer percentage impedance
The following describes the specifications of the transformer in the new facilities according to the data obtained from Tashkent Heat and Power Supply Plant.

Table 2-4-11 Specifications of newly installed transformer

Installed transformer	Unit main transformer	Station transformer	High-voltage transformer	Backup transformer
Installation site type	Externally installed	Externally installed	Externally installed	Externally installed
Model No.	T DH-40	TMH-6.3	TC-630	TPDH-10
Phase	3-phase	3-phase	3-phase	3-phase
Rated transformer voltage	115/11 kV	11/6.3 kV	6.3/0.4 kV	110/6.3 kV
Capacity	40,000 kVA	6,300 kVA	630 kVA	10,000 kVA
Connection method	Y0/△-11	Y/Y0-o	△/Y0-11	Y0/△-11
Percentage impedance	10.5	8.0	5.5	10.5
CT	600/5	600/5	-	300/5

(Source: Reply from Uzbekenergo Electrical Energy Board)

As discussed above, the JICA plant may include different specifications of the equipment and facilities of the manufacturer according to the international bid. The capacity of the station auxiliary equipment and others also differs according to the plant type. Thus, the specifications of the electrical equipment in new facilities cannot be determined in the current phase. However, from the plan of the Uzbekenergo Electrical Energy Board, the approximate capacity of the plant facilities was estimated and the specifications of the transformer were set on a tentative basis. In particular, selection of the percentage impedance of the station transformer is difficult. The following describes the general points in the selection of the percentage impedance of the station transformer as requested by the Uzbekenergo Electrical Energy Board.

(a) Conditions for selecting the transformer percentage impedance

- Impedance shall be such that the three-phase short-circuit current in the station circuit is kept below the cutoff current of the circuit breaker. (Lower limit value)
- Impedance shall be such that the voltage drop rate is kept below 15% when the maximum auxiliary equipment such as a feed water pump is started up. (Upper limit value)
- The margin of the station transformer at the time of production should be in the range of about +10% through -10%. (The Uzbekistan regulation should be obeyed.)

<u>Lower limit value</u>

$$F3\times Ic > (Qt/(\sqrt{3}\times 6.9)\times F1\times(100/(Zt+ZI))+(Qm/\sqrt{3}\times 6.69)\times F2\times 100/Zm$$

F3: Asymmetrical attenuation coefficient of circuit breaker
Ic: Rated cutoff current of circuit breaker (kA)
Qt: Transformer capacity (MVA)
F1: Asymmetrical attenuation coefficient of transformer
Zt: Transformer impedance (%)
Z1: Primary transformer impedance (%)
Qm: Total motor capacity (MVA)
F2: Asymmetrical attenuation coefficient of motor
Zm: Locked motor impedance (%)

<u>Upper limit value</u>

$$E>(Zt/Qt)[\{(R/X)(Qt-P/\eta\times\cos\phi)\times\cos\phi'+(P/\eta\times\cos\phi)\times K'\times\cos\phi''\}$$
$$+\{Qt-P/(\eta\times\cos\phi)\}\times\sin\phi'+(P/\eta\times\cos\phi)\times K'\times\sin\phi''\}$$

E: Voltage drop rate (%)
R/X: Transformer reactance
P: Capacity of the largest motor (MW)
$\eta\times\cos\phi$: Largest motor efficiency × power factor
$\cos\phi''$: Largest motor power factor at the time of startup
$\cos\phi'$: Average power factor of the motor group other than the largest motor
K: Magnification of largest motor at the time of startup
K': Corrected magnification of largest motor at the time of startup

From the above selection formula, the lower and upper limit values have been calculated with consideration given to the margin at the time of manufacturing in Uzbekistan. Thus, the transformer impedance can be expressed as follows: Lower limit value % < Zt < upper limit value. According to a tentative calculation, the selected station transformer in the new plant facilities has a capacity of 6.3 MVA with a percentage impedance of 8%.

(5) Isolated phase buses

The main circuit on the primary side from the generator outlet has a capacity of 11 kV. This is a crucial circuit for ensuring that the power produced by the generator is transmitted to the main transformer and station transformer. Moreover, the generator circuit contains large amounts of the electrical current and short-circuit current, and therefore, the isolated-phase bus characterized by excellent mechanical and electrical performances will be used. Generally, in the outdated plants made by the former Soviet Union, cable connection is mainly employed. From the viewpoint of costs, it may be possible to use cables for connection of the main circuit on the primary side. However, from the perspective of ensuring long-term reliability and safety of the facilities, use of the isolated-phase bus is recommended.

In the isolated-phase bus (IPB), a conductor made of copper or aluminum is enclosed in a metallic casing separately for each phase so that phases are completely separated from one another. This eliminates the possibility of causing inter-phase short circuiting or electric shock, and the IPB provides excellent insulation capacity and current-carrying efficiency. Further, the IPB is designed in a hermetically sealed structure to ensure excellent hermeticity. In the case of large capacities, a forced cooling system using an air cooler and fan is adopted. Since Tashkent Heat and Power Supply Plant does not have a very large capacity, the IPB will be cooled by self-cooling.

(6) 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.

* Metal-clad switch gear (M/C)
  Power is supplied to the large-sized high-voltage motor and high-voltage load (e.g., power transformer). Although there are various types of circuit breakers, vacuum circuit breakers (VCB) will be installed in the electric room of the same power plant.

* Power center (P/C)
  Power is supplied to the medium-capacity low-voltage motor, control center load, and power distribution panel load. An air circuit breaker is used as the circuit breaker.

* Control center (C/C)
  Power is supplied to the small-capacity low-voltage motor, motor operated valve, and general power source. The no-fuse breaker and electromagnetic contactor will be unitized for each feeder.

(7) High-voltage electric motors

In Tashkent Heat and Power Supply Plant, many motors are used to drive the auxiliary equipment and constitute the major components of the power generation facilities. In this power plant, three-phase induction motors are mainly employed. According to the voltage, motors are classified into two types -- a high-voltage motor (6.3 kV) and a low voltage motor (400V/220V). In response to application requirements, various types of motors are used, where these motors are different according to the state of installation (vertical or horizontal) and type of winding (squirrel cage or winding type). The overhead traveling crane required to provide special performances such as speed adjustment and startup torque characteristics is of a winding type. Except that, the squirrel cage type motors are used in general cases. It should be noted that the motor requires protection such as (1) protection against overload, (2) protection against short circuiting and (3) protection against ground faults.

(8) Protection relays for power generators and transformers

The protection relays of the existing facilities in Tashkent Heat and Power Supply Plant are located in the outdated electromagnetic movable contact type relay panels made by the former Soviet Union and are arranged on the back of the upright panel in the center operation room. The protection relays are required to provide high reliability capable of immediately meeting the requirements of plant protection. Thus, the performance of each relay must be improved to ensure excellent equipment protection and power system protection capabilities. For this reason, in the newly installed plant facilities, the relays used in the existing facilities will be replaced by the stationary relays using semiconductors. A system capable of ensuring sufficient reliability and characteristic performance will be introduced into the relay room. Further, use of the stationary relay leads to a substantial reduction in the installation space.

(9) DC UPS system

The UPS system is generally used for control. In addition, in the event that a total outage has occurred to the station power source during plant operation, this system provides safe stop of the unit and plays complementary roles. The AC power source of a charger is connected to the control center where power is supplied by an emergency generator. The basic portion of the UPS is made up of a "converter" for AC-to-DC conversion, an "inverter" for creating a stable AC power source, and a "storage battery" serving as a backup power source in the event of a blackout. Further, to provide against possible troubles, the UPS includes a "switch without instantaneous interruption" that switches between the "bypass circuit", inverter, and bypass circuit without instantaneous interruption. With consideration given to possible charger trouble and inspection, it is recommended that the charger should be structured as a dual system in such a way that, when one aspect of the system has been shut down, the system can be recharged by a battery.

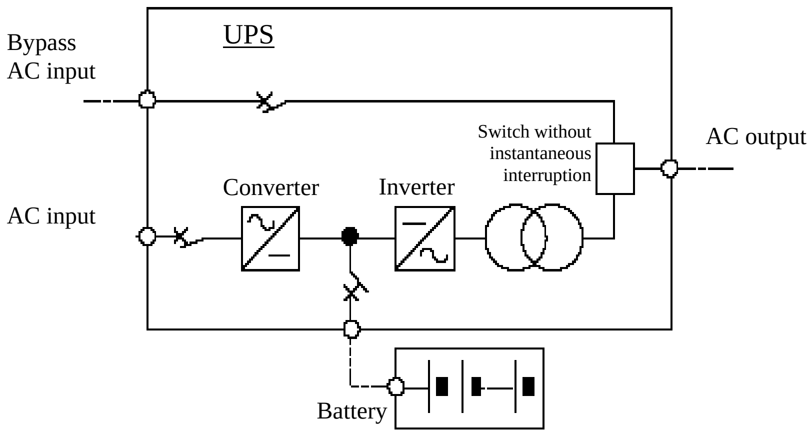


Figure 2-4-10 Overview of basic UPS system at Tashkent Heat and Power Supply Plant

(10) Emergency diesel power generator

When Tashkent Heat and Power Supply Plant has been subjected to a total outage due to a system failure or station power source trouble, the following actions must be taken:

- Safety suspension of the unit operation
- Ensuring a power source for safety and protection during blackout

- Preparation for earlier startup after the reception of power

An emergency diesel generator characterized by the startup method for meeting the above-mentioned requirements is installed to ensure earlier recovery from an accident, and to permit the stable supply of power. Should the working power source have been shut down for any failure, or should an abnormal voltage drop have occurred, an instruction is given to the automatic startup equipment by an under-voltage relay. When the engine has been started and the speed has come close to the rated level, the generator voltage is established by the stationary excitation equipment and the no-voltage status of the emergency control center is verified. After that, the emergency power receiving circuit breaker is automatically closed. When selecting the generator capacity, the overall target load should be calculated to determine the generator capacity. Further, the engine capacity should also be determined based on the load capacity. In this case, the following must be noted:

- The capacity should be sufficient for the rated load.
- During motor startup, the generator load factor should not exceed 150%. The engine overload factor must not exceed about 110%.
- The load such as a motor operated valve to be operated on an intermittent basis is operated only a short period of time with a smaller capacity. Many of such loads are not operated simultaneously. Thus, such loads are ignored when selecting the capacity.
- When determining the capacity, loads are divided into groups. The capacity should be determined based on the facility capacity according to the first group (motor load, transformer load, and resistance load), the second group (motor load). Calculate the required capacity in the steady state, and the capacity at the moment when the first group of the remaining unit has been closed, after the steady state recovered by closing of the first group. Then calculate the capacity when the steady state is recovered by closing of the entire first group and the load (turning oil pump or the like) having the maximum capacity in the second group has been started in the final stage, after the loads of the second group are started one after another.

(11) Control system in the Heat and Power Supply Plant

The control facilities of the power plant constitute a center of the plant to provide protection, surveillance and control of the entire plant, and are crucial in the event of an emergency. The power plant is required to provide wide-ranging performances to ensure stable power supply, high efficiency, superb maneuverability, and environmental protection. Thus, the man-machine communication system is mainly used in recent years because this system is characterized by highly advanced surveillance and operation and easy use of the plant, i.e., by advanced operation management.

A digital instrumentation control system meeting these requirements will be introduced into the newly installed facilities of Tashkent Heat and Power Supply Plant. The basic system structure is given in Figure 2-4-11. The basics of the digital overall instrumentation control system are found in functional decentralization among control, surveillance and management, and centralization of information management. To be more specific, this is a system structure, where many pieces of the digital control equipment fully-equipped with a self-diagnostic function, on-line maintenance function, and redundancy function are arranged on a decentralized basis through application of the microprocessor. They are effectively integrated by a computer having a top management function. The plant information is unified as the information required for operation management, and centralized management of the entire Tashkent Heat and Power Supply Plant is performed at the operator surveillance desk in the center.

The control system of the newly installed Tashkent Heat and Power Supply Plant is based on the basic concept which is implemented by introduction of the state-of-the-art information control technology characterized by a higher level of maintainability, maneuverability, and reliability for the purpose of ensuring the stable supply of power, steam, and warm water and permitting preventive maintenance. Further, for the purpose of achieving economic advantages, this basic concept is also intended to streamline the cable installation method and the control equipment, thereby achieving minimized costs. Thus, the system must be a highly reliable next-generation surveillance control system, and the facilities to be introduced should be capable of ensuring compatibility between maintainability, maneuverability, reliability, and economical performance. The next-generation surveillance control system must cover a fairly broad spectrum of menus including various forms of operations, plant data surveillance, alarm display, servo valve adjustment, and overspend tests under the graphical operation environment. Further, the system is preferably the one equipped with an on-line logic monitoring function and trend data display function through merging with a maintenance tool.

The operation and surveillance of the newly installed power plant will be performed by the CRT operator console and the backup operation panel to be installed in the center operation room. In this case:

- The operation and surveillance will basically be performed by the full CRT operation method. However, the switches and related devices capable of safe outage of the plant in an emergency operation procedure will be installed on the CRT operator console or backup operation panel as hard wired structures.
- To cope with the possible failure of the CRT surveillance function, a recording meter, indicator, and alarm that can be continuously operated under a certain load even when surveillance by the CRT is disabled will be installed on the backup operation panel as hard wired structures.
- The generator circuit breaker operation switch and synchronism detection instruments will be installed on the backup operation panel as hard wired structures.
- The control/surveillance equipment will be composed of a DCS, information management system, maintenance management system, network system, and the equipment related to them.
- Whether or not the major operation status surveillance monitor of the existing facilities is to be installed in the center operation room of the newly installed plant facilities will be determined by a separate discussion. The entire system lineup including the linkage with the currently operating data monitor system will be studied in the future.

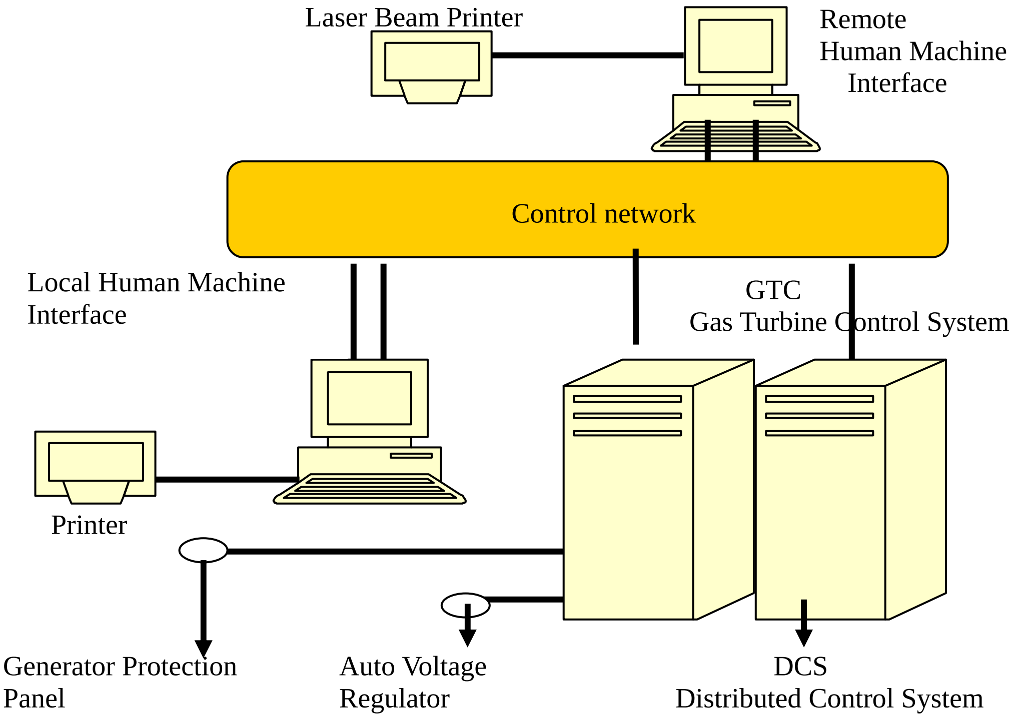


Figure 2-4-11　Structure of the basic control system in Tashkent Heat and Power Supply Plant.

(12)　Communication facilities

The newly installed plant will be provided with power communication facilities such as the facilities for transferring the information for system protection, system operation, and facility management to various offices of the power plant, substation, Uzbekenergo Electrical Energy Board and load-dispatching office, the telephone sets for connection of various divisions in the power plant, the on-premises loudspeakers connected between the plant site and center operation room, and the equipment for communication with the site (paging system). For communication with the outside, there will be partial connection with the existing communication facilities. If the paging system can be used for this purpose, it will be used as a shared system. However, in the future, this must be incorporated in the communication network of Tashkent Heat and Power Supply Plant, in conformance to the new communication system improvement program by all the sectors of the Uzbekenergo Electrical Energy Board. The Uzbekenergo Electrical Energy Board has already updated the communication system by using optical fiber cables in the outdated communication circuit among the Uzbekenergo Electrical Energy Board, Tashkent Heat and Power Supply Plant and YUKSAK substation, and is planning to improve the technological reliability by positive establishment of load-dispatching.

The communication facilities for electric power can be broadly classified as follows:

Wired facilities .... Communication cable
Carrier facilities .... Carrying by communication line, coaxial cable, and power cable (carrier wave communication by transmission line)
Radio facilities .... Multiplex radio communication and mobile radio communication

Wired facilities and power carrier wave communication are mainly used for the current communication between Tashkent Heat and Power Supply Plant, load-dispatching office, and substation. The transmission line by power carrier wave communication is not originally intended for use in communication. To meet the requirements, high frequency adjustments must be made. The carrier wave must be safely carried to the power cable without interrupting the original function of the power cable. In the Uzbekenergo Electrical Energy Board, the power cable carrier wave communication method is used for communication between the power plant and substation. These transmission circuits must be improved in such a way that, despite any operation applied to the power cable, communication will not be interrupted or communication quality will not be deteriorated. Further, means should be provided to ensure that communication service will not be interrupted, despite a failure in the transmission line. To achieve this end, a blocking coil is inserted into the branch line and the carrier wave equipment is connected to the power cable. There are a great number of transmission lines installed everywhere in the city of Tashkent and blocking coils in the power plant switching station. The blocking coil is inserted into a transmission line in a series for the purpose of reducing the loss at the high frequency of the transmission line, stabilizing the transmission properties, and avoiding radio interference with other systems. However, in conformance to the modernization of a power supply system, it is recommended to implement modernization of the facilities characterized by a high degree of system reliability in combination with wired facilities by communication cable and multiplex radio facilities by microwaves, whereby a future power communication system can be implemented. It is also recommended to install the station paging system based on state-of-the-art technology as a means of communication at the power plant on-premises.

Communication facilities at Tashkent Heat and Power Supply Plant:

- Telephone line between the power plant and Uzbekenergo Electrical Energy Board
- Telephone line for liaison between the power plant and YUKSAK substation
- Automatic telephone exchange line among various sections of the power plant
- Linkage with general external telephone line
- Linkage with LAN line
- Operation status and telemeter line between the power plant and Uzbekenergo Electrical Energy Board
- Operation status and telemeter line between the power plant and UKSAK substation
- On-premises paging equipment of the power plant
- On-premises alarm of emergency and fire alarm system
- Several small-output transceivers

(13) Lighting facilities

The main power source for lighting will be supplied by the station control center. The common control center will provide emergency lamp power source facilities, airplane warning lamps, on-premises passage lighting (low voltage sodium lamp), equipment and facilities of office buildings and various work sites, and passage work lamps. Installation of infrared disaster prevention and surveillance lighting facilities will be taken into account wherever required. It should be noted that part of the lighting facilities will be operated by automatic ON/OFF means. Partial installation of solar power supply devices will also be taken into consideration for the purpose of saving power. Since Tashkent Heat and Power Supply Plant is comparatively close to the Tashkent International Airport, installation of airplane warning lamps will be very important.

Chapter 3 Power System Analysis

Table of Contents

Chapter 3 Power System Analysis

In this chapter, power flow, voltage, and fault current analyses were conducted in order to examine the influence by connection of three Gas Turbine Cogeneration System (GTCS), including the NEDO project, on the existing power system.

3.1 Fundamental Technical Standards

In this section, technical criteria for power system planning and operation are described.

(1) Power Flow

- In case of N-1 contingency condition, the power system shall return to the 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.

(2) System Voltage

Normal Operation Condition: System voltage ±10% (Substation bus)[1]
System voltage ±5% (Generator terminal)
Abnormal Operation Condition: System voltage +10% (Transformer), System voltage +15% (Switch gear)[2]

(3) Fault Current

The maximum allowable fault currents are shown in Table 3-1-1.

Table 3-1-1 Maximum Allowable Fault Current

Voltage	Maximum Allowable Fault Current
220kV	40kA
110kV	30kA

(Source: Interview with SAESP)

(4) Reliability Criteria

N-1

(5) Transmission Lines, Transformers, Generators

The rated capacities of the conductors are shown in Table 3-1-2.

[1] Bus voltages of certain substations rise up to system voltage + 10% in maximum in the evening and drop down to system voltage –10% in nighttime. Therefore, the voltage range to be maintained is set to system voltage ±10%. (interview with National Dispatch Center, Uzbekenergo)

[2] According to the Table 5.3. Allowable overvoltage of the power-frequency equipment applied for 110-750kV, Rules for Electrical Power Plant and Network Operation, the overvoltage values varies depending on the allowable duration time. In this study, the values for the longest duration time (20minutes) were shown since the study is effective-value-based simulation.

Table 3-1-2 Rated Capacity of Conductors

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

*If the ambient temperature is 40°C, the maximum allowable currents are 81% of that at 25°C in normal operation condition and 97% in emergency condition. (At 25°C, 100% of the maximum allowable current in normal operation condition and 120% of that in emergency operation condition.)

(Source: National Dispatch Center, Uzbekenergo)

Impedances of transmission lines, transformers, and generators were provided by SAESP. Details are shown in Figure 3-1-1 and Figure 3-1-2. (Values in the fugures are 115kV base, and the unit is Ω.

(6) Frequency

Normal Operation Condition: 50±0.2Hz

Abnormal Operation Condition: 50±0.4Hz

In case of dropping frequency under 48.8Hz, load shedding operation is done to raise frequency.

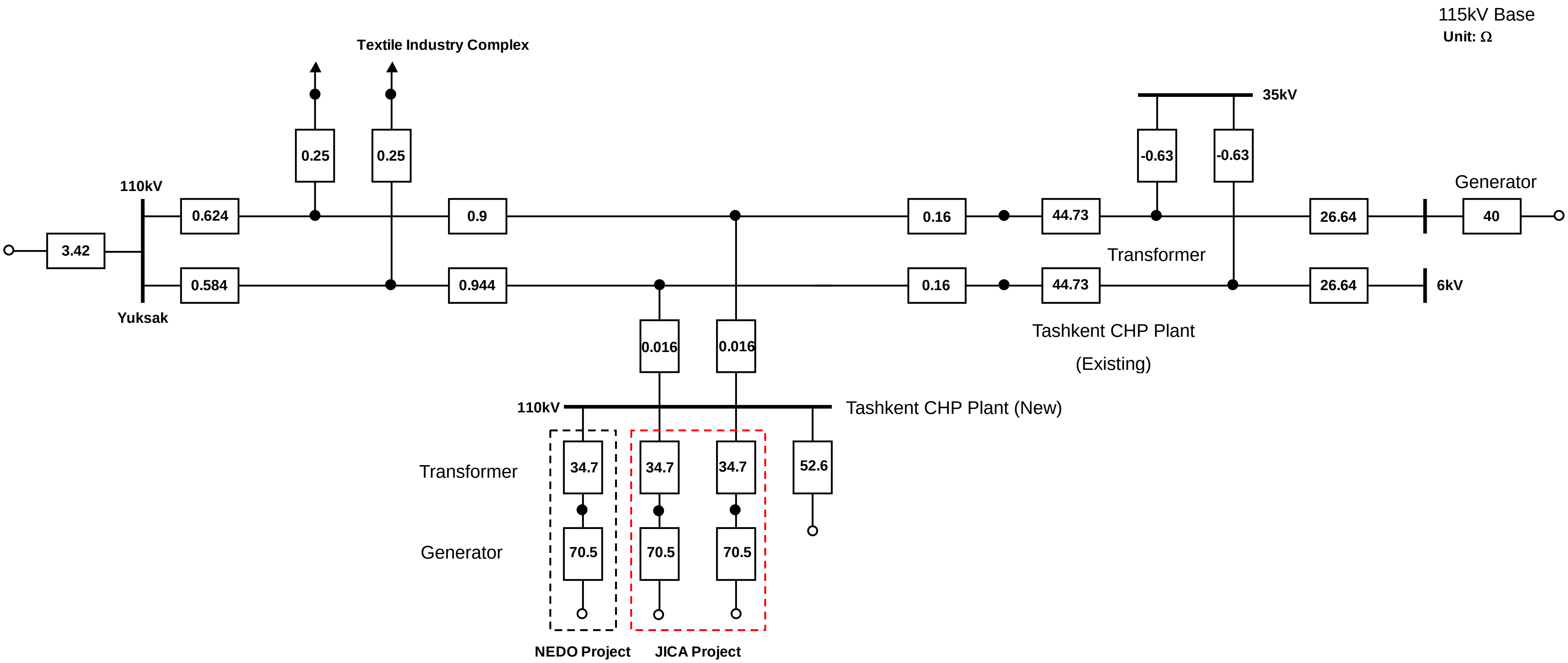


Figure 3-1-1 Positive Sequence Impedance

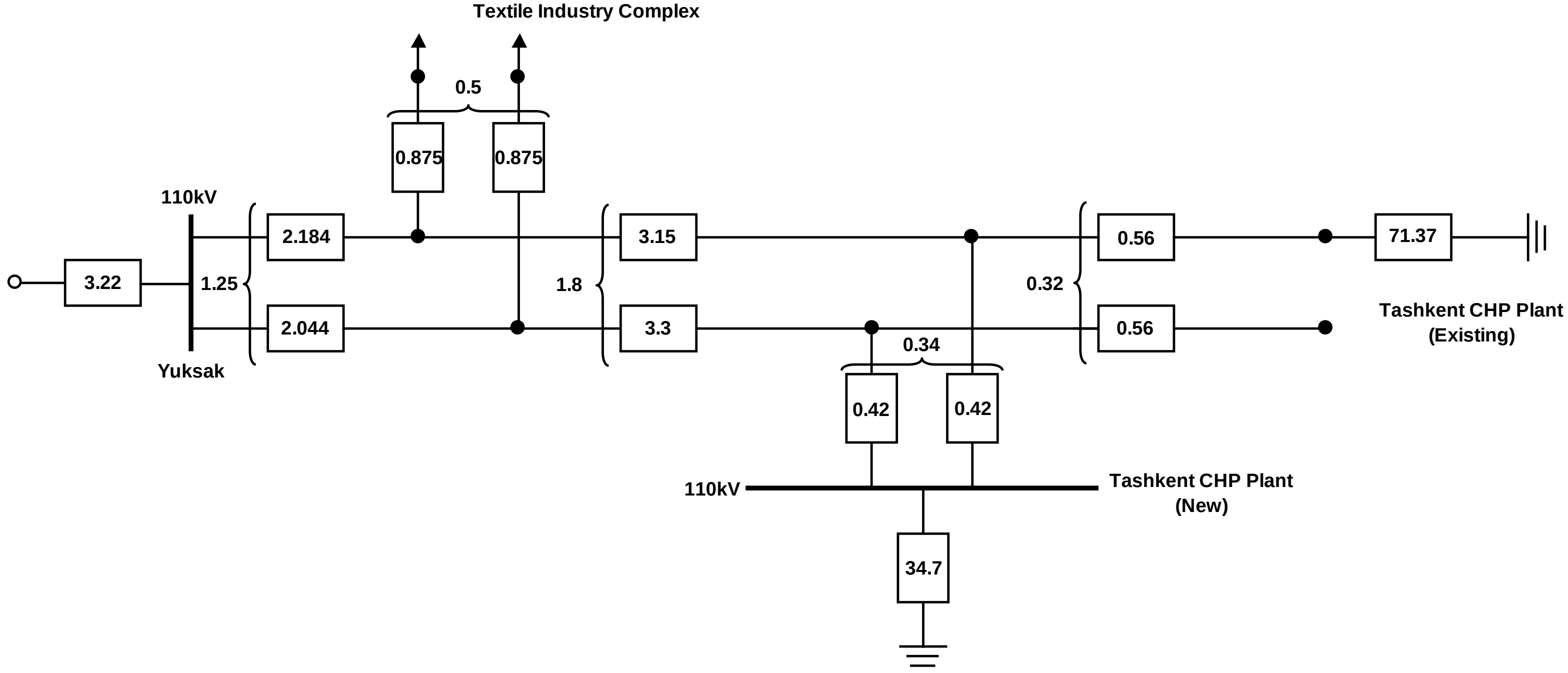


Figure 3-1-2 Zero Sequence Impedance

3.2 Study Cases

Although it is better to simulate the power system in 2015, the expected year of commencement of the JICA project operation, the power system in 2012 including three GTCSs was considered in the analysis due to lack of available data on the future plan (demand forecast, power development plan, and transmission system plan) after 2012, the expected year of commencement of the NEDO project.

4 cases, namely, summer peak and light load conditions and winter peak and light load conditions, were considered for the power flow analysis.

3.3 Analysis Model

The modeled 110kV transmission system constitutes both existing transmission line, which is from Tashkent CHP Plant to Yuksak substation, and newly connected three GTCSs. The total length of the existing line is 4.2km and the line branches off to the textile industrial complex supply line (double-circuit, length: 0.55km) at the point 2.66km away from Tashkent CHP Plant.The single-machine infinite bus system was assumed for the system behind the 110kV bus of Yuksak substation since only back impedance data was provided and details of the line constants were unknown. 110kV bus of Yuksak substation was assumed to be the slack bus for the analysis model.

3.4 Analysis Tool

PSS/E (Power System Simulator for Engineering) Ver.31, which EDL also owns, was used for the series of system analysis works.

PSS/E is the system analysis software developed by Siemens Power Technologies International (Siemens PTI) in the USA. This software has been used by wide variety of entities, such as electric utilities, engineering firms, educational institutions, etc. in more than 115 countries and can be regarded as internationally universals software. PSS/E has various analysis functions such as power flow calculation, voltage analysis, fault current analysis, stability analysis, etc. and its analysis precision and results are highly reliable.

3.5 Power Flow and Voltage Analysis

Influence on power flow and voltage caused by connecting 3 GTCS of both NEDO project and this project to the existing 110kV transmission system was studied.

3.5.1 Assumptions

- The load connected to the 35kV bus of the existing Tashkent CHP Plant, which is mainly for the airport, was assumed 50% of the peak load in off peak condition.
- The voltages of 110kV bus at Yuksak substation of both summer and winter peak load conditions were set to those provided by SAESP.
- The voltage of 110kV bus at Yuksak substation may exceed the highest allowable voltage, namely 121kV since the bus voltage rises close to 121kV even in peak load condition.

Therefore, the bus voltage at Yuksak substation was set to 121kV.

- The 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 between T-Junction – New switching station bus
  - Single circuit fault of the section between T-Junction – T-Junction to textile industrial complex

3.5.2 Analysis Results

Power flow and voltage analysis results in summer/winter peak load conditions (normal operation condition and N-1 contingency condition) and summer/winter light load conditions (normal operation condition and N-1 contingency condition) are shown. In each figure, blue line stands for 110kV system, green 35kV system, and brown 6kV system. Orange colored lines stands for either overloading or exceeding maximum allowable voltage of 121kV. The power flow values are shown in MVA.

(1) Winter peak load condition

A) Normal operation condition

Power flow and voltage analysis results are shown in Figure 3-5-1. Power flow in each section of the transmission lines was within the rated capacity (79MVA, air temperature: 40^{o}C), namely, no overloading occurred. No voltage vioration occurred.

B) N-1 contingency condition

Power flow and voltage analysis results are shown in Figure 3-5-2 and Figure 3-5-3. Power flow of the remaining circuits was within the rated capacity for abnormal operation condition (95 MVA, air temperature: 40^{o}C). No voltage vioration occurred.

(2) Summer peak load condition

A) Normal operation condition

Power flow and voltage analysis results are shown in Figure 3-5-4. Power flow in each section of the transmission lines was within the rated capacity (79MVA, air temperature: 40oC), namely, no overloading occurred. No voltage vioration occurred.

B) N-1 contingency condition

Power flow and voltage analysis results are shown in Figure 3-5-5 and Figure 3-5-6. Power flow of the remaining circuits was within the rated capacity for abnormal operation condition (95 MVA, air temperature: 40^{o}C). No voltage vioration occurred.

(3) Winter light load condition

A) Normal operation condition

Power flow and voltage analysis results are shown in Figure 3-5-7. No overloading occurred to the sections in questions; however, voltage exceeded the maximum allowable voltage (1.10pu) at 110kV buses of textile industrial complex substation, existing Tashkent CHP Plant, and new switching station since the bus boltage at Yuksak substation was set to the upper limit of the system voltage and not enough amount of reactive power was consumed due to light load. The three generators of GTCS and the generator of the existing Tashkent CHP Plant would be operated at leading power factor even if the terminal voltages of the generators were raised up to the maximum limit (1.05pu).

B) N-1 contingency condition

Power flow and voltage analysis results are shown in Figure 3-5-8 and Figure 3-5-9. No overloading occurred to the sections in questions; however, voltage exceeded the maximum allowable voltage (1.10pu) at 110kV buses of textile industrial complex substation, existing Tashkent CHP Plant, and new switching station. The three generators of GTCS and the generator of the existing Tashkent CHP Plant would be operated at leading power factor even if the terminal voltages of the generators were raised up to the maximum limit (1.05pu).

(4) Summer light load condition

A) Normal operation condition

Power flow and voltage analysis results are shown in Figure 3-5-10. Same as in normal operation condition at winter light load condition, no overloading occurred to the sections in questions; however, voltage exceeded the maximum allowable voltage (1.10pu) at 110kV buses of textile industrial complex substation, existing Tashkent CHP Plant, and new switching station since the bus boltage at Yuksak substation was set to the upper limit of the system voltage and not enough amount of reactive power was consumed due to light load. The three generators of GTCS and the generator of the existing Tashkent CHP Plant would be operated at leading power factor even if the terminal voltages of the generators were raised up to the maximum limit (1.05pu).

B) N-1 contingency condition

Power flow and voltage analysis results are shown in Figure 3-5-11 and Figure 3-5-12. Same as in N-1 contingency condition at winter light load condition, no overloading occurred to the sections in questions; however, voltage exceeded the maximum allowable voltage (1.10pu) at 110kV buses of textile industrial complex substation, existing Tashkent CHP Plant, and new switching station. The three generators of GTCS and the generator of the existing Tashkent CHP Plant would be operated at leading power factor even if the terminal voltages of the generators were raised up to the maximum limit (1.05pu).

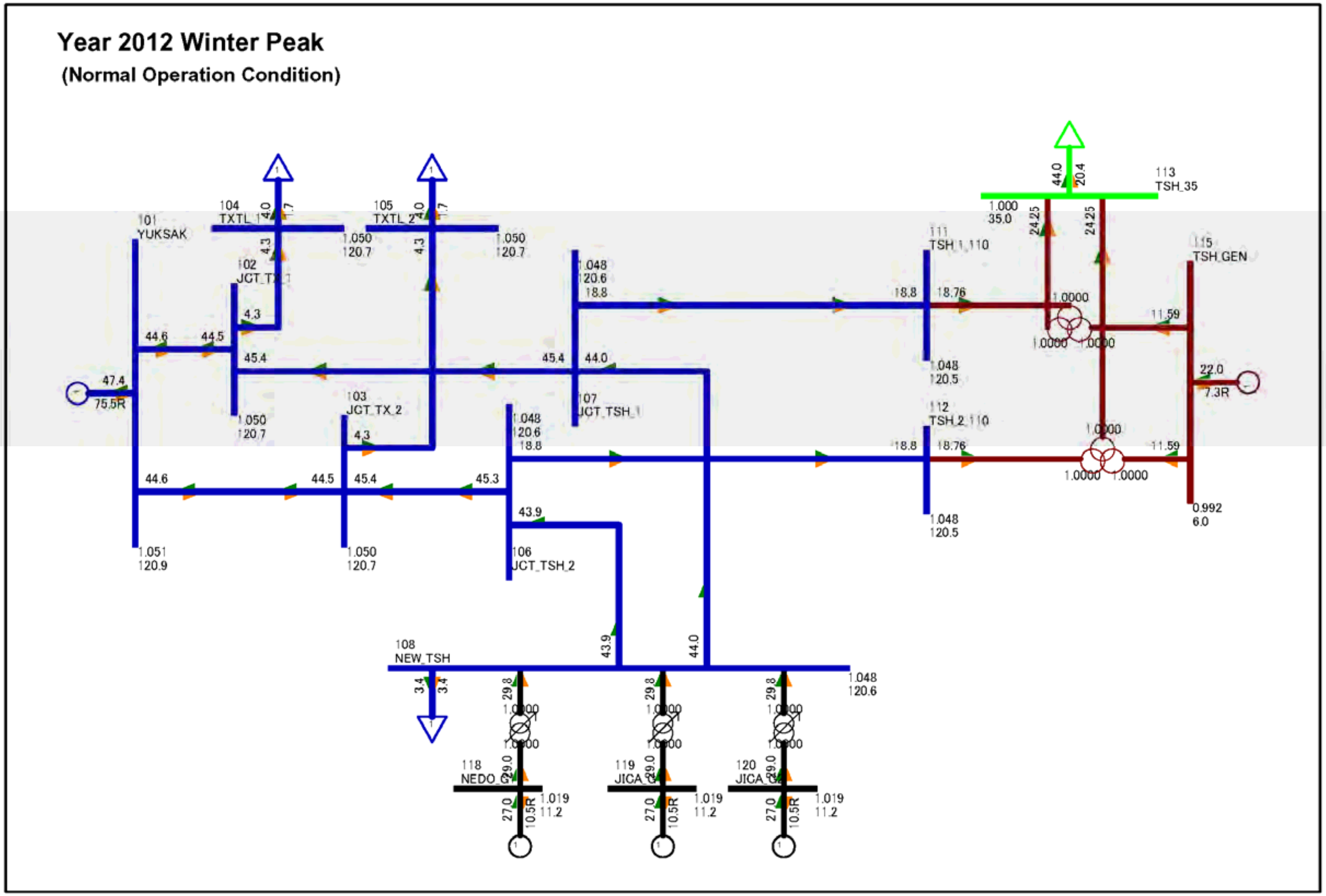


Figure 3-5-1 Power Flow and Voltage Analysis Results (Winter peak load, N-1 contingency condition)

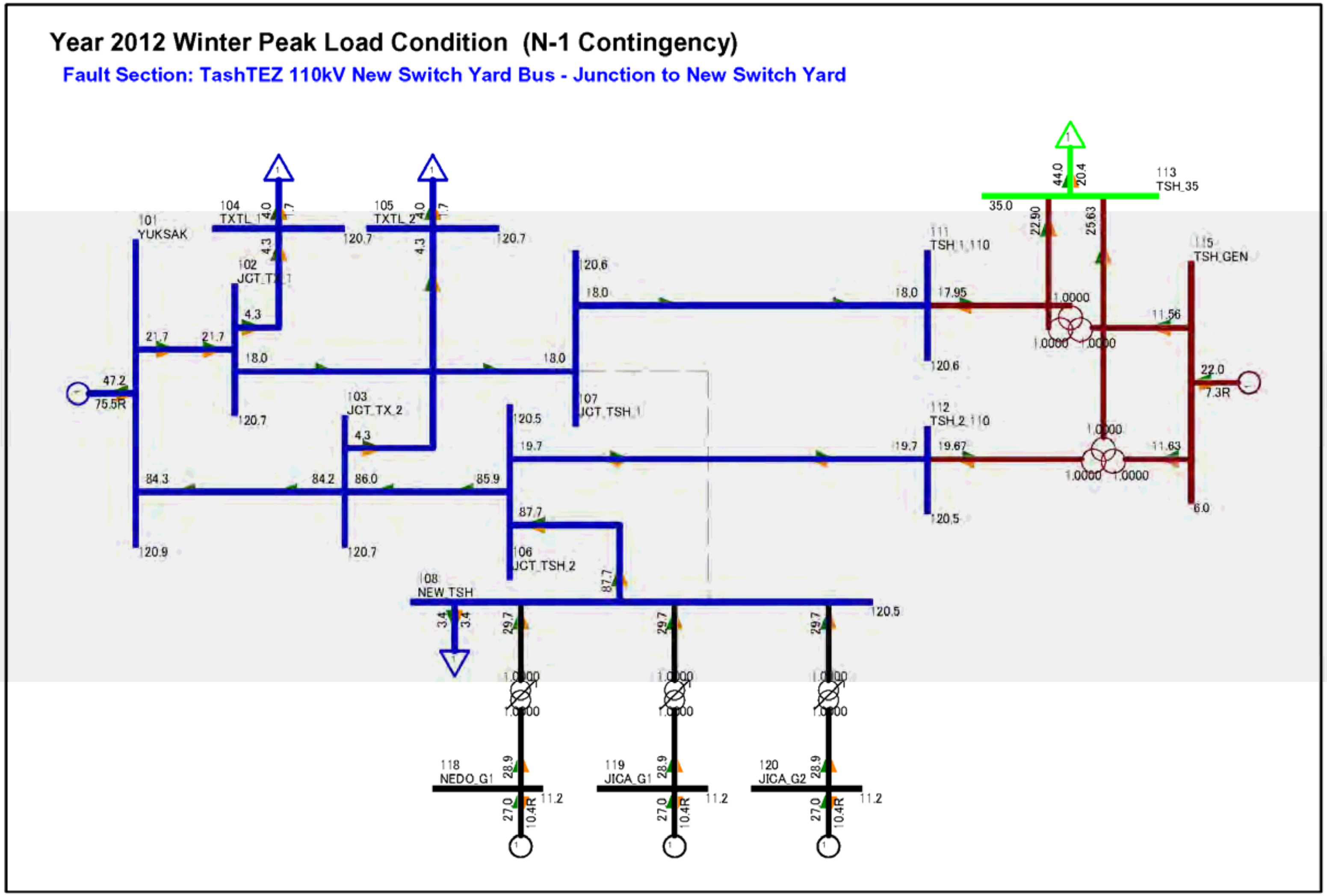


Figure 3-5-2 Power Flow and Voltage Analysis Results (Winter peak load, N-1 contingency condition)
Fault Section: Junction Tower – New Switching Station

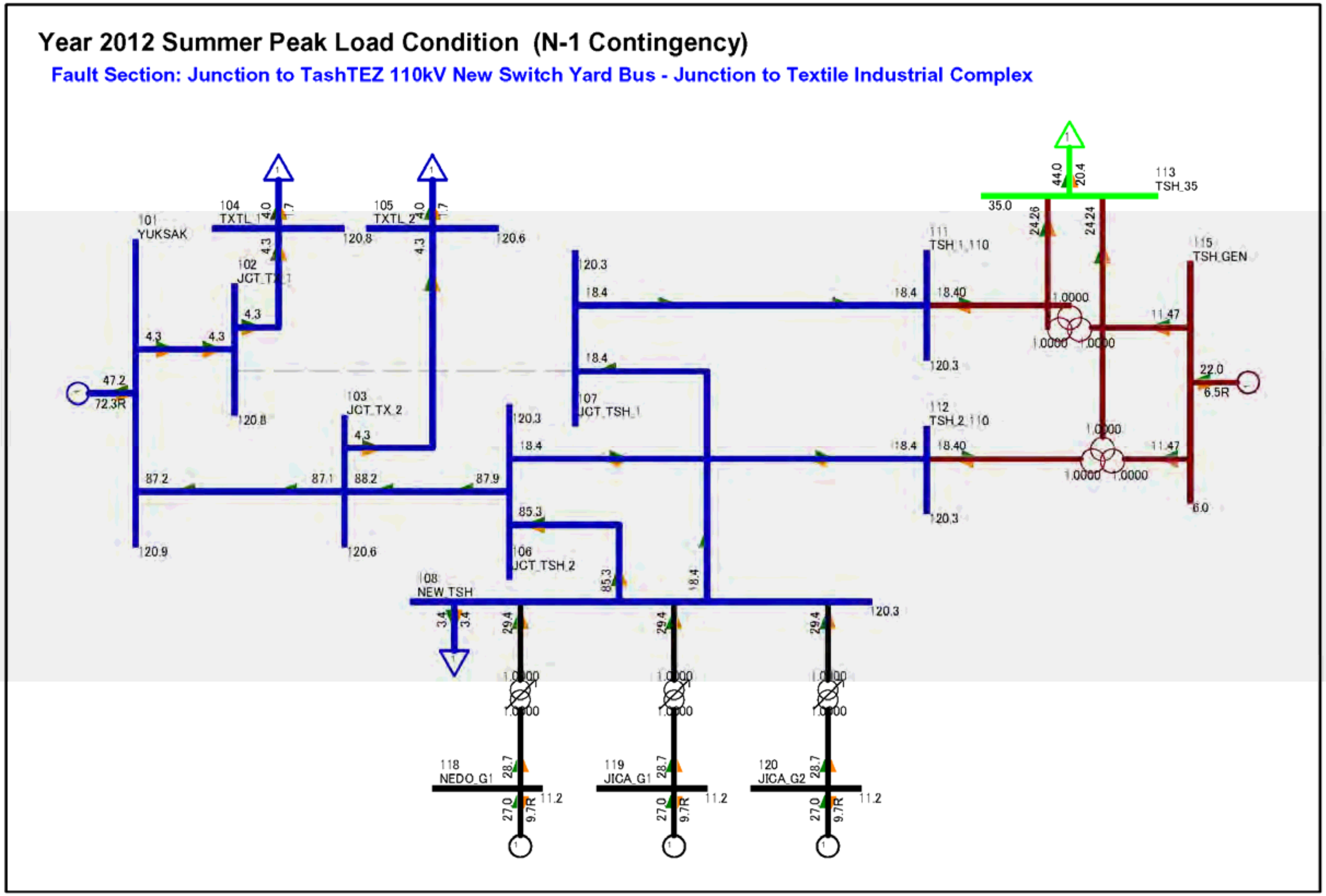


Figure 3-5-3Power Flow and Voltage Analysis Results (Winter peak load, N-1 contingency condition)
Fault Section: Junction Tower – Junction Tower to Textile Industrial Complex

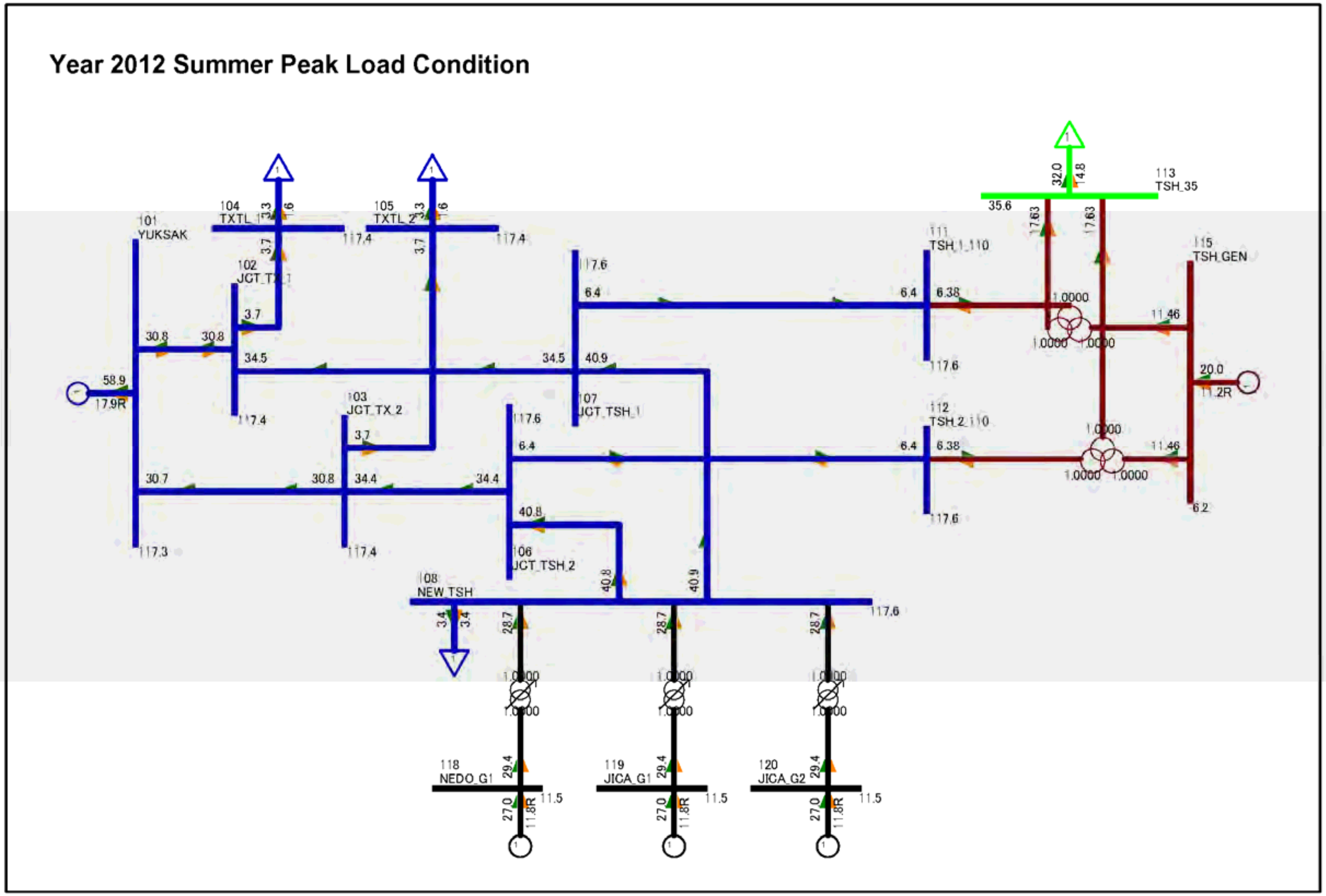


Figure 3-5-4 Power Flow and Voltage Analysis Results (Summer peak, normal operation condition)

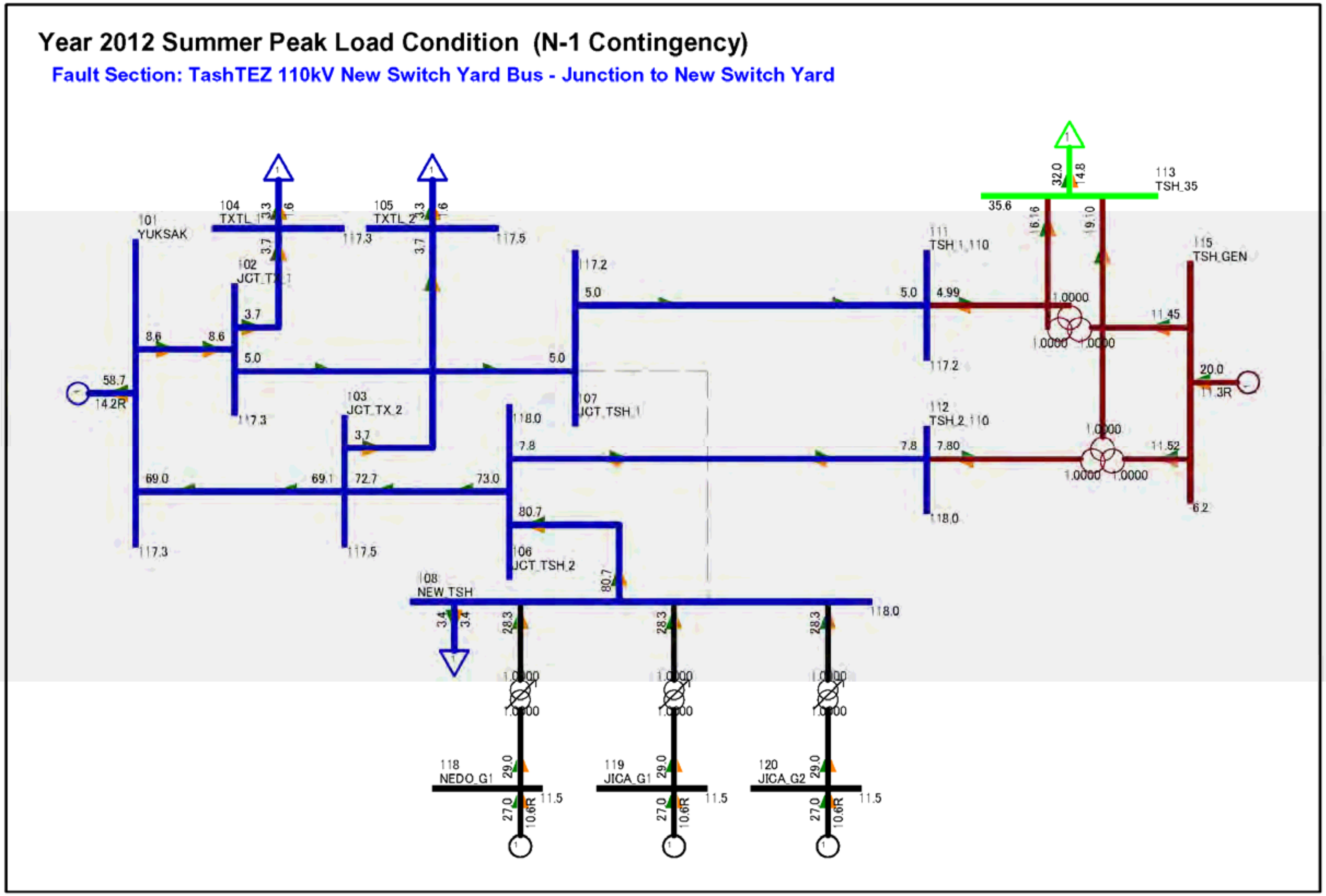


Figure 3-5-5 Power Flow and Voltage Analysis Results (Summer peak load, N-1 contingency condition)

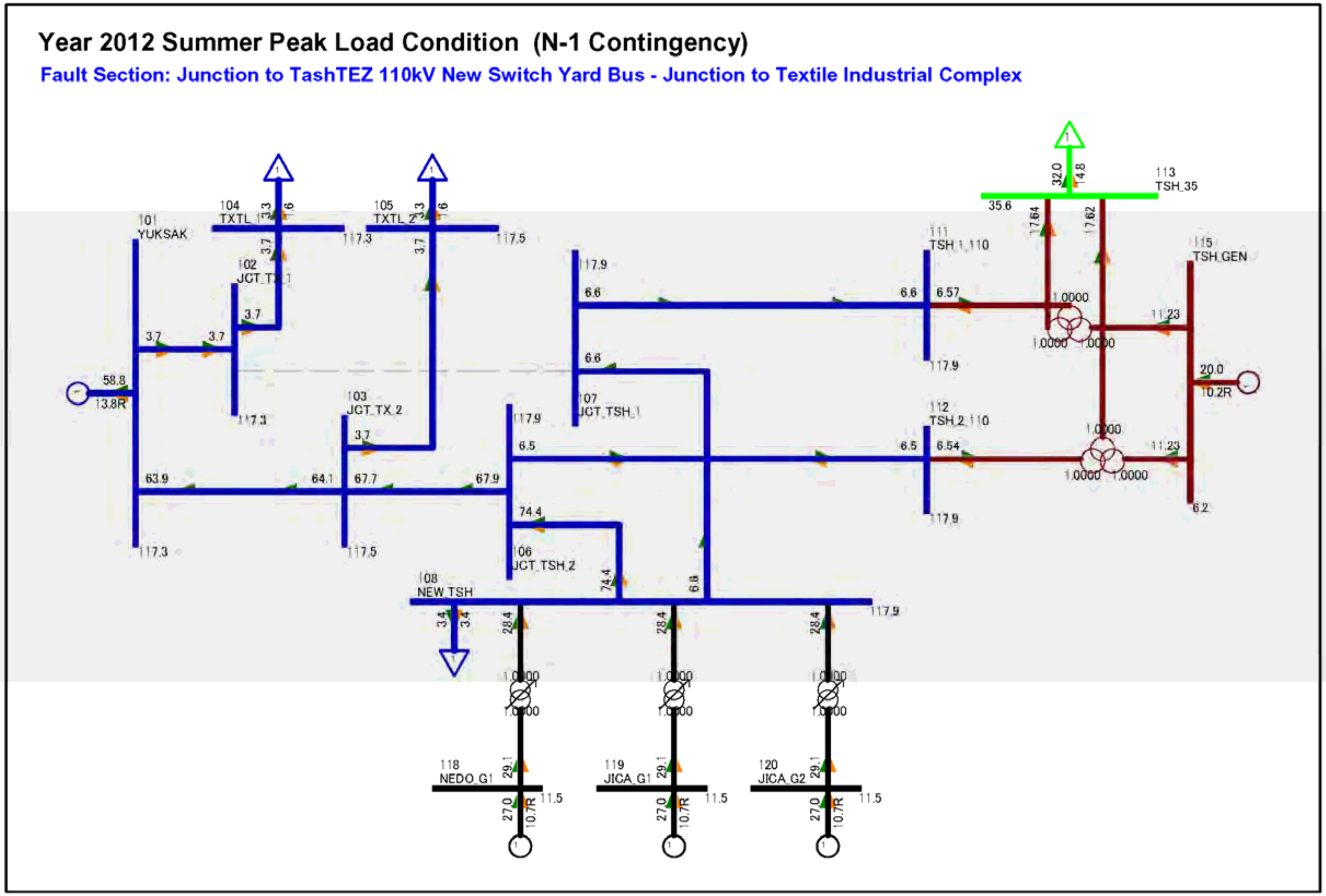


Figure 3-5-6 Power Flow and Voltage Analysis Results (Summer peak load, N-1 contingency condition)

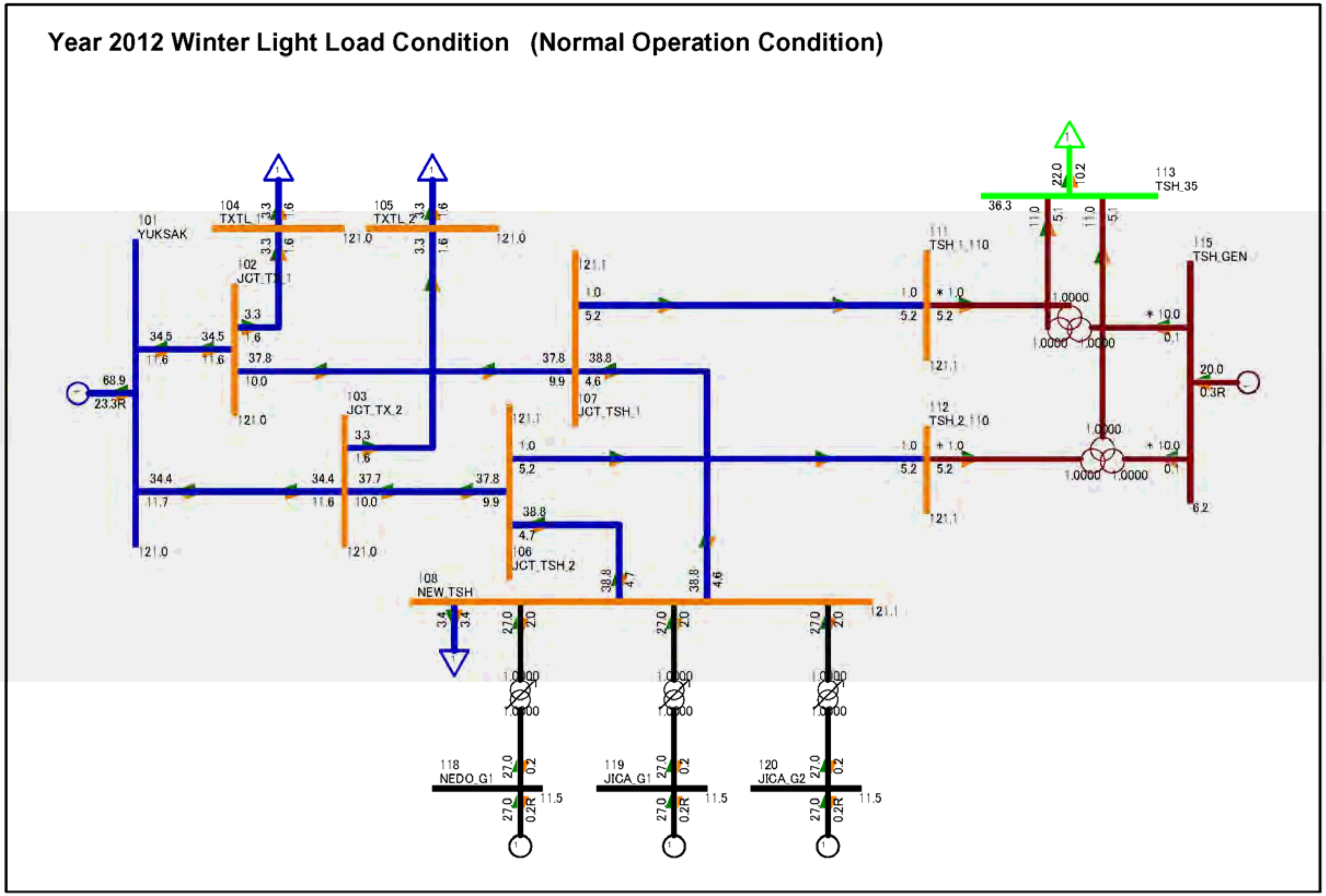


Figure 3-5-7 Power Flow and Voltage Analysis Results (Winter light load, normal operation condition)

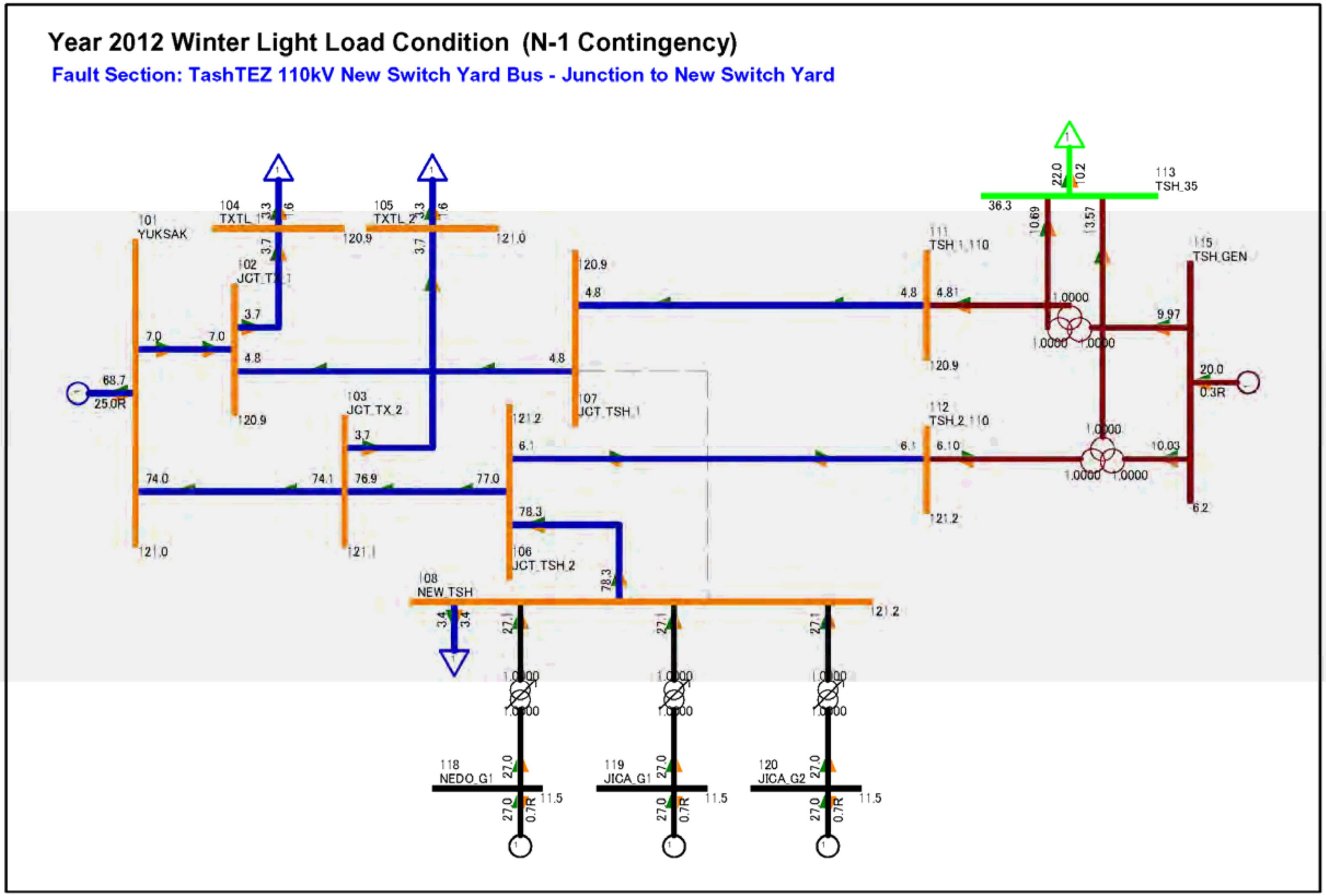


Figure 3-5-8 Power Flow and Voltage Analysis Results (Winter light load, N-1 contingency condition)

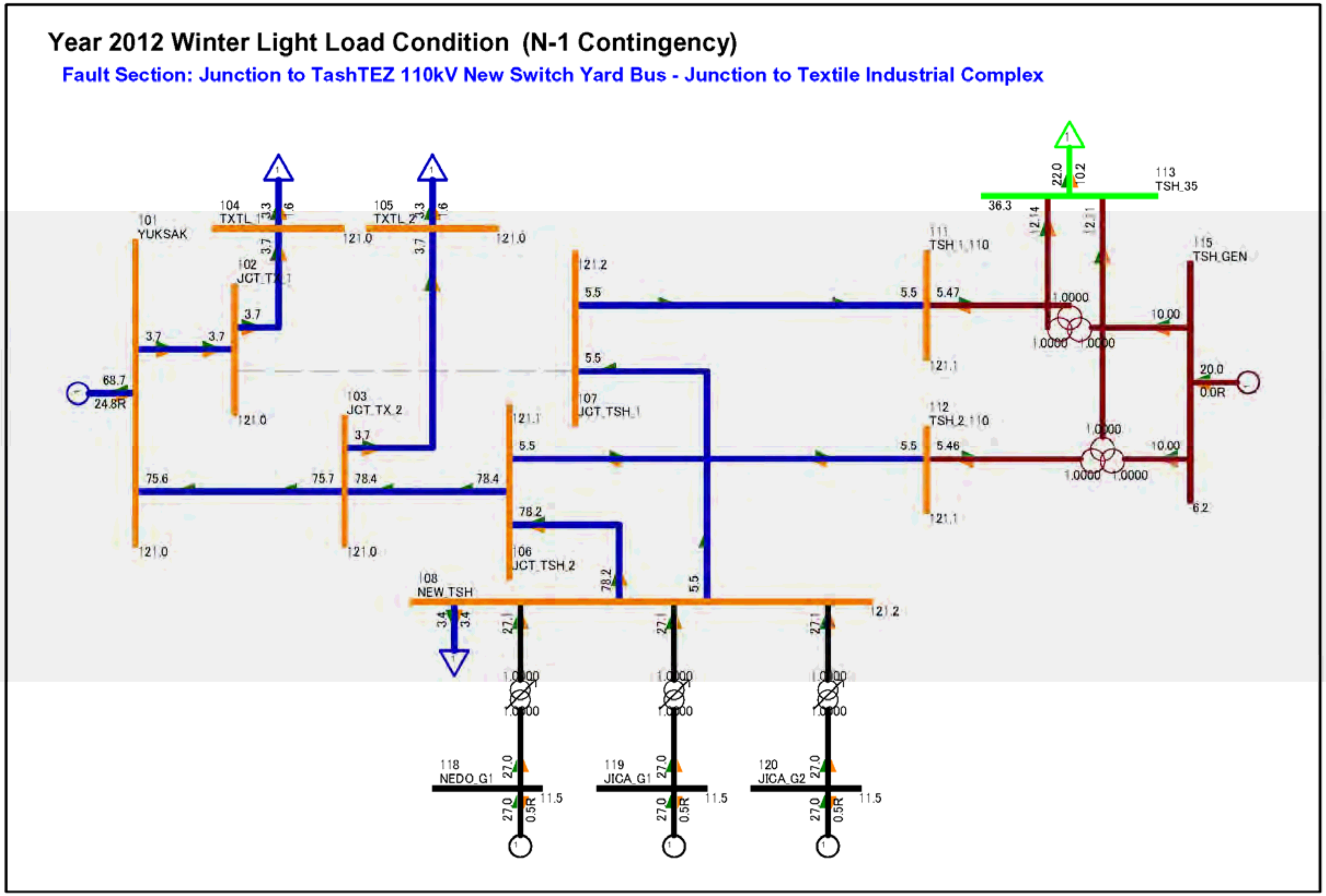


Figure 3-5-9 Power Flow and Voltage Analysis Results (Winter light load, N-1 contingency condition)

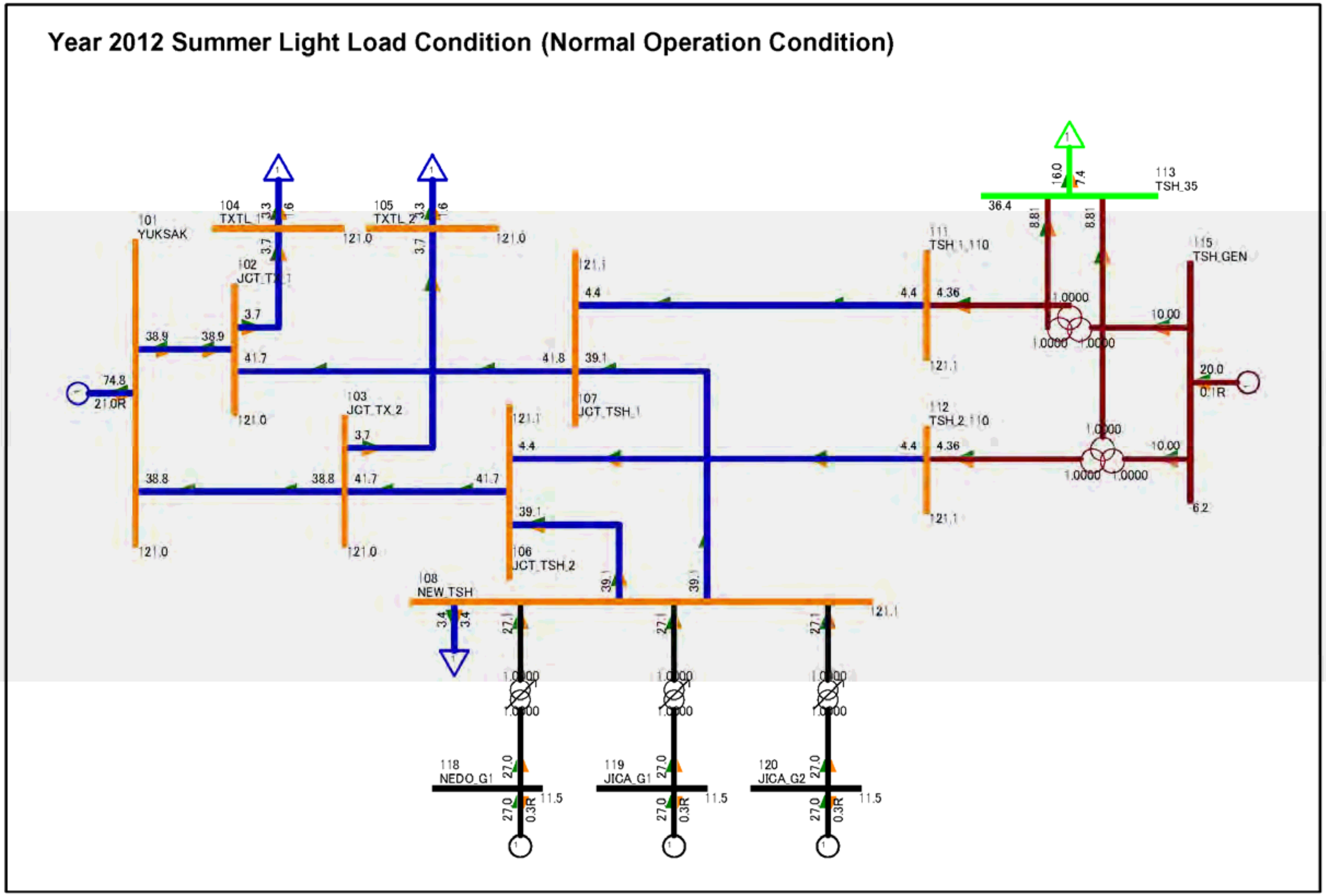


Figure 3-5-10 Power Flow and Voltage Analysis Results (Summer light load, normal operation condition)

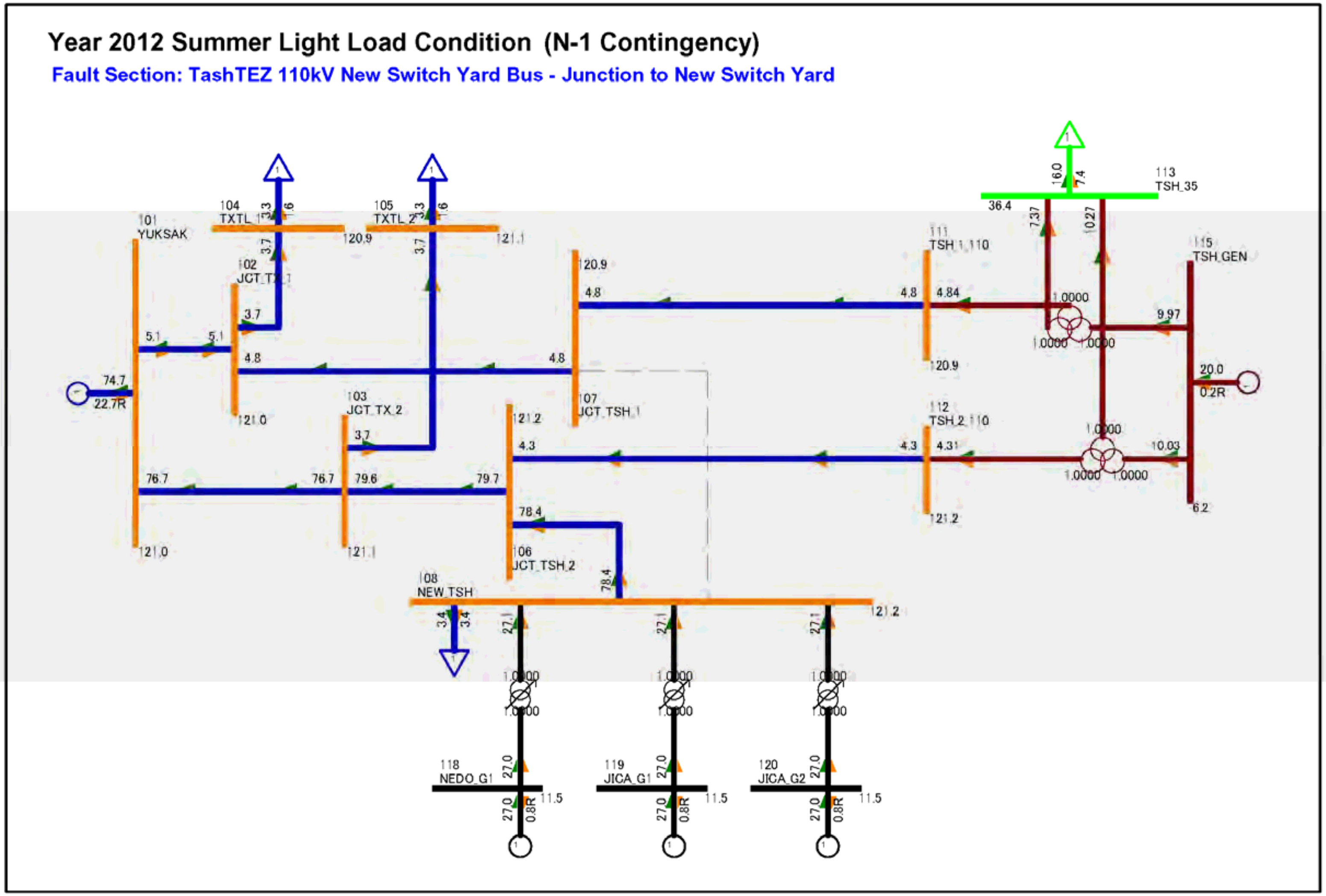


Figure 3-5-11 Power Flow and Voltage Analysis Results (Summer light load, N-1 contingency condition)
Fault Section: Junction Tower – New Switching Station

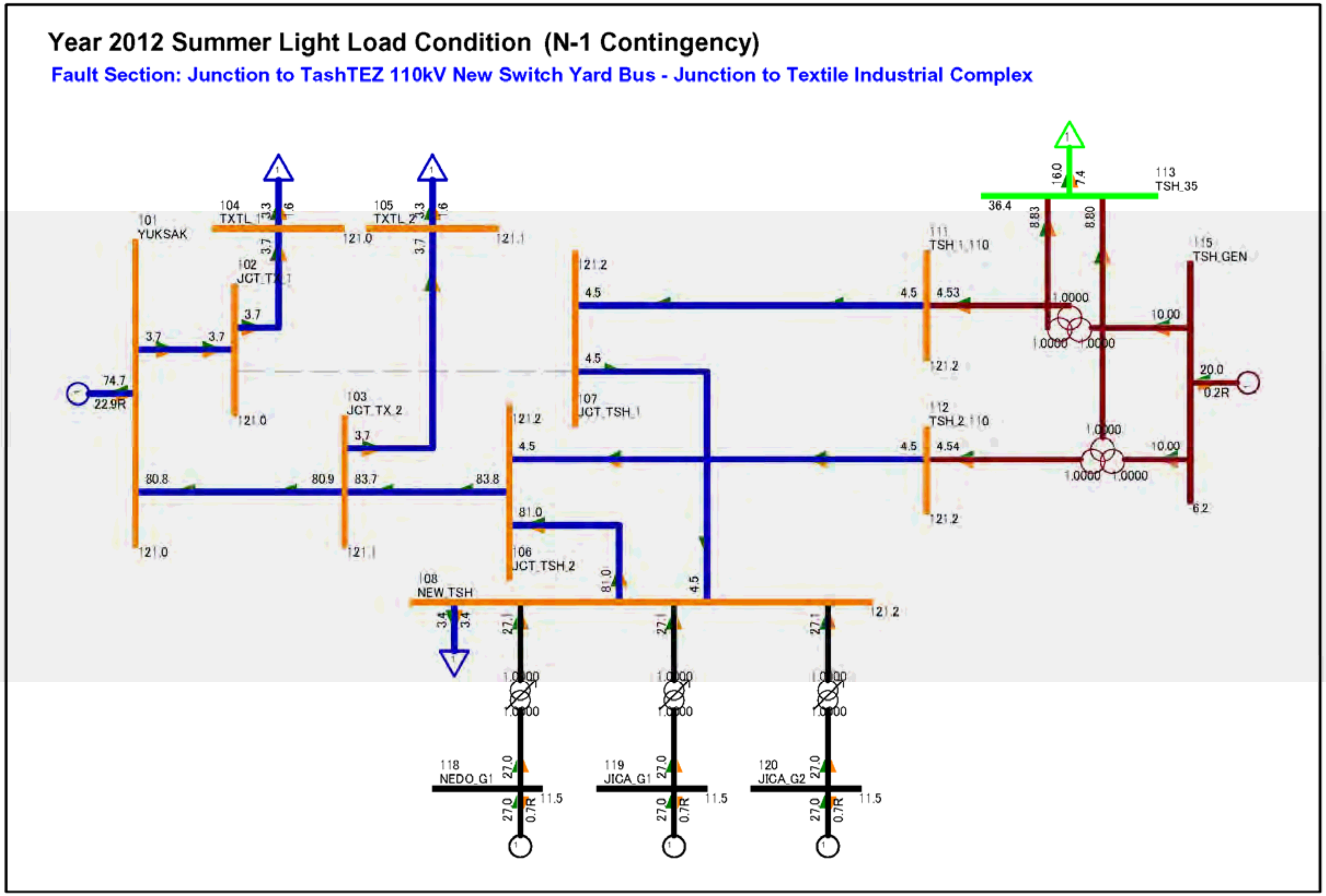


Figure 3-5-12 Power Flow and Voltage Analysis Results (Summer light load, N-1 contingency condition)
Fault Section: Junction Tower – Junction Tower to Textile Industrial Complex

3.6 Fault Current Analysis

3 phase short-circuit current and 1 line-to-ground fault current were calculated for the 110kV transmission system taking into consideration connection of 3 GTCS by both NEDO and this projects.

3.6.1 Analysis Results

Three-phase short-circuit current and single-line-to-ground fault current of the 110kV buses at Yuksak substation, textile industrial complex, existing Tashkent CHP Plant, and the new switching station are shown in Table 3-6-1. The three-phase short-circuit fault current and single-line-to-ground fault currents increased by 3.1～5.4kA and 2.9～6kA, respectively; however, still within the rated capacity of 110kV equipment (30kA).

Table 3-6-1 Fault Current Analysis Results

Substation/Power Plant	3 phase short-circuit fault current (A)		Difference (A)	Single line-to-ground fault current (A)		Difference (A)
	w/o GTCS	w/ GTCS		w/o GTCS	w/ GTCS	
Yuksak	20,282	23,392	3,110	20,427	23,384	2,957
Textile Industrial Complex	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 and Recommendations

Power flow and voltage analysis results showed that AC-185 has sufficient transmission capacity (79MVA: normal operation condition, 95MVA: emergency condition) for the section between T-junction and new switching station. In light load condition, the whole power system is operated with relatively high voltage and bus voltages may be likely to exceed the maximum allowable voltage. Under the assumed severest condition that the voltage of Yuksak 110kV bus rises up to the maximum allowable voltage of 121kV, voltage would exceed the maximum allowable voltage (1.10pu) at 110kV buses of textile industrial complex substation, existing Tashkent CHP Plant, and new switching station. The three generators of GTCS and the generator of the existing Tashkent CHP Plant would be operated at leading power factor. To resolve these issues, installation of shunt reactors to some substation buses, and transformer tap adjustment at Yuksak substation should be considered according to significance of overvoltage. Also, further study on generator operation for both NEDO and JICA projects, such as control of power output in light load condition should be considered.

Chapter 4 Survey on assisting the preparation of EIA

Table of Contents

Chapter 4 Survey on assisting the preparation of EIA

In regard to the Environmental Impact Assessment (EIA) for JICA Project planned for Tashkent CHP Plant, although the description items for Environmental Impact Statement (EIS) and related laws were identified by Phase 1 survey, the obtained data on the items were not sufficient for EIS development.
Consequently, the purposes of this survey are; to assist the development of the Environmental Impact Statement compliant to “JBIC Guideline for Environment and Social Consideration” (April 2002) and Uzbekistan domestic law, to collect the data of the present environmental level, such as ambient air quality, water quality, and noise, and estimation result thereof using calculation model and the necessary data for estimation, as appropriate, and to review the mitigation measures and monitoring plan against environmental impact during construction and operation.
Additionally, the result of the review will be compiled in a report for development and approval of the EIS to be approved in the Republic of Uzbekisntan, and the outline of the content and schedule of the public hearing will be confirmed with the relevant authority.

4.1 Current Situation of the air /water quality, noise and such

4.1.1 Current situation of 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 the Republic of Uzbekistan.
Fig. 4-1-1 shows the ambient air quality monitoring point near Tashkent CHP Plant.

Table 4-1-1 describes the monitoring result from 2006 to 2008 at this monitoring point, obtained from TEP. NO2 emitted by the Project is from 0.05 to 0.06 mg/m3 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 exceeds the MAC in the Republic of 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 Plant to be high.

Contamination level with CO and soot slightly exceeds MAC in the Republic of Uzbekistan, whereas sulphur dioxide is in a favourable level.

This project is based on the gas turbine using gas for power generation. Although environmental impact by contaminant other than nitrogen dioxide is not assumed, the actual high level of nitrogen dioxide should be taken care of.

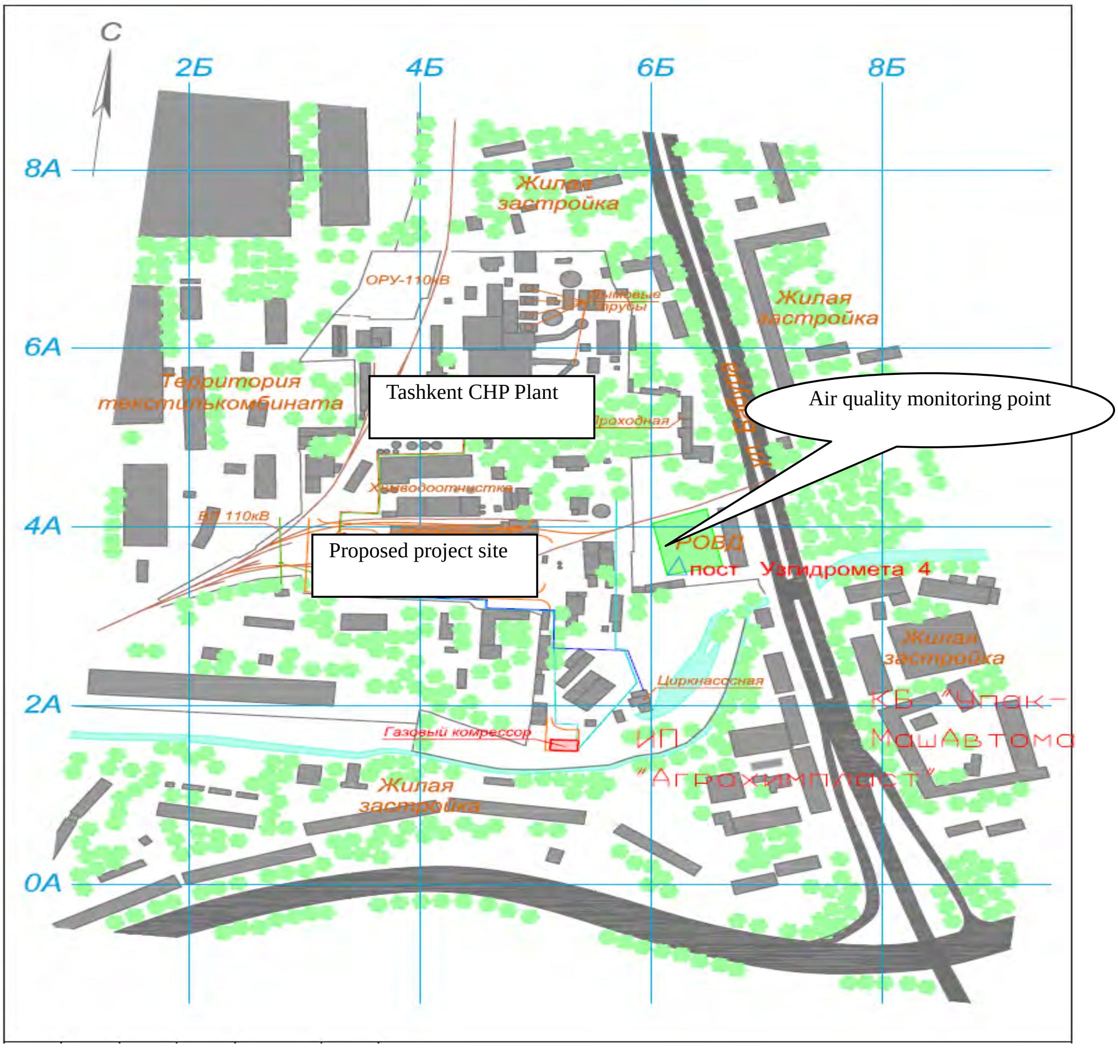


Fig.4-1-1 Ambient air quality monitoring point

Table 4-1-1 Measuerment Result and MAC of Ambient Air Contaminants

Contaminant	2006 mg/m³		2007 mg/m³		2008 mg/m³		Maximum measured value/MAC	Ratio of Maximum allowable concentration in the Republic of Uzbekistan（MAC） mg/m³(30 min.value)※1	IFC Environmental, Health and Safety (EHS) general guideline (2007) mg/m³ ※2
	Average	Maximum	Average	Maximum	Average	Maximum			
Nitrogen dioxide （NO_2）	0.05	0.24	0.06	0.25	0.06	0.37	3.41	0.085	0.2(1hour value) 0.04(1year value)
Nitrogen oxide （NO）	0.04	0.18	0.04	0.19	0.05	0.19	0.28	0.6	—
Sulphur dioxide （SO_2）	0.018	0.06	0.004	0.029	0.004	0.023	0.07	0.5	0.5(10min. value) 0.125(24hour value)
Carbon oxide （CO）	1.0	10.0	1.0	5.0	1.0	8.0	1.54	5.0	—
Soot (PM)	0.2	1.7	N/A	N/A	0.2	0.9	1.60	0.15	0.15（24hour value） 0.07（1year value）

（Note）

1. Sanitary norms, rules and hygiene normative documents of the Republic of Uzbekistan. SanPiN No. 0015-94.
2. World Health Organization (WHO): Guidelines for Air Quality 2005

4.1.2 Current situation of Water Quality

The effluent from Tashkent CHP Plant is discharged into Sarah River, a small river running from east to south adjacent to CHP, through 2 outlets.
Water quality monitoring is regularly conducted at the 2 outlets of the Tashkent CHP Plant 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 Plant shown in Table 4-1-2, the water of the rivers receiving effluent is turbid, significantly contaminated with nitrogen and phosphorus, with higher concentration than in the effluent. Fig.4-1-2 shows the significant turbidity of the present river water.
Hence, concentrations of pollutants after discharge from Tashkent CHP Plant is lower downstream compared to upstream, due to dilution.

Table 4-1-2 Water quality measurement result of effluent and river water at Tashkent CHP Plant（2008）

Item	Unit	MAC set for discharge from Tashkent CHP	Measurement result			
			River water upstream of outlet	Effluent1	Effluent 2	River water downstream of outlet
Water temperature	℃	Not exeed the 10 years maximum monthly average by 5℃	16.6	35.3	24	18.5
pH	－	6.5-8.5	7.78	7.96	7.5	7.7
Dissolved oxygen（DO）	mg/l	4－6 or more	6.9	5.8	6.5	6.6
Suspended solids（SS）	mg/l	15	26	14.1	14.1	24.3
ammonia nitrogen	mg/l	0.5	0.68	0.39	0.47	0.6
Nitrate nitrogen	mg/l	9.1	4.7	3.4	3.5	4.3
Nitrous nitrogen	mg/l	0.02	0.075	0.02	0.019	0.05
nitrate nitrogen	mg/l	0.3	0.55	0.3	0.29	0.47

Fig. 4-1-2 Present water condition in the small river (Sarah River) recieving effluent discharge

4.1.3 Current situation of Noise

It was confirmed that no noise measurement has been conducted in and around Tashkent CHP Plant site. The noise level in daytime was measured in four points 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 the Republic of Uzbekistan.

Table 4-1-3 Noise level measurement result in proposed Tashkent CHP Plant modernization site（Mesured in daytime, September 9）

Measurement point	Noise level	Uzbekistan Environmental standard		IFC EHS General Guidelines(2007)	
		day	night	day	night
West side of new gas turbine installation site（transmission line side）	54.7～56.8dB (A)	55dB(A)	45dB(A)	55dB(A)	45dB(A)
South side of new gas turbine installation site（adjecent textile factory side）	42.6～44.3dB(A)				
Apartment adjacent to Gas compressor installationsite (10 floors)	45.1～46.3dB(A)				
North side of new gas turbine installation site（existing facility side）	72.5 ～ 72.6dB(A)(machine measurement 1m : 73.1 ～73.5dB (A))				

Note that gas compressors will be installed to meet the necessity to provide compressed gas needed as fuel for gas turbine.

The gas compressor will be located at the south end of Tashkent CHP Plant, adjacent to a 10-floor apartment to the south. Therefore, the adequate mitigation measure for noise impact should be considered.

The location of the new compressor and the nearby apartment is described in Fig. 4-1-3, and the external view of the apartment is shown in Fig. 4-1-4.

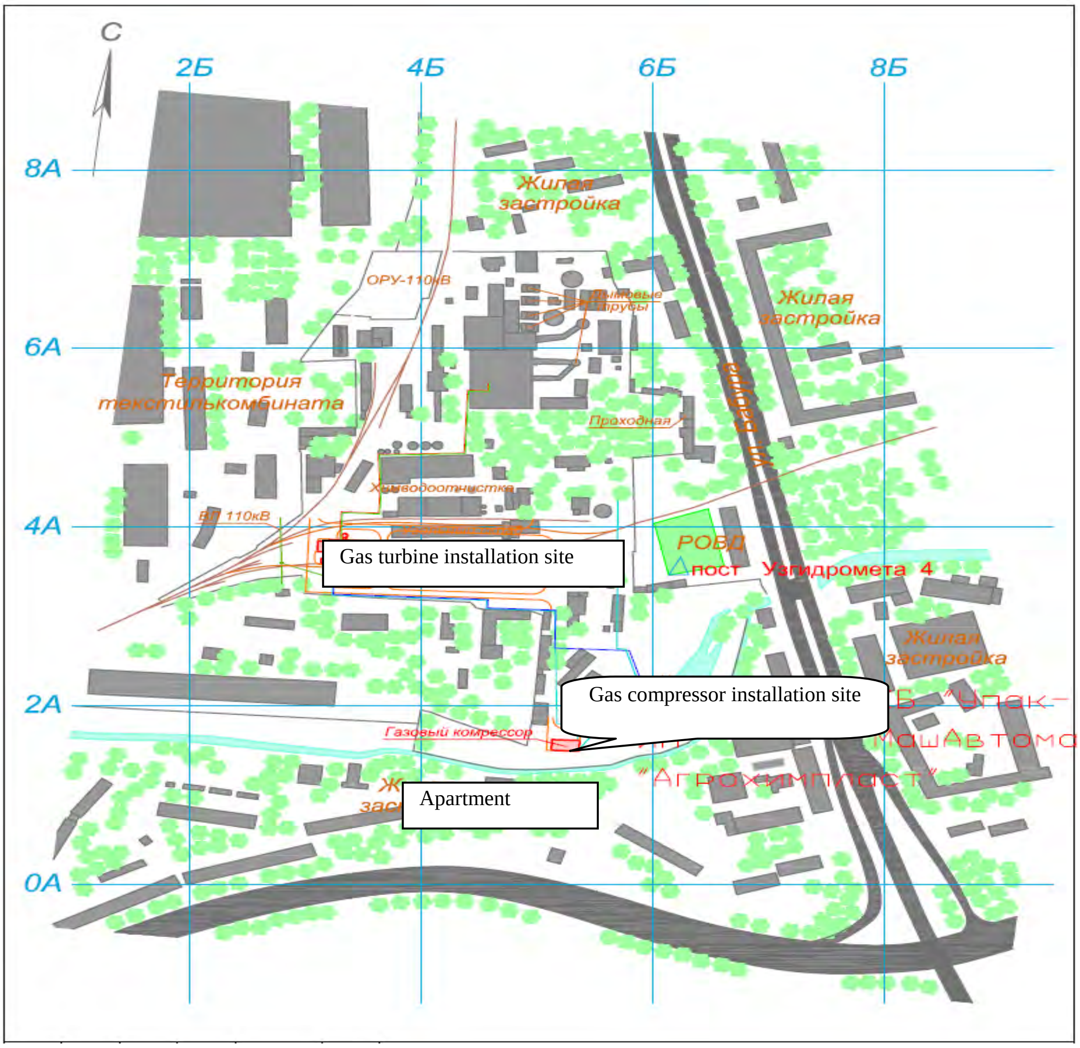


Fig.4-1-3 The location of the new compressor

Fig.4-1-4 External view of the southside apartment from the Tashkent CHP

4.1.4 Vegetation

Vegetation at the Tashkent CHP Plant and in adjacent areas is significantly well organized with plantation of ornamental tree and fruit trees.
Fig. 4-1-5 describes the typical example of planting around the existing plant site.

According to the vegetation survey conducted by TEP, there are plantings of plane, poplar, ailanthus, apricot tree, apple tree, cherry tree and others, assumingly providing habitat for bird species.

On the other hand, the proposed gas turbine installation site is mainly desert land exuberant with herbaceous species, and little concern is needed for environmental impact for flora and fauna.

Fig. 4-1-6 shows the present state of the proposed gas turbine installation site.

Fig. 4-1-5　Planting in the existing plant area

Fig. 4-1-6 Present state of the proposed gas turbine installation site

4.2 Estimation result of Ambient Air Quality and Noise Level

4.2.1 Estimation result of Ambient Air Quality

(1) Estimation result of Ambient Air Quality in EIS

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 facilities in operation
- The contribution concentration of the 3 newly installed gas turbines in operation
- The contribution concentration of the future facilities (existing facilities except Boilers No.2-4 + 3 new gas turbines) in operation

The data of emission parameter used in this estimation are shown in Table.4-2-1 and 4-2-2. The NOx concentration in emission gas of the Project facility meets internationally approved IFC standard.

Table 4-2-1 Emission data of the new facility

Parameter	Unit	NEDO 1unit	JICA 2units
		Natural gas	Natural gas
fuel consumption rate	Nm3/h	9420	9420
Normal volume of Exsaust gas (wet)	Nm3/h	220×103	220×103
volume of Exsaust gas (wet)	m3/s	101.463	101.463
Temperature of Exhaust gas	°C	180	180
Speed of Exhaust gas	m/s	5.2	5.2
Actual stack height	m	60	60
Diameter of upper stack	m	5	5
NO2 emission	g/s	2.211	2.211
NO emission	g/s	0.359	2.211
SO2 emission	g/s	0.378	0.378

Note: the values are per unit.

Table 4-2-2 Emission contentration and IFC EHS standard of NOx

Parameter	New unit (Natural gas)	IFC EHS guideline Themal Power plants(2007)
Emission contentration of NOx	50mg/m^3	50mg/m^3

Note: Emission concentration of NOx is O215% equivalent（Dry gas base）.

Table4-2-3 and Fig. 4-2-1 describes the estimated NO2 level. 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 facility.

The installation of new gas turbines equipped with appropriate mitigation measure and the demolition of the old boilers No.2-4 will contribute much to the improvement of ambient air quality: the present contribution concentration of 0.060mg/ m3 will decrease approximately 30%t to 0.043 mg/ m3.

Table 4-2-3 Maximum ground concentration of NO_2(mg/ m^3)

Contaminant	MAC	Existing facilities	New facilities	Future facilities
Nitrogen dioxide (NO_2)	0.085	0.060 (0.71MAC)	0.010 (0.12MAC)	0.043 (0.51MAC)

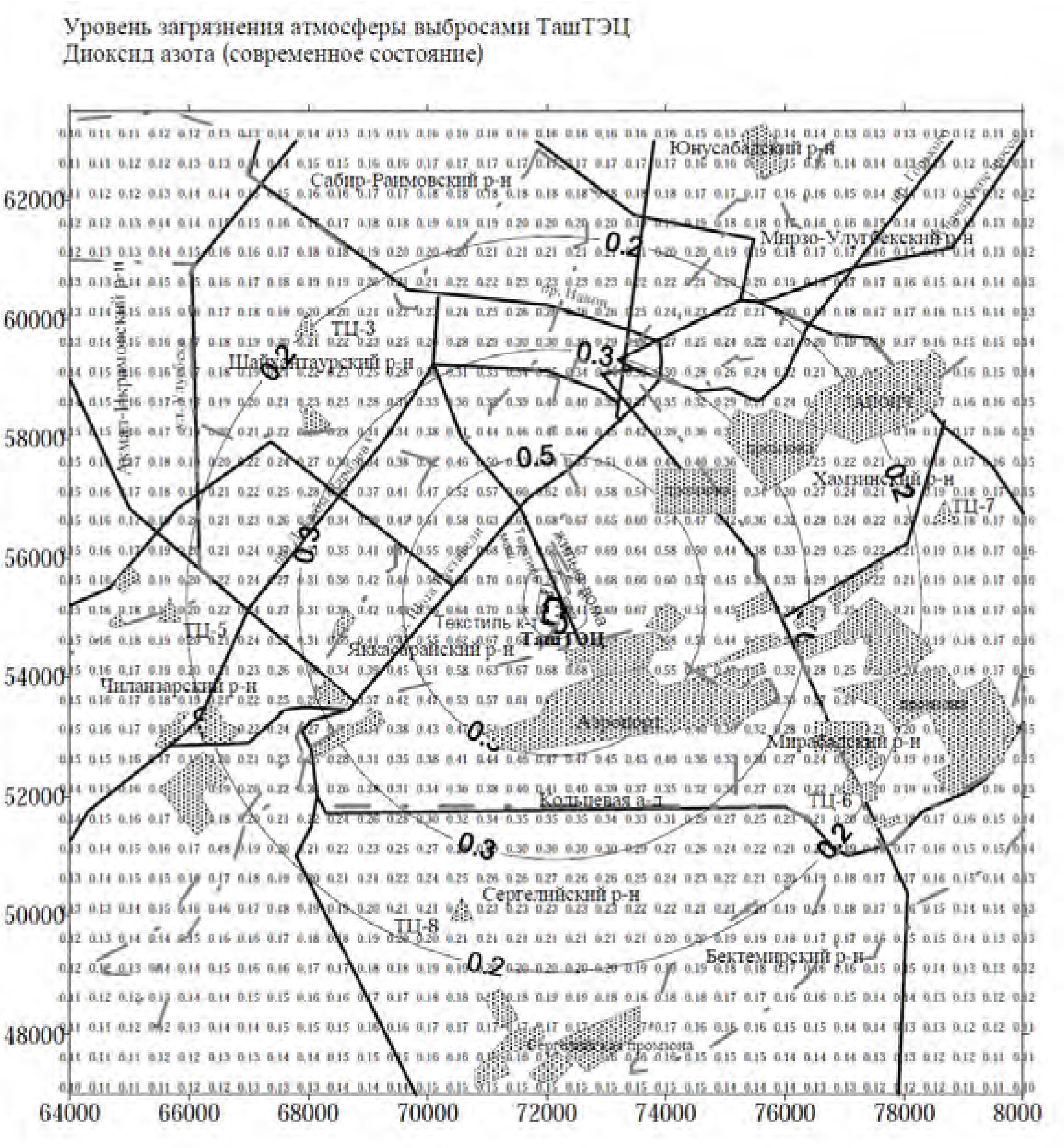


Figure 4-2-1(1) Predction results of ground level concentrarion（Existing facilities）（×MAC）

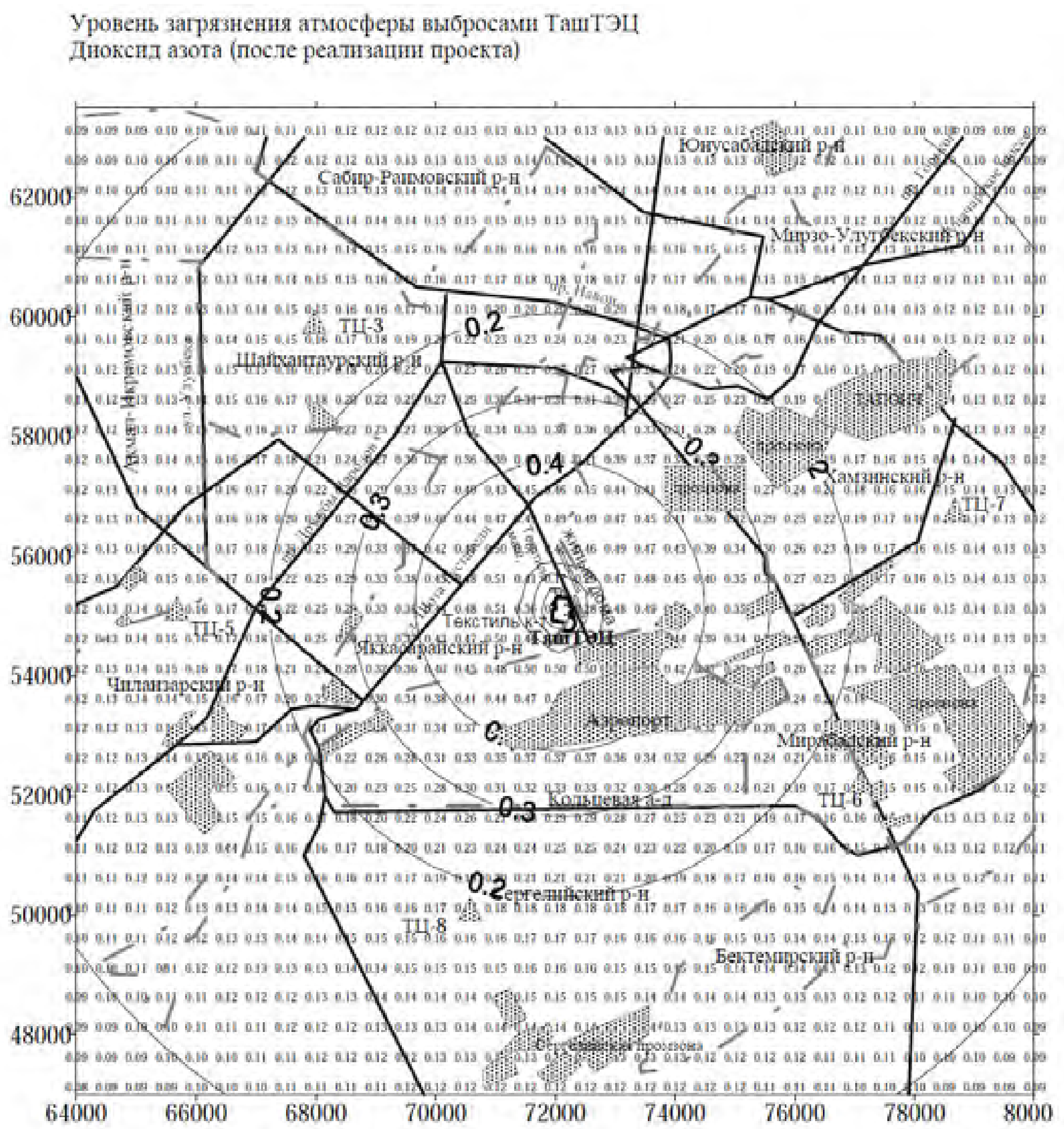


Figure 4-2-1(2) Prediction results of ground level concentrarion
（Future facilities except Boilers No.2-4 ）（×MAC）

However, this estimation is calculated with gas emission speed of 5.2m/s as shown in Table 4-2-1, which is much lower compared to the data of a power plant with general gas turbine. This could be resulted from the stack diameter being too large for the power generation capacity of the facility.

It is said that, in case of lower gas emission speed, if wind speed is 1.5 times higher than emission spped, cavity zone appears at the stack outlet and emission gas does not rise: down wash occurs as described Figure 4-2-2, which may result in higher level of concentration than normal diffusion.

Ground wind speed in the area marks 5m/s in rare occasion (1% occurrence ratio), according to EIS statement, which may mark 8m/s at stack height (60m), causing down wash with high possibility .

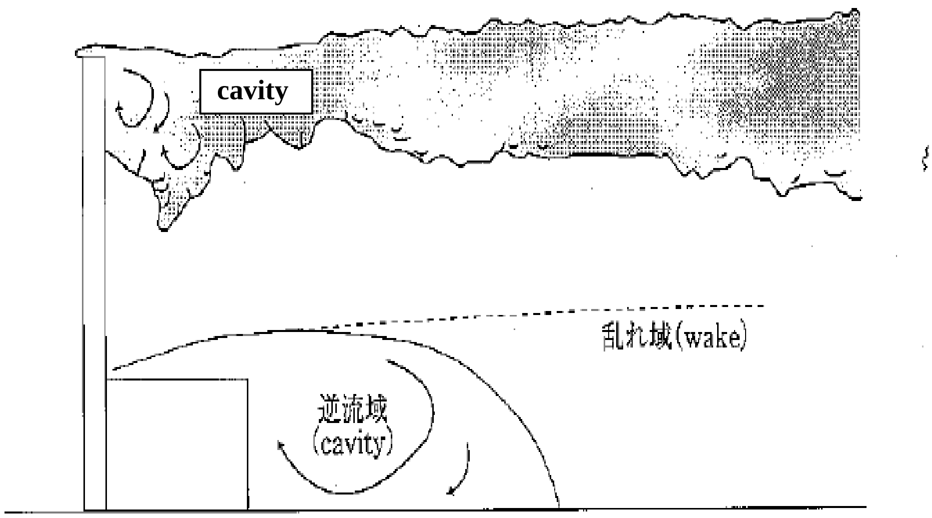


Figure 4-2-2 Dispersion on the down wash

Also, it is described in the EIS that inversion layer occurs near ground surface in Tashkent mainly in winter. The increased emission gas speed will accelerate the updraft of smoke, having effect of mitigating the gas retention near ground surface caused by the inversion layer.

The form of the stack should be improved: the outlet diameter should be made as small as possible to increase the gas emission speed up to 10~20m/s.

As the estimation is calculated using the data obtained through internet, not provided by the survey team, the simulation should be re-implemented based on the corrected data which is more environmentally mitigative, reflecting the actual conditions.

JICA received a request for submitting a formal letter requiring the re-implementation of the simulation from Tashkent CHP Plant at the on-site survey in September. Also, the request for the provision of the specific data on emission gas and such was submitted from TEP, the simulation conducting body, to the survey team.

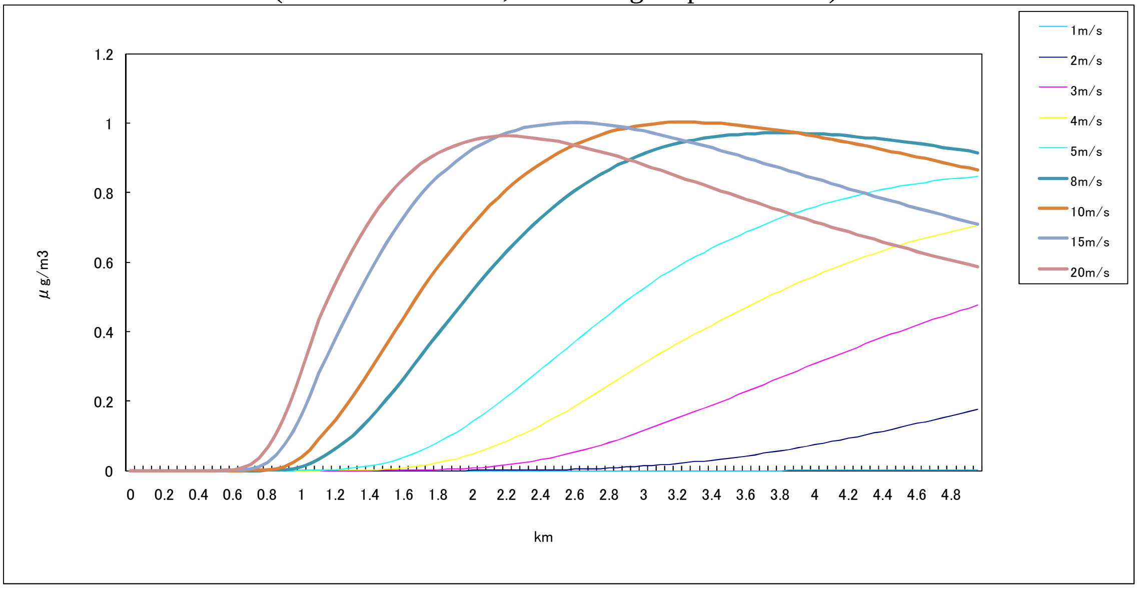
Consequently, a request letter (Appendix-1) was sent on October 21, 2009, from JICA prior to the final on-site survey in October, and at the same time the specific data for simulation was provided from JICA survey team.

(2) Estimation result of Ambient Air Quality using corrected emission data

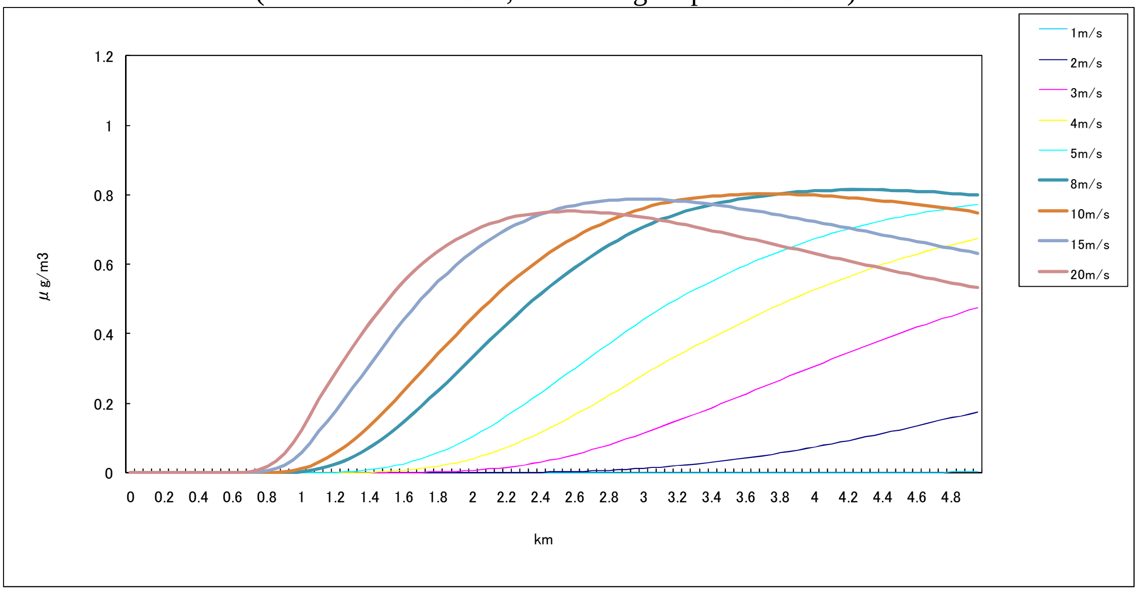
As described in (1), the major modification of data for ambient air simulation is the smaller stack diameter and the resulting acceleration of emission gas speed.
The stack diameter at the outlet is decreased from 5m to 2.8m based on stack installation example in Japan, thereby mitigating environmental impact on ambient air quality.

The comparison of the estimated ambient air quality in case of 5m and 2.8m conducted by the servey team is shown in Fig. 4-2-3. It is confirmed that the impact on ambient air quality is mitigated in case of 2.8m diameter under windspeed of over 8m/s.

(Stack diameter 5m, emission gas speed 5.2m/s)



(Stack diameter 2.8m, emission gas speed 16.5m/s)



Note: 1.Legend in the figure indicates the windspeed condition at the stack outlet.
2. The estimated value is the value per 1 gas turbine.

Fig. 4-2-3 Comparison of predicted atmosphere dispersion (stack diameter 5m/2.8m)

Additionally, it was explained that the diminution of stack diameter and acceleration of emission gas speed has the following merit:

- The increased emission gas speed will diminish the gas retention near ground surface caused by the inversion layer in winter.
- The smaller stack diameter will have economic merit of decreasing the construction cost of stacks.

The data shown in Table 4-2-4 has been provided to TEP for re-implementation of simulation by Uzbekistan authority. Technical questions posed on the data will be answered from JICA team.

The diminution of the stack diameter to 2.8m should be considered in view of the structural design standard in Uzbekistan. If the diminution could not be implemented, it was confirmed that the proposed emission gas speed should be ensured by other means, such as the integration of emission gas into one stack, thereby the simulation is appropriately conducted by TEP.

Table 4-2-4 Corrected Emission data of the newly-built facility

Parameter	Unit	NEDO 1unit	JICA 2units
		Natural gas	Natural gas
fuel consumption rate	Nm^3/h	8445	8445
Normal volume of Exsaust gas (wet)	Nm^3/h	253×103	253×103
volume of Exsaust gas (wet)	m^3/s	116.77	116.77
Temperature of Exhaust gas	°C	180	180
Speed of Exhaust gas	m/s	5.95	5.95
Actual stack height	m	60	60
Diameter of upper stack	m	5	5
NO2 emission	g/s	3.03	3.03
NO emission	g/s	0.49	0.49
SO2 emission	g/s	0.52	0.52

Note: the values are per unit.

The condition of re-implementation and the estimation result will be published as the addtional EIS, as noted in Chapter 4.5, and submitted for the Uzbekistan approval process.

4.2.2 Estimation result of Noise level

(1) Estimation result of Noise level in EIS

The noise level of the 2 new turbines of the Project and the one of NEDO Project is estimated using simulation model. The data used for the estimation is shown in Table 4-2-5.

Table 4-2-5 Power Plant Noise level (dB)

Facility	1/1 octave band center (Hz)							
	63	125	250	500	1000	2000	4000	8000
Stacks	100	83	73	59	57	56	52	42
Integrated air filter	93	86	80	76	73	71	69	68
Building （Gas turbine, HRSG）	99	91	84	77	71	58	45	33

According to the simulation result shown in Fig.4-2-4, 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.

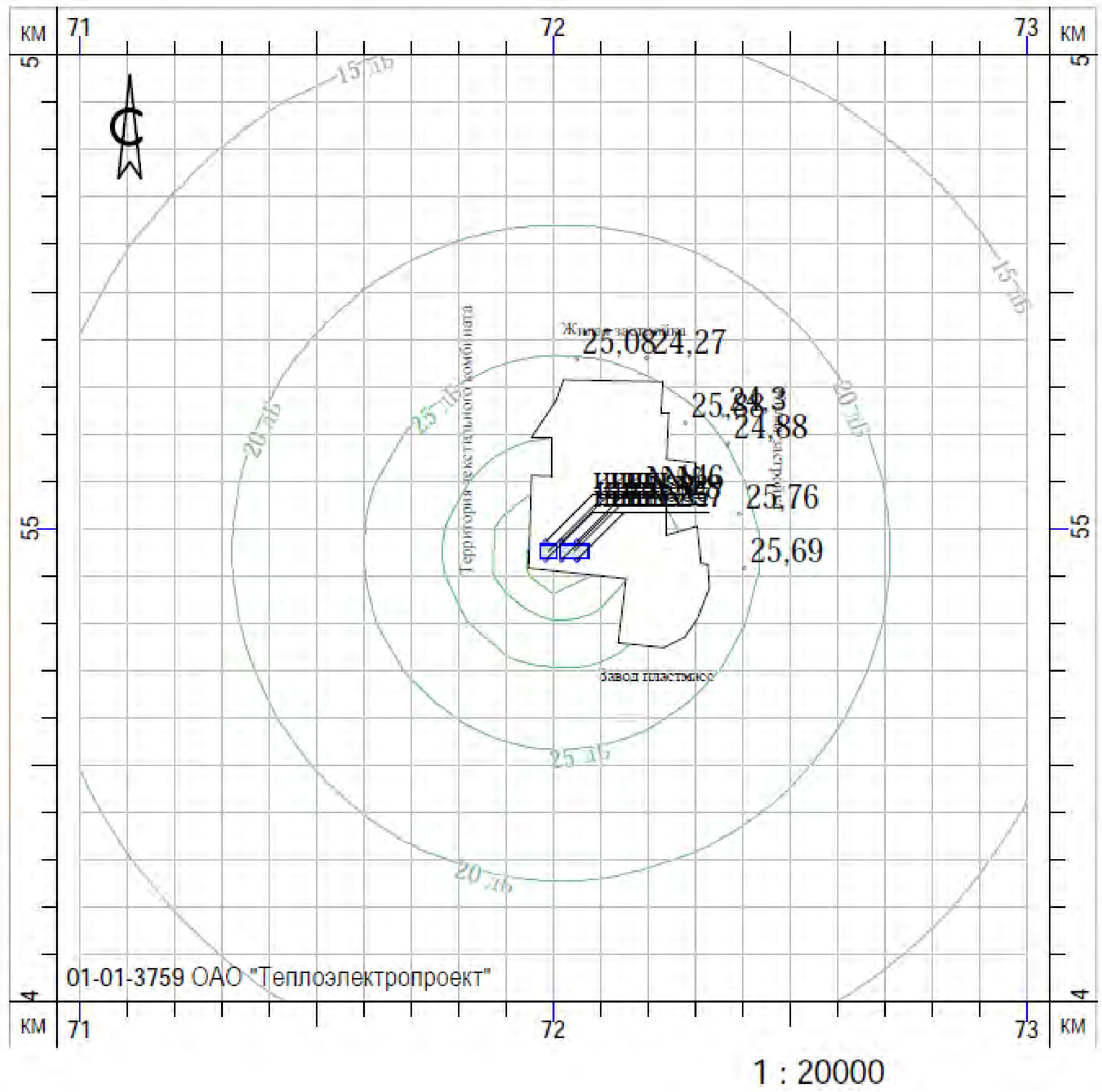


Fig. 4-2-4 Estimated noise level (excluding gas compressor)

However, similar to air quality, since this estimation is based on 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.

Similar to the case of ambient air quality, the simulation should be re-implemented based on the data reflecting the actual conditions. A formal letter of request was submitted by JICA and the specific data was provided from the survey team.

(2) Estimation result of noise level based on corrected data

It was confirmed that the estimation will be re-implemented by TEP based on the new data shown in Table 4-2-6 reflecting the actual condition such as the addition of aforementioned gas compressor as a noise source.

Table 4-2-6 Power Plant Noise Level (corrected)(dB)

Facility	1/1 octave band center (Hz)							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Stacks	76	77	71	68	61	54	52	56
Integrated air filter	81	78	81	83	90	87	85	85
Building （Gas turbine, HRSG）	66	70	73	83	79	75	79	67
Transformer	63	67	72	74	73	73	75	66
Feed-water pump	49	56	68	73	78	81	77	69
Gas compressor	58	59	63	58	50	43	41	34

Note: Values for Bulding and Gas compressor are mitigated by enclosure.

The condition of re-implementation and the estimation result will be published as the additional EIS, as noted in Chapter 4.5, and submitted for the Uzbekistan approval process.

4.3 Selection of the items to be stated in the EIA

4.3.1 Items to be stated in the EIA in the Republic of Uzbekistan

Section 10 of the Law on State Ecological Expertise determines 3 steps of EIA procedure as follows: the preliminary assessment in the planning phase; the review of the assessment; and the establishment of the final environmental standard prior to the start of the facility operation.

(1) Preparation of Environmental Impact Statement

Draft Environmental Impact Statement (EIS) should be prepared in the planning phase of the project and submitted to the State Committee for environmental protection of the Republic of Uzbekistan.

Based on the environmental review of the draft EIS, additional survey, in-situ servey, special analysis or model simulation is conducted as necessary to determine the appropriate environmental protection method and to complete the EIS.

The following description items and contents of the EIS are established in Section 11 of Provision on the State Ecological Expertise in the Republic of Uzbekistan.

- The environmental analysis result of the environmental condition, population, and land development before the project implementation.
- The operation policy and planning of the existing residential area, agricultural area, and utility lines.
- The construction plan including the potential environmental effect of the construction equipment, technology, and materials and the mitigation measure.
- The project plan including environment protection using new technology and technical analysis of alternative decision
- The system of scientific and technical measures to eliminate and reduce adverse environmental impact.
- The review of the analysis of acute environmental impact and the mitigation measure.
- The predicted environmental change caused by the introduction of the project

(2) Preparation of the Statement of Environmental Consequences

Statement of Environmental Consequences should be prepared and submitted prior to the commercial operation of the project facility.

As stated in Section 11 of the Law on State Ecological Expertise, The following contents in the Statement of Environmental Consequences should include:

- The amendment of the draft EIA resulting from the environmental review, the meeting with local residents, and the like.
- The environmental standard applied during the facility operation phase (e.c., Maximum Permissible Concentration (MPC), Maximum Permissible Emission (MPE), Maximum Permissible Storage Amount).
- The specific procedure and system of the environmental protection in operation phase
- The fundamental policy of environmental protection activity

The envisaged preparation of Environmental Impact Statement (EIS) proved unnecessary, since the draft EIS had been submitted to the State committee for environmental protection (Goskompriroды) 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 is the contents of the EIS agreed with Goskompriroдy at in-situ survey in September.

- The avoidance of environmental degradation due to the implementation of the Project is the least requirement.
- The contamination by SPM due to heavy oil combustion in winter is a current problem. Goskompriroдy decided that the demolition of the existing boilers, not the shutdown, is the absolute condition for giving approval at the final review prior to the starting of operation.
- To prevent use of heavy oil, the minimum pressure of gas supply must be guaranteed from the gas company to enable the operation of gas turbines even in pressure drop of gas supply in winter.
- Tashkent CHP Plant is in the vicinity of residential area, and there is a general misunderstanding that gas turbines are as noisy as jet airplanes. Sufficient explanation and appropriate countermeasures are essential.

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 final on-site survey.

The obtained EIS index and basic description items are described in Table 4-3-1, and compliance with JBIC checklist is shown in Table 4-3-2.

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 are not included:

- mitigation during construction phase
- monitoring plan during construction phase
- monitoring plan during operation phase

In the Republic of Uzbekistan, the monitoring plan during operation phase is to be stated at the final stage of process in SEC (Statement of Environmental Consequences). However, JICA will check the 3 contents shown above in the preliminary review for yen credit.

It must be confirmed that all those contents be added to the revised EIS, and additional data including the additional estimation of ambient air and noise should be obtained, as stated above.

JICA received a request for submitting a formal letter prior to the final survey requiring the development of the revised EIS and re-implementation of the simulation from Tashkent CHP Plant at the on-site survey in September. Additionally, there was a requiment for the preliminary notification of the comments on the revised EIS to Tashkent CHP Plant and TEP in advance.

Consequently, a request letter (Appendix-1) was sent on October 21, 2009, from JICA prior to the final on-site survey in October, and at the same time the specific data for simulation was provided from JICA survey team.

On this basis, the EIS revised content and the schedule, including public hearing and re-implementation of estimation, were reviewed in consultation with Tashkent CHP Plant and TEP at the final on-site survey, and the following was confirmed:

- The revision of EIS should be developed by adding the appropriate contents including the monitoring plan during construction and operation proposed by JICA team, detailed environmental mitigation measures during construction and operation, and modification of parameter and result of ambient air/noise estimation, as the additional EIS. The revision of the approved EIS as a whole is not required.
- The additional EIS should be submitted to Goskomprirody for approval procedure in Uzbekistan.
- The additional EIS should include the result of the public hearing.

The revised content was discussed in consultation with Goskomprirody and its final appropriateness was confirmed.

Tashkent CHP Plant requires that the content of the revised EIS be reviewed and confirmed by JICA in advance, so that delay of approval procedure due to further amendment of the revision in response to JICA comments be avoided.

Considering the schedule refered in Chapter 4.5, the timing for JICA review will be out of the survey period, and hence the review method needs to be considered in the near future.

Table 4-3-1 Approved Index and main descriptions of EIS

Index	Main descriptions
Introduction	・ Project background and need
Chapter1 Natural environment characteristic of the project site	・ Physical and geographical and climate conditions ・ Environmental impact existing sources ・ Air quality conditions ・ Surface water ・ Soils and underground water ・ Vegetation ・ Noise level ・ Health conditions of population ・ Evaluation of current environmental conditions
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 equipments ・ Fire protection system ・ Exhaust gas parameter （gas volume・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

Table 4-3-2 The Compliance of the Approved EIS Contens with JBIC Checklist

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
1 Approval and explanation	(1) EIA and Environmental Approval	① Have Environmental Impact Statement and other documents been officially completed? ② Have Environmental Impact Statement and other documents been approved by authorities of the host country's government? ③ Have Environmental Impact Statements been unconditionally approved? If conditions are imposed on the approval of Environmental Impact Statements, are the conditions satisfied? ④ In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	①The are supposed to be prepared following the recent survey. Draft EIS has already been submitted to Goskompriroday in 2 July, 2009. ②It was confirmed that Goskompriroday approved them on August 25, 2009 with no request for additional survey or simulation. ③ EIS was reviewed considering also the environmental impact from NEDO Project and approved in condition that the existing boilers No.2-4 be demolished. ④SEC(Statement of Environmental Consequences) should be prepared and submitted for approval prior to facility operatio.
	(2) Explanation to the Public	① Are contents of the Project and the potential impacts adequately explained to the public based on appropriate procedures, including information disclosure? Is understanding obtained from the public? ② Are proper responses made to comments from the public and regulatory authorities?	①The 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. Currently no explanation has been given to the public. ②Comments from the inhabitants will be described in EIS for review by Goskompriroday.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
2 Mitigation Measures	(1) Air Quality	① Do air pollutants, such as sulfur oxides (SOx), nitrogen oxides (NOx), and soot and dust emitted by power plant operations comply with the country's emission standards? Is there a possibility that air pollutants emitted from the Project will produce areas that do not comply with the country's ambient air quality standards?	①The simulation confirmed that the air quality will meet the Uzbekistan environmental standard after the installation of the new gas turbines. Additionally, the installation of new gas turbines equipped with appropriate mitigation measure and the demolition of the old boilers No.2-4 will contribute much to the improvement of ambient air quality: the present contribution concentration of 0.060mg/ m^3 will decrease approximately 30%t to 0.043 mg/ m^3. Note that ground wind speed in the area marks 5m/s in a rare case (1% occurrence ratio), according to EIS statement, which may mark 8m/s at stack height (60m). It is said that, if wind speed is 1.5 times higher than emission gas rate, downwash appears as described below, which may result in higher level of concentration than normal diffusion. The simulation should be recalculated using the gas emission spped of approximately 10m/s instead of 5m/s, for the purpose of avoiding the above-mentioned phenomenon.Parts of the data used for estimation needs reconsideration (description needed in revised EIS).
		② In the case of coal-fired power plants, is there a possibility that fugitive coal dust from coal piles, coal handling facilities, and dust from coal ash disposal sites will cause air pollution? Are adequate measures taken to prevent the air pollution?	②Natural gas is used as fuel in this Project instead of coal.
	(2) Water Quality	① Do effluents including thermal effluents from the power plant comply with the country's effluent standards? Is there a possibility that the effluents from the Project will cause areas that do not comply with the country's ambient water quality	①The existing boilers No.2-4 will be demolished and therefore the volume of effluent will not increase.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
		standards or cause a significant temperature rise in the receiving waters? ② In the case of coal-fired power plants, do leachates from coal piles and coal ash disposal sites comply with the country's effluent standards? ③ Are adequate measures taken to prevent contamination of surface water, soil, groundwater, and seawater by the effluents?	②Natural gas is used as fuel in this Project , not coal. ③The existing boilers No.2-4 will be demolished and therefore the volume of effluent will not increase.
	(3) Wastes	① Are wastes, (such as waste oils, and waste chemical agents), coal ash, and by-product gypsum from flue gas desulfurization generated by the power plant operations properly treated and disposed of in accordance with the country's standards?	①The 28 sorts of waste generated from the existing plant are appropriately treated and deposited according to law. The existing boilers No.2-4 will be demolished and therefore no increase of waste is assumed.
	(4) Noise and Vibration	① Do noise and vibrations generated by the power plant operations comply with the country's environmental standards, and occupational health and safety standards?	① The estimated noise level of the facility operation in residential area is below 30dB(A), well below the Uzbekistan standard of 45dＢ(Ａ). However, similar to air quality, since this estimation is based on 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. Parts of the data used for estimation needs reconsideration (description needed in revised EIS). The facility is designed to keep noise level at 1m from the noise source below 80dＢ(A), the Uzbekistan standard in workplace, thus maintaining satisfactory occupational environment. The vibration level will be

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
		② In the case of coal-fired power plants, are the facilities for coal unloading, coal storage areas, and facilities for coal handling designed to reduce noise?	below 50dＢ(Ａ). ②Natural gas is used as fuel in this Project instead of coal.
	(5) Subsidence	① In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	①Extraction of groundwater is not planned.
	(6) Odor	① Are there any odor sources? Are adequate odor control measures taken?	①No odor source exists.
3 Natural Environment	(1) Protected Areas	① Is the Project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the Project will affect the protected areas?	①The construction site of the Project is located in a desert land area within the Tashkent CHP Plant, not encompassing protected area.
	(2) Ecosystem	① Does the Project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? ② Does the Project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? ③ If significant ecological impacts are anticipated, are adequate environmental protection measures taken to reduce the impacts on ecosystem? ④ Is there a possibility that the amount of water (e.g., surface water, groundwater) used by the Project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as	①The construction site of the Project is located in a desert land area within the Tashkent CHP Plant, not encompassing primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats). ②～③The proposed gas turbine construction site is mainly in desert land area of herbaceous species, with no possibility of precious species habitat. Hence, no significant ecological impact is anticipated. ④～⑤The existing boilers No.2-4 will be demolished and therefore the amount of water intake, as well as water discharge, from rivers will remain the same level before and after the construction.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
		aquatic organisms? ⑤ Is there a possibility that discharge of thermal effluents, intake of a large volume of cooling water or discharge of leachates will adversely affect the ecosystem of surrounding water areas?	
4 Social Environment	(1) Resettlement	① Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? ② Is adequate explanation on relocation and compensation given to affected persons prior to resettlement? ③ Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? ④ Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? ⑤ Are agreements with the affected persons obtained prior to resettlement? ⑥ Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? ⑦ Is a plan developed to monitor the impacts of resettlement?	①～⑦The construction site of the Project is located in a desert land area within the Tashkent CHP Plant, and resettlement will not occur.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(2) Living and Livelihood	① Is there a possibility that the Project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? ② Is sufficient infrastructure (e.g., hospitals, schools, roads) available for the Project implementation? If existing infrastructure is insufficient, is a plan developed to construct new infrastructure or improve existing infrastructure? ③ Is there a possibility that large vehicle traffic associated with the Project will affect road traffic in the surrounding areas? Are adequate measures considered to reduce the impacts on traffic, if necessary? ④ Is there a possibility that diseases (including communicable diseases, such as HIV) will be introduced due to immigration of workers associated with the Project? Are adequate considerations given to public health, if necessary? ⑤ Is there a possibility that the amount of water used (e.g., surface water, groundwater) and discharge of thermal effluents by the Project will adversely affect existing water uses and uses of water areas (especially fishing)?	①The construction site of the Project is located within the Tashkent CHP Plant, not involving acquisition of new land. The Project adopts high heat efficiency equipment to contribute to heat and power demand of Tashkent. Also, the training program the Project will contribute to the education of highly expertised engineers. ②The proposed project site within the Tashkent CHP Plant is located in south of the capital city Tashkent, surrounded with existing residensial area, public offices, enterprises and factories. Further infrastructure development is not necessary. ③In this Project, fuel is provided through gas pipelines, and workers will commute by bus, like the existing workers do. Therefore, traffic of large vehicles will not increase. ④There is no special description, but the same level of public sanitation as the present condition will be conducted with new workers. ⑤The existing boilers No.2-4 will be demolished and therefore the amount of water intake, as well as water discharge, from rivers will remain the same level before and after the construction.
4 Social Environment	(3) Heritage	① Is there a possibility that the Project will damage the local archeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws?	①The construction site of the Project is located within the Tashkent CHP Plant, and there is no historical or cultural heritage.
	(4) Landscape	① Is there a possibility that the Project will adversely affect the local landscape? Are necessary measures taken?	①The construction site of the Project is located within the Tashkent CHP Plant and rather small in

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
			area (76m×195m). The impact on total landscape is assumed to be minimal.
5 Others	(1) Impacts during Construction	① Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? ② If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? ③ If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? ④ If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?	①Not stated (description needed in the revised EIA). ② The proposed gas turbine construction site is mainly in desert land area of herbaceous species, with no possibility of precious species habitat. Hence, no significant ecological impact is anticipated. ③Not stated (description needed in the revised EIA). ④Not stated (description needed in the revised EIA).
	(2) Accident Prevention Measures	① Are adequate accident prevention plans and mitigation measures developed to cover both the soft and hard aspects of the Project, such as establishment of safety rules, installation of prevention facilities, and equipment, and safety education for workers? Are adequate measures for emergency response to accidental events considered? ② In the case of coal-fired power plants, are adequate measures planned to prevent spontaneous combustion at the coal piles? (e.g., sprinkler systems).	①In Tashkent CHP Plant site, storage of backup fuel (e.g.oil) and chemicals (e.g. sulfuric acid) are set locally and accessed only through appropriate transportation route. The gas turbines of the Project are equipped with automatic control system, providing better accident mitigation compared to the exisiting facility. ②Natural gas is used as fuel in this Project instead of coal.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(3) Monitoring	① Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? ② Are the items, methods and frequencies included in the monitoring program judged to be appropriate? ③ Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? ④ Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	①～④Not stated (description needed in the revised EIA).
6 Note	Reference to Checklist of Other Sectors	① Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities). ② Where necessary, pertinent items described in the Ports and Harbors checklist should also be checked (e.g., projects including construction of port and harbor facilities).	①Existing power transmission line will be used. ②The Republic of Uzbekistan is located inland.
	Note on Using Environmental Checklist	① In the case of coal-fired power plants, the following items should be confirmed: ・Are coal quality standards established? ・Are the electric generation facilities planned by considering coal quality? ② If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the Project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, and global warming).	①Natural gas is used as fuel in this Project instead of coal. ②The demolition of the existing boilers No.2-4 will decrease the annual CO_2 emission by 123,400t, albeit a small contribution.

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

The EIS contents were examined of the compliance with JICA guideline, JBIC guideline and checklist, IFC guideline and of facility planning and emission data. The basic aspects such as ambient air quality and acoustic impact are described, whereas certain items as follows required in JBIC checklist are not included:

- Mitigation measures during construction phase
- Monitoring plan during construction
- Monitoring plan during operation phase

Major recommended mitigation measures and monitoring plan during construction/operation phase are described below.

At the final field survey, it is confirmed that recommeded plans will be basically described in the additional EIS and that approval procedures of EIS within Uzbekistan will be implemented.

Abobe mentioned, Tashkent CHP Plant requires that the content of the revised EIS be reviewed and confirmed by JICA in advance, so that delay of approval procedure due to further amendment of the revision in response to JICA comments be avoided.

On this account the review method needs to be considered in the near future.

4.4.1 Mitigation measures in construction and operation phase

(1) Mitigation measures in construction phase

Tashkent CHP Plant should be responsible for implementing mitigation measures through understanding of the Project characteristics and promoting 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.

Mitigation measures” recommended plan” during construction phase are described in Table 4-4-1.

Table 4-4-1 Major Mitigation Measures during Construction Phase

Items	Potential impact	Environmental mitigation measure plan	Items
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)	Construction enterprise
	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 ・Monitoring in the residential area	
Excavation and operation of construction equipments Excavation and operation of construction equipments	Gas emission and scattering of sand and dust from machines	・Periodic watering of deposited sand ・Monitoring in the residential area	
	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	
	Safety・Prevention of accident・Land transportation・Social infrastructure	・Plan regulation for Safety Management Plan ・Prompt transport service to hospitals ・Check transportation regulation、installment of road signs and education on safety driving ・Slowdown at residential area and school route	

(2) Mitigation measures in operation phase

Tashkent CHP Plant 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 4-4-2.

Table 4-4-2 Main environmental impact and its mitigation measures during operation

Items	Potential impact	Environmental mitigation measure plan	**Responsibility**
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 ・Monitoring of ambient air in the surrounding area	Tashkent CHP Plant
	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 ・Monitoring in the residential area ・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 ・Installation of automatic control system	

4.4.2 Monitoring Plan against impact during construction phase and operation phase

Monitoring Plan” recommended plan” against impact in construction phase and operation phase are described in the table 4-4-3.

(1) During construction

・Air quality monitoring:Measurement Parameters are SPM, NO2.

The basic place for monitoring is the exixting place. Sensitive places for impact such as schools and hospitals will be taken into consideration.

・Noise monitoring:Measurement Parameters are noise level.

The basic monitoring places are residential area and the boundary in the vicinity of Tashkent CHP. Sensitive places for impact such as schools and hospitals will be taken into consideration.

(2) During operation

・Gas emission monitoring:Measurement Parameter are NOx（NO, NO2）. Monitoring place is gas duct.

・Air quality monitoring:Measurement Parameters are NOx（NO, NO2）. The basic place for monitoring is the exixting place. Sensitive places for impact such as schools and hospitals will be taken into consideration.

・Noise monitoring Measurement Parameters are noise level. The basic monitoring places are residential area and the boundary in the vicinity of Tashkent CHP Plant. Sensitive places for impact such as schools and hospitals will be taken into consideration.

Table 4-4-3 Monitoring Item , Location and Frequency during construction and operation phase

Classification	Item	Parameter	Location	Frequency
Construction phase	Air quality	SPM,NOx（NO, NO2）	Existing monitoring point and such	Continuous
	Noise	Noise level	Boundary and residential area in the vicinity of Tashkent CHP Plant	At the time when the amount of construction work to be the maximum
Operation phase	Exhaust gas	NOx（NO, NO2）	Smoke path	Continuous(Continuous monitoring device)
	Air quality	NOx（NO, NO2）	Existing monitoring point	Continuous
	Noise	Noise level	Boundary and residential area in the vicinity of Tashkent CHP Plant	Twice a year

4.5 Schedule of EIA Implementation

4.5.1 EIA procedure

Meetings to explain to the local residents have not been held yet: it 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 described in Chapter 4.3 and 4.4.

The final field survey will focus on the following point. Regarding this point, there will be no remake of revised edition of approved EIS as a whole, but, it will be an implementation of approval procedures within Uzbekistan by making additional EIS.

The content will be monitoring plan during construction/operation, detailed environmental impact mitigation measures during construction/operation, as well as modification on the estimation of air/noise quality and the result of resident explanation meetings.

Consultation has been conducted with Goskomprirody and final confirmation has been done that these procedures are of problem free.

4.5.2 Procedure of the meeting with local residents

In the Republic of Uzbekistan, a meeting is planned and conducted by the Project operator as necessary. The procedure generally consists of five steps:
Step 1, the notification of the meeting to the related people;
Step 2, the preparation of the abstract of the EIA, distribution to the related people, and the Environmental Impact Statement being made available to public inspection;
Step 3, opening the meeting with local residents;
Step 4, collection and analysis of the opinions of local residents through questionnaire; and
Step 5, report of the result of the meeting to the related organizations.

The EIA abstract is made in Uzbek and Russian and distributed to the related parties. It is made available to the public within the power plant and the local community. The EIA explanation meeting is an opportunity of direct session with local residents, and should be open to as many local people as possible. The meeting schedule should be widely notified using newspaper and other mass media and the related website.

The meeting should consist of the explanation of the overview of the Project, including the advantage of the new facility and potential environmental impact, from the Project operator, as well as Q&A sessions. After that, the questionnaire is distributed to collect the view of the local people and ensure their understanding of the Project concept.

The result of the meetings is reported to the related organizations through the summary report of the meetings published by the Project operator, and publicized through the mass media.
The opinion from the local residents will be reflected in the final Statement of Environmental Consequences as described above.

The schedule for the implementation of the additional simulation, resident explanation meetings, making of an additional EIS and implementation of approval procedure within Uzbekistan is described in the Table 4-5-1. The schedule has been consulted/confirmed with Tashkent cogeneration plant and TEP upon final field survey.

Consultation has been conducted with Goskomprirody and final confirmation has been done that these procedures are of problem free.

However, Goskomprirody assumes invitation of specialists or researcher for resident explanation meeting. There is a need for JICA to consider and prepare co-operational system to assist the smooth implementation of resident explanation meeting such as dispatch of specialists.

The survey team can not participate in the meeting due to the schedule. If JICA is to attend the meeting, advance notification is required by E-mail or other means.

Goskomprirody requests the following 3 points be explained at the meeting: the installation of the new facility will contribute to the minimization of environmental risk; heavy oil wil not be used; and noise impact will be minimized.

Table 4-5-1 The general scheme of implementing EIA and meeting with local residents

Classification	Content of implementation	Necessary days	Schedule
1	Conducting another simulation, review content/make report for additional EIS	two months	Nov. to Dec. 2009
2	Implementing explanation meetings for the local government, the local residents, and the local community.	one month	Jan. 2010
3	Making digest edition of EIS and distribution to persons concerned, inspection of EIS at the plant/the local community.		
4	Implementaiton of EIA explanation meetings.		
5	Implementation of questionnaire to the local residents and collection/analysis of the result.		
6	Report to the institutions concerned and approval procedures on additional EIS in Uzbekistan.	one month	Feb. 2010

4.6 Draft Environmental Impact Statement

At the final field survey, it is confirmed that approval procedures of EIS within Uzbekistan will be implemented as an additional EIS with the related institutions. The content will be monitoring plan during construction/operation, detailed environmental mitigation measures during construction/operation as well as modification of air/noise quality and the result of resident explanation meetings.

The table below provides information of the JICA checkpoints on social environmental issues for Japanese ODA Loan Project and an assumed EIA schedule plan.

Schedule	Checkpoints and EIA procedure	Japanese ODA Loan Project
Dec. 2009	Reviewing the additional Uzbekistan EIS including the conduct of another simulation.	Appraisal
Jan. 2010	Implementaion of resident explanation. Final confirmation on environmental check list regarding thermal plan by JICA.	Confirmation on the content of the additional EIS and participation of the explanation meetings.
Feb. 2010	End of evaluation for the Uzbekistan EIS additional edition.	Pledge
March. 2010		E/N、L/A

Note: the environmental checklist is a former JBIC checklist and currently under revision.

4.7 Conclusion

Regarding the current water quality level around Tashkent CHP plant, existing measurement results have been collected. For the air quality around Tashkent CHP plant, high contamination level of nitrogen dioxide is confirmed and water quality of rivers with inflow of discharged water are already contaminated heavily which infer us that the concentration level is higher than the dishcharged water.
Measurement for noise has not been conducted around Tashkent CHP plant, although it is confirmed that noise level is basically quiet by using simplified sound-level meter.

EIS has been submitted to the State Nature Conservancy Council before implementing the survey and is confirmed that EIS has been approved.

Regarding the air quality prediction, the abolition of the current 3 steam boilers (No. 2 to 4) in exchange with 2 gas turbines of the project and additional 1 turbine from NEDO project has already been implemented. It is confirmend that it is contributing to improvement of the future air quality compared to that of the current situation.

It is confirmed that the noise level is extremely low through prediction survey on 2 gas turbines of the project and additional 1 turbine from NEDO project. However, due to the existence of inappropriate parameters and lack of facilities, appropriate data will be provided to TEP from the survey team and implementation of supplemental prediction survey is planned.

The basic items such as air quality, impact of noise are listed in the EIS, however, when compared to JBIC check list, it is confirmed that mitigation measures during construction as well as monitoring plan during construction/operation are not listed.

Basic approval is obtained by presenting mitigation measures during construction/operation and monitoring plan as recommendation plan for the project. The content is planned to go through the approval procedure along with the former mentioned re-implementation of air/noise quality prediction survey in Feb. 2010 as an additional edition of EIS.

The resident explanation meeting will be implemented in Jan. 2010 and the content/schedule are confirmed. Result of the meetings will also be listed in the additional edition of EIS.

It can be concluded from the above mentioned statement that the aim of the project is basically achieved, although, confirmation of the content of EIS, cooperation to implement the explanation meetings and such should be considered and implemented in a timely manner in the months ahead.

Appendix- 1

JICA

Japan International Cooperation Agency

Date: 21 th October 2009
Ref. No. R3CAC/F2009-40D

OJSC Tashkent Heat and Plant,
Mr. HASHIMOV Iskandar Mubinovich
Director, TashTEZ

RE: Study to Enhance the Collaboration with NEDO
on Tashkent Heat Supply Power Plant Modernization Project

Dear Mr.HASHIMOV Iskandar Mubinovich

We have been considering the contents of EIS which was implemented and permitted by Uzbekistan in order to make it more adjust to JICA Guideline, JBIC Guideline and IFC Guideline.
Herewith we request, on the basis of discussion of First Field Study with TashTEZ, TEP and State Committee on Environmental Protection, three points below. All of these are what we would like to discuss with related organizations on these specific contents and schedule during Second Field Study from the end of October 2009.

1. Revise of EIS

In current EIS there are fundamental information on influence of atmosphere and noise after construction, however there is little information on three points below

- Mitigation Plan during construction
- Monitoring Plan during construction
- Monitoring Plan during operation

Especially we would like to contain Mitigation Plans for duration of construction and operating separately in Chapter 8, and also contain additional Environmental Monitoring Plans in Chapter9.

2. Re-calculation of date for atmosphere and noise assessment.

We still lack enough information and data for atmosphere and noise assessment because it depends on data from Website. To sophisticate the simulation for this assessment, we request two things below.

- In current condition of TashTEZ, there is a possibility to make Downwash Phenomenon around exit of a chimney causing high-level contamination of polluted gas. Taking into consideration that TashTEZ is located near residential area, we have to re-collect and re-calculate and re-simulate data for mitigating this Phenomenon.
- As for noise assessment, there is no estimation that is taking Gas Compressors nearby apartments into account. That's why we have to re-calculate and re-simulate data far more.

3. Holding a meeting for residents near TashTEZ

You have to explain about Mitigation Plan and environmental influence to residents around TashTEZ. On First Field Study we've already discussed holding a meeting, then we request you to discuss with us more detailed contents and schedule of this meeting on Second Field Study.

All documents needed for three things above will have been prepared and distributed to TashTEZ and TEP before Second Field Study.

It would be highly appreciated if you could take our suggestion properly for effective realization of

JICA

Japan International Cooperation Agency

the captioned project.

Yours sincerely,

Fusato Tanaka
for Director,Central Asia&Caucasus Division
East and Central Asia Department

c.c.
SJSC Uzbekenergo, Chairman Mr. Teshaboev
OJSC Teploelectroproekt, Executing Director Mr. Shaismatov
JICA Uzbekistan Office, Chief Representative Mr.Ejiri