Republic of Uzbekistan
JSC Thermal Power Plant

Republic of Uzbekistan
Preparatory Survey of Navoi Thermal Power Station Modernization Project (Phase 2)

Final Report

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Abbreviations

Abbreviation	Full Name
ACSR	Aluminum Conductors Steel Reinforced
ADB	Asian Development Bank
ANSI	American National Standards Institute
AS	Aluminum-clad Steel wire
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CAREC	Central Asia Regional Economic Cooperation
cct	CirCuiT
C/P	Counterpart
CCPP	Combined Cycle Power Plant
CIS	Commonwealth of Independent States
CPI	Consumer Price Index
Df/R	Draft Final Report
EBIT	Earnings Before Interest and Tax
EBRD	European Bank for Reconstruction and Development
EDS	Every Day Stress
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EPC	Engineering, Procurement and Construction Contract
ES	Engineering Stage
F/R	Final Report
F/S	Feasibility Study
FIRR	Financial Internal Rate of Return
GNI	Gross National Income
GT	Gas Turbine
GTCC	Gas Turbine Combined Cycle
GTW	Gas Turbine World
HHV	Higher Heating Value
HP	High Pressure
HRSG	Heat Recovery Steam Generator
I&C	Instrumentation and Control
IFC	International Finance Corporation
IKL	Iso Keraunic Level
IP	Intermediate Pressure
IPP	Independent Power Producer
ISO	International Standard Organization

Abbreviation	Full Name
Ic/R	Inception Report
JICA	Japan International Cooperation Agency
JSC	Joint Stock Company
LARAP	Land Acquisition and Resettlement Action Plan
LHV	Lower Heating Value
LP	Low Pressure
MW	Mega Watt
NDA	Non-disclosure agreement
NG	Natural Gas
NGO	Non-Governmental Organization
NHC	National Holding Company
NOx	Nitrogen Oxide
O&M	Operation and Maintenance
OA	Office Automation
ODA	Official Development Assistance
OEM	Original Equipment Manufacturer
OPGW	Optical-fiber composite overhead Ground Wire
PIU	Project Implementation Unit
PS	Power Station
PSS	Power Stabilizer System
PQ	Pre-Qualification
ROW	Right-of-way
r.m.s	Root Mean Square value
R.U.S.	Rated Ultimate Strength
SAESP	Sredaz Energo Set Proekt
SNPC	Site Natural Protection Committee
SOE	State-Owned- Enterprise
SOx	Sulfur Oxide
SS	Substation
ST	Steam Turbine
TA	Technical Assistance
TEP	TEPROELEKTROPROEKT
T/L	Transmission Line
TOR	Terms of Reference
TPS	Thermal Power Station
UCSD	Unified Specific Creepage Distance
USD	United States Dollar
UTS	Ultimate Tensile Strength

Abbreviation	Full Name
UZS	Uzbekistan Sums
VAT	Value Added Tax
W/S	Work Shop
WB	World Bank

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

Units of Area

cm^2	:	square centimeter
m^2	:	square meter
km^2	:	square kilometer
ha	:	hectare

Units of Volume

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

Units of Mass

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

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
ppb	:	Parts per billion
μg/scm	:	microgram per standard cubic meter

Units of Pressure

kg/cm^2	:	kilogram per square centimeter (gauge)
mmHg	:	millimeter of mercury
mmHg abs	:	millimeter of mercury
mAq	:	meter of aqueous
atm	:	atmosphere
Pa	:	Pascal
kPa	:	kilopascal
MPa	:	megapascal
bar	:	bar

Units of Energy

kcal	:	kilocalorie
Mcal	:	megacalorie
Gcal	:	gigacalorie
kJ	:	kilo joule
MJ	:	mega joule
TJ	:	terajoule
kWh	:	kilowatt-hour
MWh	:	megawatt-hour
GWh	:	gigawatt-hour

Units of Heating Value

kcal/kg	:	kilocalorie per kilogram
kJ/kg	:	kilojoule per kilogram

Units of Heat Flux

$kcal/m^2h$	:	kilocalorie per square meter hour
kJ/m^2h	:	kilojoule per square meter hour

Units of Temperature

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

Units of Electricity

W	:	watt
kW	:	kilowatt
MW		megawatt
A	:	ampere
kA	:	kilo-ampere
V	:	volt
kV	:	kilovolt
kVA	:	kilovolt ampere
MVA	:	megavolt ampere
Mvar	:	megavar (mega volt-ampere-reactive)
Hz	:	hertz
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
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	:	micro siemens per centimeter

Units of Sound Power Level

dB	:	decibel

Units of Currency

UZS	:	Uzbekistan Sum
US$	:	US Dollar
¥	:	Japanese yen

Chapter 1

Summary

Chapter 1. Summary

1.1 Background of Survey

The maximum demand for electric power in Republic of Uzbekistan (hereinafter called "Uzbekistan") reached approx. 8,400MW in 2014. In contrast, the rated capacity of the power stations exceeds 14,100MW, but the power station facilities had generally been deteriorated and the supply capacity remained approx. 7,800MW. The average thermal efficiency of the thermal power stations sharing about 90% of the power source structure (of which 90% use natural gas) was at the low level of approx. 30%, which is one of the causes of high environmental impacts. Many of the thermal power stations have old plants that started operation 40 to 50 years ago. The average power generation capacity of all 10 thermal power stations in the country is approx. 30% lower than the rated capacity. From this background, it is urgently necessary to secure the power supply capacity by renewal of plants and to improve their reliability. It is also desired to introduce high-efficiency power generation plants for the purpose of controlling the greenhouse gas emission.

In August 2013, JICA approved the development of Gas Turbine Combined Cycle Power Plant No.2 (hereinafter called "GTCC2") in the framework of "the Navoi Thermal Power Station Modernization Project" and TEPSCO is conducting the consulting work for it at present.

On the occasion of the visit to Uzbekistan by Prime Minister Abe in October 2015, the ongoing cooperation to the power sector was declared in the joint statement by the top-leaders of the both countries.

In these situations, the Government of Uzbekistan issued the request for conducting the preparatory survey of finance and cooperation for the construction of Gas Turbine Combined Cycle Power Plant No.3 (hereinafter called "GTCC3") in the Navoi Thermal Power Station (hereinafter called "Navoi PS"). This plant will be having the power generation capacity of 600MW using high-efficiency gas turbine.

This Survey will be made for the review necessary to implement as the Japanese Official Development Assistance (ODA) loan project in regard to the objective, overview, project cost, implementing organization, and operation and maintenance system of this project, and considerations for its environmental and social aspects, under the minutes of meeting entered into by and between Uzbekistan state energy company JSC Uzbekenergo (Joint Stock Company Uzbekenergo, hereinafter called "Uzbekenergo") and JICA.

1.2 Purpose of Survey and Scope of Survey

1.2.1 Purpose of Survey

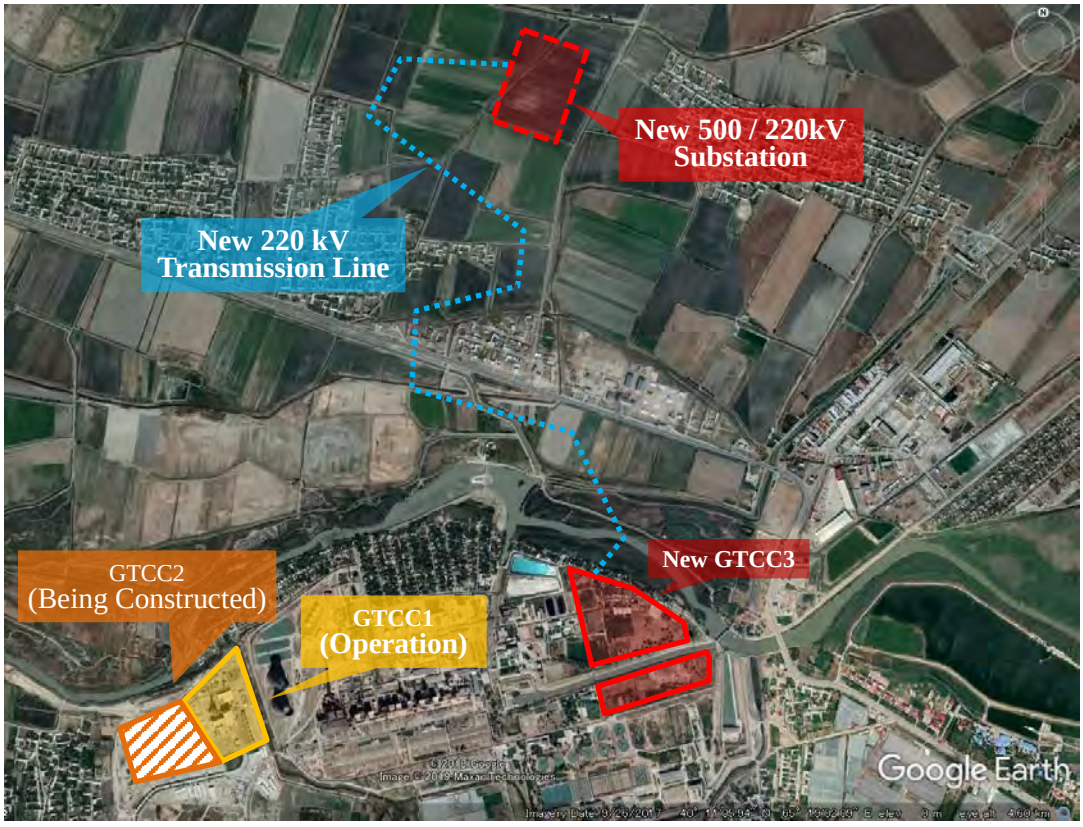
This survey has the objective to make the review necessary to implement the development of Navoi PS, under the request by the Government of Uzbekistan as an ODA loan project in regard to the necessity, overview, project cost, implementing schedule, implementing procedures (procurement and construction), implementing organization, operation and maintenance system of this project, considerations for its environmental and social aspects and others.

1.2.2 Target Area of the Survey

The main target areas of this survey are the Navoi PS, the north area in the premises of the power station and its surrounding areas. Figure 1.2.2-1 shows the positional relationship of the Metropolitan City of Tashkent and Navoi City in Uzbekistan. Figure 1.2.2-2 shows the Navoi PS, the surrounding areas of the planned construction sites of GTCC3, existing GTCC1, GTCC2, and the candidate construction site of the 220kV transmission line, /500 / 220kV Substation

(Source: Google Map, added by JICA Survey Team)

Figure 1.2.2-1 Positional Relationship Map of Metropolitan City of Tashkent and Navoi City



(Source: Google Earth, added by JICA Survey Team)

Figure 1.2.2-2 Navoi Thermal Power Station and Surrounding Areas

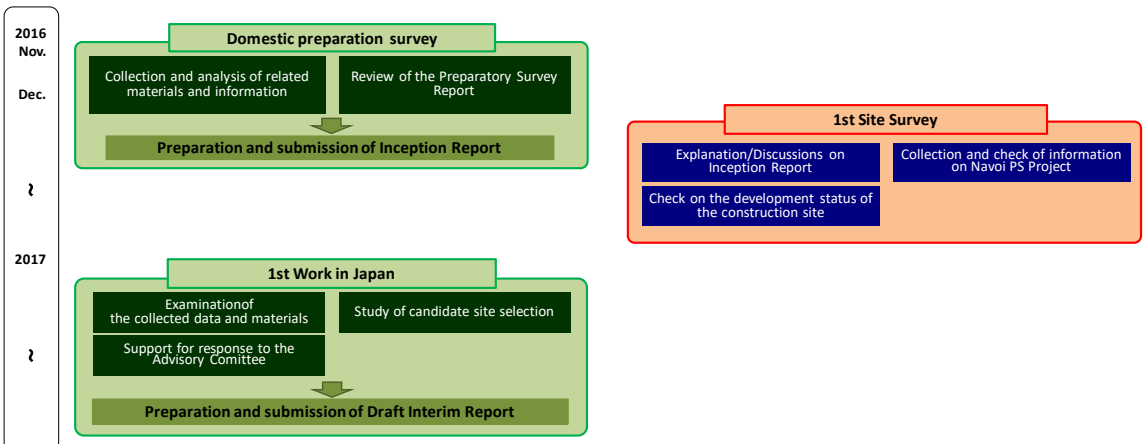
1.2.3 Scope of Survey

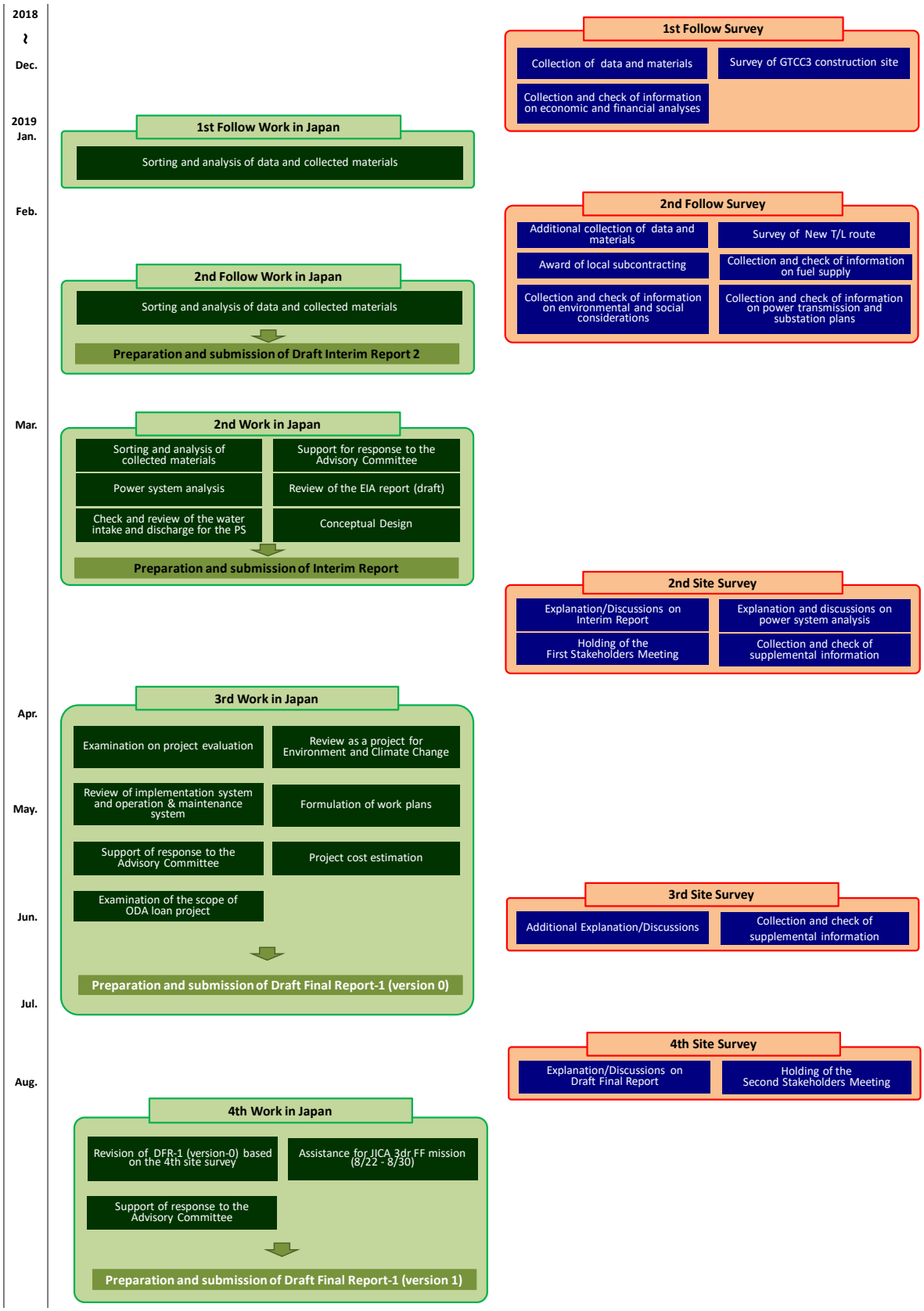
This Survey will be made on the following items:

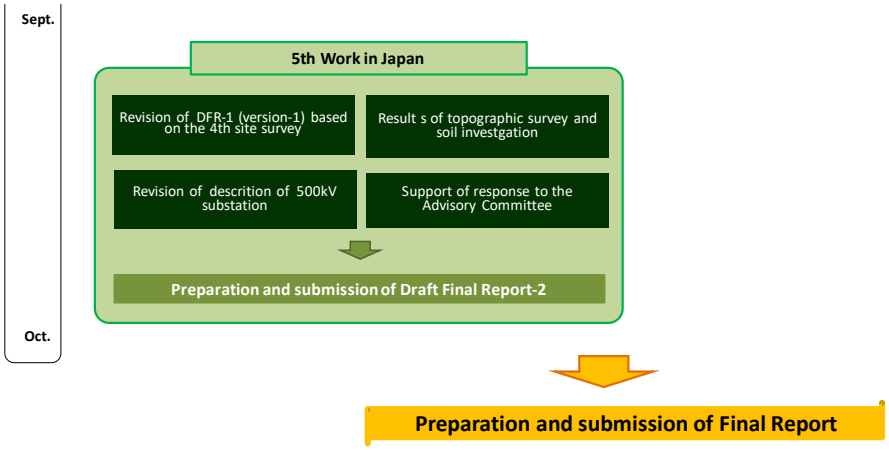
(1) Collection and analysis of related materials and information
(2) Preparation of Inception Report
(3) Explanation/discussions on Inception Report
(4) Check on survey implementation system
(5) Collection and check of information on upper-level projects
(6) Collection and check of information on electric power sector
(7) Collection and check of information on Navoi PS
(8) Use and review of the Preparatory Survey Report and the Basic Design Report for the "Navoi Thermal Power Station Modernization Project"
(9) Survey of electric power systems
(10) Check on present status and future prospect of fuel supply
(11) Check and review of water intake and discharge for the power station
(12) Collection and check of information on industrial steam supply and hot water supply facilities for heat supply to districts
(13) Topographic/geological surveys and support of selection of construction site
(14) Conceptual design
(15) Development of construction plans
(16) Project cost estimation
(17) Proposal on the scope of ODA loan project
(18) Proposal on project implementation system and operation & maintenance system
(19) Calculation of reduced volume of greenhouse gas emissions
(20) Review of the existing reports on environmental impact assessments (EIAs)
(21) Survey for checking the residents involuntary resettlement situations
(22) Making up of the brief residents resettlement action plan
(23) Assistance for holding of local stakeholders' meeting
(24) Support of response to the advisory committee for environmental and social consideration in Japan
(25) Check on environmental and social considerations for an integral part of the Project
(26) Examination on project evaluation
(27) Preparation/explanation of Interim Report
(28) Preparation/explanation of Draft Final Report
(29) Preparation of Final Report

1.2.4 Work Flow of the Survey

Work Flow of the survey is shown in the Figure 1.2.4-1.




2018
~
Dec.
2019
Jan.
Feb.
Mar.
Apr.
May.
Jun.
Jul.
Aug.
1st Follow Survey
Collection of data and materials
Survey of GTCC3 construction site
Collection and check of information on economic and financial analyses
1st Follow Work in Japan
Sorting and analysis of data and collected materials
2nd Follow Survey
Additional collection of data and materials
Survey of New T/L route
Award of local subcontracting
Collection and check of information on fuel supply
Collection and check of information on environmental and social considerations
Collection and check of information on power transmission and substation plans
2nd Follow Work in Japan
Sorting and analysis of data and collected materials
Preparation and submission of Draft Interim Report 2
2nd Work in Japan
Sorting and analysis of collected materials
Support for response to the Advisory Committee
Power system analysis
Review of the EIA report (draft)
Check and review of the water intake and discharge for the PS
Conceptual Design
Preparation and submission of Interim Report
2nd Site Survey
Explanation/Discussions on Interim Report
Explanation and discussions on power system analysis
Holding of the First Stakeholders Meeting
Collection and check of supplemental information
3rd Work in Japan
Examination on project evaluation
Review as a project for Environment and Climate Change
Review of implementation system and operation & maintenance system
Formulation of work plans
Support of response to the Advisory Committee
Project cost estimation
Examination of the scope of ODA loan project
Preparation and submission of Draft Final Report-1 (version 0)
3rd Site Survey
Additional Explanation/Discussions
Collection and check of supplemental information
4th Site Survey
Explanation/Discussions on Draft Final Report
Holding of the Second Stakeholders Meeting
4th Work in Japan
Revision of DFR-1 (version-0) based on the 4th site survey
Assistance for JICA 3dr FF mission (8/22 - 8/30)
Support of response to the Advisory Committee
Preparation and submission of Draft Final Report-1 (version 1)



(Source: JICA Survey Team)

Figure 1.2.4-1 Work Flow of the Survey

1.3 Organization of JICA Survey Team

The names and tasks of the members of the Survey Team are shown in Table 1.3-1.

Table 1.3-1 Organization of JICA Survey Team

Name	Task
Hideyuki OKANO	Team Leader/Power Development Planning
Hisashi SAITO	Power System Analysis
Mitsuo NOMURA	Mechanical Equipment/Facility Planning A
Kenji MIKATA	Mechanical Equipment/Facility Planning B
Hideki ASAYAMA	Mechanical Equipment/Facility Planning C
Etsuko KOBAYASHI	Fuel Supply Planning
Kazuo YABUKI	Electrical/Control Equipment Planning
Fumiya TOGASHI	Civil Engineering A
Naoki IKEDA	Civil Engineering B
Hitoshi NAKAUCHI	Power Transmission Facilities
Ryota TAKAHASHI	Substation Facilities
Norihiko FUKAZAWA	Environmental and Social Considerations (Natural environment B)
Mizuki KITAGAWA	Environmental and Social Considerations (Social environment)
Toshihisa IIDA	Financial Analysis

Chapter 2

General Overview of Uzbekistan

Chapter 2. General Overview of Uzbekistan

2.1 Overview of the Republic of Uzbekistan

Uzbekistan is a country with a population of approximately 32.4 million in 2017, accounting for nearly half of the combined population of the five countries in Central Asia (Uzbekistan, Kazakhstan, Kyrgyz Republic, Tajikistan, and Turkmenistan). Uzbekistan is a landlocked country, sharing borders with the four other Central Asia countries and Afghanistan. Nearly 25 years after independence in 1991, Uzbekistan remained a closed and centrally-planned economy with growth sustained by commodity export revenue that financed import-substitution industrialization. The country achieved a stable and high economic growth rate, an average of 7.9% for the last decade, and has gradually diversified its economy. With the economic growth, poverty rates have declined from 27.5% in 2001 to 12.4% in 2017[1]. Major export items include energy carriers and oil products, services, cotton, gold, mineral fertilizers, ferrous and nonferrous metals, textiles, foodstuffs, machinery and automobiles. Major trade partners are China, Russian Federation, Kazakhstan, Turkey and South Korea. In late 2006, under the leadership of newly-elected President Shavkat Mirziyoyev, the government initiated an ambition economic modernization program to strengthen growth for all of Uzbekistan citizen. In February 2017, the government issued "Strategy of actions on five priority areas of development of the Republic of Uzbekistan for 2017–2021" which set out of a comprehensive reform program, including political, administrative, judicial and economic aspects, aiming at transforming the country to a more market-oriented economy and strengthening the country's regional role as a hub in Central Asia[2]. Since then, far-ranging reforms have had a major impact on the country's political situation, economy and foreign relation

Table 2.1-1 Basic Indicators

Country Name	Republic of Uzbekistan
Surface Area	447,400 km^2
Population	33.0 million (2018)
GDP (at current price, UZS billion)	254,043 (2018)
GDP (at current price, USD million)	18.820 (2018)
GDP per capita (USD)	1,520 (2018)
GDP Growth (real, %)	5.1 (2018)

[1] World Bank (2019), "Project appraisal document for Institutional Capacity Building Project"

[2] This reform program includes: (i) enhancing state and public institutions; (ii) securing the rule of law and reform the judicial system; (iii) promoting economic development; (iv) fostering social development; and (v) ensuring personal and public security. Further, in November 2018, the government announced 'The Reform Roadmap" which outlines the government's economic reform priorities from 2019 to 2021 with focus on sustaining the momentum of Uzbekistan's transition to a competitive market-led economy. The roadmap contains five major pillars: (i) to maintain macroeconomic stability; (ii) to accelerate the market transition; (iii) to strengthen social protection and citizen services: (iv) to strengthen government's role in a market economy; and (v) to preserve environmental sustainability.

Export of goods (USD million)	11,386 (2018)
Import of goods (USD million)	18,252 (2018)
Exchange Rate (Year average)	8,069.6 UZS/USD (2018)
Exchange rate (Year-end)	8,339.6 UZS/USD (2018)

(Source: Ministry of Foreign Affairs of Japan (http://www.mofa.go.jp), IMF "World Economic Outlook Database(https://www.imf.org/en/Publications/SPROLLS/world-economic-outlook-databases#sort=%40imfdate%20descending)", IMF "2019 Article IV Consultation Staff Report", IMF "International Financial Statistics (http://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B)", ADB "Key Indicators for Asia and the Pacific 2019"

2.2 Political Situation

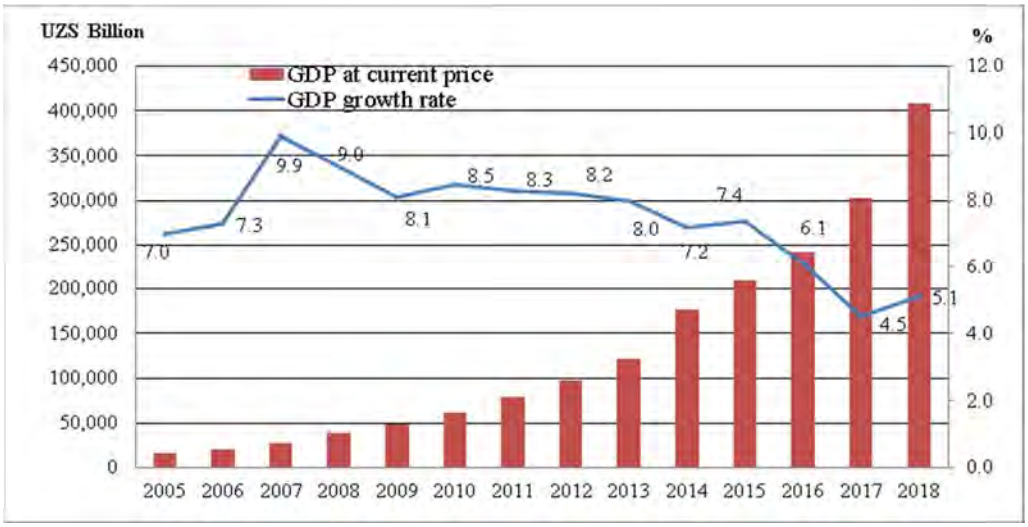
After the collapse of the Soviet Union, the political independence of Uzbekistan was proclaimed at the Supreme Council in August 31, 1991. The president is elected by popular vote for a 5-year term. The president appoints the prime minister and deputy ministers as well as provincial governors. Following the sudden death of Uzbekistan's first president, Islam KARIMOV, who led the country for 25 years, the former Prime Minister, Shavkat MIRZIYOYEV took office as president in the president election held on December 4, 2016. At the beginning of the inauguration, President MIRZIYOYOV emphasized the continuation of the previous administration's route, but has gradually developed its own color, and has launched reform routes in a wide range of fields such as politics, economy, society, and diplomacy. There have been steps to change Uzbekistan's electoral system and situation concerning political parties. The Strategy of Action encourages the Parliament to develop into a setting for healthy debate and discussion, with expanded powers for resolving the most important objectives and for implementing parliamentary control over the executives. The Strategy also encourages an expanded role for political parties across the entire country. Governors and mayors are directly elected by the people by amending the code of local and regional elections, as opposed to appointed by the President.

2.3 Macroeconomic Conditions

2.3.1 Gross Domestic Product

Uzbekistan suffered less from the collapse of Soviet Union. The GDP was restored to pre-independence levels as early as 2002, and the country has enjoyed a rapid expansion of its economy since the mid-2000s. The economy recorded 8.0 % or higher growth for seven consecutive years from 2007 to 2013 despite the deterioration in the global environment resulting from financial and economic crises. Starting in 2014, a challenging external environment, including lowered exports and remittance due to continuing weak economic activities in the euro area and Russia, the country's second largest trading partner and its primary source of remittance, slowing growth of China, the country's largest trading partner, and declining prices in Uzbekistan's GDP export commodities (natural gas, copper, and cotton), caused a contracted trade balance. The growth in 2018 picked up

moderately from 4.5 % in 2017 to 5.1 % in 2018 as production in agriculture as adversely affected by bad weather condition, despite strong investment growth (Figure 2.3.1-1)[3]. IMF[4] expected that that annual GDP growth remains steady at 5.5 % in 2019 and 6.0 % in 2020, reflecting mainly higher investment and normalization of agriculture production growth.



(Source: The State Committee of the Republic of Uzbekistan on Statistics)(http://stat.uz)

Figure 2.3.1-1 GDP at current price and GDP growth rate

The country is excessively reliant on a handful commodities (gold, oil and gas and cotton), which represent a significant share of the country's GDP. As shown in Table 2.3-1, the agriculture sector continues to play a central role in Uzbekistan's economy, representing about 32 % of GDP in 2018, though its share in the economy has been gradually declining. The agriculture sector mainly consists of cotton fiber and food products. The industry sector has expanded its share in the GDP as the country has large mineral reserves, notably of copper, gold and uranium and has reserves of oil and natural gas. In addition, Uzbekistan is progressively increasing its industrial base with the food processing, machinery, chemicals, and automotive sector.

Table 2.3-1 GDP by Sector Origin (% of GDP)[5]

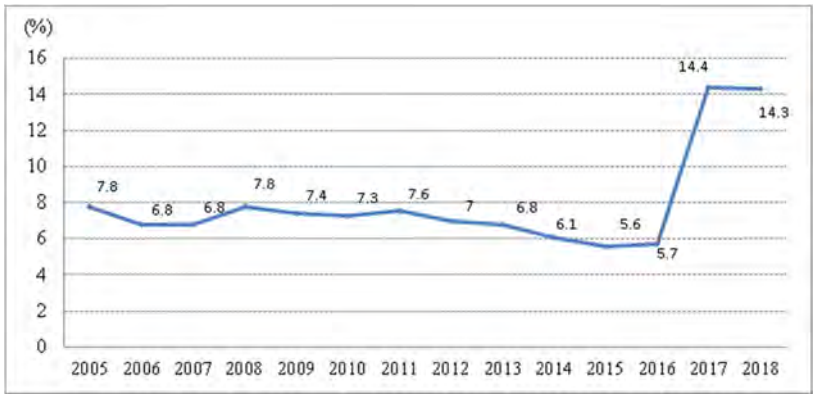
	2005	2010	2015	2016	2017	2018
Agriculture	29.5	19.8	34.1	34.0	34.0	32.4
Industry	29.1	33.3	26.2	26.6	27.9	32.0
Service	41.4	46.9	39.7	39.4	38.1	35.6

(Source: The State Committee of the Republic of Uzbekistan Statistics)

[3] In March 2019, the government revised national accounts data for 2014-2018.
[4] IMF (2018) "Republic of Uzbekistan: Staff Report for 2018 Article IV Consultation, May 2018"
[5] See note 3 above

2.3.2 Inflation and Monetary Supply

According to official figures, the inflation rate, measured by Consumer Price Index (CPI), was relatively stable, hovering between 5 % and 8 % per annum from 2005 to 2016.The inflation soared to an average of 14.4 % in 2017 and 14.3 % in 2018 from 5.7 % in 2016 (Figure 2.3.2-1). This rising inflation was driven mainly by rapid credit expansion, domestic demand growth, public wage adjustment, and the impact of devaluation of official foreign exchange rate in September 2017 on import prices and production costs. In 2018, food prices rose by 14.9 %, contributing 6.4 % percentage points to the CPI increase. Non-food products went up by 12.5 %, which led to an increase in the CPI by another 4.4 percentage points. Increase in tariffs for communication service, housing and utilities services and transport also affected the rise of CPI by 3.5 percentage points. The central bank has started tightening the monitory policy to limit monetary growth and stem inflation from beginning in the second half of 2017. The central bank hiked its policy rate from 9 % to 14 % in June 2017 and to 16 % in September 2018.



(Source: The State Committee of the Republic of Uzbekistan Statistics)

Figure 2.3.2-1 Inflation Rate (Consumer Price Index) (2005-2018)

2.3.3 Balance of Payment

After the export amount plunged for four consecutive years from 2013 to 2016, reflecting the declines in global prices for the country's export commodities (natural gas, gold, copper and cotton) and slowdown of economies in main trading partners, an improving external environment, including economic recovery in the Russian Federation and Kazakhstan as well as higher energy prices, promoted higher exports of goods and services in 2017, with a help of the currency devaluation. As a result, the current account surplus was widened to 2.7 % of GDP in 2017 from 0.4 % of GDP in 2016. However, the current account balance recorded a deficit equal to 7.1 % of GDP in 2018, reflecting several structural and policy shifts. Foreign exchange and trade liberalization removed policy props that had repressed imports in the past. Also, the shift toward expansionary credit policies pulled in additional imports, especially capital goods needed to modernize the economy. The international

reserves of the country decreased to a 12.8 billion USD in the end of 2018, which is more than 12 months of the import (Table 2.3-2).

Table 2.3-2 Balance of Payment[6]

(Unit: million USD)

	2016	2017	2018(Est.)
Merchandise Trade Balance	-2,392	-2,216	-6,867
Exports of goods	8,645	10,162	11,386
Imports of goods	11,037	12,377	18,252
Net Services	-1,539	-1,842	-2,442
Net Transfer	3,292	4,323	4,209
Net Income	934	1,215	1,523
Current Account Balance	296	1,480	-3577
Financial Account Balance	-171	-188	-2,810
Overall Balance	552	-256	-1,564
Current Account Balance (% of GDP)	0.4	2.5	-7.1
Gross Official Reserves (as of end of period) (billion USD)	26.5	28.1	27.1
Import Cover of Gross Official Reserves (month of imports)	19.3	14.4	12.8

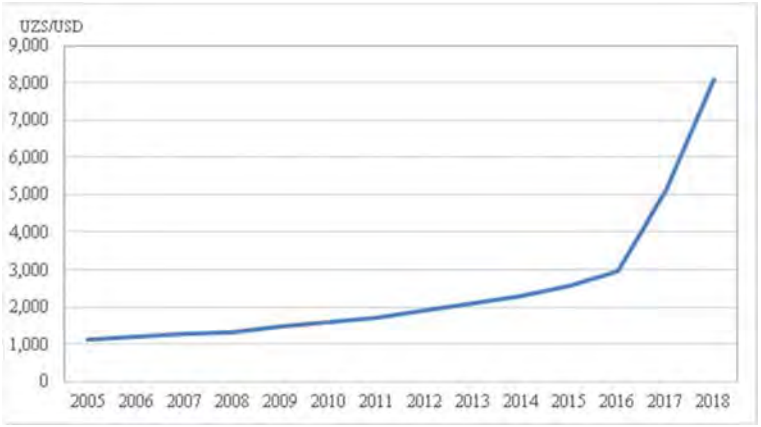
(Source: IMF "2019 Article IV Consultation Staff Report")

2.3.4 Exchange Rate

In last 10 years, the official UZS exchange rate against the USD published by the Central Bank of Uzbekistan was a depreciating trend. As shown in Figure 2.3.4-1, the currency value against USD became more than half from 2007 to 2016 with an average annual depreciation rate of 9.4 % in the same period. Under the government's overall reform initiative, on September 2, 2017, the government initiated comprehensive exchange rate reform including liberalized access to foreign exchange and unified the official and parallel foreign exchange markets. The purpose of the reform aimed to promote foreign investment, private sector development and export. Consequently, the UZS was devalued by almost 50 % from 4,210 to 8,100 against the USD. At the end of August 2019, the UZS against the USD was 9,373.93[7].

[6] The government revised the historical BOP statistics in March 2018

[7] Source: IMF, International Financial Statistics



(Source: IMF "International Financial Statistics)

Figure 2.3.4-1 Exchange Rate (period average) (UZS/USD) (2005-2018)

2.4 Government Finance and External Debt

2.4.1 Government Finance

The official budget balance has kept surplus equivalent to 0.7 % and 0.5 % of GDP in 2017 and 2018 respectively as shown in Table 2.4-1. With additional revenue from foreign exchange liberalization, favorable commodity prices and improvement in tax collection improved the total revenue from 23.7% of GDP in 2017 to 26.6 % of GDP in 2018, development spending for social programs raised expenditure from 23.7 % to GDP in 2017 to 26.6 % in 2018. The consolidated fiscal balance, including budget data adjusted for revenue and expenditure and policy-based lending operation for Fund for Reconstruction and Development, which accumulates revenues from mineral resources and stimulates investment and economic development, was estimated to record a deficit equal to 2.1 % of GDP in 2018.

Table 2.4-1 Government Finance

(Unit: billion UZS)

	2016	2017	2018(Est.)
Total revenue	59,132	71,710	108,524
Taxes	37,696	45,955	56,900
Total expenditure	58,825	69,577	106,338
Official budget balance	307	2,134	2,187
Consolidated fiscal balance[8]	-1,113	-3,598	-8,463
Total revenue (% of GDP)	24.4	23.7	26.6
Taxes (% of GDP)	15.5	15.2	17.4
Total expenditure (% of GDP)	24.3	23.0	26.1
Official budget balance (% of GDP)	0.1	0.7	0.5
Consolidated fiscal balance (% of GDP)	-0.5	-1.9	-2.1

(Source: IMF "2019 Article IV Consultation Staff Report")

[8] Consolidated fiscal balance includes budget data adjusted for revenues and expenditures, and policy-based lending of the Fund for Reconstruction and development (FRD).

2.4.2 External Debt

The total external debt outstanding rose from USD14.6 billion in 2016 to USD 17.1 billion in 2018 as shown in Table 2.4-2 due to increased public financing needs in line with the economic development. Due to the decline in nominal GDP measure in US dollar term, given the devaluation of the national currency on September 2017, the total external debt increased from 18.6 % in 2016 to 34.5 % in 2018, which is still at comfortable level, reflecting the sizable international reserves. Almost all of Uzbekistan's public and publicly guaranteed debt is denominated in foreign currency. The government began issuing treasury bills and bonds in 2018 to set benchmarks for the domestic financial market. Also, the government issued USD 1 billion of Eurobonds on Feb 2019, which was its first foray into international debt market[9]. According to the debt sustainability analysis in IMF 2019 Article IV consultation, Uzbekistan's risk of public debt and external debut distress is low, remaining below all solvency and liquidity indicators' thresholds under the baseline and stress scenarios.

Table 2.4-2 External Debt

(Unit: billion USD)

	2016	2017	2018(Est.)
Total external debt outstanding	14.6	15.6	17.1
External debt (public and public guaranteed (PPG))	6.5	7.5	10.0
External debt (private)	8.1	8.1	7.1
Total external debt (% of GDP)	18.6	34.1	34.5
External debt (PPG) (% of GDP)	8.6	20.2	20.5
External debt (private) (% of GDP)	10.0	13.9	14.0
Total debt service payment	6.5	7.5	10.0
In percent of exports of goods and services	12.8	15.3	19.5
In percent of gross international reserve	5.1	6.7	10.2

(Source: IMF "2019 Article IV Consultation Staff Report")

2.5 Social Conditions

2.5.1 Population

The total population of Uzbekistan was 33.0 million in 2018, which increased from 28.6 million in 2010 (Table 2.5-1). The average annual population growth for the last decade was 1.9 %. The population density has been increased, and the country has the highest population and population density among the five countries in the Central Asia.

[9] Uzbekistan is rated at BB- at S&P and Fitch Rating, and B1 (B+ equivalent) at Moody's.

Table 2.5-1 Population Trends (2000-2018)

			2000	2005	2010	2015	2016	2017	2018
Total population (million)			24.7	26.2	28.6	31.3	31.8	32.4	33.0
Population growth (annual change, %)			1.4	1.2	2.9	1.8	1.8	1.7	1.7
Density (persons per square km)			55	58	64	70	71	72	74

(Source: ADB "Key Indicators for Asia and the Pacific 2019")

2.5.2 Labor Force

The labor force has been growing consistently as a steady growth of population resulted in an increase in working-age population. Given the growing economy, the total number of employed increased to 13.3million in 2018 from 11.6 million in 2010. Official unemployment is extremely low: around 32,000 job seekers were registered as unemployed (about 0.2 % of the total labor force) in 2017. The employment of the agriculture sector accounted for about 27 % of the employed labor force and the service sector employed nearly 50 % of the labor force in 2017 as shown in Table 2.5-2.

Table 2.5-2 Labor Force in Uzbekistan

	2010	2014	2015	2016	2017	2018
Total labor force (thousands)	11,645	13,505	13,768	14,022	14,357	14,642
Employed	11,628	12,818	13,058	13,298	13,520	13,273
Unemployed (registered)	16	3	3	5	14	32
Annual growth of labor force (%)	2.6	2.6	1.9	1.8	2.4	2.0
By Occupation						
Agriculture (% of employed)	26.8	27.5	27.6	27.4	27.3	NA
Industry (% of employed)	22.7	22.8	22.9	23.1	23.1	NA
Service (% of employed)	50.5	49.7	49.5	49.5	49.5	NA

(Source: ADB "Key Indicators for Asia and the Pacific 2019")

Chapter 3

Overview of the Power and Heat Supply Sector in Uzbekistan

Chapter 3. Overview of the Power and Heat Supply Sector in Uzbekistan

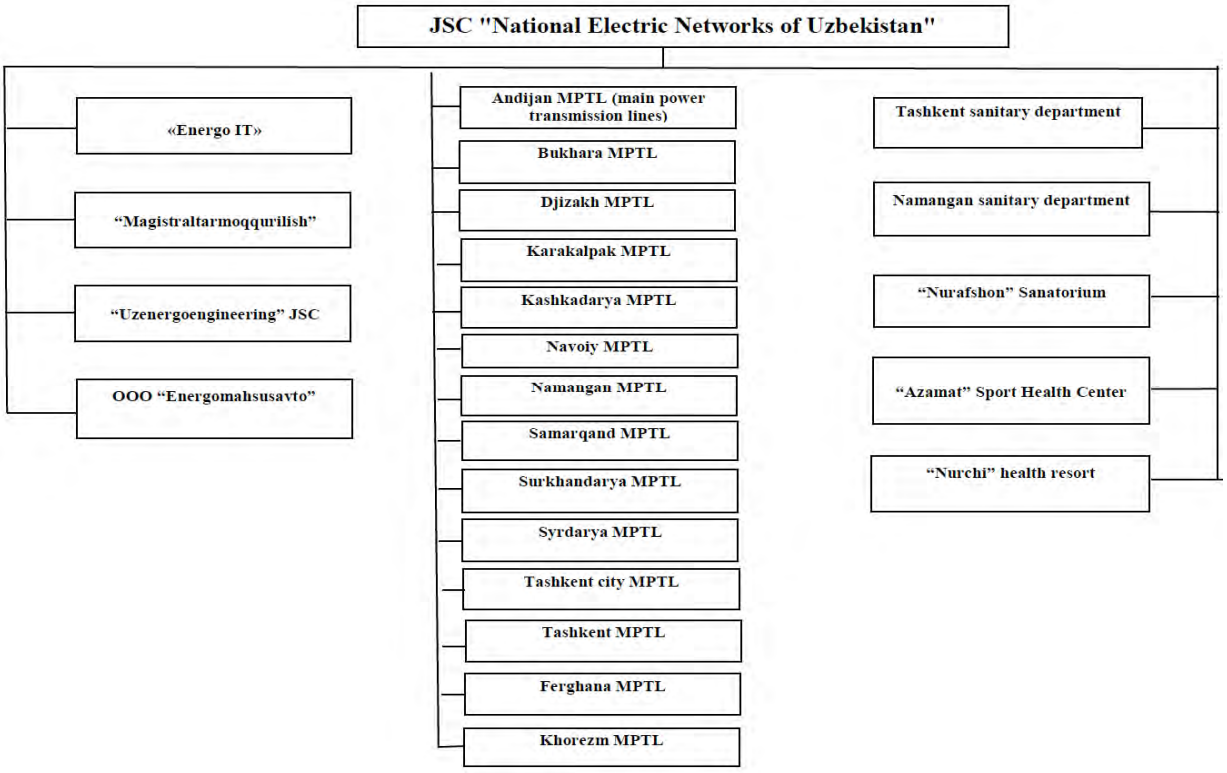
3.1 Overview of Power Sector in Uzbekistan

3.1.1 Organization

In the Republic of Uzbekistan, there was reorganization in August 2001, and the Ministry of Electric Power and Electrification was changed into the State Joint Stock Company Thermal Power Plant (hereinafter referred to as JSC Thermal Power Plant). JSC Thermal Power Plant includes a power generation company, power transmission company, power distribution company, affiliated company (EnergoSotish, etc), and coal company (Ugol).
In May 2019, JSC Uzbekenergo was split off into following three separate companies.

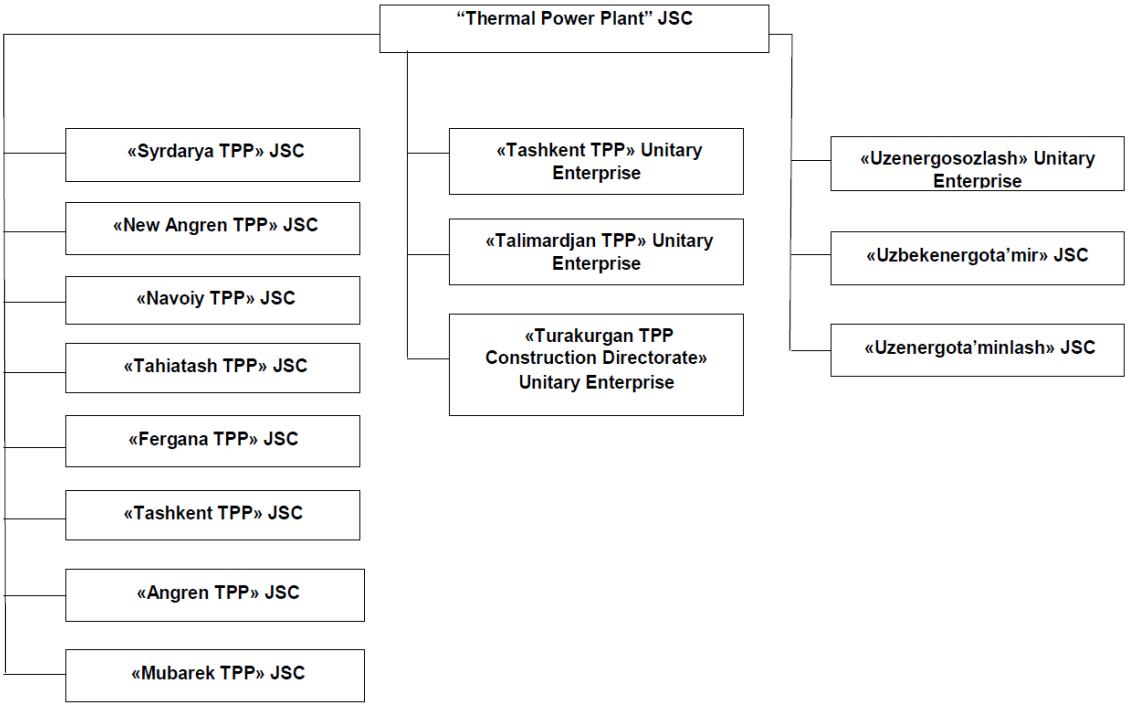
- JSC "National Electric Networks of Uzbekistan"
- JSC "Thermal Power Plant"
- JSC "Regional Electric Networks"

The organization structures of each company are shown in Figure 3.1.1-1, Figure 3.1.1-2 and Figure 3.1.1-3.



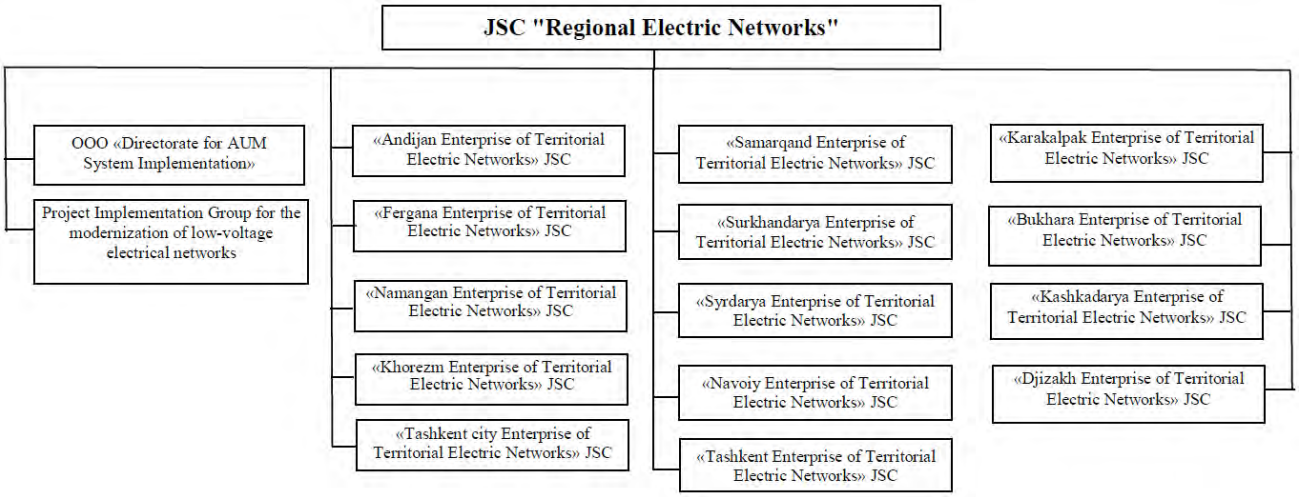
(Source: Ministry of Energy)

Figure 3.1.1-1 Organizational Structure of JSC "National Electric Networks of Uzbekistan"



(Source: Ministry of Energy)

Figure 3.1.1-2 Organizational Structure of the JSC "Thermal Power Plant"



(Source: Ministry of Energy)

Figure 3.1.1-3 Organizational Structure of JSC "Regional Electric Networks"

3.1.2 Overview of the Existing Power Generation Facilities

In 2017, JSC “Thermal Power Plant” produced 52,143 GWh of electric power. The generation capacity of all the power generation facilities in the Republic of Uzbekistan exceeds 13,500 MW.

The JSC “Thermal Power Plant” anticipates a substantial increase (around 1 to 3 %) in electricity demand. To meet this growing demand, the company is planning to maintain the capacity of self-support through introduction of new facilities, to improve the reliability and quality of power supply, to save power, and to enhance operation efficiency of fuel and power. Furthermore, to protect the local ecosystem and to enhance global environment, the company is making efforts to develop an on-site power generation technology and renewable energy source. Table 3.1.2-1 and Table 3.1.2-2 show the overview of the existing thermal power plants and hydraulic power plants. Power generation facilities in Uzbekistan consist of 10 thermal power plants (of which three are cogeneration power plants) and 28 hydraulic power plants. The overall installed capacity is 13,552 MW (12,158 MW by thermal power plants plus 1,394 MW by hydraulic power plants). Of these, the capacity of each of following four power plants is over 1,000 MW: Syrdarya thermal power plant (3,000 MW), Navo-Angren thermal power plant (2,100 MW), Tashkent thermal power plant (1,860 MW), Navoi thermal power plant (1,250 MW). Furthermore, three cogeneration power plants as well as thermal power plants supply heat to thirteen regions.

Many of these power plants have been operating for 40 to 50 years after commencement of commercial operation, and require renewal or replacement due to degradation.

Capacity of hydroelectric power plants of the company is 1.4 million kW, and those are mainly united into cascades of hydroelectric power plants and operate under watercourse.

Table 3.1.2-1 Overview of the Facilities in the Existing Thermal Power Plants

No.	Name of Plant	Type of Plant	No. of Turbine - Generator Units	Total Installed Capacity (MW)	Type of Fuel	Year of Initial Operation	Total Current Effective Capacity(MW)	Cumulative Operating Hours of All Unit (hours)
1	Syrdarya TPP	Steam Turbine & Boiler	10	3,065	Gas, Oil	1972-1981	2,647	2,636,377
2	Novo-Angren TPP	Steam Turbine & Boiler	7	2,100	Coal, Gas, Oil	1985-1995	1,200	913,979
3	Tashkent TPP	Steam Turbine & Boiler	12	2,230	Gas, Oil	1963-1971	1,900	3,509,270
4	Navoi TPP	Steam Turbine & Boiler	12	1,618	Gas, Oil	1963-1981	1,214	2,748,198
6	Takhiatash TPP	Steam Turbine & Boiler	5	630	Gas, Oil	1962-1990	449	948,631
7	Angren TPP	Steam Turbine & Boiler	8	393	Coal, Oil, Coal Bed Methane	1957-1963	200	1,176,593
8	Fergana CHP	Steam Turbine & Boiler	7	305	Gas	1954-1979	50	779,583
9	Mubarek CHP	Steam Turbine & Boiler	2	60	Gas	1985-1986	50	309,885
10	Tashkent CHP	Steam Turbine & Boiler	1	57	Gas	1939-1964	51	483,680
5	Talimarjan TPP	Steam Turbine & Boiler	1	1,700	Gas, Oil	2004	1,598	123,142
	Total	-	-	12,158	-	-	9,359	13,629,338

(Source: JSC Thermal Power Plant)

Table 3.1.2-2 Overview of the Facilities in the Existing Hydraulic Power Plants

No	Name of plant	Type of plant	Place	Number of Unit	Total installed Capacity	Beginning year of operation	Total valid plant capacity (MW)
1	Charvak HPP	Hydraulic Power	Tashkent region	4	600	1970-1972	620.5
2	Khodjikent HPP	Hydraulic Power	Tashkent region	3	165	1976	165
3	Gazalkent HPP	Hydraulic Power	Tashkent region	3	120	1980	120
4	Chirchik GES	Hydraulic Power	Tashkent region	10	190.7	1941-1956	190.7
5	Kadyrya GES	Hydraulic Power	Tashkent region	8	44.6	1933-1946	44.6
6	Nizne-Bozsu GES	Hydraulic Power	Tashkent region	10	50.8	1943-1960	50.8
7	Tashkent GES	Hydraulic Power	Tashkent	10	29	1926-1954	29
8	Farkhad GES	Hydraulic Power	Syrdarya region	4	126	1948-1960	126
9	Sharikhan GES	Hydraulic Power	Andijan region	6	27.8	1943	27.8
10	Samarkand GES	Hydraulic Power	Samarkand region	9	40	1945	40
	Total	-	-	-	1,394	-	1,414

(Source: JSC Thermal Power Plant)

Table 3.1.2-3 shows transition of installed capacity of thermal and hydroelectric power plants. Capacity of those plants is increasing.

Table 3.1.2-3 Transition of Installed Capacity of Thermal and Hydroelectric Power Plants

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2016**	**2017**
Thermal Power Plant	10619	10619	10619	10619	10619	10619	10619	11112	11029	11079	12129
Hydro Electric Power Plant	1738,5	1741.5	1741.5	1741.5	1812.5	1857.5	1859.5	1859.5	1859.5	1859.5	1859.5
Total	12357,5	12360.5	12360.5	12360.5	12431.5	12476.5	12478.5	12971.5	12888.5	12938.5	13988.5

(Source: JSC Thermal Power Plant)

Table 3.1.2-4 shows transition of available capacity of each thermal power plant. As shown in Table 3.1.2-4, average deteriorated ratio (= (Installed capacity – Available capacity)/Installed capacity x 100) shows around 20.4%. This means that about 20.4% of the capacity has been lost,

Table 3.1.2-4 Transition of Available Capacity of the Existing TPPs

Name of Thermal Power Plant	Available capacities, MW				
	2013	2014	2015	2016	2017
Syrdarya Thermal Power Plant	2500	2500	2670	2710	2710
Novo-Angren Thermal Power Plant	1250	1280	1280	1280	1280
Tashkent Thermal Power Plant	1640	1640	1640	1640	1640
Navoi Thermal Power Plant	1400	1400	1358	1358	1358
Talimarjan Thermal Power Plant	780	780	730	780	1680
Takhiatash Thermal Power Plant	500	500	500	500	500
Angren Thermal Power Plant	120	120	115	115	250
Fergana Heat Power Plant	130	130	130	130	130
Mubarek Heat Power Plant	60	60	60	60	60
Tashkent Heat Power Plant	50	50	50	50	50
Total TPP:	8430	8460	8533	8623	9658

(Source: JSC Thermal Power Plant)

Table 3.1.2-5 shows power consumption in each category for 6 years. In this 6 years, power consumption for each category is slightly increasing except for street lighting cities.

Table 3.1.2-5 Power Consumption in each Category

Year / Category	2013	2014	2015	2016	2017	2018
Industrial consumers	1,934	2,011	2,031	2,049	2,165	2,269
Non-industrial consumers, budget organizations,	1,021	984	1,028	1,042	1,094	1,052
Street lighting of cities	11	10	11	10	11	12
Organization of trading, cafes, restaurants and services area	-	-	-	-	-	-
Household	1,181	1,183	1,280	1,248	1,286	1,325
TOTAL	4,146	4,189	4,351	4,349	4,556	4,658

(Source: JSC Thermal Power Plant)

Table 3.1.2-6 shows fuel consumption records at thermal power plants including heat and power plants.

Table 3.1.2-6 Fuel Consumption at Thermal Power Plants

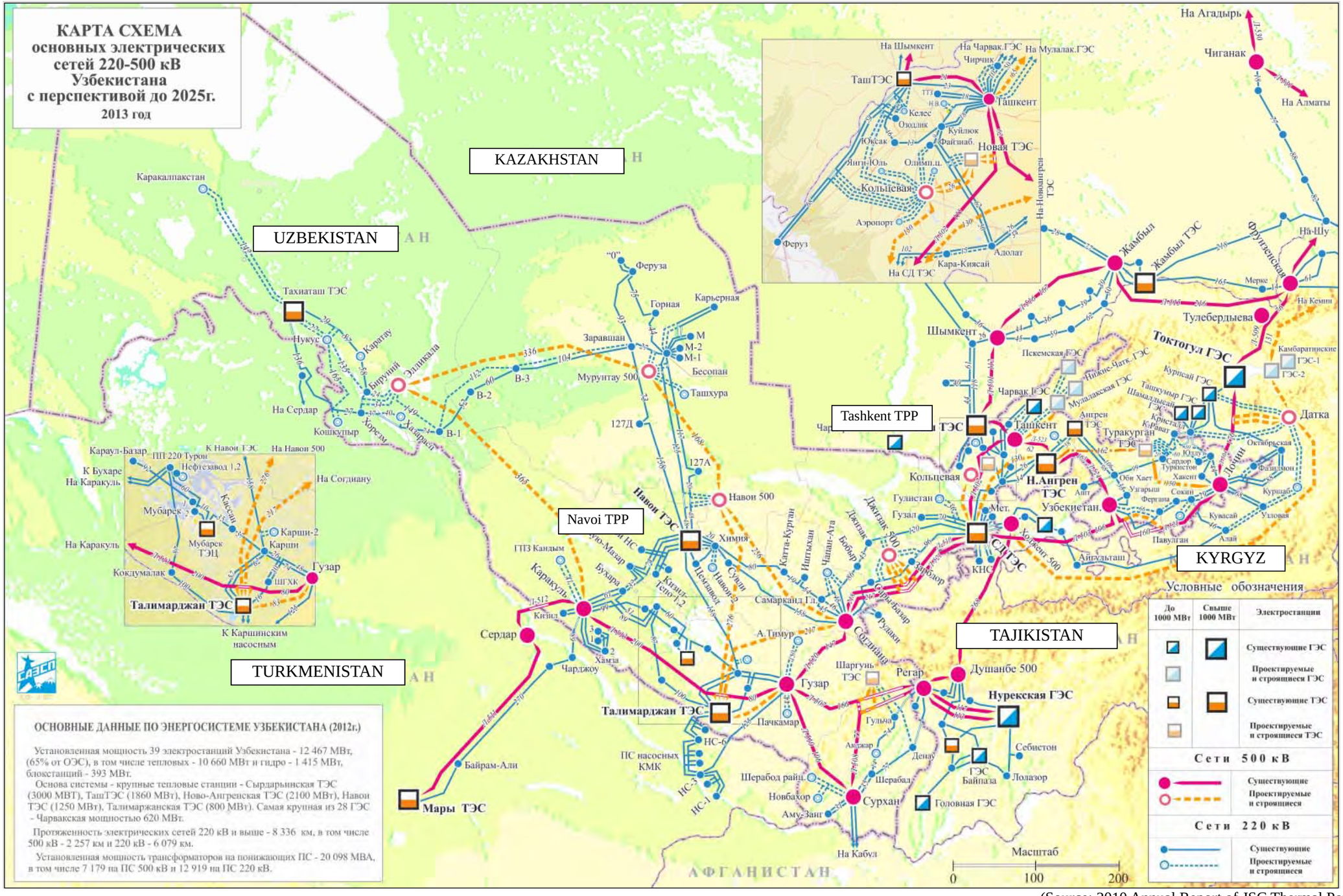
Type of Fuel	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2016	2017
Coal	M tons/yr	2770.2	2664.9	2187.2	2613.3	2010.1	2214.2	2623.8	4409.1	3583.4	3185.2	3317.4
Natural Gas	Gm^3/yr	12948.2	12967.6	14608.4	13695.8	13774.6	14875.1	14722.1	14914.7	15323.9	16051.9	15207.7
Mazut	M tons/yr	778.6	565.4	244.1	239.7	246.4	200.7	171.8	146.8	162.1	59.7	148.6
Coal Gas	Gm^3/yr	360.6	302.2	221.2	330.0	259.4	274.9	331.2	301.9	305.0	291.8	268.3

(Source: JSC Thermal Power Plant)

3.1.3 Overview of Power Transmission Facilities

(1) Power grid system

The power grid system in the Republic of Uzbekistan was constructed at the time of the former Soviet Union, where five countries including Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan were assumed as constituting one integral area. Thus, after independence of each country, the power grid system constitutes an international linkage system. The 500 kV transmission line is also linked to Russia via Kyrgyzstan and Kazakhstan. Thus, the power grid system is characterized by a large scale system and operation of stable frequency. The 500 kV and 220 kV lines are used in the trunk network, and the 110 kV lines serve for local supply systems. The vast majority of the trunk network consists of one-circuit transmission lines. The outage at the time of transmission line trouble is minimized by parallel operation of the 500 kV and 220 kV circuits.



(Source: 2010 Annual Report of JSC Thermal Power Plant)

Figure 3.1.3-1 Power grid System for the Republic of Uzbekistan

As explained in subsection 3.1.4, there has not been much fluctuation in demands over the past decade. Reinforcement work was not applied to the 500 kV transmission line of the trunk network for some time since 1991, as shown in Table 3.1.3-1 reflecting such demand. However, to meet the requirements for further reduction of transmission loss and subsequent increase in demand, expansion work was performed in 2007 and 2008. As of 2017, the 500 kV transmission line measures 2,257 km, the 220 kV transmission line measures 6,200 km, and the 110 kV transmission line measures 15,300 km.

Table 3.1.3-1 Information about New Construction and Modernization of Electrical Networks of JSC Thermal Power Plant

Year	Length of Transmission Lines / km			
	500 kV	220 kV	110 kV	35 kV
Ongoing Projects (2018 – 2022 year)	117 15	722 30	299 421	235 396
Projects under development (2023 – 2025 year)	1,445 20	876 40	506 561	456 529
Promising Projects (2026 – 2030 year)	519 15	1,047 30	881 421	740 396

(Upper: new construction of transmission line, Lower: Modernization of transmission line)

(Source: JSC Thermal Power Plant)

i. Current Power System Configuration around Navoi TPP

Existing Navoi TPP has 14 lines of 220 kV transmission lines, including the fourth line to Chemistry (Himia) SS, and has eight lines of 110 kV transmission lines.

The 220 kV transmission line is connected to the Navoi Mining and Metallurgical Complex (NMMC), located in the north of Navoi TPP, with the three transmission lines. And, Bkhara SS is connected by the two transmission lines via K-Mazar SS. Furthermore, it is connected to Chemistry (Himia) SS by the four transmission lines, and to Talimarjan TPP by the one transmission line via Karshi SS.

In addition, it is connected with Shemzavod SS by the one line and Kyzirtepo SS by the two lines of transmission line, and the other 1 line is used for regional power supply.

The 110 kV transmission lines are all used for load supply to the neighboring areas.

ii. Development plan around Navoi TPP

The following major developments are planned in the suburbs of Navoi TPP and in the North West region.

Further development of the Navoi Mining and Metallurgical Complex (NMMC) is planned in the Besopen region. And, railroad development is also planned between Samarkand area and Bukhara area, and between Navoi area and Misken area via Kanimekh area (360 km), and also between Misken area and Urgench area (87 km) and between Misken area and Nukus area (196 km). In addition, development of Kandym gas processing facility in Bukhara area is planned. The North West area and the Besopan area are more than 360 km apart, and are connected only by 220 kV single-line transmission. As a result, it is not possible to exchange sufficient amounts of power between the two regions.

Therefore, construction of the following 500 kV transmission lines is planned to improve the reliability of the power system in these areas.

- ✓ Between Sarymai SS and Karakul SS in the North West region (currently planned)
- ✓ Between Muruntau SS and Sarymay SS in the North West region (future planned)
- ✓ Between Navoi SS and Muruntau SS in Navoi area (future planned)

Finally, with the construction of the 500 kV transmission line between Navoi SS and Talimarjan TPP, the series of 500 kV transmission line projects are completed. The construction of the 500 kV transmission lines with the substations will ensure reliable, high-quality power supply in the required amounts to all consumers in these areas.

iii. System Planning in the North West Region and Navoi Region

Grid development is planned in the North West region and Navoi region in the following four stages.

- Stage I

Two 100 Mvar reactive power compensators (SVC) will be installed to maintain the voltage of Besopan SS to which large-scale mining equipment is connected.

- Stage II

In preparation for the construction of Sarymay SS, the 220 kV switch yard will be constructed. In addition to this, construction of the following 220 kV transmission lines will be conducted.

- ✓ Between Sarymai SS and Zarafshan SS (226 km)
- ✓ Between Takhiatash TPP and Khorezm SS (198 km)
- ✓ Between Khorezm SS and Sarymay SS (185 km)

- Stage III

In preparation for the construction of Navoi SS, the 220 kV switch yard will be constructed. And, construct the 500 kV transmission line between Navoi SS and Besopan SS (180 km) and operate at the voltage of 220 kV. This transmission line is changed its connecting point from Besopan SS to Muruntau SS and used as the 500 kV transmission line when Muruntau SS will start operation. In addition, the 220 kV transmission line will be constructed between Takhiatash PS and Beruni SS (129 km), and the 220 kV transmission line between Beruni SS and Sarymai SS (140 km).

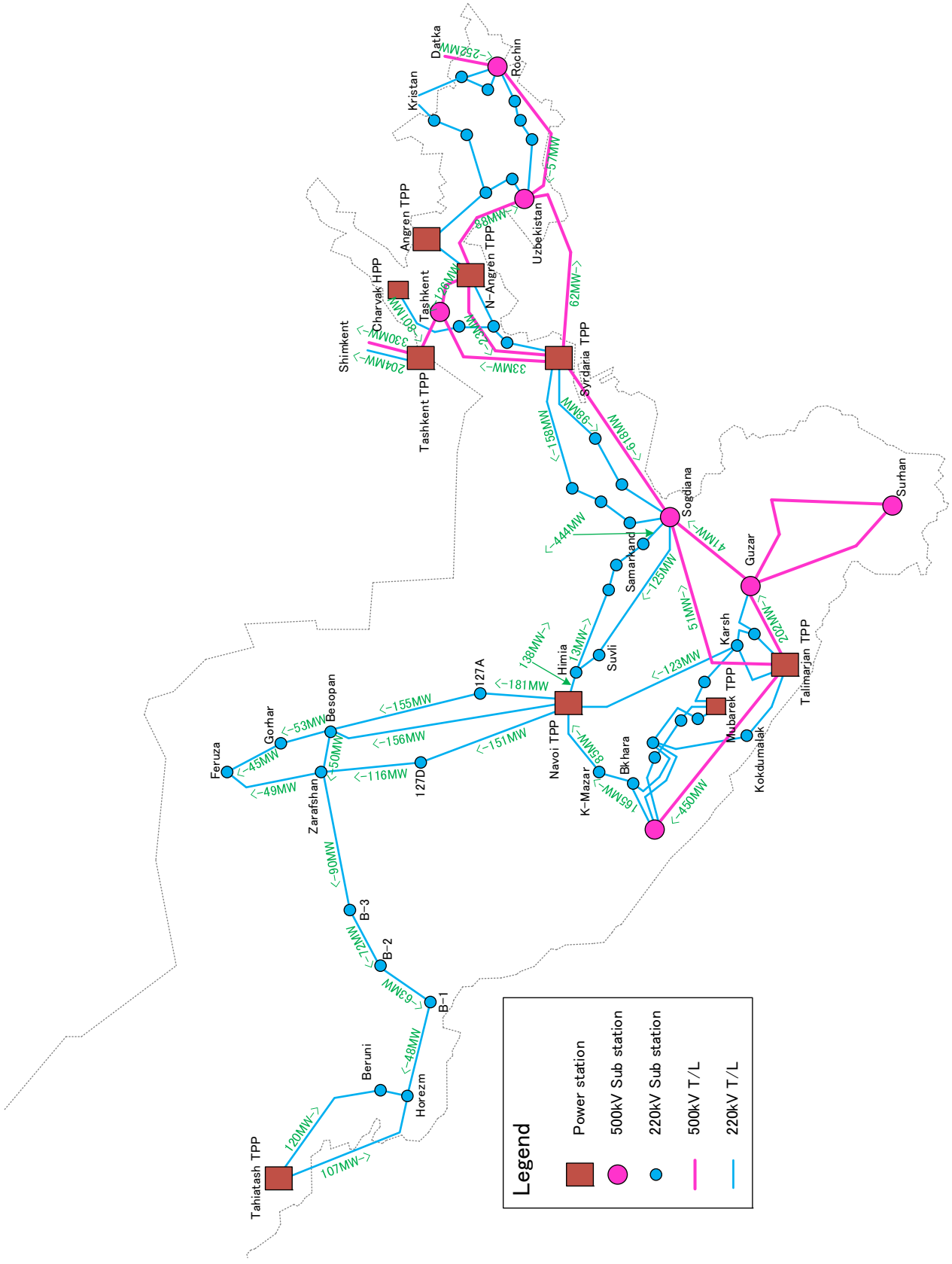
- Stage IV

As the final stage of the grid planning in the North West part and the Navoi region, construct the 500 kV transmission line between Sarymay SS and Karakul SS (255 km). The transmission line connection between Navoi SS and Besopan SS (180 km) constructed with 500 kV specification and operated at 220 kV is changed to Navoi SS and Muruntau SS (163 km) and operated as the 500 kV transmission line.

(2) Power flow

Table 3.1.3-2 shows the power flow condition in whole Uzbekistan at 21:00 on 20 June 2018. Uzbekistan can be divided into five regions of the East, the South, the Central, the South West and the North West, and major power plants such as Tashkent TPP, Angren TPP, Novo Angren TPP, Syrdaria TPP, and Charvak HPP are located in the Central region. The power generated by the power plants in the Central area is transmitted to the South West area via Syrdaria TPP. From Syrdaria TPP to the west, the power flow of 618 MW is transmitted by the 500 kV transmission line and 256 MW by the 220 kV transmission line.

Load supply to the North West area is through the 220 kV transmission lines connected to Navoi TPP. The South West area and the North West area are connected by a single 220kV transmission line, but due to transmission capacity limitations, sufficient power interchange cannot be performed between these areas. In addition, Besopan SS, Gorhar SS, Feruza SS and Zarafshan SS in the South West area are located far from the power plant (such as Navoi TPP, Tahiatash TPP), so these are making it difficult to maintain the voltage of each substation.



(Source: JSC Thermal Power Plant)

Figure 3.1.3-2 Power flow in the Uzbekistan Power System

(3) Loss in power transmission and distribution

The loss in power transmission and distribution can be divided into technical loss and non-technical loss. The technical loss rate of Table 3.1.3-2 shows a transition of about 10 % up to the year 2010 from 2006. After that, a rapid increase can be observed. This may have been caused by the degradation of power transmission and distribution facilities. However, the reason for a rapid increase amid the stagnation of the overall demand is not yet clear. The reduction in the loss rate is effective in reducing the amount of primary energy used, hence in protecting the global environment. It is necessary to examine the reasons in greater detail and to take required measures.

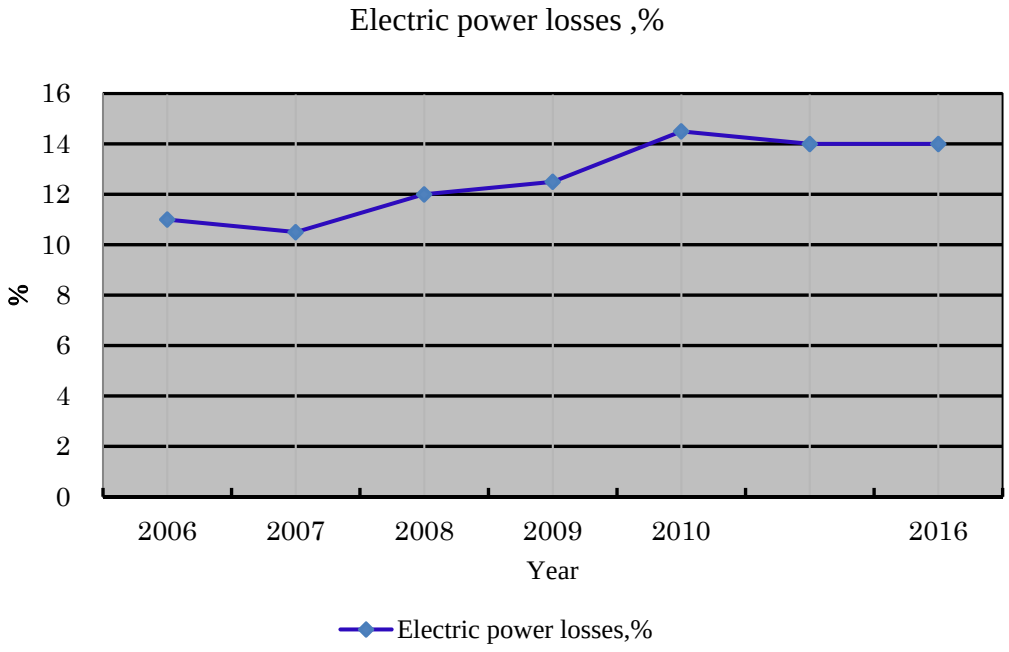
Focusing on the transmission line as an example, the old transmission line is aging aggravated, and as shown in the table, the average number of years passed is also 35 years. Transmission loss is also relatively high with aged deterioration, and it is said to be a loss of 15 to 20 % or more of the total power generation amount.

Also, many of Uzbekistan's power transmission lines have small conductor sizes, and the resistance of that conductor is high, so losses become noticeable at high operation. Despite the recent increase in demand, old wires are being used, which is supposed to be the case. As a countermeasure, it can be thought that improvement is achieved by introducing Japanese low-loss electric conductor (LL-ACSR).

Table 3.1.3-2 Line Length and Aging (at 2017)

Voltage	Line length (km)	Average Aging (year)
500kV	2.257	33
220kV	6,200	35
110kV	15.300	33

(Source : Survey Team)



(Source: JSC Thermal Power Plant modified by Survey Team)

Figure 3.1.3-3 Transition of Power Transmission and Distribution Loss Rate

3.1.4 Power Demand

Table 3.1.4-1 shows the transition of the generation and consumption of power in the last 9 years. The overall demand for electric power in the Republic of Uzbekistan had exhibited annual increase for seven years, even though the demand for electric power had reduced until 2011 after independence in 1991 due to economic confusion and stagnation of industrial activities. Economy has been on an upward trend, and the overall demand for electric power is also on an upward trend, even though this trend is slow.

Table 3.1.4-2 shows the transition of the imported and exported electric power. As described above, electric power is exchanged among Uzbekistan and the surrounding countries. The export and import power exhibits a swing for each year, while the range is stabilized from 800 MW to 1,200 MW. The possible cause for increase of import power in 2018 is to make up for the gap between the demand for electric power and the generation of electric power in the Republic of Uzbekistan as seen from Table 3.1.4-1.

Table 3.1.4-1 Transition of Electricity Generation and Electricity Consumption in the last 9 Years

Year / Category	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total amount of electric power (resource) supplied, MW	8,054	8,052	8,260	8,516	8,539	8,625	9,074	9,056	10,220
Total amount of accounted electric power (production supply), MW	8,220	8,198	8,102	8,578	8,291	8,581	9,386	9,347	9,611

(Source: JSC Thermal Power Plant)

Table 3.1.4-2 Transition of the Imported and Exported Electric Power in the last 9 Years

Type of Fuel	2010	2011	2012	2013	2014	2015	2016	2017	2018
Exported Power, MW	1,096	1,055	873	1,080	837	891	1,130	1,167	1,149
Imported Power, MW	930	909	1,031	1,019	1,085	937	812	876	1,758

(Source: JSC Thermal Power Plant)

Table 3.1.4-3 Transition of the Maximum Power Demand

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Maximum power demand, MW	8,054	8,052	8,260	8,516	8,539	8,625	9,074	9,056	10,220

(Source: JSC Thermal Power Plant)

3.1.5 Power Generation Development Plan

(1) In the Republic of Uzbekistan

In the Republic of Uzbekistan, the position of the most important national investment items for gas development, electric power development and others has been clearly defined by the Executive Order of the President in an effort to ensure a sustainable development of economy. According to Power Generation Development Plan up to 2024 made by JSC "Thermal Power Plant".

Table 3.1.5-1 Power Generation Development Plan (2020 - 2024)

No.	Name of plants		2020		2021		2022		2023		2024		Total Output
			Unit	MW	Unit	MW	Unit	MW	Unit	MW	Unit	MW	MW
1	Syrdarya TPP	Power unit	-	-	-	-	2	500	4	1300	4	1300	3,100
2	New Angren TPP	Power unit	-	-	2	200	2	400	2	400	1	200	1,200
3	Tashkent TPP	Power unit	2	275	2	260	3	260	5	675	-	-	1,470
4	Navoiy TPP	Power unit	-	-	-	-	2	250	4	500	-	-	830
		Turbine generating unit	-	-	-	-	2	80	-	-	-	-	
5	Tahiatash TPP	Power unit	-	-	-	-	-	-	2	320	-	-	490
		Turbine generating unit	-	-	2	170	-	-	-	-	-	-	
6	Angren TPP	Turbine generating unit	-	-	-	-	-	-	-	-	4	100	100
7	Fergana TPP	Turbine generating unit	-	-	-	-	2	60	-	-	-	-	60
8	Talimardjan TPP	Power unit	-	-	-	-	1	780	-	-	-	-	780
	Total		2	275	6	630	6	2330	17	3195	9	1600	8,030

(Source: JSC Thermal Power Plant)

(2) Development plan around Navoi TPP

The following major developments are planned in the suburbs of Navoi TPP and in the North West region.

Further development of the Navoi Mining and Metallurgical Complex (NMMC) is planned in the Besopen region. And, railroad development is also planned between Samarkand area and Bukhara area, Navoi area and Kanimekh area and Misken area (360 km), and also between Misken area and Urgench area (87 km) and between Misken area and Nukus area (196 km). In addition, development of Kandym gas processing facility in Bukhara area is planned.

The North West area and the Besopan area are more than 360 km apart, and are connected only by 220 kV single-line transmission. As a result, it is not possible to exchange sufficient amounts of power between the two regions.

Therefore, construction of the following 500 kV transmission lines is planned to improve the reliability of the power system in these areas.

- ✓ Between Sarymai SS and Karakul SS in North West region (currently planned)
- ✓ Between Muruntau SS and Sarymay SS in the North West region (future planned)
- ✓ Between Navoi SS and Muruntau SS in the Naboi area (future planned)

Finally, with the construction of the 500 kV transmission line between Navoi SS and Talimarjan TPP, the series of 500 kV transmission line projects are completed. The construction of the 500 kV transmission lines with the substations will ensure reliable, high-quality power supply in the required amounts to all consumers in these areas.

3.1.6 Power Demand Forecast

JSC Thermal Power Plant planned power generation by their Thermal Power Plant from 2020 to 2030 is shown in Table 3.1.6-1. During the term its growth rate will be around 4.5 % - 9.7 % per year.

As described in item 3.1.2, the available capacity of the existing thermal power plants is reduced to 79.6 % of their installed capacity in 2017. Therefore, new installation or modernization of power plant is necessary to cover such gap between maximum power demand and available capacity. On the other hand, 8,030MW generation capacity is planned to be developed, as shown in Table 3.1.5-1. This figure includes the capacity by replacement of the existing power plants. Therefore, to keep the stability of power supply to correspond to increasing power demand, it is necessary to implement said power generation development plan steadily.

Table 3.1.6-1 Power Demand Forecast up to 2030

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electric Power Demand, MW	11,849	12,473	13,216	14,315	15,032	15,780	16,568	17,384	18,159	19,226	20,254
Growth Ratio (vs. previous year)	9.7 %	5.3 %	6.0 %	8.3 %	5.0 %	5.0 %	5.0 %	4.9 %	4.5 %	5.9 %	5.3 %

(Source: JSC Thermal Power Plant)

3.1.7 Renewable Energy in Uzbekistan

JSC Thermal Power Plant is promoting Renewable Energy in Uzbekistan to diversify fuel and energy balance, JSC Thermal Power Plant plans to implement the following projects.

Table 3.1.7-1 Renewable Energy Project in Uzbekistan

No.	Name of Project	Capacity	Period of Implementation	Project cost	Foreign partner/lender
1	Construction of a solar photovoltaic plant with a capacity of 100MW in Navoi region (pilot project)	100 MW	2019-2021	100.0	International Financial Corporation
2	Construction of a solar photovoltaic plant with a capacity of 100MW	100 MW	2019-2022	100.0	International Financial Corporation
3	Construction of a solar photovoltaic plant with a capacity of 100MW	100 MW	2020-2021	100.0	Being elaborated with Total Eren (France)
4	Construction of a solar photovoltaic plant with a capacity of 100MW	100 MW	2020-2022	100.0	Being elaborated with Total Eren (France)
5	Construction of a solar photovoltaic plant with a capacity of 200MW	200 MW	2020-2023	200.0	International Financial Corporation
6	Construction of a solar photovoltaic plant with a capacity of 200MW	200 MW	2022-2024	200.0	International Financial Corporation
7	Construction of a solar photovoltaic plant with a capacity of 200MW	200 MW	2023-2025	200.0	International Financial Corporation
8	Construction of a solar photovoltaic plant with a capacity of 200MW	200 MW	2024-2027	200.0	International Financial Corporation
9	Construction of a solar photovoltaic plant with a capacity of 200MW	200 MW	2024-2027	200.0	To be determined
10	Construction of a solar photovoltaic plant with a capacity of 200MW	200 MW	2026-2028	200.0	To be determined
11	Construction of a solar photovoltaic plant with a capacity of 200MW	200 MW	2027-2029	200.0	To be determined
12	Construction of a solar photovoltaic plant with a capacity of 200MW	200 MW	2027-2030	200.0	To be determined
13	Construction of a wind power plant with a capacity of 100MW	100 MW	2019-2022	120.0	EBRD
14	Construction of a wind power plant with a total capacity of 500MW	500 MW	2019-2025	825.0	Being elaborated with Masdar Company (UAE)
15	Construction of a wind power plant with a capacity of 100MW	100 MW	2021-2023	120.0	To be determined
16	Construction of a wind power plant with a capacity of 100MW	100 MW	2022-2024	120.0	To be determined
17	Construction of a wind power plant with a capacity of 100MW	100 MW	2022-2025	120.0	To be determined
18	Construction of a wind power plant with a capacity of 200MW	200 MW	2024-2026	240.0	To be determined
19	Construction of a wind power plant with a total capacity of 200MW	200 MW	2025-2027	240.0	To be determined
20	Construction of a wind power plant with a total capacity of 200MW	200 MW	2025-2028	240.0	

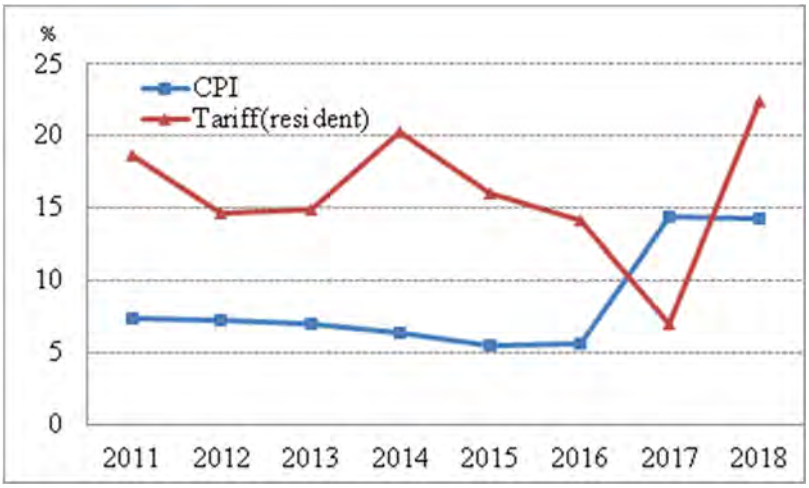
(Source: Ministry of Energy)

3.2 Electricity Tariff

3.2.1 Electricity Tariff

Uzbekistan's electricity tariff had been low compared to several other countries with compatible GDP[1]. This was primarily driven by the low domestic cost of natural gas relative to international prices. Tariff reform was initiated in the period of 2002 and 2004. This effort brought a significant reduction of cross-subsidy to the power sector by mid-2000s[2]. Since 2004, the electricity tariffs have been raised almost semiannually, outpacing the annual rate of inflation except for 2017 as shown in Figure 3.2.1-1, with the government's commitment to maintain tariffs at a level that covers operation and maintenance cost and capital costs. As a part of financial recovery action plan[3] in which JSC Uzbekenergo (currently JSC Thermal Power Plant) proactively launched to ensure its financial sustainability in response to the deterioration of its balance sheet due to a sharp depreciation of the local currency by about 90 % against USD in 2017 because of its exposure to foreign currency debts, JSC Thermal Power Plant, supported by ADB, initiated the development of new tariff setting methodology to ensure gradual full cost recovery and optimize tariff structure as well as a strategy to implement it in a time bound manner while at the same time identifying and mitigating adverse social impact.

In April 2019, the government of Uzbekistan approved the main direction of the electricity tariff policy for the period until 2030[4] and regulations of procedure for electricity tariff formation that will be implemented from January 2020. The main directions include: (i) providing to consumers of access to the electric power on reasonable and competitive rates; (ii) ensuring financial stability and investment appeal of electric industry; (iii) establishment of the principles of pricing on the electric power aimed at providing complete covering of operating and capital costs; (iv) implementation of the differential tariff; (v) gradual introduction of a tariff formation technique until 2023. The Resolution also provided for keeping established electricity tariff unchanged for at least 3 years from 2023.



(Source: JSC Uzbekenergo (JSC TPP PIU), The Survey Team)

Figure 3.2.1-1 Tariff and CPI

[1] World Bank (2011), "Project Appraisal Document for Talimarjan Transmission Project"
[2] ADB(2005), "Electricity Sectors in CAREC (Central Asia Regional Economic Cooperation) Countries"
[3] The financial recovery action plan prioritizes (i) revenue increase by developing and implementing a new cost recovery tariff, (ii) corporate restricting including divestment of noncore assets, and (iii) improvement pf operating efficiency, IFRS-compliant classification and impairment provisions on account receivables and payables.
[4] Resolution of the cabinet of ministers of the Republic of Uzbekistan of April 13, 2019 No.310

The retail electricity tariff for residences increased from UZS 250/kWh (USD0.029) in November 2018 to USZ 280/kWh (USD0.033) in June 2019 as shown in Table 3.2.1-1. Also, starting from January 2019, the quota of electricity consumption was introduced as an experiment[5]. The weighted average sales price of electricity for last three years exceeded the average production cost of electricity as shown in Table 3.2.1-2. From the viewpoint of beneficiary payment principle and JSC Uzbekenergo's financial performance, continuing tariff revision above inflation is appropriate to ensure sufficient investment in the power sector in the long run.

The electricity tariffs are regulated by the central government. A methodology and framework for implementing tariffs for JSC Thermal Power Plant is provided by Resolution 239 of the Cabinet of Ministers[6]. The Ministry of Finance sets and revises electricity tariffs, considering needs for additional investments in power facilities as well as JSC Uzbekenergo's solvency and others, based on the tariff petition calculated by JSC Uzbekenergo and UzGosEnergoNadzor, which is a regulatory agency for the energy sector in technical aspects. The Resolution dated on April 13, 2019 provides a new electricity tariff formulation, in which the inter-agency Tariff Commission under the Cabinet of Ministers of the Republic of Uzbekistan serves as a regulatory authority and the state antimonopoly body exercises control over the correctness of formation and the application of tariff. The Commission contains seven members, and Deputy Prime Minister (Minister of Finance) is appointed as the chairman of the Commission.

Table 3.2.1-1 Electricity Tariff by Customer Category

（Unit: UZS/KWh）

Cat.	Customer	Nov-2018	June-2019
1	Consumer groups about the connected capacity of 750kVA and above, with exception of the budget organizations, pumping stations of farms and association of consumers as well as pumping stations financed from the state budget	331.00 (USD 0.04)	370.00 (USD 0.04)
2	Electricity consumers at single rate, except for residential customers	331.00 (USD 0.04)	370.00 (USD 0.04)
3	Residential consumers Residential consumers living in multi-unit, houses and hostels centrally equipped with electric cookers for food preparation	250.00 (USD 0.03) 125.00 (USD 0.01)	280.00 (USD 0.03) 140.00 (USD 0.01)
4	Consumers group which use electric energy for electric heating, hot water, and food preparation except for budget organization	350.00 (USD 0.04)	390.00 (USD 0.05)
5	Consumers producing products providing separate services according to the List approved by the decree of the President of the Republic	365.00 (USD 0.04)	409.00 (USD 0.05)

（Source: JSC Uzbekenergo (JSC TPP PIU)）

[5] The benchmark quota electricity consumption is 300kw/hour per month per consumer. For the consumption volumes being within the limit of the quota, the payment will be executed at the rate established, and for the consumption volumes exceeding the quota the payment will be executed by using the coefficient of 1.2.

[6] The Resolution is a general regulatory framework for setting tariffs for any regulated monopoly entities in Uzbekistan.

Table 3.2.1-2 Production Cost of Electricity for JSC Uzbekenergo

	2015	2016	2017
Power Generation (GWh)	53,963.6	55,095.4	56,841.0
Sales Prices (UZS/kWh)	108.14	115.79	156.85
Production Cost (million UZS)	4,627,303.7	5,075,316.9	6,329,755.0
Production Cost per Unit (UZS/kWh)	85.8	95.1	111.4

（Source: JSC Uzbekenergo (JSC TPP PIU)）

The electricity tariff for JSC Navoi PS which was come into effect since Nov 2018 is 265.48 UZS/kWh (USD0.03). The Ministry of Finance sets and revises electricity tariffs, considering the total production cost of electricity including O&M cost, depreciation, financing cost and taxes, based on the tariff petition calculated by JSC Thermal Power Plant and UzGosEnergoNadzor. The weighted average sales price for the period of 2015-2017 exceeded the production cost during the same period except for 2016 as shown in Table 3.2.1-3. A further tariff increase will enhance the financial stability of JSC Navoi PS.

Table 3.2.1-3 Production Cost of Electricity for JSC Navoi PS

	2015	2016	2017
Power Generation (GWh)	8,214	8,544	7,862
Average sales price (UZS/kWh)	99.8	108.1	115.8
Production Cost (million UZS)	681,960	1,326,415	775,126
Production Cost (UZS/kWh)	83.0	155.2	98.6

（Source: JSC Uzbekenergo (JSC TPP PIU)）
(Note: The production cost in 2016 included the other cost incurred for the write-off of account payable.)

3.3 Heat Supply Sector in Uzbekistan

3.3.1 Overview of Heat Supply Sector in Uzbekistan

The supply of heat is an important basis for livelihood for the people of Uzbekistan and the heat is used as hot water supply and space heating in winter. The government targets the formation of a system for the supply of heat to all parts of the country in an effort to raise the living standards of the people.

The Uzbekistan government has a system for independent operation of heat supply by provinces and the system is operated in 14 areas comprised of the 12 provinces. Each province has an organization for managing the operation of the heat supply system and this organization operates and manages the heat supply plants, hot water boilers and the heat supply piping network. Moreover, the government has an agency called Uzkommuhizmat (Agency of Utility Services) directly under its jurisdiction to provide technical support to the heat supply operation organization in an effort to achieve more efficient operation throughout all areas of the country.

The organization for managing the heat supply operation of each province supplies the hot water produced in the boilers under its management to consumers via the heat supply plant and heat supply network. The heat supply system of Uzbekistan was one that was designed and constructed for the entire Soviet Union and is characterized by being a centralized integrated management system of a network consisting of long-distance heat supply from heat supply plants having large capacity and using inexpensive primary fuel. The heat source is principally these hot water boilers but there are heat plants that are supplied heat from heat and power supply plants operated by JSC Thermal Power Plant.

In the Uzbekistan country, as the preceding paragraph described, for every state, a heat service business is divided and is managed. Management organization was established under the state government and has managed the heat distribution company (Issiklik Manbai) which is taking charge of heat supply in each area.

3.3.2 Overview of Heat Supply Sector in Navoi District

In JSC Navoi PS, heat, both steam and hot water, is a major byproduct of electricity generation and used for both household and industrial purposes. JSC Navoi PS provides heat to its customers including fertilizer plants and residents. Regarding the steam supply, it has been carried out towards “Navoi Azot” JSC (Navoi nitrogen plant JSC), which is the largest organic fertilizers (ammonia, urea) production company in Uzbekistan.

The demand for heat supply is on the rise these days. The reason is the development of the economic and social sectors of the Samarkand-Bukhara region and the expansion of Navoi Azot JSC. Main heat consumers are Navoi Azot JSC, Navoi Mining-and-Metallurgical Integrated Works SE and greenhouse facilities.

About hot water supply, wholesale supply is carried out to the Navoi heat distribution company. JSC Navoi PS is collecting the return of hot water, and has managed a supply and return facility of between the Navoi heat distribution companies. The Navoi heat distribution company is supplying hot water to their consumer in Navoi. Billing of both steam and hot water is calorie-based under the same tariff table. Consumed amounts of steam and hot water are converted to calories. Heat tariff is revised every year as JSC Navoi PS submits a tariff petition to the Ministry of Finance with production cost data once a year. The Ministry of Finance is in charge of review and approval of heat tariff as well.

3.3.3 Heat Tariff

The recent history of heat tariff for JSC Uzbekenergo is shown in Table 3.3.3-1 below. There are two types of customer category. The Ministry of Finance sets and revises heat tariffs in the same way as it decides electricity tariffs. The tariff is revised twice a year. The sales prices were increased by 54.6 % from 2015 to 2017, while the production cost was increased by 41.2 % during the same period. A further tariff increase will enhance the financial stability of JSC Thermal Power Plant.

Table 3.3.3-1 Tariff Table of Heat for JSC Uzbekenergo

Cat	Customer	Price (UZS/Gcal)						
		Sept./2015	Oct./2015	July/2016	Oct./2016	Sep./2017	May/2018	Aug./2018
1	All customers except households	47,879	52,281	57,640	61,748	64,218	72,408	74,034 (USD8.68)
2	For households	25,800	27,120	32,031	32,031	33,312	37,560	38,400 (USD4.50)

(Source: JSC Uzbekenergo (JSC TPP PIU))

Table 3.3.3-2 Production Cost of Heat for JSC Uzbekenergo

	2015	2016	2017
Usable Heat (1,000 Gcal)	7,931.8	7,454.0	7,253.9
Average sales price (UZS/Gcal)	30,087	35,707	39,328
Total Cost (million UZS)	306,415.3	355,313.9	395,557.8
Unit Cost (UZS/Gcal)	38,631.4	47,667.3	54,530.2

(Source: JSC Uzbekenergo (JSC TPP PIU))

The heat tariff for JSC Navoi PS which was come into effect since June 2018 is shown in Table 3.3.3-3 below. There are two types of customer category. The Ministry of Finance sets and revises heat tariffs in the same way as it decides electricity tariffs. The weighted average sales price for the period of 2015-2017 exceeded the production cost during the same period except for 2016 as shown in Table 3.3.3-4. A further tariff increase will enhance the financial stability of JSC Navoi PS.

Table 3.3.3-3 Tariff Table of Heat for JSC Navoi PS since June 2018

Cat	Customer	Price (UZS/Gcal)
1	All customers except wholesale customers	129,384 (USD15.2)
2	Wholesale customers	129,384 (USD15.2)

(Source: JSC Uzbekenergo (JSC TPP PIU))

Table 3.3.3-4 Production Cost of Heat for JSC Navoi PS

	2015	2016	2017
Usable Heat (Gcal)	1,789,237	1,826,068	1,713,868
Average sales price (UZS/Gcal)	39,026.8	48,456.8	53,681.3
Total Production Cost (million UZS)	62,010	142,706	90,617
Unit Cost (UZS/Gcal)	34,657.3	78,149.4	52,872.6

(Source: JSC Uzbekenergo (JSC TPP PIU))

(Note: The production cost in 2016 included the other cost incurred for the write-off of account payable.)

Chapter 4

Current Situation of Power Plant Site

Chapter 4. Survey of Power Plant Site

4.1 Site Situation

Uzbekistan is characterized by typical continental climate consisting of a very hot summer, comparatively cold winter, a great temperature difference between daytime and night-time, and dry weather with little precipitation.

The planned project site is adjacent to the existing Navoi PS located in the suburbs of Navoi of Uzbekistan approximately 360 km west-southwestern (WSW) of Tashkent, capital of Uzbekistan (see Figure 1.2.2-1). The Navoi PS and the candidate construction site are located on the left bank of the Zeravshan River. The main target areas of this survey are the northeast area in the premises of Navoi PS and its surrounding areas. In this project, the area adjacent to the east side of the existing Navoi PS is proposed as a candidate site for construction by JSC Thermal Power Plant.

Figure 4.1-1 shows the Navoi PS, and the surrounding areas of the candidate construction sites of GTCC3, the existing GTCC1, the construction site of GTCC2 which is under construction, and the candidate construction site of the 200kV / 500 kV Substation. Wide area which occupy center of the site is existing conventional power plant (made by former Soviet Union, hereinafter called "Navoi-old").

（Source: Google Earth, added by JICA Survey Team）

Figure 4.1-1 Location of the Navoi Thermal Power Station

Table 4.1-1 shows the main data on temperature extracted from EIA report.

Table 4.1-1 Main Characteristics about Temperature

(°C)

Characteristics	Value
Average annual temperature	+ 15.9
Average maximum temperature	+ 22.8
Maximum temperature	+ 40.0
Average minimum temperature	+ 9.2
Minimum temperature	- 13.0
Average air temperature in January	+ 3.0
Average air temperature in July	+ 30.9
Average surface temperature of soil	+ 18.0
Minimum surface temperature of soil	- 5.0
Maximum surface temperature of soil	+ 69.0

(Source: EIA Report)

4.2 Existing facilities

4.2.1 Navoi-old

Navoi-old is the conventional thermal power plant, consisted of 11 Steam Turbines and 12 boilers and 11 generators. The amount of rated generating steam is 5,040 t/h and the rated power generation output is 1,250 MW.

It supplies not only electric power but also industrial steam for neighboring factories and hot water for district heating. Since it is the one and only supplier of these heat energies in the area, the Navoi PS has become indispensable for the important heat sources. The heat produced in the power station is in the form of steam and hot water. Steam is sent to neighboring factories (Navoi AZOT), and hot water is sent to each home in Navoi city. Existing units of Navoi thermal power station are tabulated below.

Table 4.2.1-1 Existing Units of Navoi Thermal Power Station

Unit No	Type of Plant			Start-up year	Type of steam turbine	Status	
		Heat					
	Power	District Heating	Industrial			as of Dec. 2016	Planned to be rehabilitated by Russia as of Dec. 2018
	MW	Gcal/hr	Gcal/hr				
1	25	34	50	1963	EC	Reserved	
2	25	34	50	1963	EC	Reserved	○
3	150	-	-	1964	C	Operation	○
4	150	33	-	1965	EC	Operation	○
5	50	-	200	1966	B	Operation	○
6	60	66	26	1967	EC	Stop	
7	50	-	199	1971	B	Operation	
8	160	33	-	1968	EC	Operation	
9	160	33	-	1969	EC	Operation	
10	-	100	-	1972	No steam turbine	Operation	
11	210	-	-	1980	C	Operation	
12	210	-	-	1981	C	Operation	
GTCC1	477.75	-	43	2013	EC	Operation	
GTCC2	450	100	100	(2020)	EC	Under construction	

EC Extraction condensing
C Condensing
B Back pressure

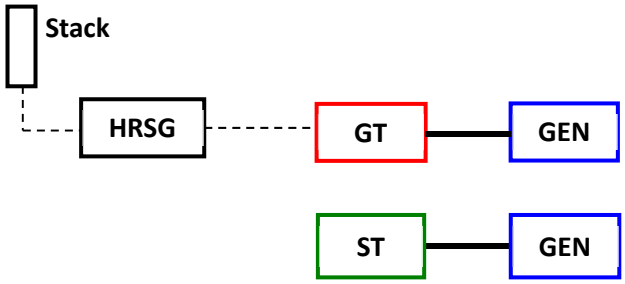
（Source: Pre-FS report of GTCC2 and information from JSC Thermal Power Plant）

4.2.2 GTCC1

GTCC1 is combined cycle power plant. The rated generation output is 478 MWe, located on the west side of Navoi-old. Mechanical draft wet cooling tower system has been adopted.
GTCC1 was put into commercial operation in October 2012.

(1) Configuration of GTCC1

Configuration of GTCC1: Multi shaft type without bypass stack
The gross power output of GTCC1: 477.8 MWe
The gross power output of Gas Turbine Generator: 313.6 MWe
The gross power output of Steam Turbine Generator: 164.2 MWe
Auxiliary Power: 4.4 MWe
Plant Net Power Output: 473.5 MWe



(Source: JICA Survey Team)

Figure 4.2.2-1 Diagram for Configuration of GTCC1

After commercial operation, GTCC1 has encountered the followings.

(2) Scale adhesion to condenser tubes

Please see 7.1.6 (1) – 7.

(3) Plugging of GT air filters by humid plume

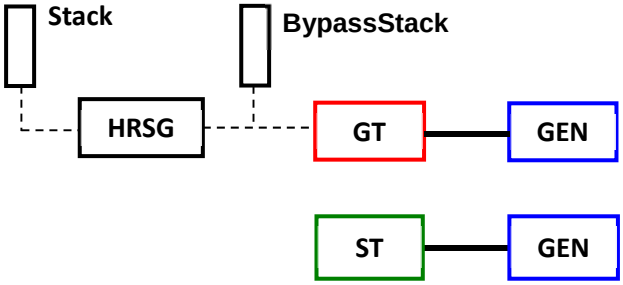
Draft loss of GT air filter increased due to the effects of moisture in cooling tower exhaust air and dust in atmospheric air.
Adverse effect of humid exhaust air to GT air filter and switchyard:
Water vapor in cooling tower exhaust air freezes over on GT air filter and open air switchgears in winter season. Since the draft loss suddenly went up exceeding the limitation in a short time such as 10 minutes, it is difficult to prevent the gas turbine trip.
Measures considered applicable to the Project are as following:
In GTCC2, applying air cooled condenser system, this issue will disappear.
In June 2019, GTCC1 was operating at almost rated load.

4.2.3 GTCC2

GTCC2 is combined cycle cogeneration power plant of multi-shaft arrangement with a bypass stack, located on the west side of GTCC1. The rated generation output is 450 MWe. Air cooled condenser cooling system has been adopted. Construction work was started from January 2017 and GTCC2 is under construction at present.

(1) Configuration of GTCC2

Configuration of GTCC2: Multi shaft type without bypass stack
The gross power output of GTCC2: 473.5 MWe
The gross power output of Gas Turbine Generator: 317.1 MWe
The gross power output of Steam Turbine Generator: 156.4 MWe
Auxiliary Power: 23.5 MWe
Plant Net Power Output: 450 MWe



(Source: JICA Survey Team)

Figure 4.2.3-1 Diagram for Configuration of GTCC2

4.3 Field Survey

The survey team conducted field investigation in December 2016, December 2018, February 2019 and August 2019. In this section, outline of the main points about area is mainly noted.

4.3.1 Environmental Status

(1) Land use of the candidate site

The candidate site consists of cultivated land and an area of dachas (seasonal cottage), and the land is totally owned by the power plant. The south and central part of the candidate site is farmland partly planted with wheat and other crops by the workers hired by the power plant. The other part of the farmland is leased individually and used for cattle grazing and farming. The leased land will be vacated by contract before the construction work of the power plant starts. The rows of approximately 70 dachas exist in the north side of the candidate site.

(Photo: JICA Survey Team)

Figure 4.3.1-1 A Dacha Observed in the Candidate Site

(2) The candidate site for the switchyard and the transmission line route

The candidate site for the switchyard is situated within Navbakhor District, on the location marked on the map by the survey team. The land is owned by Government and the procedure for land acquisition will be explained in detail in Chapter 12-10.

The transmission line (hereinafter called T/L) route connecting the power plant and the switchyard is also shown in the map by the survey team. The land for the T/L route is mainly used as cultivation. Compensation associated with land acquisition for construction of T/L towers will be necessary and will be explained in detail in Chapter 12-10.

(3) Fishery and river traffic at Zeravshan River

There is no use of fishery and river traffic at Zeravshan River.

4.3.2 Cooling Water Intake Condition

Construction candidate sites are along the Zeravshan River, and it is supposed that cooling water will be taken from the river if one-through cooling system will be adopted. About the study for selection of condenser cooling system, it is described in Chapter 7.

In addition, the survey team has not obtained the quantitative information about yearly water flow rate and fluctuation of water level of Zeravshan River at the present moment. It's necessary to verify available water quality and water level data for deciding the cooling water system.

4.3.3 Construction Area Characteristics

From the result of survey, taking into consideration the information from satellite photographs of Google earth, it's judged that candidate site area is wide enough to arrange the required facilities for GTCC3.

4.3.4 T/L

Field survey found the following.

(1) The Route of T/L

GTCC3 is planned to connect to Power Grid via new 220kV switchyard (future) which will be constructed at the other side of Zeravshan River. As North area of both candidate sites for GTCC3 is residential area, the route of T/L needs to go through over the canal between these candidate sites, and across Zeravshan River. After that, it seems the most appropriate that the route of T/L go along by the road of the other side of Zeravshan River and arrive at the new 220kV switchyard.

(2) Transmission Tower[1]

The survey team surveyed the existing 220 kV transmission towers around Navoi PS. There were 2 typical 220 kV Transmission Towers. One is 1 CirCuiT (cct) transmission tower for sending electric power from GTCC1 to existing 220 kV switchyard such as Figure 4.3.4-1. Second was 2cct transmission tower for ending electric power from the existing 220kV switchyard to Besopan substation such as Figure 4.3.4-2.

Figure 4.3.4-1 1cct Transmission Tower

Figure 4.3.4-2 2cct Transmission Tower

[1] All Photo in this section: JICA Survey Team

(3) Insulator[2]

In the field survey around Navoi PS, there were various types of Insulator such as glass insulator, porcelain insulator and polymer insulator (Figure 4.3.4-2, Figure 4.3.4-3, Figure 4.3.4-4). And the numbers of insulators for 220kV T/L were diverse from 22 to 25 (Figure 4.3.4-5, Figure 4.3.4-6, Figure 4.3.4-7).

Figure 4.3.4-3 Porcelain Insulator

Figure 4.3.4-4 Polymer Insulator

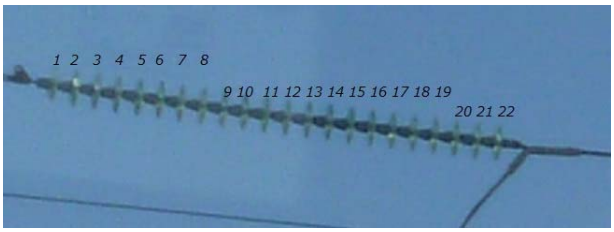


Figure 4.3.4-5 Insulator String of 22 Insulators

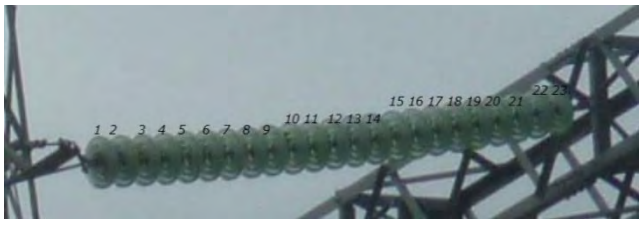


Figure 4.3.4-6 Insulator String of 23 Insulators

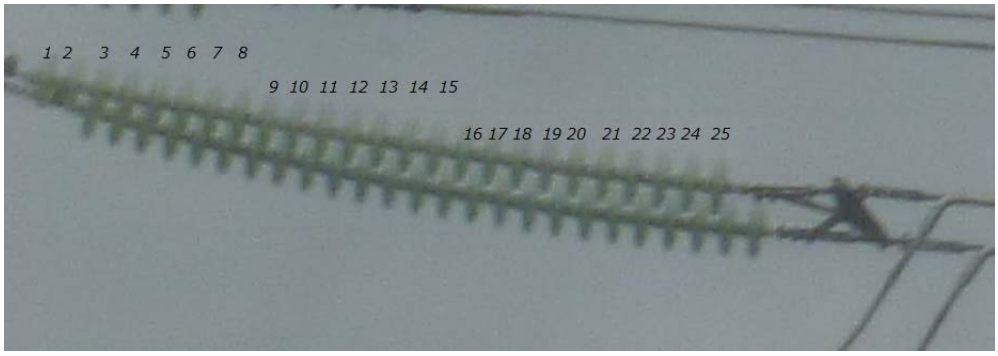


Figure 4.3.4-7 Insulator String of 25 Insulators

[2] All Photo in this section: JICA Survey Team

(4) Conductor

Regarding 220 kV T/L around Navoi PS, conductor per phase is single Aluminum Conductors Steel Reinforced (ACSR) 300 mm^2 as Figure 4.3.4-2 or double ACSR600 mm^2 as Figure 4.3.4-1. And T/L less than 220 kV has single conductor per phase. Conductor arrangement in Figure 4.3.4-1 is horizontal 1cct arrangement, as in Figure 4.3.4-2 is vertical 2cct arrangement.

(5) Ground wire

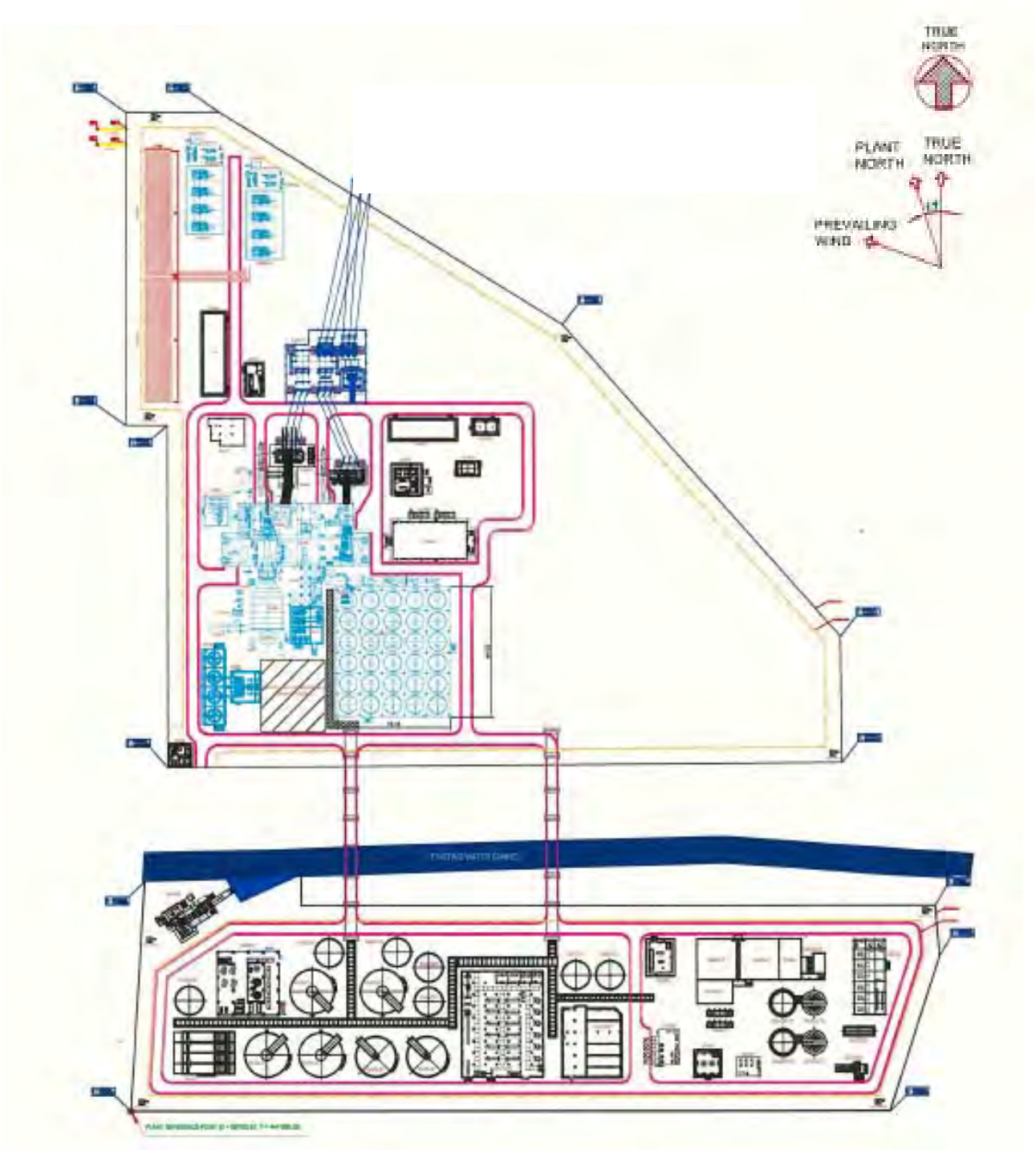
220 kV T/L around Navoi PS has double ground wires as in Figure 4.3.4-1 and Figure 4.3.4-2. And T/L which has the capacity of less than 220 kV has single ground wire.

4.3.5 220 kV switchyard (500 kV Substation)

The new switchyard will be constructed since there is no space to install new switchyard equipment at the existing 220 kV switchyard in Navoi PS. The candidate site for the new switchyard is north side of Navoi PS and across from the Zeravshan River as shown in the Figure 4.1-1. The road between the existing highway and the new switchyard will be built in order to transport some equipment for switchyard by the road. JSC Thermal Power Plant explained the survey team the power development plan and that the new substation would be operated as a 220 kV switchyard firstly (there is no 220/500 kV transformer and 500 kV equipment). And some 220/500 kV transformers and 500 kV equipment in the switchyard will be installed in the future. But JSC Thermal Power Plant hasn't decided when the switchyard is operated as a substation yet. JSC Thermal Power Plant also thinks that the new 220 kV switchyard feeds the transmission line for Besopan by GTCC3 and will feed the 500 kV T/L for Muruntau, Sogdiana and Talimarjan substation in the future. The land for 220 kV switchyard is supposed to be covered with the 500 kV equipment.

4.4 Example of layout plan

Figure 4.4-1 is an example of the deployment plan under consideration as of August 2019.
The arrangement of the equipment is general, and the layout may change depending on the detailed study in the future, so it is only for reference at this time.



(Source: Survey Team)

Figure 4.4-1 Example of layout plan

Chapter 5

Fuel Supply Plan

Chapter 5. Fuel Supply Plan

5.1 Reserves and Development Status of Natural Gas

Uzbekistan is blessed with diverse mineral resources and is one of the few countries that is completely self-sufficient in energy resources. Among them, natural gas reserve is 18th in the world, and consumption is the15th[1]. The oil & gas market is the largest in Central Asia and steadily growing fast, used for both domestic consumption and exports.

Table 5.1-1 illustrates the transition of the total proved reserves of natural gas in Uzbekistan.

Table 5.1-1 Amount of Proven Natural Gas Reserves in Uzbekistan

(Unit: trillion cubic meter)

	At end 1998	At end 2008	At end 2017	At end 2018
Proved reserves	1.2	1.3	1.2	1.2

（Source: BP Statistical Review of World Energy June 2019）

Natural gas represented the majority of consumption (86.3 percent), while consumption of petroleum products (9.3 percent), coal (2.5 percent), and hydroelectricity (1.9 percent) represented the remainder[2].

In Uzbekistan, oil and gas are managed through the Uzbeknetegaz state-owned enterprise, with the government inheriting the policies of the former Soviet Union.

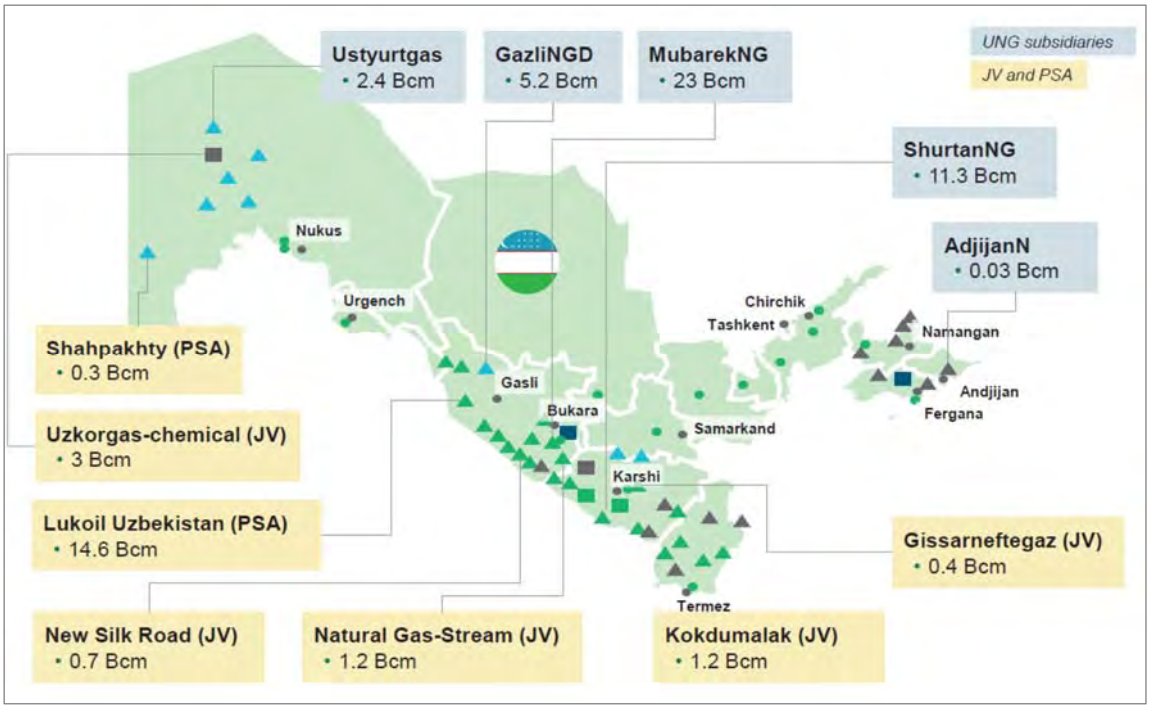
Uzbekneftegaz was founded in 1992 and became a national enterprise in 1998. With many group companies affiliated, the entire group exclusively carries out the mining, production and transportation projects of domestic petroleum and natural gas.

It has been very successful in joint ventures with regional and international Oil & Gas companies.

Figure 5.1-1 shows the domestic development status. In order to further development of the entire value chain, international O & G players are accepted for the discovery of new gas fields.

In addition, modern EOR[3] technology is introduced to maintain the current production level.

[1] Source: CIA World Factbook 2018
[2] Source: energypedia (https://energypedia.info/wiki/Uzbekistan_Energy_Situation)
[3] Enhanced Oil Recovery. Method for efficient recovery of crude oil



（Source: Energy Charter）

Figure 5.1-1　Development Status of Natural Gas in Uzbekistan

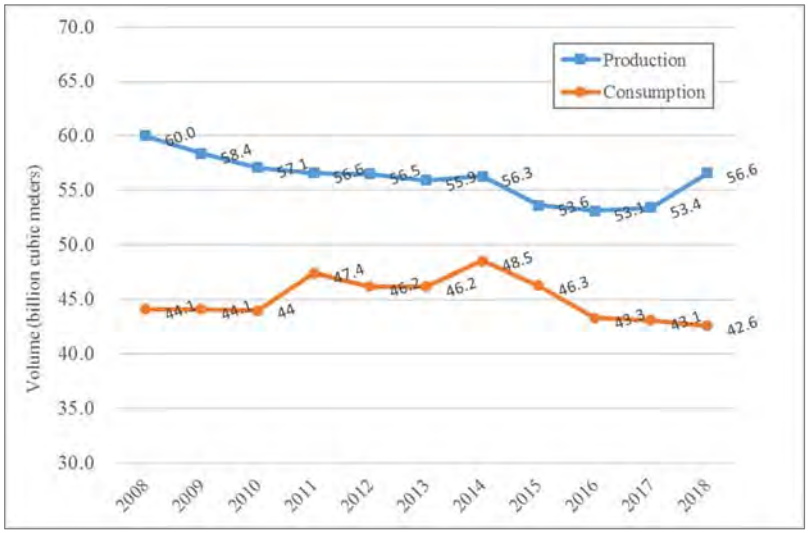
Produced gas is also supplied to China and Russia（Figure 5.1-2）.

（Source: Energy Charter）

Figure 5.1-2　Uzbekistan's Gas Transportation System Provides access to China & Russia Markets

5.2 Production and Consumption Volumes of Natural Gas

The following describes the proved production and consumption volumes of natural gas in Uzbekistan during the period from 2008 to 2018. Both production and consumption of natural gas seems to be almost flat since 2008, but consumption is gradually decreasing.



（Source: BP Statistical Review of World Energy 2019）

Figure 5.2-1 Proven Production and consumption Volumes of Natural Gas (2008-2018)

Uzbekistan does not import natural gas, so the difference between production and consumption volumes indicates the amount of export. Natural gas exports in 2018 have fallen by more than 40% compared to the highest in the past decade. The economic slowdown in major trading partners such as Russia and China has an impact on import and export in general, and the case of natural gas is also as an example.

（Source: CEIC https://www.ceicdata.com/en）

Figure 5.2-2 Natural Gas Export in Uzbekistan (2008-2018)

5.3 Possibility of Gas Supply to GTCC3

5.3.1 Future production volume and domestic distribution forecast

The amount of gas to be supplied in Uzbekistan is as shown in the Table 5.3.1-1

Table 5.3.1-1 Design Values of Forecast Indicators of the sources and distribution balance of natural gas for 2018-2030

(Billion cubic meter)

№	Balance items	2019 Forecast	Project for										
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Natural gas production	63.6	66.0	69.0	69.9	70.5	70.6	70.9	71.2	71.6	71.7	71.9	72.1
2	Consumption in the republic	48.0	50.4	53.4	51.7	55.6	56.4	61.8	61.7	63.5	64.3	65.2	66.1
2.2.	Supply to consumers	37.4	39.8	40.5	41.2	42.0	42.7	43.5	44.2	45.0	45.8	46.6	47.5
	- to industries	28.2	30.0	30.5	31.0	31.6	32.1	32.6	33.2	33.7	34.3	34.9	35.5
	Including JSC "Uzbekenergo"	16.5	16.6	16.7	16.8	16.9	17.0	17.0	17.1	17.2	17.3	17.4	17.5
	- to the population	9.1	9.8	10.0	10.2	10.4	10.6	10.8	11.1	11.3	11.5	11.7	12.0

(Source: Ministry of Energy of the Republic of Uzbekistan)

5.3.2 Verification of the Adequacy and Feasibility of the Project

Forecast of natural gas supply to Navoi GTCC3 and GTCC4[4] for the next 30 years is expected to reach 1,700 - 1,800 million m^3 per year[5].

The fuel consumption of the M701J Model Gas Turbine[6] estimated by the Study Team is 115,485 m^3 / hr (air temperature 15 ° C, gas turbine rated output). Assuming that GTCC4 has the same design as GTCC3, the fuel consumption will simply double when GTCC4 is completed.

As a result of back-calculating how long the annual operating time will be, that of the two units can be covered by the above-mentioned expected gas supply amount is 7,500 hours approximately.

① Assuming that the annual operation time is 7,500 hours (utilization rate 85%; 8760 x 0.85 = 7446)

② The annual fuel consumption of GTCC3 is expected to be 866,140,000 m^3 (115,485 x 7,500)

③ The above supply amount of 1,700 to 1,800 millon m^3 is sufficient.

[4] Future construction is planned.
[5] Source: Ministry of Energy of the Republic of Uzbekistan
[6] The gas turbine model is described in detail in Chapter 7

5.3.3 Verification of Natural Gas Supply Agreement

In January 2019, the contract for gas supply in 2019 was signed between Uztransgas JSC and the "Navoi power plant" JSC. According to this, the gas volume to be distributed quarterly and monthly to the Navoi area is Table 5.3.3-1.

Table 5.3.3-1 The Volume of Natural Gas Supplied by Agreement in 2019

(Million cubic meter)

Term	Volume	Breakdown	
1 quarter	832	Jan.	288
		Feb	257
		Mar	287
2 quarter	587	Apr	218
		May	201
		Jun	168
3 quarter	681	Jul	218
		Aug	229
		Sep	233
4 quarter	865	Oct	282
		Nov	279
		Dec	303
Total			2,965

(Source: Uztransgaz JSC and JSC Navoi PS)

According to the contract:

- Power plant submits to the Supplier a demand of natural gas on the basis of confirmed standards (clause 6 of the rules for use of natural gas).
- The power plant can change the initially set gas consumption halfway if it submitted at the appropriate time.
- Contracts are concluded annually. after the expiration of the contract, if consumer(power plant) does not apply in writing about its cancellation or modification, it is considered extended for the next year.

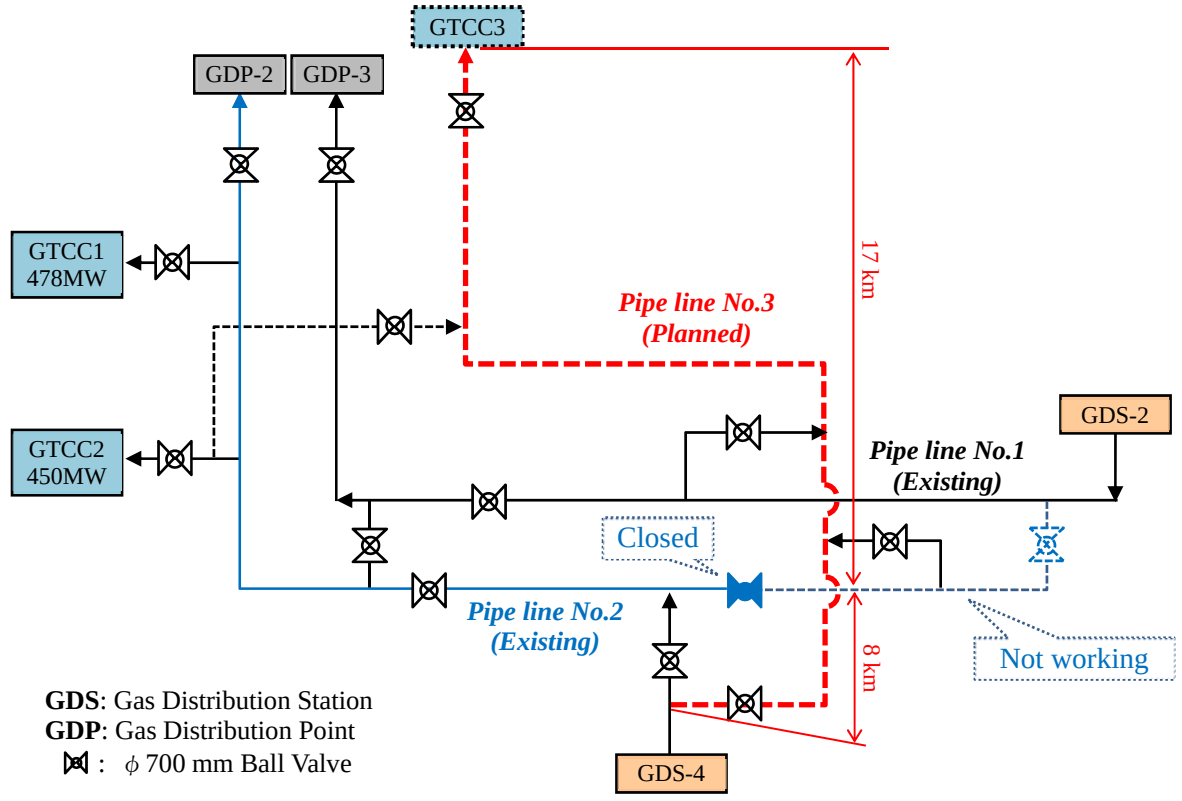
The above is the contract contents of 2019, it is expected that the same will apply to the operation of GTCC3.

5.4 Placement Location of New Gas Pipeline

In order to supply gas to existing power plants and GTCC2 (under construction), two gas pipelines have already been installed around the site. For the GTCC3, a new gas pipeline will be installed.

Figure 5.4-1 shows existing pipelines, and development plan for future gas pipeline with the construction of GTCC3. Those will be connected from GDS (Gas Distribution Station)-GTCC2 or GDS-GTCC4 and supply plan will be decided according to the specifications of Uztrans gas finally.

It can be supplied from any GDS to the all four power stations GTCC1. In order to prevent the supply will be interrupted even if some problem occurs at any part of those pipelines, some bypass lines are provided in each of the three pipelines. Moreover, the NO.2 pipeline has some parts that are not currently used.



(Source: Ministry of Energy of the Republic of Uzbekistan / JSC Navoi PS)

Figure 5.4-1 Gas Pipeline Development around Navoi Site

A compressor is placed in front of each plant and planned to boost the supply gas (8 MPa → 12 MPa)

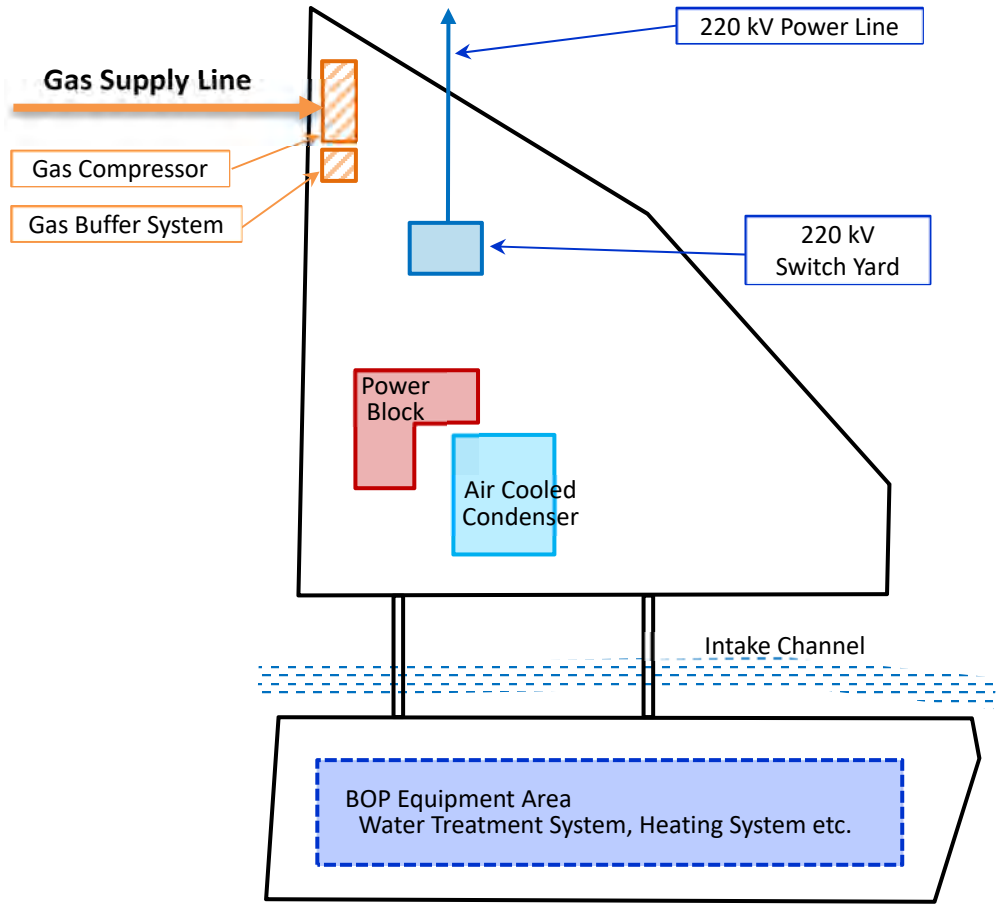
After the start of GTCC3 operation, the supply amount to the former power plant is scheduled to decrease. After that, some unit of Navoi-old will be expected to be used as a standby generator to operate only during peak period. The government of Uzbekistan decides whether to stop the plant or not finally.

The outline of the pipeline route newly installed to supply gas to GTCC3 and GTCC4 planned at present is shown in the Figure 5.4-2.

(Source: Google Earth added by JICA Survey Team)

Figure 5.4-2 The Outline of the Pipeline Route for GTCC3

Outline layout plan of GTCC 3 and installation image of gas supply line are as follows.
Gas Buffer System will be described later in Chapter 7.
The placement of each BOP equipment in the southern side of intake canal will be examined in detail in the future.



(Source: JICA Survey Team)

Figure 5.4-3 Outline Layout Plan of GTCC3 and Gas Pipeline

5.5 Procedure of Gas Pipeline Construction

This section describes a general overview of gas pipeline construction procedure.
The main process are listed below.

(1) Route selection & survey of ROW.

(2) Specific pipeline routes and facilities that need to be newly introduced will be considered after construction site decision. At the present moment, no information on pipes newly constructed in accordance with the existing construction of the existing pipe and Unit 2 and peripheral equipment thereof is available.

(3) Preparation of ROW

Prior to pipeline installation, the ROW will be cleared of trees and bush and building structure.

(4) Stringing & bending of gas pipeline

The pipe will be transported to the ROW. The pipe will be strung and bent where necessary to allow for fitting the pipeline.

(5) Welding of gas pipeline

Individual lengths of the gas pipeline will be joined using welding machines.

(6) Excavation of gas pipeline

The project will excavate the pipe trench with specialized equipment according to site conditions.

(7) Lowering in & tie-ins of gas pipeline

Gas pipeline will be lowered into a trench.

(8) Backfilling & testing of gas pipeline

The trench is backfilled using excavated material to prevent damage to the pipe. A test will be conducted to evaluate the integrity of the completed pipe.

(9) Clean-up of ROW

The ROW will be restored.

Chapter 6

Network Analysis and Grid Connection Plan

Chapter 6 Network Analysis and Grid Connection Plan

6.1 Outline of Grid Connection Plan

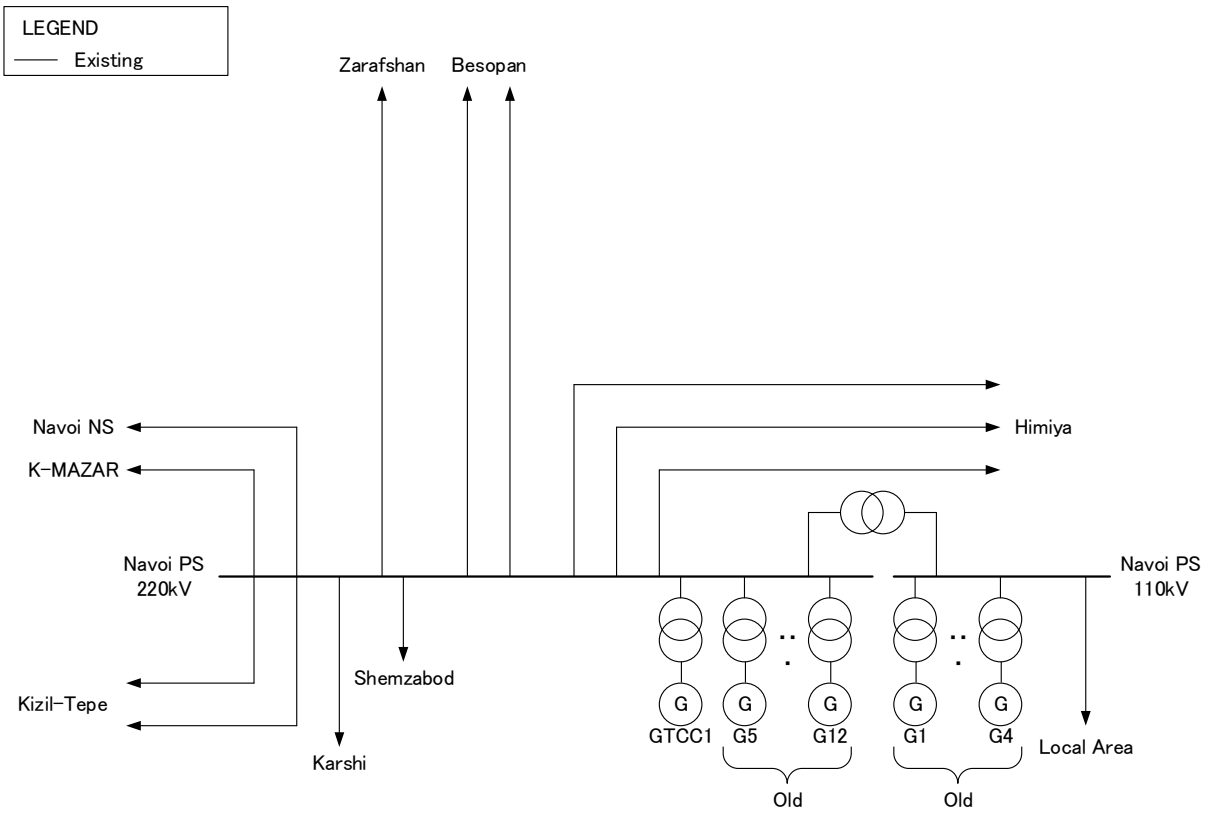
The outline of the connection plan of the power equipment to the grid around Navoi PS is shown below.

6.1.1 Outline of Connection

The system connection from the current situation until the operation start of Navoi GTCC3 is shown below. Furthermore, the connection of the 500 kV T/L scheduled for operation in the future also is indicated.

(1) Current state

The connection of the current power equipment is shown in Figure 6.1.1-1.



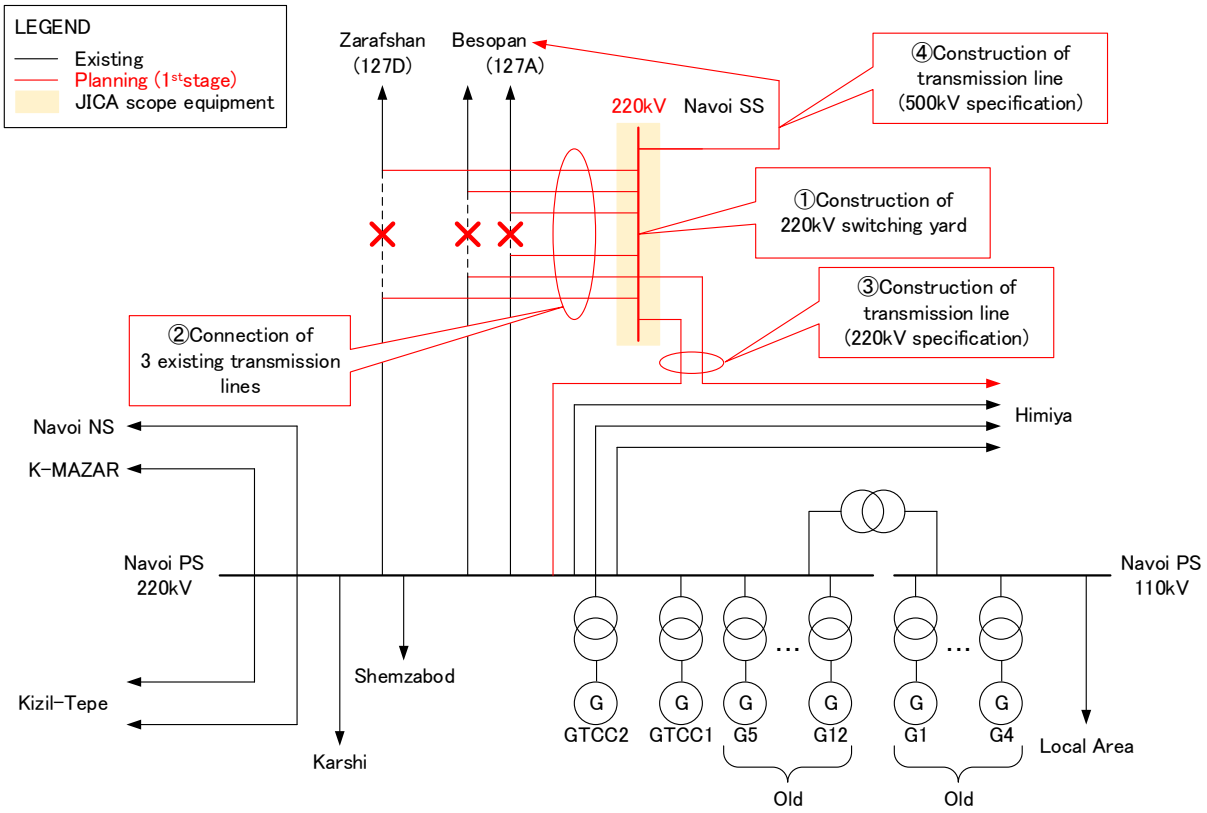
(Source: JICA Survey Team)

Figure 6.1.1-1 System connection around Navoi PS (current situation)

T/Ls extending from the 220 kV bus of Navoi PS (existing conventional power plant) to Besopan SS (and 127A SS), Zarafshan SS (via 127D SS) and Himiya (Chemical) SS are connected.

(2) Construction of Navoi switchyard

At the beginning of its operation, Navoi SS starts operation as the 220 kV switchyard. When Navoi SS is operated as the switchyard, the system connection is shown Figure 6.1.1-2.



(Source: JICA Survey Team)

Figure 6.1.1-2 System connection around Navoi PS (Switchyard starts operation)

Construction of Navoi switchyard is started before construction of Navoi GTCC3 (①).
This facility is scheduled to eventually be the 500 kV / 220 kV SS, but it is scheduled to start operation as the switchyard of 220 kV at first.

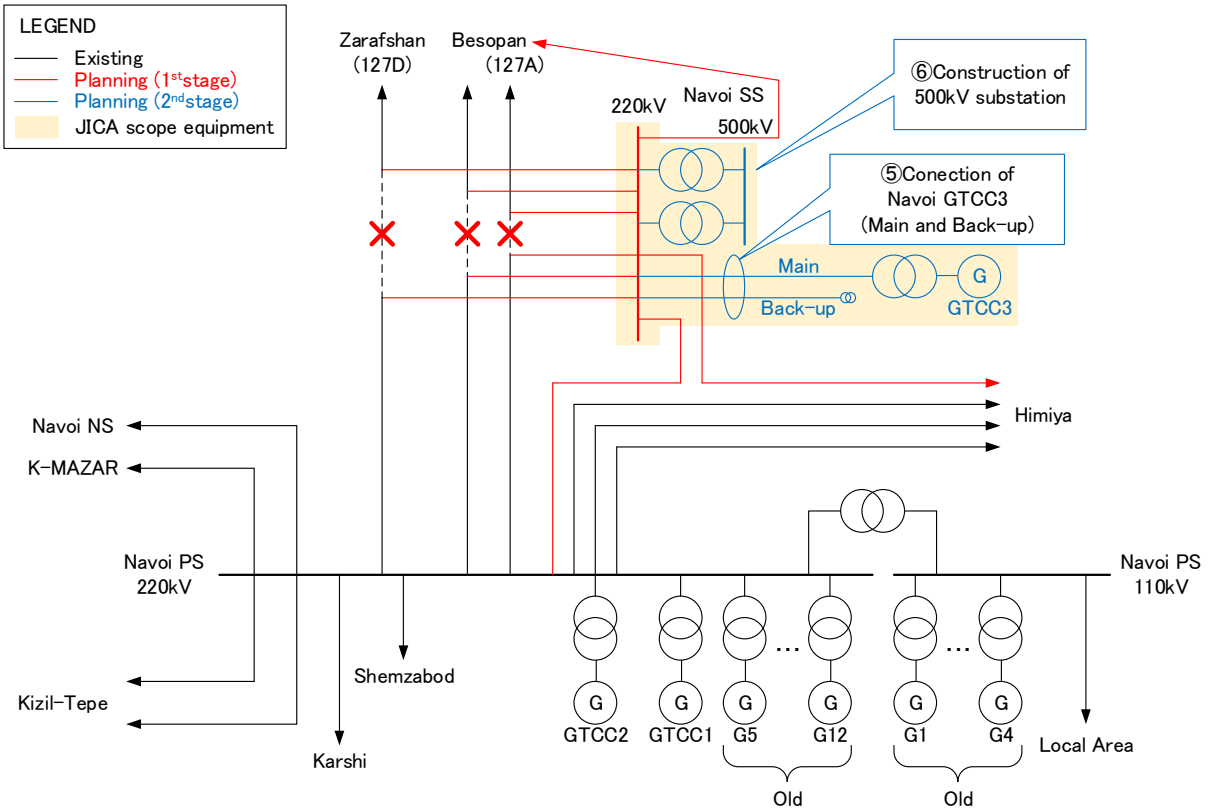
Three T/Ls connecting to Besopan SS (and 127A SS) and Zarafshan SS (via 127D SS) from the existing Navoi PS are drawn into the new 220 kV switchyard (②). In addition, one T/L is added between Navoi PS and Himiya (Chemical) SS (③). This T/L is connected via Navoi switchyard rather than directly connecting Navoi PS and Himiya (Chemical) SS.

In addition, the 220 kV T/L is added from Navoi switchyard to Besopan SS (④). This T/L will be operated as the 500 kV T/L after Navoi switchyard will be changed to the 500 kV / 220 kV SS.

The colored area equipment is included in the scope of JICA. And, the connection of 3 existing T/L to the Navoi switchyard and 220 kV T/L between Navoi switchyard and Besopan SS are not included in the scope of JICA.

(3) Construction of Navoi GTCC3

After construction of Navoi switchyard, Navoi GTCC3 is connected to the grid. The connection where Navoi GTCC3 is connected to the grid is shown in Figure 6.1.1-3.



(Source: JICA Survey Team)

Figure 6.1.1-3 System connection around Navoi PS (GTCC3 starts Operation)

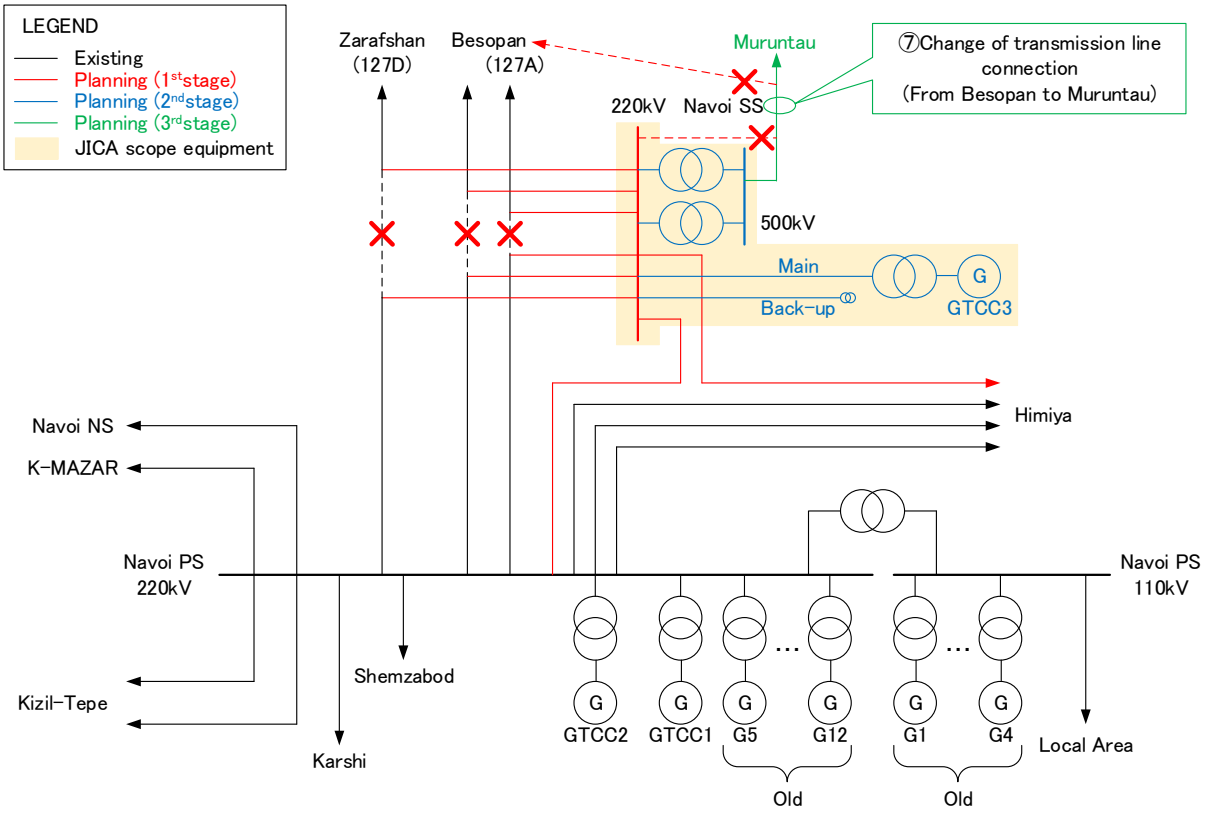
The T/L connecting from GTCC3 to Navoi switchyard is one circuit T/L of 2×600 conductors (⑤). The operating voltage is 220 kV, but the T/L specification is designed for 500 kV.

The 500 kV / 220 kV SS is constructed at the same time as the construction of Navoi GTCC3 (⑥). However, it does not operate as the 500 kV / 220 kV SS and continues to operate as the switchyard. After that, the operation will be changed to the 500 kV / 220 kV SS according to the development status of the surrounding power system.

The colored area equipment is included in the scope of JICA.

(4) 500 kV operation of Navoi SS

After the completion of 500 kV / 220 kV Muruntau SS located at the northern of Navoi GTCC3, the 220 kV Navoi switchyard will change its operation to the 500 kV / 220 kV SS. The system connection around Navoi GTCC3 is shown in Figure 6.1.1-4.



(Source: JICA Survey Team)

Figure 6.1.1-4 System connection around Navoi PS (500 kV SS starts Operation)

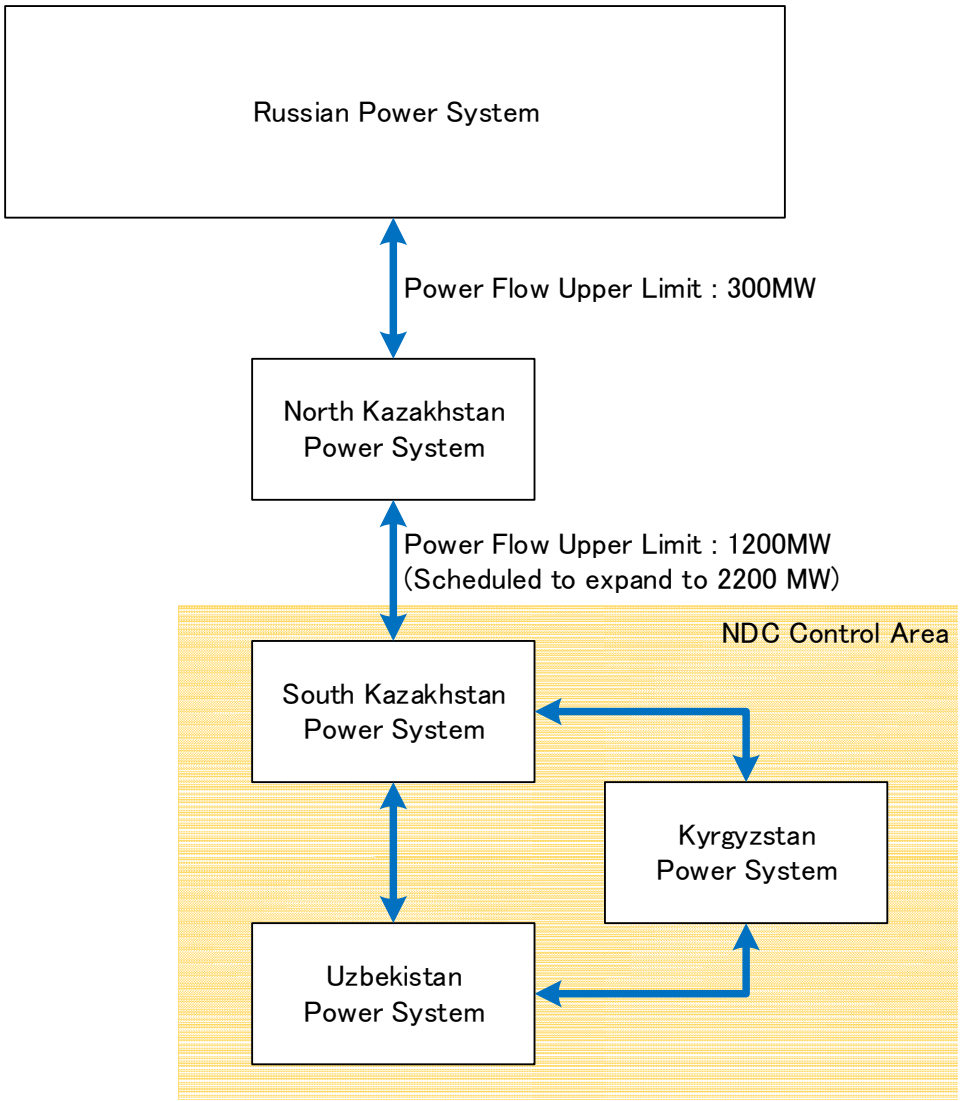
In order to cope with an increase in load demand in northern Navoi area, the 220 kV T/L connected to Besopan SS will be changed to 500 kV and connected to Muruntau SS (⑦).

The colored area equipment is included in the scope of JICA. And, this 500 kV T/L between Navoi SS and Muruntau SS is not included in the scope of JICA.

6.1.2 International Interconnection Line

Uzbekistan power system is connected to Kazakhstan and Kyrgyzstan power systems through international interconnection line. This power system can be divided into Russian grid, North Kazakhstan grid and Central Asian grid (included South Kazakhstan, Uzbekistan, and Kyrgyzstan). And Central Asian grid is controlled by NDC (National Dispatching Center) in Tashkent. (As of February 2019)

Figure 6.1.2-1 shows the connection between Uzbekistan power system and other regional power systems through international interconnection line.



(Source: JICA Survey Team)

Figure 6.1.2-1 Connection between Uzbekistan power system and other regional power systems

There are power flow limits in the international interconnection line, 300 MW between Russian grid and North Kazakhstan grid, and 1200 MW between North Kazakhstan grid and Central Asia grid included Uzbekistan power system. NDC in Tashkent controls each generator in Central Asia power system so that the power flow between North Kazakhstan grid and Central Asian grid does not exceed the specified value (1200MW).

About the frequency control system, Russian power system is performing FFC (Flat Frequency Control), and North Kazakhstan power system and Central Asia power system are performing TBC (Tie Bias Control).

NDC predicts the amount of power consumption in the area included South Kazakhstan, Kyrgyzstan and Uzbekistan based on the past power consumption results and the weather forecasts, and controls the generator output of each power plant. The actual load consumption is measured by SCADA (Supervisory Control And Data Acquisition) system installed at each substation and transmitted to NDC. When the balance between the generated power and the load consumed power is broken, NDC sends output change commands to the power plants to correct the generator outputs. These commands are being conducted by the telephone call from the operator.

Since Russian grid and other regional grids including Uzbekistan power system are very large, so it is thought that the problem of frequency fluctuation does not occur. Even if a sudden demand unbalance arises within Uzbekistan power system, it will be compensated by Russian grid and other regional grids through international interconnection line, so that large frequency fluctuation does not occur.

As a reference, Tajikistan and Turkmenistan power grid belong to different power system. And these are not connected to the Uzbekistan grid including Russian grid, which means that the frequency control method is different.

Due to the power system configuration as described above, in Uzbekistan it is thought that frequency fluctuation does not occur at the time of dropout of the large capacity generator. However, it is necessary to operate so that the power flow of the international interconnection line between different grids does not exceed the specified value. For example, the international interconnection line with Russian grid has a power flow upper limit of 300 MW. In this case, although the power dropout of up to 300 MW is allowed, if more power dropout occurs, it should be dealt with by load shedding.

In Uzbekistan power grid, the Emergency Automatic Load Shedding System is installed to each large-scale power generator, and the load supply in the vicinity area is stopped according to the dropped electric power caused by generator trip. For example, if the generator of 450 MW connected Uzbekistan power grid suddenly drops out, the load shutdown of 150 MW will occur in the same area. However, although the load shedding occurs when a large capacity generator drop out, international interconnection lines are never disconnected, and the frequency of the whole power system included Uzbekistan is always kept constant.

6.2 Network Analysis

6.2.1 Objective

As noted in the previous chapters, JSC TPP made a plan to construct GTCC3 in Navoi PS. The objective of this analysis is to verify expected impact on the power system when power generated by GTCC3 is evacuated to the power grid. The survey team has carried out three types of analyses which are power flow, fault current and dynamic stability. Methodologies for their analyses are described below.

- Power Flow Analysis
  In terms of reliability, power flow has been calculated under normal conditions and single contingency (N-1[1]) conditions to find out if the voltages of all buses are within the allowable limit and to verify no equipment is overloaded.
- Fault Current Analysis
  Fault current at each bus in any substations and power stations has been calculated to determine if the fault current is within the rated current breaking capacities of existing circuit breakers.
- Dynamic Stability Analysis
  In dynamic stability analysis, a sequence of occurring and clearing of a fault has been simulated under each fault location condition to determine if all generators can sustain their synchronicities.

6.2.2 Premise

The analyses have been conducted using PSS/E (Version 33.0.1) developed by Siemens Power Technologies International (Siemens PTI). A PSS/E data set has been constructed on the basis of the information provided by JSC TPP and SAESP[2]. Table 6.2.2-1 shows conditions of the analyses.

Table 6.2.2-1 Conditions of the Analyses

No.	Grid Configuration	Year of demand load assumption	Season
Case 1	220 kV Switchyard	2023	Summer
Case 2			Winter
Case 3		2025	Summer
Case 4			Winter
Case 5	500 kV / 220 kV Substation		Summer
Case 6			Winter

(Source: JICA Survey Team)

According to the plan of JSC TPP, the construction of Navoi GTCC3 is expected to be completed in 2023. At this point, Navoi 500 kV / 220 kV SS will have not started its operation and will be operating as the 220 kV switchyard (Case 1 and Case 2). After that, it is planned to change the 220 kV switchyard to the 500 kV / 220 kV SS in 2025 (Case 5 and Case 6).

[1] An N-1 is the state that single electric facility is stopped from operating at normal conditions.
[2] SredAz Energo Set Proekt : "SAESP" is a design institute affiliated with JSC TPP and Uzbekistan National Electric Networks JSC which is responsible for designing a HV (500 kV-110 kV) transmission line, substation and power system analysis, national grid, etc.

In addition, in consideration of the maximum demand load variation, the same analysis is conducted for the demand forecast in 2025 (Case 3 and Case 4).

In Uzbekistan, a daily maximum power demand appears at evening or night time, and that of the winter season is larger than that of the summer season. In general, analyses are conducted under the maximum demand condition, which occurs at evening time in the winter season. On the other hand, in the summer season, T/L capacity decreases due to ambient temperature increase. Therefore, analyses should be conducted under the summer season conditions considering the transmission capacity decreases. During the summer season, maximum demand occurs at night time like the winter season. So, the ambient air temperatures in the evening (winter season) and at night (summer season) were reflected in the calculation. In this analysis, it was assumed that the outdoor temperature in winter is 0 degree C and in summer is 35 degree C.

The connection diagram of the power system for this analysis which include 220 kV switchyard is shown Figure 6.2.2-1, and the same one which include 500 kV / 220 kV SS is shown Figure 6.2.2-2.

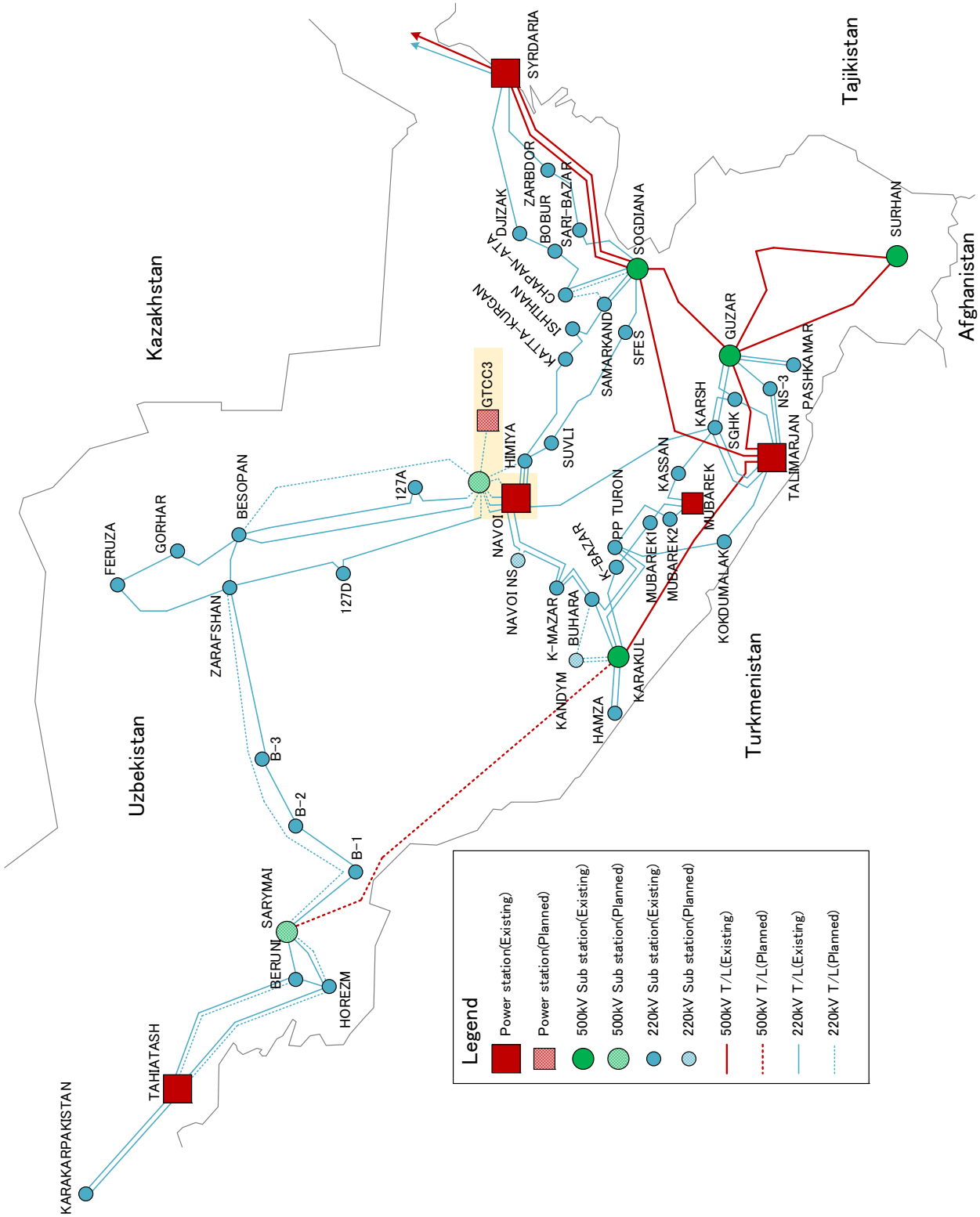
The power system of Uzbekistan can be separated into two areas at Syrdaria PS. One of them is the eastern power system including the capital city Tashkent. The rest is the western power system including Navoi PS.

The power system of the east side at Syrdaria PS is connected to Kazakhstan via 500 kV T/Ls. The eastern power system is much bigger than the western power system.

Therefore, in this analysis, the power system of the east side at Syrdaria PS has been treated as the Infinity Bus[3]. So, analysis data has been prepared for the power system at the west side from Syrdaria PS.

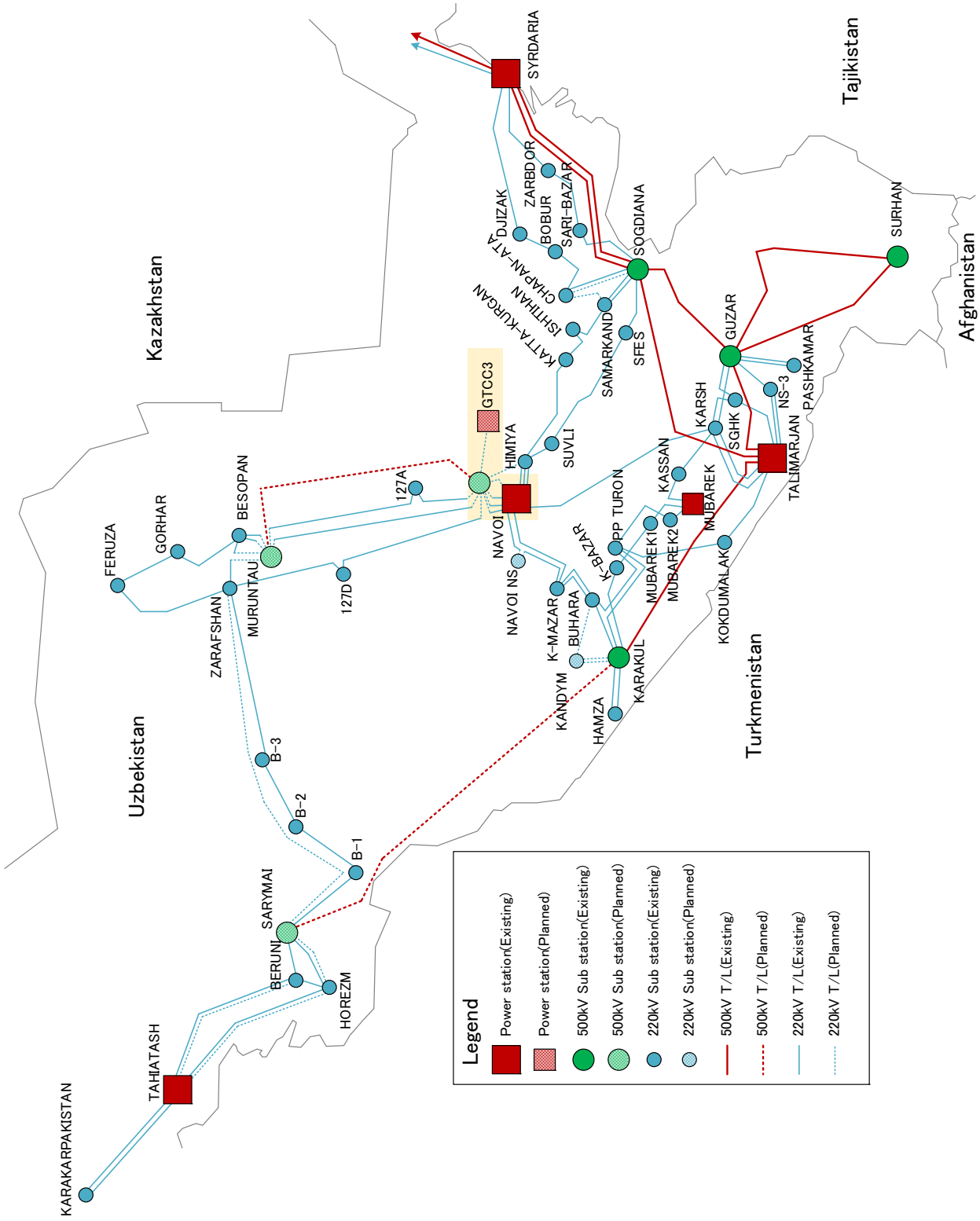
Major five power stations have been simulated in this analysis, including Navoi PS, Talimarjan PS, Mubarek PS, Takhiatash PS and Syrdaria PS. And all T/Ls of 500 kV and 220 kV have been simulated.

[3] Infinity Bus is a virtual voltage source with constant voltage and constant frequency.



(Source: JICA Survey Team)

Figure 6.2.2-1 Connection Diagram of the Power System for the Analyses (with 220 kV Switchyard)



(Source: JICA Survey Team)

Figure 6.2.2-2 Connection Diagram of the Power System for the Analyses (with 500 kV / 220 kV Substation)

6.2.3 Equipment Constant

The basic constants of each electrical equipment used for this analysis are shown below.

(1) T/L

Table 6.2.3-1 shows a list of T/Ls used in Uzbekistan. A single conductor T/Ls are used in the 110 kV and the 220 kV system, and three conductor T/Ls are used in the 500 kV system.

Table 6.2.3-1 T/Ls Used in Uzbekistan

Rated Voltage [kV]	Number of Conductors	Size [mm^3]	R [ohm/km]	X [ohm/km]	Y [micro S/km]	Rated Current[A] (at 25 degree C)
110	1	120	0.235	0.458	2.472	375
		150	0.190	0.450	2.512	450
220		240	0.121	0.435	2.600	605
		300	0.098	0.429	2.640	710
		400	0.075	0.420	2.700	825
		500	0.060	0.413	2.740	945
500	3	300	0.034	0.310	3.970	2040
		330	0.029	0.308	3.600	2190
		400	0.025	0.306	3.620	2475
		500	0.020	0.304	3.640	2835

(Source: JSC Thermal Power Plant, SAESP)

The R value in the table shows the resistance value when the ambient air temperature is 25 degrees.

Table 6.2.3-2 to Table 6.2.3-5 show the conductor type, rated voltage and length of each T/L used for this analysis.

Table 6.2.3-2 T/L Data Used for Analysis (Part 1)

No.	Node		ID	Rated V [kV]	Type	Length [km]	Remarks
	From	To					
1	Guzar	Sogdiana	1	500	3×400 3×300	134.7	
2	Guzar	Talimarjan	1	500	3×330	79.8	
3	Karakul	Sarymai	1	500	3×400	255.0	
4	Karakul	Talimarjan	1	500	3×330 3×300	201.2	
5	Sogdiana	Talimarjan	1	500	3×400 3×300	217.5	
6	Sogdiana	Syrdaria	1	500	3×400 3×300	220.7	
7	Sogdiana	Syrdaria	2	500	3×400 3×300	216.5	
8	Talimarjan	Talimarjan	1	500	3×500	0.9	
9	Horezm	Tahiatash	1	220	240	165.0	
10	Horezm	Tahiatash	2	220	400	197.8	
11	Horezm	Beruni	1	220	300	55.9	
12	Horezm	Sarymai	1	220	240	155.7	
13	Horezm	Sarymai	2	220	400	151.9	
14	Tahiatash	Beruni	1	220	400	124.6	
15	Tahiatash	Beruni	2	220	300	153.0	
16	Tahiatash	Karakarpakis	1	220	300	143.0	
17	Tahiatash	Karakarpakis	2	220	300	143.0	
18	Beruni	Sarymai	1	220	400	139.5	
19	Navoi	K-Mazar	1	220	500	70.0	
20	Navoi	Karsh	1	220	400	162.9	
21	Navoi	Himiya	1	220	500	20.1	
22	Navoi	Himiya	2	220	500	20.6	
23	Navoi	Himiya	3	220	500	22.5	
24	Navoi	GTCC2	1	220	2×500	0.5	
25	Navoi	GTCC1	1	220	2×500	0.6	
26	Navoi	Navoi SS	1	220	300	6.0	
27	Navoi	Navoi SS	2	220	300	5.6	
28	Navoi	Navoi SS	3	220	240	6.4	
29	Navoi	Navoi SS	4	220	500	5.6	

(Source: JSC Thermal Power Plant, SAESP)

Table 6.2.3-3 T/L Data Used for Analysis (Part 2)

No.	Node		ID	Rated V [kV]	Type	Length [km]	Remarks
	From	To					
30	Navoi	Navoi NS	1	220	500	40.6	
31	K-Mazar	Buhara	1	220	500	27.2	
32	K-Mazar	Buhara	2	220	500	27.2	
33	K-Mazar	Navoi NS	1	220	500	30.6	
34	Buhara	PP Turon	1	220	400	42.7	
35	Buhara	Karakul	1	220	400	60.7	
36	Buhara	Kandym	1	220	400	89.4	
37	PP Turon	Mubarek-2	1	220	300	65.0	
38	PP Turon	Kokdumalak	1	220	240	83.0	
39	PP Turon	Karakul	1	220	400	90.5	
40	Mubarek-2	Mubarek	1	220	400	6.5	
41	Mubarek	Mubarek-1	1	220	400	11.5	
42	Mubarek	Kassan	1	220	400	34.2	
43	Mubarek-1	K-Bazar	1	220	400	73.0	
44	K-Bazar	Karakul	1	220	400	92.0	
45	Kassan	Karsh	1	220	400	37.8	
46	Kokdumalak	Talimarjan	1	220	240	99.5	
47	Talimarjan	SGHK	1	220	400	16.0	
48	Talimarjan	Karsh	1	220	400	60.3	
49	Talimarjan	Karsh	2	220	400	60.3	
50	Talimarjan	NS-3	1	220	400	86.6	
51	Talimarjan	NS-3	2	220	400	86.6	
52	SGHK	Karsh	1	220	500	56.0	
53	SGHK	Guzar	1	220	500	78.0	
54	Karsh	Guzar	1	220	500	74.0	
55	NS-3	Guzar	1	220	400	125.0	
56	Guzar	Pashkamar	1	220	300	41.0	
57	Guzar	Pashkamar	2	220	300	41.0	
58	Karakul	Hamza	1	220	300	26.1	
59	Karakul	Hamza	2	220	300	26.1	
60	Karakul	Kandym	1	220	240	45.0	
61	Karakul	Kandym	2	220	240	45.0	
62	Himiya	Suvli	1	220	500	26.9	

(Source: JSC Thermal Power Plant, SAESP)

Table 6.2.3-4 T/L Data Used for Analysis (Part 3)

No.	Node		ID	Rated V [kV]	Type	Length [km]	Remarks
	From	To					
63	Himiya	Katta-Kurgan	1	220	500	80.0	
64	Himiya	Navoi SS	1	220	500	21.4	
65	Suvli	SFES	1	220	500	90.0	
66	Katta-Kurgan	Ishtihan	1	220	500	16.8	
67	Samarkand	Sogdiana	1	220	300	46.2	
68	Samarkand	Sogdiana	2	220	500	44.5	
69	Samarkand	Chapan-Ata	1	220	400	58.4	
70	Samarkand	Ishtihan	1	220	500	55.3	
71	Sogdiana	Sari-Bazar	1	220	400	93.2	
72	Sogdiana	Chapan-Ata	1	220	300	42.9	
73	Sogdiana	Chapan-Ata	2	220	400	34.4	
74	Sogdiana	SFES	1	220	500	61.0	
75	Bobur	Djizak	1	220	300	43.7	
76	Bobur	Chapan-Ata	1	220	300	64.7	
77	Sari-Bazar	Zarbdor	1	220	400	46.9	
78	Zarbdor	Syrdaria	1	220	400	97.4	
79	Djizak	Syrdaria	1	220	400 300	132.7	
80	127A	Navoi SS	1	220	300	63.9	
81	127A	Besopan	1	220	300	116.5	
82	Besopan	Zarafsyan	1	220	240	26.6	
83	Besopan	Gorhar	1	220	300	43.5	
84	Besopan	Navoi SS	1	220	300	179.6	
85	Besopan	Navoi SS	2	220	3×400	166.0	
86	127D	Zarafsyan	1	220	240	72.7	
87	127D	Navoi SS	1	220	240	152.7	
88	Zarafsyan	Feruza	1	220	300	92.8	
89	Zarafsyan	B-3	1	220	300	103.5	
90	Zarafsyan	Sarymai	1	220	400	226.0	
91	Feruza	Gorhar	1	220	300	74.8	
92	B-3	B-2	1	220	300	59.8	
93	B-2	B-1	1	220	300	51.5	
94	B-1	Sarymai	1	220	240	8.1	
95	Navoi SS	GTCC3	1	220	2×600	2.7	

(Source: JSC Thermal Power Plant, SAESP)

Table 6.2.3-5 T/L Data Used for Analysis (Part 4)

No.	Node		ID	Rated V [kV]	Type	Length [km]	Remarks
	From	To					
96	Horezm	Hozaras	1	110	120	46.7	
97	Horezm	Hozaras	2	110	150	46.7	
98	Hozaras	Tuyamajun	1	110	150	52.5	
99	Hozaras	Tuyamajun	2	110	150	49.7	
100	Hozaras	Tuyamajun	3	110	150	33.0	
101	Karakarpakis	UGHK	1	110	240	1.0	
102	Karakarpakis	UGHK	2	110	240	1.0	
103	Muruntau	Navoi SS	1	500	3x400	177.0	

(Source: JSC Thermal Power Plant, SAESP)

(2) Transformer

Transformer constants at each substation used for this analysis are shown in Table 6.2.3-6.

Table 6.2.3-6 Transformer Data Used for Analysis (for Substation)

No.	Substation Name	Rated Capacity [MVA]	Rated Voltage[kV]		Remarks
			V1	V2	
1	Syrdaria	2×500	500	220	
2	Sogdiana	2×500	500	220	
3	Guzar	2×500	500	220	
4	Talimarjan	2×500	500	220	
5	Karakul	2×500	500	220	
6	Sarymai	2×500	500	220	
7	Navoi	2×500	500	220	
8	Muruntau	2×500	500	220	

(Source: JSC Thermal Power Plant, SAESP)

All transformer constants were assumed to be the same, and the value was set to R12 = 0.002526 pu and X12 = 0.126276 pu, R23 = 0.004655 pu and X23 = 0.232766 pu, R31 = 0.007715 pu, X31 = 0.385759 pu at a self-rated capacity base.

(3) Generator

In this analysis, the rated output of Navoi GTCC3 was set to 600MW. The generator outputs under each analysis condition are shown in Table 6.2.3-7.

Table 6.2.3-7 Generator Output Used for Analysis

No.	Generator Name	Initial Output [MW]				Remarks
		2023		2025		
		Sumner	Winter	Sumner	Winter	
1	Navoi GT3	458.3	500.0	458.3	500.0	GTCC3
2	Navoi ST3	91.7	100.0	91.7	100.0	GTCC3
3	Navoi GT1	220.0	314.0	220.0	314.0	
4	Navoi ST1	134.2	164.0	134.2	164.0	
5	Navoi GT2	220.0	315.0	220.0	315.0	
6	Navoi ST2	108.0	135.0	108.0	135.0	
7	Navoi #4	150.0	150.0	150.0	150.0	
8	Navoi #5,#7,#9	260.0	260.0	260.0	260.0	
9	Navoi #11,#12	420.0	420.0	420.0	420.0	
10	Mubarek #1,#2	42.0	42.0	42.0	48.0	
11	Mubarek GTCC	105.0	130.0	105.0	130.0	
12	Tahiatash GT1	155.0	160.0	155.0	160.0	
13	Tahiatash ST1	75.0	80.0	75.0	80.0	
14	Tahiatash GT2	155.0	160.0	155.0	160.0	
15	Tahiatash ST2	75.0	80.0	75.0	80.0	
16	Tahiatash #7	175.0	195.0	175.0	195.0	
17	Syrdaria #7-#10	1250.0	1250.0	1250.0	1250.0	
18	Talimarjan #1	750.0	780.0	750.0	800.0	
19	Talimarjan GT2,GT3	440.0	628.0	440.0	628.0	
20	Talimarjan ST2,ST3	220.0	308.0	220.0	310.0	
21	Tuyamajun	100.0	75.0	100.0	75.0	
22	UGHK	68.0	68.0	68.0	68.0	
23	SFES	65.0	15.0	65.0	15.0	

(Source: JICA Survey Team)

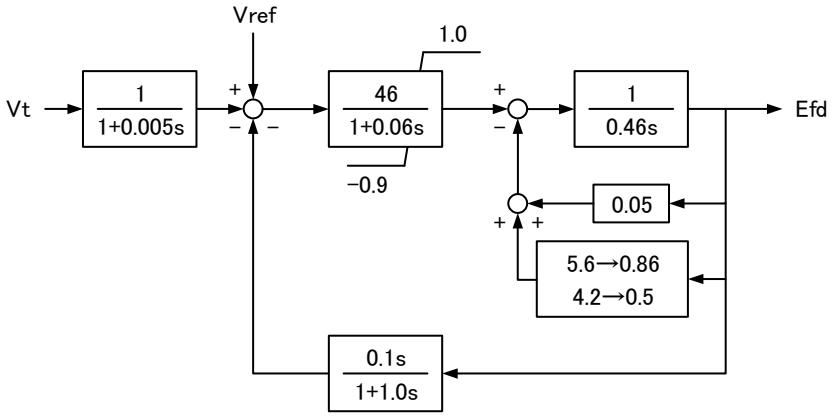
There are two types of generators in the power grid used this analysis. One of them is thermal power generator, and the other is hydro power generator. The constant of each type of generator is shown Table 6.2.3-8

Table 6.2.3-8 Generator Constant Data Used for Analysis

Item	unit	Thermal power generator	Hydro power generator
Xd	[pu]	1.550	0.990
Xd'	[pu]	0.280	0.350
Xd"	[pu]	0.190	0.250
Xq	[pu]	1.550	0.660
Xq'	[pu]	0.650	-
Xq"	[pu]	0.190	0.250
Tdo'	[sec]	6.500	5.250
Tdo"	[sec]	0.035	0.030
Tqo'	[sec]	1.250	-
Tqo"	[sec]	0.035	0.050
Xl	[pu]	0.150	0.150
Inertia H	[sec]	5.0 (Gas turbine) 4.0 (The Others)	5.0

(Source: JICA Survey Team)

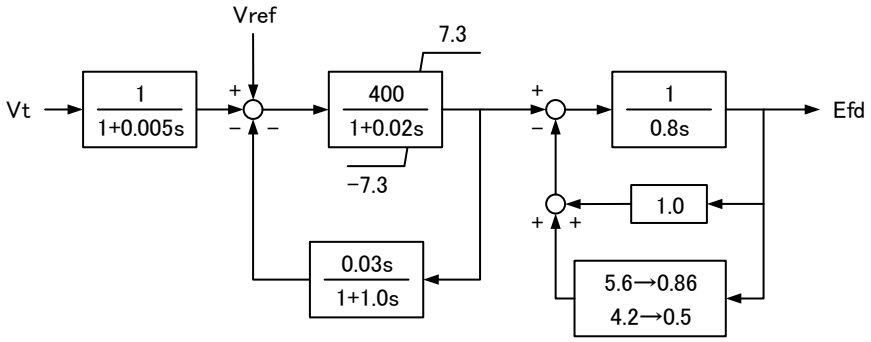
The AVR (Automatic Voltage Regulator) block which controls the voltage of the generator was used three types, DC type, AC type and thyristor type. The AVR control block diagrams for each type are shown in Table 6.2.3-1 to Figure 6.2.3-3.



(Source: JICA Survey Team)

Figure 6.2.3-1 DC Type AVR Control Block Diagram

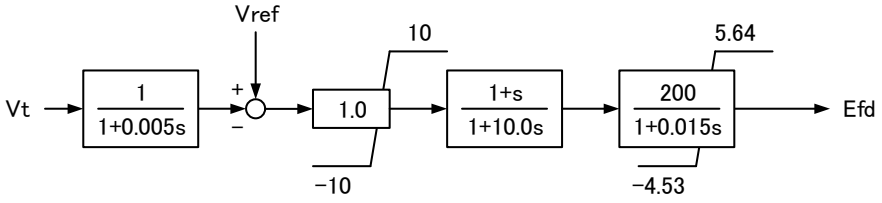
The DC type of AVR block was set to the generator that was made in relatively old era.



(Source: JICA Survey Team)

Figure 6.2.3-2 AC Type AVR Control Block Diagram

The AC type of AVR block was set to the relatively new generator.

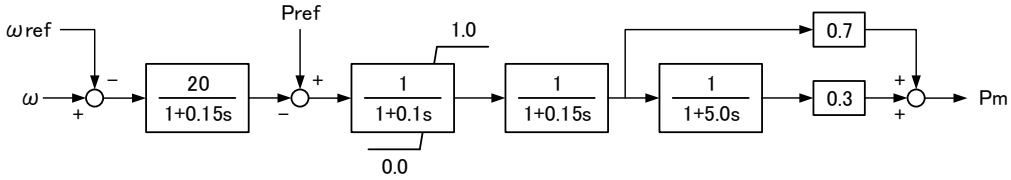


(Source: JICA Survey Team)

Figure 6.2.3-3 Thyristor Type AVR Control Block Diagram

The Thyristor type of AVR block was set to the latest generators, including Navoi GTCC3.

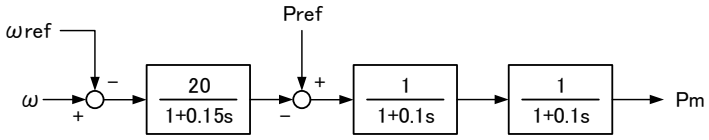
The governor block which adjusts the output of the generator used two types of general speed relay type and gas turbine type for this analysis. The governor control block diagrams for each type are shown in Table 6.2.3-4 to Figure 6.2.3-5.



(Source: JICA Survey Team)

Figure 6.2.3-4 General Speed Relay Type Governor Control Block Diagram

This general speed relay type of governor block was used for steam turbine generators and hydroelectric generators.



(Source: JICA Survey Team)

Figure 6.2.3-5 Gas Turbine Type Governor Control Block Diagram

This gas turbine type of governor block was used for gas turbine generators.

Table 6.2.3-9 shows the combinations of constants set for each generator.

Table 6.2.3-9 Combination Set for Generator Constant Data Used for Analysis

No.	Generator Name	Generator Constant			Remarks
		Type	AVR	Governor	
1	Navoi GT3	Thermal	Thyristor	Gas Turbine	GTCC3
2	Navoi ST3	Thermal	Thyristor	Speed Relay	GTCC3
3	Navoi GT1	Thermal	Thyristor	Gas Turbine	
4	Navoi ST1	Thermal	Thyristor	Speed Relay	
5	Navoi GT2	Thermal	Thyristor	Gas Turbine	
6	Navoi ST2	Thermal	Thyristor	Speed Relay	
7	Navoi #4	Thermal	DC	Speed Relay	
8	Navoi #5,#7,#9	Thermal	DC	Speed Relay	
9	Navoi #11,#12	Thermal	AC	Speed Relay	
10	Mubarek #1,#2	Thermal	AC	Speed Relay	
11	Mubarek GTCC	Thermal	Thyristor	Speed Relay	
12	Tahiatash GT1	Thermal	Thyristor	Gas Turbine	
13	Tahiatash ST1	Thermal	Thyristor	Speed Relay	
14	Tahiatash GT2	Thermal	Thyristor	Gas Turbine	
15	Tahiatash ST2	Thermal	Thyristor	Speed Relay	
16	Tahiatash #7	Thermal	DC	Speed Relay	
17	Syrdaria #7-#10	Thermal	AC	Speed Relay	
18	Talimarjan #1	Thermal	Thyristor	Speed Relay	
19	Talimarjan GT2,GT3	Thermal	Thyristor	Gas Turbine	
20	Talimarjan ST2,ST3	Thermal	Thyristor	Speed Relay	
21	Tuyamajun	Hydro	DC	Speed Relay	
22	UGHK	Thermal	DC	Speed Relay	
23	SFES	Thermal	AC	Speed Relay	

(Source: JICA Survey Team)

(4) Load

The load amounts used for the analysis are shown in Table 6.2.3-10 to Table 6.2.3-11. “P” represents active power, the unit is “MW”, and “Q” represents reactive power, the unit is “Mvar”.

The load used for this analysis is shown in Table 6.2.3-10 to Table 6.2.3-11. Each load was set assuming the maximum load in summer and winter in 2023 and 2025.

Table 6.2.3-10 Load Data Used for Analysis (Part 1)

No.	Name	Rated Voltage [kV]	2023				2025			
			Summer		Winter		Summer		Winter	
			P	Q	P	Q	P	Q	P	Q
1	Guzar	500	365.4	-58	481.7	-27.4	365.4	-58.0	481.7	-27.4
2	Guzar	500	294.9	-88.6	388.7	-60.9	294.9	-88.6	388.7	-60.9
3	Beruni	220	86.8	34.4	124.9	45.9	88.5	30.7	103.7	35.8
4	Navoi	220	115.1	44.3	65.8	29.4	64.6	28.0	75.8	32.8
5	K-Mazar	220	129.4	39.8	139.2	46.8	147.9	41.9	173.8	49.1
6	Buhara	220	192.7	83.4	221.3	83.4	219.2	70.0	258.2	82.5
7	Buhara	220	-45.0	-10.0	-63.0	-15.0	-53.0	-10.0	-63.0	-15.0
8	PP Turon	220	25.0	15.0	30.0	14.0	24.5	8.4	28.9	9.9
9	Mubarek-2	220	26.0	9.6	28.9	10.9	38.8	10.0	45.7	11.8
10	Mubarek	220	33.8	19.9	37.8	21.7	47.3	27.6	55.6	32.4
11	Mubarek-1	220	30.2	10.5	32.4	11.7	32.1	8.8	37.7	10.3
12	K-Bazar	220	31.2	11.1	33.7	10.0	44.2	19.1	47.4	17.9
13	Kassan	220	58.4	18.3	61.8	18.8	47.5	18.6	55.8	21.8
14	Kokdumalak	220	34.6	18.0	37.6	19.6	40.0	18.8	47.1	22.1
15	Talimarjan	220	-4.9	-2.0	-4.9	-2.0	-4.9	-2.0	-4.9	-2.0
16	SGHK	220	77.8	30.6	90.1	35.2	129.5	53.1	152.2	62.3
17	Karsh	220	214.8	65.2	252.1	74.4	243.6	64.4	286.0	75.3
18	NS-3	220	366.1	15.1	274.5	14.9	165.1	-9.0	194.1	-10.6
19	Guzar	220	175.9	46.5	197.0	52.0	246.0	72.5	289.2	85.1
20	Karakul	220	32.1	16.4	35.7	18.5	34.8	14.0	41.3	16.8
21	Hamza	220	187.2	15.5	150.8	10.1	84.5	41.9	100.1	50.1
22	Himiya	220	257.7	101.3	281.7	109.2	276.8	105.1	324.4	122.4
23	Suvli	220	108.7	34.5	120.4	37.5	112.2	34.0	131.5	39.6
24	Katta-Kurgan	220	176.0	75.1	191.8	82.1	177.0	75.2	205.9	86.6
25	Samarkand	220	264.5	114.4	290.1	127.0	293.0	143.0	341.5	165.1
26	Samarkand	220	-5.0	-2.0	-5.0	-2.0	-5.0	-2.0	-5.0	-2.0

(Source: JICA Survey Team)

Table 6.2.3-11 Load Data Used for Analysis (Part 2)

No.	Name	Rated Voltage [kV]	2023				2025			
			Summer		Winter		Summer		Winter	
			P	Q	P	Q	P	Q	P	Q
27	Bobur	220	7.3	2.7	7.9	2.7	7.6	2.9	8.7	2.9
28	Sari-Bazar	220	79.2	22.9	121.0	30.6	81.1	23.6	124.1	31.3
29	Zarbdor	220	51.6	16.3	19.2	5.0	53.1	16.5	19.4	5.1
30	Djizak	220	187.8	77.1	199.6	43.5	190.4	78.9	199.6	42.6
31	127A	220	26.4	9.1	23.9	10.2	24.6	6.1	24.6	6.1
32	Besopan	220	340.5	78.9	344.3	82.5	429.8	107.2	429.6	106.8
33	127D	220	25.5	13.7	25.1	14.5	33.0	19.4	33.0	19.7
34	Zarafsyan	220	55.0	18.0	57.6	19.5	33.0	13.8	33.0	13.9
35	Feruza	220	108.0	34.0	110.7	35.6	105.3	29.6	105.3	29.6
36	B-3	220	17.2	2.3	17.3	2.3	17.5	2.8	17.6	2.9
37	B-2	220	10.2	2.5	10.2	2.5	12.4	3.5	12.4	3.5
38	B-1	220	13.3	3.0	13.3	3.0	15.5	3.4	15.6	3.4
39	Gorhar	220	7.5	2.5	7.6	2.6	7.2	4.3	7.2	4.3
40	Chapan-Ata	220	179.8	64.3	199.8	78.4	193.6	67.7	225.8	78.2
41	Ishtihan	220	85.3	31.3	84.1	31.2	64.7	19.6	75.3	22.6
42	Kandym	220	49.3	17.2	51.2	15.2	48.5	15.7	52.1	16.1
43	Pashkamar	220	138.2	58.3	142.4	71.4	155.4	65.6	160.2	80.4
44	Navoi NS	220	72.4	29.9	94.8	39.3	84.8	33.8	99.6	39.6
45	Syrdaria	220	421.1	199.9	414.2	185.1	449.1	212.9	436.7	184.6
46	Syrdaria	220	354.9	30.0	519.8	82.6	386.1	21.2	579.6	83.1
47	Syrdaria	220	-15.0	-6.0	-15.0	-6.0	-15.0	-6.0	-15.0	-6.0
48	Tahiatash	110	189.5	75.5	222.2	88.2	207.7	71.7	243.4	83.6
49	Horezm	110	283.5	104.9	328.4	109.9	294.1	89.6	338.9	102
50	Hozaras	110	14.8	5.3	26.4	14.5	17.2	5.3	20.0	6.1
51	Tuyamajun	110	7.1	4.1	10.0	6.0	5.0	2.0	5.9	2.3
52	Karakarpakis	110	29.8	16.4	34.8	18.8	47.1	26.0	55.1	30.1
53	Navoi	110	272.9	116.6	299.3	126.7	295.8	123.2	346.6	143.3
54	UGHK	33	68.0	21.9	69.5	23.4	70.1	22.0	70.3	23.3

(Source: JICA Survey Team)

6.2.4 Power Flow Analysis

The impact of Navoi GTCC3 operation on the power grid has been confirmed by power flow analysis. The analysis results are described below.

(1) Criteria of power flow

The voltage and overload criteria used for the power flow analysis are described below.
Table 6.2.4-1 shows the voltage criteria of the power flow analysis in Uzbekistan. There are two types of limits for 220 kV electric facilities at normal condition and emergency condition for each maximum and minimum limit. On the other hand, the electric facilities of 500 kV have only one limit for each maximum and minimum value.

Table 6.2.4-1 Voltage criteria of the power flow analysis

Voltage condition		Rated voltage	
		220 kV	500 kV
Maximum	Emergency	252 kV (115 %)	525 kV (105 %)
	Normal	231 kV (105 %)	
Normal		220 kV (100 %)	500 kV (100 %)
Minimum	Normal	209 kV (95 %)	475 kV (95 %)
	Emergency	198 kV (90 %)	

(Source: JSC Thermal Power Plant, SAESP)

Table 6.2.4-2 shows the overload criteria of the power flow analysis in Uzbekistan.

Table 6.2.4-2 Overload criteria of the power flow analysis

Condition	Rated voltage	
	220 kV	500 kV
Emergency	100 %	100 %
Normal		

(Source: JSC Thermal Power Plant, SAESP)

The upper limit of the power flow is always 100 %, regardless of the rated voltage or state of the power system (normal or emergency).

Although it does not matter in the power flow analysis, the allowable range of the frequency is 50 Hz ± 0.2 Hz.

Table 6.2.4-3 shows the change of T/L current capacity due to ambient temperature variations. In case that 25 degrees C is base ambient temperature, T/L current capacity is 1.24 times at 0 degrees C and 0.88 times at 35 degrees C, respectively.

Table 6.2.4-3 Change of Transmission Line Current Capacity

Ambient Temperature [degree C]	-5	**0**	5	10	15	20	25	30	35	40
Coefficient	1.29	1.24	1.20	1.15	1.11	1.05	1.00	0.94	0.88	0.81

(Source: JSC Thermal Power Plant, SAESP)

(2) Calculation results

The power flow calculation results in each case of Table 6.2.2-1 are shown below.

1) Case 1

In Case 1, Navoi 500 kV / 220 kV SS is not operating, but is operating as the 220 kV switchyard, and the load demand assumed to be the summer season in 2023.

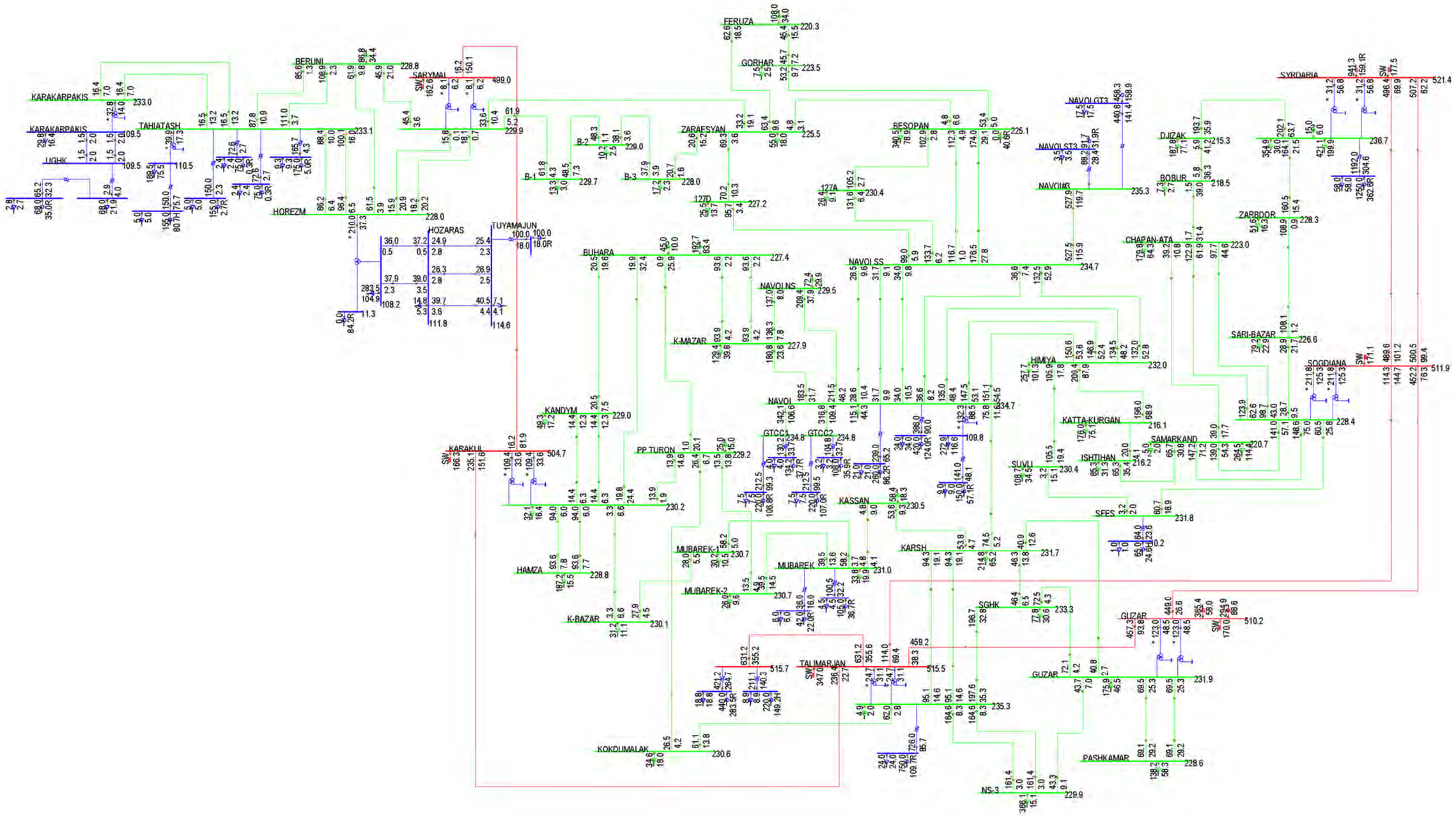
In the normal condition, it was confirmed that the system can be operated in a sound state without causing an overload and / or voltage drop. The result of power flow analysis in the normal condition is shown in Figure 6.2.4-1.

And Table 6.2.4-4 shows overloads and voltage drops that occurred under N-1 conditions.

In the case of N-1 condition, overload occurred in 5 T/Ls of 220 kV, and bus voltage drop occurred in 4 substations of 220 kV.

These voltage drops occurred when assuming under N-1 condition for single T/L. And, these overloads and voltage drops occurred even when Navoi GTCC3 was not connected.

Therefore, these overloads and voltage drops were not be caused by the operation of Navoi GTCC3.



(Source: JICA Survey Team)

Figure 6.2.4-1 Power Flow Analysis Result (Case 1, Normal Condition)

Table 6.2.4-4 Result of Power Flow Calculation under N-1 Conditions (Case 1)

No.	Over Loaded Circuit						Contingency				
	Name (From node)	kV	Name (To node)	kV	ID	Value [%]	Name	kV	Name	kV	ID
1	Bobur	220	Djizak	220	1	107.0	Djizak	220	Syrdaria	220	1
2	Bobur	220	Chapan-Ata	220	1	110.1	Djizak	220	Syrdaria	220	1
3	Djizak	220	Syrdaria	220	1	102.8	Sogdiana	500	Syrdaria	500	1
						103.6	Sogdiana	500	Syrdaria	500	2
						100.4	Talimarjan	500	Talimarjan	500	1
4	Samarkand	220	Sogdiana	220	1	106.3	Himiya	220	Katta-Kurgan	220	1
						101.4	Samarkand	220	Sogdiana	220	2
5	Samarkand	220	Ishtihan	220	1	107.2	Himiya	220	Katta-Kurgan	220	1
No.	Low Voltage Node						Contingency				
	Name	kV	-	-	Value[pu]	Value[kV]	Name	kV	Name	kV	ID
1	Katta-Kurgan	220	-	-	0.8220	180.84	Himiya	220	Katta-Kurgan	220	1
2	Ishtihan	220	-	-	0.8399	184.77	Himiya	220	Katta-Kurgan	220	1
3	Bobur	220	-	-	0.8572	188.58	Djizak	220	Syrdaria	220	1
4	Djizak	220	-	-	0.7956	175.04	Djizak	220	Syrdaria	220	1

(Source: JICA Survey Team)

2) Case 2

In Case 2, same as Case 1, Navoi 500 kV / 220 kV SS is not operating, but is operating as the 220 kV switchyard, and the load demand assumed to be the winter season in 2023.

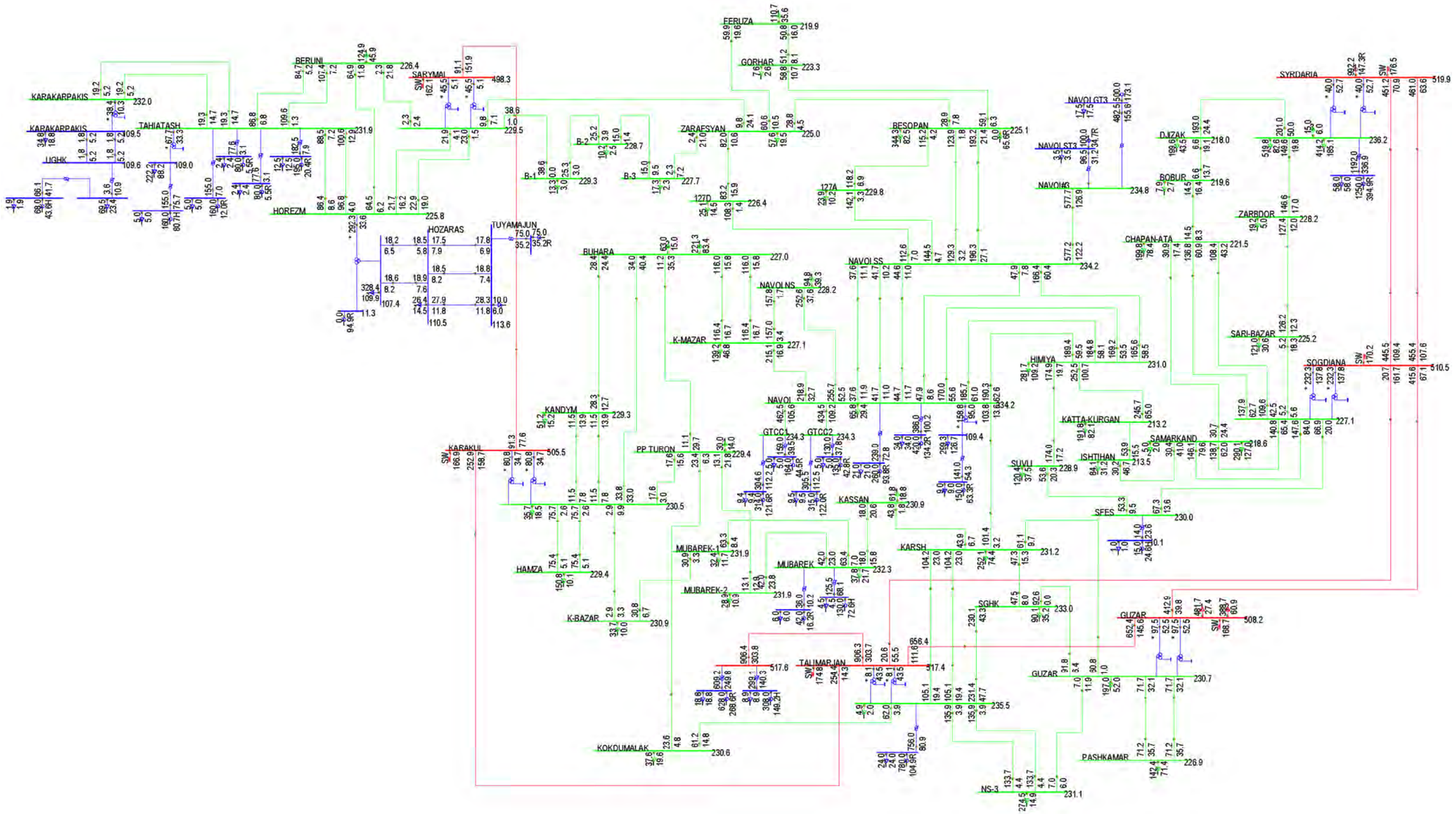
In the normal condition, same as Case 1, it was confirmed that the system can be operated in a sound state without causing an overload and / or voltage drop. The result of power flow analysis in the normal condition is shown in Figure 6.2.4-2.

And Table 6.2.4-5 shows overloads and voltage drops that occurred under N-1 conditions.

The overload did not occur, and the voltage drop occurred in the same 4 substations of 220 kV as Case 1.

Same as Case 1, these voltage drops occurred when assuming under N-1 condition for single T/L. And, these voltage drops occurred even when Navoi GTCC3 was not connected.

Therefore, these overloads and voltage drops were not be caused by the operation of Navoi GTCC3.



(Source: JICA Survey Team)

Figure 6.2.4-2 Power Flow Analysis Result (Case 2, Normal Condition)

Table 6.2.4-5 Result of Power Flow Calculation under N-1 Conditions (Case 2)

No.	Over Loaded Circuit						Contingency				
	Name (From node)	kV	Name (To node)	kV	ID	Value [%]	Name	kV	Name	kV	ID
-	None										
No.	Low Voltage Node						Contingency				
	Name	kV	-	-	Value[pu]	Value[kV]	Name	kV	Name	kV	ID
1	Katta-Kurgan	220	-	-	0.7797	171.53	Himiya	220	Katta-Kurgan	220	1
2	Ishtihan	220	-	-	0.8004	176.09	Himiya	220	Katta-Kurgan	220	1
3	Bobur	220	-	-	0.8777	193.10	Djizak	220	Syrdaria	220	1
4	Djizak	220	-	-	0.8328	183.21	Djizak	220	Syrdaria	220	1

(Source: JICA Survey Team)

3) Case 3

In Case 3, Navoi 500 kV / 220 kV SS is not operating, but that is operating as the 220 kV switchyard, and the load demand assumed to be the summer season. Case 3 assumed the load demand to be 2025, not 2023, using the same power system configuration as Case 1 and Case 2.

In the normal condition, it was confirmed that the system can be operated in a sound state without causing an overload and / or voltage drop. The result of power flow analysis in the normal condition is shown in Figure 6.2.4-3.

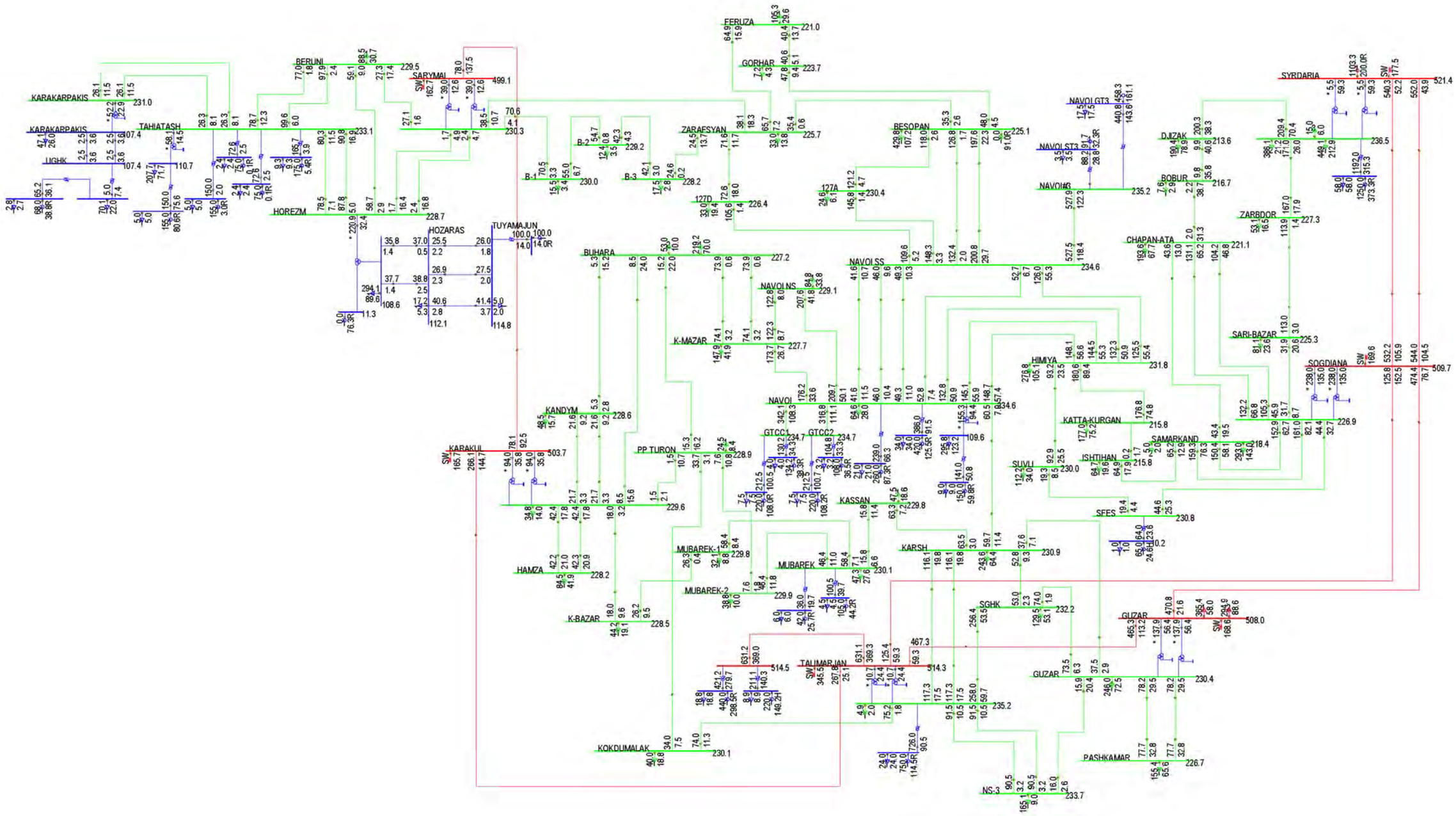
And Table 6.2.4-6 shows overloads and voltage drops that occurred under N-1 conditions.

In the case of N-1 condition, overload occurred in 5 T/Ls, and bus voltage drop occurred in 4 substations.

Same as Case 1 and Case 2, overload occurred in 5 T/Ls of 220 kV, and bus voltage drop occurred in 4 substations of 220 kV.

These voltage drops occurred when assuming under N-1 condition for single T/L. And, these overloads and voltage drops occurred even when Navoi GTCC3 was not connected.

Therefore, these overloads and voltage drops were not be caused by the operation of Navoi GTCC3.



(Source: JICA Survey Team)

Figure 6.2.4-3 Power Flow Analysis Result (Case 3, Normal Condition)

Table 6.2.4-6 Result of Power Flow Calculation under N-1 Conditions (Case 3)

No.	Over Loaded Circuit						Contingency				
	Name (From node)	kV	Name (To node)	kV	ID	Value [%]	Name	kV	Name	kV	ID
1	Bobur	220	Djizak	220	1	112.5	Djizak	220	Syrdaria	220	1
2	Bobur	220	Chapan-Ata	220	1	115.9	Djizak	220	Syrdaria	220	1
3	Djizak	220	Syrdaria	220	1	108.6	Sogdiana	500	Syrdaria	500	1
						109.5	Sogdiana	500	Syrdaria	500	2
						104.6	Talimarjan	500	Talimarjan	500	1
4	Samarkand	220	Sogdiana	220	1	109.7	Himiya	220	Katta-Kurgan	220	1
						110.8	Samarkand	220	Sogdiana	220	2
5	Talimarjan	220	SGHK	220	1	100.5	Guzar	500	Sogdiana	500	1
						120.7	Guzar	500	Talimarjan	500	1
						102.6	Talimarjan	220	Karsh	220	1
						102.6	Talimarjan	220	Karsh	220	1
No.	Low Voltage Node						Contingency				
	Name	kV	-	-	Value[pu]	Value[kV]	Name	kV	Name	kV	ID
1	Katta-Kurgan	220	-	-	0.8217	180.8	Himiya	220	Katta-Kurgan	220	1
2	Ishtihan	220	-	-	0.8396	184.7	Himiya	220	Katta-Kurgan	220	1
3	Bobur	220	-	-	0.8339	183.5	Djizak	220	Syrdaria	220	1
4	Djizak	220	-	-	0.7685	169.1	Djizak	220	Syrdaria	220	1

(Source: JICA Survey Team)

4) Case 4

In Case 4, Navoi 500 kV / 220 kV SS is not operating, but that is operating as the 220 kV switchyard, and the load demand assumed to be the winter season. Case 4 assumed the load demand to be 2025, not 2023, using the same power system configuration as Case 1 and Case 2.

In the normal condition, it was confirmed that the system can be operated in a sound state without causing an overload and / or voltage drop. The result of power flow analysis in the normal condition is shown in Figure 6.2.4-4.

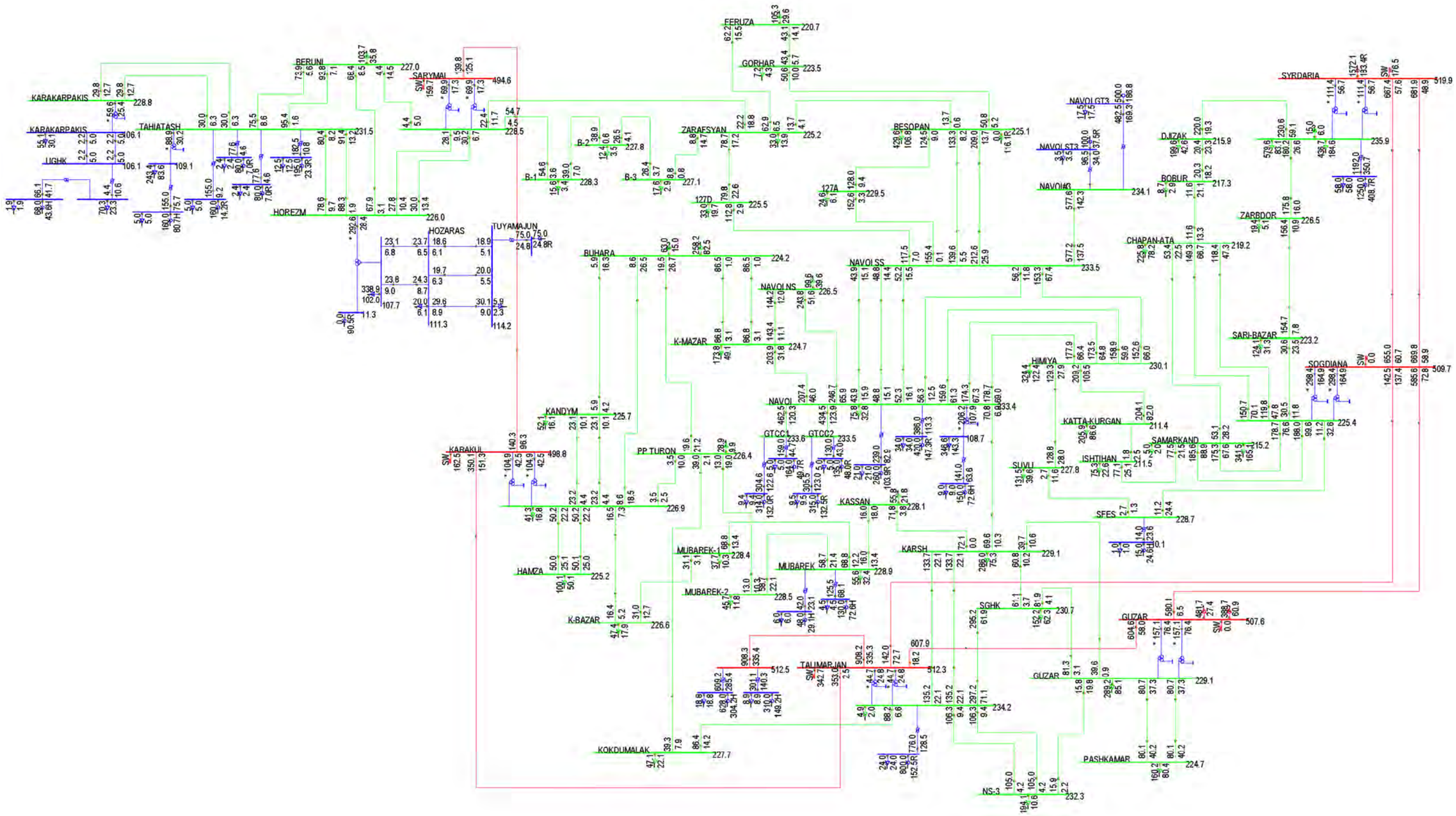
And Table 6.2.4-7 shows overloads and voltage drops that occurred under N-1 conditions.

In the case of N-1 condition, overload occurred in 2 transformers and 1 T/L of 220 kV, and bus voltage drop occurred in 5 substations of 220 kV.

Due to the increase in load demand, overload occurred at the transformers at Sogdiana SS and the 220 kV T/Ls between Talimarjan SS and SGHK SS.

Same as Case 1 to Case 3, these voltage drops occurred when assuming under N-1 condition for single T/L. And, these overloads and voltage drops occurred even when Navoi GTCC3 was not connected.

Therefore, these overloads and voltage drops were not be caused by the operation of Navoi GTCC3.



(Source: JICA Survey Team)

Figure 6.2.4-4 Power Flow Analysis Result (Case 4, Normal Condition)

Table 6.2.4-7 Result of Power Flow Calculation under N-1 Conditions (Case 4)

No.	Over Loaded Circuit						Contingency				
	Name (From node)	kV	Name (To node)	kV	ID	Value [%]	Name	kV	Name	kV	ID
1	Sogdiana	500	Wnd 1	-	1	120.8	Sogdiana	500	Sogdiana	220	2
		220	Wnd 2			112.1	Sogdiana	500	Sogdiana	220	
2	Sogdiana	500	Wnd 1	-	2	120.8	Sogdiana	500	Sogdiana	220	1
		220	Wnd 2			112.1	Sogdiana	500	Sogdiana	220	
3	Talimarjan	220	SGHK	220	1	102.6	Guzar	500	Talimarjan	500	1
No.	Low Voltage Node						Contingency				
	Name	kV	-	-	Value[pu]	Value[kV]	Name	kV	Name	kV	ID
1	Ishtihan	220	-	-	0.7621	167.7	Himiya	220	Katta-Kurgan	220	1
2	Katta-Kurgan	220	-	-	0.7388	162.5	Himiya	220	Katta-Kurgan	220	1
3	Samarkand	220	-	-	0.8766	192.9	Himiya	220	Katta-Kurgan	220	1
4	Bobur	220	-	-	0.8527	187.6	Djizak	220	Syrdaria	220	1
5	Djizak	220	-	-	0.8064	177.4	Djizak	220	Syrdaria	220	1

(Source: JICA Survey Team)

5) Case 5

In Case 5, Navoi 500 kV / 220 kV SS is operating, and the load demand assumed to be the summer season in 2025.

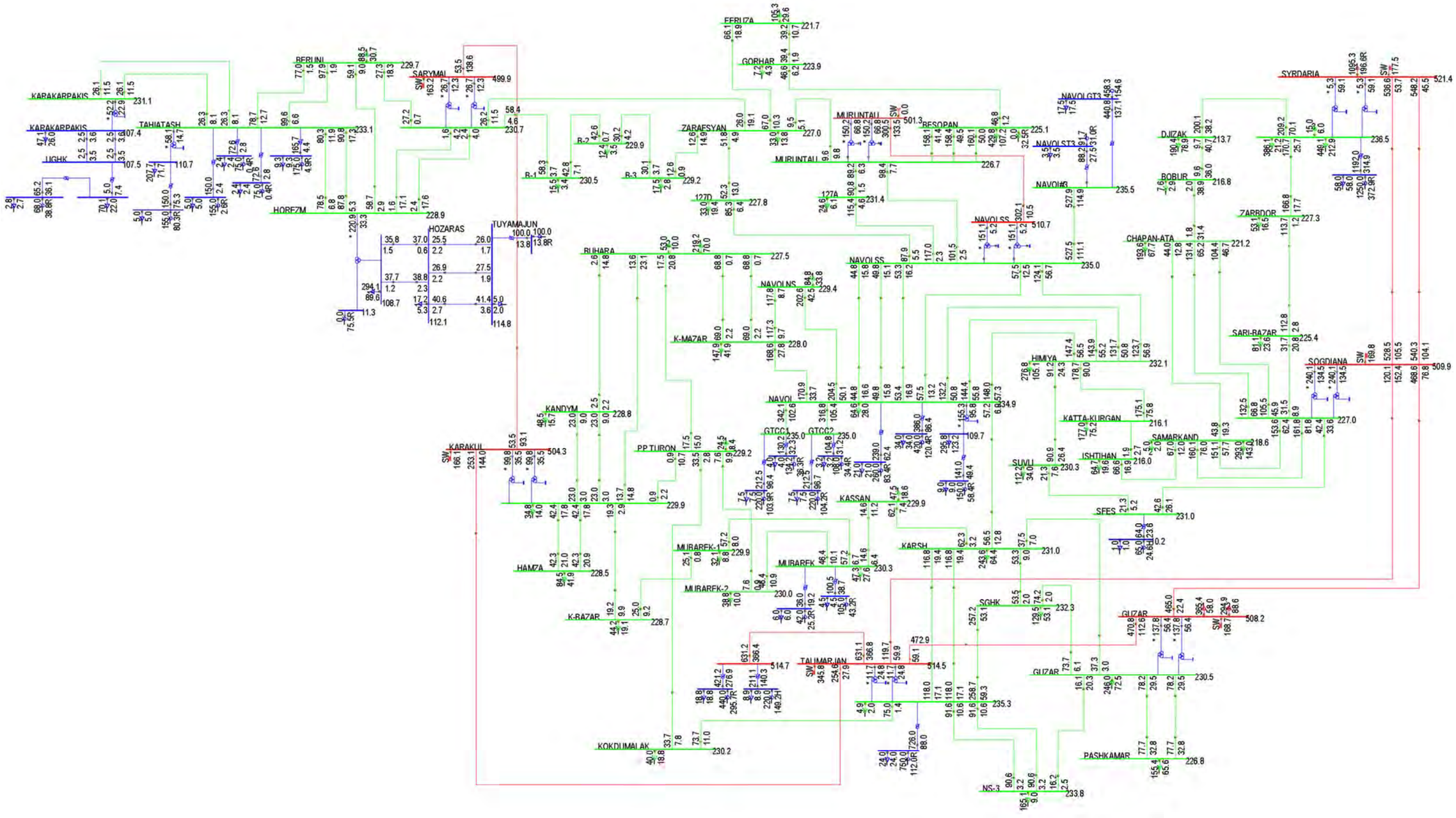
In the normal condition, it was confirmed that the system can be operated in a sound state without causing an overload and / or voltage drop. The result of power flow analysis in the normal condition is shown in Figure 6.2.4-5.

And Table 6.2.4-8, Table 6.2.4-9 shows overloads and voltage drops that occurred under N-1 conditions.

In the case of N-1 condition, overload occurred in 6 T/Ls of 220 kV, and bus voltage drop occurred in 4 substations of 220 kV.

These voltage drops occurred when assuming under N-1 condition for single T/L. And, these overloads and voltage drops occurred even when Navoi GTCC3 was not connected.

Therefore, these overloads and voltage drops were not be caused by the operation of Navoi GTCC3.



(Source: JICA Survey Team)

Figure 6.2.4-5 Power Flow Analysis Result (Case 5, Normal Condition)

Table 6.2.4-8 Result of Power Flow Calculation under N-1 Conditions (Case 5) –Part 1-

No.	Over Loaded Circuit						Contingency				
	Name (From node)	kV	Name (To node)	kV	ID	Value [%]	Name	kV	Name	kV	ID
1	Bobur	220	Chapan-Ata	220	1	115.7	Djizak	220	Syrdaria	220	1
2	Bobur	220	Djizak	220	1	112.3	Djizak	220	Syrdaria	220	1
3	Besopan	220	Muruntau	220	2	101.1	Besopan	220	Muruntau	220	1
					3	100.0					
					1	117.0	Besopan	220	Muruntau	220	2
					3	101.2					
					1	116.4	Besopan	220	Muruntau	220	3
					2	101.8					
4	Samarkand	220	Sogdiana	220	1	109.7	Himiya	220	Katta-Kurgan	220	1
						111.1	Samarkand	220	Sogdiana	220	2
5	Djizak	220	Syrdaria	220	1	108.3	Sogdiana	500	Syrdaria	500	1
						109.2	Sogdiana	500	Syrdaria	500	2
6	Talimarjan	220	SGHK	220	1	102.8	Talimarjan	220	Karsh	220	1
						102.8	Talimarjan	220	Karsh	220	2
						100.5	Guzar	500	Sogdiana	500	1
						121.2	Guzar	500	Talimarjan	500	1

(Source: JICA Survey Team)

Table 6.2.4-9 Result of Power Flow Calculation under N-1 Conditions (Case 5) –Part 2-

No.	Low Voltage Node						Contingency				
	Name	kV	-	-	Value[pu]	Value[kV]	Name	kV	Name	kV	ID
1	Djizak	220	-	-	0.7699	169.4	Djizak	220	Syrdaria	220	1
2	Bobur	220	-	-	0.8351	183.7	Djizak	220	Syrdaria	220	1
3	Katta-Kurgan	220	-	-	0.8226	181.0	Himiya	220	Katta-Kurgan	220	1
4	Ishtihan	220	-	-	0.8405	184.9	Himiya	220	Katta-Kurgan	220	1

(Source: JICA Survey Team)

6) Case 6

In Case 6, Navoi 500 kV / 220 kV SS is operating, and the load demand assumed to be the summer season in 2025.

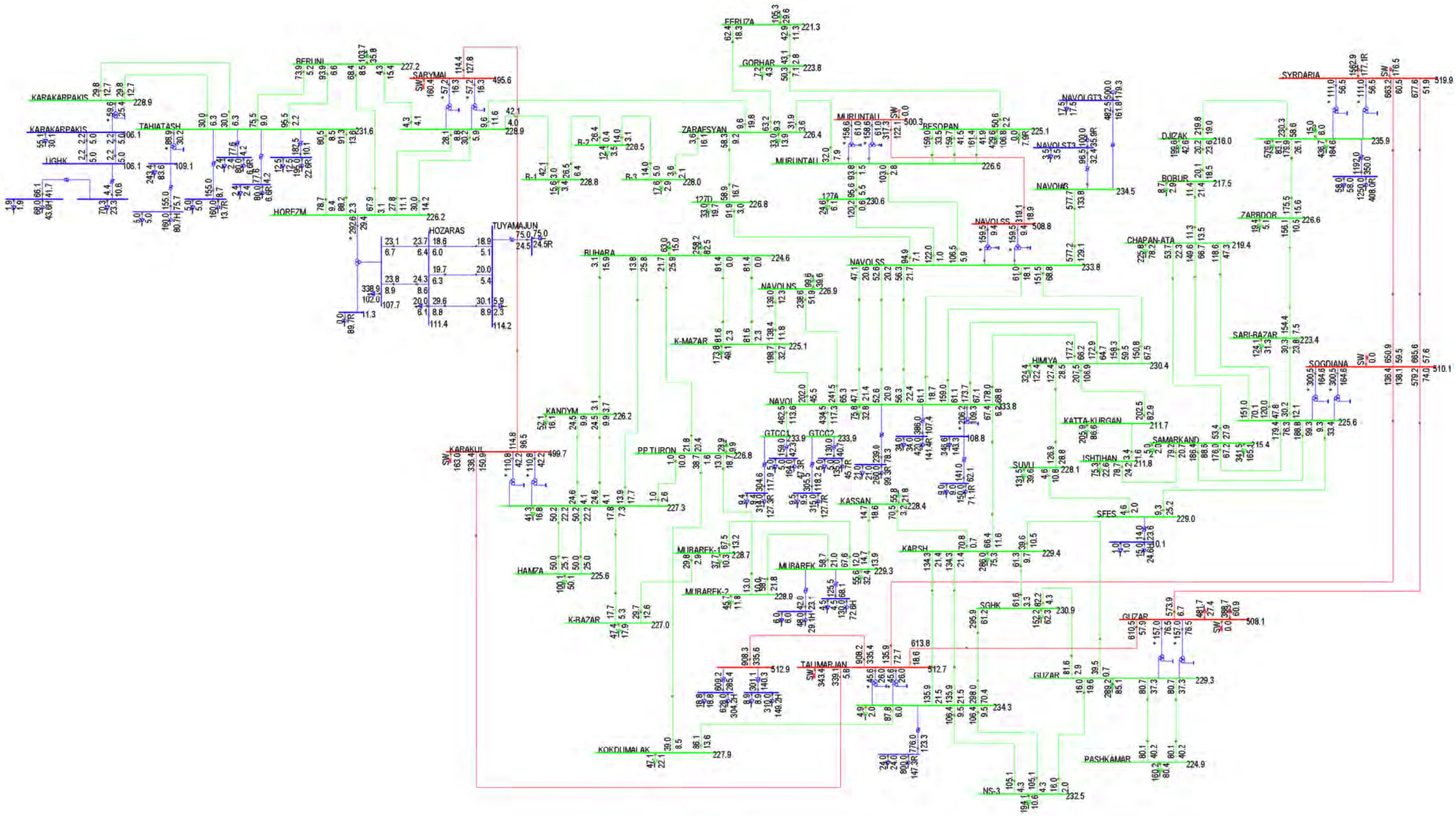
In the normal condition, it was confirmed that the system can be operated in a sound state without causing an overload and / or voltage drop. The result of power flow analysis in the normal condition is shown in Figure 6.2.4-6.

And Table 6.2.4-10 shows overloads and voltage drops that occurred under N-1 conditions.

In the case of N-1 condition, overload occurred in 2 transformers and 1 T/L of 220 kV, and bus voltage drop occurred in 5 substations of 220 kV. The calculation results were almost the same as in Case 4.

Same as the others cases, these voltage drops occurred when assuming under N-1 condition for single T/L. And, these overloads and voltage drops occurred even when Navoi GTCC3 was not connected.

Therefore, these overloads and voltage drops were not be caused by the operation of Navoi GTCC3.



(Source: JICA Survey Team)

Figure 6.2.4-6 Power Flow Analysis Result (Case 6, Normal Condition)

Table 6.2.4-10 Result of Power Flow Calculation under N-1 Conditions (Case 6)

No.	Over Loaded Circuit						Contingency				
	Name (From node)	kV	Name (To node)	kV	ID	Value [%]	Name	kV	Name	kV	ID
1	Sogdiana	500	Wnd 1	-	1	121.3	Sogdiana	500	Sogdiana	220	2
		220	Wnd 2			112.6					
2	Sogdiana	500	Wnd 1	-	2	121.3	Sogdiana	500	Sogdiana	220	1
		220	Wnd 2			112.6					
3	Talimarjan	220	SGHK	220	1	102.9	Guzar	500	Talimarjan	500	1
No.	Low Voltage Node						Contingency				
	Name	kV	-	-	Value[pu]	Value[kV]	Name	kV	Name	kV	ID
1	Katta-Kurgan	220	-	-	0.7404	162.9	Himiya	220	Katta-Kurgan	220	1
2	Ishtihan	220	-	-	0.7637	168.0	Himiya	220	Katta-Kurgan	220	1
3	Samarkand	220	-	-	0.8779	193.1	Himiya	220	Katta-Kurgan	220	1
4	Djizak	220	-	-	0.8080	177.8	Djizak	220	Syrdaria	220	1
5	Bobur	220	-	-	0.8543	187.9	Djizak	220	Syrdaria	220	1

(Source: JICA Survey Team)

(3) Conclusion of power flow analysis

Power flow analysis was carried out for each of Case 1 to Case 6 in Table 6.2.2-1.

As a result of this analysis, in all cases, it was confirmed that under normal conditions, overloading of the T/L and bus voltage drops did not occur.

On the other hand, in the N-1 condition, overload was occurred at the following T/Ls and transformers.

- Transmission Lines (220 kV)
  From Bobur SS to Djizak SS
  From Bobur SS to Chapan-Ata SS
  From Djizak SS to Syrdaria SS
  From Samarkand SS to Sogdiana SS
  From Samarkand SS to Ishtihan SS
  From Talimarjan SS to SGHK SS
  From Besopan SS to Muruntau SS
- Transformers (500 kV / 220 kV)
  Bank #1 at Sogdiana SS
  Bank #2 at Sogdiana SS

In addition, the bus voltage dropped at the following 220 kV substations.

- 220 kV Bus
  Katta-Kurgan SS
  Ishtihan SS
  Bobur SS
  Djizak SS
  Samarkand SS

But, the above overloads and bus voltage drops occurred regardless of the operation of Navoi GTCC3. Therefore, it was confirmed that the operation of Navoi GTCC 3 did not cause these overloads and voltage drops, and did not cause any new problems other than the systematic problems existing power grid already had.

In order to solve the above problems, the following power grid reinforcement is required.

- ✓ Add 220 kV T/L (From 1 circuit to 2 circuits)
  From Djizak SS to Syrdaria SS
  From Himiya SS to Katta-Kurgan SS
  From Talimarjan to SGHK SS
- ✓ Thickening of conductor
  From Samarkand SS to Sogdiana SS (500mm^2)
  From Besopan SS to Muruntau SS (300mm^2)
- ✓ Add Transformer Bank
  1 bank add at Sogdiana SS

6.2.5 Fault Current Analysis

The impact of Navoi GTCC3 operation on the power grid has been confirmed by fault current analysis. The analysis results are described below.

(1) Criteria of fault current

The maximum fault current in each voltage level was determined and was given by JSC TPP. Specific premises of fault current analysis are shown Table 6.2.5-1.

Table 6.2.5-1 Specific premises of fault current analysis

Item	Description
Bus Voltage Before the Fault	1.0 pu at all buses
Transformer Tap	Center tap
Source Reactance of Generator	Sub-transient (Xd")
Fault Type	Three phase short circuit (3LS) One line to ground (1LG)
Allowable Maximum Current	31.5 kA at 500 kV Buses 40.0 kA at 220 kV Buses

(Source: JICA Survey Team)

All fault currents are supplied from the generator and do not depend on the generator initial output and the amount size of the load.

In this analysis cases (Case 1 to Case 6), the power system used for this analysis can be divided into two systems: the system of connecting 220 kV switchyard (Case 1 to Case 4) and the system of connecting 500 kV / 220 kV SS (Case 5 and Case6).

Since the same generators were used in all cases, only the circuit configurations of connecting 220 kV switchyard and connecting 500 kV / 220 kV SS differ.

Therefore, this fault current analysis was performed for two types of systems, including 220 kV switchyard and including 500 kV / 220 kV SS.

In order to verify the influence of Navoi GTCC3, the fault current of each bus was calculated before and after Navoi GTCC3 was connected.

(2) Calculation results

Fault current calculation results in each case are shown in Table 6.2.5-2 to Table 6.2.5-5.

Table 6.2.5-2 Fault Current Calculation Result Connecting 220 kV Switchyard (Part 1)

No.	Bus Name	Rated kV [kV]	Fault Current [kA]				Allowable Fault Current [kA]
			With GTCC3		Without GTCC3		
			3LS	1LG	3LS	1LG	
1	Guzar	500	9.49	8.94	9.44	8.92	31.5
2	Karakul	500	5.97	6.01	5.91	5.97	
3	Sogdiana	500	11.87	10.64	11.82	10.61	
4	Sarymai	500	3.62	3.79	3.59	3.78	
5	Talimarjan	500	12.81	14.74	12.73	14.68	
6	Talimarjan	500	12.76	14.72	12.68	14.66	
7	Syrdaria	500	20.76	21.06	20.74	21.04	
8	Horezm	220	6.50	6.34	6.48	6.33	40.0
9	Tahiatash	220	9.48	11.49	9.47	11.48	
10	Beruni	220	5.76	6.39	5.76	6.38	
11	Karakarpakistan	220	3.12	2.63	3.12	2.63	
12	Navoi PS	220	30.76	37.40	25.54	31.32	
13	K-Mazar	220	10.95	10.34	10.57	10.11	
14	Buhara	220	10.65	10.54	10.40	10.37	
15	PP Turon	220	8.56	6.47	8.47	6.44	
16	Mubarek-2	220	7.91	7.49	7.87	7.47	
17	Mubarek	220	8.57	9.35	8.53	9.32	
18	Mubarek-1	220	7.01	6.32	6.98	6.30	
19	K-Bazar	220	4.61	4.55	4.59	4.54	
20	Kassan	220	7.90	8.29	7.87	8.27	
21	Kokdumalak	220	4.68	4.52	4.67	4.51	
22	Talimarjan	220	23.00	28.40	22.89	28.28	
23	SGHK	220	13.41	11.97	13.36	11.95	
24	Karsh	220	13.73	14.33	13.65	14.26	
25	NS-3	220	6.81	7.12	6.80	7.11	
26	Guzar	220	14.33	16.49	14.28	16.44	
27	Karakul	220	11.62	13.89	11.48	13.76	
28	Hamza	220	7.63	9.43	7.57	9.36	
29	Himiya	220	21.82	22.24	19.15	20.13	
30	Suvli	220	9.07	6.09	8.68	5.96	
31	Katta-Kurgan	220	5.86	7.11	5.77	7.02	

(Source: JICA Survey Team)

Table 6.2.5-3 Fault Current Calculation Result Connecting 220 kV Switchyard (Part 2)

No.	Bus Name	Rated kV [kV]	Fault Current [kA]				Allowable Fault Current [kA]
			With GTCC3		Without GTCC3		
			3LS	1LG	3LS	1LG	
32	Samarkand	220	9.63	11.45	9.56	11.39	40.0
33	Sogdiana	220	15.95	18.46	15.84	18.37	
34	Bobur	220	4.45	3.70	4.44	3.69	
35	Sari-Bazar	220	4.47	4.34	4.47	4.34	
36	Zarbdor	220	4.52	3.25	4.52	3.24	
37	Djizak	220	4.04	5.03	4.03	5.02	
38	127A	220	5.34	3.25	5.15	3.18	
39	Besopan	220	7.28	5.14	7.01	5.03	
40	127D	220	3.82	2.34	3.74	2.31	
41	Zarafsyan	220	6.35	4.65	6.17	4.57	
42	Feruza	220	3.21	3.84	3.17	3.79	
43	B-3	220	3.47	2.21	3.44	2.20	
44	B-2	220	4.03	2.77	4.00	2.76	
45	B-1	220	6.82	6.67	6.78	6.64	
46	Gorhar	220	4.01	3.00	3.93	2.97	
47	GTCC2	220	29.95	35.46	25.03	30.06	
48	Sarymai	220	8.03	9.55	7.97	9.50	
49	Chapan-Ata	220	9.69	10.82	9.65	10.79	
50	Ishtihan	220	5.87	6.82	5.80	6.75	
51	Kandym	220	7.25	5.68	7.18	5.65	
52	Pashkamar	220	7.12	7.58	7.11	7.57	
53	SFES	220	6.73	6.65	6.67	6.61	
54	GTCC1	220	29.81	35.12	24.94	29.84	
55	Navoi SS (Switchyard)	220	28.67	32.06	23.22	25.33	
56	Navoi#3 (GTCC3)	220	25.82	27.80	-	-	
57	Navoi NS	220	9.61	9.53	9.20	9.25	
58	Syrdaria	220	27.63	33.76	27.62	33.74	

(Source: JICA Survey Team)

Table 6.2.5-4 Fault Current Calculation Result Connecting 500 kV / 220 kV Substation (Part 1)

No.	Bus Name	Rated kV [kV]	Fault Current [kA]				Allowable Fault Current [kA]
			With GTCC3		Without GTCC3		
			3LS	1LG	3LS	1LG	
1	Guzar	500	9.49	8.94	9.44	8.92	31.5
2	Karakul	500	5.98	6.02	5.92	5.98	
3	Sogdiana	500	11.87	10.64	11.82	10.61	
4	Sarymai	500	3.63	3.81	3.6	3.79	
5	Talimarjan	500	12.81	14.74	12.73	14.68	
6	Talimarjan	500	12.76	14.72	12.68	14.66	
7	Navoi SS (Substation)	500	5.99	6.39	5.43	5.85	
8	Muruntau	500	4.06	4.22	3.83	4.05	
9	Syrdaria	500	20.76	21.06	20.74	21.04	
10	Horezm	220	6.51	6.35	6.49	6.34	40.0
11	Tahiatash	220	9.49	11.49	9.48	11.49	
12	Beruni	220	5.77	6.39	5.76	6.39	
13	Karakarpakistan	220	3.12	2.63	3.12	2.63	
14	Navoi	220	30.83	38.22	25.62	32.29	
15	K-Mazar	220	10.96	10.34	10.58	10.11	
16	Buhara	220	10.65	10.54	10.4	10.37	
17	PP Turon	220	8.56	6.47	8.47	6.44	
18	Mubarek-2	220	7.91	7.49	7.87	7.47	
19	Mubarek	220	8.57	9.35	8.53	9.31	
20	Mubarek-1	220	7.01	6.32	6.98	6.3	
21	K-Bazar	220	4.61	4.55	4.59	4.54	
22	Kassan	220	7.9	8.29	7.87	8.27	
23	Kokdumalak	220	4.68	4.52	4.67	4.51	
24	Talimarjan	220	23	28.4	22.89	28.28	
25	SGHK	220	13.41	11.97	13.36	11.95	
26	Karsh	220	13.73	14.33	13.65	14.26	
27	NS-3	220	6.81	7.12	6.8	7.11	
28	Guzar	220	14.33	16.49	14.28	16.44	
29	Karakul	220	11.62	13.89	11.48	13.76	
30	Hamza	220	7.63	9.43	7.57	9.37	
31	Himiya	220	21.85	22.41	19.19	20.37	
32	Suvli	220	9.07	6.1	8.69	5.97	
33	Katta-Kurgan	220	5.86	7.11	5.77	7.02	
34	Samarkand	220	9.63	11.45	9.56	11.39	

(Source: JICA Survey Team)

Table 6.2.5-5 Fault Current Calculation Result Connecting 500 kV / 220 kV Substation (Part 2)

No.	Bus Name	Rated kV [kV]	Fault Current [kA]				Allowable Fault Current [kA]
			With GTCC3		Without GTCC3		
			3LS	1LG	3LS	1LG	
35	Sogdiana	220	15.95	18.46	15.84	18.37	40.0
36	Bobur	220	4.45	3.7	4.44	3.69	
37	Sari-Bazar	220	4.47	4.34	4.47	4.34	
38	Zarbdor	220	4.52	3.25	4.52	3.24	
39	Djizak	220	4.04	5.03	4.03	5.02	
40	127A	220	5.5	3.49	5.29	3.42	
41	Besopan	220	8.37	8.95	7.97	8.64	
42	127D	220	3.88	2.42	3.79	2.4	
43	Zarafsyan	220	6.76	5.41	6.55	5.32	
44	Feruza	220	3.42	4.08	3.36	4.02	
45	B-3	220	3.52	2.26	3.49	2.26	
46	B-2	220	4.06	2.8	4.04	2.79	
47	B-1	220	6.86	6.7	6.82	6.67	
48	Gorhar	220	4.36	3.52	4.25	3.47	
49	GTCC2	220	30.02	36.12	25.1	30.87	
50	Sarymai	220	8.08	9.6	8.02	9.54	
51	Chapan-Ata	220	9.69	10.82	9.65	10.79	
52	Ishtihan	220	5.87	6.82	5.8	6.76	
53	Kandym	220	7.25	5.68	7.18	5.65	
54	Pashkamar	220	7.12	7.58	7.11	7.57	
55	SFES	220	6.73	6.65	6.67	6.61	
56	GTCC1	220	29.87	35.76	25.01	30.62	
57	Navoi SS (Substation)	220	28.75	34.25	23.29	27.69	
58	Navoi#3 (GTCC3)	220	25.87	28.71	-	-	
59	Navoi NS	220	9.61	9.53	9.21	9.26	
60	Muruntau	220	9.04	10.63	8.58	10.19	
61	Syrdaria	220	27.63	33.76	27.62	33.74	

(Source: JICA Survey Team)

(3) Conclusion of fault current analysis

Whether Navoi GTCC3 was connected to the 220 kV switchyard or to the 500 kV / 220 kV SS, the fault current increased. However, the fault current at the all 500 kV bus was 31.5 kA or less, and at the all 220 kV bus was 40.0 kA or less, so it was confirmed that each of the bus fault current was below the allowable level of fault current.

6.2.6 Dynamic Stability Analysis

The impact of Navoi GTCC3 operation on the power grid has been confirmed by dynamic stability analysis. The analysis results are described below.

(1) Specific premises

Specific premises of dynamic stability analysis are shown Table 6.2.6-1.

Table 6.2.6-1 Specific premises of dynamic stability analysis

Item	Description
Fault type	Three phase short circuit
Fault clearance time	70 msec after the fault occurring
Switching sequences	3LS-O (T/L trip after three phase short circuit)
Load characteristics	Reclosing sequence was not assumed to be included in the simulations as a more severe condition
Fault location	Active powers were treated as constant current loads, and reactive powers were treated as constant impedance loads during dynamic stability simulations

(Source: JICA Survey Team)

Table 6.2.6-2 shows the fault location and T/Ls to be opened in order to remove a fault.

Table 6.2.6-2 Fault Locations in the Dynamic Stability Analysis

No.	Transmission Line		Rated kV [kV]	Fault Location
	From Node	To Node		
1	Navoi SS	Besopan SS	220	Navoi SS
2	Navoi SS	127A SS		Navoi SS
3	Navoi SS	127D SS		Navoi SS
4	Navoi PS	K-Mazar SS		Navoi PS
5	Navoi PS	Karsh SS		Navoi PS
6	Himiya SS	Katta-Kurgan SS		Himiya SS
7	Besopan SS	Gorhar SS		Besopan SS
8	Zarafsyan SS	Sarymai SS		Zarafsyan SS
9	Sarymai SS	Karakul SS	500	Sarymai SS
10	Navoi SS	Muruntau SS		Navoi SS

(Source: JICA Survey Team)

The 220 kV T/L (Navoi SS to Besopan SS) described in No. 1 in the above table is used only for the system connected to the 220 kV switchyard. Therefore, this dynamic analysis were made for Case 1 to 4 listed in Table 6.2.2-1 and not calculated for Case 5 and 6.

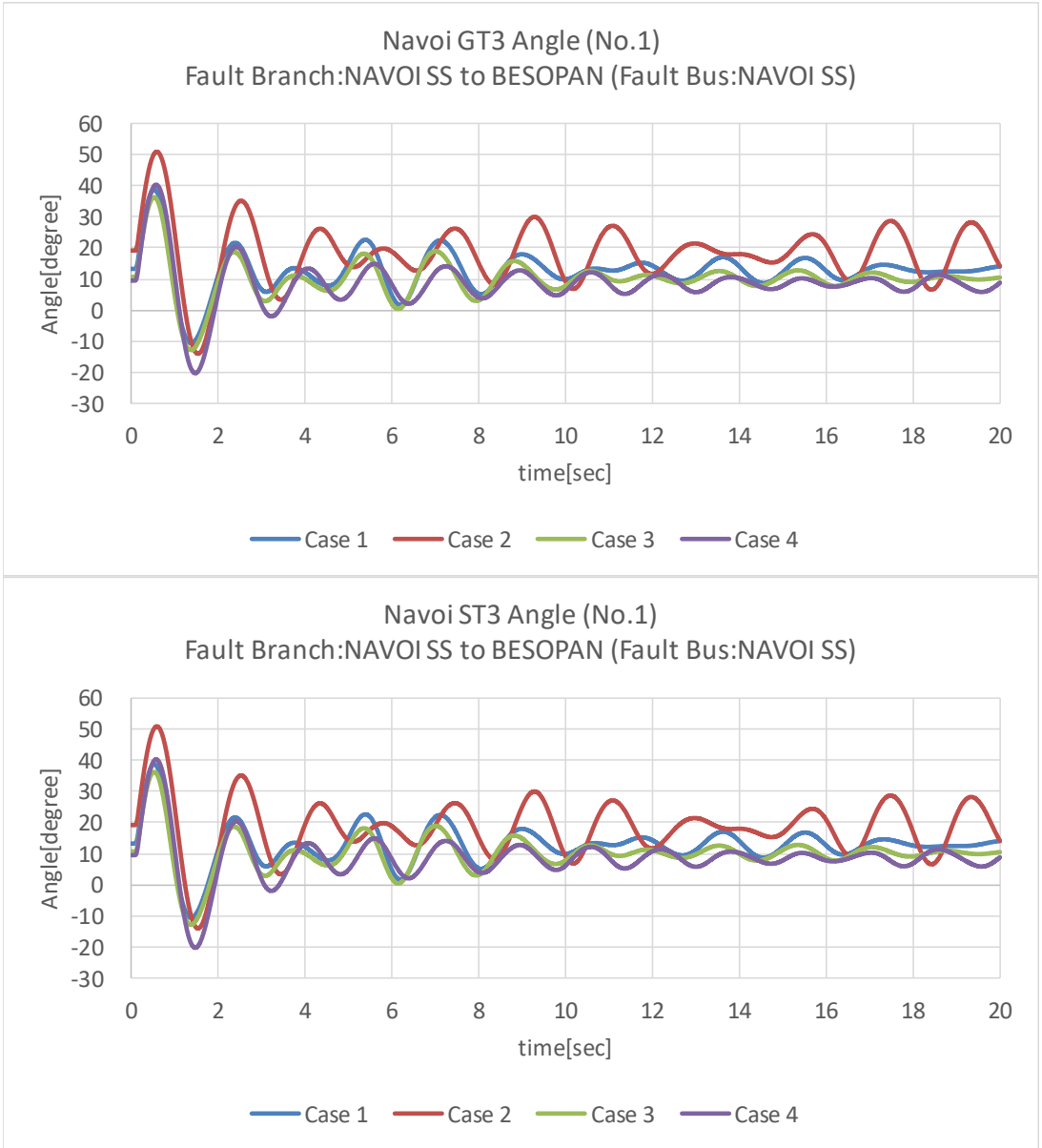
Similarly, since the 500 kV T/L (Navoi SS to Muruntau SS) described in No.10 in the above table is only used for the system connected to the 500 kV / 220 kV SS, so it was calculated only in case 5 and 6 and not calculated in the other cases.

(2) Calculation Results

The generator angle waveforms of Navoi GTCC3 (GT and ST) in each transient stability analysis cases are shown in Figure 6.2.6-1 to Figure 6.2.6-10.

1) From Navoi SS to Besopan SS

Figure 6.2.6-1 shows the generator angle waveform when the fault occurs on the T/L between Navoi SS and Besopan SS. The fault location was set at the end of Navoi SS.



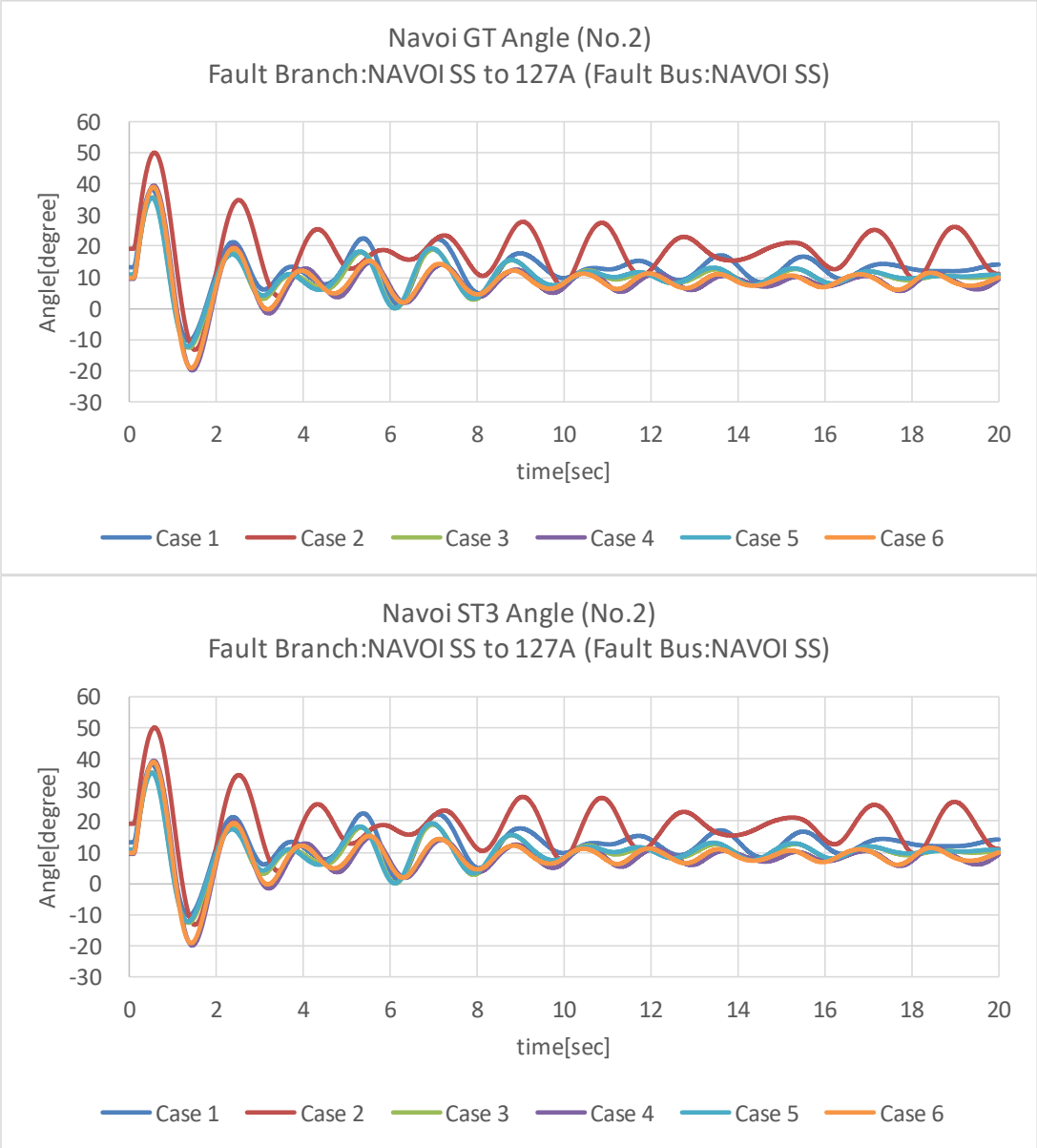
(Source: JICA Survey Team)

Figure 6.2.6-1 Transient Stability Analysis Result (From Navoi SS to Besopan SS)

In all cases (Case 1 to Case 4), it was confirmed that the oscillation of the generator converged after the T/L fault.

2) From Navoi SS to 127A SS

Figure 6.2.6-2 shows the generator angle waveform when the fault occurs on the T/L between Navoi SS and 127A SS. The fault location was set at the end of Navoi SS.



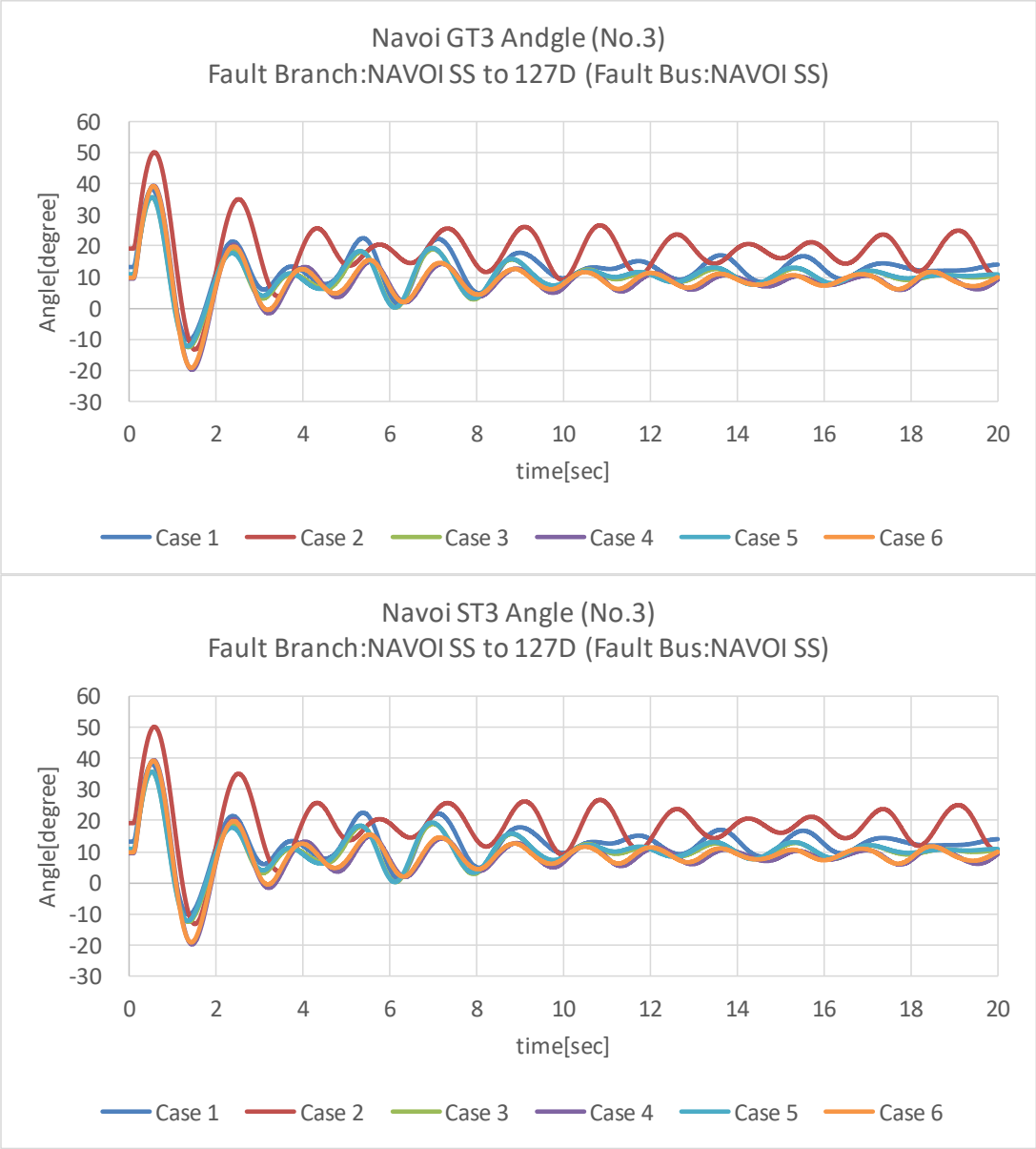
(Source: JICA Survey Team)

Figure 6.2.6-2 Transient Stability Analysis Result (From Navoi SS to 127A SS)

In all cases (Case 1 to Case 6), it was confirmed that the oscillation of the generator converged after the T/L fault.

3) From Navoi SS to 127D SS

Figure 6.2.6-3 shows the generator angle waveform when the fault occurs on the T/L between Navoi SS and 127D SS. The fault location was set at the end of Navoi SS.



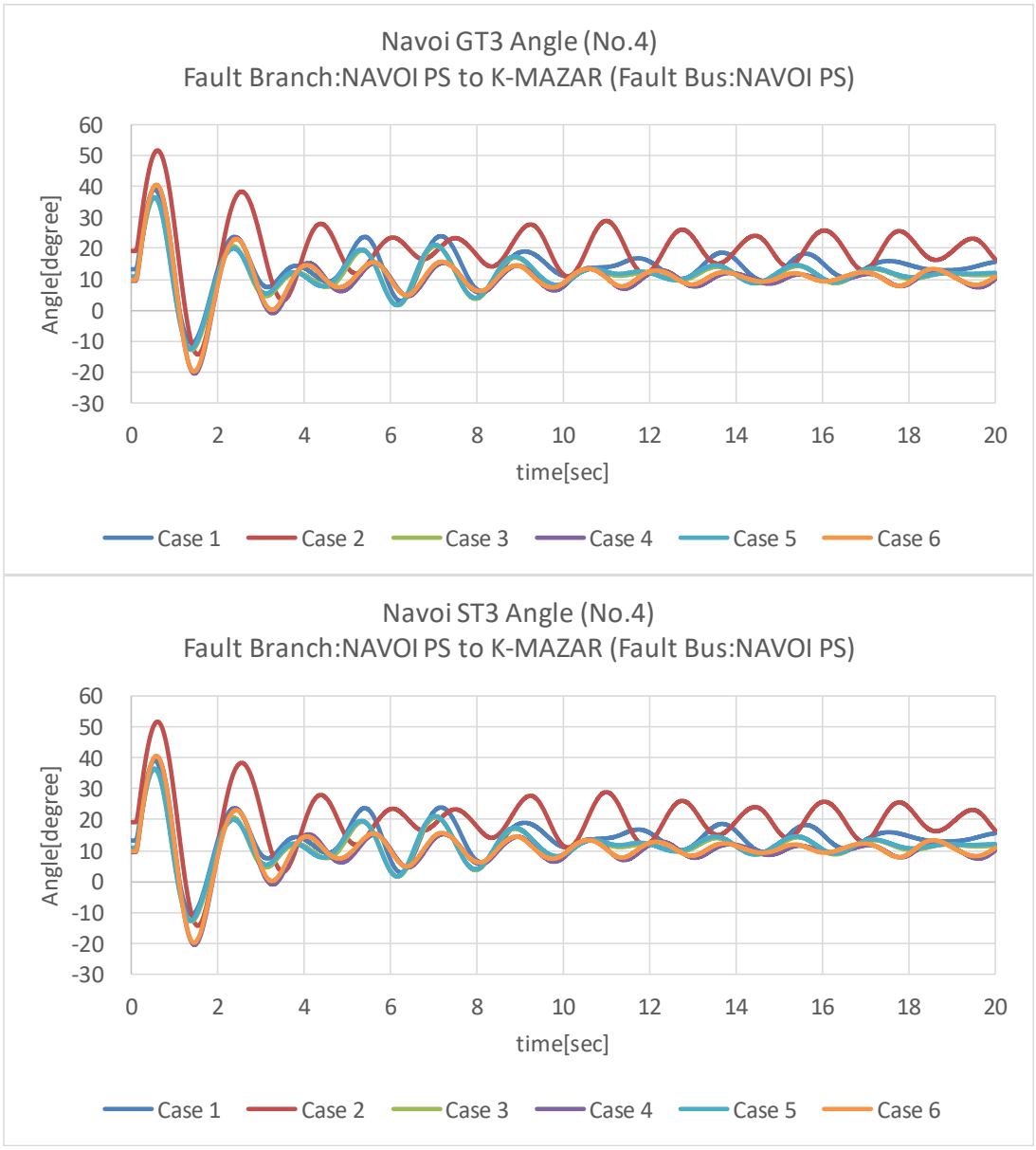
(Source: JICA Survey Team)

Figure 6.2.6-3 Transient Stability Analysis Result (From Navoi SS to 127D SS)

In all cases (Case 1 to Case 6), it was confirmed that the oscillation of the generator converged after the T/L fault.

4) From Navoi PS to K-Mazar SS

Figure 6.2.6-4 shows the generator angle waveform when the fault occurs on the T/L between Navoi PS and K-Mazar SS. The fault location was set at the end of Navoi PS.



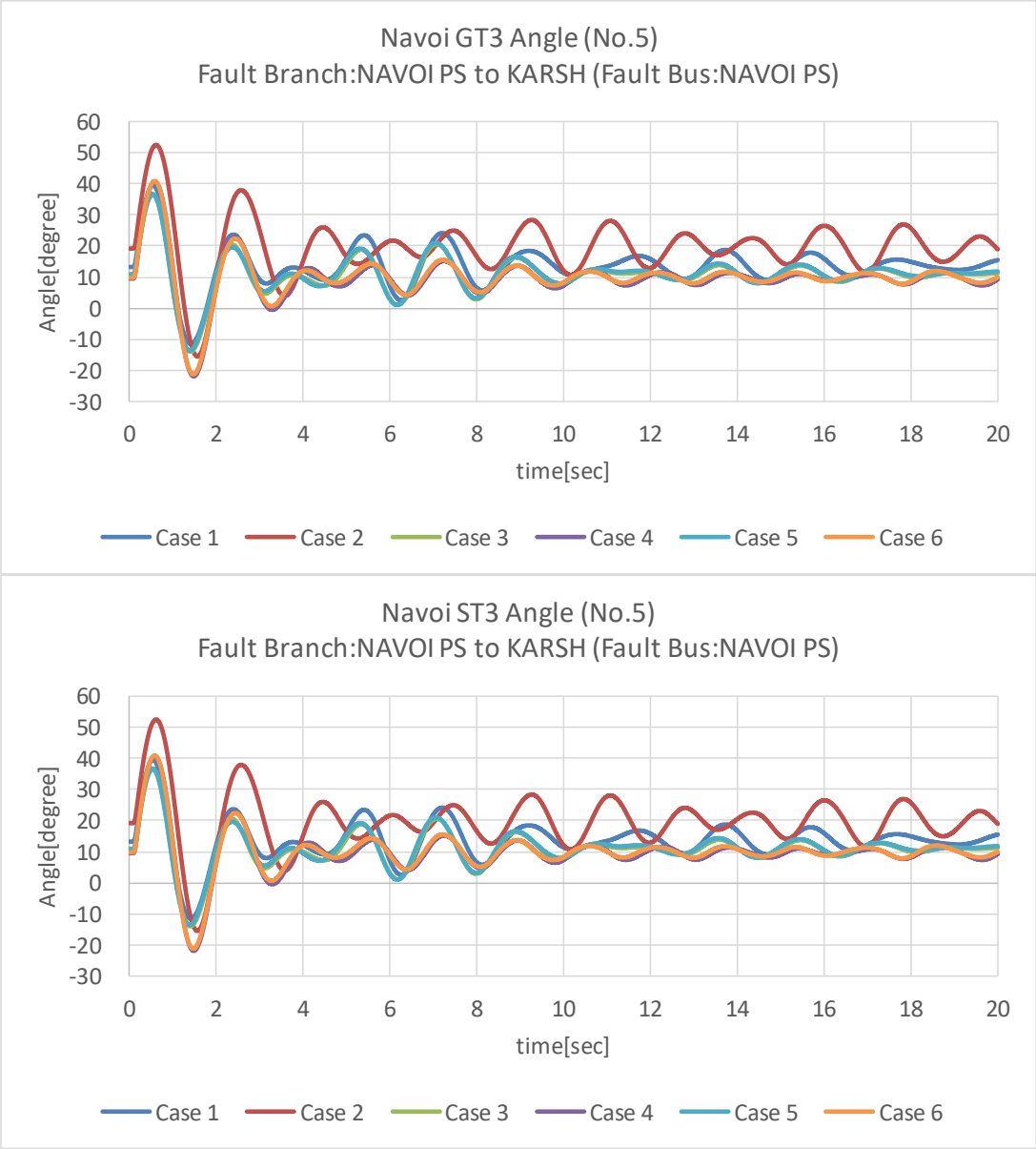
(Source: JICA Survey Team)

Figure 6.2.6-4 Transient Stability Analysis Result (From Navoi PS to K-Mazar SS)

In all cases (Case 1 to Case 6), it was confirmed that the oscillation of the generator converged after the T/L fault.

5) From Navoi PS to Karsh SS

Figure 6.2.6-5 shows the generator angle waveform when the fault occurs on the T/L between Navoi PS and Karsh SS. The fault location was set at the end of Navoi PS.



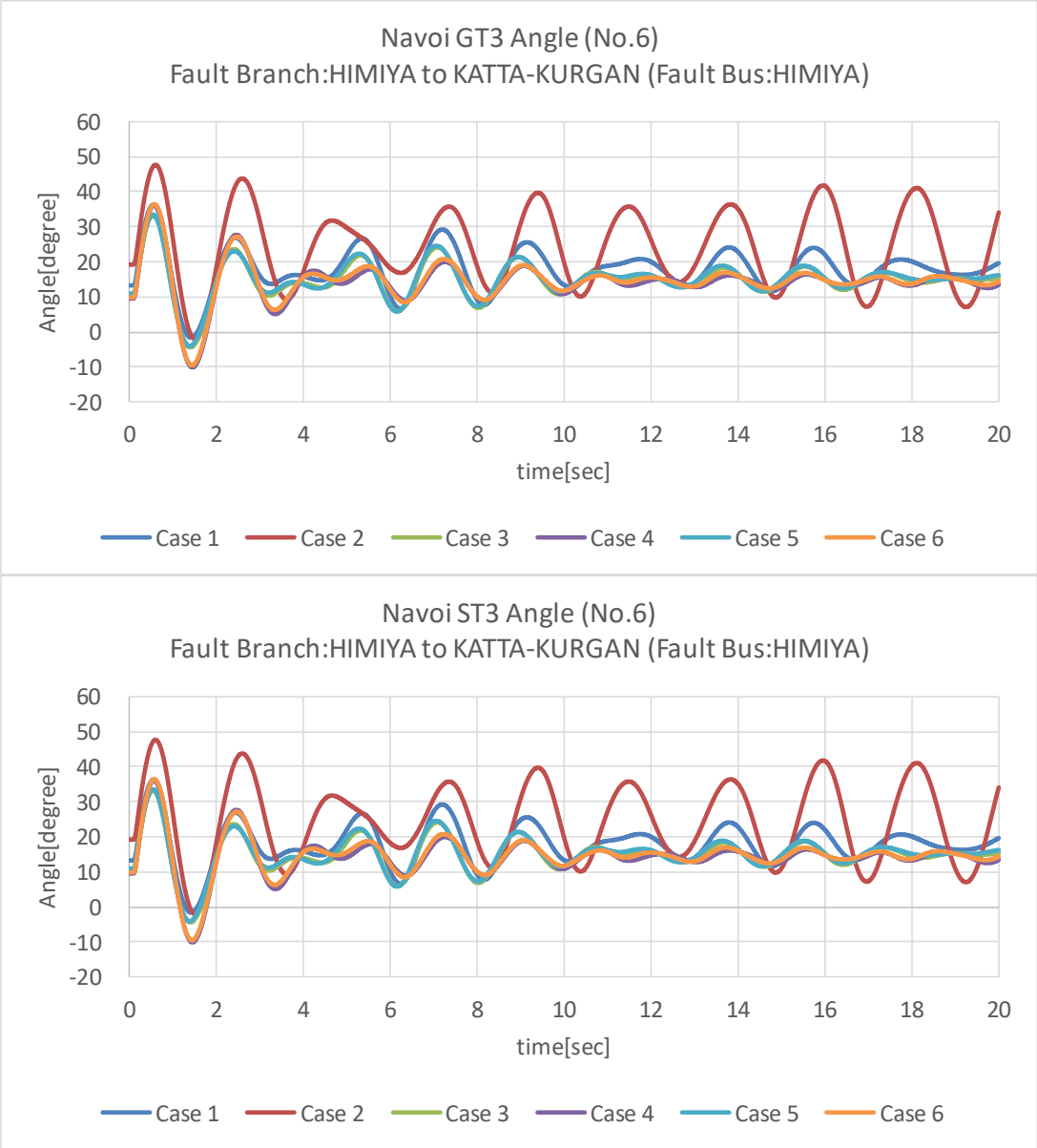
(Source: JICA Survey Team)

Figure 6.2.6-5 Transient Stability Analysis Result (From Navoi PS to Karsh SS)

In all cases (Case 1 to Case 6), it was confirmed that the oscillation of the generator converged after the T/L fault.

6) From Himiya SS to Katta-Kurgan SS

Figure 6.2.6-6 shows the generator angle waveform when the fault occurs on the T/L between Himiya SS and Katta-Kurgan SS. The fault location was set at the end of Himiya SS.



(Source: JICA Survey Team)

Figure 6.2.6-6 Transient Stability Analysis Result (From Himiya to Katta-Kurgan SS)

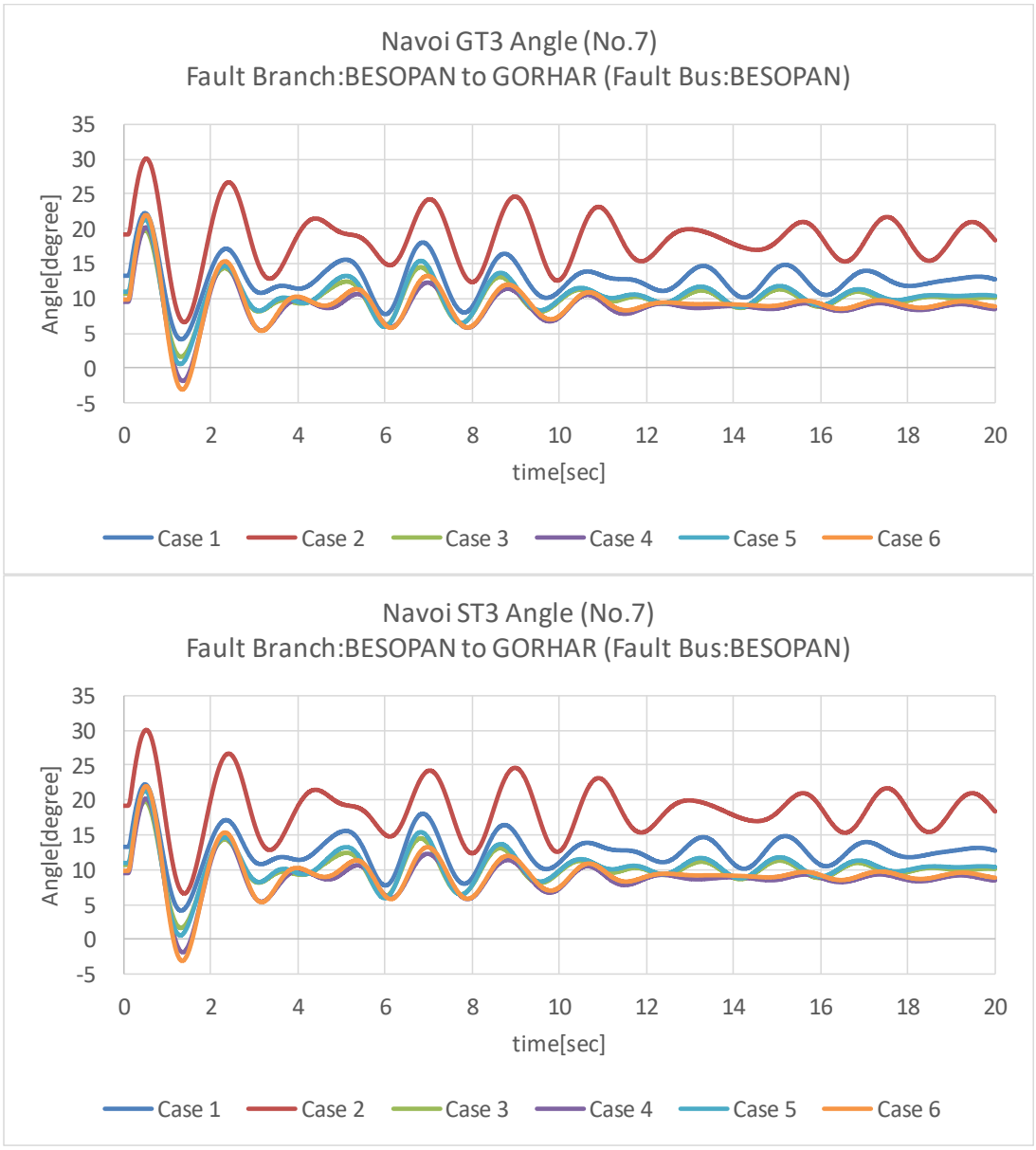
The speed of the convergence of generator oscillations was slower compared to the previous cases. In particular, in the Case 2, it was confirmed that the vibration of the generator tends to diverge.

It had been cleared from the result of the power flow calculation that when this T/L was disconnected, it was not possible to maintain the bus voltage of each of Katta-Kurgan SS and Ishtihan SS.

It was also confirmed from the result of the transient stability calculation that when this T/L was disconnected, the system could not be operated stably.

7) From Besopan SS to Gorhar SS

Figure 6.2.6-7 shows the generator angle waveform when the fault occurs on the T/L between Besopan SS and Gorhar SS. The fault location was set at the end of Besopan SS.



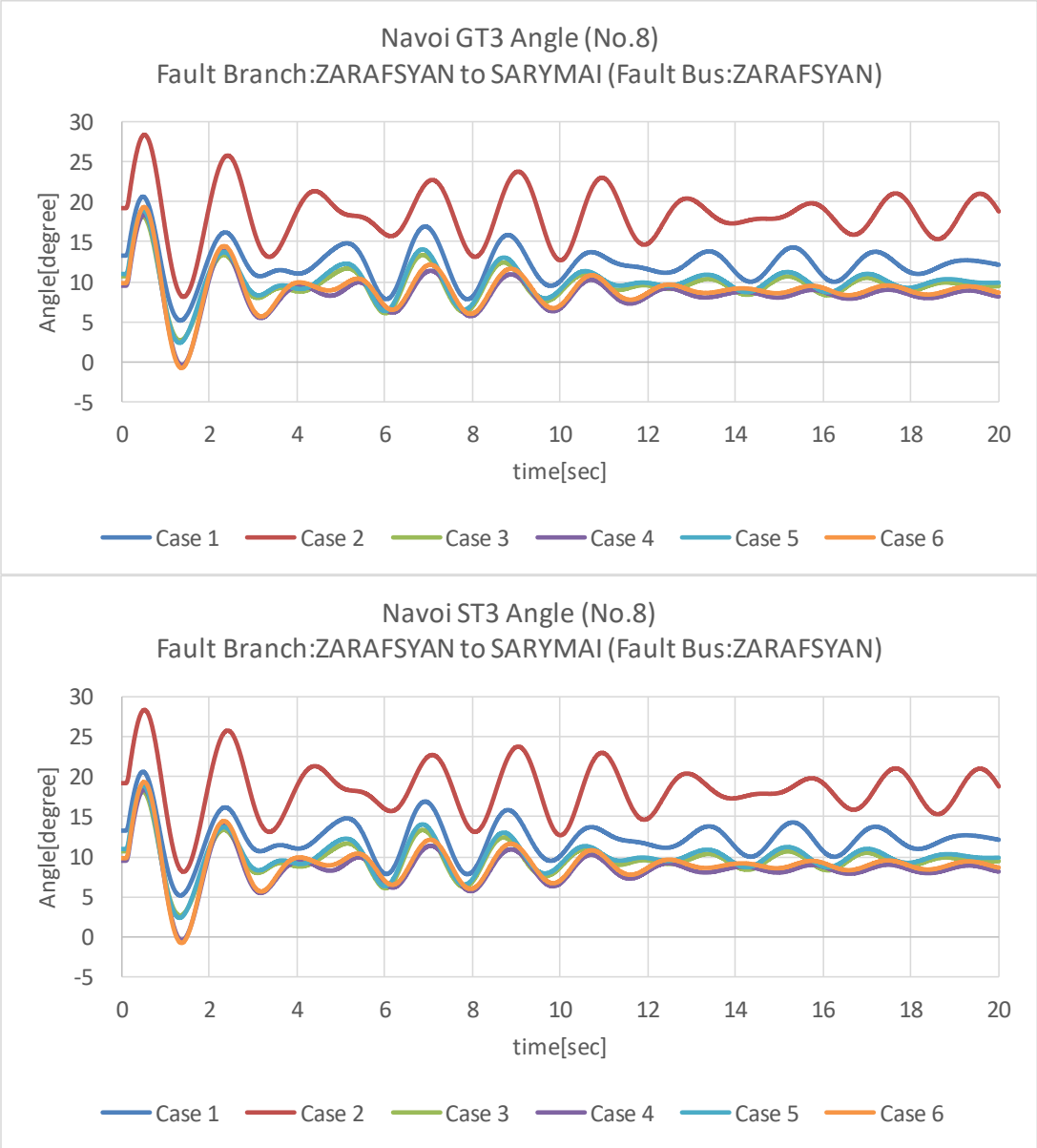
(Source: JICA Survey Team)

Figure 6.2.6-7 Transient Stability Analysis Result (From Besopan SS to Gorhar SS)

In all cases (Case 1 to Case 6), it was confirmed that the oscillation of the generator converged after the T/L fault.

8) From Zarafshan SS to Sarimai SS

Figure 6.2.6-8 shows the generator angle waveform when the fault occurs on the T/L between Zarafshan SS and Sarimai SS. The fault location was set at the end of Zarafshan SS.



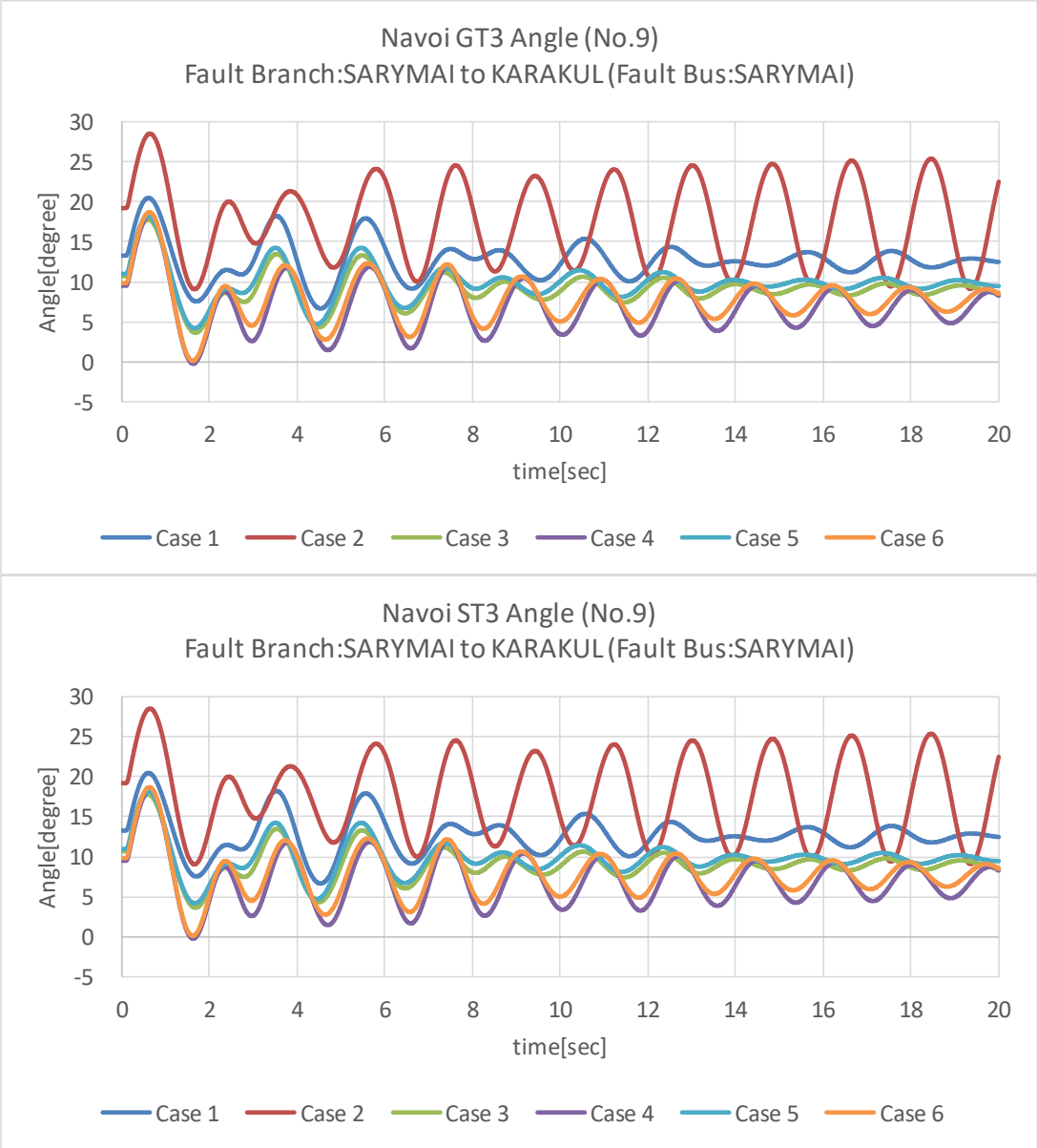
(Source: JICA Survey Team)

Figure 6.2.6-8 Transient Stability Analysis Result (From Zarafshan SS to Sarimai SS)

In all cases (Case 1 to Case 6), it was confirmed that the oscillation of the generator converged after the T/L fault.

9) From Sarimai SS to Karakul SS

Figure 6.2.6-9 shows the generator angle waveform when the fault occurs on the T/L between Sarimai SS and Karakul SS. The fault location was set at the end of Sarimai SS.



(Source: JICA Survey Team)

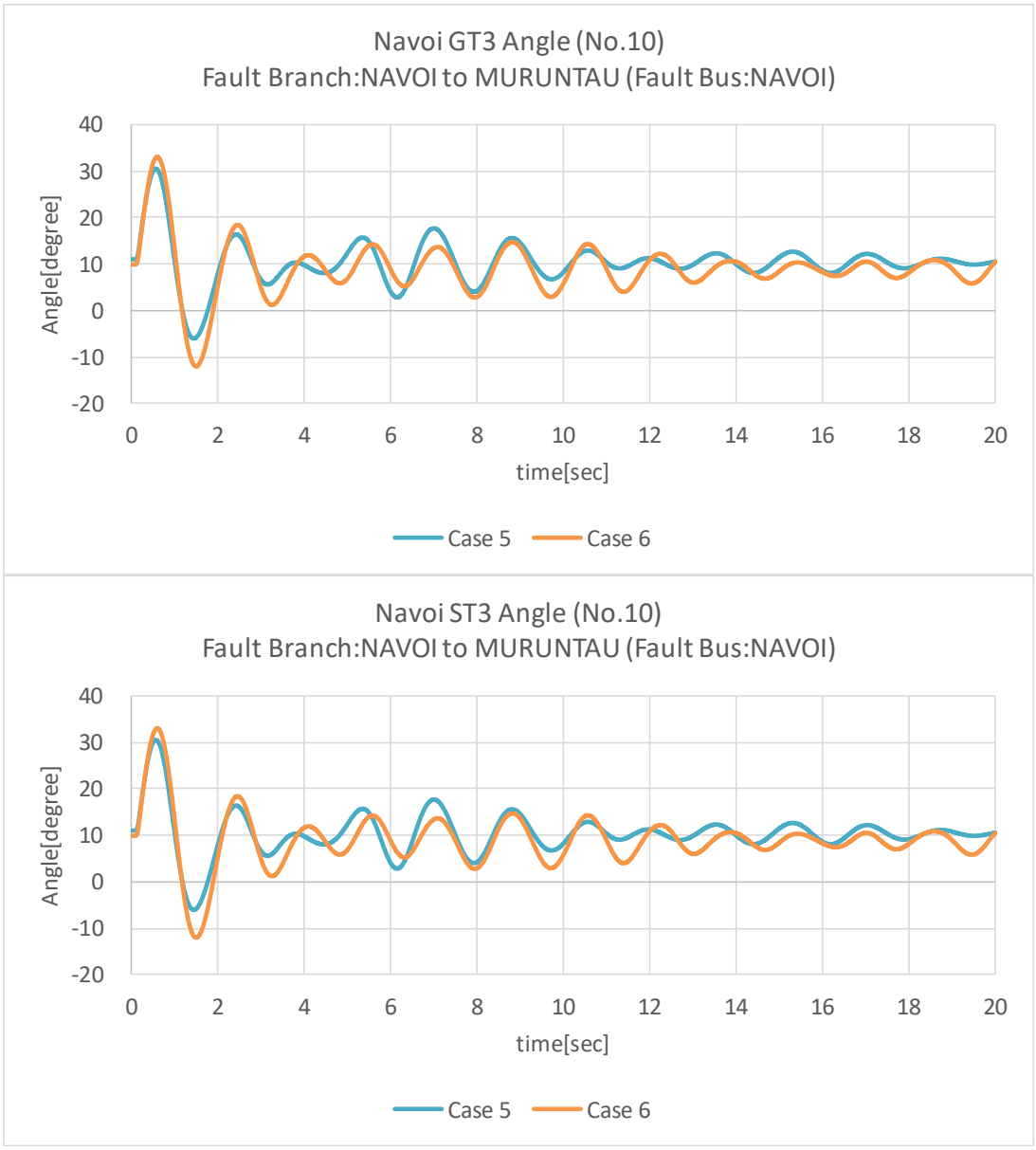
Figure 6.2.6-9 Transient Stability Analysis Result (From Sarimai SS to Karakul SS)

In Case 2, it was confirmed that the generator oscillation diverged after T/L disconnection. In other cases (Case 1, from Case 3 to Case 6), it was confirmed that the generator oscillation converges.

Since the 500 kV T/L between Sarimai SS and Karakul SS is a single line, when this T/L is disconnected, the generator groups in the northwestern region can become unstable. The 500 kV T/L between Sarimai SS and Karakul SS plays an important role in the grid stabilization in the northwest region, so the grid may become unstable if this T/L is disconnected.

10) From Navoi SS to Muruntau SS

Figure 6.2.6-10 shows the generator angle waveform when the fault occurs on the T/L between Navoi SS and Muruntau SS. The fault location was set at the end of Navoi SS.



(Source: JICA Survey Team)

Figure 6.2.6-10 Transient Stability Analysis Result (From Navoi SS to Muruntau SS)

In all cases (Case 5 to Case 6), it was confirmed that the oscillation of the generator converged after the T/L fault.

(3) Conclusion of dynamic stability analysis

The impact of Navoi GTCC3 being connected to the grid was verified by dynamic stability analysis.

In most cases, after the T/L fault, it was confirmed that the oscillation of the generators slowed down gently without step out.

However, when the fault occurred at the T/L between Himiya SS and Katta-Kurgan SS, it was confirmed that the fluctuation of the generator tends to expand. These were caused by the T/L accident under the single line operation, and it had been confirmed that when the same T/L was disconnected also in the power flow calculation, the sound operation could not be performed.

In addition, when the fault occurred at the 500 kV T/L between Sarimai SS and Karakul SS, the generator fluctuation tended to expand. This seemed to be that the system became unstable due to the phase angle of the northwestern system being expanded by the disconnection of the 500 kV T/L and the synchronization power being lowered.

Usually, the generator is equipped with Power System Stabilizer (PSS) to improve the damping characteristics of the generator. However, this feature is not used in Uzbekistan. If this PSS can be used, it is possible to suppress the generator fluctuation after the power system fault, so the use of PSS is highly recommended.

However, before that, it is necessary to simulate in detail the excitation characteristics of each generator.

6.2.7 Conclusion

To verify expected impact on the power system when Navoi GTCC3 is connected to the power grid, power flow analysis, fault current analysis and dynamic stability analysis were conducted.

The year to be analyzed was 2023 when the new substation will built near Navoi PS and start its operation as the switchyard. In addition, the load demand in 2025 was also analyzed, taking into consideration the variation in demand load. After that, analysis was also conducted on the condition that the switchyard will be operated as a substation.

In all cases, the maximum demand in summer season and winter season was set as the analysis target.

According to the result of the power flow analysis, in the normal condition, it was confirmed that no overload and / or voltage drop occurs and the power system could be operated properly.

In the N-1 condition, overload occurred on some of the T/Ls and transformers, and voltage drop at some substations were also confirmed. However, these overloads and voltage drops occurred even if Navoi GTCC3 was not connected, which was the problem of the existing power system, not the influence of connection of Navoi GTCC3.

From the results of the power flow analysis, it could be confirmed that there will be no harmful effect on the power system due to the connection of Navoi GTCC3.

According to the result of the fault current analysis, it was confirmed that the fault current at each buses was less than the allowable current in all cases. By connecting Navoi GTCC3 to the power grid, the fault current of each node will increase, but the allowable current will not be exceeded.

From the results of the fault current analysis, it could be confirmed that there was no harmful effect on the power system due to the connection of Navoi GTCC3.

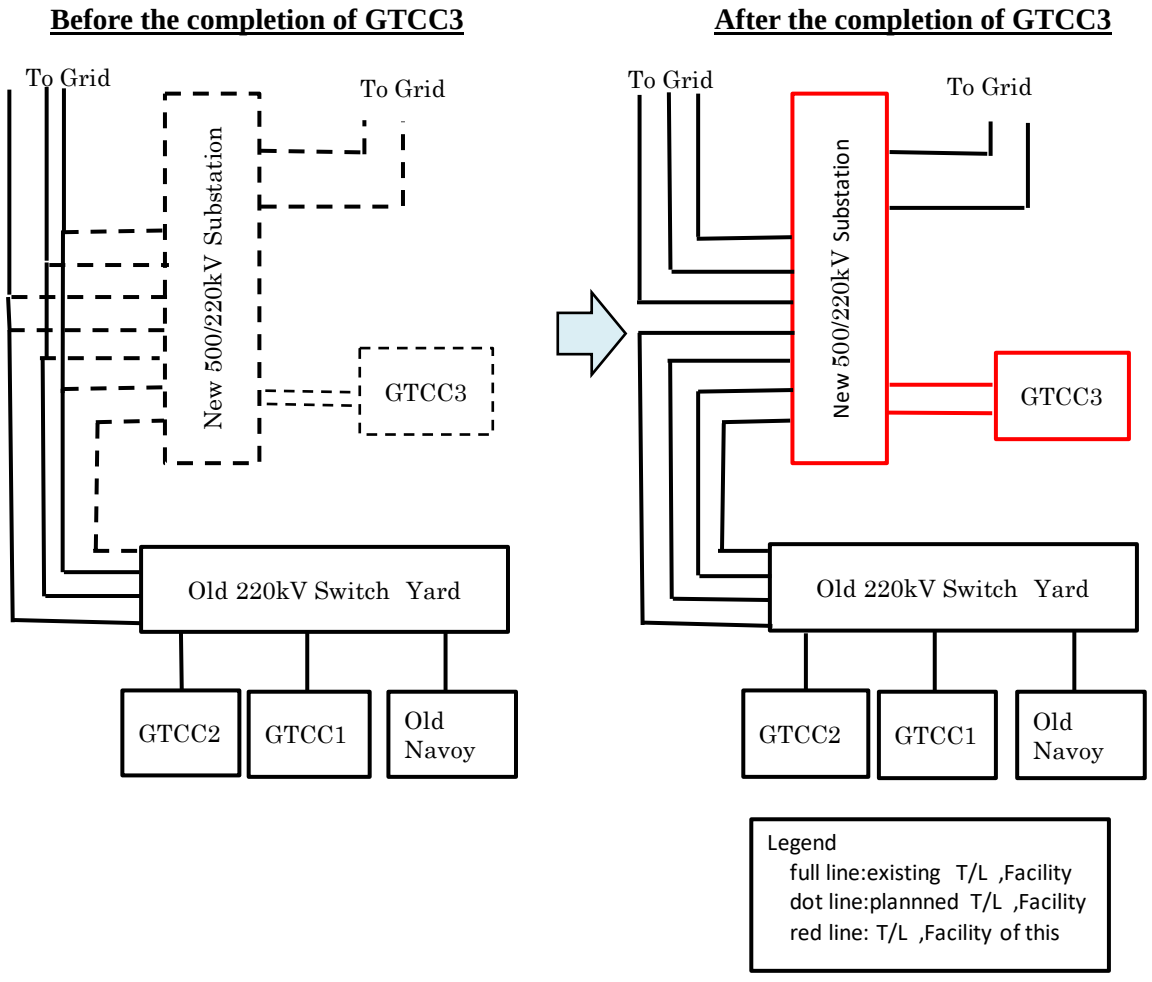
According to the result of the dynamic stability analysis, in most cases, it was confirmed that the oscillation of the generator gradually declined after the T/L fault. In some cases, it was confirmed that the generator oscillation after the accident did not converge and tended to diverge. In the case of the accident on the T/L where the voltage drop occurred in the power flow calculation, it was confirmed that generator oscillation did not converge and diverged.

Usually, the excitation system of the generator is equipped with PSS for the stabilization of the generator. However, in Uzbekistan PSS is not used. In particular, in the case of a generator equipped with a state-of-the-art thyristor-type excitation system, the use of PSS is strongly recommended, since the damping of the generator tends to decrease if PSS is not used. In using PSS, it is necessary to perform simulation with the excitation system of each generator in detail and to determine the set value of PSS.

6.3 Grid Connection Plan

6.3.1 T/L Plan

Grid Connection Plan of T/L for the GTCC3 that are planned by SAESP and JSC TPP, are shown in Figure 6.3.1-1. The planned T/L routes which connect to GTCC3 decided by JSC TPP, are shown in Figure 6.3.1-2 on the basis of field survey about T/L and other information. In this plan, the number of transmission tower is 11 (from TL1 to TL11) and the route length of transmission line is 3.92km (see Table 6.3.1-20). The scope of this survey for T/L is mainly the new T/L between (220kV) switchyard of new 500 kV Substation and GTCC3. The study of 500kV substation will be conducted by SAESP and JICA Survey Team will review it and describe its evaluation in final report.



(Source: SAESP, modified by JICA Survey Team)

Figure 6.3.1-1 Grid Connection Plan

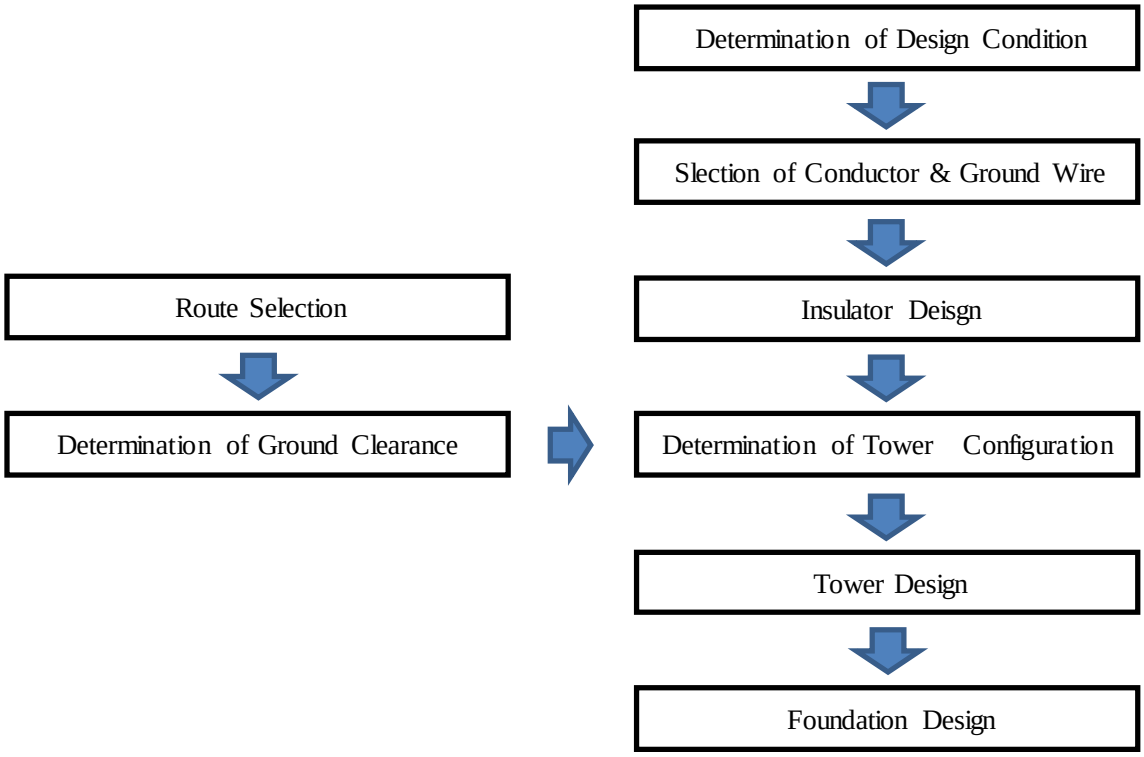
(Source: Google Earth, added by JICA Survey Team)

Figure 6.3.1-2 The actual T/L route

(1) T/L design

New T/L between GTCC3 and new (220kV) switchyard is designed based on the Rules of Electrical Installation (PUE) and Gsudarstvennyy Standart (GOST). The T/L is also designed by the flow chart as shown in Figure 6.3.1-3.

In this project, two lines of the transmission line for generator start-up and the transmission line for generated power are required.



(Source: JICA Survey Team)

Figure 6.3.1-3 T/L Design Flow

(2) Route Selection

JICA Survey Team planned two proposal routes from GTCC3 to 500kV substation (operated as 220 kV switch yard for the moment).

The T/L route which is planned by the survey team is shown in Figure 6.3.1-4. The parts of the power plant outlet (TL0-1, TL0-2, TL1-1) and substation entrance (TL1-6, TL1-7) are common.

Table 6.3.1-1 Preliminary Route Length of each proposal

Route	Number of Towers	Route Length(km)
1st proposal	9 (TL0-1,TL0-2,TL1-1,TL1-2,TL1-3, TL1-4,TL1-5,TL1-6,TL1-7)	3.49
2nd proposal	11 (TL0-1,TL0-2,TL1-1,TL2-1,TL2-2,TL2-3, TL2-4,TL2-5,TL2-6,TL2-7, TL1-6,TL1-7)	4.28

(Source: JICA Survey Team)

The following table shows the result of examining the transmission line plan for connecting GTCC3 under construction plan to the Navoi thermal power plant in Uzbekistan.

For both the first and second proposals, referring to the rout of the previous Plan, the power station exit was set at the north side of the power station with the shortest distance from the 500 kV substation. Also, in order to avoid the houses, transmission lines are going out in the northeast direction. Regarding the route, we examined two proposals, and the 2nd proposal has the same part of the previous plan, which the Uzbekistan side examined (though the location of the power station is different).

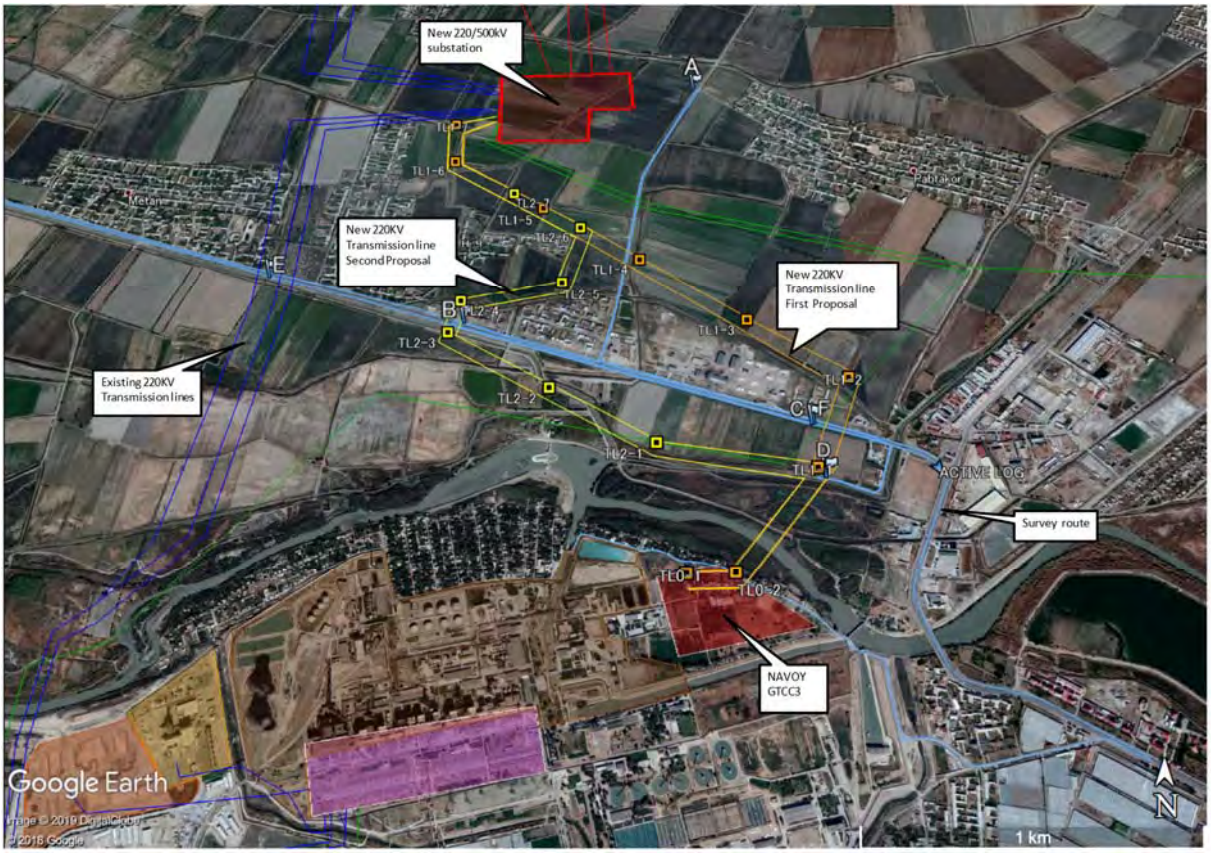
Table 6.3.1-2 Preliminary Comparison of two proposal routes.

	the 1st proposal route	the 2nd proposal route
outline	・The first proposal is smaller than the second proposal in terms of the number of towers and the route length.	・The first proposal is more than the second proposal in terms of the number of towers and the route length.
Approximate cost	・ 1.95 MUSD (2cct TL) 2.44 MUSD (2 x 1cct TL) （Recent unit price per km of developing countries used）	・ 2.40 MUSD (2cct TL) 3.00 MUSD (2 x 1cct TL) （Recent unit price per km of developing countries used）
Impact on construction of GTCC3	・Although two steel towers stand in the power plant premises, they are located at the power plant boundary, so it seems that there is little effect.	・Same as the first plan.
Social impact	・Transmission lines at the outlet of the power station pass through the villa's area, so it is necessary to relocate several villas.	・ As with the first plan, it is necessary to relocate several villas at the exit of substation. ・ Since the transmission line is positioned to divide between villages, there is a possibility that the residents feel a sense of oppression.
Environmental scale	・ The transmission line passes through the north side of the private house village and passes through the position far from the residence from the second plan, so it seems that there is little influence on sunshine and view.	・The transmission line passes the south side of the private house village and passes the position closer to the residence than the 1st plan, so there is a possibility of influencing the view.
Conclusion	・Although the first plan seems to be superior overall, including economic aspect, the final route was eventually decided on the second route by JSC TPP. Because it was found that there was a plan to build a building for the government agency on the route of the first plan, so the transmission tower site could not be secured.	

(Source: JICA Survey Team)

Based on this route plan, we investigated the site.

The survey route and survey spot (A~G) are shown in the figure.



（Source: Google Earth, added by JICA Survey Team）

Figure 6.3.1-4 Preliminary Route Survey

For the approaching and crossing of other transmission lines, distribution lines and communication lines with this new transmission line are satisfied with Uzbekistan Electrical Installations Code (PUE).

Specifically, at the time of crossing of the 220 kV transmission line with the other transmission and distribution lines, a vertical distance of 4 to 7 m is necessary according to the crossing span length, and at the time of approaching, a horizontal distance of 6 m is necessary. And at the time of crossing and approaching of the 220kV transmission line with communication lines, a vertical distance of 4 m is required.

The issues and the pictures of each survey spot are as shown in the table.

Table 6.3.1-3 Issues at the survey site

Survey spot	Item	Issue	Photo
A	500kV Substation site	The position is not clear. It was a wheat field and the land was cultivated.	
	Distribution line	It is located from the south to the north along the road near the substation. The transmission line drawn into the substation will pass over the distribution line.	
	Water pipe	There is a water supply pipe along the waterway near the road near the substation. It needs to be constructed so as not to be affected.	
B	Gas station	There is a gas station in the north from point B. It is necessary to relocate to adopt the route of the second proposal.	
	Road	It passes east to west against the proposed transmission line route. In order for the transmission line to cross, it is necessary to obtain a sufficient ground clearance.	

B	Distribution line	There is a distribution line along the road heading from east to west. In the transmission line proposal, it is necessary to cross.	
C	Transmission line	There is a transmission line which seems to be 110 kV orthogonal to the road. It is parallel to the route of the first plan and it is necessary to consider separation.	
	Distribution line	There is a transmission line which seems to be 35 kV orthogonal to the road. It is parallel to the route of the first plan and it is necessary to consider separation.	
D	110kV Transmission line	In parallel with the route of the first proposal, there is a 110 kV transmission line. It is necessary to consider the separation from this transmission line.	
	110kV Transmission Tower	There is a 110 kV transmission line orthogonal to the route of the first plan, it is necessary to consider the separation from this transmission line. It also branches north.	
	Distribution line	There is a distribution line orthogonal to the route of the first plan. It is necessary to cross over the distribution line.	

D	Pipeline	There is a river that is orthogonal to the route of the first plan, and there is a pipeline crossing the river. It is necessary to construct so as not to give an influence.	
E	Cross point of Transmission line	There was a place where the existing 220 kV transmission line crossed the 110 kV transmission line. It will be helpful at crossing points of this project.	
	Cross point of Distribution line	There was a place where the existing distribution line crossed the 110 kV transmission line. It will be helpful at crossing points of this project.	
F	110kV Transmission line	In parallel with the route of the first proposal, there is a 110 kV transmission line. It is necessary to consider the separation from this transmission line.	
G	Villa	There is a villa in the outlet part of the power plant. It is necessary to avoid the villa from ROW or relocate the villa.	
	Farmland	There is farmland at the outlet of the power plant. There is a possibility that the transmission line can pass through this part.	

(Source: JICA Survey Team)

(3) Design Condition

1) Design Voltage

Rated voltage of the T/L is 220 kV and then various Design Voltages is shown in Table 6.3.1-4. Here the survey team assumed that the maximum voltage is 245 kV (route means square : r.m.s.), lightning impulse withstand voltage is 1050 kV (peak) and temporary power frequency overvoltage is 450 kV (peak) based on the rated voltage 220 kV (r.m.s.) of the existing transmission system. (Source: IEC60071-1) Switching surge voltage was assumed as 822 kV (peak) by taking into account the switching surge coefficient 2.8, the atmospheric pressure correction coefficient 1.2 and the breakdown voltage coefficient 1/0.9 (Source: JICA Survey Team).

Table 6.3.1-4 Design Voltages

Rated Voltage	Maximum Voltage	Lightning Impulse Withstand Voltage	Short-duration Power Frequency Overvoltage	Switching Surge Withstand Voltage
220 kV	245(252*)kV(r.m.s.)	1050 kV(Peak)	450 kV(Peak)	822 kV(Peak)

Remarks: * Maximum Voltage in operation (115%) of Uzbekistan 220 kV Power system.

(Source: IEC60071-1, JICA Survey Team)

2) Design Current

Generator rated output is 550MW at summer and 600MW at winter. Therefore rated current is calculated by the following equation. Here, the calculation conditions of the allowable current (voltage coefficient 1.05, power factor 0.9) were based on the allowable current table in Uzbekistan.

Rated current I = 550(MW) ÷ (220 (kV) x 1.05) ÷ √3 ÷ 0.9 = 1527(A) at summer.

= 600(MW) ÷ (220 (kV) x 1.05) ÷ √3 ÷ 0.9 = 1666(A) at winter.

The allowable current for summer(45℃) and winter(0℃) of the electric conductors commonly used in Uzbekistan are as shown in the following table according to the allowable current table in Uzbekistan. For reference, calculation results based on the CIGRE method are also described.

Table 6.3.1-5 Allowable Current Capacity of Candidate Conductor

Phase Conductor (ambient temp.)	Single conductor (25℃)	Twin Conductor (0℃)		(45℃)		Cigre method(45℃)
ACSR400 mm^2	825	2046	(＞1666)	1221	＜1527	1379
ACSR500 mm^2	945	2344	(＞1666)	1399	＜1527	1565
ACSR600 mm^2	1050	2604	(＞1666)	1554	＞1527	1733

*Remark:Conductor temperature is 70℃

(Source: JICA Survey Team)

The Table 6.3.1-5 shows that double bundle of ACSR 600 mm^2 is appropriate. Fault current of 220kV transmission line from GTCC3 to new Navoi substation is approximately 20kA for three phase fault or 25kA for line to ground fault. ACSR 600 mm^2 is satisfied with this condition since that instantaneous allowable current is about 50kA at 1 second. And we selected the ground wire as AS100 mm^2 and OPGW100 mm^2 according to this condition.

3) Ambient air temperature

Table 6.3.1-6 Ambient air temperature

Kind of Temperature	degree
Maximum air temperature Highest	45 ˚C
Minimum air temperature	-30 ˚C
Annual mean air temperature	15 ˚C
Temperature in case of glazed frost	-5

(Source: JICA Report" Supplemental Study to enhance the collaboration with NEDO on Tashkent Heat Supply Power Plant Modernization Project")

4) Wind Velocity/Wind Pressure

Maximum normative wind velocity pressure ; 500 Pa (wind velocity: 28 m/sec)
Conductor installation condition : 60 Pa (wind velocity: 10 m/sec)

5) Rainfall

Annual average rainfall 213mm (Source: World Bank/ The Climate Change Knowledge Portal)

6) Icing Level

Icing Level II: Thickness: 10 mm, Density: 0.9 g/cm_3

(Source: JICA Report "Preparatory Survey on Navoi Thermal Power Station Modernization Project")

7) Contamination Level

Taking account of the site near the desert area and the industrial area, Contamination Level is assumed to be pollution class of e- very Heavy: 53.7 mm/kV (USCD: unified specific creepage distance).

(Source: IEC60815-2, JICA Survey Team)

8) Frequency of lightning strokes

Isokeraunic level (IKL) is assumed with 15-25. (Source: JICA Report "Preparatory survey on Turakurgan Thermal Power Station Construction Project")

And frequency of earth lightning stroke (Frequency/Year/km^2) = 0.1×IKL = 1.5-2.5

(Source: JICA Survey Team)

9) Conductor Load Condition

Conductors load conditions are shown in Table 6.3.1-7.

Table 6.3.1-7 Various Conductor Load Condition

Condition Case	Temperature (°C)	Wind Pressure			Glazed Frost	Remarks
		MAX (500Pa)	Still	Special		
1	45	-	○	-	-	Maximum Temperature
2	-30	-	○	-	-	Minimum Temperature
3	15	-	○	-	-	Annual Mean Temperature
4	-5	-	○	-	○*	Glazed Frost
5	-5	○	-	-	-	Max wind Pressure
6	-5	-	-	125Pa	○*	Snow Storm
7-1	-15	-	-	60Pa	-	Working Time
7-2	75**	-	○	-	-	Maximum operation Temperature of Conductors

Remarks : *Thickness 10 mm, Density of Ice: 0.9 g/cm^3. ** Conductor Temperature

（Source: JICA Report “Preparatory survey on Turakurgan Thermal Power Station Construction Project”）

10) Required Safety Factor on Strength

(a) Safety Factor for Conductors and Ground Wires

The permissible tension of conductors and cables for overhead line (more than 1kV) in PUE, the permissible tensions of conductors and Safety Factor, are shown in Table 6.3.1-8.

Table 6.3.1-8 Safety Factor for Conductors and Ground Wire

Condition	Safety Factor (%Ultimate Tension strength)	
	Conductor	Ground Wire
Maximum load at the minimum air temperature(-30℃) Stringent (Most severe) condition	1/0.45 (45%UTS)	2.0 (50%UTS)
Maximum load at the annual mean temperature (15℃) (EDS condition)	1/0.3 (30%UTS)	1/0.35 (35%UTS)

(Source: JICA Report “Preparatory survey on Turakurgan Thermal Power Station Construction Project”)

(b) Safety Factor for Insulators and Insulator Strings

Based on Table 6.3.1-8, the permissible tension for the most severe condition is assumed to be 45% of Rated Ultimate Strength (RUS) of insulator. And safety factor of insulator strings is also assumed to be 1/0.45.

(c) Safety Factor for members of Towers

- 1.5 to yield strength of material under normal condition (= stringent condition)
- 1.1 to yield strength of under broken-wire condition (= normal condition + one ground wire or one phase conductor breakage)

(Source: JICA Report "Preparatory survey on Turakurgan Thermal Power Station Construction Project")

(d) Safety Factor for Foundations of Towers

- 2.0 under normal condition
- 1.5 under broken-wire condition

(Source: JICA Report "Preparatory survey on Turakurgan Thermal Power Station Construction Project")

(4) Maximum span length

The maximum span length between Towers is 600 m. (assumed by the survey team)

(5) Right of Way (ROW)

ROW is set as 25m from the center of Tower to each side perpendicular to direction of conductors.

(6) Ground Clearance

The most severe state for the ground clearance of conductors will occur when the conductor's temperature rises to 75 degrees under still air conditions. As for this project, the minimum height of the conductors above ground provided by JSC TPP is shown in Table 6.3.1-9.

Table 6.3.1-9 The ground clearance of conductors

Classification	Height[m]
Plain (not access to)	7
Populated area	8
Crossing roads	15

(Source: JSC Thermal Power Plant)

(7) The minimal distance to the crossing and approaching object

The restrictions on the minimal distance from the transmission line to the crossing and approaching various objects are described in PUE, and the main ones are as shown in Table 6.3.1-10.

Table 6.3.1-10 the minimal distance to the crossing and approaching object

Object	The minimal distance(m)		
Communication and wire-broadcasting wires	4		
Transmission and Distribution line under 220kV	Span<200m	300m	450m
	4	5.5	7
Buildings and facilities	5		
Railway	8.5 (non-public narrow gauge 7.5)		
Trackless lines and tramways	12		
The maximum level of water in navigable rivers, canals, etc. at maximum temperatures	7		
The ground or overhead pipelines and Ropeways	5		

(Source: PUE, JICA Survey Team)

(8) Conductor & Ground Wire Design

1) Type of Conductor and Ground Wire

Design current (see 6.3.1 (3) 2)) proved that double conductors of ACSR (Aluminum Cable Steel Reinforced) 600mm^2 for conductor of T/L are appropriate for the Project, according to the reference table for allowable continuous current of conductor from JSC Thermal Power Plant. At the request of the Uzbekistan side, ACSR300mm^2 was adopted as the wire on the opposite circuit for the auxiliary transformer. The technical characteristics for the conductor and ground wire are shown in Table 6.3.1-11. Regarding conductors, ACSR/AS(Aluminum-clad steel), with a core covered with aluminum steel, is applied in this report, though ACSR, with a galvanized steel core, is usually applied as normal conductors in Uzbekistan because ACSR/AS has a long life span for corrosion resistance with the core covered with aluminum.

Regarding ground wire as well as conductors, AS type covered with aluminum is applied in this report. According to JSC TPP, Optical fiber composite Ground Wire (OPGW) is applied to 220 kV T/L. Therefore, OPGW is also studied in this report.

Table 6.3.1-11 the technical characteristics for the conductor and ground wire

Type	Conductor			Ground wire	
	ACSR/AS600mm^2 (600/72)	LL750mm^2/HRAS	ACSR/AS300mm^2 (300/66)	AS 95mm^2	OPGW100mm^2
Component of stranded wires	AL 54/3.70 AS 19/2.20	18/TW-1(4.97)-2-AL +14/TW(4.77)-AL +9/TW(4.68)-AL +7/2.80-HRAS	AL 30/3.50 AS 19/2.10	AS7/3.5	23AS:8/3.8 OP unit 1/6.0
Total area of aluminum wires [mm^2]	580	754.2	288.5	-	-
Total area of conductor [mm^2]	652.2	797.3	354.3	93.3	105.4
Overall diameter [mm]	33.2	33.2	24.5	12.5	13.4
Weight [kg/km]	2,170	2,403	1,313	626	613
Ultimate tensile strength [kN]	183.8	184.7	126.27	121.4	98.3
Modulus of elasticity [GPa]	72.9	67.2	82.0	15	15.2
Coefficient of linear expansion x [10^{-6}/℃]	20.5	21.7	19.3	15.0	12.9
DC resistance at 20℃[Ω/km]	0.05091	0.038	0.10226	0.925	0.411
Number of conductors per phase	2	2	1	-	-
Allowable continuous current (ambient 25℃)	1050	1253	680	-	-

(Source: JICA Survey Team)

*1: Trapezoidal Wire

*2: Value in parenthesis: equivalent diameter

2) Maximum Working Tension and Every Day Stress (EDS)

The maximum span length was assumed 600 m. The maximum working tension and the EDS of both the conductor and the ground wires satisfy the determined safety factors as shown in Table 6.3.1-8.

The result is shown as Table 6.3.1-12.

Table 6.3.1-12 the result of Maximum Tension & Sag for Conductor & Ground Wire

Condition Case			ACSR600 mm^2	LL750mm^2	ACSR300 mm^2	AS 95 mm^2	OPGW100 mm^2
No.	℃	Maximum Tension/Maximum/Sag (%UTS)	60kN/28.2m (32.6%UTS)	60kN/30.2m (32.5%UTS)	41kN/27.6m (32.5%UTS)	25kN/23.5m (20.6%UTS)	25kN/23.8m (25.4%UTS)
1	45	Maximum Temperature	36.8kN/26.8m	37.9kN/28.9m	23.4kN/25.7m	20.4kN/13.6m	19.8kN/13.8m
2	-30	Minimum Temperature	42.5kN/23.1m	43.3kN/25.1m	26.9kN/22.8m	21.7kN/12.8m	21.0kN/12.9m
3	15	Annual Mean Temperature (EDS) (%UTS)	38.8kN/25.4m (21.1%UTS)	39.8kN/27.4m (21.5%UTS)	24.8kN/25.0m (19.6%UTS)	20.9kN/13.3m (17.2%UTS)	20.2kN/13.4m (20.5%UTS)
4	-5	Glazed Frost	59.8kN/25.6m	60.0kN/27.3m	41.5kN/25.0m	24.9kN/22.7m	24.8kN/22.9m
5	-5	Max wind Pressure	49.8kN/25.0m	49.6kN/26.9m	33.6kN/24.9m	22.7kN/17.5m	22.5kN/18.2m
6	-5	Snow Storm	60.8kN/25.7m	60.9kN/27.4m	41.6kN/25.7m	25.3kN/23.5m	25.3kN/23.8m
7-1	-15	Working Time	41.3kN/23.9m	42.2kN/25.9m	25.6kN23.6m	21.5kN/13.0m	20.8kN/13.2m
7-2	75	Maximum operation Temperature of Conductors	35.1kN/28.2m	36.3kN/30.2m	21.8kN/27.6m	19.9kN/14.0m	19.3kN/14.1m

(Source: JICA Survey Team)

3) Sags and Tensions of the Ground wires

The sags of ground wires under EDS condition must be below 80% of the conductors' sag at the standard span length for avoiding a reverse flashover from the ground wires to conductors and direct

lightning stroke to the conductors. The tension of the ground wires are determined to satisfy the safe clearance of conductors and ground wires in the mid-span. The result is also shown as Table 6.3.1-12.

(9) Determination of Insulator Design

1) Insulator type and size

Based on the IEC, Insulator unit applied to these T/Ls is porcelain or toughened glass insulator with ball and socket, complying IEC60305. The120kN type of insulator is applied for suspension towers and 160kN type insulator is applied for the tension (angle) towers. And for both insulators, we adopted a long creeping distance insulator for the pollution area such as Navoi. The technical characteristics of the insulators are shown in Table 6.3.1-13.

Table 6.3.1-13 Technical Characteristics of Insulator

Type	U120BP	U160BSP
Rated Ultimate Strength [kN]	120	160
Nominal diameter [mm]	280	330
Nominal spacing [mm]	146	146
Nominal Creepage Distance	440	440

(Source: IEC 60305)

2) Number of Insulator per String

According to existing transmission line, the numbers of insulators for 220kV T/L are usually22–25 units. However, based on IEC, the number of insulators for U120BP and U160BSP determined by the contamination level ”Very Heavy” is 18 units, and the number designed by the lighting impulse withstand voltage (LIWV) and arcing horn, is also 18 units. Therefore, JICA Survey Team adapts 18 units as maximum insulator units in this report.

However, it is necessary to study in detail design stage in consideration the actual contamination level at the site.

3) Insulator Strings (Span Length: 600m)

Insulator fittings also have to secure the same strength as the insulators as shown in Table 6.3.1-14.

Table 6.3.1-14 the strength of Insulator Assembly

Conductor	Tower type	Maximum Tension	Insulator type (RUS)	Permissible Strength(45%RUS)
ACSR/AS 600mm^2 (300 mm^2)	Tension	122.8kN (Double)	Double strings of 160kN (320kN)	144>122.8
	Suspension	26.2kN	Double strings of	108>26.2

Conductor	Tower type	Maximum Tension	Insulator type (RUS)	Permissible Strength(45%RUS)
		(Double)	120kN (240kN)	
LL-ACSR 750mm^2/HRAS	Tension	123.1kN (Double)	Double strings of 160kN (320kN)	144 >123.1
	Suspension	28.3kN (Double)	Double strings of 120kN (240kN)	108 >28.3

(Source: JICA Survey Team)

(10) Determination of Tower Configuration

1) Clearance Design

According to PUE, the values of clearance diagram are described as shown in Table 6.3.1-15.

Table 6.3.1-15 Swinging Angle and Insulation Clearance

Item	Normal	Abnormal
Wind Velocity [m/s]	10m/s	29m/s
Swinging angle of suspension strings	10 deg.	50 deg.
Swinging angle of tension strings (jumper)	10 deg.	50 deg.
Value of clearance diagram [mm]*	1,800	550

(Source: JICA Survey Team and * PUE)

2) The height of the tower

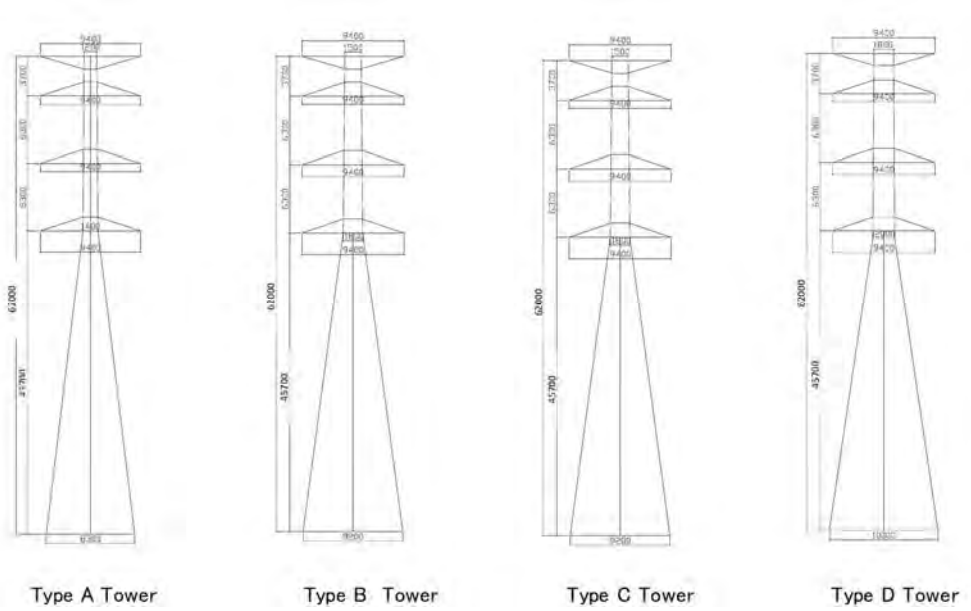
The height under lowest cross arms of the tower is 45.7m, which is the sum of 15m of ground clearance and 30.7m of conductor dip. And the height from lowest cross arm to top of the tower is 16.3m. Then the height of the tower is about 62m. Since topographical survey are not conducted in this report, it is necessary to review the height of tower at the time of detailed design.

3) The cross arm length of the tower

Considering the clearance diagram, the cross arm length is 9.4m. In order to lower the probability of lightning strikes on the conductor, the lengths of the ground cross arm and the conductor cross arm were made the same. Also it is necessary to review the cross arm length at the time of detail.

4) Tower Configurations

The towers shall normally be of the following 4 types as shown in Figure 6.3.1-5 and Table 6.3.1-16.



(Source: JICA Survey Team)

Figure 6.3.1-5 The Shapes of 4 Tower Types

Table 6.3.1-16 Tower Types and the Applied Conditions

Type (Double Circuit)	Position of Use	Angle of Deviation or Entry	Type of Insulator
A	Straight Line	0 – 5	Suspension
B	Angle	0 – 10	Tension
C	Angle	10 – 30	Tension
D	Dead end	60－90	Tension

(Source: JICA Survey Team)

5) Tower Design

The steel tower design results were based on the results of similar 220 kV class transmission lines conducted in the past. .

Table 6.3.1-17 Unit Weight of the Towers

A [ton]	B [ton]	C [ton]	D [ton]
18	24	30	39

(Source: JICA Survey Team)

a) Foundation Design

The foundation load was similarly estimated based on the past design results of the 220 kV class transmission line. In addition, Pad and Chimney Type Foundation was applied as the basic shape.

Table 6.3.1-18 Sample of Assumed Geological Condition & Foundation Design Data

Geological condition & Foundation Design data	
Effective angle resisted for Lift force of soil θ (°)	30
Equivalent unit volume weight of soil γ' (t/m^3)	1.6
Compressive Strength q' (t/m^2)	80
unit volume weight of Concrete (t/m^3)	2.24

(Source: JICA Survey Team)

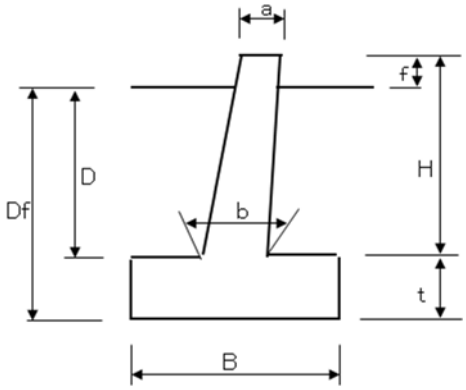


Figure 6.3.1-6 Sample of Pad and Chimney Type Foundation

(Source: JICA Survey Team)

Table 6.3.1-19 Assumed Foundation Loads and Concrete Volume (Pad & Chimney)

Tower type	Compressive load [kN]	Tensile load [kN]	Unit concrete Volume [m^3]
A	556	447	25
B	717	593	57
C	1126	888	81
D	2,134	1564	111

(Source: JICA Survey Team)

(11) Outline Design of Transmission line

We estimated the span length, horizontal angle of transmission line and level, etc. based on the coordinate data on Google Earth, and created a transmission line profile and performed a rough design. The results are as follows.

Table 6.3.1-20 Outline Design of Transmission line

Tower No.	Latitude	Longitude	Direction Angle	Horizontal Angle	Distance (m)	Level (m)	Tower Type			Wieght (ton)	Concrete (m^3)	Insulator		
												Tension	Suspension	J.Support
PS	40° 9'41.20"N	65° 19'11.92"E	346° 28' 34.54"		68	0.0			Guntry			6		
TL1	40° 9'43.33"N	65° 19'11.25"E	41° 49' 51.11"	R 55° 21' 17"	87	−2.0	Tension	Dead end	D	39	111	12		3
TL2	40° 9'45.43"N	65° 19'13.71"E	343° 35' 28.27"	L 58° 14' 23"	488	−6.0	Tension	Dead end	D	39	111	12		3
TL3	40° 10'0.58"N	65° 19'7.87"E	286° 55' 41.79"	L 56° 39' 46"	358	−5.0	Tension	Dead end	D	39	111	12		3
TL4	40° 10'3.96"N	65° 18'53.37"E	288° 18' 19.96"	R 1° 22' 38"	370	−6.0	Suspension		A	18	25		6	
TL5	40° 10'7.72"N	65° 18'38.49"E	0° 39' 16.58"	R 72° 20' 57"	365	−5.0	Tension	Dead end	D	39	111	12		3
TL6	40° 10'19.47"N	65° 18'38.68"E	76° 10' 18.07"	R 75° 31' 1"	461	−4.0	Tension	Dead end	D	39	111	12		3
TL7	40° 10'23.07"N	65° 18'57.59"E	11° 28' 55.35"	L 64° 41' 23"	249	−5.0	Tension	Dead end	D	39	111	12		3
TL8	40° 10'30.97"N	65° 18'59.69"E	309° 49' 28.82"	L 61° 39' 27"	454	−5.0	Tension	Dead end	D	39	111	12		3
TL9	40° 10'40.36"N	65° 18'44.95"E	309° 37' 41.68"	L 0° 11' 47"	494	−3.0	Suspension		A	18	25		6	
TL10	40° 10'50.54"N	65° 18'28.86"E	18° 1' 45.65"	R 68° 24' 4"	290	−5.0	Tension	Dead end	D	39	111	12		3
TL11	40° 10'59.47"N	65° 18'32.66"E	80° 39' 13.35"	R 62° 37' 28"	237	−4.0	Tension	Dead end	D	39	111	12		3
SS	40° 11'0.85"N	65° 18'42.39"E				−4.0			Guntry			6		
Total					3921					348	938	96	12	27

(Source: JICA Survey Team)

6.3.2 500/220kV Navoi Substation

(1) Design concept

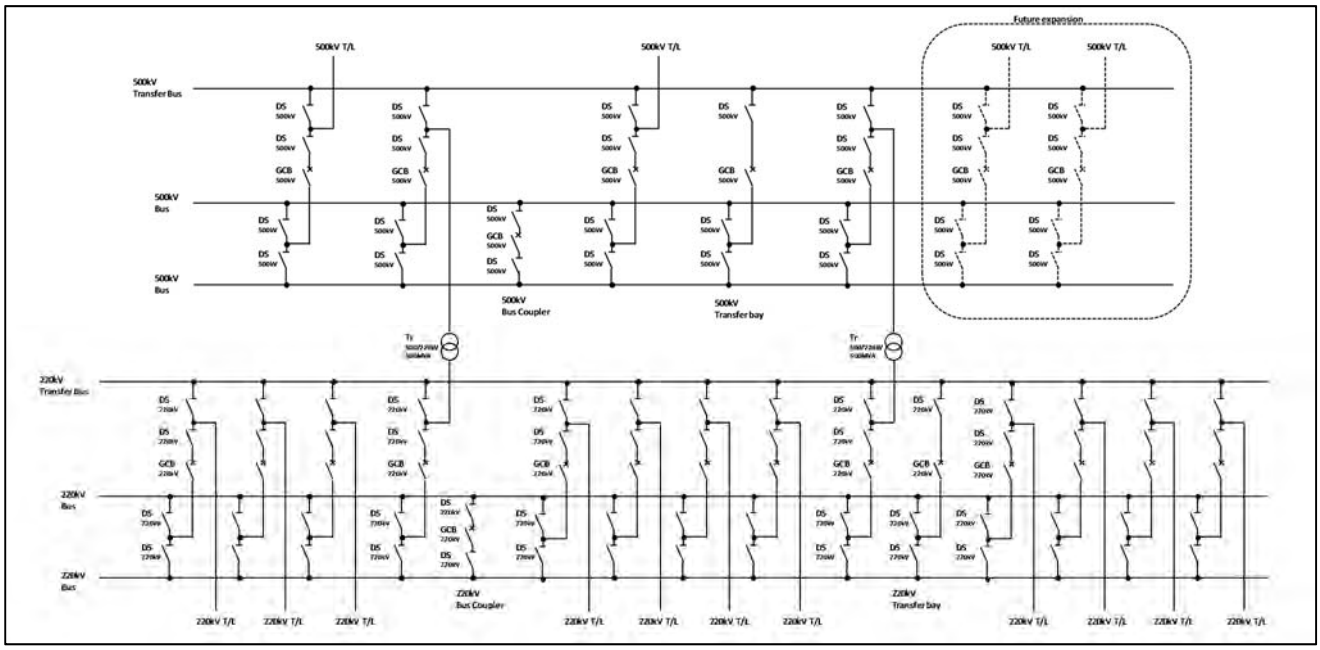
JICA Survey Team discussed with JSC TPP the substation and concluded that the a new separate 500k/220V substation will be constructed since there is no space to extend additional switchyard bays at the existing 220 kV switchyard in Navoi PS. The candidate site for the new substation is located north side of Navoi PS across the Zaravshan River. In order to divert the existing 220kV transmission lines, at first stage the 220kV switchyard of the 500/220kV Substation will be commissioned and operated and then the 500kV switchyard will be commissioned and operated as a 500 kV substation.

The study of the 500/220kV substation was carried out by SAESP and JICA Survey Team reviewed the same.

(2) Single Line Diagram and Layout

The substation single line diagram (SLD) and the substation layout are shown in Figure 6.3.2-1 and Figure 6.3.2-2 respectively.

JICA Survey Team confirmed 220kV busbar configuration to be “Double busbar with Transfer busbar type” referring to Turakurgan Switchyard and Sarimay Substation. For 500kV busbar, it is confirmed that the busbar type has not already been defined by SAESP. Therefore, JICA Survey Team assumed the 500kV busbar type to be “Double busbar with Transfer busbar type” temporally.



(Source: JICA Survey Team)

Figure 6.3.2-1 Single Line Diagram of New 500/220 kV Substation

JICA Survey Team is provided with the layout of 500/220kV Sarimay Substation for applying to the new 500/220kV Navoi Substation, according which a required area is 550m x 400m =22 ha.

As a result of JICA Survey Team review of the provided layout, the following points are raised:

1) The substation is an outdoor air insulated switchgear (AIS) type,
2) There is enough space for 220kV switchyard even considering the outgoing/incoming 220kV transmission lines of the new 500/220kV Navoi Substation,
3) 500kV and 220kV transmission line connection directions differ from the site condition of the new 500/220kV Navoi Substation. This point needs further study by SAESP,
4) Since 500kV busbar type is yet to be defined by SAESP, the busbar type might change depend on SAESP design.

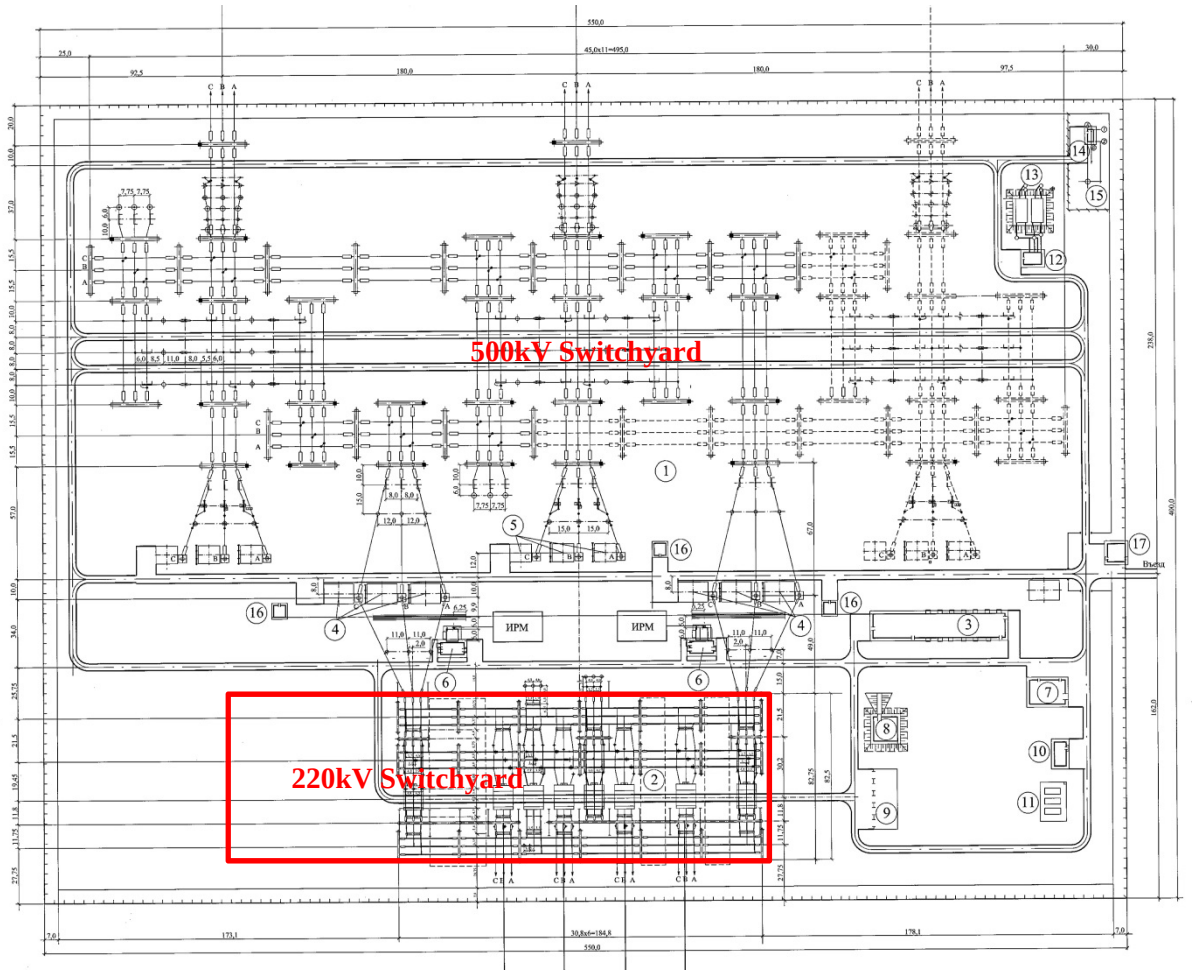


Figure 6.3.2-2 Layout of New 500/220 kV Navoi Substation

(Source: SAESP supplied Layout of 500/220kV Sarimay Substation for 500/220kV Navoi Substation)

6.3.3 Specification and quantity of main facilities

(1) T/L Specification and quantity

Each quantity obtains from Table 6.3.1-20.

1) Tower

Material is galvanized steel angle based on SS400. Tower height is around 60m. Tower width is from 8m to 10m. Total amount is 348 ton.

2) Concrete

Reinforced concrete with appropriate amount of rebar should be used. Total Volume is 938m^3.

3) Conductor

The survey team selected ACSR/AS600mm^2 and LL-ACSR/AS750mm^2. The former has a slightly lower construction cost, while the latter has a better life cycle cost. Although it is JSC Thermal power plant to decide which is better, the Survey Team recommends the latter. Total length of conductor is 24.7km, but also includes conductor for jumpers and sag. And the length of ACSR300mm^2 for

auxiliary transformer is 12.4km.

4) Ground wire

The survey team selected OPGW and AS and Total length of each wire is 4.2km, but also includes wire for sag.

5) Insulator strings

Types of insulator strings are tension type, suspension type and jumper type. The tension type insulator is U160BSP, and the suspension type and jumper type insulator is U120BP. The number of tension type insulator strings is 96 sets. And the number of suspension type insulator strings is 12 sets. The number of jumper type insulator strings is 27 sets with 3 sets for 9 towers each.

6) Accessories

Accessories are dumper, clamp and so on. Each of them should be properly installed.

(2) Substation major facility

Major facilities of 500/220kV Navoi Substation are listed in Table 6.3.3-1.

Table 6.3.3-1 Major Facilities of 500/220kV Navoi Substation

No.	Name	Specification	Qty.	Unit
1	500kV Switchgear yard (AIS)	Double busbar with Transfer busbar	-	-
1-1	Transmission line	GCB*1, DS*4, CT*1, VT*1, LA*1	2	cct
1-2	Transmission line (Reactor)	180MVAR Reactor*1, DS*1	1	set
1-3	Transformer primary	GCB*1, DS*4, CT*1, LA*1	2	cct
1-4	Bus Coupler	GCB*1, DS*2, CT*1, VT*2	1	set
1-5	Transfer bay	GCB*1, DS*3, CT*1, VT*1	1	set
1-6	Other equipment	Conductor, Steel structure, etc.	1	lot
2	Transformer Yard	-	-	-
2-1	Main Transformer	500/220/33kV, 500MVA	2	set
2-2	Auxiliary Transformer	33/0.415kV, 500kVA	2	set
2-3	33kV Switchgear	GCB*1, DS*2, VT*1,LA*1	2	set
2-4	Other equipment	Conductor, etc.	1	lot
3	220kV Switchgear Yard (AIS)	Double busbar with transfer bus bar	-	-
3-1	Transmission line	GCB (with CT)*1,DS*4,VT*1, LA*1	11	cct
3-2	Transformer secondary	GCB (with CT)*1,DS*4, LA*1	2	cct
3-3	Bus Coupler	GCB (with CT)*1,DS*2, VT*2	1	set
3-4	Transfer bay	GCB (with CT)*1,DS*3, VT*1	1	set

No.	Name	Specification	Qty.	Unit
3-5	Other equipment	Conductor, Steel structure, etc.	1	lot
4	Control & Protection system		-	-
4-1	500kV Control & Protection system		1	lot
4-2	220kV Control & Protection system		1	lot
4-3	SCS		1	lot
4-4	RTU (for connection to NCC)		1	lot
5	Communication system		1	lot
6	LV AC Distribution system		1	lot
7	DC Dist. system, Charger, Battery		1	lot
8	Power and Control cable		1	lot
9	Earthing system and lightning protection		1	lot
10	Firefighting Equipment		1	lot

(Source: JICA Survey Team)

Current Ratings for the equipment are as per Table 6.3.3-2.

Table 6.3.3-2 Current Ratings for Equipment

Rated voltage	Rated current	Rated short time withstand current
500kV	2,000A, 3,150A	31.5kA
220kV	2,000A, 3,150A	40.0kA

(Source: JICA Survey Team)

6.3.4 Construct Cost Estimation

(1) T/L cost estimation

T/L construction cost was estimated as shown Table 6.3.4-1.The cost is 3.69 MUSD.

Table 6.3.4-1 Assumed Estimation for TL Construction Cost

Assumption:
(1) Length: 3.92km
(2) Ratio of Tenssion Towers for All Towers
: Plain Area 18% of Suspenssion Towers (2units), 82% of Tenssion Towers (9units) :
(3) Average Span: 340m
(4) Foundation Type: 100% of Pad &Chimny Type Foundations
(5) Soil Conditions: Normal

Category	No.	Items	220kV, 2cct, (3.9km), Plain Area Condutcor : 2xACSR600 or LL-ACSR750						Remarks
			Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	Tower	ton	348	2,400	835,200	835,200	0	
	2	LL-ACSR750mm^2	km	24.7	12,000	296,400	296,400	0	
	3	ACSR300mm^2	km	12.4	4,000	49,600	49,600	0	
	4	OPGW	km	4	5,500	22,000	22,000	0	
	5	OH G.W.	km	4	1,500	6,000	6,000	0	
	6	Suspension Insulator String	set	12	3,400	40,800	40,800	0	
	7	Tension Insulator String	set	96	4,000	384,000	384,000	0	
	8	Jumper support Insulator String	set	27	1,400	37,800	37,800	0	
	9	Accessories	lot	1	26%	434,668	434,668	0	
		Subtotal				2,108,260	2,106,468	0	
COSTOF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & S. Investigation	km	4	3,500	14,000	9,520	4,480	
	2	Access Construction	km	4	2,500	10,000	6,800	3,200	
	3	Land Clearing	km	4	2,000	8,000	5,440	2,560	
	4	Foundation (Volume of Concrete)	m^3	938	750	703,500	478,380	225,120	
	5	Tower Erection	ton	348	550	191,400	130,152	61,248	
	6	Stringing	km	4	15,000	60,000	40,800	19,200	
	7	Inland Transportion			CIF*18%	379,487	258,051	121,436	
	8	Miscellaneous	lot	1	5%	68,319	46,457	21,862	
	9	General Expenses	lot	1	10%	143,471	97,560	45,911	
		Subtotal				1,578,177	1,073,160	505,017	
		Total				3,686,437	3,179,628	505,017	

(Source: JICA Survey team)

(2) 500/220kV Navoi Substation Construction Cost Estimation

Substation construction cost is estimated as shown Table 6.3.4-2. The total cost is 52.37 MUSD.

Table 6.3.4-2 Assumed Estimation for Substation Construction Cost

Assumption:
(1) 500kV/220kV: AIS
(2) Digital Relay
(3) Soil Conditions: Normal

Category	No.	Items		500kV: 6bay AIS 220kV: 15bay AIS						Remarks
				Unit	Q'ty	Unit Rate (US$)	Amount (US$)	FC (US$)	LC (US$)	
COST, INSURANCE AND FREIGHT	1	500kV Switchrear yard	500kV, AIS, Double busbar with transfer busbar	-	-					
	1-1	Transmission Line	GCB*1, DS*4, CT*1, VT*1, LA*1	cct	2	686,632	1,373,264	1,373,264	0	
	1-2	Transmission Line (Reactor)	180MVAR Reactor*1, DS*1	set	1	3,606,217	3,606,217	3,606,217	0	
	1-3	Transformer primary	GCB*1, DS*4, CT*1, LA*1	cct	2	600,049	1,200,098	1,200,098	0	
	1-4	Bus Coupler	GCB*1, DS*2, CT*1, VT*2	set	1	638,296	638,296	638,296	0	
	1-5	Transfer bay	GCB*1, DS*3, CT*1, VT*1	set	1	634,714	634,714	634,714	0	
	1-6	Other equipment	Conductor, Steel structure, etc.	lot	1	2,831,983	2,831,983	2,831,983	0	
	2	Transformer Yard	-	-	-					
	2-1	Main Transformer	500/220/33kV, 500MVA	set	2	5,235,247	10,470,494	10,470,494	0	
	2-2	Auxiliary Transformer	33/0.415kV, 500kVA	set	2	20,746	41,492	41,492	0	
	2-3	33kV Switchgear	GCB*1, DS*2, VT*1, LA*1	set	2	33,726	67,452	67,452	0	
	2-4	Other equipment	Conductor, etc.	lot	1	44,667	44,667	44,667	0	
	3	220kV Switchrear yard	220kV, AIS, Double busbar with transfer busbar	-	-					
	3-1	Transmission Line	GCB (with CT) *1, DS*4, VT*1, LA*1	cct	11	400,000	4,400,000	4,400,000	0	
	3-2	Transformer secondary	GCB (with CT) *1, DS*4, LA*1	cct	2	340,000	680,000	680,000	0	
	3-3	Bus Coupler	GCB (with CT) *1, DS*2, VT*2	set	1	380,000	380,000	380,000	0	
	3-4	Transfer bay	GCB (with CT) *1, DS*3, VT*1	set	1	350,000	350,000	350,000	0	
	3-5	Other equipment	Conductor, Steel structure, etc.	lot	1	2,754,280	2,754,280	2,754,280	0	
	4	Control & Protection system		-	-					
	4-1	500kV Control & Protection system		lot	1	1,100,000	1,100,000	1,100,000	0	
	4-2	220kV Control & Protection system		lot	1	3,260,000	3,260,000	3,260,000	0	
	4-3	SCS		lot	1	2,000,000	2,000,000	2,000,000	0	
	4-4	RTU (for connection to NCC)		lot	1	180,000	180,000	180,000	0	
	5	Communication system		lot	1	400,000	400,000	400,000	0	
	6	LV AC Distribution system	Included in Miscellaneous	lot	1	0	0	0	0	
	7	DC Dist. System, Charger, Battery		lot	1	100,000	100,000	100,000	0	
	8	Power and Control cable	Included in Miscellaneous	lot	1	0	0	0	0	
	9	Earthing system and lightning protection	Included in Miscellaneous	lot	1	0	0	0	0	
	10	Firefighting Equipment		lot	1	630,000	630,000	630,000	0	
			Subtotal				37,142,957	37,142,957	0	
COST OF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Civil and Erection		lot	1	CIF*30%	11,142,887	0	11,142,887	
	2	Inland Transportion		lot	1	CIF*5%	1,857,147	0	1,857,147	
	3	Miscellaneous		lot	1	CIF*6%	2,228,577	1,114,289	1,114,288	
			Subtotal				15,228,611	1,114,289	14,114,322	
			Total				52,371,568	38,257,246	14,114,322	

(Source: JICA Survey Team)

(3) Total construction cost

Total construction cost related T/L and Substation is estimated to be 56.06 MUSD.

6.3.5 Construction Schedule

(1) Whole Schedule for T/L Construction

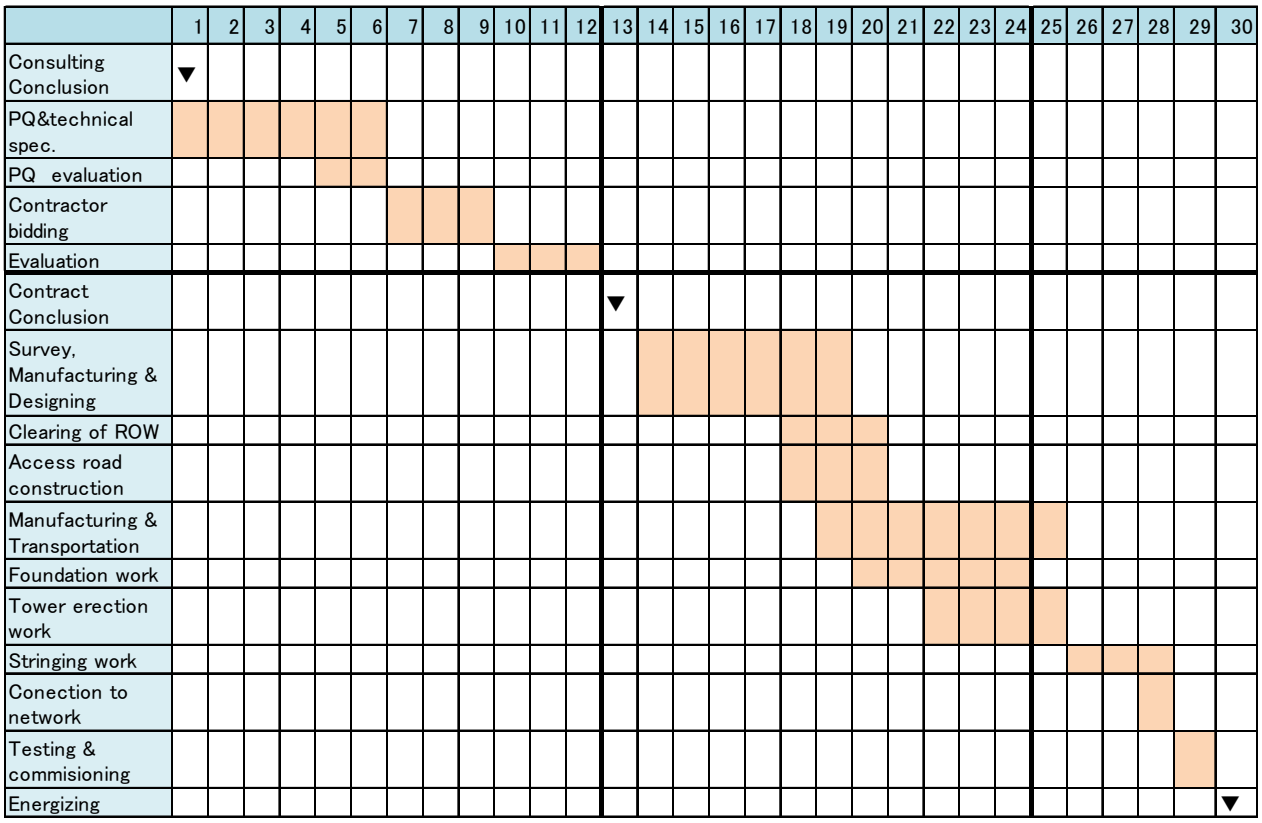


Figure 6.3.5-1 Construction Schedule for Transmission Line

(Source: JICA Survey Team)

(2) Whole Schedule for 500/220kV Navoi Substation

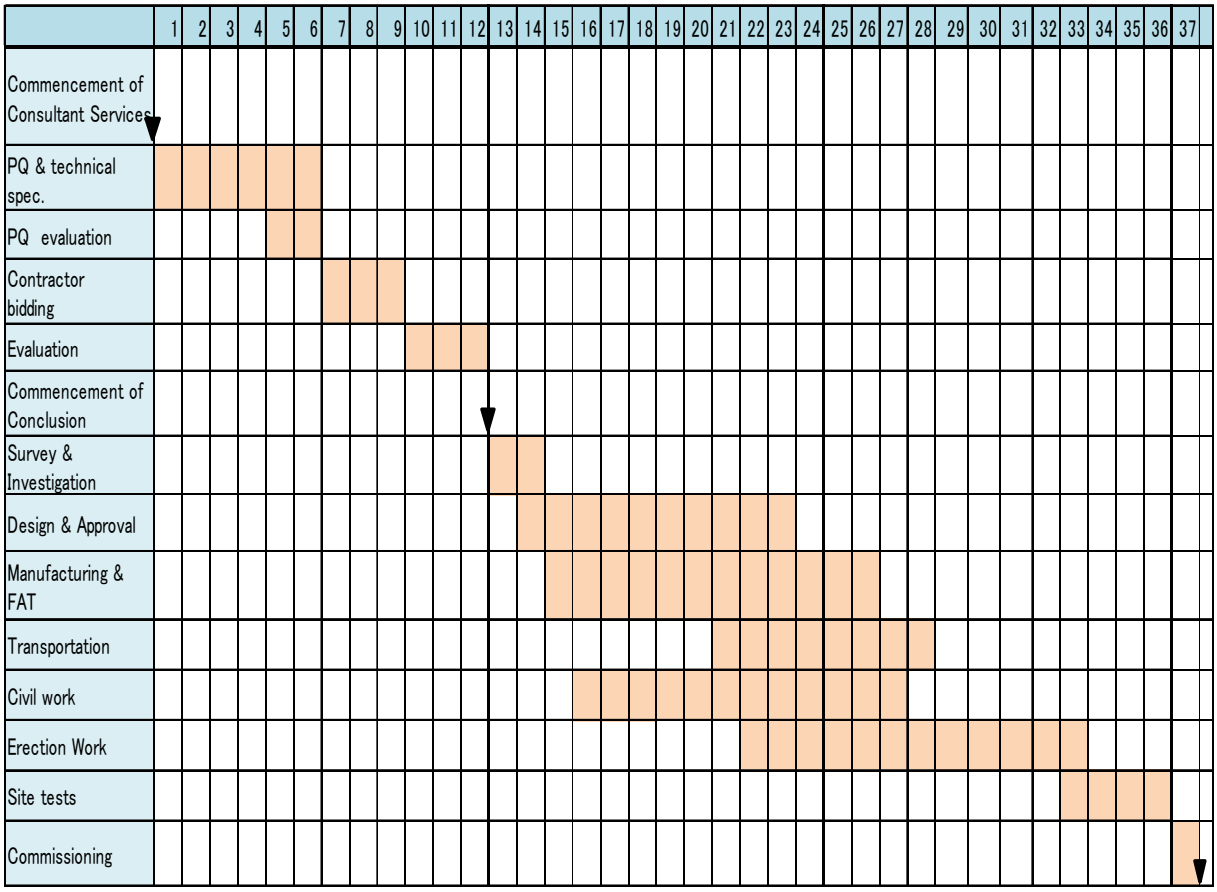


Figure 6.3.5-2 Construction Schedule for 500/220kV Navoi Substation

(Source: JICA Survey Team)

6.3.6 Countermeasure for transmission losses

(1) Current issue of the transmission network/electricity loss

Figure 6.3.6-1 shows technical and commercial losses in Uzbekistan as electricity moves from generation facility to transmission and further distribution grids. It is estimated that in 2017, the technical losses in the generation stage amounted to 0.6% of total generation, but in the transmission and distribution grids they increase 10 times to 6%. Technical and commercial losses in the distribution stage add another 25-30%, bringing total losses to 36.7% of the generated electricity.

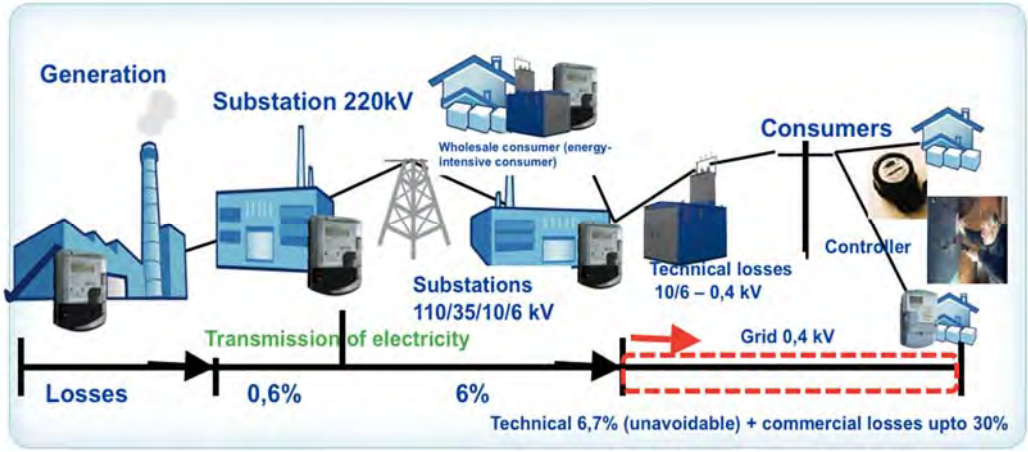


Figure 6.3.6-1 Schematic depiction of technical and commercial losses of electricity in Uzbekistan

(Source: UE presentation on smart metering, November 2017)

And The Speech of the President at the Congress on December 22, 2017 is as follows. ***"About 17 billion cubic meters of gas will be delivered to "Uzbekenergo" company. It generates 56 billion kilowatt of electricity. Unfortunately, we have outdated transmission lines. As a result, 15-20% of electricity is lost in the network without reaching the consumer."***

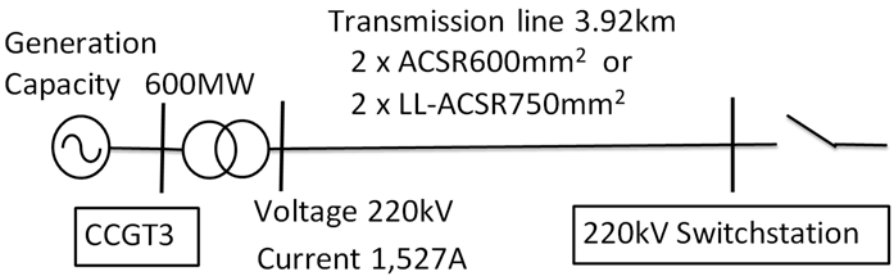
(2) Countermeasure for Transmission loss by introduction of Low Los ACSR

As an example, the following simplified model is considered.

1) Calculation Model

This is the example of transmission line from GTCC3 to 220kV S.S.

- Generation Power:550MW, Operation rate 85.6%(7500 hour/year)
- Transmission Voltage: 220kV



(Source: Survey team)

Figure 6.3.6-2 Calculation Model

2) Evaluation about the operation cost reduction by introduction of LL-ACSR

The transmission loss was examined as follows for GTCC3. Assuming that the unit price of electricity per kWh is 0.0180 US $, an annual cost reduction of 0.03 MUSD can be expected as an effect of the reduction in transmission loss. Also, the cost increase due to the introduction of LL-ASCR can be recovered in4.38 years.

Future Loss reduction *with Low Loss Conductors* ***/ Catching up Details***

$ Years to Catch Up: 4.38 [years] $ Loss reduction per Year: 0.0322 [MUS$]

*Formula: CUYears = Δprice*LineLength*6/Loss reduction, Loss reduction = Losses*PGcost*7500h, Linelength=3.92km*

**** Prices*** *(includes accessories)* ***ACSR 600mm² * : 6,000 [US$/km]***

LL - ACSR. 750mm² : 12,000 [US$/km]

** The ACSR price in Uzbekistan is estimated by the JICA team*

**** Losses 3x2xI² x(R_{ACSR} -R_{LL})xL: 239 [kW]***

*Losses = 3*2*I² *ΔR*LineLength , R_{ACSR} = 0.0656 [ohm/km], R_{LL} = 0.0482 [ohm/km] , L=3.92[km]*

I (Estimated) : 763.5 [A/cond]

Ampere per cond. rated current/1cct/2cond.=1527/1/2

**** Power Generation Cost ** : 0.0180 [US$/kWh]***

*** Uzbekistan averge generation cost of thermal power plant*

Chapter 7

Basic Design

Chapter 7 Basic Design

7.1 Conceptual Design

7.1.1 Design Conditions

Design conditions shall be specified to complete the feasibility study for this Project. However, not all the detailed design conditions have been finalized because of the tight schedule for discussion and study during the preparation period of the feasibility study. Consequently, some design conditions may be tentative or assumed at this stage of the feasibility study and subject to revision or finalization during the detailed design stage of this Project. The following Table 7.1.1-1 shows the design conditions necessary for completion of the preparatory survey on Navoi Thermal Power Plant Modernization Project (Phase 2).

Table 7.1.1-1 Design Conditions and Specifications

Description	Conditions and/or Specifications	
(1) Basic Design Conditions	**Rated**	**Range**
a. Dry bulb temperature (°C)	15.0	- 28.0 to 47.0
b. Barometric pressure (kPa)	97.4	
c. Altitude (m)	332.91	
d. Relative humidity (%)	60.0	20.0 to 80.0
e. Wet bulb temperature (°C)	10.9	- 21.0 to 36.6
f. Temperature of cooling water (Zeravshan River)	18.0	As per site ambient conditions and design of cooling tower (where applied)
g. Type of fuel	Specified natural gas	
h. Supply pressure of natural gas at terminal point (barg)	10	10 to 12
i. Supply temperature of natural gas at terminal point (°C)	15	-5 to 22
j. Export heat		
1) High pressure industrial steam		
Heat output (Gcal/hr)	30 (126 GJ/hr)	0.0 to 30 (0.0 to 126 GJ/hr)
Pressure (ata)	21 (2.06 MPa) ± 5%	
Temperature (℃)	350 ± 3%	
2) Medium pressure industrial steam		0.0 to 70
Heat output (Gcal/hr)	70 (293 GJ/hr)	(0.0 to 293 GJ/hr)
Pressure (ata)	8 ~ 13 (0.78 ~1.27 MPa) ± 5%	
Temperature (℃)	350 ± 3%	0.0 to 100 (0.0 to 419 GJ/hr)
3) Hot water heating steam		
Heat output (Gcal/hr)	100 (419 GJ/hr)	

Description	Conditions and/or Specifications
Pressure (barg) Temperature (℃) 4) Return drain of industrial steam Return rate (%) Pressure (barg) Temperature (℃) 5) Hot water supply and return Supply pressure (barg) Supply temperature (℃) Return pressure (barg) Return temperature (℃)	3 ±1 200 ±20 31 2 80 8 ~ 16 110 0.5 ~ 4 55
k. Maximum export heat capability	Dependable on model of GT, site ambient conditions, and design concept of manufacturer
l. Conditions to define the maximum capability of bottoming and electrical systems	Ambient conditions: Dry bulb temperature 15.0 ºC Relative humidity 60.0 % Wet bulb temperature 10.9 ºC Supplementary firing temperature if applicable: Later Export heat amount: Industrial steam supply 100 Gcal/hr District heating steam supply 0 Gcal/h At the conditions of ambient temperature below -5ºC, the gas turbine shall be operated in load limiter mode.
m. Economically operable service life	30 years with reasonable repair and/or replacement of consumable and/or normal wear and tear of parts
n. Make-up water for process	Demineralized Zeravshan River water
o. Make-up water for auxiliary cooling tower	Pre-Treated Zeravshan River water
p. Make-up water for hot water	Pre-Treated City water
(2) Specification of Main Equipment 1) Plant	
a. Number of GTCC blocks	One (1) block of GTCC units
b. Shaft configuration of one GTCC unit	Multi-shaft combined-cycle plant consisting of main equipment of one (1) gas turbine, one (1) steam turbine, one (1) HRSG and two (2) generators
c. Type of operation	Combined-cycle operation
d. Type of control system	Micro-processor based DCS type
e. Type of steam turbine condenser cooling system	Air cooled condenser
2) Gas Turbine	

Description	Conditions and/or Specifications
a. Type of supplier	Original equipment manufacturers that have conducted the full development of the prototype of the proposed type of machine and have performed successive upgrades.
b. Applicable standards	ISO 3977 Part 3 or equivalent
c. Type of configuration	Open cycle, single shaft, heavy duty, natural gas fired, cold end drive, axial exhaust type
d. Type of installation	Indoor installation with sound attenuation enclosure
e. Rating	Continuous base load rating with the load weighing factor of 1.0 for EOH calculation
f. Rotating speed	3,000 rpm
g. Type of coupling	Directly coupled with generator by integrated solid coupling
h. Shaft strength	To be designed to withstand the transient torque due to short circuit or out-of-phase synchronization, whichever is greater.
i. Temperature class	Latest version of H/J -class with a wealth of commercial operating experience
j. Shaft lateral vibration	As per ISO 7919-Part 4 “Gas Turbine Sets”
k. Minimum allowable speed variation range on continuous load operation	3,000 rpm ±3%
l. Dry low NOx combustion system for natural gas	Yes
m. Inlet air cooling system	Yes
n. Type of starting device	Synchronous generator/motor with a thyristor frequency converter
o. Compressor on-line and off-line cleaning device	Yes
p. Wet type air compressor cleaning device	Yes
q. Anti-freezing device of GT inlet air filter	Yes
r. Pre-heater of natural gas fuel	As per manufacturer's option
s. Type of inlet air filter	Multi-stage type with dust removal efficiency of more than 99.5% for ISO fine dust.
t. Bypass stack	No
3) HRSG	
a. Applicable standard	Relevant ASME Pressure Vessel Codes or equivalent
b. Type of configuration	Lateral or vertical gas flow type with evaporation drums and natural circulation

Description	Conditions and/or Specifications
c. Type of cycle	Triple-pressure, reheat
d. Type of installation	Outdoor installation with canopy
e. Flue gas exit temperature	Not lower than 90 °C in consideration of low temperature corrosion of HRSG lower heating section and impact on the environment
f. Supplementary firing	Yes or no depending upon the heat and power output requirements and model of gas turbine (if required)
g. Flue gas stack	Standalone type fabricated with steel plates supported by steel structures with a height of 90 m in consideration of the impact on the environment
h. Flue gas velocity at flue gas stack exit	Not more than 25 m/s
4) Steam turbine	
a. Applicable standard	ISO 14661 or equivalent
b. Type of configuration	Two (2)-casing, three (3)-admission, sliding pressure, extraction condensing, axial or downward exhaust type
c. Type of cycle	Triple-pressure, reheat type
d. Type of pressure control of extraction steam	Internal pressure control type and/or external pressure control type
e. Type of installation	Indoor installation with sound attenuation cover
f. Rotating speed	3,000 rpm
g. Minimum allowable speed variation range on continuous load operation	3,000 rpm ±3%
h. Type of coupling	Coupled with generator by clutch or directly coupled with generator by integrated solid coupling
i. Shaft strength	To be designed to withstand the transient torque due to short circuit or out-of-phase synchronization, whichever is greater.
j. Shaft lateral vibration	As per ISO 7919-Part 2 “Large Land-based Steam Turbine Generator Sets”
k. Steam bypass	Yes
5) Condenser	
a. Type	Forced Draft Direct Air Cooled Condenser (ACC)
b. Design inlet air temperature	15 °C
c. Design inlet air wind velocity	4 (m/s)
6) Hot water production system	
a. Type	Heat exchange type between water and extracted steam
b. Capacity	100 Gcal/hr (419 GJ/h)

Description	Conditions and/or Specifications
c. Hot water supply temperature	110 °C
d. Return water temperature	55 °C
7) Generators	
a. Applicable standard	IEC 60034-3 or equivalent
b. Type	Horizontally mounted, cylindrical rotor, rotating field, hydrogen or water or air cooled synchronous type
c. Rated voltage	22 kV (18-25 kV; as per manufacturer standard)
d. Type of exciter	Static or brushless type
e. Winding insulation material class	IEC Class F
f. Maximum rise in temperature of the winding insulation	IEC Class B
8) Main Transformers	
a. Type of cooling	Oil natural and air forced type /oil forced and air forced (ONAF/OFAF)
b. Primary voltage (Low voltage side)	Generator voltage for GTG 24 kV for STG 17.5 kV
c. Secondary voltage (High voltage side)	for GTG 220 kV for STG 220 kV
(3) Operational Requirements	
1) Type of operation	
a. Type of basic operation	Continuous base load operation
b. Anticipated range of plant controllable power load without steam bypass	30 to 100 %
c. Speed droop power load operation	Yes
d. Frequency control operation	Yes
e. Constant gas turbine inlet temperature operation	Yes
f. Gas turbine simple cycle operation	No
g. Operation manner	LCD operation from remote control room by keyboard and mouse.
h. Blackout start capability	No
i. Isolated operation of gas turbine from network in an emergency	Yes
2) Time required for start-up to full power after pushing start-up button (time for purge and synchronization is not included)	
a. Cold start	At longest 4 hours
b. Warm start	At longest 3 hours
c. Hot start	At longest 2 hours
d. Very hot start	At longest 1 hour

Description	Conditions and/or Specifications
3) Voltage rating of auxiliary equipment power source	Bus voltage (Supply voltage) / Equipment voltage
a. Medium voltage	AC 6,300 V / AC 6,000 V
b. Low voltage switchgear	AC 400 V / AC 380 V
c. Motor control center (MCC)	AC 400 V / AC 380 V
d. 400/230V Distribution Board	AC 400/230 V / AC 380/220 V
e. UPS	AC 230 V
f. DC	DC 220 V
(4) Basal Conditions for Arrangement of Main Equipment	
1) Gas turbine, steam turbine and generator	To be installed inside the gas and steam turbine (separate) building(s) with a ventilation system, an overhead travelling crane and laydown bay for carrying in and out of bulky components and maintenance spaces.
2) HRSG	To be installed on the same center axis as the gas turbine generator.
3) Arrangement of axes of gas and steam turbine generators	To be arranged in parallel
4) Gas turbine air filter	To be located as high as possible above ground level
5) Control and monitoring and electrical equipment	To be located in the rooms integrated with the turbine building or in the separate building
(5) Emission	
1) Exhaust gas emissions (O_2 15% dry basis) (75 - 100% load of gas turbine over all specified ambient conditions)	
a. NOx (ppmv)	< 25
b. SOx (ppmv)	Changeable depending on sulfur content in fuel
c. CO (ppmv)	< 15
d. PM_{10} (mg/Nm^3)	< 10
2) Airborne noise emission with steady state conditions without background noise	
a. Sound pressure level at a height of 1 m on the station boundary	< 55 dB(A): Daytime < 45 dB(A): Nighttime
b. Sound pressure level at a height of 1 m and a distance of 1 m from equipment or enclosure	< 85 dB(A)

Description	Conditions and/or Specifications
(6) Properties of Fuel Gas	
a. Temperature	Performance point: 15 °C Min. -5 °C, Max. 22 °C
b. Pressure	Performance point: 10 barg Min.10 barg, Max. 12 barg
c. Composition	Perf. Point / Range (will be provided later)
CH_4 mol %	92.951 Min. / Max.
C_2H_6 mol %	3.999 Min. / Max.
C_3H_8 mol %	0.920 Min. / Max.
n-C_4H_{10} mol %	0.210 Min. / Max.
i-C_4H_{10} mol %	0.170 Min. / Max.
n-C_5H_{12} mol %	0.060 Min. / Max.
i-C_5H_{12} mol %	0.080 Min. / Max.
C_6H_{14} mol %	0.160 Min. / Max.
N_2 mol %	0.510 Min. / Max.
O_2 mol %	0.020 Min. / Max.
CO_2 mol %	0.920 Min. / Max.
H_2S mol %	0.000 Min. / Max.
Total mol %	100
d. Net specific energy (Lower calorific value)	48,082 kJ/kg ~
e. Gross specific energy (Higher calorific value) at performance point	53,363 kJ/kg ~
f. Specific gravity (0 ℃)	0.782 kg/m^3N ~
g. Wobbe Index (Gas Index) defined by ISO3977-4	48,343 kJ/m^3N ~
(7) Make-up Water for Bottoming System	
a. Type of water	Demineralized Zeravshan River water
b. Temperature	0°C to 28°C
e. Flow rate	175 t/h/unit
(8) Make-up Water for Hot Water	
a. Type of water	Pre-treated city water
b. Temperature	10 °C to 30 °C
e. Flow rate	386 t/h max./unit
(9) Operation and Maintenance	
1) Gas turbine	Supply of spare parts as per LTSA Contract
2) Other equipment	Supply of spare parts for two (2) years of actual operating hours.
3) Training of O&M staff at EPC contractor's works	Yes

Description	Conditions and/or Specifications
4) Three (3) resident engineers (mechanical, electrical and control) of EPC contractor during defect liability period for operation and maintenance support	Yes
5) Inspection intervals of gas turbine on an EOH basis	
a. Combustion inspection	12,000 hours
b. Turbine inspection	24,000 hours
c. Major inspection	72,000 hours
6) Inspection intervals of other equipment	As per recommendation of manufacturer
7) Replacement intervals of filter elements	More than 8,000 actual operating hours for ISO fine dust
(10) Guarantee Items	
1) Gas turbine gross power output on simple cycle mode	No
2) Gas turbine gross power output efficiency on simple cycle mode	No
3) Plant net power output	Yes
4) Plant net power output efficiencies	Yes
5) Plant net thermal efficiencies	Yes
6) Exhaust gas emissions at 75 - 100% load of gas turbine over all specified ambient conditions	
a. NOx	Yes
b. CO	Yes
c. PM_{10}	Yes
7) Airborne noise emissions on steady state conditions under all specified operating conditions	
a. Sound pressure levels at a height of 1 m on the station boundary limit	Yes
b. Sound pressure level at a distance of 1 m and a height of 1 m from equipment or noise attenuation cover	Yes
8) Successful completion of two (2) weeks reliability run	Yes
9) Shaft vibration of gas and steam turbine sets based on related ISO standards during the reliability run	Yes

(Source: Information from JSC Thermal Power Plant and estimated by JICA Survey Team)

7.1.2 Outline of the Plant System

This plant is a combined cycle cogeneration plant (GTCC) which concurrently produces both heat and power energies. The plant is comprised of the following main components; a gas turbine, a gas turbine generator, an HRSG with a supplementary firing facility (if necessary), a steam turbine, a steam turbine generator, a fuel gas compressor station, a water treatment system for plant make up water, service water and exported steam, a hot water production system with water treatment system for hot water make up, and a waste water treatment system.

The plant shaft configuration will be studied for the selected model of gas turbine.

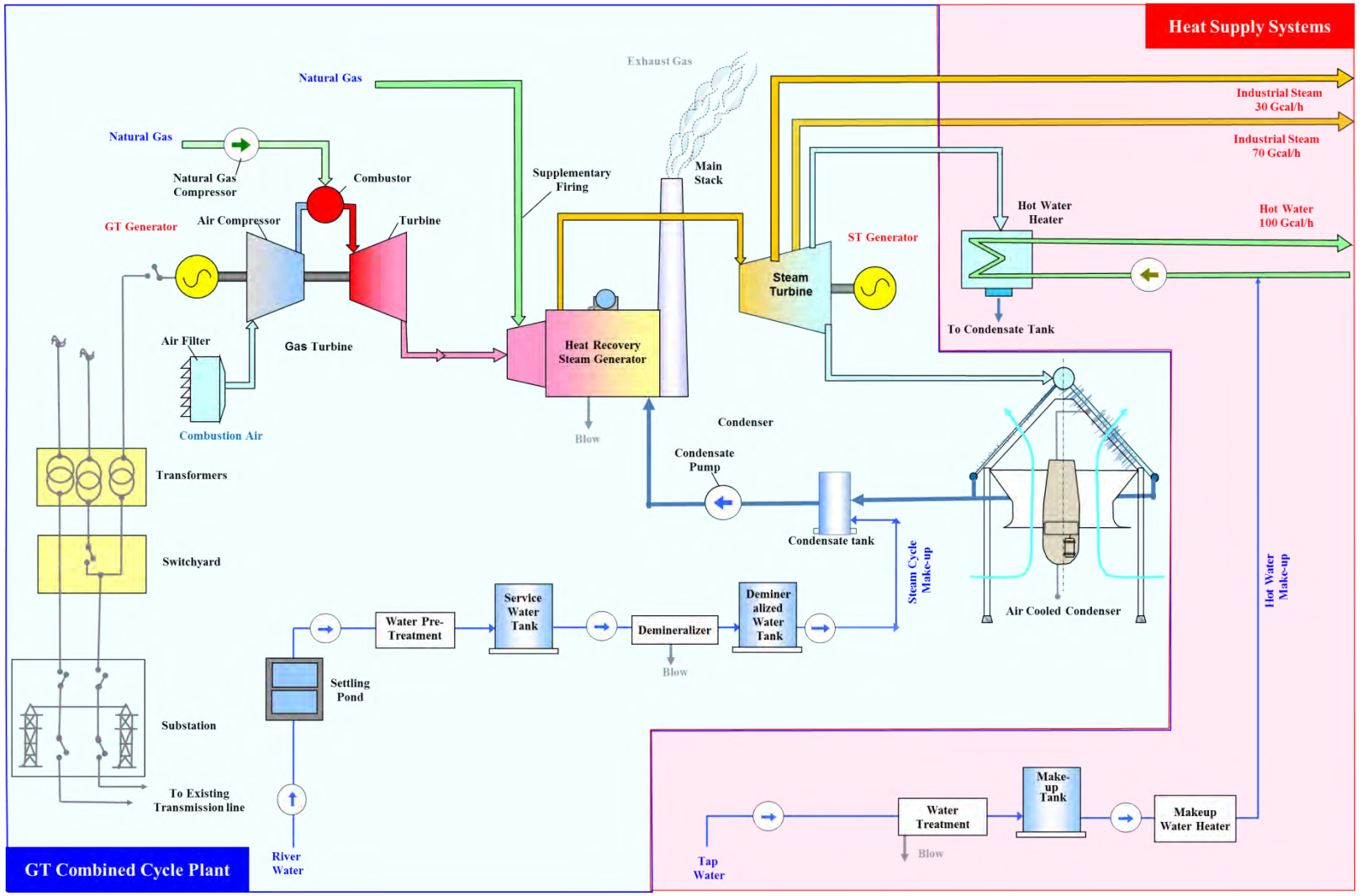
The gas turbine is of a larger capacity, higher performance H/J class type which are available in the world market with a wealth of commercial operating experience.

The HRSG is of triple-pressure and reheat cycle type. The H/J class gas turbine is commonly coupled with the triple-pressure and reheat cycle HRSG to elevate the plant thermal efficiency.

Depending upon the heat and power requirements for this project, the bottoming system to be coupled with H/J class gas turbine may meet the requirements without provision of the supplementary firing.

The steam turbine is of three-admission, triple-extraction of high, medium and low pressure steams and of condensing type. The high pressure steam may be extracted from cold reheat line and the medium pressure steam is extracted from the IP steam turbine section and they are exported to adjacent company, Navoi AZOT, as industrial steam as it is. The low pressure steam from the LP steam turbine section is supplied to the production system of the district hot water. The pressure of the extracted steam is controlled with the extraction control valves integrated in the steam turbine, or externally controlled.

The hot water production system consists of a water storage tank, water treatment facilities, deaeration facility, steam supply system to water heat exchangers and a hot water storage tank. Figure 7.1.2-1 is a simplified schematic diagram of the cogeneration system of this project.



(Source: JICA Survey Team)

Figure 7.1.2-1 Simplified Schematic Diagram of Total Cogeneration System

7.1.3 Study on Shaft Configuration

(1) Type of Shaft Configuration

Here made is the simple comparison study on the type of the shaft configuration of the combined cycle power plant (hereinafter to be collectively called as GTCC) comprised of the one (1) gas turbines one (1) heat recovery steam generator (hereinafter to be collectively called as HRSG), one (1) steam turbines and generator(s).

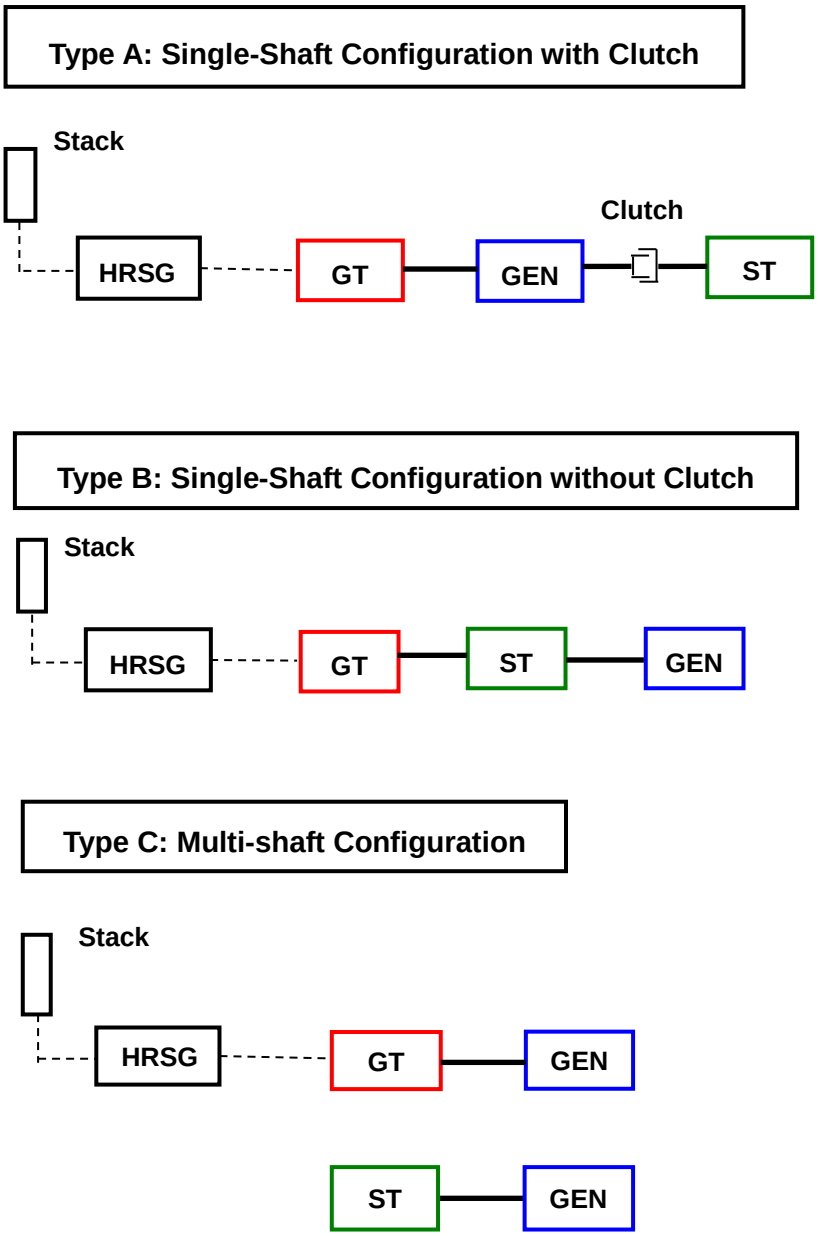
For this project, the GTCC using the largest capacity gas turbine of H or J class with the highest temperature and largest volume of exhaust gas is envisaged. In case that the gas turbine simple cycle operation is specified, a bypass stack with a diverter damper is required. However, the diverter damper cannot cope with the reliable and functional operation for a long time because it is of a huge dimension and exposed to higher temperature. Therefore, this study is performed provided that the gas turbine simple cycle operation is under no consideration.

Basically, there are two (2) types of shaft configurations of a single-shaft and multi-shaft configurations. In case of a single-shaft configuration, the gas turbine and steam turbine shafts are connected on the same shaft. In this case, the larger capacity generator common to gas and steam turbines is employed. In case of this shaft configuration, two (2) types are to be considered. One is the type with a clutch between the generator and the steam turbine. This type is called as Type A in this shaft configuration study. One main reason for installation of the clutch is because the steam turbine can be located at the end of the shaft. The other is the type without the clutch. This type is called as Type B shaft configuration.

In case of a multi-shaft configuration, the gas turbine and steam turbine shafts are separate. This type is called as Type C shaft configuration. In this case, a bypass stack with a diverter damper used to be equipped for a simple cycle mode operation of the gas turbine. However, in case of use of the H/J class gas turbine for 50 Hz use, the damper size exceeds eight (8) meters square. It is impossible to expect reliable and functional operation of such a larger size damper for long time in atmosphere of the higher temperature more than 600 ^{o}C. Consequently, the bypass stack is not considered for Type C shaft configuration.

The comparison study is performed from the viewpoints of plant thermal efficiency, operating flexibility, operability, start-up requirement, application experience, plant operating reliability, plant maintenance cost, installation footprint area, phased construction, construction cost, power generation cost, transportation and impact on electrical networks among above three (3) types of GTCC shaft configurations.

Figure 7.1.3-1 shows skeletons of the types A, B and C shaft configurations.



(Source: JICA Survey Team)

Figure 7.1.3-1 Type of Shaft Configuration

As shown above, in case of Types A and B shaft configurations, one (1) large capacity generator common to both gas and steam turbines is employed. In case of Types C shaft configuration, an individual generator is employed for the gas and steam turbines.

(2) Plant Thermal Efficiency

The capacity size of the generator of Type A shaft configuration is the same as Type B shaft configuration. The capacity sizes of the gas and steam turbine generators of Type C shaft configuration are approximately two third and one third times Types A and B shaft configurations. Therefore, the efficiency of the gas turbine generator of Type C shaft configuration is less by approximately 0.2 % relatively and the efficiency of the steam turbine generator of Type C shaft configuration is less by approximately 0.8 % relatively.

Consequently, the plant thermal efficiency of each shaft configuration can be relatively expressed as tabulated in the below table.

Table 7.1.3-1 Plant Thermal Efficiency

Type of Shaft Configuration	A	B	C
Plant Thermal Efficiency (%)	100.0	± 0.0	−0.40

(Source: JICA Survey Team)

(3) Operational Flexibility

In any types of shaft configurations, the plant could be operated on only the conditions that all the components of the power train are healthy.

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-2 Operational Flexibility

Type of Shaft Configuration	A	B	C
Operational Flexibility	Base	Similar	Similar

(Source: JICA Survey Team)

(4) Operability

The GTCC can be operated only by automatic adjustment of the fuel flow into the gas turbine and the operation cycle of start-up, steady operation and shut down can be fully automated irrespective of the type of the shaft configuration. There is, therefore, no substantial difference with the operability among any types of shaft configurations.

In case of Types A and B shaft configurations, the plant consists of four (4) major components of a gas turbine, a HRSG, a steam turbine and a generator. While, Type C shaft configuration consists of five (5) major components. The results through above discussion can be summarized as tabulated below.

Table 7.1.3-3 Operability

Type of Shaft Configuration	A	B	C
Operability	Base	Similar	Slightly complex

(Source: JICA Survey Team)

(5) Plant Start-up Requirement

In case of Type A shaft configuration, the gas turbine and generator can be started as the steam turbine is forced to be slowly rotated at the low speed because the clutch works as the fluid coupling even if the clutch is mechanically disengaged. This is a reason why the gas turbine cannot operate on a simple cycle mode even if the clutch is installed between the generator and the steam turbine. The steam turbine is started after the steam flow enough for start-up of the steam turbine is produced with the HRSG and then is engaged with the gas turbine and generator. Therefore, the auxiliary steam requirement is limited as the steam flow for cooling of the steam turbine rear stage blades is not necessary during the start-up cycle.

In case of Type B shaft configuration, the steam turbine is forced to be rotated together with the gas turbine and generator. Therefore, the auxiliary steam for cooling of the steam turbine rear stage blades is required. Consequently, much more auxiliary steam is required for start-up of Type B shaft configuration.

In case of Type C shaft configuration, firstly, the gas turbine and generator will be started up as the steam turbine is in standstill conditions. The steam turbine and generator cannot be started up until the steam with conditions enough for start-up of the steam turbine is produced with the HRSG in its power train. The steam produced during the time from the gas turbine start-up to the steam turbine start-up is dumped into the condenser. For the purpose, some steam for sealing of the steam turbine glands is required.

In cases of Types A and C shaft configurations, the power requirements for the starting devices are same and approximately 2.0 % of the gas turbine power output. In case of Type B shaft configuration, the starting device power requirement is larger because the steam turbine must be rotated together with the gas turbine and generator and is approximately 2.5 %.

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-4 Plant Start-up Requirement

Type of Shaft Configuration		A	B	C
Start-up Requirements	External steam	Yes with less steam	Yes with more steam	Yes with less steam
	Starting device power requirement	Approx. 2.5 %	Approx. 2.0 %	Approx. 2.0 %

(Source: JICA Survey Team)

(6) Application Experience

Table 7.1.3-19 Application Experience of MHPS J Class Gas Turbine, Table 7.1.3-20 Application Experience of GE H Class Gas Turbine and Table 7.1.3-21 Application Experience of SMS H Class Gas Turbine show Application Experience Lists of GTCCs using H and J classes of gas turbines of GE, MHPS and SMS respectively. Table 7.1.3-22 Number of GTCCs every Type of Shaft Configuration is the summary table of previous three (3) tables showing the number of GTCCs every type of shaft configuration. According to this table, it can be found that there are application experiences similar with three (3) types of shaft configurations of A, B and C. The application experiences of single shaft GTCCs with a SSS clutch exist more in 3,000 rpm gas turbine than 3,600 rpm one.

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-5 Application Experience

Type of Shaft Configuration		A	B	C
Application Experience	3,000 rpm	Base	Less	Similar
	3,600 rpm	Base	Similar	Similar
	Total	Base	Similar	Similar

(Source: JICA Survey Team)

(7) Plant Operating Reliability

The plant operating reliability of each shaft configuration type of GTCC can be evaluated by the plant operating probability to be theoretically calculated with the operating reliability factors of the main equipment which are presumed as relative values based on our experiences and engineering sense as tabulated below:

Name of Equipment	Equipment Operating Reliability Factor
Gas turbine:	D1 = 0.980

Heat recovery steam generator: D2 = 0.985
Steam turbine: D3 = 0.990
GT/ST generator and transformer: D4 = 0.995
SSS Clutch: D5 = 0.998
GT generator and transformer: D6 = 0.995
ST generator and transformer: D7 = 0.995

The plant operating probability can be divided into two (2) types of probability on an operating hour basis (POPH) and generated power energy basis (POPE).

(1) POPH

The following Table 7.1.3-6 Theoretical Calculation Equation of Plant Operating Probability shows the theoretical calculation equations of POPHs for three (3) types of shaft configurations. The Table 7.1.3-7 Theoretical Calculation Results of POPH is the theoretical calculation results of POPHs which can be obtained by substituting the values of above equipment operating reliability factors into the equations of Table 7.1.3-9 Theoretical Calculation Results of POPE.

Table 7.1.3-6 Theoretical Calculation Equation of Plant Operating Probability on Operating Hour Basis (POPH)

Type of Shaft Configuration	Type A	Type B	Type C
POPH	D×D4×D5	D×D4	D×D6×D7

(Source: JICA Survey Team)

Where, D = D1×D2×D3

Table 7.1.3-7 Theoretical Calculation Results of POPH

Type of Shaft Configuration	Type A	Type B	Type C
POPH	0.94897	0.95087	0.94611

(Source: JICA Survey Team)

The POPH of each type of shaft configuration means the theoretical operating probability on an operating hour basis of the plant under the assumed operating reliability factors of main equipment. As can be seen from Table 7.1.3-9 Theoretical Calculation Results of POPE, the POPH of Type B shaft configuration (1 on 1 single-shaft configuration without a clutch) is highest because the number of main equipment constituting the power train is the lowest. The reason why the PORH of Type C shaft configuration is less than Type A is because the some operating reliability factors of main equipment consistuating Type C are lower than Type A..

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-8 Theoretical Calculation Results of POPH in Relative Percentage

Type of Shaft Configuration	A	B	C
POPH	100 %	+ 0.19 %	-0.29 %

(Source: JICA Survey Team)

(2) POPE

The total POPE of each type of shaft configuration means the theoretical operating probability on a generated power energy basis of the plant under the assumed operating reliability factors of main equipment. Therefore, it can be calculated by multiplying the POPH in Table 7.1.3-9

Theoretical Calculation Results of POPE by the relative plant thermal efficiency described in the previous sub-section (2) "Plant Thermal Efficiency". The calculation results are shown in the Table 7.1.3-18 Summary of Comparison Study Results on Type of Shaft Configuration and of similar tendency to that of the POPE.

Table 7.1.3-9 Theoretical Calculation Results of POPE

Type of Shaft Configuration	Type A	Type B	Type C
POPE	0.94897	0.95087	0.94233

(Source: JICA Survey Team)

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-10 Theoretical Calculation Results of POPE in Relative Percentage

Type of Shaft Configuration	A	B	C
POPE	100 %	+ 0.19 %	-0.66 %

(Source: JICA Survey Team)

(8) Plant Maintenance Cost

The plant maintenance cost is generally dependent upon the number of main equipment of the power train to be employed. From such a point of view, it is envisaged that the maintenance cost of the Type A is higher than Type B because Type A is additionally equipped with a clutch. However, the maintenance cost difference between both Types is deemed negligible small. The Type C is composed of two (2) generators and transformers, while Types A and B consist of one (1) generator and transformer. Therefore, the maintenance cost of Type C is deemed to be slightly higher than Types A and B.

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-11 Maintenance Cost

Type of Shaft Configuration	A	B	C
Plant maintenance Cost	Base	Similar	Slightly high

(Source: JICA Survey Team)

(9) Installation Footprint Area

In case of the GTCC consisting of one (1) gas turbine, the installation footprint area of the power train for a multi-shaft type GTCC is generally larger than the single-shaft type GTCC.

Figure 7.1.3-2 shows the installation footprint areas of the power trains of Type A and Type C shaft configuration GTCCs. As can be seen from this figure, the installation footprint area of Type C shaft configuration is larger by approximately 40 % than Type A.

That of Type A shaft configuration is deemed to be inconsiderably larger than that of Type B because the space to install the SSS clutch is required.

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-12 Installation Footprint Area

Type of Shaft Configuration	A	B	C
Installation Footprint Area	Base	Similar	+40 %

(Source: JICA Survey Team)

(10) Phased Construction

In any cases of three (3) types of GTCCs, the phased construction where the gas turbine will be constructed in advance is not available because of no bypass system of the gas turbine exhaust gas.

The multi-shaft configuration with the bypass system has the specific feature that the phased construction can be available. The completion time of the gas turbine package is normally faster than the bottoming system, which means that it can be put into commercial operation on a simple cycle in advance of a combined cycle operation. This feature is more advantageous for the project which must cope with steeply increasing power demand.
The results through above discussion can be summarized as tabulated below.

Table 7.1.3-13 Phased Construction

Type of Shaft Configuration	A	B	C
Phased Construction	No	No	No

(Source: JICA Survey Team)

(11) Construction Cost

The construction costs of three (3) types of GTCCs are estimated using a software program and the results are shown in relative cost difference as tabulated below.

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-14 Construction Cost

Type of Shaft Configuration	A	B	C
Construction Cost	100% (Base)	+2.5 %	+11.4 %

(Source: JICA Survey Team)

The main reason why the construction cost of Type B is heigher than Type A shaft configuration is because the steam turbine is of downward exhaust and double-flow type and the turbine shaft center height must be higher than Types A and C shaft configurations, consequently the turbine building height of the Type B must be elevated.

It is the reason why the construction cost of the Type C is higher than any other Types that the Type C consists of two (2) generators and its turbine building space area must be largest.

(12) Relative Power Generation Cost

The relative power generation costs of Type B and C against Type A can be calculated by such manners as described below.

1) Annual capital recovery cost

The annual capital recovery cost (depreciation plus interest) is proportional to the construction cost. Therefore, the relative annual capital recovery costs of three (3) types of GTCCs could be as shown below:

Type of Shaft Configuration	Annual Relative Recovery Cost
A	100.00% (Base)
B	+ 2.5 %
C	+ 11.4 %

2) Annual fuel consumption

The annual fuel consumption is proportional to the POPH. Therefore, annual relative fuel consumptions of the other two (2) Types against Type A are estimated as tabulated below:

Type of Shaft Configuration	Annual Relative Fuel Consumption
A	100.00 %
B	+ 0.19 %
C	- 0.29 %

3) Annual relative generated power energy

Annual relative generated power energy is proportional to POPE. Therefore, their relative values can be obtained as below.

Type of Shaft Configuration	Annual Relative Generated power energy
A	100.00 %
B	+ 0.19 %
C	- 0.66 %

4) Relative power generation cost

The power generation cost (GC) can be roughly calculated with the following equation.

$$GC = A \times \frac{CC}{PE} + B \times \frac{FC}{PE} = \frac{A \times CC + B \times FC}{PE} \quad (1)$$

Where,

$A \times \frac{CC}{PE}$: Generation cost due to annual capital recovery cost

$B \times \frac{FC}{PE}$: Generation cost due to annual fuel cost

GC: Generation cost
CC: Construction cost
FC: Annual fuel consumption
PE: Annual generated power energy
A: Proportional constant coefficient
B: Proportional constant coefficient

The total differential form of the above equation (1) can be expressed as shown below:

$$\frac{\Delta GC}{GC} = \frac{A \times \Delta CC + B \times \Delta FC}{A \times CC + B \times FC} - \frac{\Delta PE}{PE} \quad (2)$$

Where, if the ratio of $B \times \frac{FC}{PE}$ to $A \times \frac{CC}{PE}$ is assumed to be *K*, the equation (2) can be transformed as shown below:

$$\frac{\Delta GC}{GC} = \frac{1}{1+K}\frac{\Delta CC}{CC} + \frac{K}{1+K}\frac{\Delta FC}{FC} - \frac{\Delta PE}{PE} \quad (3)$$

The equation (3) is the method to calculate the minor change of the generation cost due to minor changes of the construction cost (CC), annual fuel consumption (FC) and annual generated power energy (PE).

The calculation results of relative generation costs for $K = 1.5$ (tentatively assumed for the case of this project) are calculated as tabulated below:

Table 7.1.3-15 Power Generation Cost

Type of Shaft Configuration	A	B	C
Power Generation Cost	100.0 %	+0.92 %	+5.06 %

(Source: JICA Survey Team)

(13) Transportation and Handling

Among main components of the gas turbine, HRSG, steam turbine, generator and step-up transformer, the heaviest and bulkiest component which cannot be divided in parts for transportation is the generator stator. Among three (3) types of shaft configurations, the generator of Types A and B shaft configurations is heavier and bulkier than Type C because their capacity common to the gas and steam turbines is approximately 1.5 times them of Type C. Therefore, the transportation and handling of Types A and B shaft configuration is deemed to be more difficult compared with Types C.

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-16 Transportation and Handling

Type of Shaft Configuration	A	B	C
Transportation and Handling	Base	Same	Easier

(Source: JICA Survey Team)

(14) Impact on Electrical Networks

The gas turbine/generator cannot be operated on a simple cycle mode due to no bypass system of the gas turbine exhaust gas. Therefore, the maximum power output for each type of shaft configuration, which may be quit from the electrical networks when either component out of main components of the power train is troubled, is roughly estimated as tabulated below. The maximum power output is estimated on the conditions that the H/J class GTCC is operated with a heat export of 100 Gcal/hr at an ambient temperature of 0 degree C.

Type A: 700 MW
Type B: 700MW
Type C: 700 MW

From above results the impact on the electrical networks when the power train trips is the same for all Types of shaft configurations.

The results through above discussion can be summarized as tabulated below.

Table 7.1.3-17 Impact on Electrical Networks

Type of Shaft Configuration	A	B	C
Impact on Electrical Networks	Base	Same	Same

(Source: JICA Survey Team)

The impacts on the electrical networks are technically analyzed and confirmed in the later stage of this feasibility study.

(15) Study Summary

The study results described above are summarized in Table 7.1.3-18 Summary of Comparison Study Results on Type of Shaft Configuration. The cell highlighted by yellow color show that the type of shaft configuration of the colored cell is more advantageous than other type(s) of shaft configuration(s) in terms of the related comparison item.

As shown in this table, if the shaft configuration is selected by the total number of highlighted cells, Type A shaft configuration is ranked as a top priority and Type C shaft configuration a bottom priority. On the other hand, there may exist the thought that the type of shaft configuration should not be selected by the total area of highlighted cells because the type of shaft configuration to be selected is changeable depending upon where the priority is placed.

The construction and power generation costs are the most crucial comparison items for introduction of the project. From Table 7.1.3-18 Summary of Comparison Study Results on Type of Shaft Configuration, Type A shaft configuration is most advantageous in terms of them.

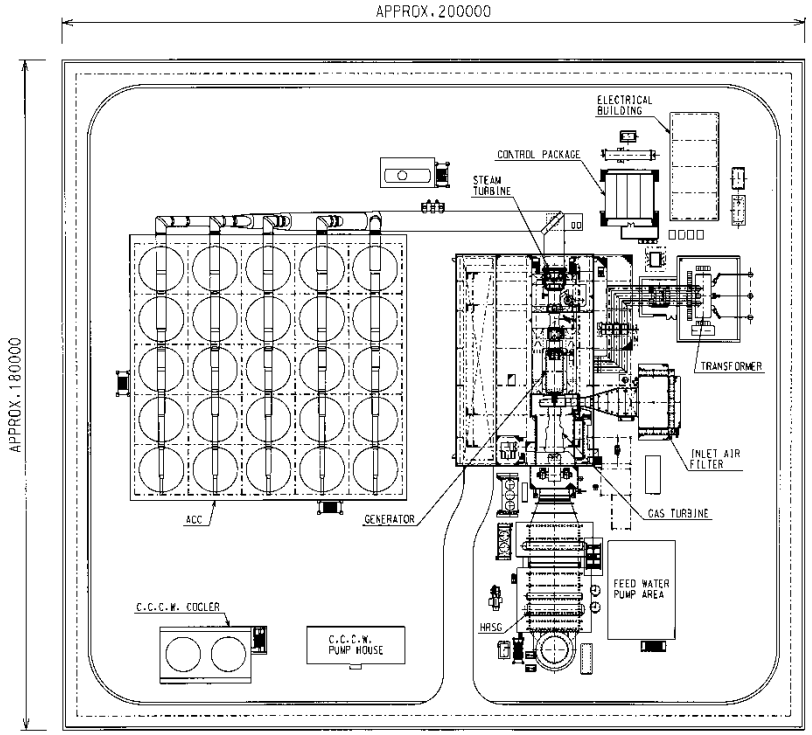
In terms of the application experiences with the type of shaft configuration of H/J class GTCC, any types have sufficient application experiences.

Judging from above discussion results, Type A seems to be the most recommendable. However, in case of Type A it is not confirmed that the generator stator which is the bulkiest and heaviest component not divided into parts can be economically transported.
Consequently, Study Team will recommend Type C shaft configuration GTCC and all the studies hereinafter are carried out on Type C shaft configuration which is of multi-shaft type.

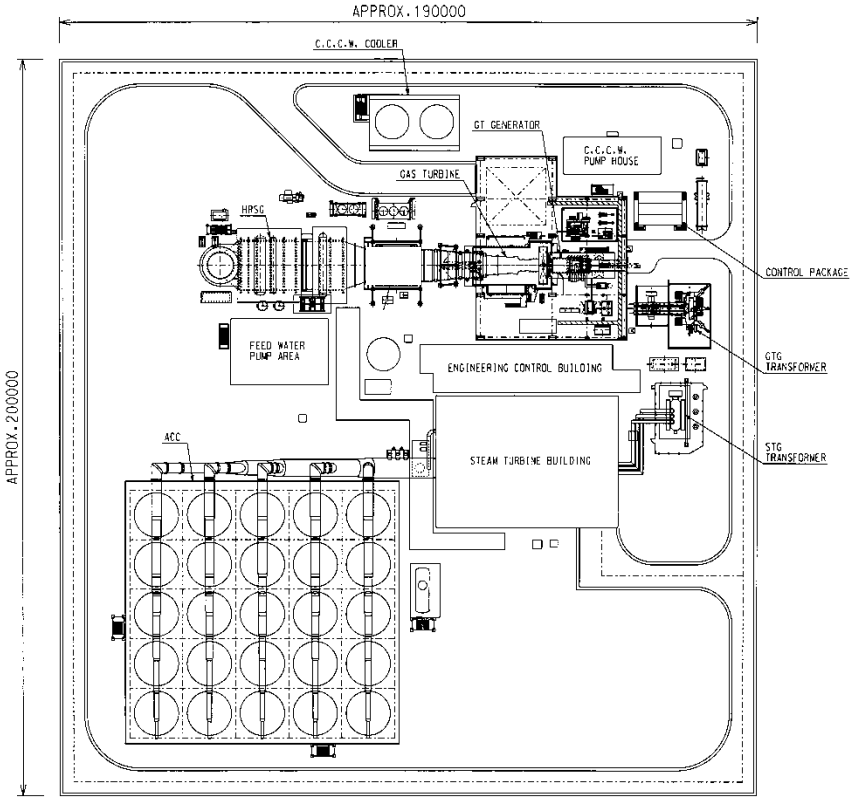
Table 7.1.3-18 Summary of Comparison Study Results on Type of Shaft Configuration

Comparison Item		Type of Shaft Configuration		
		A	B	C
1. Thermal Efficiency		Base (100 %)	± 0.0 %	- 0.4 %
2. Operational Flexibility		Base	Similar	Similar
3. Operability		Base	Similar	Slightly complex
4. Start-up Requirement	External steam	Base	More steam required	Similar
	Power for starting device	Approx. 2.0 % of GT capacity	Approx. 2.5 % of GT capacity	Approx. 2.0 % of GT capacity
5. Application Experience	3,000 rpm GTCC	Base	Less	Similar
	3,600 rpm GTCC	Base	Similar	Similar
6. Operating Reliability	PORH	Base (100%)	+ 0.19 %	-0.29 %
	PORE	Base (100%)	+ 0.19 %	-0.66 %
7. Maintenance Cost		Base	Similar	Similar
8. Footprint Area of Power Block		Base (100%)	Similar	+ 40 %
9. Phased Construction		No	No	No
10. Construction Cost		Base (100%)	+ 2.50 %	+ 11.4 %
11. Power Generation Cost		Base (100%)	+0.92 %	+5.06 %
12. Transportation		Base	Similar	Slightly easier
13. Impact on Electrical Networks		Base	Same	Same

(Source: JICA Survey Team)



Single-shaft Configuration



Multi-shaft Shaft Configuration

(Source: Courtesy of MHPS)

Figure 7.1.3-2 Installation Footprint Area of Types A and Type C Shaft Configurations

Table 7.1.3-19 Application Experience of MHPS J Class Gas Turbine

Name of Power Station	Country	Model	Number of Units	Configuration	SSS Clutch (Yes/No)	Commercial Operation
Kawasaki PS	Japan	M701J	2 units	Single-Shaft, 1on1 x 2	N	2016
Himeji No.2 PS	Japan	M501J	6 units	Single-Shaft, 1on1 x 6	N	2013～2015
Shin Oita PS	Japan	M501J	1 unit	Single-Shaft, 1on1 x 1	N	2016
T-point, Takasago	Japan	M501JAC	1 unit	Multi-Shaft, 1on1 x 1	N	2015
Pocheon GTCC	Korea	M501J	1 unit	Multi-Shaft, 1on1 x 1	N	2016
Chuncheon CPP	Korea	M501J	1 unit	Single-Shaft, 1on1 x 1	Y	2017
Osan	Korea	M501J	1 unit	Multi-Shaft, 1on1 x 1	N	2016
Shin Pyongteak	Korea	M501J	2 units	Multi-Shaft, 2on1 x 1	N	2019
Dongducheon	Korea	M501J	4 units	Multi-Shaft, 2on1 x 2	N	2014
Yulchon II	Korea	M501J	2 units	Multi-Shaft, 2on1 x 1	N	(S/C)2013 (C/C)2014
Ulsan #4	Korea	M501J	2 units	Multi-Shaft, 2on1 x 1	N	(S/C)2013 (C/C)2014
Grand River Dam Authority	America	M501J	1 unit	Multi-Shaft, 1on1 x 1	N	2017
Greensville County	America	M501J	3 units	Multi-Shaft, 3on1 x 1	N	2018
Others: MHPS has Supply Experiences of J class gas turbines over 55 units.						

(Source:MHPS website (https;//www.mhps.com/))

Table 7.1.3-20 Application Experience of GE H Class Gas Turbine

Name of Power Station	Country	Model	Number of Units	Configuration	SSS Clutch (Yes/No)	Commercial Operation
Inland	America	7H	2 units	Multi-Shaft, 1on1 x 2	N	2008
Exelon	America	7HA.02	4 units	Multi-Shaft, 2on1 x 2	N	2017
TVA Allen	America	7HA.02	2 units	Multi-Shaft, 2on1 x 1	N	2017
Sewaren	America	7HA.02	1 unit	Multi-Shaft, 1on1 x 1	N	2018
Rio Grande	Brazil	7HA.02	3 units	-	-	2019
Trafford	UK	9HA.01	3 units	Single-Shaft, 1on1 x 3	Y	2018
Thorpe	UK	9HA.01	2 units	Single-Shaft, 1on1 x 2	Y	2019
Baglan Bay	UK	9H	1 unit	Single-Shaft, 1on1 x 1	Y	2002
EDF Bouchain	France	9HA.01	1 unit	Single-Shaft, 1on1 x 1	Y	2016
Leverkusen	Germany	9HA.01	1 unit	Single-Shaft, 1on1 x 1	Y	Later
Kazan	Russia	9HA.01	1 unit	Co-gen(GT+HRSG)	N	2016
Anyang	Korea	7HA.02	2 units	Multi-Shaft, 2on1 x 1	N	2018
Chubu	Japan	7HA.01	6 units	Multi-Shaft, 3on1 x 2	N	2017～2018
Hokkaido	Japan	9HA.01	1 unit	Single-Shaft, 1on1 x 1	Y	2019
Futsu	Japan	9H	3 units	Single-Shaft, 1on1 x 3	N	2008～2010
MPPMCL/Bhikki	Pakistan	9HA.01	2 units	Multi-Shaft, 2on1 x 1	N	2017
MPPMCL/Balloki	Pakistan	9HA.01	2 units	Multi-Shaft, 2on1 x 1	N	2017
MPPMCL/Haveli Bahadur Sha	Pakistan	9HA.01	2 units	Multi-Shaft, 2on1 x 1	N	2017
Alba Power Station 5	Bahrain	9HA.01	3 units	Multi-Shaft, 1on1 x 3	N	2019
EGAT Bang Pakong	Thailand	9HA.01	2 units	Multi-Shaft, 2on1 x 1	N	2020
Central Nuevo Pueruto 2	Argentina	9HA.01	1 unit	Multi-Shaft, 1on1 x 1	N	2017
Others: General Electric has over 70 H-class gas turbines under contract with 23 units in the field.						

(Source: GE website)

Table 7.1.3-21 Application Experience of SMS H Class Gas Turbine

Name of Power Station	Country	Model	Number of Units	Configuration	SSS (Yes/No)	Commercial Operation
E. On/Utrich Hartman	Germany	SGT5-8000H	1 unit	Single-Shaft, 1on1 x 1	Y	2011
Dangjin 3	Korea	SGT6-8000H	1 unit	Single-Shaft, 1on1 x 1	Y	2013
Cape Canaveral	America	SGT6-8000H	3 units	Multi-Shaft, 3on1 x 1	N	2013
Andong	Korea	SGT6-8000H	1 unit	Single-Shaft, 1on1 x 1	Y	2014
Ansan	Korea	SGT6-8000H	2 units	Multi-Shaft, 2on1 x 1	N	2014
Cengiz Enerji Samsun	Turkey	SGT5-8000H	1 unit	Single-Shaft, 1on1 x 1	Y	2015
Düsseldorf	Germany	SGT5-8000H	1 unit	Single-Shaft, 1on1 x 1	Y	2015
Enerji SA/Bandirma II	Turkey	SGT5-8000H	1 unit	Single-Shaft, 1on1 x 1	Y	2016
Stadtwerke Dusseldorf AG/Fortuna	Germany	SGT5-8000H	1 unit	Single-Shaft, 1on1 x 1	Y	2016
Burullus	Egypt	SGT5-8000H	8 units	Multi-Shaft, 2on1 x 4	N	2017
New Capital	Egypt	SGT5-8000H	8 units	Multi-Shaft, 2on1 x 4	N	2017
Beni Suef	Egypt	SGT5-8000H	8 units	Multi-Shaft, 2on1 x 4	N	2017
CAPCO/Black Point Power Station	China	SGT5-8000H	1 unit	Single-Shaft, 1on1 x 1	N	2020
Others: Siemens has 85 H-class gas turbines under contract with around 60 units in commercial operation already.						

(Source: Siemens website)

Table 7.1.3-22 Number of GTCCs every Type of Shaft Configuration

Type of Shaft Configuration		Type of Shaft Speed (rpm)	Number of GTCCs			Total
			MHPS	GE	SMS	
Single-shaft	Type A	3,000	0	9	6	18
		3,600	1	0	2	
	Type B	3,000	2	3	0	12
		3,600	7	0	0	
Multi-shaft	Type C	3,000	0	8	12	41
		3,600	10	9	2	
Total			20	29	22	71

(Source: Prepared by JICA Survey Team)

7.1.4 Candidate Gas Turbines and Performance

(1) Design Codes and Standards

The gas turbine system shall be basically designed as per ISO 3977-3 "Gas turbines-Procurement-Part3: Design requirements" and ISO 21789 "Gas turbine applications-Safety" or equivalent codes and standards.

(2) Candidate Models

The gas turbine is the most important component to influence the operating reliability of the combined cycle power plant therefore it is required to be possessed of the highest operating reliability. Unlike custom-made steam turbines which are designed every time an order is placed, the gas turbine is normally of manufacturer's standard design to avoid the longer development time before delivery and depress the cost due to custom design. It is a normal practice to select the proper gas turbine models to meet the requirements for the project among the standard lineups of gas turbine manufacturers.

The performance specifications of standard design gas turbines which are available in the present market are annually published as the Gas Turbine World Handbook. Their performances are not specified on the site conditions, but normally on ISO conditions. In the case of this project, the power output as a gas turbine combined cycle cogeneration plant (hereinafter to be called collectively GTCC) is supposed to be nominally specified at 600 MW considering employment of larger size gas turbine than the existing gas turbines under a heat supply of 200 Gcal/hr on the site rated conditions of ambient dry bulb temperature of 15 ºC, 60 % relative humidity, and barometric pressure of 97.4 kPa on natural gas The heat and power output capacities shall be finalized through this feasibility study considering the model of gas turbine to be applied for this project and intents of the Counterpart. Choosing the gas turbine models to meet the said heat and power output capacity requirements, they shall be of H and J class models with a power output capacity from 450 MW to 550 MW on ISO conditions and natural gas depending upon provision of the supplementary firing.

The gas turbine is always in the process of development and its design parameters are upgraded year by year. Nowadays, the H and J classes of models of gas turbines with higher performances than F class models have been accumulating commercial operating experiences. However, reportedly some model(s) suffers from serious problems and are forced to be countermeasured. Therefore, confirmation shall be made at the PQ stages to whether the models which may be proposed have the successful commercial operating experience sufficient to verify the operating reliability of them. For the purpose of confirmation of such a situation, the proposed gas turbine shall meet the criteria requirements. The criteria requirements shall be such that the proposed gas turbine shall be the machine technically similar to the reference gas turbines of which commercial operation experiences at the time of execution of Prequalification are as described below.

a) The total successful commercial operating hours of at least two (2) reference gas turbines shall be not less than 48,000 actual operating hours (AOH) as a total.

b) The successful commercial operating hours of one (1) unit out of the reference gas turbines shall be more than 24,000 AOH from commencement of the first commercial operation and shall contain the continuous operation of more than 8,000 AOH.

c) The hot gas path inspection has been performed for at least one (1) unit of the reference gas turbines after 16,000 AOH from commencement of the first commercial operation and the hot gas path parts have been confirmed to have had been in the healthy conditions without any difficulties such as abnormal damages to the hot gas path parts

d) The minimum successful commercial operating hours of each of the reference gas turbines shall be not less than 12,000 AOH.

e) Each of the Forced Outage Factors (FOFs) of all the gas turbines with the same Model No. as the Reference Gas Turbines for Period Hours (PH) from the first commercial operation commencement to one (1) month before the PQ Application Submission Deadline shall be less than 1.0 %.

The data and information on the commercial operating experiences of the reference gas turbines shall be testified with the written confirmation letter(s) undersigned by the plant owner(s). The definition of technical similarity of the proposed gas turbine with the reference gas turbines shall be made at the PQ stage.

In consideration of above statements, therefore, the Survey Team decided that the candidate models of the gas turbines to be chosen for this project shall be of H and J classed as specified in the 2016-17 GTW Handbook and 2018 GTW Specs .

From such circumstances, three (3) gas turbines shall be chosen as candidate models for this project with the performance parameters shown in the Table 7.1.4-1 Performance Parameter of Candidate Model of Gas Turbine on ISO conditions as per said Handbook and Specs.

Table 7.1.4-1 Performance Parameter of Candidate Model of Gas Turbine

Model of Gas Turbine	9HA.01	M701J	STG5-8000H
ISO base rating (MW)	446.0	493.0	450.0
Efficiency (%)	43.1	42.9	≥41.0
Pressure ratio	23.5	23.0	20.0
Exhaust gas flow rate (kg/s)	857.7	896.7	934.8
Exhaust gas temp (°C)	628.8	641.7	630.0

(Source: 2016-17 GTW Handbook and 2018 GTW Specs)

(3) Gas Turbine Manufacturers

According to said Handbook and Specs, the gas turbine OEM manufacturers of above Three (3) models of gas turbines are as tabulated in the following Table 7.1.4-2 Manufacturers of Three (3) Models of Gas Turbines:

Table 7.1.4-2 Manufacturers of Three (3) Models of Gas Turbines

Model of Gas Turbine	OEM Manufacturer
9HA.01	GE
M701J	MHPS
STG5-8000H	Siemens

(Source: 2016-2017 GTW Handbook)

To make technical support for sophisticated gas turbine machine possible, the gas turbine shall be supplied by an original equipment manufacturer (OEM) of the gas turbine to be proposed, which has developed, designed, manufactured and will be able to technically and substantially support its maintenance.

7.1.5 Plant Performance by Candidate Gas Turbine

The GTCC3 shall be comprised of the candidate gas turbines which are available in the present world market and the bottoming system suited to them. Therefore, the plant performance shall be naturally changeable depending upon the performance of the type of candidate gas turbine and the design parameters of the bottoming system. This section describes the plant performance calculated for every candidate gas turbine.

(1) Basic Calculation Conditions
Such basic calculation conditions as ambient conditions and export heat amounts are as specified as the site rated conditions in Table 7.1.1-1 Design Conditions and Specifications.

(2) Candidate Models of Gas Turbines
The plant performance shall be calculated for three (3) candidate models of gas turbines of which performance parameters are shown in the Table 7.1.5-1 Predicted GTCC Performance by Candidate Gas Turbine of the previous section.

(3) Type of Bottoming System
The combined cycle plant is a combination of "Topping System" of a gas turbine with Brayton Cycle and "Bottoming System" of a boiler-steam turbine with Rankine Cycle. The performance and construction cost of the combined cycle plant is changeable due to how the bottoming system is designed for the given Topping System of the gas turbine. In general, the more complicated the cycle of the bottoming cycle is, the higher the performance and construction cost of the combined cycle plant. In case of employment of the H/J class gas turbine, the triple-pressure and reheat cycle bottoming system is commonly employed. The three (3) types of steams for export are extracted from the cold reheat line, intermediate and low pressure sections of the steam turbine respectively.

(4) Design Parameters of Bottoming System
The design parameters of the bottoming system may be individual depending upon design concepts of manufacturers of combined cycle power plants to be proposed. The design parameters of the bottoming system shall be specified in consideration of expected operating range of the heat export. For the purpose of calculation of heat and mass balances of four (4) candidate models of GTCCs, therefore, the design parameters of the bottoming system are preliminarily assumed as tabulated below.

- Cycle Configuration — Triple-pressure, reheat
- HRSG
  - Type — Supplementary Firing Type
  - Supplementary Firing Temperature Limit — 750 °C
  - Location of Supplementary Firing — Between SH and RH modules
- Steam Conditions at Turbine Throttle Valve Inlet at Site Rated Conditions
  - HP Steam
    - Temperature — 600 °C
    - Pressure — 15.7 MPa (160.0 ata)
  - IP Steam
    - Temperature — 600 °C
    - Pressure — 2.9 MPa (30.0 ata) for H models
      3.4 MPa (35.0 ata) for J model

LP Steam
Temperature — Mixed temperature of LP SH and IPT outlet steams
Pressure — 0.49 MPa (5.0 ata) for H models; 0.54 MPa (5.5 ata) for J model

- Deaerator
  - Temperature: 138 °C
  - Pressure: 0.34MPa (3.5 ata)
- Pre-heater Inlet Temperature: 55 °C
- HRSG Outlet Gas temperature: Above 90 °C
- Export Steam Conditions

HP Steam
Temperature: 350 °C
Pressure: 2.1 MPa
Energy: 30 Gcal/hr (126 GJ/hr)

IP Steam
Temperature: 350 °C
Pressure: 1.1 MPa
Energy: 70 Gcal/hr (293 GJ/hr)

LP Steam
Temperature: 220 °C
Pressure: 0.4 MPa
Energy: 100 Gcal/hr (419 GJ/hr)

- Ratio of Return Water to Export Steam: 0 %
- Make-up Water Temperature: 25 °C
- Condenser
  - Type: Mechanical draft direct air cooled type
  - Inlet air temperature: 15 °C
  - Outlet air temperature: 27 °C
  - Terminal temperature difference: 8 °C
  - Pressure: 0.0573 ata
- Duct Pressure Loss up to Condenser: 0.025 at
- Turbine Back Pressure: 0.0823 at

(5) Heat and Mass Balance Calculation Results

The heat and mass balances of GTCCs for three (3) candidate models of gas turbines are calculated based on the site rated conditions and bottoming system design parameters stated in the previous sub-section for three (3) cases of no supplementary firing, 650 °C and 750 °C of supplementary firing temperatures. The results are summarized as tabulated in the Table 7.1.5-1 Predicted GTCC Performance by Candidate Gas Turbine.

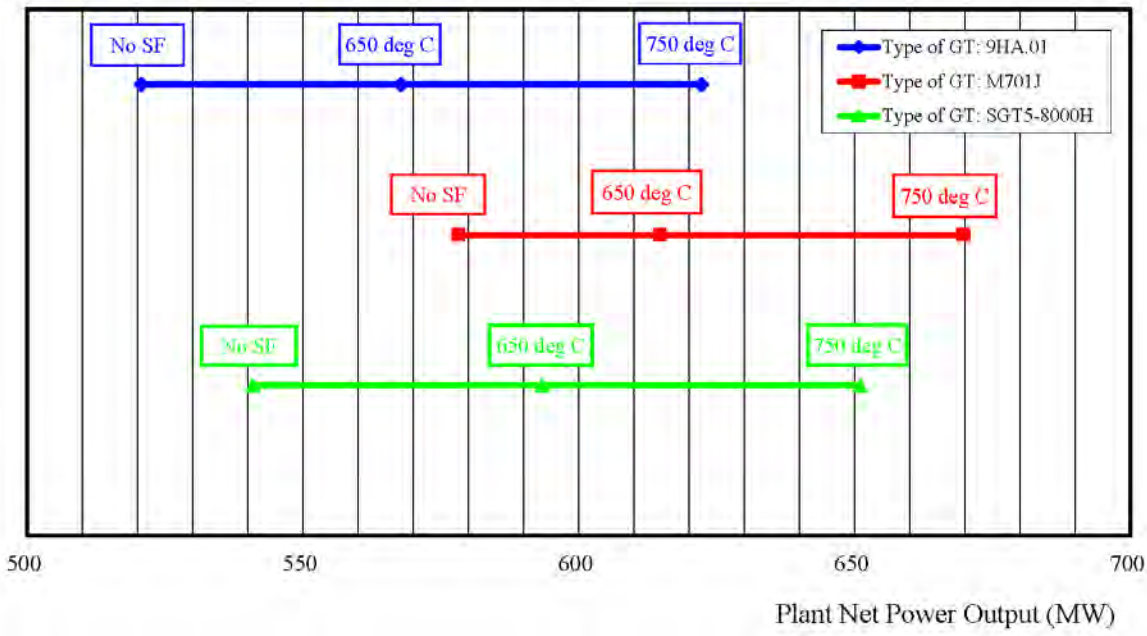
Table 7.1.5-1 Predicted GTCC Performance by Candidate Gas Turbine

Type of Model of Gas Turbine	9HA.01			M701J			SGT5-8000H		
Supplementary Firing Temperature (ºC)	No SF	650	750	No SF	650	750	No SF	650	750
Plant Gross Power Output (MW)	540.0	589.0	645.7	599.9	638.0	695.3	561.1	615.6	675.6
GT Gross Power Output (MW)	421.1			467.2			424.9		
ST Gross Power Output (MW)	118.9	167.9	224.6	132.6	170.8	228.1	136.2	190.7	250.7
Plant Gross Thermal Efficiency (%)	79.4	75.8	72.3	76.2	73.6	70.5	76.9	73.6	70.1
PlanyAuxiliary Power Requirement (MW)	19.3	21.3	23.5	21.7	23.3	25.5	20.1	22.2	24.5
Plant Net Thermal Efficiency (%)	77.4	73.9	70.3	74.3	71.8	68.5	74.9	71.6	68.2
Plant Net Power Output (MW)	520.7	567.8	622.3	578.2	614.7	669.8	541.0	593.4	651.0
Plant Net Power Output Efficiency (%)	53.5	52.4	51.2	53.0	52.1	50.9	52.4	51.5	50.3

(Source: JICA Survey Team)

The plant net power output increases as the supplementary firing temperature in the heat recovery steam generator (HRSG) is higher. Figure 7.1.5-1 shows the applicable ranges of the plant net power outputs of the three (3) candidate GTCC plants under the heat export of 200 Gcal/hr to be calculated by elevating the supplementary firing temperature up to 750 ºC which is commonly the maximum permissible temperature in the HRSG. From this figure, the plant net power output requirement of the Project can be specified at 600 MW which is the median value of the applicable power output ranges of the GTCC plants by the three (3) candidate gas turbines. This power output requirement can be applicable by all the candidate GTCC plants. Therefore, from the above discussion, the plant net power output requirement in the bidding documents shall be specified as follows.

"The plant net power output shall be specified at 600 MW under the heat export of 200 Gcal/hr on the site rated conditions"

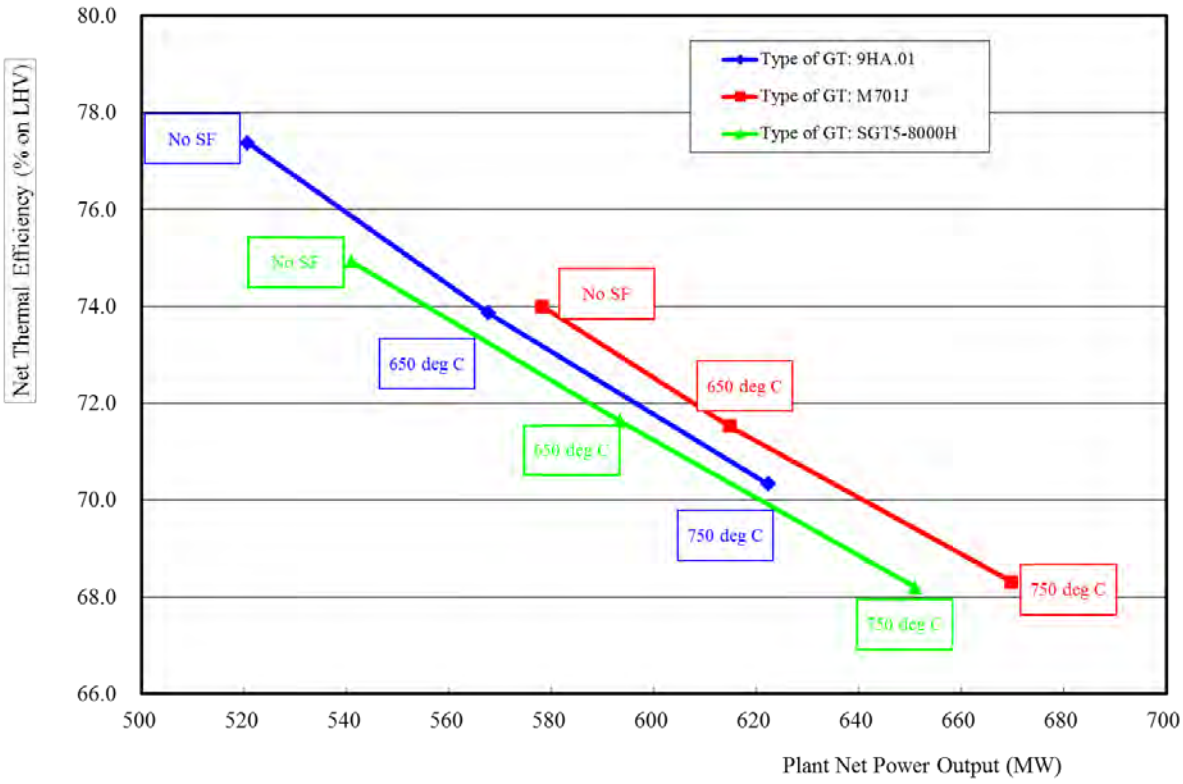


(Source: JICA Survey Team)

Figure 7.1.5-1 Applicable Range of Plant Net Power Output

Figure 7.1.5-2 is the relationship between the plant net power output and thermal efficiency based on the data of the Table 7.1.5-1 Predicted GTCC Performance by Candidate Gas Turbine. From this figure, the plant net thermal efficiency for the specified applicable power output of 600 MW is predicted to be higher than 71.0 % under the rated heat export on the site rated conditions. Therefore, the plant net thermal efficiency requirement in the bidding documents should be specified as follows in consideration of certain allowance for the thermal efficiency prediction.

"The plant net thermal efficiency less than 69.5 % under the rated heat export on the site rated conditions shall not be considered".



(Source: JICA Survey Team)

Figure 7.1.5-2 Relationship between Plant Net Power output and Thermal Efficiency

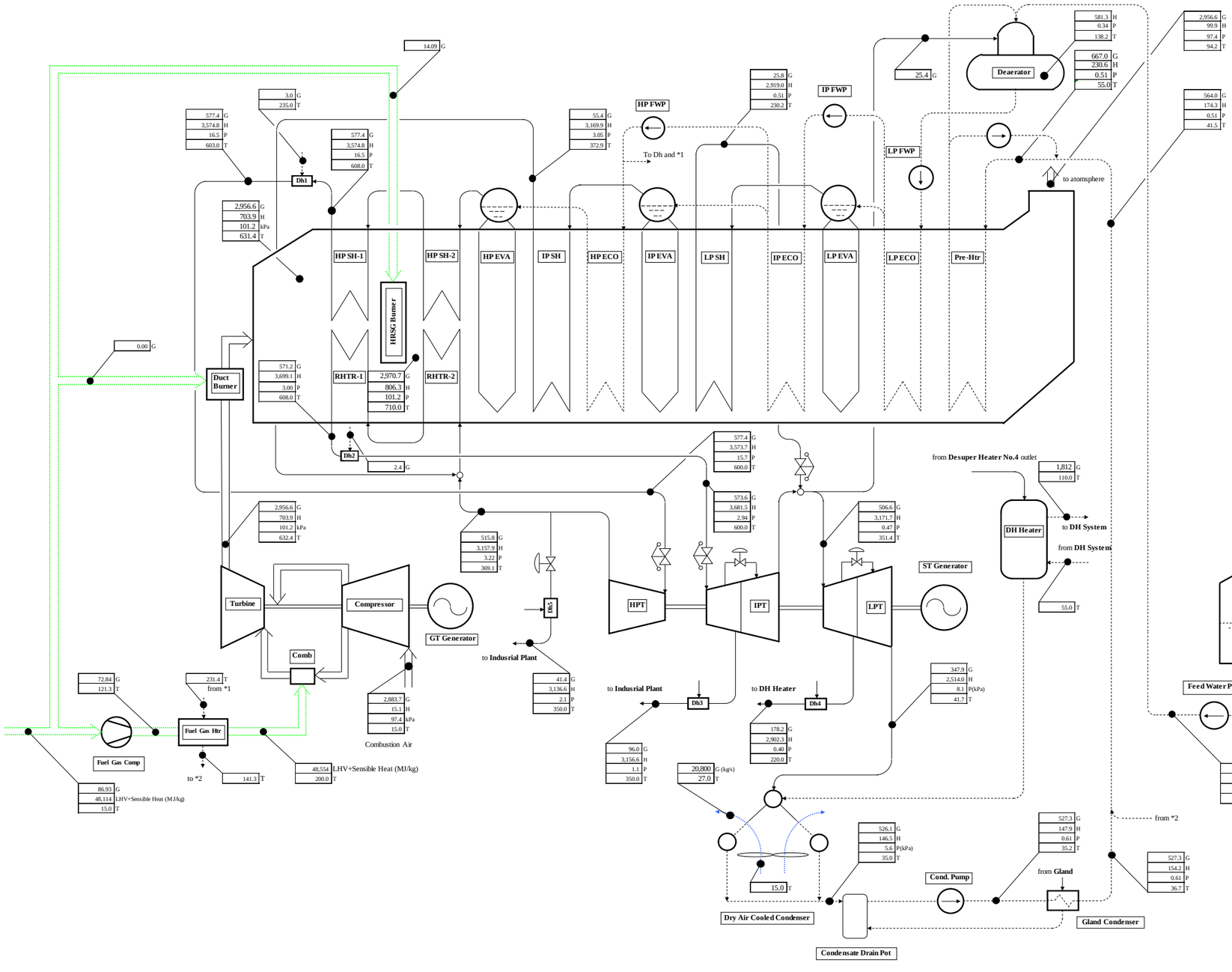
As stated above, it is not possible to foreseen what is the supplementary firing temperature of the candidate GTCC plant. Therefore, the heat and mass balance diagrams for the three (3) models of GTCC plants are calculated on the conditions that the plant net power output will be 600 MW that is the maximum requirement figure of the plant net power output. Table 7.1.5-2 Main Parameter of Heat and Mass Balance is the main parameters of heat and mass balance calculation results for three (3) models of GTCC plants.

Table 7.1.5-2 Main Parameter of Heat and Mass Balance

Type of Model of Gas Turbine	9HA.01	M701J	SGT5-8000H
Plant Gross Power Output (MW)	622.5	622.7	622.4
GT Gross Power Output (MW)	421.1	467.2	424.9
ST Gross Power Output (MW)	201.4	155.5	197.5
Plant Gross Thermal Efficiency (%)	73.6	74.8	73.2
PlanyAuxiliary Power Requirement (MW)	22.5	22.7	22.4
Plant Net Power Output (MW)	600.0	600.0	600.0
Plant Net Thermal Efficiency (%)	71.7	72.5	71.2
Plant Net Power Output Efficiency (%)	51.6	52.4	51.3
Plant Fuel Flow Rate (t/hr)	86.9	85.6	87.5
GT Fuel Flow Rate (t/hr)	72.8	81.7	77.3
Supplementary Firing Fuel Flow Rate (t/hr)	14.1	4.0	10.2
Supplementary Firing Temperature (°C)	710.0	623.5	661.4
HRSG Outlet Gas Temperature (°C)	94.2	103.6	98.8

(Source: JICA Survey Team)

The heat and mass balance diagrams of three (3) models of GTCC plants are shown on the pages to be continued.



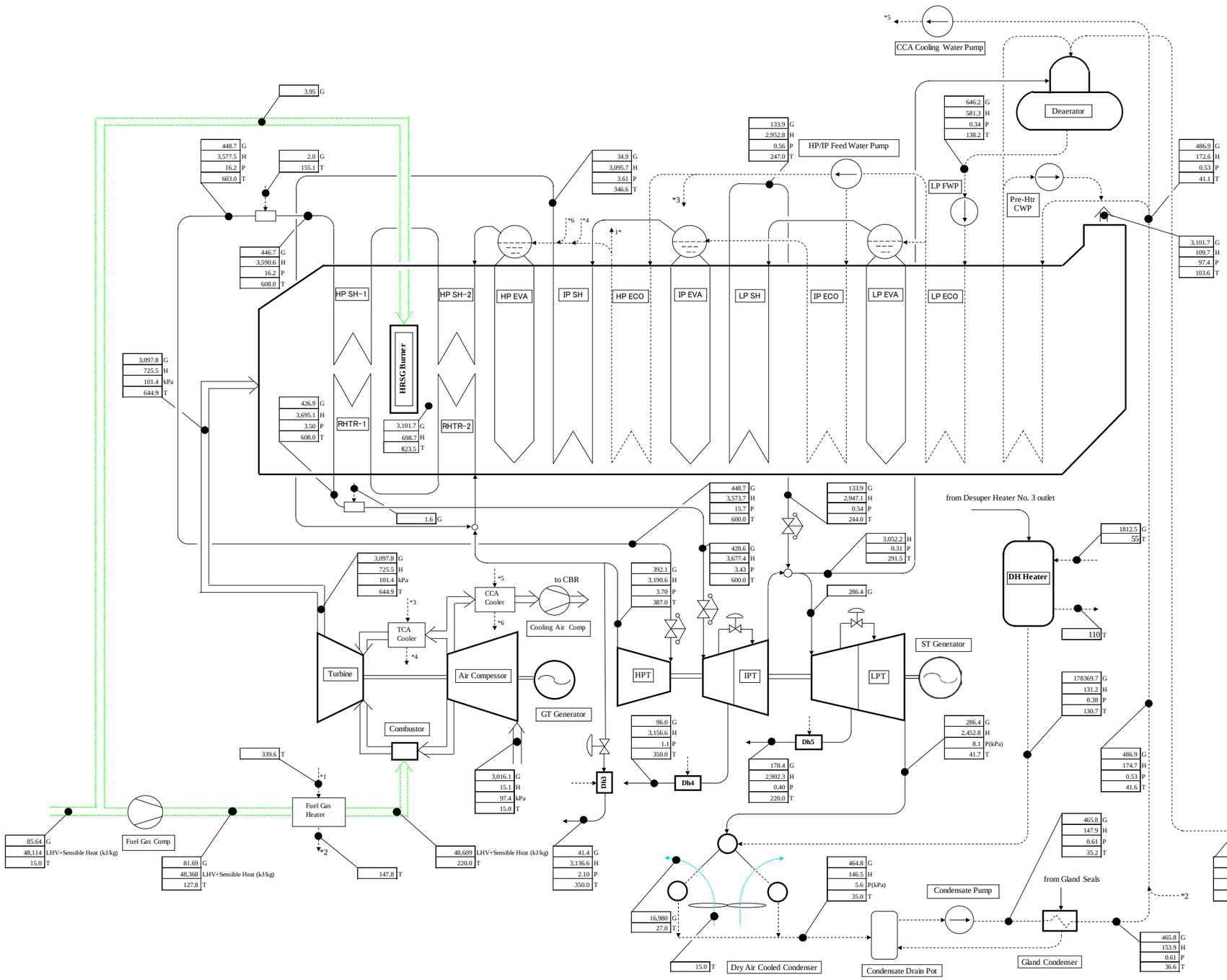
Net Heat Output		
High pressure steam	30.0	Gcal/hr
Medium pressure steam	70.0	Gcal/hr
Low pressure steam	100.0	Gcal/hr
Total	200.0	Gcal/hr
Gross Power Output		
Gas turbine/generator	421,100	kW
Steam turbine/generator	201,400	kW
Total	622,500	kW
Plant Gross Heat and Power Output	855,100	kW
Plant Gross Thermal Efficiency	73.6	%
Plant Gross Power Output Efficiency	53.6	%
Plant Auxiliary Power Requirement	22,500	kW
Plant Net Power Output	600,000	kW
Plant Net Thermal Efficiency	71.7	%
Plant Net Power Output Efficiency	51.6	%

Operating Conditions		
Dry Bulb Temperature	15.0	°C
Ambient Pressure	97.4	kPa
Relative Humidity	60.0	%
Wet Bulb Temperature	10.8	°C
Type of Fuel	Natural Gas	
Net Specific Energy	48,080	kJ/kg
Supplementary Firing Temp	710.0	°C

Heat and Mass Balance Diagram
at Rated Conditions on Natural Gas
Type of Gas Turbine GE 9HA.01
Type of Cooling System Direct Air Cooled Type

(Source: JICA Survey Team)

Figure 7.1.5-3 Heat and Mass Balance Diagram of GTCC by GE 9HA.01 Gas Turbine



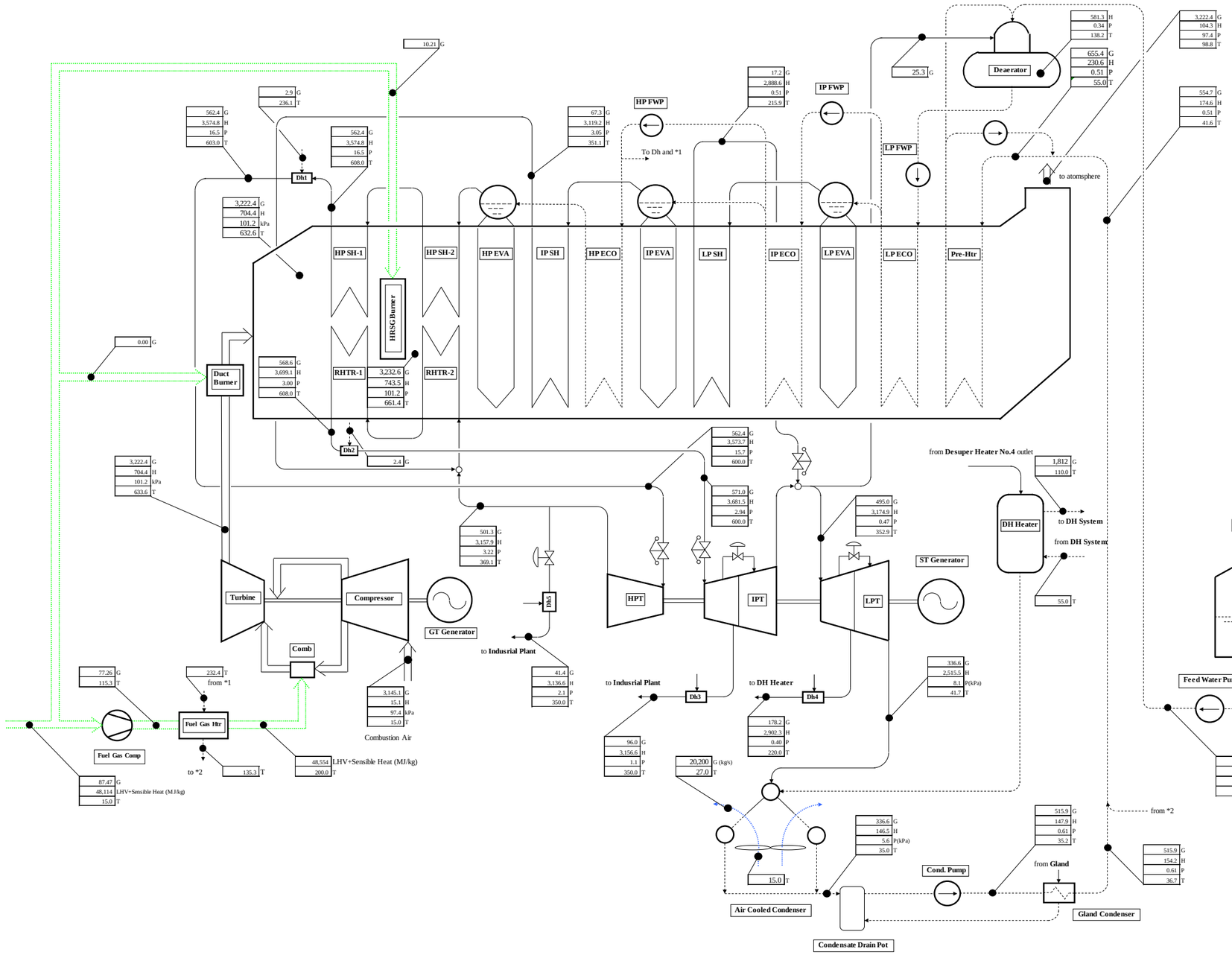
Net Heat Export		
High pressure steam	30.0	Gcal/hr
Medium pressure steam	70.0	Gcal/hr
Low pressure steam	100.0	Gcal/hr
Total	200.0	Gcal/hr
Gross Power Output		
Gas turbine generator	467,200	kW
Steam turbine generator	155,500	kW
Total	622,700	kW
Total Gross Heat and Power Output	856,500	kW
Plant Gross Thermal Efficiency	74.8	%
Plant Gross Power Output Efficiency	54.4	%
Plant Auxiliary Power Requirement	22,700	kW
Plant Net Power Output	600,000	kW
Plant Net Thermal Efficiency	72.5	%
Plant Net Power Output Efficiency	52.4	%

Operating Conditions		
Dry Bulb Temperature	15.0	°C
Ambient Pressure	97.4	kPa
Relative Humidity	60.0	%
Wet Bulb Temperature	31.8	°C
Type of Fuel	Natural Gas	
Net Fuel Specific Energy	48,080	kJ/kg
Supplementary Firing Temperature	623.5	°C

Heat and Mass Balance Diagram
at Site Rated Ambient Conditions on Natural Gas
Type of Gas Turbine MHPS M701J
Type of Cooling System Direct Air Cooled Type

(Source: JICA Survey Team)

Figure 7.1.5-4 Heat and Mass Balance Diagram of GTCC by MHPS M701J Gas Turbine



Net Heat Output		
High pressure steam	30.0	Gcal/hr
Medium pressure steam	70.0	Gcal/hr
Low pressure steam	100.0	Gcal/hr
Total	200.0	Gcal/hr
Gross Power Output		
Gas turbine/generator	424,900	kW
Steam turbine/generator	197,500	kW
Total	622,400	kW
Plant Gross Heat and Power Output	855,000	kW
Plant Gross Thermal Efficiency	73.2	%
Plant Gross Power Output Efficiency	53.3	%
Plant Auxiliary Power Requirement	22,400	kW
Plant Net Power Output	600,000	kW
Plant Net Thermal Efficiency	71.2	%
Plant Net Power Output Efficiency	51.3	%

Operating Conditions		
Dry Bulb Temperature	15.0	°C
Ambient Pressure	97.4	kPa
Relative Humidity	60.0	%
Wet Bulb Temperature	10.8	°C
Type of Fuel	Natural Gas	
Net Specific Energy	48,080	kJ/kg
Supplementary Firing Temp.	661.4	°C

Heat and Mass Balance Diagram
at Site Rated Ambient Conditions on Natural Gas
Type of Gas Turbine SMS SGT5-8000H
Type of Cooling System Direct Air Cooled Type

Figure 7.1.5-5 Heat and Mass Balance Diagram of GTCC by Siemens SGT5-8000H Gas Turbine

(6) Definition of Maximum Capacity of Gas Turbine Generator

The gas turbine commonly displays the characteristics that the power output increases up to the mechanical limit defined by the manufacturer as the ambient temperature decreases. In other words, the maximum capacity of the gas turbine is changeable depending upon the ambient temperature. However, the maximum capacity of the generator is not changed with the ambient temperature. Therefore, it shall be defined at which ambient temperature the generator should be designed so as to cope with the maximum capacity of the gas turbine. It is the common practice that the generator should be designed to meet the maximum capacity of the gas turbine at the monthly averaged value of the lowest ambient temperature of the coldest month of the site in consideration of the economy of the plant.

The data of ambient temperatures in Navoi site area is not currently available. In lieu of this, such data in Tashkent has been obtained from the internet. The Figure 7.1.5-6 Monthly Averaged Values of Daily Lowest, Mean and Highest Ambient Temperatures shows the variation of the monthly averaged lowest, mean and highest ambient temperatures for 2001 through 2010. According to this figure, the average of the monthly averaged values of daily lowest ambient temperatures of the winter season of December, January and February is calculated at minus 0.5 ^{o}C.

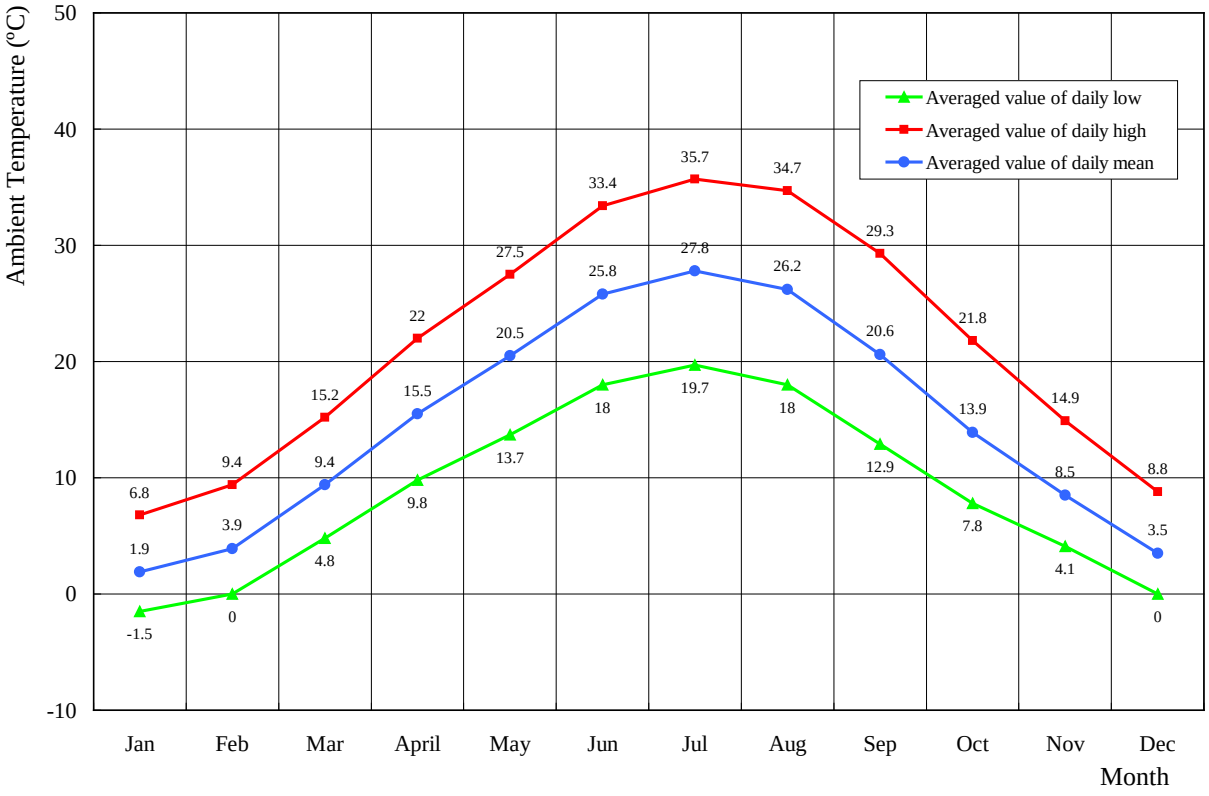
Therefore, the maximum capacity of the gas turbine generator shall be so designed as to meet the maximum capacity of the gas turbine at the ambient temperature of 0 ^{o}C rounded up. The related electrical equipment such as a main transformer, main cables and a main circuit breaker shall also be designed to cope with the maximum capacity of the gas turbine generator.

(7) Definition of Maximum Capacity of Steam Turbine Generator

The steam turbine power output increases with increase of the HRSG steam evaporation rate and decreases with increase of the steam heat energy extracted from the steam turbine. The steam evaporation rate increases with decrease of the ambient temperature. And the heat energy to be exported tends to increase with decrease of the ambient temperature.

On the medium ambient temperature, such a plant operation where the priority will be placed on the more power output production requirement may be envisaged since the power output efficiency of the GTCC plant is far higher. However, the steam supply energy for industrial use shall be reserved at the almost constant rate through the year.

From such reasons stated above, the maximum power output capability of the steam turbine shall be defined on the conditions that the steam heat energy for the district heating use is not extracted and that the industrial steam of 100 Gcal/hr is extracted at the ambient temperature of 15 ^{o}C and the supplementary firing temperature which is specified to produce the plant net power output of 600 MW on the site rated conditions.



(Source: Prepared by JICA Survey Team from information on https://en.wikipedia.org/wiki/Tashikent)

Figure 7.1.5-6 Monthly Averaged Values of Daily Lowest, Mean and Highest Ambient Temperatures

7.1.6 Condenser Cooling System

Three (3) types of alternative condenser cooling system, a forced draft air cooled condenser system (MACCS), a once-through cooling system (OTCS) and an mechanical draft wet cooling tower cooling system (MCTCS), are considered as possible cooling systems for the steam turbine condenser for the Project. The advantages and disadvantages of these alternative cooling systems are variable depending upon the site conditions, water availability, water quality and its associated scaling problem in CW system equipment, operating conditions and economic conditions, such as the electric power sales price and fuel costs.

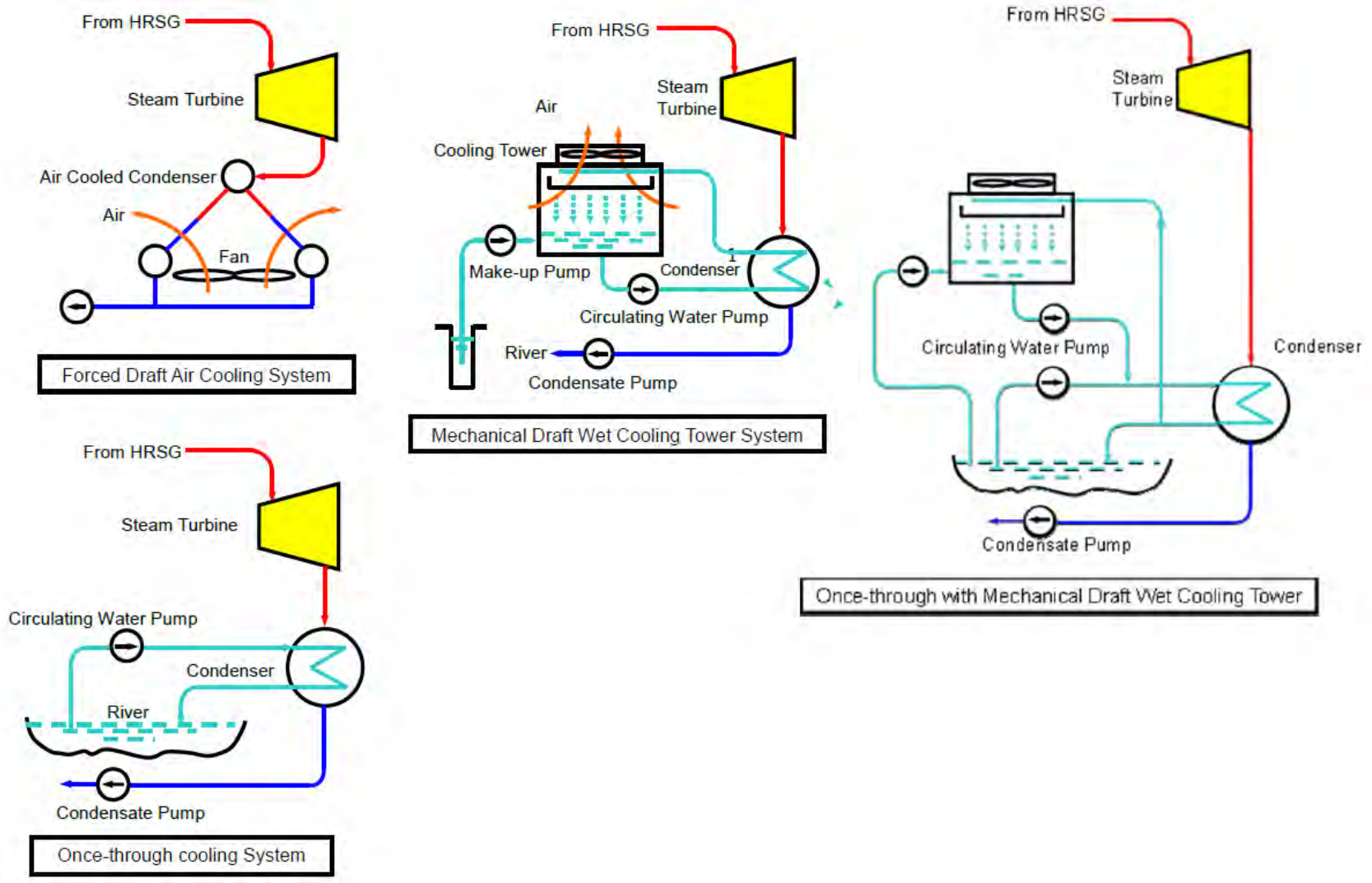
Alt.1: Forced Draft Air Cooled Condenser System (MACCS)
The forced draft air cooled condenser is commonly used when the site is located in place where water is not available or scarce, such as deserts or inland areas, or other cooling system such as wet cooling tower system or once-through cooling system are not applicable for any reason, such as scaling problem. The condenser pressure is normally the highest among the above three (3) cooling system types. Therefore, the steam turbine power output is the lowest. The auxiliary power required to operate the cooling system is large because many air draft fans must be operated. The installation footprint area for this system is the largest. However, the system is most friendly to the environment in that no water is used.

Alt.2: Once-through Cooling System (OTCS)
The once-through cooling system is commonly employed when the site is located on a riverside (or seaside, lakeside), and the circulating cooling water flow rate sufficient to cool the condenser is available economically without any environmental impacts. It is most important to adopt this cooling system to confirm that the sufficient cooling water quantity is available from the Zeravshan River throughout a whole year (seasons) of operation. The condenser pressure is normally the lowest among the three (3) alternative types of condenser cooling system. Therefore, the steam turbine power output is usually the highest among these alternatives. In this Project, however, this performance advantage of once-through cooling system when compared with MCTCS would not be so notable because design wet bulb temperature of cooling tower is rather low. Construction cost of this system (OTCS) will be the lowest among the alternatives.

Alt.3 : Mechanical Draft Wet Cooling Tower Cooling System (MCTCS)
The mechanical draft wet cooling tower type is commonly used when sufficient circulating cooling water flow rate is not available economically, but the water flow rate to compensate for the evaporation and blow-down losses of cooling tower is obtainable. In GTCC1, this system is adopted and the Survey Team was told that GTCC1 encountered serious and inherent problems of scale deposit to the CW equipment, due to the quality of the make-up water (Zeravshan River). For this reason, a mechanical draft wet cooling tower cooling system (MCTCS) is not considered to be recommendable at this stage.

In addition to the above alternatives, combined once-through and wet cooling tower system will be studied as requested by the counterpart (JSC Thermal Power Plant)) .
This combined system involves OTCS and MCTCS that are installed in parallel. In this system, MCTCS can assist condenser cooling when water availability from Zeravshan River is not sufficient for condenser cooling.

The schematic diagrams of these types of cooling system are shown on the next page.



(Source: JICA Survey Team)

Figure 7.1.6-1 Schematic Diagram of the Alternative Condenser Cooling Systems

(1) Comparison Study of Condenser Cooling Systems

1) General

This study is carried out from technical and economical points of view to select the most suitable cooling system for the Project. The impact on circumferential environments is also examined. In the combined cycle plant, the performances of the gas turbine which is a topping cycle are not affected by the type of cooling system, but those of the steam turbine of a bottoming cycle are affected. Therefore, it is effective enough for technical and economic evaluation if the performance differences due to the type of cooling system of only the steam turbine are examined.

Although sufficient information and data necessary to conduct the study have not yet been obtained at this stage, preliminary study was attempted based on the followings conditions including tentatively assumed ones.

2) Conditions

(a) Type of combined cycle cogeneration plant

This study shall be conducted for the combined cycle cogeneration plant (GTCC) which uses the F-class gas turbine, for selection of the optimum cooling system. In case that gas turbine of different types from F-class is adopted, comparative relative results among MACCS, OTCS and MCTCS will show similar tendency.

(b) Site ambient conditions

The heat load of the condenser cooling system of the GTCC is significantly changeable depending upon the ambient conditions. Therefore, the study shall be performed at the averaged ambient conditions through the year.

For that purpose, the following site ambient conditions are assumed as averaged values through the year.

Averaged dry bulb temperature	15.0 °C
Averaged relative humidity	60.0 %
Averaged wet bulb temperature	10.9 °C
Averaged Zeravshan River water temperature	18.0 °C

(c) Operating conditions of the Plant

The comparison study is conducted provided that the plant is scheduled to be run at a full power output load with the heat supply of 200 Gcal/hr (Industrial steam of 100 Gcal/hr and Low pressure steam to hot water system of 100 Gcal/hr) on a natural gas firing with an annual availability factor of 85 % (7,446 hours) through the year.

(d) Economic conditions

The economic evaluation of the condenser cooling system is conducted comparing the construction cost for the condenser and cooling system plus the loaded costs as the net present values due to the shortage of the annual power sales of the steam turbine and the difference of the maintenance costs among the three (3) types of cooling system. For the purpose, the following economic indexes are utilized:

Power sales tariff	0.055 $/kWh (182 Sum/kWh)
Maintenance cost of MACCS	1.5 % of construction cost of it
Maintenance cost of OTCS	2.5 % of construction cost of it
Maintenance cost of MCTCS	5.0 % of construction cost of it

Discount rate	12.0 %
Transmission and distribution loss	13.0 %
Evaluation periods (year)	30 years

3) Shortage of Annual Net Sales Power (GWh) due to Type of Cooling System

The steam turbine gross power output at the generator terminals can be obtained from the heat and mass balance calculation result by estimating the steam turbine exhaust pressure which will be defined at the used energy end point (UEEP) of the steam turbine. The turbine exhaust pressure will be determined for each type of cooling system on specified site ambient conditions. It is normally deemed that the said pressure is equal to the condenser pressure except for the air-cooled condenser. In case of the air-cooled condenser, pressure loss will occur in the steam duct between the steam turbine exhaust connection and the air-cooled condenser. The net power output at the power station is defined as the value after the auxiliary powers related to the cooling system are deducted from the gross power output. The annual net sales power is estimated by multiplying the net power output by the annual operating hours and deducting the system power loss. The shortage of the annual net power is defined as the difference from the case of maximum annual net power sales.

(a) Estimation of pressure at UEEP

The pressure at UEEP can be estimated from the commonly acceptable characteristic values for each type of cooling system on the site ambient conditions specified above. The estimated pressures for each cooling system are as tabulated in the table shown below:

Description	Temperature and Pressure
1. MACCS	
a. Ambient dry bulb temperature (°C)	15.0
b. Air temperature rise (°C)	12.0
c. Terminal Temperature difference (°C)	8.0
d. Condenser saturated temp. (°C)	=15.0+12.0+8.0 = 35.0
e. Condenser saturated pressure (kPa)	5.62
f. Estimated pressure loss (kPa)	2.45
g. Estimated pressure at UEEP (kPa)	8.07
2. OTCS	
a. Zeravshan River water temperature (°C)	18.0
b. Cooling water temperature rise (°C)	6.0
c. Terminal temperature difference (°C)	5.0
d. Condenser saturated temp. (°C)	=18.0+6.0+5.0 = 29.0
e. Condenser saturated pressure (kPa)	4.00
f. Estimated pressure loss (kPa)	0
g. Estimated pressure at UEEP (kPa)	4.00
3. MCTCS	
a. Ambient wet bulb temperature (°C)	10.9
b. Approach temperature (°C)	8.0
c. Cooling range (°C)	6.0
d. Terminal temperature difference (°C)	5.0
e. Condenser saturated temp. (°C)	=10.9+8.0+6.0+5.0 = 29.9
f. Condenser saturated pressure (kPa)	4.22
g. Estimated pressure loss (kPa)	0
h. Estimated pressure at UEEP (kPa)	4.22

To reduce scale (Calcium carbonate) deposition on cooling water system equipment, such as condenser tubes, cooling tower inside and CW pipe inside, cooling water temperature rise in OTCS and MCTCS is taken as low as 6.0 °C.

Following studies are made based on GTCC with gas turbine of M701J. In case that gas turbine of different types from M701J is adopted, comparative relative results among MACCS, OTCS and MCTCS will show similar tendency.

(b) Gross power output of steam turbine

The gross power outputs of the steam turbines for three (3) alternative types of cooling system can be obtained from the heat and mass balance calculation results for the specified exhaust pressures at UEEP. They are as tabled below:

Type of Cooling System	Gross Power Output (kW)
Mechanical draft air cooling system	128,854
Once through cooling tower system	133,709
Mechanical draft wet cooling tower system	133,440

(c) Auxiliary power related to cooling system

The auxiliary power of the equipment pertaining to the cooling system is different depending upon its type. The auxiliary powers for the foresaid three (3) types of cooling system are roughly estimated by correcting the relevant data of similar plants to the site conditions of this Project. The study results are summarized as described below.

MACCS	
Draft fans for condenser in total (Q=17,420 m^3/hr, H=15 mmH_2O)	4,620 kW
Auxiliary cooling tower fans in total (Q=470 m^3/s, H=12 mmH_2O)	100 kW
Auxiliary cooling tower make up pump (Q=60 m^3/hr, H=30 mH_2O)	10 kW
CW booster pump (Q=4,000 m^3/hr, H=40 mH_2O)	710 kW
Total	5,440 kW
OTCS	
Circulating water pumps in total (Q=27,200 m^3/hr h, H=21 mH_2O)	1,910 kW
CW booster pump (Q=4,000 m^3/hr, H=15 mH_2O)	270 kW
Total	2,180 kW
MCTCS	
Circulating water pumps in total (Q=27,200 m^3/hr, H=29 mH_2O)	2,630 kW
Draft fans for cooling tower in total (Q=2,820 m^3/s, H=12 mmH_2O)	600 kW
Cooling tower make up pump (Q=842 m^3/hr, H=20 mH_2O)	80 kW
CW booster pump (Q=4,000 m^3/hr, H=10 mH_2O)	180 kW
Total	3,490 kW

(d) Net power output of steam turbine

From the gross power outputs and auxiliary required powers estimated above, the net power outputs are calculated as shown below:

Type of Cooling System	Net Power Output (kW)
MACCS	123,414
OTCS	131,529
MCTCS	129,950

(e) Annual net sales power

The annual net sales power for three (3) types of cooling systems are estimated as shown below in consideration of net power output, annual availability factor and transmission and distribution loss.

Type of Cooling System	Annual Net Sales Power (GWh)
MACCS	799.5
OTCS	852.0
MCTCS	841.8

(f) Shortage of annual net sales power

In accordance with the previously prescribed definition, the shortage of annual net sales power for each cooling system is calculated as shown below:

Type of Cooling System	Shortage of Annual Net Sales Power (GWh)
MACCS	52.6
OTCS	± 0 (base: maximum annual net power sales case)
MCTCS	10.2

4) Technical Evaluation

(a) Mechanical draft air cooled condenser system (MACCS)

This type of system has been used for the power or heat and power plants which are built in areas where water sources are not available in the vicinity of plants as inland and desert areas. The steam from the steam turbine is directly condensed by ambient air through the finned tubes. For this purpose, large amount of surface area is required for the heat transfer finned tubes because of less heat transfer coefficient between the air and steam.

As described in the previous sub-section, the net power output of the steam turbine with the MACCS is less than that with the OTCS and MCTCS .

The finned tubes can be kept clean by employment of automatic water wash devices which will be periodically operated on-line. The cleaning interval shall be decided, depending upon the fouling tendency of them. In case of clean air condition, the cleaning interval is said to be commonly a half year. The site for this Plant belongs to a clean, uncontaminated area, unlike other industrial areas. It is supposed for the finned tubes to be less contaminant. The air leakage into tubes could be detected by use of an infrared camera. The finned tubes where the leakage will be detected could be blinded with plugs and be replaced when the plant is at standstill. Therefore, any routine maintenance is basically not required.

In consideration of the above statements, the maintenance cost of MACCS is assumed to be 1.5 % of the construction cost of it, which is lower than those of OTCS and MCTCS because of easier maintenance as mentioned above.

The MACCS is technically matured and there are many installation experiences with such large capacity systems as required for this Plant, and there are many experiences with air cooled condensers for the combined cycle plants, which have been installed in sites of freezing weather conditions where the ambient temperature is far lower than minus 20 ^{o}C. In addition, many MACCSs are installed in desert areas where there is no cooling water. This means that the MACCS is applicable for ambient conditions as high as 40 °C.

The mechanical sounds from the axial air fans are supposed to be the noise source of the mechanical draft direct air cooled condenser. It is possible that the sound pressure levels around the condenser will be allowable from the environmental consideration point of view by employment of lower noise fans and installation of noise protection skirts at the air inlet. For example, it is confirmed that the noise levels on the ground level around the similar mechanical

draft air cooled condenser located in Japan are less than 85 dB(A).

(b) Once-through cooling system (OTCS)

In a once-through circulating water system, water is taken from a body of water such as a river, lake, or ocean, pumped through the condenser, and discharged back to the source.

The once-through circulating water system is the most popular arrangement for condenser cooling systems where the site is located on a riverside (or seaside, lakeside), and the circulating cooling water flow rate sufficient to cool the condenser is available, stably and economically through a year without any environmental impacts. A once-through circulating water system has two significant advantages, generally. First, the relatively low temperature of most water sources used for once-through cooling makes this the most efficient cycle heat rejection system design. Second, the simple system arrangement typically makes once-through cooling the cycle heat rejection system design with the lowest capital and operating costs.

The disadvantage of this system is that the heated water is discharged back to the original water source, where the added heat is gradually dissipated to the earth's atmosphere.

However, it may take a long time for the source water temperature to return to normal, or a new equilibrium temperature may be reached at a level higher than the normal temperature as long as the plant is in operation. Before construction of a once-through cooling system, environmental permits typically require determination of flow and temperature patterns around the circulating water discharge to estimate the thermal impact. Environmental impact assessment is necessary in this viewpoint. Using water resources may affect water use in industry and agriculture, and it may require permission by water authority.

(c) Mechanical draft wet cooling tower cooling system (MCTCS)

This system is common to the power or heat and power plants to be built in areas where the water source with necessary amount of flow rate capacity for a once-through type is not available.

In case of use of wet cooling tower, some percentage of the circulating water flow rate must be made up to compensate for the blow-down water, and evaporation and water drift losses depending upon the design parameters of the cooling tower. The evaporation loss can be calculated as 1.03 % of the circulating water flow rate for the cooling tower design parameters previously specified. Some part of the circulating water must be so blown down that the solid concentration in the circulating water is 2 or 4 times that in the make-up water. In order to reduce concentration of scale forming material in cooling water, concentration rate of cooling tower is presumed as low as 1.5 times.

Depending upon the quality of the make-up water and the contamination of ambient air, any kinds of slime and algae may occur in the cooling system and the tower fills may be scaled. Therefore, any measures by dosing of suitable chemicals must be taken to protect this system from them. The make-up water for cooling tower will be supplied from Zeravshan River after treated by clarifiers and filters. The Navoi Nos. 11 and 12 units as well as GTCC1 unit are suffering from problems caused by improper make-up water quality where the Zeravshan River water is used as the make-up water. In this connection, slime, algae and scaling may happen on the parts in contact with the circulating water. In order to protect from such problems, water quality control and chemical dosing may be required. Cleaning of the condenser tubes must be carried out off-line.

The mechanical sounds from the axial flow fans and water circulating pumps and dripping sounds of water droplets could be supposed as noise sources of this system. The sounds from the axial air fans can be attenuated by employment of low noise type of fans and cylindrical hood at the air exit. The circulating water pumps could be covered with the noise attenuation enclosure for reduction of noise as required. The dripping sounds could be minimized by

installation of the air inlet louvers. By such noise protection measures as described above, the sound pressure levels around the cooling tower could be suppressed to less than 85 dB (A).
The cooling tower may be confronted by any inherent problems which occur in freezing weather conditions. Examples include visible plume, ice formation inside the air intake structure and formation of ice board on the ground in the vicinity around the tower. For instance, the installation of the cooling tower is prohibited in the vicinity of highways in the northern parts of USA.

Effect of plumes exhausted from stacks and water droplets due to drift loss on surrounding facilities and equipment shall also be considered.

MCTCS is adopted in GTCC1 and the Survey Team was told that GTCC1 encountered serious and inherent problems of scale deposit to the CW equipment, due to the quality of the make-up water (Zeravshan River). Accordingly, MCTCS is not considered to be recommendable at this stage, unless effective solution to prevent such scaling problem is established.

(d) Combined once-through and wet cooling tower system (OTCS + MCTCS)
Combined system involves OTCS and MCTCS that are installed in parallel. In this system, MCTCS can assist condenser cooling when water availability from Zeravshan River is not sufficient for condenser cooling.

5) Economic Evaluation
Following studies are made based on GTCC with gas turbine of M701J. In case that gas turbine of different types from M701J is adopted, comparative relative results among MACCS, OTCS and MCTCS will show similar tendency.

(a) Loaded cost due to difference in annual net sales power
The loaded cost is defined to be equal to the net present value (NPV) due to the shortage of the annual net sales power by the steam turbine among MACCS, OTCS and MCTCS. In this case study, the annual net sales power is 817.7 GWh for MACCS, 852.0 GWh for OTCS and 841.8 GWh for MCTCS as shown in the previous sub-section 3).

In this economic evaluation, Present Value Method is applied. In the method, all costs such as construction cost, fuel cost, electricity loss cost, operation costs, maintenance costs, etc. shall be converted to present values and the total amount of these costs shall be compared with the subject systems. If the amount of a system is the lowest, the system shall be evaluated as the most economical system.
The present value (PV) of various costs can be calculated with the following formula.

$$PV = F_{PV} \times A$$

Where,
A: Annual cost (US$)
F_{PV}: Present value factor which is defined as the ratio of the present value of annual costs for a lifetime to the annual cost continued for the lifetime and given by the following equation.

F_{PV} = Present value of annual costs for a lifetime / Annual cost
= 1/(1+i/100)^1 +1/(1+i/100)^2+1/(1+i/100)^3+….+1/(1+i/100)^n
= {1-1/(1+i/100)^n} / {(1+i/100)-1} = 8.06

Where,
i: Annual discount rate (%), 12%
n: Plant service lifetime (year), 30 years

To evaluate difference in annual power sales among three alternatives,

A=P x S

Where

P: Power sales tariff (US$/kWh)

S: Difference in annual sales power (kWh/annum)

Substituting the said preconditioned values in the previous sub-section (1)-2)-(d) and the shortage of annual net sales power of MACCS (52.6 GWh/annum) and MCTCS (10.2 GWh/annum) against OTCS (base) into the above equation, the present value factor F_{PV} = 8.06 and the loaded cost due to the shortage of annual sales power can be calculated as shown below:

Table 7.1.6-1 Difference in Power Sales Revenue

Type of Cooling System	MACCS	OTCS	MCTCS
Annual net sales power (GWh)	799.5	852.0	841.8
Difference in annual sales power, S (GWh)	52.6	(Base)	10.2
Power sales tariff, P (US$/kWh)	0.055	0.055	0.055
present value factor, FPV	8.06	8.06	8.06
Present value of power sales (million US$)	23.4	(Base)	4.6

(Source: JICA Survey Team)

As shown on the above, the loaded cost due to shortage of annual power sales of MACCS is 23.4 MMUS$ and that for MCTCS is 4.6 MMUS$.

(b) Maintenance cost

The maintenance cost difference happens among MACCS, OTCS and MCTCS with the preference of the former to the latter. Therefore, the NPV of the annual maintenance cost difference should be considered for economic evaluation.

Table 7.1.6-2 Maintenance Cost

Type of Cooling System	MACCS	OTCS	MCTCS
Annual maintenance cost, % of construction cost	1.5	2.5	5.0
Annual maintenance cost ((million US$)	0.39	0.27	0.65
Present value of maintenance cost (million US$)	3.2	2.2	5.2

(Source: Estimated by JICA Survey Team)

Air cooled condenser needs water cleaning of finned tube elements, however, the cleaning can be done from outside of air cooled condenser without stopping the power plant. Maintenance cost of air cooled condenser is limited to low amount. Tubular surface condenser will be cleaned by continuous on-load tube cleaning system by sponge balls. In case scale forms and accumulate on internal surface of condenser tubes in OTCS, off-load condenser tube cleaning will also be carried out at intervals as necessary. In case of MCTCS, where scaling problem is envisaged, in addition to condenser tube cleaning, wet cooling tower may need periodical acid

cleaning minimum once a year and chemical injection to cooling water may be necessary. The power plant must be stopped for minimum one week for cleaning work, therefore, power sales loss cost may occur in addition to cleaning work cost. These costs are included in the above cost for MCTCS. Scaling problem in MCTCS is generally more serious and inherent than OTCS because of concentration of scaling materials in cooling water by evaporation and recirculation.

(c) River water cost and dosing chemical cost

MCTCS needs the river water consumption to make up the evaporated, drifted and blown down water of cooling tower. Therefore, the costs of water and dosing chemicals are necessary to be taken into consideration. The present values of these costs are estimated as shown below. The chemical consumptions and unit prices of chemicals are calculated in accordance with the actual experiences of Navoi GTCC1 in 2013.

a) Zeravshan River water cost

MCTCS needs river water of 844 t/hr for the makeup water of wet cooling tower. On the other hand MACCS does not use river water except make up water of 60 t/hr for auxiliary cooling tower. River water unit price is assumed to be 0.039 US$/ m^3 (129 Sum/m^3) as per Preparatory Study of GTCC2.

Table 7.1.6-3 River Water Cost

Type of cooling system	MACCS	OTCS	MCTCS
Water consumer	Makeup for auxiliary cooling tower	None	Makeup for cooling tower
River water consumption (t/h)	60	0	844
Annual river water consumption (million ton)	0.45	0	6.29
Annual river water cost (million US$)	0.017	0	0.246
Present value of river water cost (million US$)	0.14	0	1.98

(Source: JICA Survey Team)

b) Cost of chemicals for cooling water treatment

With the cooperation of Navoi PS in the course of basic design of GTCC2, the performance data of the existing unit were investigated. When it applies to GTCC3 in case of MCTCS, the results are as shown as follows:

The cost of water treatment chemicals is required annually 2.1 million US$. When the annual cost is converted into the construction cost equivalent for the plant life period of 30 years, the amount becomes 17.6 million US$.

Table 7.1.6-4 Chemical Cost for Cooling Water Treatment

Name	Unit Price	Chemical Consumption (plan) (kg/day)			Annual Chemical Cost (Capacity factor = 85%)		Present value factor	PV of chemical cost
	(1000 sum/kg)	River water	Circulating Water (Makeup)	Total	million Sum	million US$	-	million US$
Sodium hypochlorite (NaClO, 12%)	0.58	1,211	5.189	6,400	1,152	0.350	8.06	2.82
Ferric chloride ($FeCl_3$, 40%)	2.92	4,358	0	4,358	3,944	1.197	8.06	9.64
Bio-dispersant	7.70	0	13	13	30	0.009	8.06	0.07
Antiscalant (Scale inhibitor)	132.00	0	46	46	1,879	0.570	8.06	4.59
Sulfuric acid (H2SO4, 98%)	0.16	0	3,823	3,823	189	0.057	8.06	0.46
Total	1.584	5,569	9,071	14,640	7,194	2.183	8.06	17.59

(Source: Estimated by JICA Survey Team based on the data of Navoi GTCC1)

Table 7.1.6-5 Chemical Cost for Cooling Water Treatment

Type of Cooling System	MACCS	OTCS	MCTCS
Kind of equipment	Auxiliary cooling tower	-	Cooling tower
Chemical consumption (kg/day)	1,041	0	14,640
Chemical Unit Price (US$/kg)	0.481	-	0.481
Annual Chemical Cost (million US$)	0.16	0	2.18
Present value of Chemical Cost (million US$)	1.3	0	17.6

(Source: Estimated by JICA Survey Team based on the data of Navoi GTCC1)

(d) Reduction of ST and GT power output

The tentative economic effect of power reduction in MCTCS due to scale trouble as well as power reduction in MACCS and OTCS due to high ambient air temperature/high river water temperature conditions in summer season can be calculated as shown in Table 7.1.6-6 .

Generally, power reduction in summer of MACCS is larger than that of MCTCS. However, in the case of Navoi PS, since the raw water which is supplied from Zeravshan River contains extremely high hardness, severe scale deposition on condenser tubes in MCTCS reduces power output lager than that of MACCS.

Table 7.1.6-6 Economic Effect of Power Reduction

Item	Unit	MACCS	OTCS	MCTCS	Remarks
Reduced power	MW	78	82	150	At $T_{amb.}$=35°C
Daily duration of power reduction	hr/day	4	4	4	
Days of summer season	day/year	90	90	90	assumed
Annual power loss	GWh/year	28.1	29.5	54.0	
Annual fuel saving due to power reduction	10^6 kcal/year	40,248	42,312	77,400	Generation efficiency 60% is assumed.
Power sales tariff	US$/kWh	0.055	0.055	0.055	
Transmission line loss	%	13	13	13	
Fuel unit price	US$/$10^6$ kcal	5.04	5.04	5.04	
Reduction of power sales	10^6 US$/year	0.90	0.84	2.60	
Saving of fuel cost	10^6 US$/year	0.20	0.21	0.39	
Annual amount of loss cost	10^6 US$/year	1.15	1.21	2.21	
Present value factor	-	8.06	8.06	8.06	For 30 years operation
Present Value of amount of loss	million US$-PV	9.24	9.71	17.76	

(Source: Estimated by JICA Survey Team)

Power reduction in summer in case of MCTCS is derived from relation between MW reduction and ambient air temperature of actual operation data of GTCC1. Power reduction for MACCS is calculated by SOAPP; Combined Cycle Plant Simulation Tool developed by US Electric Power Research Institute (EPRI).

The reduced powers of 150 MW and 78 MW in Table 7.1.6-6 are at ambient air temperature of 35 °C. In case of OTCS, the highest water temperature of Zeravshan River in summer is considered to be around 30 °C. The amount of loss cost, which is the balance of power sales loss and fuel cost saving, is annually 1.15 million US$, 1.21 million US$ and 2.21 million US$ for MACCS, OTCS and MCTCS respectively, which are equivalent to present value of 9.24 million US$, 9.71 million US$ and 17.76 million US$.

(e) Construction cost for three alternative condenser cooling systems

The construction costs for the alternative three cooling systems are estimated through the computer software, and referring to the relevant cost of similar projects and hearing from certain manufacturer of the air cooled condenser. The estimated costs are summarized as shown below:

The construction cost of MACCS is the highest and that of OTCS is the lowest.

Table 7.1.6-7 Construction Cost of Condenser Cooling System

Unit : Million US$

Item	MACCS	OTCS	MCTCS
Water Cooled Condenser	NA (#1)	1.8	1.8
Air Cooled Condenser	25.1	NA (#1)	NA (#1)
Cooling tower and CW system	-	8.0	9.5
Auxiliary cooling tower	1.0	NA (#1)	NA (#1)
River water treatment system (#2)	0.2	NA (#1)	1.6
CW intake/discharge structure	NA (#1)	1.1	0.1
Total of Construction Cost	26.3	10.9	13.0

(Source: Estimated by JICA Survey Team)

Note;
#1: NA means that the item is not applicable for the system.
#2: River water treatment system for MACCS means the treatment system for the makeup for auxiliary cooling tower for MACCS.
River water treatment system composes sedimentation ponds, filters, pumps, piping and valves, etc. for makeup water of wet cooling tower and auxiliary cooling tower only. The construction costs of the water treatment systems do not include those for the other plant service water and demineralized water.

f. Life cycle cost

The construction cost plus the present values of annual operation and maintenance costs for three alternative types of condenser cooling system are as tabulated below.

Table 7.1.6-8 Evaluated Life Cycle Cost

Unit : Million US$

Type of Cooling System	MACCS	OTCS	MCTCS	OTCS + MCTCS
Life Cycle Cost				
Construction Cost of Cooling System	26.3	10.9	13.0	Max. 23.9
Difference in annual net sales power	23.4	(Base)	4.6	1.2
Power reduction in summer	9.2	9.7	17.8	17.8
Maintenance Cost	3.2	2.2	5.2	3.0
River Water Cost	0.14	0	1.98	0.5
Chemical Cost for cooling system	1.3	0.5 (Chlorination)	17.6	4.8
Total	63.5	23.3	60.2	51.2

(Source: Estimated by JICA Survey Team)

Note: 1) Each item with sharp mark (#) shows the present value of annual cost for 30 year operation.
2) As for OTCS + MCTCS, it is assumed that MCTCS is operated during 3 months in summer and OTCS is operated the rest of 9 months of a year.

As can be seen from the above figures, the OTCS is most advantageous from the Evaluated Life Cycle Cost point of view. To apply OTCS, however, availability of cooling water from Zeravshan River, as shown on the next clause, and quality of cooling water (to prevent scale deposit on CW equipment) is necessary to be thoroughly taken into account.

6) Availability of Cooling Water from Zeravshan River

As for availability of cooling water from Zeravshan River, it is presumed that current status are as follows from the information obtained up to now.

As shown on Table 7.1.6-9, consumption of Zeravshan River water for condenser cooling system of Navoi PS is estimated as approximately 842 million m^3/year, when GTCC3 with once-through condenser cooling system is put into operation. While, it is mentioned on Pre-FS (EIA) report of GTCC2 that limit for water use is 860.0 million m^3 (maybe per year). Considering other Zeravshan River water consumption than condenser cooling system, such as plant make up water (demineralized water), service water (filtered water), etc. and future conditions and water balance of Zeravshan River, stable and sufficient water supply from Zeravshan River to Navoi PS will not be secured, if existing units of Navoi PS continue to operate as the status of 2016. Therefore, it does not seem that once-through condenser cooling system will be recommended for GTCC3 unless some existing units are decommissioned (retired).

Table 7.1.6-9 Cooling Water Consumption of Navoi PS

Unit No	Type of Plant			Type of steam turbine	Type of CW system	CW flow	Make up flow	Cooling Water Source	Status	River water consumption
		Heat								
	Power	District Heating	Industrial						as of	
	MW	Gcal/hr	Gcal/hr			m^3/hr	m^3/hr		Dec. 2016	m^3/h
1	25	34	50	EC	OT	5000	-	River (Direct)	Reserved	0
2	25	34	50	EC	OT	5000	-	River (Direct)	Reserved	0
3	150	-	-	C	OT	21000	-	River (Direct)	Operation	21000
4	150	33	-	EC	OT	21000	-	River (Direct)	Operation	21000
5	50	-	200	B	No condenser	0	-	-	Operation	0
6	60	66	26	EC	OT	8000	-	River (Direct)	Stop	0
7	50	-	199	B	No condenser	0	-	-	Operation	0
8	160	33	-	EC	OT	21000	-	River (Direct)	Operation	21000
9	160	33	-	EC	OT	21000	-	River (Direct)	Operation	21000
10	-	100	-	No steam turbine	No condenser	0	-		Operation	0
11	210	-	-	C	NCT	25000	1090	River through settling pond	Operation	1090
12	210	-	-	C	NCT	25000	incl. in above	River through settling pond	Operation	incl. in the above
CTCC1	477.75	-	43	EC	FCT	21000	750	Potable water	Operation	750
GTCC2	450	100	100	EC	ACC	0	60		2020	60
GTCC3	500	100	100	EC	OT	27200			2022	27200
Total	2677.8	533	768			200200	1840			113040

EC Extraction condensing
C Condensing
B Back pressure

OT Once through
NCT Natural draft wet cooling tower
FCT Mechanical draft wet cooling tower
ACC Air cooled condenser

River water consumption/year = 113040 * 7446 (LF=85%) = 841.7 mil m^3/y
Limit of water use 860.0 mil m^3/y

(Source: Information from JSC Thermal Power Plant and estimated by JICA Survey Team)

7) Operating Experience of Existing GTCC1

Navoi PS started the commercial operation of Combined Cycle Cogeneration Plant Unit No. 1 (hereinafter referred to as GTCC1) in October 2012. After a while, steam turbine exhaust pressure rose due to scale adhesion to condenser tubes, and also the situations occurred in which the generating powers of steam turbine as well as gas turbine were forced to be limited to prevent the scale adhesion in the condenser tubes.
In corporation with Navoi PS, Consultant conducted a field investigation of GTCC1 in July 2014 to reconsider the cooling systems appropriate for GTCC2.

(a) Scale Adhesion in Condenser Tubes

After more than a year operation, GTCC1 experienced scaling trouble in the circulating water system, particularly in condenser tubes, despite all kinds of chemicals had been added to the cooling tower and water treatment plant according to the manuals. The results of water tests performed by the Station specialists, say that sediments are of carbonate and sulfate origin. The measurement of the condenser tube scales was conducted during the periodic maintenance works in June 2014. The results are as shown in Table 7.1.6-10 Scale of Condenser Tubes. Despite short operation time of 20 months, the scale became as thick as a range from 1.0 mm to 1.8 mm.
This scale deposition deteriorated condenser vacuum extremely.

Table 7.1.6-10 Scale of Condenser Tubes

Location of Condenser	Scale Thickness (June 26, 2014)
Tubes in Upper Half (CW outlet side)	1.8 mm
Tubes in Lower Half (CW inlet side)	1.0 mm

(Source: Information from Navoi PS)

(b) Chemicals for Cooling Water Treatment

From the data presented by Navoi PS, it became clear that the wet cooling tower system consumes chemicals for the circulating water treatment and the annual cost of the chemicals goes up to 2.4 million US$, which is so much higher than that had been expected in the Preparatory Survey.

Table 7.1.6-11 Chemical Cost for Cooling Tower in GTCC1 (2013)

Name	Unit Price	Chemical Consumption (kg/day)			Annual chemical cost (#3)	
	1000 sum/kg	River water pre-treatment (#1)	Circulating water treatment (#2)	Total	million Sum	million US$
Sodium hypochlorite (NaClO, 12%)	0.58	950	4,072	5,022	904	0.38
Ferric chloride (FeCl3, 40%)	2.917	3,420	0	3,420	3,095	1.31
Biodisperant	7.7	0	10	10	24	0.01
Antiscalant (Scale inhibitor)	132	0	36	36	1,474	0.62
Sulfuric acid (H_2SO_4, 98%)	0.159	0	3,000	3,000	148	0.06
Total	1.584	4,370	7,118	11,488	5,645	2.39

#1, #2: River water of 750 t/h is pre-treated to produce wet cooling tower makeup of 662.6 t/h.
#3: Annual chemical cost is calculated in the basis of 85% capacity factor.

(Source: Information from Navoi PS)

(c) Reduction of Power Output

More importantly than the above paragraphs, it was confirmed that the condensate temperature had to be suppressed to some extent lower than 45°C in order to inhibit the growing up of scale deposition within an acceptable range, taking the high salinity concentration of water in Zeravshan River into consideration. Since the upper limit of condensate temperature is as low as 45°C and the flow rate of circulating water was reduced by increased system flow resistance due to heavy scale deposition in the condenser tubes, the maximum power output of steam turbine had to be limited in summer season. Moreover, in order to limit the steam turbine output, it is necessary to reduce the gas turbine output by twice of the steam turbine output reduction. Total power reduction of steam turbine and gas turbine was found to be at most more than 100MW from the rated power output of the GTCC1.

Table 7.1.6-12 Operating Situation of GTCC 1

Item	Contents
Maximum power output at ambient air humidity 60%, temperature 15°C	478MW
Max. load to be at above 20°C	420- 440MW
Actual maximum load from April to 26 June 2014	330-370MW
Amount of underrun during the period	172,000,000 kWh
Electricity unit price	84.9 sums/kWh (0.043$/kWh)
Amount of power sales loss cost	14.6 billion sums (7.3 million $)
Scale formation in condenser tubes	Up to 1.8 - 2.0 mm thickness
Reason for intense scale formation	Excessive salinity of water in Zeravshan river (Use of chemicals for water softening does not have the desired effect.)
Acid cleaning period	June 26 to July 4, 2014 (9 days)
Kind of acid	Acetic acid
Quantity of used acid	60 tons
Cost of used acid	136,810,231.00 sum (68,000US$)
Interval of acid washes to obtain the maximum load	not less than once a year
Visual inspection of sprinklers of wet cooling tower	Due to the formation of scale, the plastic sprinklers were damaged by the weighting and shall be replaced in every 4 years.

(Source: JICA Survey Team by Information from Navoi PS)

8) Study Summary

The study results described above are summarized in Table 7.1.6-13.

The Survey team will recommend air cooled condenser, mainly because it can avoid scaling problem of wet cooling tower system that GTCC1 has encountered and it is not affected by uncertainties of enough and stable cooling water supply from Zaravshan river required for once-through cooling system.

Table 7.1.6-13 Comparison of Cooling Water System (in case of M701J, 1 on 1 GTCC)

	Forced Draft Air Cooled Condenser System	Once-through Cooling System	Mechanical Draft Wet Cooling Tower Cooling System	Combined Once-through and Wet Cooling Tower Cooling System
Basic design condition	Dry bulb temperature 15.0 ºC	Zeravshan River water temperature 18.0 ºC	Wet bulb temperature 10.9 ºC	River water temp.18.0 ºC Wet bulb temp. 10.9 ºC
ITD	20 ºC	11 ºC	19 ºC	11 ºC / 19 ºC
Condenser pressure	8.07 KPaa	4.00 KPaa	4.22 KPaa	4.00 KPaa / 4.22 KPaa
Net power output of steam turbine	123,414 kW (Base)	131,529 kW (+ 6.6%)	129,950 kW (+ 5.3%)	129,950 kW ～131,529 kW (+ 5.3% ～ + 6.6%)-
Water consumption for make up	60 t/h	None	844 t/h	-
Power reduction in summer	78 MW	82 MW	150 MW	82 MW ～150 MW
Construction cost	Base (26.3 mil USD)	▲ 59% (10.9 mil USD)	▲ 51% (13.0 mil USD)	▲ 9% (Max. 23.9 mil USD)
Life cycle cost	Base (63.5 mil USD)	▲ 63% (23.3 mil USD)	▲ 5% (60.2 mil USD)	▲ 19% (51.2 mil USD) (*)
Track record	Many, mainly in overseas	Many in Japan and overseas	Many, mainly in overseas	Rare
Experience in Navoi P/S	Under construction for GTCC2	Applied for Existing Units No.1,2,3,4,6,8,9	Applied for GTCC1, which experienced serious scaling trouble of condenser and cooling tower	No experience (TEPSCO)

(Source: JICA Survey Team)

(*) Operation of wet cooling tower system is assumed to be 3 month/ year in summer season.
Although the above comparison was made in case of GTCC of M701F5 gas turbine, the tendency of the result is applicable to GTCC with other types of gas turbine.

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9) Arrangement (Installation) of air cooled condenser

Alternative air cooled condenser arrangement (installation) that it is installed to strand the intake channel was proposed by the counterpart.

Because of the following reasons, the Survey team will not recommend to install air cooled condenser stranding the intake channel.

1) Condenser performance

a) The counterpart may propose this alternative arrangement to expect improvement of air cooled condenser performance by suction air cooled over river water surface of intake channel. However, there is a possibility that the intake air of the condenser comes from land portion, not over river water surface, and also it is difficult to take effect of humidity into consideration, so that this alternative arrangement of air cooled condenser includes uncertainties that makes it difficult to secure guaranteed performance.

b) There is a possibility that the exhaust duct from steam turbine eh¥exhaust to inlet of air cooled condenser becomes longer, that may affect heat transfer area of air cooled condenser or performance.

2) Erection work

Foundations of air cooled condenser are necessary to be installed inside the intake channel, and difficulty of erection work will increase.

3) Maintenance work

Ordinal maintenance work such as oil male up to reduction gear, check of instrumentation and visual checks may be possible in the same manner as in the case of usual installation, but large replacement work such as motor replacement may require higher cast because the intake channel prevents access of heavy construction machines.

7.2 Scope of the Project

7.2.1 General

The scope of this Project includes the design, manufacture, transportation and delivery to the site, construction at the site, testing and commissioning, and maintenance for a period of one (1) year after Taking Over of the plant herein described.

The combined cycle cogeneration plant to be installed shall be of nominal 600 MW plus/minus 20 MW highly efficient combined cycle block in a one on one multi-shaft configuration comprising one (1) low-NOx gas turbine, one (1) triple pressure reheat, outdoor type heat recovery steam generator (HRSG) equipped with supplementary firing burners as necessary, one (1) reheat, three admission, triple-extraction, condensing type steam turbine, two (2) electric generators, and plant auxiliary equipment.
The cooling system for the condenser is air cooled condenser. The cooling system for the closed circuit cooling water of plant auxiliary equipment shall be of mechanical draft wet cooling tower type.

The gas turbine and supplementary firing system, as necessary, shall be designed for natural gas exclusive firing. Gas supply would be from Navoi Gas Distribution Station to the site at 1.0~1.2 MPa(g) at the terminal point. Booster gas compressors shall be included in the scope of work, to boost up the pressure to the required pressure in the gas turbine combustion chamber.

Transmission lines for GTCC3 to new 220 kV switchyard and 220 kV bay and bus to be installed in new 220 kV switchyard shall be included in the scope of this project.

The power plant shall supply the industrial steam of 21 ata (2.06 MPaa), 350 ºC (high pressure) and 8 ~ 13 ata (0.78 ~ 1.27 MPaa), 350 ºC (medium pressure) for neighboring chemical companies, Navoi AZOT, and the steam of 3 ± 1 barg and 200 ± 20 ºC to heat the hot water for district heating. These steam supplies shall be extracted from the steam turbine and their heat capacities shall be 30 Gcal/hr, 70 Gcal/hr and 100 Gcal/hr respectively. The industrial steam supply system and the hot water supply system including steam and hot water piping to the connection points at the existing main piping as well as their make-up water treatment systems and water treatment system for industrial steam return drain shall be included in the scope of this project.

The plant does not need to be capable of starting in system blackout conditions.

Due to the severe cold climate during winter at the project site, icing of pipes, equipment and instruments is anticipated. Design conditions for the ambient temperature range are specified in Section 7.1.1. The plant shall be equipped with appropriate anti-icing appurtenances where necessary.

7.2.2 Scope of Work

The facility and equipment, as described herein, shall include the following:

(1) Power generation equipment
1) One set of gas turbine and auxiliaries and flue gas exhaust system
2) One set of steam turbine, and auxiliaries
3) One set of heat recovery steam generator and auxiliaries
4) One set of gas turbine generator and One set of steam turbine generator, and their step-up transformers, One set of unit transformer, one set of auxiliary transformer and auxiliaries
5) One set of main stack
6) 220 kV switchyard, interconnections and auxiliaries

(2) Transmission Lines and Substation
1) New 220 kV Transmission lines to the new 220 kV Switchyard
2) New 220 kV bay and bus in the new 220 kV Switchyard
3) New 500 kV substation

(3) Heat Supply System

(4) Mechanical Equipment of Auxiliaries and Balance of Plant (BOP)
1) Forced Draft Air Cooled Condenser for steam turbine and auxiliary cooling system.
2) Gas skid and instrument air facilities
3) Gas pipe from metering station to the plant and booster compressor station
4) River water supply facilities
5) Water treatment plant
6) Waste water treatment plant
7) Cranes and miscellaneous hoist
8) Fire fighting, alarm and detection system
9) Heating, ventilation, and air conditioning (HVAC) system
10) General service air system and instrument air system
11) Workshop and chemical laboratory equipment and miscellaneous items
12) Service and potable water system
13) Gas generating system

(5) Electrical Equipment of Auxiliaries and Balance of Plant (BOP)
1) Station electrical supply system comprising unit and station transformers, bus duct connections, medium/low voltage boards, auxiliary transformers, motor control centers, etc.

2) 220 V station DC supply system
3) 230 V AC station UPS system
4) Distributed control system (DCS)
5) Station earthing / grounding system
6) Telecommunication system
7) Lightning protection system
8) Emergency diesel generator (EDG)
9) Cathodic protection system
10) Lighting and small power supply system including emergency lighting
11) Compound / perimeter lighting system
12) External lighting

(6) Civil and Building Works

(7) Environmental
1) On-line emission continuous monitoring system
2) On-line ambient air continuous monitoring system
3) Sampling and analysis
4) Other equipment
5) Landscaping and environmental blending

(8) Miscellaneous

The scope of this Project also includes the following:
1) Tools and appliances
2) Spare parts for two (2) years continuous operation
3) First fill of oils and greases, and flushing oil and chemicals.
4) All consumable items for the one (1) year maintenance period.
5) Fire barrier installation conforming to the Fire Services Department requirement
6) Training of Power Plant's staff
7) Keys and key cabinets system for all plant and equipment
8) Supply of operation and maintenance (O & M) manuals
9) Air pollution study and determination of stack dimensions
10) Statutory and local authorities approval

7.3 Basic Systems for Plant Design

7.3.1 Gas Turbine System

(1) Design Codes and Standards
The gas turbine system shall be basically designed as per ISO 3977-3 "Gas turbines-Procurement-Part 3: Design requirements" and ISO 21789 "Gas turbine applications-Safety."

(2) Gas Turbine
The gas turbine shall be of single shaft configuration, open cycle, heavy duty H or J class temperature level type with dry low NOx design suitable for the specified natural gas.

The gas turbine design shall be with a minimum number of bearings, and shall be located on a steel frame or on adequate steel structures and concrete foundation, so sized as to withstand the transient torque imposed on the shaft in case of short circuit of the generator or out-of-phase synchronization, whichever is larger. The power output shall be taken out at the cold end of the shaft.

The gas turbine shall be complete with all auxiliary systems such as starting system, lube oil supply system, inlet air filtration system, fuel gas supply system, turning device, control and monitoring equipment necessary for safe, reliable and efficient operation with the fuel specified. The gas turbine shall be designed for indoor installation in an enclosure to meet the specified noise requirements.

The gas turbine shall be designed for continuous base load operation according to the manufacturer's standard, burning natural gas with the specified composition range. The gas turbine shall be capable of start-up, loading and shut down using the specified natural gas.

The gas turbine shall be provided with an automatic start-up and control system capable of being operated from the central control room of the plant.

The control system of the gas turbine shall be such that it is capable of performing the following operations as a combined cycle:

- Constant load operation at all loads between the minimum and full loads
- Governor free (droop) operation
- Turbine inlet temperature constant operation
- No load operation for certain periods of time without being not synchronized as a simple cycle
- Minimum load operation not more than 30% of the full load as a combined cycle on the full power of the steam turbine keeping all the bypass valves closed.
- Automatic purging cycle to ensure that specified natural gas is removed from the gas turbine and entire exhaust system up to the exit of the stacks. The purging time shall be adjustable depending upon the volume to be air-purged.
- The load rejection from the full load without tripping for easy re-synchronization.

The gas turbine shall be of horizontally split case construction for convenience for maintenance and shall permit easy access to stationary and moving blades without undue difficulties.

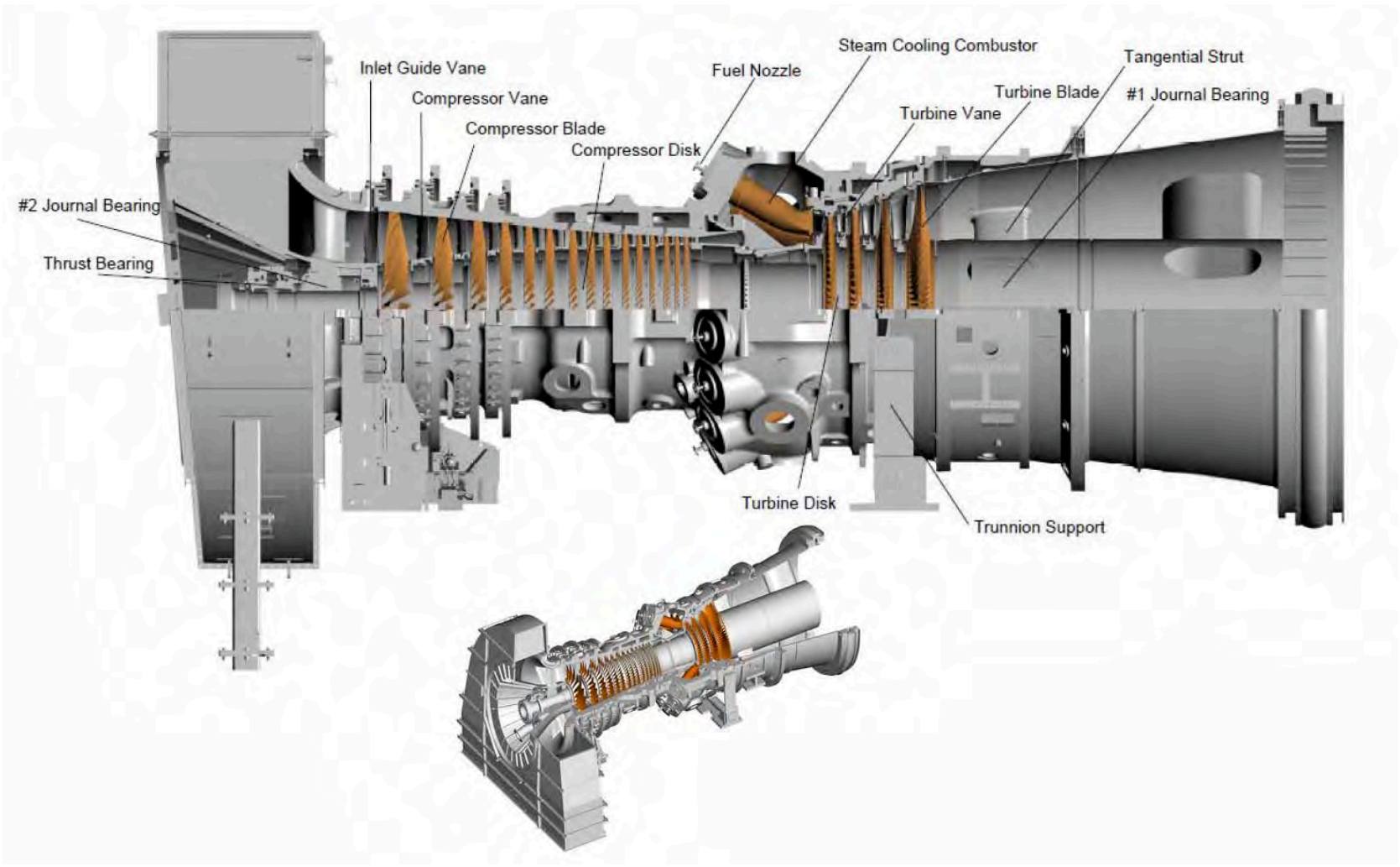
The entire gas turbine casing shall be heat and sound insulated in such a manner as to allow easy removal and replacement for overhaul and inspection. The insulation material shall be of asbestos free non-combustion and chemically inert material and shall be covered by sheet metal. The design of the heat and sound insulation shall be in a manner to avoid the lube oil soaking in.

Around the gas turbine there shall be working space of at least 0.8 m width without any interference by piping, cabling, walls, etc.

The journal bearings shall be of sleeve bearing type. The axial thrust force shall be oriented in one direction during all steady state operating conditions and shall be absorbed by an adjusted axial thrust bearing. All main bearings of hydrodynamic type shall be equipped with bearing oil outlet temperature indicators and monitors and vibration indicators and monitors. The monitors shall be capable to actuate alarm and/or trip as per manufacturers' practices.

Borescope parts for inspection of all critical inner parts shall be provided.

Figure 7.3.1-1 shows the longitudinal cross section of the typical J class gas turbine which is one of the candidate gas turbines applicable for this Project.



(Source: MHPS Catalogue)

Figure 7.3.1-1 Longitudinal Cross Section Drawing of Typical J-class Gas Turbine

(3) Starting System

The starting device and associated power supply equipment shall be suitable for the acceleration of the gas turbine/generator and the extended operation during purge and compressor cleaning cycles. The rating of the starting device shall be determined so as to produce the starting and acceleration torque with a proper margin to allow for the gas turbine/generator to accelerate to the rated speed from standstill within 25 minutes (excluding the purge and synchronization time) on all machine state conditions without any difficulties throughout the specified ambient temperature range. The starting device and starting power supply capacity shall be minimized as long as the train will be accelerated within the specified time.

The type of starting device for the H or J class 3,000 rpm gas turbine/generator has to be of a synchronous generator/motor with a static frequency converter (thyristor type) because any other types of starting devices are not applicable from the technical and economical points of view.

The starting system should preferably be rated without limit on the number of starts to be attempted at least three (3) times in succession.

Interlocks shall be provided to prevent the gas turbine/generator from starting in case the lube oil pressure is not sufficient to rotate the gas turbine/generator rotor.

Any starting device shall disengage automatically and shut down before it reaches the maximum allowable speed. The starting device is normally disengaged at the self-sustaining speed or idle speed and is at rest during operation. Failure of the disengagement shall automatically abort the starting sequence.

The gas turbine/generator shall be capable of starting instantaneously from any standstill conditions as long as it is on reserve condition.

The starting control system, including any pre-start actions such as turning, shall be of manual and automatic as defined below:

Manual start:	The start-up sequence shall be held and advanced at the events such as cranking, purging, firing and at the minimum governor setting speed.
Automatic start:	The start-up sequence shall be automatically advanced to the minimum governor setting speed or the readiness to synchronizing or to the pre-set load.

The starting control system shall be provided with an automatic purge function to ensure safe operation.

(4) Lube Oil Supply System

The lube oil supply system shall be basically designed as per the requirements of the latest version of API 614 or equivalent standard. A complete lube oil system shall be provided and shall be fully integrated with jacking oil system (if applicable), oil purification system and dirty oil drains for the gas turbine/generator. The lube oil system shall have sufficient capacity to accommodate the requirements of the systems that will be supplied with the lube oil.

The system shall include sufficient standby equipment to allow any items of equipment within the lube oil system to be taken out of service for maintenance without restricting the operation of the plant.

The lube oil system shall be preferably separated from that of the steam turbine/generator.

The retention time of the oil reservoir shall not be less than eight (8) minutes based on the normal flow rate of oil and the retention capacity which is the total volume below the minimum operating level in accordance with API Standard 614 in case that a lube oil system without sufficient commercial operating experiences will be used..

Alarms shall be at least made on the occurrence of the following situations:

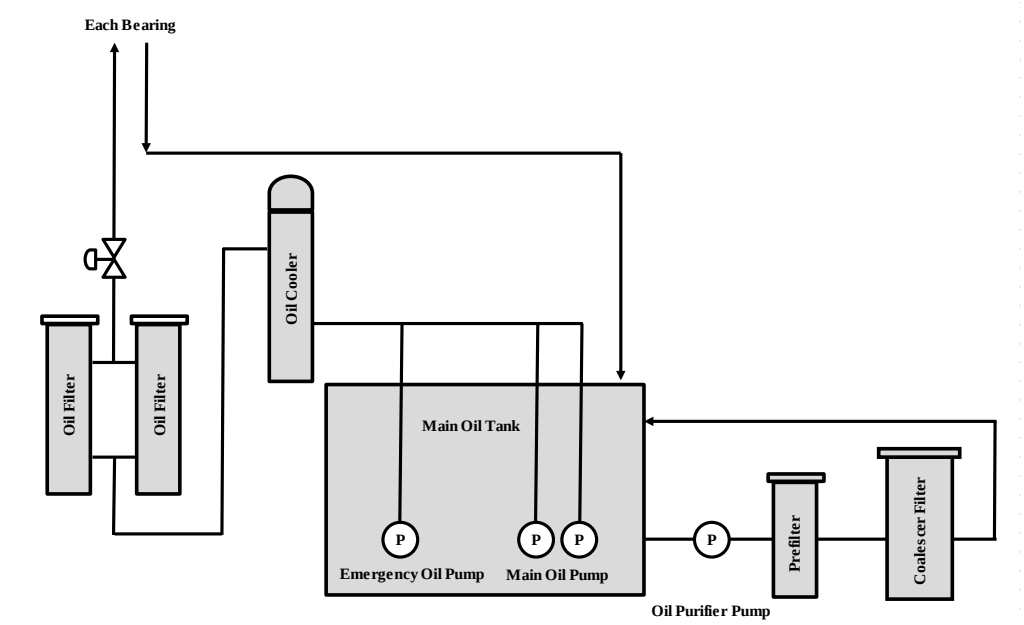
Lube oil supply pressure low
Lube oil reservoir level low
Lube oil discharge temperature high
Lube oil supply temperature high
Lube oil filter differential pressure high

All bearing drain lines and oil wells are to be provided with visual indicators capable of being observed from a local platform or operating floor level.

The outlets of relief valves shall be routed to the oil reservoir tank.

In the event of AC power failure, the emergency DC oil pump to be operated for rundown of the rotating shafts and bearing cool-down shall be automatically put into operation. A combined AC/DC tandem motors-driven pump shall not be accepted.

Where oil is supplied from a common system to two (2) or more machines, the characteristics of the oil shall be specified by the Contractor. The Contractor shall ensure that the specified oil meets the requirements of the different machines and is locally procurable. Figure 7.3.1-2 Typical Flow Diagram of Lube Oil Supply System is a typical flow diagram of lube oil supply system



(Source: JICA Study Team)

Figure 7.3.1-2 Typical Flow Diagram of Lube Oil Supply System

(5) Fuel Supply System

The gas turbine combustion system shall be of a single-fuel design burning the specified natural gas indigenous in Uzbekistan.

The natural gas pipeline terminal point may locate just outside the power plant boundary fence. The pressure at the terminal point is specified from 1.0 to 1.2 MPa (g). The dust particle distribution data necessary for design of the pre-treatment facility will be examined in due course of time.

The fuel gas supply system shall be such that it can supply the gas turbine with the specified natural gas under normal conditions with a proper pre-treatment, and the necessary booster compressor system as per required under worst supply conditions. The booster compressor system shall be consisted from a plural number of compressors. It shall be such that the gas turbine shall be kept in the operating conditions even the during of the time when one (1) compressor will trip and the spare compressor will reach the rated conditions.

The fuel gas supply system shall cover all the equipment required for the start-up, shut down and continuous operation of the gas turbine. A flow metering valve, pressure-regulating valve, shut-off valve, flow meter, fine filter and distributing manifold, but not limited to such equipment, shall also be included in the scope.

Any fuel gas heating facility where the fuel gas may be heated with hot air extracted from the gas turbine compressor as a turbine cooling media for improvement of the thermal efficiency of the plant may be provided depending upon the gas turbine manufacturer.

Any other conditions necessary for the design of the gas turbine shall be examined at the detailed design stage.

(6) Air Intake System

1) General

The air supply for a gas turbine shall be taken from a high-level atmospheric air inlet external to the gas and steam turbine building. The air intake shall also be positioned to avoid the ingress of any exhaust gases from the main stack of the heat recovery steam generator.

The design of the hood shall permit ready access to the air filtration system. After filtration, the air shall be directed to the inlet flange of the gas turbine compressor.

The intake system shall be complete with inlet screen and louvers, filters, airtight duct from filters to compressor inlet, foreign object damage protection screen, sound attenuators and all controls and instrumentation necessary for safe control.

The number of access points and penetrations into the air inlet system for maintenance and inspection shall be minimized. Any door or hatch shall be capable of being securely locked, and interlocks shall be provided to prevent any attempted start with any door or hatch not properly closed.

2) Air Filtration System

The air intake filtration system shall be accomplished by a multi-stage dry system consisting of a prefilter and a HEPA filter equivalent to Class E12 to EN 1822. The air filtration system shall be so designed that its initial weight arrestance efficiency will not fall below 99.5 % for ASHRAE test dust.

The replacement interval of filter elements shall not be shorter than 6,000 operating hours for the dust concentration of 0.1 mg/m^3 with ASHRAE test dust.

The air intake shall be equipped with a silencer downstream of the filtration system and the whole of the ducting shall be sealed to avoid ingress of unfiltered air.

The air filters chosen shall be suitable to reduce the sand, dust and salt content of the atmospheric air to a level which is not detrimental to the life of the gas turbine unit and under the most adverse atmospheric conditions of the site.

A self-cleaning type air filtration system is not acceptable.

The design shall minimize the inlet system pressure drop. The instrumentation and control equipment shall also be kept to a minimum but must include a differential pressure monitor across every stage of the filtration system.

3) Air Inlet Ductwork

The ductwork shall be complete with all the necessary expansion joints, guide vanes, supports and supporting steelwork, vibration isolators, flanges, silencing equipment, cladding and any other items necessary to complete the system.

The expansion joint shall be such that no loads or forces are transmitted to the gas turbine inlet flange.

Sliding joints shall not be used in the ductwork. All expansion joints shall be flanged for removal without disturbing the main sections of the ductwork.

No entrapped nuts, bolts or rivets shall be used inside the ductwork downstream of the filtration system.

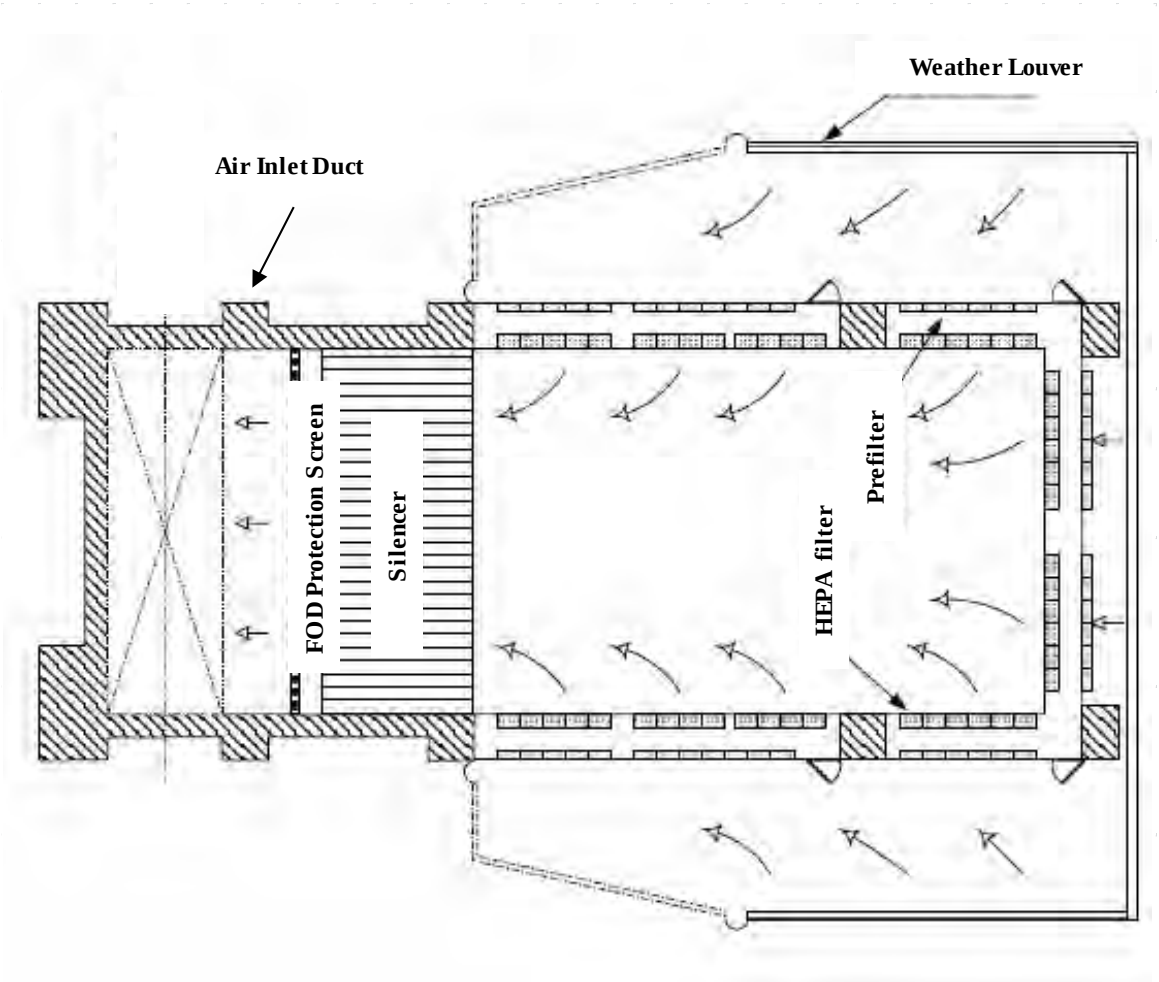
Bypass doors shall be provided in the ductwork to allow the air filtration system to be bypassed in the event of excessive differential pressure across the filtration system. The construction of the bypass door shall be preferably of a counter weight type. An alarm in the control room shall be initiated on high filter differential pressure. On further increase in differential pressure, a further alarm shall be initiated together with automatic opening of the bypass doors.

4) Silencer

A silencer shall be provided to control the noise from the air compressor to the specified level. The silencer acoustic panels shall be designed for the service life of thirty (30) years at the full load condition of the gas turbine. The silencer shall be capable of being removed from the ductwork without dismantling or removing any other ductwork than that containing the silencer. The silencer acoustic panels shall be constructed from stainless steel. The infill and panels shall be fully resistant to the worst atmospheric conditions anticipated on the site. Precautions shall be taken to prevent settling or packing of the infill material. The infill material shall be vermin proof.

5) Foreign Object Damage (FOD) Protection Screen

Since there is a possibility of foreign objects entering the gas turbine and causing damage of rotating parts, the FOD protection screen shall be installed at the compressor inlet to reduce the size of objects that can enter to a size that is not liable to cause such damage. The location of the screen shall be sufficiently upstream to avoid the potential for large objects to cause significant localized flow blockage that may induce blade failure. The Figure 7.3.1-3 is the typical air intake system.



(Source: JICA Study Team)

Figure 7.3.1-3 Typical Air Intake System

7.3.2 Steam Turbine System

(1) Design Codes and Standards

The steam turbine system shall be basically designed as per the latest version of ISO 14661 "Thermal turbines for industrial applications" or equivalent codes and standards.

(2) Steam Turbine

The steam turbine shall be of a reheat, three-admission, double-extraction, two-casing, condensing type directly connected to the generator. The steam shall be downward or axially exhausted to a condenser. Condenser is a air cooled condenser. The steam turbine shall be of a three (3) pressure-level turbine with HP, IP and LP sections. The high and medium pressure level of steam may be extracted from the cold reheat line and IP section for export to adjacent industrial companies (Navoi AZOT). The low pressure level of steam may be extracted from the LP section for production of hot water for district heating.

The steam turbine and ancillary systems shall be designed to run continuously under all specified conditions over the specified lifetime of the plant.
The steam turbine maximum capability shall be defined so as to cope with such parameters as steam pressure, temperature, flow rate to be developed by the HRSG under conditions of full condensing with steam extraction of 100 Gcal/hr for industrial steam and no steam extraction for hot water system, and with maximum allowable supplementary firing temperature, at ambient temperature of 15 ℃.

The steam turbine shall be complete with all auxiliary systems such as a steam condenser, a lube oil supply system, a control oil supply system, admission steam stop and control valves, extraction control valves, a governing system, a steam bypass system, a turning device, control and monitoring equipment necessary for safe, reliable and efficient operation. The steam turbine shall be designed for indoor installation in an enclosure suitable for specified noise requirements.

The steam turbine design shall be with adequate number of bearings, and shall be located on a steel frame or on adequate steel structures and concrete foundation, so sized as to withstand the transient torque imposed on the shaft in case of short circuit of the generator or out-of-phase synchronization, whichever is larger. The power output shall be taken out at the LP turbine section side.

The turbine blading shall be designed so that it withstands the continuous operation under any loads at any network frequency from 48.5 to 51.5 Hz with any allowable time limitation for under frequency less than 48.5 Hz.

Blades shall be thoroughly protected against erosion from moisture. The last stage blades shall be protected against erosion by flame hardening or by erosion shields of satellite or other suitable material. Other erosion protection provisions such as drain grooves on the last few stationary blades and turbine casing will also be considered if such provisions are proven to be effective.

The steam turbine shall be designed so that the expected life expenditure of the main components shall not exceed 75% of the expected lives of them through the specified service hours when it will be operated on the specified conditions.

The turbine shall be provided with necessary number of borescope ports to inspect the conditions of the blades at periodical intervals.

The steam turbine shall be designed with proven materials having a wealth of commercial operating experiences on the similar operating conditions. Especially, special attention shall be paid to the material of integrated single rotor where operating conditions are different at front and rear parts of it.

As for design of the casing and its pipe connections, it shall be taken into account that the most severe conditions of pressure and temperature may simultaneously act upon them. In addition to the calculated minimum thickness of the casing, allowance shall be made for corrosion if the casing is not of a corrosion-resistant material.

The rotor shall be designed to be safe against the speed at least 10 % above the momentary speed which may happen under the maximum operating temperature. If the rotor is of built-up construction, the disc shall remain secure at the speed mentioned above.

7.3.3 Heat Recovery Steam Generator (HRSG) System

(1) Introduction and Scope

This part of the specification covers the one Heat Recovery Steam Generator (HRSG) complete with ducting, mountings, integral valves and pipes, and other specified items associated with the one gas turbine generator of the combined cycle block.

The HRSG shall be of the fired (as necessary), three-pressure, natural or forced circulation, reheat type of proven design in accordance with the requirements of BS 1113 or equivalent, where applicable.

The HRSG shall be designed to accept the maximum exhaust gas mass flow from a gas turbine at base continuous output with minimum specified ambient temperature and the heating surfaces shall be designed to take into account, the variation on the temperature/flow profile which will occur in the gases leaving the gas turbine under differing loads and ambient conditions.

The HRSG shall be capable of following the inherent rapid start-up and shut down of the gas turbine without undue thermal stress.

The HRSG shall be designed to operate on the exhaust gas of the gas turbine fired with natural gas. If necessary, the HRSG shall be designed to operate with a supplementary burning system fired with natural gas. The purpose of the supplementary firing system is to maximize the quantities of extraction steam from the steam turbine for the industrial steam supply system and the hot water supply system especially in the winter season. The capacity of the supplementary firing system shall be determined carefully by the manufacturer taking into consideration the maximum allowable temperature of the hot gas duct as well as adverse effects on HRSG steam temperature control and others, however, the maximum firing rate shall be limited to the flue gas temperature rise to 750 ^{o}C.

In the case of steam turbine trip, the HRSG shall be able to continue operation using the steam turbine bypass system and supply the heating steam instead of the steam turbine extraction steam.

The HRSG design shall be such as to minimize the back-pressure on the gas turbine while maintaining the rated output and steam conditions.

The HRSG should be constructed of large, factory-tested, shippable modules to reduce installation time. Following heat transfer modules shall be considered, as applicable, for the HRSG design:

- High Pressure Superheater Section
- High Pressure Evaporator Section
- High Pressure Economizer Section
- Reheater Section
- Intermediate Pressure Superheater Section
- Intermediate Pressure Evaporator Section
- Intermediate Pressure Economizer Section
- Low Pressure Superheater Section
- Low Pressure Evaporator Section
- Low Pressure Economizer Section
- Condensate Preheater (if required)

To minimize the outage time for inspection and maintenance, provision shall be made to allow ready access to the flue gas path, tubing, and other pressure parts. Access doors with integral seals to prevent gas leakage to atmosphere shall be provided.

The HRSG shall be designed for indoor installation to protect both personnel and equipment from the external environment. Freeze protection measures shall be devised separately for HRSG equipment in particular during the winter season.

The steam drums shall be sized sufficiently large to accommodate water level variations during start-up and during operating transient conditions without resorting to wasteful water dumping or risk of carry over. The drum capacity shall also be sufficient such that tripping of any one operating boiler feed water pump shall not cause HRSG trip prior to standby feed water pump reaching its operating load. Particulars of the general layout of the water circulating system including the number and internal diameter of feeders and mains for each circuit shall be provided.

The HRSG shall be arranged with the total pressure parts comprising steam drums, superheaters, reheaters, evaporators, economizers, headers, down comers and integral pipe work in the form of a self-contained unit supported by its own steel structure. This structure is to be quite independent of any building except for normal points of interconnection with access galleries, platforms, or stairways.

The design of the HRSG and associated ancillary and auxiliary systems shall have been developed for both base load and cycling service in particular where component material stress and structural design are concerned. Any special features for the HRSG necessary to permit both constant and variable pressure operation for the turbine steam temperature matching shall be incorporated. The capacity in terms of interval at maximum continuous steaming rate between normal water level, low water level, low water level alarm, low water level trip and minimum level at which the HRSG will not sustain damage shall be not less than ten seconds.

(2) Design and Operating Conditions

HRSG shall be suitable for the normal and abnormal operating conditions to suit the proven combined cycle plant design and as per the Heat Balance Diagrams.

The gas side of the HRSG passages shall be designed for the maximum temperature, pressure and mass flow that can be anticipated under all operating conditions (including trip situation). The

maximum values will not necessarily be concurrent.

The HRSG shall be able to meet the requirements of sustained base load as well as two shift operation.

The HRSG shall be capable of automatic variable pressure operation both for sustained base load as well as two cycling regimes, to minimize the turbine thermal stress levels and obtain the desired flexibility and efficiency. The manufacturer shall define the variable pressure characteristics of the HRSG including the minimum load at which variable pressure operation can be sustained.

Under conditions of total load rejection, the operation of the HRSG shall be rapidly transferred to the steam turbine bypass operation mode by means of the high pressure, intermediate pressure and low pressure steam bypass system and the thermal load of the HRSG shall be reduced in accordance with the gas turbine shut down characteristics. In the case of the steam turbine generator trip, the gas turbine and HRSG shall be able to continue operation in the steam turbine bypass operation mode to supply steam for the neighboring industries and the hot water supply system instead of the steam turbine for at least a few days until the back up from the existing power plants becomes available.

The HRSG design shall be optimized for continuous efficient operation over the entire operating range of the gas turbine. The efficiency between 75% and 100% MCR shall be maximized.

The feed water quality shall meet the requirement of the HRSG and steam turbine as per applicable code.

(3) Design Standards and Codes of Practice

All materials, designs, manufacture, construction, and inspection and testing shall conform to criteria and recommendations of the relevant codes and standards.

All pressure parts, mountings, fittings and sub-assemblies shall be designed, constructed, and tested to conform to the requirements of the approved Inspection Authority.

(4) Design and Construction of HRSG

1) HRSG Gas Path

The gas turbine exhaust gas path through the HRSG shall be horizontal or vertical with water and steam tubing located horizontally/vertically across the gas stream to suit the plant layout and as per the manufacture's standard design.

The heating surfaces of various modules in the gas stream shall reduce the gas temperature to the lowest value practicable, with each of the fuels available to the gas turbine, without risk of damage from corrosive sulfur products at the economizer outlet or within the stack. Control of the feed water temperature to ensure that metal temperatures in any part of the economizer remain above the dew point shall be achieved via the deaerator.

The tubes and headers in each plenum shall be completely drainable and provision shall be provided to gain access to the tubing for inspection and maintenance.

2) Tubes

The tubes shall be of solid drawn or electrical resistant welding (EWR) steel as per the manufacturer's experiences. The design, manufacture and testing of the tubes shall be in accordance with the relevant standard specification.

Adequate circulation ratio shall be provided to minimize circulation upsets that may occur during rapid start-up or load change.

Fins added to the heat exchanger tubing to improve the heat transfer characteristics must be continuously welded to the outside surface of the tubes.

All welds and tube connections to headers shall be outside the gas passage and readily accessible for inspection and maintenance.

3) Superheaters and Reheaters

The H.P superheater tubing shall be designed and located in the HRSG unit such that the steam temperature at delivery to the steam turbine will not exceed the H.P steam chest and rotor stated limits, with the gas turbine at base continuous output with highest anticipated ambient temperature, without recourse to desuperheating the steam. The design will be compatible with the requirements of constant and variable pressure operation and the variable characteristics of the gas turbine exhaust gas flow.

The design of the H.P., I.P and L.P superheater within the HRSG units shall ensure even distribution of steam through the tubes at all loads.
Superheaters and reheaters shall be in the form of fully drainable elements.
Superheater and reheater tubes are to be designed for with no steam flow in tubes during start-up. Material selection shall conform to the same.
Austenitic stainless steel shall not be used anywhere in the superheater.

4) Evaporators

The HP., IP and LP evaporator plenums will be designed to achieve a steam generation rate such that the gas leaving the zones is not more than 17.5ºC above the steam saturation temperature in that zone. (i.e. temperature difference at the pinch point: maximum 17.5 ºC).

The evaporator shall be designed to operate over the full load range of the HRSG without drumming or vibration and the design will ensure an even distribution of water through the tubes. The evaporator elements shall be drainable completely.

5) Economizers

The HP, IP and LP economizers shall be designed to ensure stable non-steaming operation/single phase flow throughout the full operating range of the HRSG. Connections shall be arranged between the steam drum and the economizer inlet to enable circulation of water to be maintained through the economizer during start-up. Should recirculation of water through the economizer be necessary during start-up or low load conditions, the connections shall be arranged complete with a pump to allow this. The economizer elements shall be drainable completely.

6) Condensate Preheater (if applicable)

A condensate preheater for HRSG as the last heat recovery module shall be provided, if necessary for maximum heat recovery. The condensate preheater shall be designed for the condensate extraction pump shut off head. Material selection for the preheater shall be suitable for undeaerated condensate water.

7) Steam Temperature Control

The steam temperature at the outlet of the superheaters and reheaters shall be controlled using direct spray type desuperheaters.

The capacity of each desuperheater shall be selected taking all operating conditions especially operations with the supplementary firing system into consideration.

Spray water control station shall have a motorized isolation valve in the common line, interlocked to close automatically when the steam temperature reaches below a set point and to prevent water induction into steam turbine.

8) Safety Valves

Safety valves of approved number, design, and capacity shall be mounted in approved locations in accordance with the requirements laid down by the relevant regulations.

The safety valves at the superheater outlet shall be sized to have a discharge capacity equal to at least 20% of the maximum steam quantity generated by the HRSG. The safety valves at the steam drum shall have total discharge capacity equal to at least the remaining of the maximum steam quantity required for the protection of the HRSG.

Safety valves on the reheater must be sized to pass the maximum reheater flow without a rise in reheater inlet pressure of more than 10% of the highest set pressure.

9) HRSG Insulation and Cladding

The whole of HRSG shall be insulated internally and/or externally and all external insulation shall be cladded in accordance with the Specification to provide an entirely weatherproof unit suitable for indoor operation.
The insulation shall be of proven material and suitable for continuous service at the maximum operating temperature.

10) Access and Inspection Doors

Adequate access and inspection doors of an approved type and size shall be provided to allow free entry for maintenance and cleaning of the HRSG gas-path, and pressure parts.

11) Blowdowns and Drains

The steam drum shall be provided with a continuous drum water blowdown connection, located to ensure preferential discharge of concentrated drum water, complete with parallel slide isolating and regulating valves in accessible positions adjacent to the drum connection, capable of controlling the rate from 0.05% minimum to 4% maximum of the HRSG steam rating.

Intermittent blowdown and drain piping shall be included where necessary from all drainable sections of the HRSG down to the intermittent blow down tanks.

HRSG shall be provided with a continuous and intermittent blowdown tanks.

An adequate number of electrically operated blowdown valves and superheater and reheater drain valves shall be provided for automatic operations during start up, load operation, and shut down of the HRSG.

12) Economizer/Condensate Preheater Recirculation System (if applicable)

Economizer/condensate preheater recirculation pumps shall be provided if the overall plant design demands such an arrangement for the safe and efficient operation with the desired flexibility and reliability of the plant as specified in the Design Consideration under start-up and low load operation.

(5) HRSG Control & Instrumentation Requirements

1) General

The control and protection requirements for the HRSG are principally bounded by the following:

- On the gas side by the gas turbine exhaust
- On the feed water/steam side by the HP/IP and LP feed water pumps discharge and the HRSG HP/IP and LP steam stop valves.

The control system for the HRSG shall be implemented in the Distributed Control System (DCS). All necessary control functions and interlocks required for safe and efficient operation of the HRSG shall be incorporated within the DCS. Separate DCS Field Control Stations/Remote I/O Stations shall be provided for interlock and protection related parameters and signals meant for control and monitoring purpose.

The control functions of HRSG shall comprise of the following as minimum:

- HP, IP and LP feed water control
- Start-up/load rate control
- Superheated steam temperature control
- Reheated steam temperature control etc.

The main protection/interlock associated with HRSG shall be implemented by utilizing the signals associated with the following as minimum:

- Gas Turbine Trip
- High-High and Low-Low Drum Level
- Steam Turbine Trip
- Steam Turbine steam bypass failure
- Local and Remote Emergency Trip, etc.

The start up, operation within the normal load range and shut down of the HRSG shall be fully automated up to the functional group level. However, the initial HRSG filling operation and the establishment of initial HRSG drum level shall be manually controlled and supervised from the Central Control Room and only local manual control may be provided for minor drain and vent valves, where these are not automatic and which are not required during normal steam rating.

The HRSG shall be capable of constant pressure operation up to 60% load and thereafter on variable pressure operation.

In the incidence of a steam turbine trip (at any load), excessive rate of increase of the HP/IP superheater temperature within the HRSG or a HRSG trip due to say a loss of feed water supply shall initiate the appropriate interlocks to trip the gas turbine within a preset time.

In the case of a steam turbine trip, the steam turbine bypass system shall be functioned to maintain the HRSG in a ready condition

MTBF (Mean Time Between Failure) of HRSG control & protection system, except for the transmitter, detecting elements and regulating devices, shall be more than 100 thousand hours

of design.

The manufacturer shall supply the following instrumentation, control and protection system with all necessary components and accessories, but not be limited to:

- HRSG modulating control system
- HRSG system sequence control
- HRSG autonomous control system
- HRSG instrumentation etc.

2) Turbine Exhaust Gas Control Requirements

All control and instrumentation systems required for the regulation and supervision of the heat input to the HRSG shall include all temperature and pressure measurement both on the gas and feed/steam sides.

Automatic HRSG start up shall be possible under the full spectrum of operating conditions which shall include the following:

- The run up and loading of the gas turbine generator and HRSG
- The start up of the HRSG from any initial temperature condition (i.e. cold to full load temperature) with the associated gas turbine generator operating conditions.

To control the temperature and pressure rise of the HRSG and steam piping during start-up, the firing and load pick up rate of the gas turbine shall be set to predetermined one based on the conditions of HRSG and gas turbine at start-up. And also the HRSG is required to be able to accommodate the full exhaust gas flow for all conditions of start-up and during transient operating conditions.

In addition to the start up requirements, the control system shall meet the following disturbance conditions:

- It shall maintain maximum steam generation compatible with the turbine bypass capacity in the event of the steam turbine tripping to permit the reloading of the latter with the minimum of delay.

- It shall minimize the effect of a partial or total block load rejection and maintain the HRSG in a state, which shall minimize the delay in the subsequent re-connection and loading of the steam turbine.

The control and supervisory functions of the following plant items shall be considered:

- The gas passage between the inlet and the HRSG exhaust.
- The HRSG LP economizer, drum, evaporator and superheat sections
- The HRSG HP/IP economizer, drum, evaporator and superheater sections
- The HRSG preheater and deaerator sections

The principal sequence and protection control functions shall include the following as minimum:

- The start-up and HRSG Loading Control

The requirement for these control functions is sequential in nature. The sequence controls of HRSG stop valves and associated bypass valves including all necessary state monitoring shall be controlled by these control functions.

Only local manual controls are considered necessary for the operation of the diverter flap, to be restricted by a Permit-to-Work system.

- Shut-down

This function shall be capable of being initiated both manually and automatically from the central control system. The shut down function shall initiate co-ordinated closing of the TEG inlet and closing of HRSG stop valves after an appropriate delay. The stopping of HRSG feed water pumps and circulation pumps may be regarded as manual action.

This sequence function shall initiate the tripping of the gas turbinewithin a preset time after the HRSG is tripped.

The HRSG supervision shall not exercise any direct control functions but shall comprise of all measurement hardware required for the monitoring of the operational state of the HRSG.

3) Feed Water Control Requirement

The control and instrumentation system required to regulate feed water supply to HRSG shall include feed water regulation valves, instrumentation associated with drum level, main steam flow and feed water flow together with feed water pumps.

Feed control system shall comprise of single element drum level control operating on low load feed water control valve and three element control operating on the full load feed water control valve nominally rated for min. flow to 100% MCR feed water flow. Differential pressure across the feed water control station shall be maintained at constant value by varying the scoop position of the feed water pumps.
The system shall be designed to maintain the drum level within acceptable limits under all anticipated HRSG load changes and disturbances such as transfer from the duty feed water pump to the standby feed water pump etc.
The principal modulating control functions to be associated are:

(a) Start up feed water control
(b) Normal load feed water control

4) Drum Level/Feed Water Control

The control system shall comprise of single element drum level control operating on low load feed water control valve and a three element control operating on full load control valve (in case of HP & IP on one of the full load control valve). Low load feed water control valve is envisaged for controlling the drum level during plant start-up and low load operation up to 30% MCR. For normal load up to 100% MCR, full load control valve is envisaged to maintain the drum level. A stand-by full load feed water control valve (in HP & IP feed water control stations) shall be provided for improving the availability during on-line maintenance of the main valve. Facility shall be provided for both manual and automatic changeover from single element to three element control and vice versa.

The three element function shall consist of the steam flow, feed water flow and drum level. Steam flow measurements shall be pressure and temperature compensated and the drum level measurements shall be pressure compensated.

The feed water control shall develop the flow control signal for matching between feed water flow and steam flow using drum level deviations from the drum level set-point.

5) Main Steam Temperature Control

The steam temperature shall be designed to maintain the main steam temperature at the turbine inlet by means of the spray control valves. One or more stages spray control based on HRSG design shall be used for the control of superheater temperature.

The spray desuperheater shall be provided with shut-off valves. The feed forward circuit shall be used for the sufficient control response.

6) HRSG Autonomous Control System

The HRSG autonomous control system shall interface with the data highway of the Distributed Control System (DCS) through process I/O interface devices. The process I/O system shall have duplicated system architecture

The interface type shall be of either the conventional hardwired I/O interface (I/O) or the remote I/O interface (R-I/O)

The following ACS of the HRSG auxiliaries shall be interfaced to the data highway through I/O interface devices but not be limited to:

- HRSG metal temperature measurement system
- Environmental measurement system
- Water/steam sampling system
- Instrument air compressor system
- Service air compressor system

7) Instrumentation

The manufacturer shall provide all necessary instruments for HRSG and auxiliaries to allow centralized control and monitoring facilities from the operators' consoles in Central Control Room, through microprocessor based Distributed Control System (DCS).

The following field control and instrument devices shall be provided:

- Gauges, Transmitters, etc.
- Detecting elements such as flow element, thermocouple, pressure switches and temperature switches, etc.
- Regulating devices such as control valves, vanes, dampers, and drives, etc.
- Local instrument panels (if necessary)
- All piping, tubing and wiring necessary for satisfactory operation shall be provided.

This shall include instruments for measuring the following minimum process parameters:

(a) Feed water
(b) Drum
(c) Steam

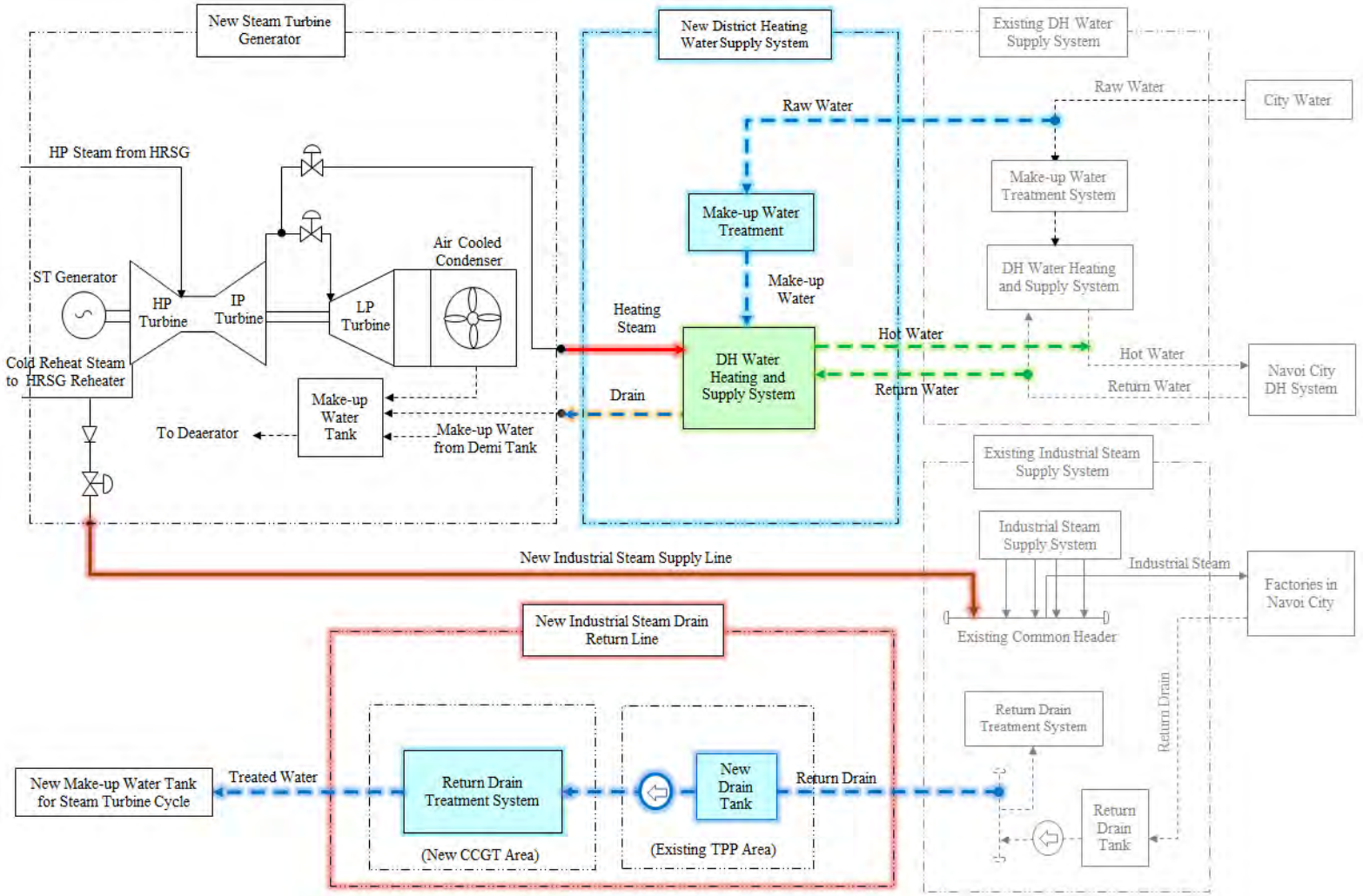
HRSG metal temperature, drum level viewing system including indicator (optical fiber system) and all other necessary pertinents.

The manufacturer shall provide all local instruments.

- Pressure gauges
- Thermometers
- Flow indicator
- Level gauges
- Limit switches, etc.

7.3.4 Heat Supply System

In the framework of the Navoi Thermal Power Station Modernization Project (Phase 2), the planned GTCC3 shall be fitted with an extended Hot Water Supply System for Navoi city (District Heating Water) and Industrial Process Steam Supply System for neighboring industries (Navoi AZOT) for the consolidation of the already existing systems.
The new installations are mainly intended for Hot Water Supply and Industrial Process Steam Supply for the consolidation of the already existing systems.
Both new installations shall have a thermal capacity of 100 Gcal/hr each.
Supply steam to the hot water system will be extracted from LP section of new steam turbine.
Industrial process steam supply will be extracted from cold reheat line or IP section of new steam turbine.



(Source: JICA Survey Team)

Figure 7.3.4-1 Preliminary Process Flow Diagram of Heat Supply System

(1) Hot Water System

1) Scope

The scope of New Hot Water System is shown in Figure 7.3.4-1. The scope consists of Hot Water Heating and Supply System and Make-up Water Treatment System, and shall include all necessary heat exchangers, tanks, pumps, piping, valves, ion exchangers for water treatment, electrical and I&C equipment and all other equipment and accessories required for the system.

2) Design particulars of hot water supply system

Design particulars of hot water supply system are as follows.

Table 7.3.4-1 Design particular of hot water supply system

Item		Unit	Supply	Return	Make-up
Pressure		kg/cm2 (g)	8.2~16.3 (8~16 bar(g))	0.51~4.08 (0.5~4 bar(g)	City Water
Temperature (Note)		°C	110	55	15~36
Water Flow	Summer	t/h	240	none	240
	Winter	t/h	1,580	1264	316
Thermal Out put	Summer	Gcal/hr	15.6		
	Winter	Gcal/hr	100.0		

(Note) The supply temperature shall be regulated two times a day as per the schedule of the temperature in Table-I-2.

(Source: JICA Survey Team)

3) Steam conditions of primary (heating steam) circuit

Hot water heating steam supply conditions, extracted from steam turbine, for GTCC3 are as follows.

Supply pressure: 3 ± 1 bar (g)
Supply temperature: 200 ± 20 °C

4) Circulating Water inside “Hot-Water” systems

The district heating system of Navoi City is based on an open DH water circulation system. This means that all urban consumers are using circulation water processed in TPP as hot household tap water.

Thus the circulation water has to follow local drinking water standards, including also special treatment of such make-up waters.

The quality of the DH water circulating inside the network shall have parameters in accordance to the local standard RD 34-37-10-504, as follows.

Table 7.3.4-2 Requirements for circulating Water inside “Hot-Water” systems

No.	Description	Unit	Quality
1	Free carbonic acid	mg/l	absent
2	pH	-	8.3 – 9.0
3	Diluted oxygen	μg/dm^3	< 50
4	Suspended solids	mg/dm^3	< 5
5	Oil products	mg/dm^3	< 1

(Source: JICA Survey Team)

5) City water analysis

City water shall be utilized as make up of hot water system, of which analysis are as shown below.

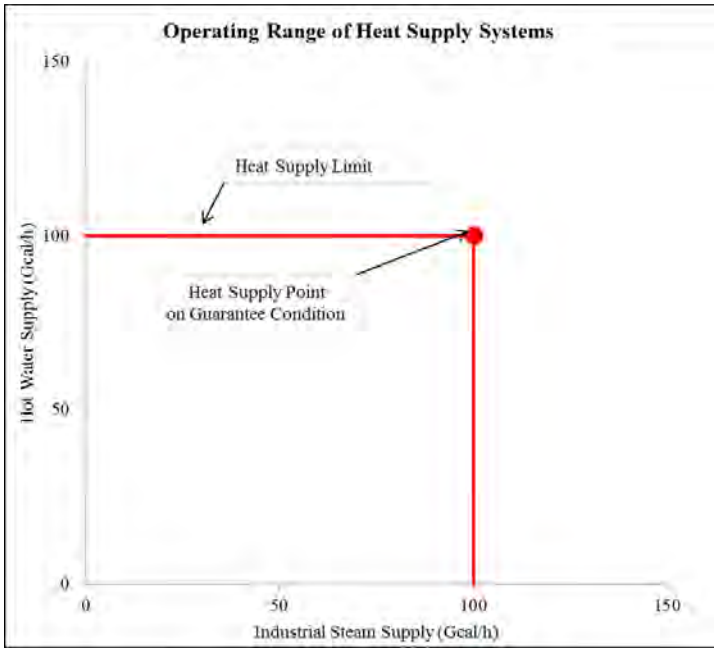
Table 7.3.4-3 Chemical Analysis of city water in Navoi

Description of Parameters	Molecular weight in kg/kmol	Minimal Value		Maximum value	
		mg/l	mg-eq./l	mg/l	mg-eq./l
Alkalinity	-	-	3.2	-	4.4
Dissolved solids	-	1300	-	2000	
Total hardness		-	11.9	-	18
Bicarbonates	61.02	195.2	3.2	268	4.4
Chlorides	35.48	77.9	2.2	110.0	3.1
Sulfates	48.03	500	10.41	680	14.16
Nitrates	62.01	6.0	0.1	10.4	0.17
Calcium	20.04	107	5.34	200	9.98
Magnesium	12.16	83.9	6.9	96	7.9
Sodium	23.0		3.59		
Iron total	56.0	5.0			
SiO_2^-		8.3		13.0	
pH		8.3		8.3	

(Source: Information from JSC Thermal Power Plant)

6) Operating range of hot water system

The maximum operating ranges of heat supply systems are 100 Gcal/hr for the industrial steam supply system and 100 Gcal/hr for the hot water supply system respectively.



(Source: JICA Survey Team)

Figure 7.3.4-2 Operating Range of Heat Supply System

7) Operating conditions of new hot water supply system

Table 7.3.4-4 Operating conditions of new hot water supply system

Item		Unit	Value
Economic life time		year	30
Annual operating hours	Heating and ventilation	hr/year	3408 (142 days/year)
	Hot water supply	hr/year	8400 (15 days for maintenance/year)

(Source: TEP)

8) Heat balance of hot water system
Please see Table 7.3.4-5.

Table 7.3.4-5 Heat Balance of Hot Water System (tentative) at guaranteed condition of 100Gcal/h

1. Hot Water Side

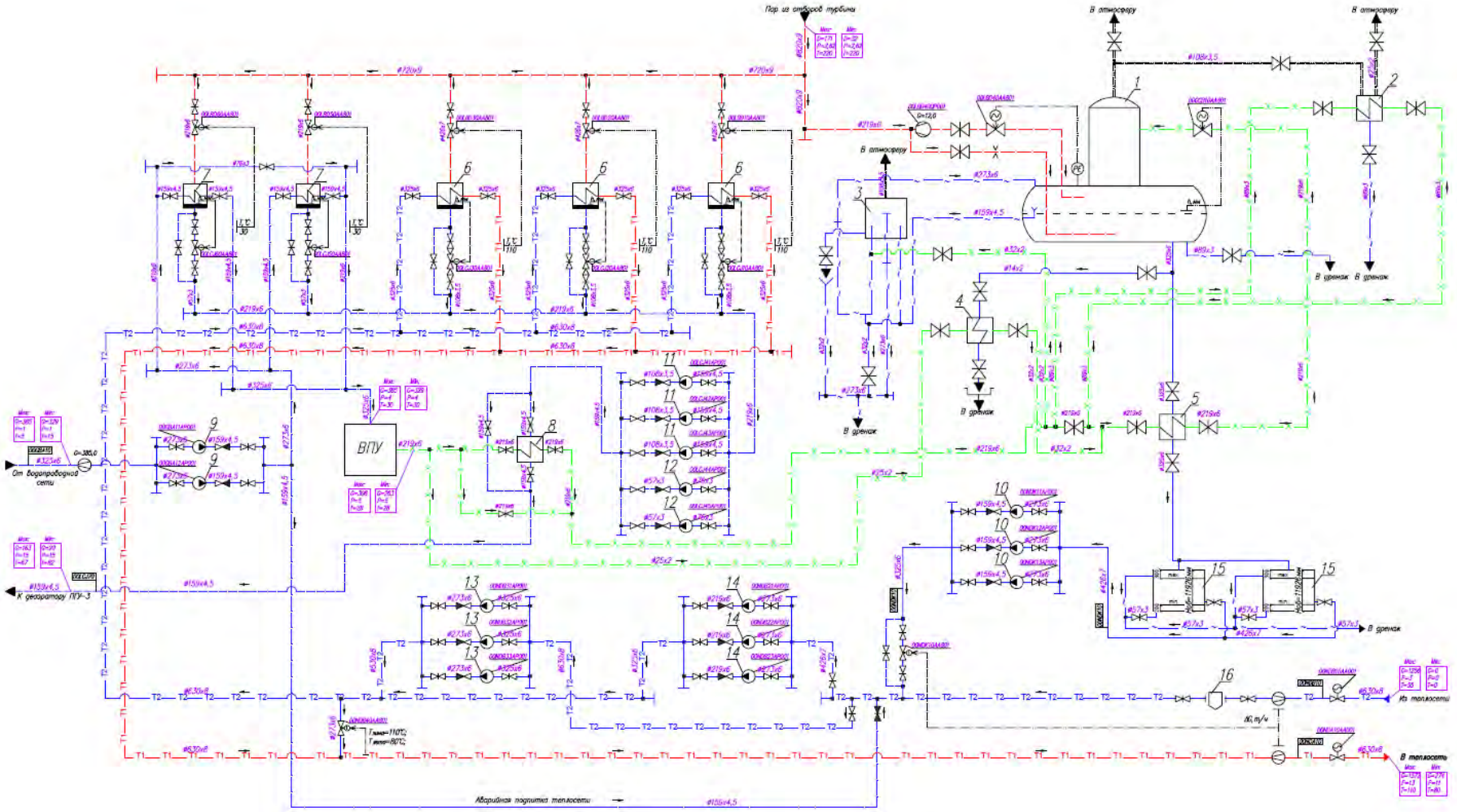
Item	Unit	Winter	Summer	Remarks
(1) Hot water supply				
Flow rate	t/h	1,531	240	G1: Q4 = 100 Gcal/h in Winter, G1 in Summer = 15% of G1 in Winter
Pressure	kg/cm^{2}a	13.26	11.03	P1: Input 120 mWC/ 100 mWC in Winter/Summer
Temperature	ºC	110	80	T1: Input, For Summer, changed from 70 ºC to 80 ºC
Enthalpy	kcal/kg	110.4	80.2	H1
Thermal energy	Gcal/h	169.0	19.2	Q1=G1*H1/1000
(2) Hot water return				
Return flow rate	%	80	0	80% in winter, 0 % in Summer (Input)
Flow rate	t/h	1225	0	G2=G1*Return Flow Rate/100
Pressure	kg/cm^{2}a	4.09	1.53	P2: 30 mWC in Winter /5 mWC in Summer
Temperature	ºC	55	40	T2: Input
Enthalpy	kcal/kg	55.1	40.0	H2
Thermal energy	Gcal/hr	67.5	0.0	Q2=G2*H2/1000
(3) Hot water make up				
Source	-	City water	City water	
Flow rate	t/h	306	240	G3=G1-G2
Pressure	kg/cm^{2}a	1.0332	1.0332	P3: Input
Temperature	ºC	5	15	T3: Input
Enthalpy	kcal/kg	5	15.1	H3(from steam table)
Thermal energy	Gcal/hr	1.53	3.62	Q3=G3*H3/1000
(4) Thermal energy				
Calculated value	Gcal/h	100.0	15.6	Q4=Q1-Q2-Q3
Required value	Gcal/h	**100.0**	-	Qreq
.deviation	Gcal/hr	**0.0**	-	(Q4-Qreq) to be zero.

2. Heating Steam Side

Item	Unit	Winter	Summer	Remarks
(5) Steam				
Source	-	IP Turbine Exhaust	IP Turbine Exhaust	
Flow Rate	T/H	**174.5**	**27.0**	G5: Goal seek (deviation=0)
Pressure	kg/cm^{2}a	2.91	2.91	P5: Input
Temperature	ºC	220	220	T5: Input
Enthalpy	kcal/kg	694.4	694.4	H5(From Steam Table)
Thermal Energy	Gcal/hr	121.2	18.7	Q5=G5*H5/1000
(6) Drain				
Return to	-	Makeup Water Tank	Makeup Water Tank	The drain shall be returned to the make-up water tank for steam turbine cycle.
Return Flow Rate	%	100	100	R6%: Input
Pressure Loss	%	10	10	ΔP%: Input
Flow Rate	t/h	174.5	27.0	G6=G5*R6%/100
Pressure	kgcm2a	2.62	2.62	P6=P5*(100-PL%)/100
Temperature	ºC	121	115	T6: Input
Enthalpy	kcal/kg	121.4	115.3	H6(From Steam Table)
Thermal Energy	Gcal/hr	21.2	3.1	Q6=G6*H6/1000
(7) Thermal Energy				
Calculated Value	Gcal/hr	100.0	15.6	Q7=Q5-Q6
Hot Water Side Q4	Gcal/hr	**100.0**	**15.6**	
Deviation	Gcal/hr	**0.0**	**0.0**	=Q7-Q4, To Be Zero.

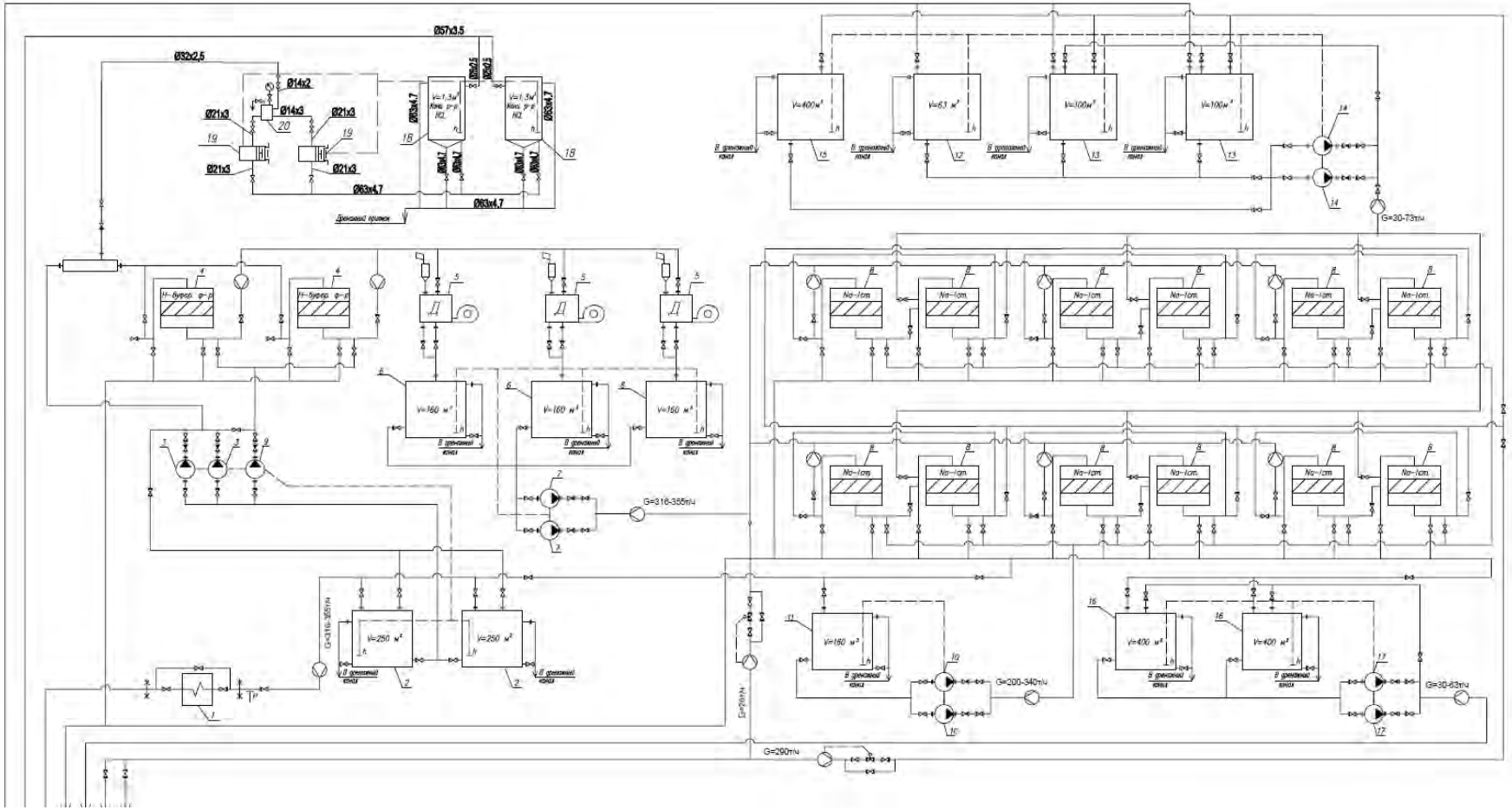
Remarks: The above table calculates roughly the heat balance of the Hot Water Supply System.
In the engineering works of the contract, more detail calculation shall be performed

(Source: Estimated by JICA Survey Team)



(Source: Information from TEP)

Figure 7.3.4-3 Flow Diagram of Steam, Condensate and Hot Water Supply System



(Source: Information from TEP)

Figure 7.3.4-4 Flow Diagram of Water Treatment System for Hot Water Make-up

(2) Industrial Steam Supply System

1) Scope

The scope of New Industrial Steam Supply System is shown in Figure 7.3.4-1 Preliminary Process Flow Diagram of Heat Supply System. The scope consists of steam supply piping up to tie-in points of the existing steam supply pipe and return drain pipe from the tie-in points of existing return drain pipe (or existing return drain tank), and water treatment system for industrial steam return drain. The scope shall include all necessary piping, valves, heat exchangers, tanks, pumps, water cleaning equipment, electrical and I&C equipment and all other equipment and accessories required for the system.

2) Design conditions of Industrial Steam Supply System

(a) Thermal capacity

Guaranteed thermal production capacity is 100 Gcal/hr.

(b) Steam conditions of industrial process steam supply

Industrial process steam supply conditions, extracted from steam turbine of GTCC3 are as follows.

Table 7.3.4-6 Steam conditions of industrial process steam supply

	Supply pressure	Supply temperature	Heat output	Source
	ata	℃	Gcal/hr	
High pressure steam	21 (2.06 MPaa)	350	30	Cold reheat line
Medium pressure steam	8 ~ 13 (0.78 ~1.27 MPaa)	350	70	IP section of steam turbine

(Source: Information from JSC Thermal Power Plant)

(c) Industrial return condensate drain

31 % of the industrial steam supply will be returned, treated and recovered in to the main condensate cycle.

(d) Water quality of drain of industrial steam

Water quality of drain of industrial steam is as follows.

Table 7.3.4-7 2014 Monthly Mean Quality of Return Industrial Steam Drain by NCC Navoi AZOT

N	Month	Hardness mg-eqv./l	Fe ppb	Cu ppb	Silicic Acid ppb	pH	BOD mgO2/l	Petrochemicals ppb
1	Jan	1	65	28	40	7.1		0.2
2	Feb	2	73	28	83	7.8	24	0.2
3	Mar	1	48	24	35	7		0.1
4	Apr	1	55	27	44	7		0.3
5	May	3	130	31	95	7.9	32	0.3
6	Jun	1	54	21	41	7		0.1
7	Jul	1	78	20	38	7		0.1
8	Aug	1	66	20	35	7		0.2
9	Sep	5	144	24	138	7.3	27	0.3
10	Oct	2	90	21	98	7.1	15	0.2
11	Nov	1	45	20	37	7		0.1
12	Dec	1	55	20	34	7		N/A

(Source: Information from JSC Thermal Power Plant)

(e) Pressure and Temperature of Industry steam drain water

Pressure: 2 bar (g)

Temperature: 80 ℃

(f) Water quality of treated drain

Return industrial steam drain shall be treated to reach up the following water quality.

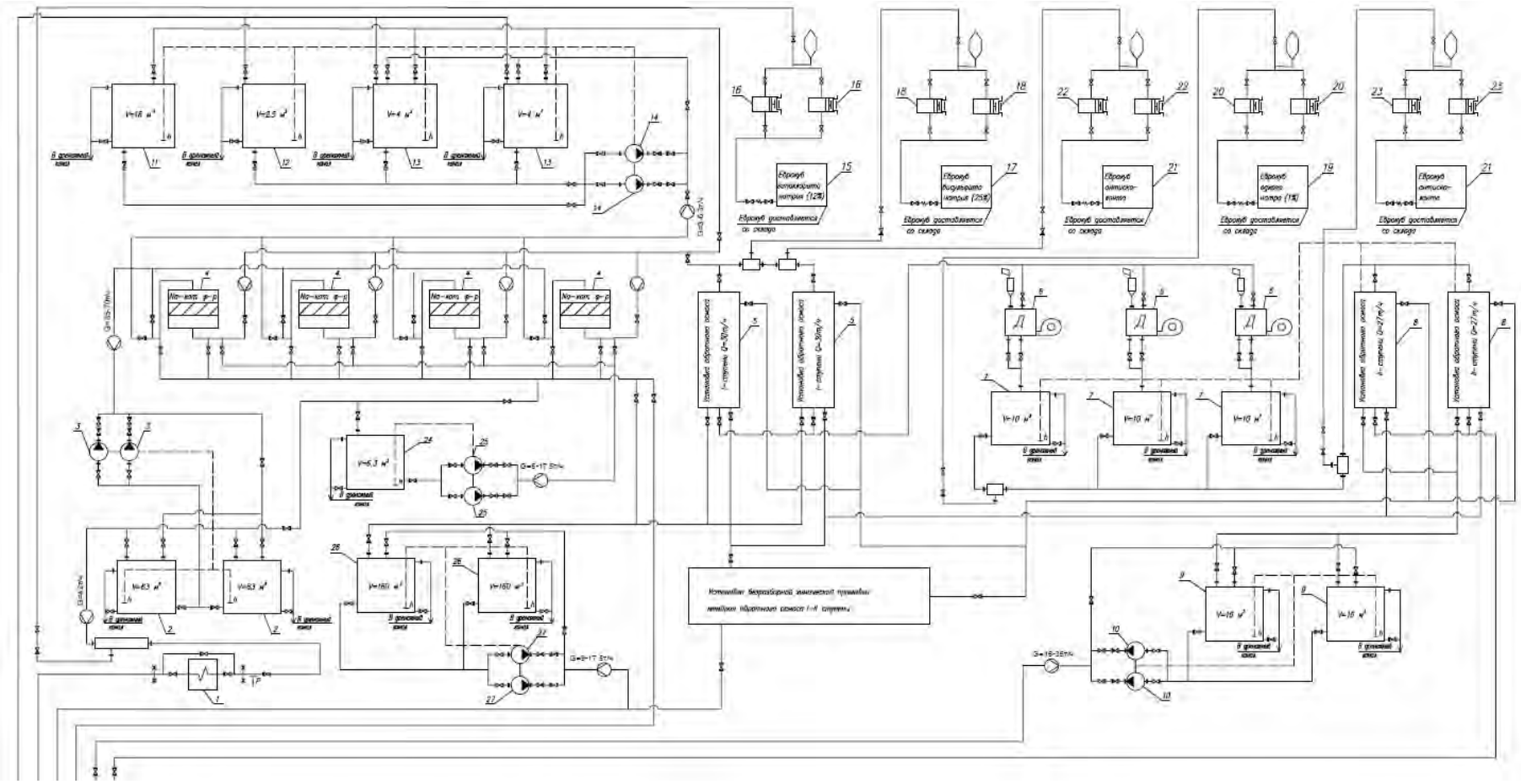
Table 7.3.4-8 Allowable Water Quality of Return Industrial Steam Drain by NCC Navoi AZOT

No.	Description	Unit	Quality
1	Hardness	μg-eq/dm^3	< 50
2	pH	-	8.5 – 9.5
3	Fe	μg/dm^3	< 100
4	Cu	μg/dm^3	< 20
5	Petrochemicals	μg/dm^3	0.5
6	Silicic Acid	μg/dm^3	< 120
7	Oxygen	mgO_2/l	< 5

(Source: Information from TEP)

(g) Flow rate of Industry steam drain water (guarantee condition)

Approximately 42,000 kg/hr (31% of industrial steam supply)



(Source: Information from TEP)

Figure 7.3.4-5 Flow Diagram of Industrial Steam Drain Treatment System

7.3.5 Water Treatment and Waste Water Treatment Plant

(1) Pre-Water Treatment System

Water source for the plant is river water from Zeravshan River.

Pre-water treatment system consists of the settling ponds and the pre-water treatment facilities including lime-soda softening clarifiers, multimedia filters, sludge dewatering system and associated chemical dosing system. After pre-treatment, treated water shall be fed to the service water tanks.

Pre-water treatment system shall be applied for the system that the suspended and dissolved impurities shall be removed by Coagulation, lime-soda softening and sedimentation.

Raw water from water intake is fed to settling ponds. The settling ponds are provided to increase the water treatment capability of this Plant. Before entering to the settling pond, online coagulant dosing will be done if necessary. The settling ponds serve continuously removal of the suspended solids and supply the necessary retention time for coagulation reaction. The water will be fed to the clarifier by Clarifier Feed Pumps. Before clarification process, online lime and anionic polymer will be dosed. Then clarified water is fed to filters, which serve continuously removal of suspended solids larger than 20-30μm, turbidity, total hardness and alkalinity in the water.
Filtered pre-treated water is collected in service water tanks and will be sent to demineralization system. Some part of Pre-treated water in service water tank is used for backwash purpose of filters.
These pre-treatment processes cause sludge production. Thus, sludge treatment system is provided. Sludge from clarifiers will be collected in sludge pit and transferred to sludge dewatering system.
Water treatment system shall prevent adverse effect on facilities of power plant caused by suspended solids and calusium in Zeravshan river water.

1) Design Conditions.

(a) Quality of Zeravshan River water

The quality of Zeravshan River water shall be in accordance with the following Table.

Table 7.3.5-1 Quality of Zeravshan River Water (GTCC2 condition)

Parameters	Unit	Average	Range
Temperature	(°C)	17.6	6~29
P- / M-Alkalinity	(meq/l)	0.2/4.3	0.1~0.3/3.0~5.3
pH	(-)	8.3	8.1~8.4
Suspended Solid	(mg/l)	2,198	106~11,311
Dissolved Solid	(mg/l)	1,454	1,061~2,089
Chlorine (Cl)	(mg/l)	85.9	56~118
Sulfate (SO_4)	(mg/l)	540	364~672
Hardness (Total)	(meq/l)	13.5	9.8~18.5
Hardness (Ca)	(meq/l)	6.74	4.2~11.0
Hardness (Mg)	(meq/l)	6.76	4.0~9.8
Nitrite (NO_2)	(mg/l)	0.18	0.1~0.3
Nitrate (NO_3)	(mg/l)	8.3	5.0~11.0
Iron (Fe)	(mg/l)	4.9	1.0~8.4

Parameters	Unit	Average	Range
Copper (Cu)	(mg/l)	BDL	BDL
Petroleum products	(mg/l)	0.19	0.05~0.33
Dissolved Oxygen (O_2) before	(mg/l)	4.73	4.2~5.8
Dissolved Oxygen (O_2) after	(mg/l)	4.65	3.1~6.0

BDL: Below Detectable Limit

(Source: Information from JSC Thermal Power Plant)

(b) Quality of Pre-Water Treatment Water

The treated water quality from the pre-water treatment shall be suitable for service water and for the demineralized water plant. The qualities of outlet of pre-water treatment system shall be as following.

1. Total Suspended Solids - < 1 mg/l
2. Total Hardness - 4.5 mg equiv. /l
3. M. Alkalinity - 2.7 mg equiv. /l
4. pH - 7 - 7.5.

(2) Demineralized Water Treatment System

The Demineralization Plant produces the demineralized water required for:

- Industrial steam supply
- Steam cycle
- Inlet air evaporated cooler (if applicable)
- Auxiliary cooling system
- Closed cooling water system
- GT water washing system
- Sampling system
- Hydrogen generator (if applicable)
- Regeneration and chemical dilution
- Chemical laboratory uses
- Flushing water supply for mechanical pump seals
- Miscellaneous uses

The demineralized water stream will consist of reverse osmosis system (RO) and mixed bed polishing system (MBP) (or cation tower, anion tower, mixed bed polisher, vacuum degasifier, regeneration system), pumps, tanks, and pipes.

The demineralized water plant shall have two (2) streams with each sufficient production capacity.

The period between regenerations shall not be less than twenty (20) hours, and the regeneration period shall be less than four (4) hours.

The raw water quality shall be taken account of in the design of the Demineralizer plant.

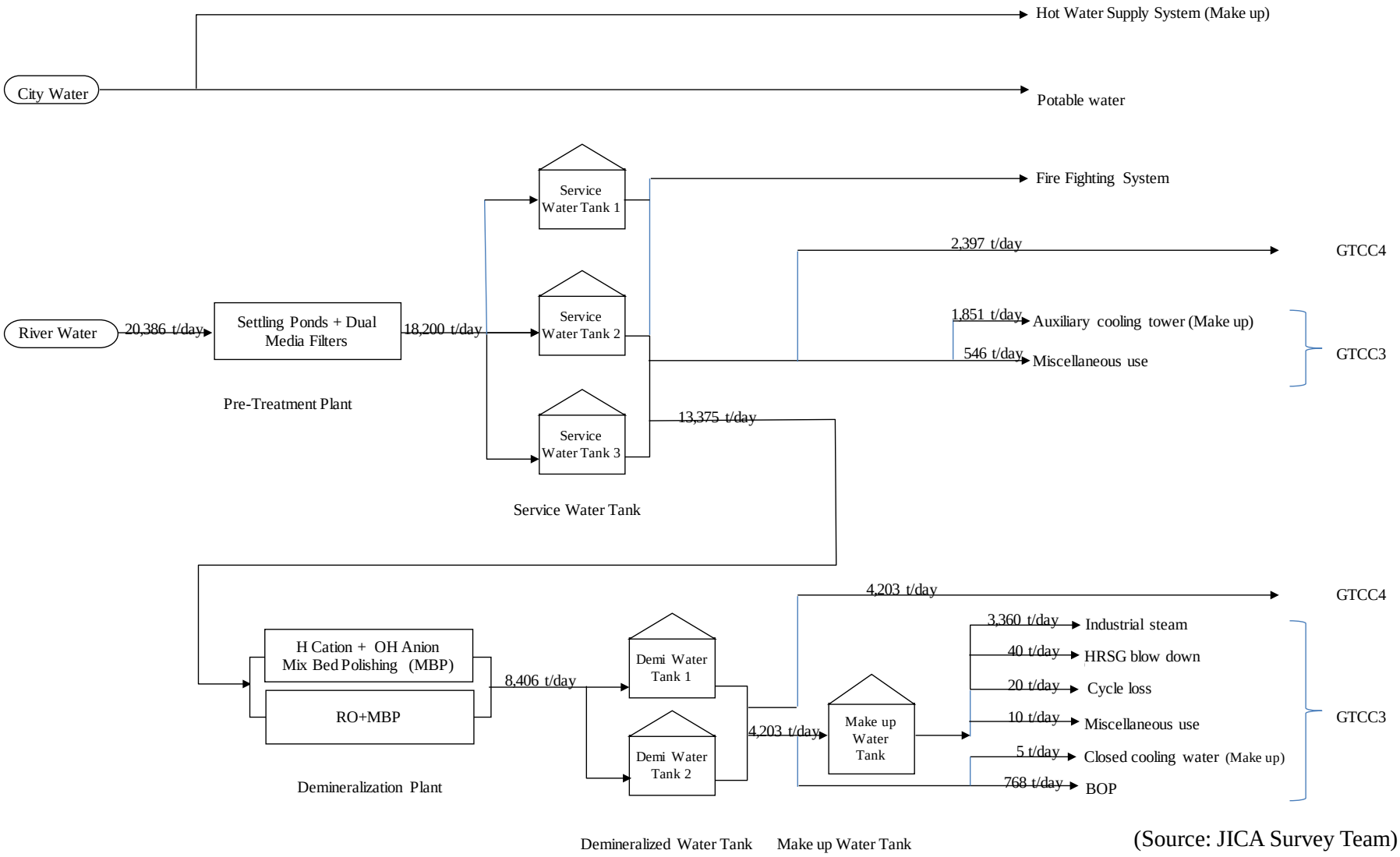
Under all operating conditions the plant shall produce water equal to or better than the specified quality for the boiler feedwater, which shall be as follows:

Table 7.3.5-2 Quality of demineralized water

Item	Unit	Demineralized Water
Conductivity	μS/cm @ 25ºC	Max. 0.2
Total Silica	mg/l	Max. 0.02
pH	-	-
Suspended Solids	mg/l	-
Turbidity	Degree	-
Total Fe	mg/l	Max. 0.01
Total Cu	mg/l	Max. 0.005
CO_2	mg/l	Max. 2
Cl^-	mg $CaCO_3$/l	-
SO_4^{-2}	-	-
TDS	mg/l	-
Residual C1	mg/l	-
Sodium and Potassium	mg/l	Max. 0.01

(Source: JICA Survey Team)

Total station water requirement from Zeravshan river for GTCC3 is presumed to be 10,157 t/day = 3.7 mil m3/y, which is less than available water from Zeravshan river of 18.3 mil m3/y ((860 – 841.7) as shown on table 7.1.6-9, even if GTCC3 adopts once-through cooling type.



(Source: JICA Survey Team)

Figure 7.3.5-1 Schematic Diagram of Water Treatment System

(3) Waste Water Treatment System

The wastewater treatment system consists of wastewater collecting system, oil separators, wastewater storage ponds, wastewater treatment plant (including coagulation, sedimentation, filtration, sludge thickening and dewatering process), and their accessories.

The wastewater from the Plant can be mainly categorized into the following sources:

a) Chemical wastewater (including chemicals, metals, and suspended matters)
   - Wastewater discharged from chemical processes such as demineralization
   - HRSG blowdown and Hot water system blowdown
   - Drains from GT/ST and HRSG equipment areas
   - Wastewater irregularly discharged from the processed, such as HRSG chemical cleaning and HRSG wet-conservation, GT wash water, Hot water system wash water

b) Sanitary (approximately 200 personnel)
c) Rainwater and underground water
d) Other domestic wastewater
e) HRSG wash water

The chemical wastewater shall be treated by adequate wastewater treatment process to meet applicable environmental requirements at the final discharge pit.

The wastewater from HRSG chemical cleaning, HRSG wet-conservation, GT water wash etc., which is irregularly discharged, shall be pre-treated by using the wastewater storage ponds, shall be treated by the wastewater treatment plant and the treated waste water shall be discharged to the river. The waste from pre-treatment processes, the waste from GT wash water and HRSG wash water shall be drained to evaporation ponds for further dewatering system or off-site disposal.

The cooling tower blow down water, if applicable, shall be pre-treated by the wastewater storage ponds and shall be treated by the wastewater treatment plant and the treated wastewater shall be discharged to the river.

The sanitary and other domestic wastewater shall be treated by the sewage system and sewage after treatment shall be discharged to the river.

Design Data of Waste Water Treatment Plant are as follows.

- Installation: Outdoors
- Type: Coagulation-Sedimentation-filtration
- Number of trains: One (1) train
- Treated water quality: Refer to Table 7.3.5-3, below

Table 7.3.5-3 Waste Water Discharge Extreme Limits at Waste Water Discharge Point (latest environmental standard of Uzbekistan)

Description	Unit	Limit Value
Water temperature	°C	to obey local reguration
pH	-	6,5-8,5
oil	mg/l	0,1
Suspended solids	mg/l	150
BOD	mg/l	5
As (Arsenic)	mg/l	Not to be defined
Pb (lead)	mg/l	Not to be defined
Fe (Iron)	mg/l	0,2

(Source: Information from JSC Thermal Power Plant)

7.3.6 Fuel Gas Supply System

The natural gas is separated at the terminal point and is supplied to GTCC3. After that, the natural gas is led to the pre-treatment system having a filtering function to remove foreign substances.
After the foreign substances have been removed, the natural gas is led to the fuel gas compressor so that the pressure is increased up to the level required at the inlet of the gas turbine. This required pressure level is approximately 3 through 5 MPa although this value differs according to each gas turbine manufacturer. Since the operation of the gas turbine depends on the fuel gas compressor, it is recommended to install a total of three fuel gas compressors including one standby, similar to the case of GTCC2.

In addition, survey team plan to provide a buffer tank upstream of the gas compressor in case of the gas compressor trips. Though buffer tank is called a "tank", accurately it is a large-diameter pipe that spans tens of meters, and always stores gas in it. Similar equipment is adopted for GTCC2, and it is assumed that the specification of the equipment for GTCC3 will be equivalent to GTCC2. The specifications of buffer tank will be examined after the specifications of the gas supply facility are decided.

7.3.7 BOP (Balance of Plant)

BOP which will be shared for GTCC3 and GTCC4 are listed below table. Further study on BOP will be made in the next stage (Basic Design stage).

Table 7.3.7-1 List of BOP which are shared for GTCC3 and GTCC4

	BOP (Balance of Plant)
1	WATER INTAKE SYSTEM
2	CHEMICAL DOSING SYSTEM
3	WATER PRE-TREATMENT SYSTEM
4	SERVICE WATER PLANT
5	DEMINERALIZED WATER TREATMENT PLANT
6	POTABLE WATER SYSTEM
7	WASTE WATER TREATMENT SYSTEM
8	TURBINE LUBRICATING STORAGE TANK
9	FIRE-WATER SUPPLY SYSTEM
10	CENTRAL CONTROL ROOM

	BOP (Balance of Plant)
11	DISTRICT HEATING SYSTEM
12	COMPRESSED AIR SYSTEM
13	FUEL GAS PIPELINE（from tie-in point of fuel gas pipeline to inlet of fuel gas treatment system of GTCC3）
14	FUEL GAS TREATMENT SYSTEM
15	NITROGEN SYSTEM
16	HYDROGEN SYSTEM
17	OXYGEN SYSTEM
18	LABORATORY
19	ADMINISTRATION BULDING
20	ENGINEERING CENTER BUILDING
21	WORKSHOP
22	WAREHOUSE
23	GATE HOUSE

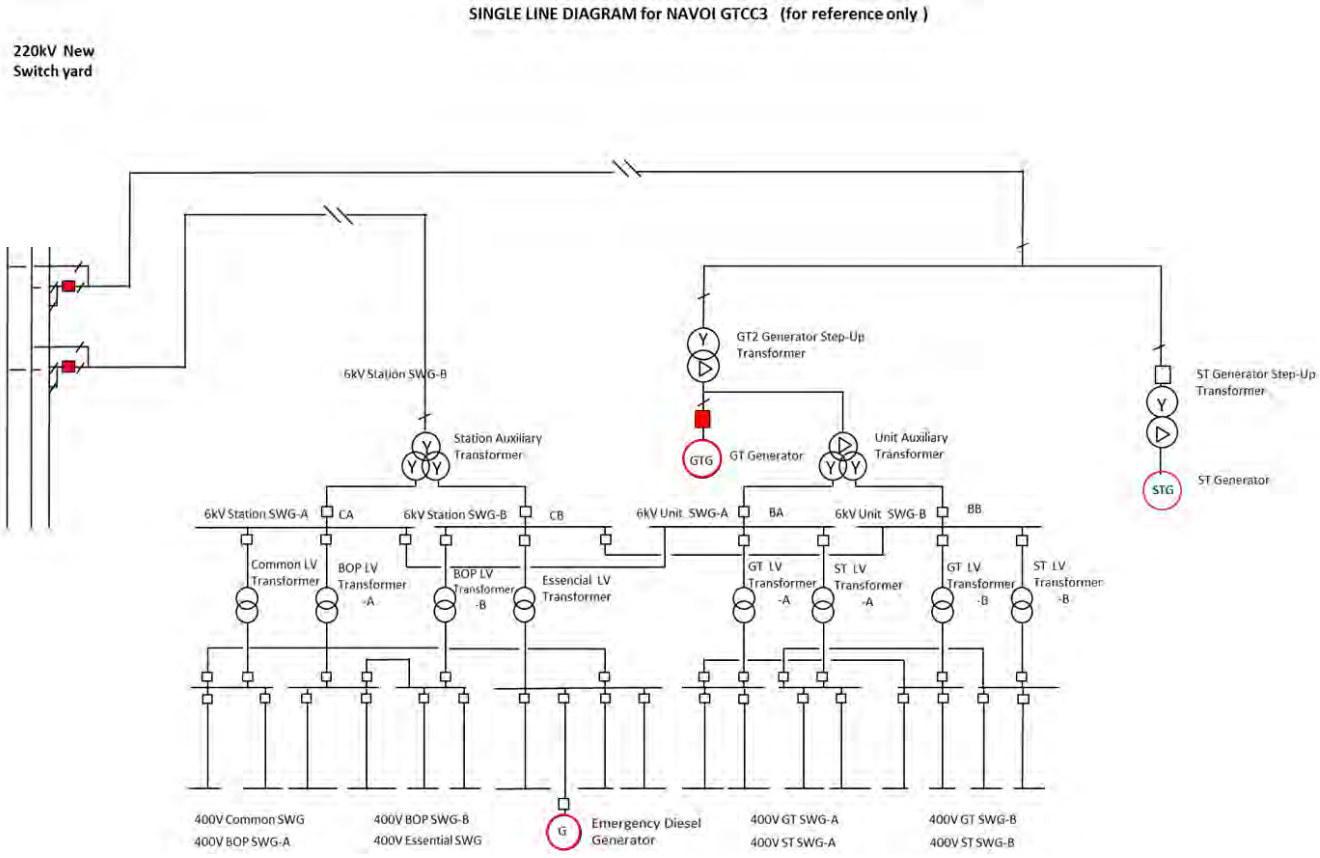
(Source: JICA Survey Team)

7.3.8 Electrical Equipment

(1) Electrical System

1) Key Singleline Diagram of Generating Power

Figure 7.3.8-1 Scheme of generator main circuit shows the overall singleline Diagram. Following description is applied for NAVOI GTCC3.



(Source: JICA Survey Team)

Figure 7.3.8-1 Scheme of generator main circuit

The electrical system for GTCC3 shall be designed on the basis of the multi shaft configuration having two (2) generators, i.e. Gas Turbine Generator (hereinafter called as "GTG") and Steam Turbine Generator (hereinafter called as "STG") and two (2) transformers, i.e. Gas Turbine step-up Transformer (hereinafter called as "GT transformer") and Steam Turbine step-up Transformer (hereinafter called as "ST transformer"). The voltage of the power output from the GTG and STG will be stepped up to 220 kV via GT transformer and ST transformer. The output from these two transformers is merged and transmitted to the new 220 kV switchyard. The bus switching arrangement utilizes double main bus and one circuit breaker with transfer bus scheme.

During the unit operations, the power source to the unit auxiliary loads under 6.3 kV unit bus shall be fed from the GTG via Unit auxiliary transformer, and from 220 kV switchyard via Station auxiliary transformer. During the unit shut down and the unit start-up, the power source to the unit auxiliary loads shall be fed from 220 kV switchyard via Unit auxiliary transformer and Station auxiliary transformer. The Unit auxiliary transformers shall be connected to 6.3 kV unit bus BA and BB via the circuit breakers. On the other hand, Station auxiliary transformer shall be connected to the 6.3 kV unit bus CA and CB via the circuit breakers. The power will be distributed to the auxiliary loads from the 6.3 kV unit buses.

The auxiliary system and associated equipment shall be designed with flexibility and adequate redundancy to provide a reliable source of power for all auxiliaries that will be required for the new plant.

GTG shall be synchronized by GTG circuit breaker when GTG is attained at rated speed and voltage. Next STG shall be synchronized by STG circuit breaker when STG is attained at rated speed and voltage.

Generating power from GTCC3 shall be sent to 220kV switchyard. Double main bus and transfer bus shall be installed for 220kV switchyard.

(2) Generators

1) GT Generator and ST Generator

The overview specifications of the Generators are shown below.

Table 7.3.8-1 Overview Specifications of the Generators

Generator	GTG	STG
Type	Three Phase Synchronous	Three Phase Synchronous
Number of Poles	2	2
Number of Phases	3	3
Net Power	506.2 MW	193.8 MW
Rated Capacity	596 MVA	228 MVA
Frequency	50 Hz	50 Hz
Rated Speed	3,000 min^{-1}	3,000 min^{-1}
Terminal Voltage	24.0 kV *1	17.5 kV *1
Power Factor	0.85 (Lagging)	0.85 (Lagging)
Rotor Cooling Method	Hydrogen	Hydrogen or Air Cooled
Stator Cooling Method	Hydrogen or Water Cooled	Hydrogen or Air Cooled

(Source: JICA Survey Team)

*1: To be determined by supplier

2) Type of Generator Cooling System

The generators cooling system shall be adopted of hydrogen gas, water or air cooled type.

As a result of recent technological advance of cooling performance and windage loss reduction, an air-cooled system is adopted in generators of 300 MVA class. It is not possible

to select air cooled type for GTG because of the capacity shortage (GTG rated capacity: 596 MVA > Maximum air cooled generator capacity: 300 MVA). When hydrogen gas cooling type Generator is selected, hydrogen supply system for Generator Cooling is necessary and shall be included in Scope of Works by the Contractor.
However it is possible to select air cooled type for STG (STG rated capacity: 228 MVA < Maximum air cooled generator capacity: 300 MVA). Air-cooled system has some advance from hydrogen gas-cooled system such as; simpler system, easy operation and maintenance, allowing for cost savings.

(3) Excitation Method

1) Excitation System

Each generator shall be provided with thyristor static excitation system which makes it possible to provide full ceiling voltage, either positive or negative, almost instantaneously under conditions of system disturbances. The system shall include transformer, automatic voltage regulator system (hereinafter called as “AVR”) cubicle, thyristor, convertor cubicle and field circuit breaker. Current transformer for control, regulation, protection and metering of the generator would be either provided in the generator stator terminal bushing both on the lines as well as neutral sides, or would be housed in IPB.

2) Automatic Voltage Regulator System

The generator manufacturer shall have AVR. AVR detects generator voltage and control the reactive power to control the generator voltage.

(4) GT Start-up Method

GT start-up method shall be selected thyristor or motor driven torque converter start-up method.

(5) Transformers

1) GT Transformer

GT Transformer shall step up from GTG voltage (24.0 kV) to transmission line voltage (220 kV).
GT Transformer shall have tap changing mechanism, oil insulation three (3) phase transformers or four (4) single phase transformer (One for spare). Cooling type shall be Oil Natural Air Forced (hereinafter called as “ONAF”) type or Oil Forced Air Forced (hereinafter called as “OFAF”). Phase connection shall be Delta-Star (hereinafter called as “Δ-Y”) type.

2) ST Transformer

ST Transformer shall step up from STG voltage (17.5kV) to transmission line voltage (220 kV).
ST Transformer shall have tap changing mechanism, oil insulation three (3) phase transformer or four (4) single phase transformer (One for spare). Cooling type shall be ONAF type. Phase connection shall be Δ-Y type.

3) Unit Auxiliary Transformer

Unit Auxiliary Transformer shall step down from GTG voltage (24.0kV) to Unit Bus BA and BB (6.3 kV).
Unit Auxiliary Transformer shall have tap changing mechanism, oil insulation three (3) phase transformers. Cooling type shall be Oil Natural Air Natural (hereinafter called as “ONAN”) or Oil Natural Air Forced (hereinafter called as “ONAF”).type. Phase connection shall be Delta-Wye-Wye (hereinafter called as “Δ-Y-Y”) type.

4) Station Auxiliary Transformer

Station Auxiliary transformer shall step down from transmission line voltage (220 kV) to Unit Bus CA and CB (6.3 kV).

Station Auxiliary transformer shall be oil insulation three (3) phase transformer. Cooling type shall be ONAN or Oil Natural Air Forced (hereinafter called as "ONAF"). Phase connection shall be Y -Y-Y type with Stabilizing Winding.
The overview specifications of the Transformers are shown below.

Table 7.3.8-2 Specifications for Transformers

Transformer		GT Transformer	ST Transformer	Unit Aux. Transformer	Station Aux. Transformer
Rated Voltage	1st	24.0 kV	17.5 kV	24.0 kV	220.0 kV
	2nd	220.0kV	220.0 kV	6.3 kV	6.3 kV
Rated Capacity	1st	600 MVA	230 MVA	25 MVA	40 MVA
	2nd	600 MVA	230 MVA	12.5/12.5 MVA	20/20 MVA
Phase Connection		Δ-Y	Δ-Y	Δ-Y-Y	Y-Y-Y
Cooling Type		ONAF	ONAF	ONAN/ONAF	ONAN/ONAF

(Source: JICA Survey Team)

(6) Single Phase Transformer and Three Phase Transformer
Comparison of Three Phase Transformer and Single Phase Transformer is shown in the following Table.
Single Phase Transformer has advantage in case of transportation or replacement of one phase transformer by accident. On the other hand, Single Phase Transformer is more expensive because of necessity of the spare transformer, control equipment for each transformer, each basement and connection equipment between single phase transformer. Three phase transformer and single phase transformer are equal in performance aspect.
Therefore transformer method shall be three phase transformer or single phase transformer method. In recent under the condition of the improved product reliability, three phase transformer is preferable, if it is free from transport limitation of the weight and dimension.

Table 7.3.8-3 Three Phase Transformer and Single Phase Transformer

Type	Three Phase Transformer	Single Phase Transformer
Unit	One (1)	Four (4) : Three (3) + Spare One (1)
Transportation	Base	Easier
Cost	Base	Higher
Space	Base	Larger
Construction	Base	Longer
Management	Base	Same
Reliability	Base	Same

(Source: JICA Survey Team)

(7) Generator Circuit Breaker and Disconnecting Switch
GT circuit breaker and GT disconnecting switch are set at primary side of GT transformer for synchronization. ST circuit breaker and ST disconnecting switch are set at secondary side of ST transformer for synchronization.

GTG is synchronized at 220 kV power system via GT circuit breaker when GTG is attained at rated speed and voltage. Next STG is synchronized at 220 kV power system via ST circuit breaker when STG is attained at rated speed and voltage. GTG and STG can be synchronized at 220kV power system breaker which is formed by double bus and one circuit breaker with transfer bus scheme.

(8) Isolated Phase Bus

The isolated phase bus (hereinafter referred to as “IPB”) duct shall be natural air cooled and shall deliver the generator output to the GT/ST step-up transformer, potential transformers, generator surge protection equipment, unit auxiliary transformer and excitation transformer.

(9) Seal Oil Equipment

Seal oil equipment is necessary when hydrogen cooling method is adopted. The generator seal oil system shall be designed to minimize leakage. It shall consist of two AC motor driven seal oil pumps, one for main another one for stand-by with a 100% capacity emergency backup DC motor driven seal oil pump.

(10) Hydrogen Generation System

Hydrogen generation system is necessary when hydrogen cooling method is adopted. Hydrogen generation system currently provides an economical hydrogen supply solution for generator cooling system.

(11) Unit Electric Supply

The unit electric supply shall be configured from unit transformer and auxiliary transformer.

The equipment used for power plant operation shall be powered from the unit transformer. The equipment used for common equipment (water handling, waste water handling, etc.) shall be powered from the auxiliary transformer system.

Moreover, as electric power source for emergencies, 1 set of 3 phase diesel fueled generator is installed for power plant and this enables obtaining safety electricity upon total cessation of the operation of the power plant.

Table 7.3.8-4 House Load Apportion shows house load apportion.

Table 7.3.8-4 House Load Apportion

Type	Power supply voltage [V]	Power supply board classification	Usage classification
Three (3) phases AC	6,300	6.3 kV Medium Voltage switchgear	Load>200 kW
	400	400V Low Voltage switchgear	90 kW<Load<=200 kW
		Motor Control Center	Load<=90 kW
One (1) phase AC	230	AC Distribution Board	Small power and Lighting
	230	AC distribution board (UPS)	Instrument, Interlock, control
DC	220	DC Motor Control Center DC distribution board	DC load

(Source: JICA Survey Team)

1) 6.3kV Unit Bus

6.3kV Unit Bus shall supply necessary auxiliary power for plant operation.

The design of 6.3 kV unit bus shall be based on the four (4) configurations of BA, BB, CA and CB.

Unit Auxiliary Transformer shall step down GTG voltage (24.0 kV) to 6.3kV for unit bus BA and BB.

Station Auxiliary transformer shall step down from transmission line voltage (220 kV) to 6.3kV for unit bus CA and CB.

Unit bus BA/BB and CA/CB shall be connected via bus-tie circuit breaker and disconnecting switch. Basically the bus-tie circuit breaker shall be opened. The bus-tie circuit breaker and disconnecting switch shall be closed in case of Unit Auxiliary or Station Auxiliary transformer accident. Unit bus CA/CB evacuates Unit bus BA/BB the electric power in that case. Also Unit Bus CA/CB evacuates Unit Bus BA/BB the electric power when plant accidentally tripped.
6.3 kV unit bus shall supply necessary auxiliary power and 400 V Unit Bus.

2) 400 V Unit Bus
400 V unit bus shall supply the power to motors and auxiliary equipment.

3) 220 V DC Supply System
220 V DC supply system shall have battery equipment and DC load shall be supplied by the power from DC distribution board. Plant can stop safely by DC power from battery under blackout condition.

4) Uninterruptible Power System (UPS)
Uninterruptible power system (UPS) shall be to supply continuous AC power to the essential AC bus. Uninterruptible power system shall be supplied from AC supply source and 220 V DC supply system.

5) Emergency Diesel Generator Equipment (EDG)
Plant shall have one (1) emergency diesel generator equipment at least.
It shall be capable to supply emergency power from emergency diesel generator equipment. Emergency AC power shall be supplied from emergency diesel generator to 400 V emergency unit bus. Blackout Start Generator shall not be considered same as GTCC2.

6) Site grounding
IEEE-80 recommendations shall be applied to determine grounding system requirements for this plant. The entire ground grid system shall exclusively utilize copper conductors with exothermic connections for in-ground connections.

(12) Generator Main Circuit Protection
The typical protections for GTG, STG, GT transformer and ST transformer are shown in the following table.

Table 7.3.8-5 Generator Main Circuit Protection

Name	Factor
GT Generator differential	$87G_{GT}$
GT Transformer differential	$87T_{GT}$
ST Generator differential	$87G_{ST}$
ST Transformer differential	$87T_{ST}$
Current unbalance	46
Loss of excitation	40
Reverse power	67
Stator ground detection	51GN
Generator over excitation	24
Generator overvoltage	59
Generator under voltage	27G
Generator over/under frequency	81

(Source: JICA Survey Team)

Generators and transformers shall be protected by 87G and 87T. As a back-up protection for generator, distance relay and restricted earth fault relay as well as voltage type ground fault relay is also proposed.

(13) 220kV Switchyard

The overview specification of the 220kV Switchyard is shown in following Table 7.4.7-6 (Ex. Type of Busbar, Type of substation, Number of bay, Number of circuit breaker, etc.) shall be added later.

7.3.9 I&C Equipment

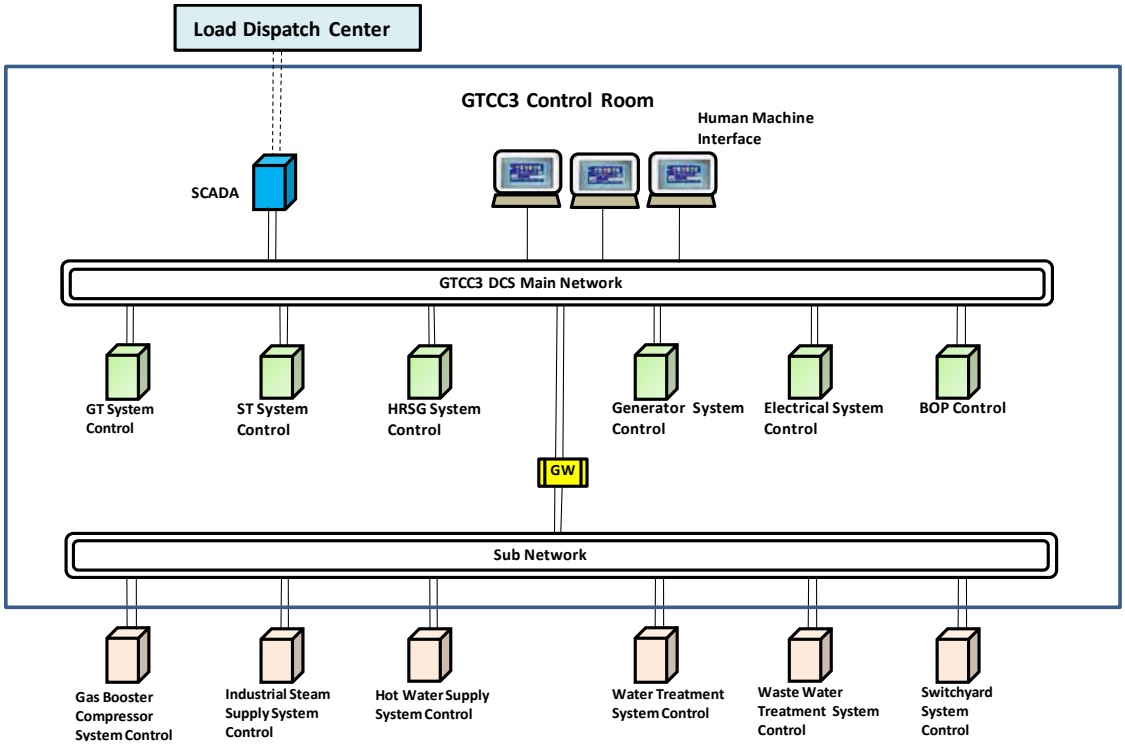
(1) Control Philosophy

The control system shall control and monitor the status of equipment and process variables associated with the GTCC3 to ensure safe and efficient operation with the applicable specifications and performance requirements.

All control and monitoring functions necessary for startup, normal operation and shutdown of the GTCC3 shall be provided in Central Control Room (CCR). The CCR shall normally be manned.

(2) System Configuration of the Control and Monitoring System

Figure 7.3.9-1 Configuration for GTCC3 Control shows Configuration for GTCC3 Control.



(Source: JICA Survey Team)

Figure 7.3.9-1 Configuration for GTCC3 Control

The design of all instrumentation and control systems shall provide the maximum security for plant personnel and equipment while safely and efficiently operating the new plant under all conditions with the highest possible availability.
Operator Workstation with Human Machine Interface (HMI) and a microprocessor based Distributed Control System (DCS) including redundant controllers using a plant-wide redundant communication highway shall be provided to allow the operators to control GTCC3, and to receive monitoring and alarm information.

- The computing and electric power section shall be duplex and the input and output of the DCS will be single.
- Power supply shall be duplex with both AC and DC (butted method)
- Operation during normal times will be through the use of a mouse while confirming the Liquid Crystal Display (LCD) screen.

The operating and monitoring system of the power station are configured by DCS, Supervisory Control and Data Acquisition (SCADA), maintenance and repair system, network system and related equipment.
The DCS is comprised of the HMI/LCD operation system, turbine control system, data assembly system, sequence control system, process I/O system and peripheral equipment. Each independent system is interfaced with DCS.

(3) Control Functions

The design of the control system for the new plant shall utilize the state-of-the-art DCS (Distributed Control System) with data logging system in combination with proprietary controls furnished with the gas turbine / generator, steam turbine / generator, HRSG and BOP (Balance of Plant), gas compressor system and so on.
The operator console of the plant installed in the CCR (Central Control Room) shall be used for the primary operator interface and shall contain LCD with keyboards and mouse. CCR shall equip with shift operator's room, locker room, WC & shower room etc. in order to create better environment condition for operators.
The gas turbine control system, steam turbine control system, HRSG and BOP control system shall be tied into the DCS with redundant communications networks and hardwired signals for critical control signals.
Those remaining control and monitoring signals for gas compressor control system, heat sources supply control system and so on shall be brought directly or via Remote I/O into the DCS I/O cabinets.
The LCD graphics shall provide the operator with control, monitoring, recording/trending, status, and alarming of equipment and process conditions.
The detector/instrument for protection/control of gas turbine, steam turbine and HRSG shall be redundancy/triple configuration to enhance the reliability of the new plant.
The control system shall be designed to operate and control the new plant with fully automatic, and shall give information of conditions of the new plant and guidance of operation/trouble shootings during start-up, steady state operation and shutdown to the operators.
The configuration of control logic and graphic display of the control system shall be designed for maintenance engineers to be able to easily and correctly modify and change them at site.
DCS shall have the following functions.

1) Turbine automatic operation control system
- Gas turbine operation, control and protection including gas turbine supervisory instruments.
- Steam turbine control and protection including turbine supervisory instruments
- HRSG control and protection
- Generator protection, excitation, voltage regulation and synchronization systems
- Electrical equipment control and protection including supervisory instruments
- Balance of plant control

2) Data collection equipment
- Scan and alert
- Process computation (including performance computation)
- Data log function and data display

3) Maintenance function

Maintenance tools (Engineering Work Station) for the maintenance of DCS are installed and these tools shall have the following functions.
- Control system setting/modification function
- System diagram setting/modification function

These systems have independent monitoring and control. In the event of a defect in the devices, the impact on the power station will be large. For this reason, calculation system, power supply system etc. are multiplexed in order to contribute to the reliable operation of system. The DCS shall be designed to provide for continuous load operation between 30% and 100% load.

Operator can select each mode to correspond to the plant condition. The typical control modes are shown in the following table.

Table 7.3.9-1 Control Mode by DCS

Control Mode	Event
Full-Automatic	The startup or shutdown shall be done by one-push button. Master sequence is related with each sequence and operation status. For example, GT, HRSG, ST startup is automatically executed from preparation to full load under normal operation via GTCC3 startup process.
Semi-Automatic	The startup or shutdown shall be done by step by step. Operator can proceed to step the GTCC3 startup and shutdown process to recognize the each breakpoint accomplishment by master sequence.
Manual	In the “Individual” mode, the startup or shutdown shall be manually done.

(Source: JICA Survey Team)

(4) Field Instrumentation

Field instrumentation for GTCC3 such as pressure / level / flow / temperature – transmitters / switches / instruments, flue gas analyzers, vibration detector, etc., shall be provided for monitoring the status of equipment and the process variables associated with the GTCC3 to ensure safe, efficient operation and performance requirements.

All units are established according to the International System of Units (SI).

Main field instrumentations are as follows:
- Pressure/Differential pressure measurements;
- Level measurements;
- Flow measurements;

- Temperature measurements;
- Density measurements;
- Chemical measurements (pH, conductivity, etc.);
- Vibration measurements;
- Position indicators of dampers/valves;
- Continuous Emission Monitoring System (CEMS)

All outdoor mounted instruments shall be designed to withstand the outdoor ambient temperatures, dust, etc. Adequate freeze protection system installations shall be set up in case of the instrument line freezing.

(5) I&C Equipment Power Supply

I&C equipment power supply will be from following switchboards:

- 400 / 230V, 50Hz normal supply,
- 230 V, 50Hz Safe AC
- 220 V Battery DC

DC supply system for GTCC3 shall not rely on existing Unit and shall be independent.

Other I&C equipment power shall be supplied, as follows:

- 24 VDC redundant
- 48 VDC redundant (if necessary).

(6) Telecommunication System

Telecommunication shall be included in the following system

- CCTV System by IP cameras, Video server and IP Network
- IP telephone system
- Master Clock System
- Uninterruptible power supply (UPS) system

(7) Fire Detection and Alarm System

Fire Detection and Alarm System including smoke detectors, alarm sirens and cables infrastructure shall be provided on the plant.

7.3.10 Civil Engineering and Architectural Facilities

The following lists up the planned GTCC No.3 structures and buildings for Civil & Architectural engineering point of view:

Table 7.3.10-1 List of Civil Engineering and Architectural Facilities

Main Plant Area
Steam Turbine Building
Gas Turbine Building
Central Control Building
HRSG (foundation)
Stack (foundation)
Continuous Emission Monitoring System House
Feed Water Pump House
Auxiliary Cooling Tower
Auxiliary Cooling Water Pump House
Air Cooled Condenser (foundation)
Closed Cooling Water Pump House
Condensate Pump House for ACC
Compressed Air Building
Nitrogen Generation Plant
Hydrogen Generation Plant
Oxygen Generation Plant
Hydrogen & CO2 Bottle Storage area
Emergency Diesel Generator
Oxygen Scavenger Building
Turbine Lubricating Storage Tank (foundation)
(GT) Electrical & Control Building
Local Control Room for ST & HRSG
Dirty Condensate Tank (foundation)
Pipe Rack at Main Plant area
BOP Area
District Heating Building
Fire Water Pump House
Chemical Ware House
Settling Pond
DH Water Storage Pond
Service & Fire Water Storage Tank (foundation)
RO Product Tank (foundation)
DM Water Storage Tank (foundation)
Make-up Water Tank (foundation)
Town Water Equalization Tank (foundation)
Water Treatment Plant
Chemical Dosing Building
Raw Water Clarifier
DH Clarifier
Thickener (WTP)
Coagulation Flocculation Tank (foundation)
Sludge Thickener (WWTP)
Clear Water Pit

Sludge Treatment Building
Lime Silo
Sedimentation Tank
Backwash Pit
Waste Water Treatment Plant
Waste Water Pond
Oil Contaminated Sedimentation Pond
Water Intake Structure
Water Intake Pump House
Pipe Rack at BOP area
Water treatment plant for return drain from Navoi AZOT
Switch Yard Area
220kV Switchyard (foundation)
Transformer Station (foundation)
Unit Auxiliary Transformer (GT) (foundation)
Main Transformer (GT) (foundation)
Main Transformer (ST) (foundation)
Fuel Gas Compressor Building
GT Control Package for Gas Compressor (foundation)
Pipe Corridor at Fuel Gas area
Non-Plant Buildings
Administration Building
Work Shop
Ware House
Laboratory
Gate House
Parking

(Source: JICA Survey Team)

7.3.11 Soil Investigation and Topographic Survey

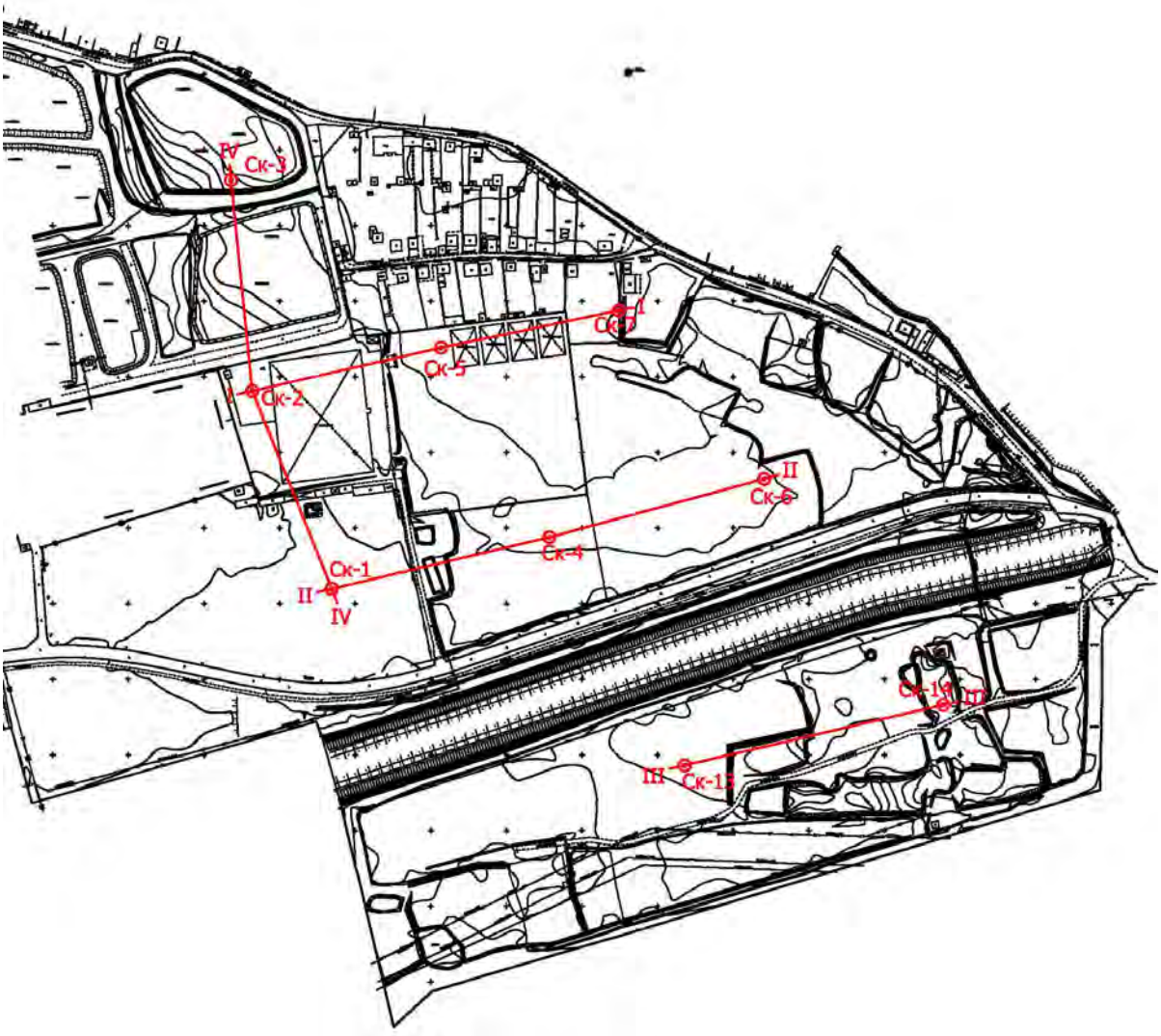
Civil and Architectural facilities foundation is determined based on the soil investigation result shown in below. The foundation system that can be considered at this stage is the direct foundation and the pile foundation. In addition, it is necessary to take ground improvement as countermeasure against liquefaction at the time of earthquake into account.

(1) Location of Soil Investigation

Locatons of soil investigation is 14 points which are shown in the Figure 7.3.11-1. Five points (Ck-8 to Ck-12) are located outside of the power plant boundary. These investigation points are determined base on the transmission line route which is shown in the Figure.6.3.1-4.

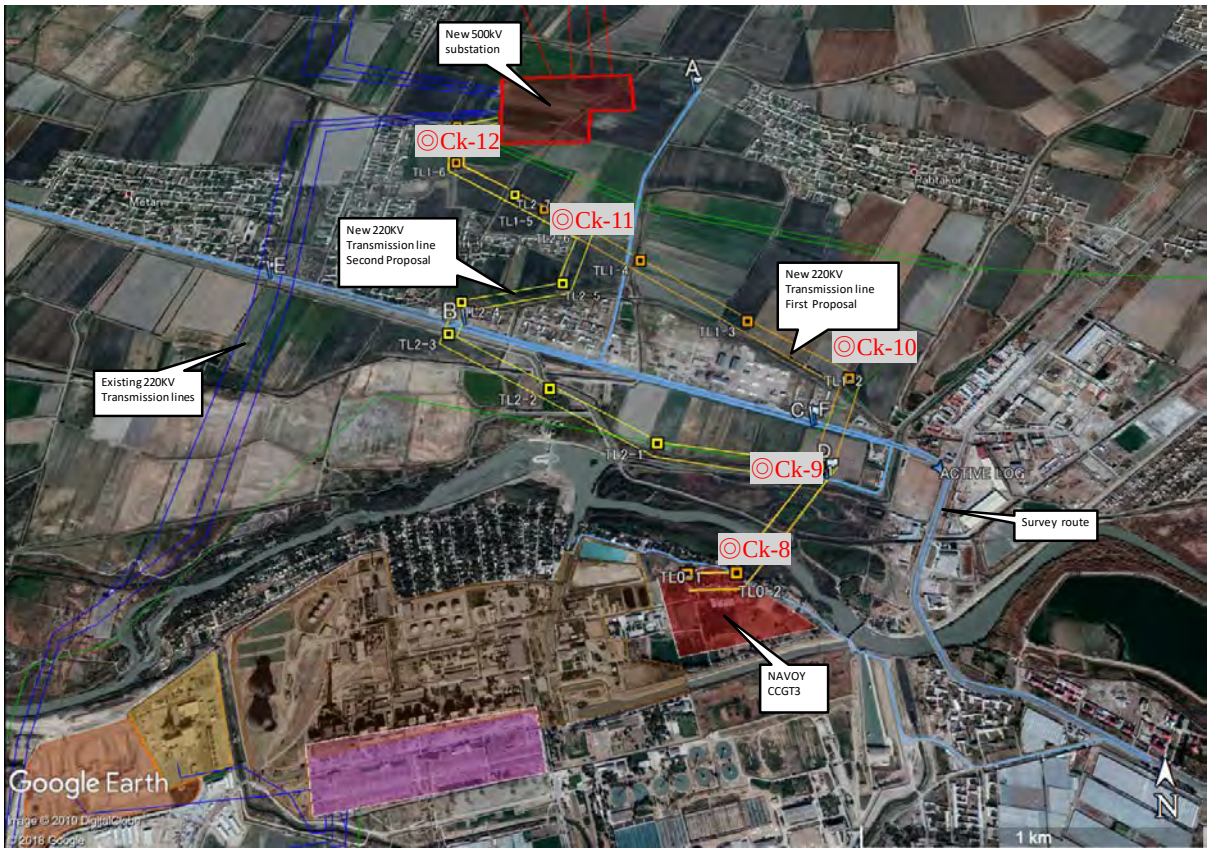
In the meantime, transmission line route had been changed and location of boring points are difference from the changed transmission line route. However, it seems that it is not so difference of the geological conditions between route 1 and 2.

It is preferable to conduct soil investigation for the location just under transmission line tower during the detailed design stage.



(Source : JICA survey team)

Figure 7.3.11-1 Location of Soil Investigation (inside of power plant site)
（Ck-1,2,3,4,5,6,7,13,14）



(Source : JICA survey team)

Figure 7.3.11-2 Location of Soil Investigation (outside of power plant site) Ck-8,9,10,11,12)

Table 7.3.11-1 shows the coordinates of each boring points.

Table 7.3.11-1 Coordinates of each boring points

No.	Boling point	X	Y
1	C_K-1	4449809.890	697734.570
2	C_K-2	4449940.640	697681.890
3	C_K-3	4450080.110	697667.840
4	C_K-4	4449843.910	697878.403
5	C_K-5	4449969.213	697806.680
6	C_K-6	4449882.505	698020.449
7	C_K-7	4449993.901	697924.456
8	C_K-8	4450151.183	697930.527
9	C_K-9	4450423.286	697983.328
10	C_K-10	4450926.904	698377.710
11	C_K-11	4451599.495	697384.488
12	C_K-12	4452019.546	696765.483
13	C_K-13	4449693.212	697967.893
14	C_K-14	4449733.179	698138.920

(Source : JICA survey team)

(2) Investgation items

Investigation items and quantity are shown in Table 7.3.11-2.

Table 7.3.11-2 Investigation Items and Quantity

No.	Types and names of works	unit of measurement	Quantity
	Field work:		
1.	Core drilling of wells ∅ up to 132 mm with depth up to 30.0 m	lm	420
2.	Standard penetration test (SPT)	test	225
3.	Selection of monoliths	monolith	60
4.	Sampling of abnormal soil	sample	55
5.	Groundwater sampling	sample	3
	Laboratory work:		
6.	Full complex of determination of soil physical properties	Deter.	60
7.	Compression test of soils by "one curve method “	test	8
8.	Compression test of soils by “two curves” method	test	28
9.	Shear test of soils	test	18
10.	Determination of particle size of soils	deter	47
11.	Chemical analysis of water and hydrochloric acid extract from soils	analysis	8
12.	Chemical analysis of groundwater	analysis	3

(Source : JICA survey team)

(3) Soil boring log

According to the investigation results in the project site, soil layer having more than 50 of N value is shown at the depth of 5 to 10m from surface.

Out side of the power plant, soil layer having more than 50 of N value is shown at the depth under 5 m from surface.

Generally, geological condition is good.

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-1	Drilling diameter:	132 mm
		Drilling date:	25.07.2019	Ground water level:	5,6
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	316.07
Prepared:	Maniurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
	1	0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
	1							1.5-1.95	1	2	3	2	3	4	12	30
	2							3.0-3.45	2	2	4	3	3	5	15	-
	3					Loess-like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.										
	4							4.5-4.95	1	1	5	4	4	5	18	30
1	5	0.3	4.6	4.3												
	5							6.0-6.45	1	1	6	5	6	7	24	30
	6					Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level	▼ 5.6 25.07.2019									
2	7	4.6	7.2	2.6												
	7							7.5-7.95	2	4	10	12	13	15	50	29
	8							9.0-9.45	6	8	11	12	13	14	50	29
	9															
	10					Sandy medium gravel, mainly coarse fractions with inclusion of gruss, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%.		10.5-10.95	6	9	10	13	11	16	50	27
	11															
4	12	7.2	11.8	4.6				12.0-12.45	9	11	13	18	19	-	50	22
	13					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy clayey boulder up to 39%.		13.5-13.95	9	12	15	16	19	-	50	22
5	14	11.8	14.3	2.5												
	15					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		15.0-15.45	12	13	19	21	10	-	50	20
	16							16.5-16.95	11	13	18	26	6	-	50	19
6	17	14.3	16.8	2.5												
	18							18.0-18.45	12	14	21	29	-	-	50	14
	19							19.5-19.95	13	14	24	26	-	-	50	12
	20							21.0-21.45	28	29	35	15	-	-	50	11
	21															
	22							22.5-22.95	30	32	38	12	-	-	50	10
	23							24.0-24.45	31	34	40	10	-	-	50	10
	24															
	25					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.										
	26															
	27															
	28															
	29															
5	30	16.8	30.0	13.2												

(Source : JICA survey team)

Figure 7.3.11-3 Soil boring log（Ck-1）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-2	Drilling diameter:	132 mm
		Drilling date:	31.07.2019	Ground water level:	6.2
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	334.93
Prepared:	Mansurov R.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	G.P.T depth, m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, cm
		0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
	1							1.5-1.95	2	1	2	3	2	2	10	30
	2					Loess-like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low-thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.		3.0-3.45	3	4	4	6	7	7	24	30
	3															
	4							4.5-4.95	4	5	6	7	8	10	31	30
1	5	0.3	5.2	4.9				6.0-6.45	4	7	8	8	10	12	38	30
	6					Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level	▼ 6.2 17.07.2019									
	7							7.5-7.95	5	8	9	9	10	13	41	30
	8															
2	9	5.2	9.0	3.8		Sandy medium gravel, mainly coarse fractions with inclusion of gruss, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%.		9.0-9.45	7	10	11	11	12	13	47	30
4	10	9.0	10.0	1.0				10.5-1.95	11	14	18	26	6	-	50	18
5	11	10.0	11.5	1.5		Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		12.0-12.45	11	13	15	22	13	-	50	20
	12															
	13							13.5-13.95	12	14	17	23	10	-	50	19
	14					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		15.0-15.45	12	14	19	21	10	-	50	19
	15															
6	16	11.5	15.6	4.1				16.5-16.95	13	17	20	25	5	-	50	18
	17							18.0-18.45	14	19	21	25	4	-	50	18
	18															
	19							19.5-19.95	15	23	22	28	-	-	50	15
	20							21.0-21.45	18	21	23	27	-	-	50	14
	21															
	22					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		22.5-22.95	18	24	25	25	-	-	50	13
	23							24.0-24.45	21	31	32	18	-	-	50	13
	24															
	25							25.5-25.95	23	30	34	16	-	-	50	12
	26															
	27															
	28															
	29															
5	30	15.6	30.0	14.4												

(Source : JICA survey team)

Figure 7.3.11-4 Soil boring log（Ck-2）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-3	Drilling diameter:	132 mm
		Drilling date:	31.07.2019	Ground water level:	5.6
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov R.R	Wellhead elevation:	331.09
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
	0	0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
	1							1.5-1.95	2	1	2	2	3	3	10	30
	2					Loess like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low-thickness interlayers of irregulgranular sand, sometimes with fragmental soils inclusion.		3.0-3.45	4	3	4	4	5	5	18	30
	3							4.5-495	4	5	6	6	7	5	24	30
	4															
	5															
1	6	0.3	5.8	5.5		Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level		6.0-6.45	5	6	7	6	5	6	24	30
2	7	5.8	7.0	1.2			▼ 6.8	7.5-7.95	6	7	7	9	8	9	33	30
	8					Sand is mainly semi-gravel, coarse and dusty in some places, brown in color, with the inclusion of gruss and gravel, water-saturated, lies in the form of lenses and interlayers in clay and very coarse soils.										
3	9	7.0	9.2	2.2				9.0-9.45	7	9	10	15	13	12	50	29
	10					Sandy medium gravel, mainly coarse fractions with inclusion of gruss, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%		10.5-10.95	10	13	10	12	15	13	50	26
4	11	9.2	10.6	1.4				12.0-12.45	11	13	13	15	17	5	50	24
5	12	10.6	12.0	1.4		Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%		13.5-13.95	13	13	14	15	19	2	50	23
	13															
	14					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		15.0-15.45	13	14	14	16	20	-	50	21
6	15	12.0	15.6	3.6				16.5-16.95	12	15	15	17	18	-	50	20
	16							18.0-18.45	12	15	16	19	15	-	50	19
	17							19.5-19.95	13	16	16	20	14	-	50	18
	18							21.0-21.45	14	16	17	21	12	-	50	17
	19							22.5-22.95	15	17	18	23	9	-	50	17
	20							24.0-24.45	16	17	19	25	6	-	50	16
	21					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.										
	22															
	23															
	24															
	25															
	26															
	27															
	28															
	29															
5	30	15.6	30.0	14.4												

(Source : JICA survey team)

Figure 7.3.11-5 Soil boring log（Ck-3）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-4	Drilling diameter:	132 mm
		Drilling date:	27.07.2019	Ground water level:	5.8
Customer:	Tokyo Electric Power Service CO, LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	334,88
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
	1	0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
1	2					Loess-like sandy loams and more rarely loams of light brown color, from hard to semiflluid consistency, with low-thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.		1.5-1.95	2	3	2	3	3	3	11	30
	3							3.0-3.45	4	4	3	4	4	5	16	30
	4							4.5-4.95	5	6	5	4	4	6	19	30
	5	0.3	5.0	4.7												
3	6					Sand is mainly semi-gravel, coarse and dusty in some places, brown in color, with the inclusion of grues and gravel, water-saturated, lies in the form of lenses and interlayers in clay and very coarse soils.	▼ 5.8 27.07.2019	6.0-6.45	5	4	5	4	6	6	21	30
	7							7.5-7.95	5	5	5	6	7	8	26	30
	8	5.0	7.5	2.5												
4	9					Sandy medium gravel, mainly coarse fractions with inclusion of gruss, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy clayey boulder up to 44%.		9.0-9.45	7	7	10	12	13	15	50	30
	10	7.5	10.0	2.5				10.5-10.95	7	8	9	12	15	14	50	29
5	11					Sandy pebbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		12.0-12.45	8	9	10	13	17	10	50	28
	12	10.0	11.5	1.5												
6	13					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		13.5-13.95	8	9	11	14	18	7	50	26
	14							15.0-15.45	9	11	12	14	20	4	50	25
	15	11.5	14.8	3.3												
5	16					Sandy pebbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		16.5-16.95	9	12	12	15	23	-	50	22
	17							18.0-18.45	10	13	13	16	21	-	50	21
	18							19.5-19.95	11	14	14	17	19	-	50	20
	19							21.0-21.45	12	15	15	18	17	-	50	19
	20							22.5-22.95	12	15	16	19	15	-	50	18
	21							24.0-24.45	13	16	17	21	11	-	50	17
	22															
	23															
	24															
	25															
	26															
	27															
	28															
	29															
	30	14.8	30.0	15.2												

(Source : JICA survey team)

Figure 7.3.11-6 Soil boring log（Ck-4）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-5	Drilling diameter:	132 mm
		Drilling date:	01.08.2019	Ground water level:	6.0
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	334.33
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, mm
	0.0		0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
	1							1.5-1.95	2	3	2	3	3	4	12	30
	2					Loess-like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low-thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.		3.0-3.45	3	4	4	4	5	4	17	30
	3															
	4							4.5-4.95	5	5	6	4	5	4	19	30
1	5	0.3	5.0	4.7		Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level	▼ 6.0 01.08.2019	6.0-6.45	5	6	8	6	7	8	28	30
2	6	5.0	6.2	1.2												
3	7	6.2	7.2	1.0		Sand is mainly semi-gravel, coarse and dusty in some places, brown in color, with the inclusion of grus and gravel, water-saturated, lies in the form of lenses and interlayers in clay and very coarse soils.		7.5-7.95	8	7	9	11	10	9	39	30
	8															
4	9	7.2	9.0	1.8		Sandy medium gravel, mainly coarse fractions with inclusion of grus, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%		9.0-9.45	8	8	13	10	15	12	50	29
5	10	9.0	10.5	1.5		Sandy cobbles, mainly fine fractions with inclusion of grus and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		10.5-10.95	8	10	14	15	16	5	50	27
	11							12.0-12.45	9	10	14	15	18	3	50	25
	12					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.										
	13							13.5-13.95	10	11	15	17	18	-	50	22
6	14	10.5	14.3	3.8				15.0-15.45	10	12	16	18	16	-	50	21
	15															
	16							16.5-16.95	11	12	17	20	13	-	50	20
	17															
	18							18.0-18.45	11	13	17	21	12	-	50	19
	19															
	20							19.5-19.95	12	13	18	23	9	-	50	18
	21															
	22					Sandy cobbles, mainly fine fractions with inclusion of grus and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		21.0-21.45	12	14	19	24	7	-	50	17
	23															
	24							22.5-22.95	13	15	20	25	5	-	50	16
	25															
	26							24.0-24.45	14	15	22	28	-	-	50	15
	27															
	28															
	29															
5	30	14.3	30.0	15.7												

(Source : JICA survey team)

Figure 7.3.11-7 Soil boring log（Ck-5）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-6	Drilling diameter:	132 mm
		Drilling date:	29.07.2019	Ground water level:	5.9
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	334.87
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth, m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows: T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
	1	0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.		1.5-1.95	2	2	3	2	3	3	11	30
	2					Loess-like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low-thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.		3.0-3.45	3	2	4	3	4	2	13	30
	3							4.5-4.95	4	4	5	4	6	4	19	30
1	4															
	5	0.3	5.2	4.9				6.0-6.45	5	6	6	7	8	8	29	30
	6					Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascention and below of groundwater level	▼ 5.9	7.5-7.95	8	7	8	6	7	6	27	30
2	7															
	8	5.2	8.0	2.8		Sand is mainly semi-gravel, coarse and dusty in some places, brown in color, with the inclusion of grass and gravel, water-saturated, lies in the form of lenses and interlayers in clay and very coarse soils.		9.0-9.45	8	8	9	10	10	12	41	30
3	9	8.0	9.2	1.2												
	10					Sandy medium gravel, mainly coarse fractions with inclusion of grass, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%.		10.5-10.95	8	9	10	11	12	15	48	30
	11							12.0-12.45	9	9	11	12	13	14	50	29
4	12	9.2	12.1	2.9		Sandy cobbles, mainly fine fractions with inclusion of grass and gravel, water-saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		13.5-13.95	9	10	12	14	14	10	50	27
5	13	12.1	12.6	0.5												
	14					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		15.0-15.45	10	11	13	16	17	4	50	25
6	15	12.6	14.2	1.6				16.5-16.95	11	12	14	15	18	3	50	23
	16															
	17							18.0-18.45	11	13	15	17	18	-	50	22
	18															
	19							19.5-19.95	12	14	17	20	13	-	50	20
	20															
	21					Sandy cobbles, mainly fine fractions with inclusion of grass and gravel, water-saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%		21.0-21.45	13	15	20	21	9	-	50	18
	22							22.5-22.95	14	17	21	23	6	-	50	17
	23															
	24							24.0-24.45	15	18	22	24	4	-	50	16
	25															
	26															
	27															
	28															
	29															
5	30	14.2	30.0	15.8												

(Source : JICA survey team)

Figure 7.3.11-8 Soil boring log（Ck-6）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-7	Drilling diameter:	132 mm	S.W.T. depth	Standard penetrant test						Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
		Drilling date:	01.08.2019	Ground water level:	5.8									
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov B.R.	Wellhead elevation:	333.96									
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:										

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	m	S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm		
	1	0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
	2					Loess-like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low-thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.		1.5-1.95	2	2	3	2	3	3	11	30
	3							3.0-3.45	3	4	3	4	4	4	15	30
	4							4.5-4.95	5	4	5	6	5	4	20	30
1	5	0.3	5.2	4.9				6.0-6.45	6	5	7	6	5	5	23	30
	6					Alternating loess like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level	▼ 5.8 07.08.2019								
2	7	5.2	7.3	2.1				7.5-7.95	7	6	8	8	8	9	33	30
	8					Sandy medium gravel, mainly coarse fractions with inclusion of gruss, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%.		9.0-9.45	7	7	9	9	10	10	38	30
4	9	7.3	9.5	2.2												
	10					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		10.5-10.95	8	8	9	10	11	11	41	30
5	11	9.5	11.2	1.7				12.0-12.45	9	9	10	11	12	13	46	30
	12					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.										
6	13	11.2	12.6	1.4				13.5-13.95	10	11	11	12	13	14	50	30
	14							15.0-15.45	10	12	12	13	14	11	50	28
	15															
	16							16.5-16.95	11	12	12	14	15	9	50	26
	17							18.0-18.45	12	13	13	15	17	5	50	24
	18															
	19							19.5-19.95	12	14	14	17	19	-	50	21
	20							21.0-21.45	13	15	15	18	17	-	50	20
	21					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.										
	22							22.5-22.95	14	16	16	19	15	-	50	19
	23							24.0-24.45	15	17	18	20	12	-	50	18
	24															
	25															
	26															
	27															
	28															
	29															
5	30	12.6	30.0	17.4												

(Source : JICA survey team)

Figure 7.3.11-9 Soil boring log（Ck-7）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-8	Drilling diameter:	132 mm
		Drilling date:	01.08.2019	Ground water level:	2.0
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yulgopov R.R.	Wellhead elevation:	-
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
		0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
1	1	0.3	1.0	0.7		Loess-like sandy loams and more rarely loams		1,5-1.95	2	1	2	2	1	2	7	30
2	2	1.0	2.0	1.0		Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level	▼ 2.0 01.08.2019	3.0-3.45	2	2	3	2	2	3	10	30
	3															
	4							4.5-4.95	5	4	6	15	17	12	50	29
	5															
	6					Sandy medium gravel, mainly coarse fractions with inclusion of gruss, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%.		6.0-6.45	10	12	15	18	17	-	50	21
	7							7.5-7.95	13	15	15	17	18	-	50	20
4	8	2.0	8.0	6.0												
	9					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		9.0-9.45	17	20	21	22	7	-	50	18
	10							10.5-10.95	23	25	23	27	-	-	50	14
5		8.0	10.5	2.5												
	11					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		12.0-12.45	23	25	26	24	-	-	50	13
	12															
	13							13.5-13.95	24	26	27	23	-	-	50	12
6	14	10.5	13.8	3.3												
	15					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		15.0-15.45	24	26	28	22	-	-	50	11
	16							16.5-16.95	25	27	29	21	-	-	50	10
	17															
	18							18.0-18.45	26	27	30	20	-	-	50	9
	19							19.5-19.95	27	28	31	19	-	-	50	9
	20															
	21							21.0-21.45	28	29	32	18	-	-	50	8
	22							22.5-22.95	29	30	33	17	-	-	50	8
	23							24.0-24.45	30	31	34	16	-	-	50	8
	24															
	25															
	26															
	27															
	28															
	29															
5	30	13.8	30.0	16.2												

(Source : JICA survey team)

Figure 7.3.11-10 Soil boring log（Ck-8）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-9	Drilling diameter:	132 mm
		Drilling date:	01.08.2019	Ground water level:	1.7
Customer:	Tokyu Electric Power Service CO. LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	-
Prepared:	Mansurov A.F.	Executor:	MusabekKov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
1	1	0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
3	1	0.3	0.8	0.5		Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level		1.5-1.95	2	1	2	1	1	2	6	30
	2	0.8	1.2	0.4			▼ 1.7									
	3							3.0-3.45	3	7	10	11	12	13	46	30
4		1.2	3.5	2.3		Sandy medium gravel, mainly coarse fractions with inclusion of gruss, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%										
	4							4.5-4.95	8	10	12	14	17	7	50	28
	5							6.0-6.45	10	11	13	15	17	5	50	26
	6							7.5-7.95	11	12	15	17	18	-	50	22
	7					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.										
	8							9.0-9.45	12	14	17	20	13	-	50	21
	9															
	10							10.5-10.95	13	16	19	22	9	-	50	20
5		3.5	10.5	7.0												
	11					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		12.0-12.45	14	18	20	23	7	-	50	19
6	12	10.5	12.2	1.7												
	13							13.5-13.95	15	20	21	25	4	-	50	18
	14															
	15							15.0-15.45	17	21	23	27	-	-	50	14
	16															
	17							16.5-16.95	18	23	25	25	-	-	50	13
	18															
	19							18.0-18.45	19	25	27	23	-	-	50	12
	20															
	21					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		19.5-19.95	21	26	30	20	-	-	50	11
	22							21.0-21.45	23	27	31	19	-	-	50	10
	23							22.5-22.95	24	28	33	17	-	-	50	9
	24							24.0-24.45	27	29	34	16	-	-	50	8
	25															
	26															
	27															
	28															
	29															
5	30	12.2	30.0	17.8												

(Source : JICA survey team)

Figure 7.3.11-11 Soil boring log（Ck-9）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-10	Drilling diameter:	132 mm
		Drilling date:	02.08.2019 год	Ground water level:	3.6
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	-
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
		0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
1	1 2 3	0.3	2.6	2.3		Sand is mainly semi-gravel, coarse and dusty in some places, brown in color, with the inclusion of gruss and gravel, water-saturated, lies in the form of lenses and interlayers in clay and very coarse soils.		1.5-1.95	2	2	2	1	2	2	7	30
								3.0-3.45	2	2	5	8	12	11	36	30
2		2.6	3.1	0.5		Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level	▼ 3.6 02.08.2019									
4	4 5 6 7 8 9 10	3.1	10.0	6.9		Sandy medium gravel, mainly coarse fractions with inclusion of gruss, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%.		4.5-4.95	12	13	15	15	17	3	50	29
								6.0-6.45	13	15	17	17	16	-	50	22
								7.5-7.95	14	15	17	16	17	-	50	20
								9.0-9.45	15	17	18	16	16	-	50	20
								10.5-10.95	15	16	16	17	17	-	50	20
5	11 12 13 14 15	10.0	15.0	5.0		Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		12.0-12.45	16	18	17	17	16	-	50	18
								13.5-13.95	20	22	24	26	-	-	50	14
								15.0-15.45	25	24	23	27	-	-	50	13
6	16 17	15.0	17.2	2.2		Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		16.5-16.95	26	25	25	25	-	-	50	12
								18.0-18.45	27	27	27	23	-	-	50	11
5	18 19 20 21 22 23 24 25 26 27 28 29 30	17.2	30.0	12.8		Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		19.5-19.95	28	30	30	20	-	-	50	10
								21.0-21.45	28	31	33	17	-	-	50	9
								22.5-22.95	30	32	34	16	-	-	50	8
								24.0-24.45	31	33	37	13	-	-	50	8

(Source : JICA survey team)

Figure 7.3.11-12 Soil boring log（Ck-10）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-11	Drilling diameter:	132 mm
		Drilling date:	02.08.2019	Ground water level:	3.4
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	-
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
	1	0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
1	2	0.3	2.4	2.1		Loess-like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low-thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.		1.5-1.95	2	2	2	1	2	2	7	30
2	3	2.4	3.3	0.9		Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level	▼ 3.4	3.0-3.45	2	2	3	8	10	11	32	30
4	4							4.5-4.95	10	10	12	13	12	13	50	28
	5	3.3	5.0	1.7		Sandy medium gravel, mainly coarse fractions with inclusion of grass, water saturated		6.0-6.45	12	11	13	15	15	7	50	24
	6							7.5-7.95	13	15	16	17	17	-	50	22
	7															
	8							9.0-9.45	15	13	17	16	17	-	50	21
	9					Sandy cobbles, mainly fine fractions with inclusion of grass and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.										
	10							10.5-10.95	12	14	15	17	18	-	50	20
	11							12.0-12.45	15	17	17	18	15	-	50	18
	12															
	13							13.5-13.95	19	20	22	28	-	-	50	14
	14															
5	15	5.0	15.0	10.0				15.0-15.45	23	25	26	24	-	-	50	12
	16					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		16.5-16.95	24	25	27	23	-	-	50	11
6	17	15.0	16.8	1.8												
	18							18.0-18.45	26	28	30	20	-	-	50	10
	19							19.5-19.95	28	30	32	18	-	-	50	9
	20															
	21					Sandy cobbles, mainly fine fractions with inclusion of grass and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		21.0-21.45	30	31	34	16	-	-	50	8
	22							22.5-22.95	31	33	37	13	-	-	50	8
	23							24.0-24.45	33	37	39	11	-	-	50	8
	24															
	25															
	26															
	27															
	28															
	29															
5	30	16.8	30.0	13.2												

(Source : JICA survey team)

Figure 7.3.11-13 Soil boring log（Ck-11）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-12	Drilling diameter:	132 mm	S.P.T depth	Standard penetrant test						Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, sm
		Drilling date:	04.08.2019	Ground water level:	3.5									
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	-									
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:										

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	m	S1	S2	T1	T2	T3	T4		
									75.0 mm	75.0 mm	75.0 mm	75.0 mm	75.0 mm	75.0 mm		
		0.0	0.3	0.3		Top soil - loams and sandy loams with plant roots inclusions.										
1	1 2	0.3	2.5	2.2		Loess-like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low-thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.		1.5-1.95	2	2	2	1	2	2	7	30
	3							3.0-3.45	2	2	5	10	12	12	39	30
2		2.5	3.5	1.0		Alternating loess-like loams and sandy loams of brown colos, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level	▼ 3.5 04.08.2019									
	4							4.5-4.95	10	11	12	13	13	12	50	29
	5							6.0-6.45	10	12	10	12	15	13	50	28
	6					Sandy medium gravel, mainly coarse fractions with inclusion of grus, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%.		7.5-7.95	10	13	12	14	14	10	50	27
	7							9.0-9.45	10	11	12	13	14	10	50	27
4	8 9 10	3.5	10.0	6.5				10.5-10.95	12	13	13	14	13	10	50	25
	11							12.0-12.45	17	15	18	20	12	-	50	20
	12							13.5-13.95	20	19	22	24	4	-	50	18
	13					Sandy cobbles, mainly fine fractions with inclusion of grus and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		15.0-15.45	25	26	27	23	-	-	50	14
	14							16.5-16.95	25	27	30	20	-	-	50	13
5	15	10.0	15.5	5.5				18.0-18.45	26	28	32	18	-	-	50	12
	16							19.5-19.95	27	30	34	16	-	-	50	11
	17					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		21.0-21.45	28	31	36	14	-	-	50	10
6		15.5	17.5	2.0				22.5-22.95	29	33	39	11	-	-	50	9
	18							24.0-24.45	30	34	40	10	-	-	50	8
	19															
	20															
	21															
	22					Sandy cobbles, mainly fine fractions with inclusion of grus and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.										
	23															
	24															
	25															
	26															
	27															
	28															
	29															
5	30	17.5	30.0	12.5												

(Source : JICA survey team)

Figure 7.3.11-14 Soil boring log（Ck-12）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-13	Drilling diameter:	132 mm
		Drilling date:	09.08.2019	Ground water level:	6.7
Customer:	Tokyo Electric Power Service CO. LTD	Geologist:	Yusupov B.B.	Wellhead elevation:	535.39
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration T1+T2+T3+T4, cm
	1	0.0	1.3	1.3		**Fill-up grounds - redeposited sands with inclusions of loams and sandy loams, break stone and gruss.**		1.5-1.95	2	2	2	1	2	2	7	30
	2					Loess-like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low-thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.		3.0-3.45	2	3	2	3	2	2	9	30
	3															
	4							4.5-4.95	4	4	4	5	4	4	17	30
	5															
1	6	1.3	5.7	4.4		Alternating loess-like loams and sandy loams of brown color, from semifluid to fluid consistency, with low-thickness interlayers of sand with gravel inclusions. Soils of EGE-2 occur in the zone of capillary ascension and below of groundwater level		6.0-6.45	10	13	13	14	15	8	50	30
2	7	5.7	6.5	0.8			▼ 6.7 06.08.2019	7.5-7.95	15	17	16	18	16	-	50	22
	8					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.											
	9							9.0-9.45	15	16	17	18	15	-	50	21
5	10	6.5	10.0	3.5				10.5-10.95	16	18	18	20	12	-	50	20
6	11	10.0	11.2	1.2		Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		12.0-12.45	17	20	20	22	8	-	50	19
	12															
	13							13.5-13.95	18	22	21	24	5	-	50	17
	14															
	15							15.0-15.45	19	24	25	25	-	-	50	14
	16															
	17							16.5-16.95	21	26	27	23	-	-	50	13
	18															
	19							18.0-18.45	23	28	30	20	-	-	50	12
	20															
	21					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		19.5-19.95	24	30	32	18	-	-	50	11
	22							21.0-21.45	27	31	34	16	-	-	50	10
	23							22.5-22.95	30	33	37	13	-	-	50	9
	24							24.0-24.45	32	35	39	11	-	-	50	8
	25															
	26															
	27															
	28															
	29															
5	30	11.2	30.0	18.8												

(Source : JICA survey team)

Figure 7.3.11-15 Soil boring log（Ck-13）

Project:	Construction of Navoi CCGT-3 and CCGT-4	Field number:	Ck-14	Drilling diameter:	132 mm
		Drilling date:	09.08.2019	Ground water level:	6.8
Customer:	Tokyo Electric Power Service CO, LTD	Geologist:	Yusupov R.R.	Wellhead elevation:	335.29
Prepared:	Mansurov A.F.	Executor:	Musabekov A.A.	Coordinates:	

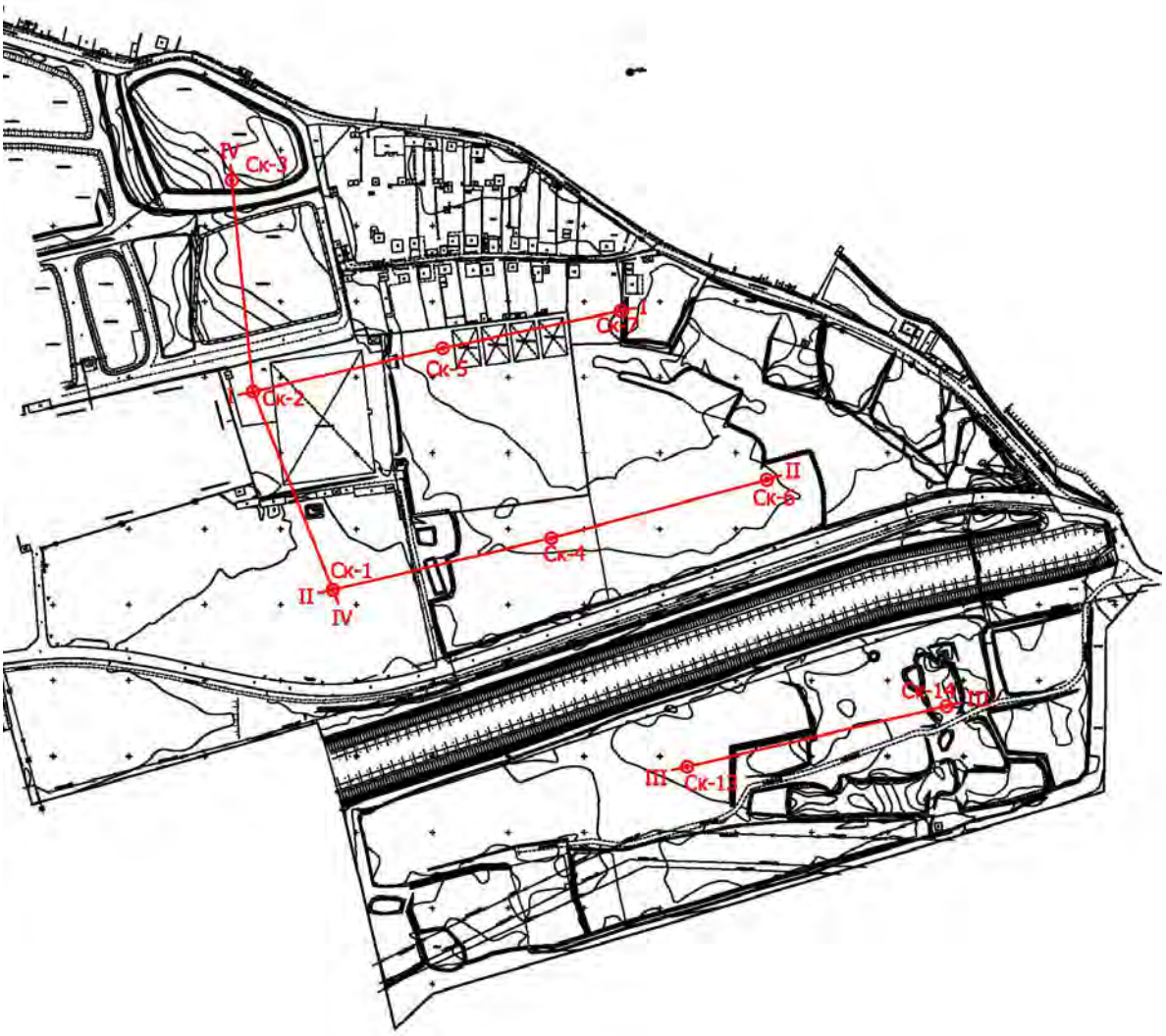
Item number	Depth scale, m	Superface of stratum depth, m	Subface of stratum depth, m	Layer thickness, m	Lithologic section	Rocks description	Ground water level, m	S.P.T depth m	Standard penetrant test S1 75.0 mm	S2 75.0 mm	T1 75.0 mm	T2 75.0 mm	T3 75.0 mm	T4 75.0 mm	Number of blows T1+T2+T3+T4	Penetration (T1+T2+T3+T4)x100
	1					Fill-up grounds - redeposited sands with inclusions of loams and sandy loams, break stone and gruss.		1.5-1.95	2	2	2	2	1	2	7	30
	2	0.0	2.5	2.5				3.0-3.45	2	2	3	2	3	2	10	30
	3					Loess-like sandy loams and more rarely loams of light brown color, from hard to semifluid consistency, with low-thickness interlayers of inequigranular sand, sometimes with fragmental soils inclusion.		4.5-4.95	5	4	6	4	4	5	19	30
	4															
	5							6.0-6.45	10	12	13	15	15	7	50	28
1	6	2.5	5.8	3.3												
2		5.8	6.5	0.7		Alternating loess-like loams and sandy loams of brown color.										
4	7	6.5	7.5	1.0		Sandy medium gravel, mainly coarse fractions with inclusion of gruss, water saturated, from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 44%.	▼ 6.8 09.08.2019	7.5-7.95	15	18	18	19	13	-	50	22
	8															
	9					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		9.0-9.45	16	20	21	25	4	-	50	17
5	10	7.5	9.6	2.1				10.5-10.95	17	21	23	27	-	-	50	14
	11					Conglomerate on carbonate cement, consisting of fragments of sedimentary and metamorphic rocks.		12.0-12.45	18	23	25	25	-	-	50	13
6	12	9.6	12.5	2.9				13.5-13.95	19	25	27	23	-	-	50	12
	13															
	14							15.0-15.45	20	27	29	21	-	-	50	11
	15															
	16							16.5-16.95	21	28	30	20	-	-	50	11
	17															
	18							18.0-18.45	22	30	32	18	-	-	50	10
	19															
	20							19.5-19.95	23	31	34	16	-	-	50	9
	21					Sandy cobbles, mainly fine fractions with inclusion of gruss and gravel, water-saturated from fragments of sedimentary and metamorphic rocks, with sandy-clayey boulder up to 39%.		21.0-21.45	24	33	37	13	-	-	50	9
	22															
	23							22.5-22.95	27	37	40	10	-	-	50	8
	24															
	25							24.0-24.45	30	40	42	8	-	-	50	8
	26															
	27															
	28															
	29															
5	30	12.5	30.0	17.5												

(Source : JICA survey team)

Figure 7.3.11-16 Soil boring log（Ck-14）

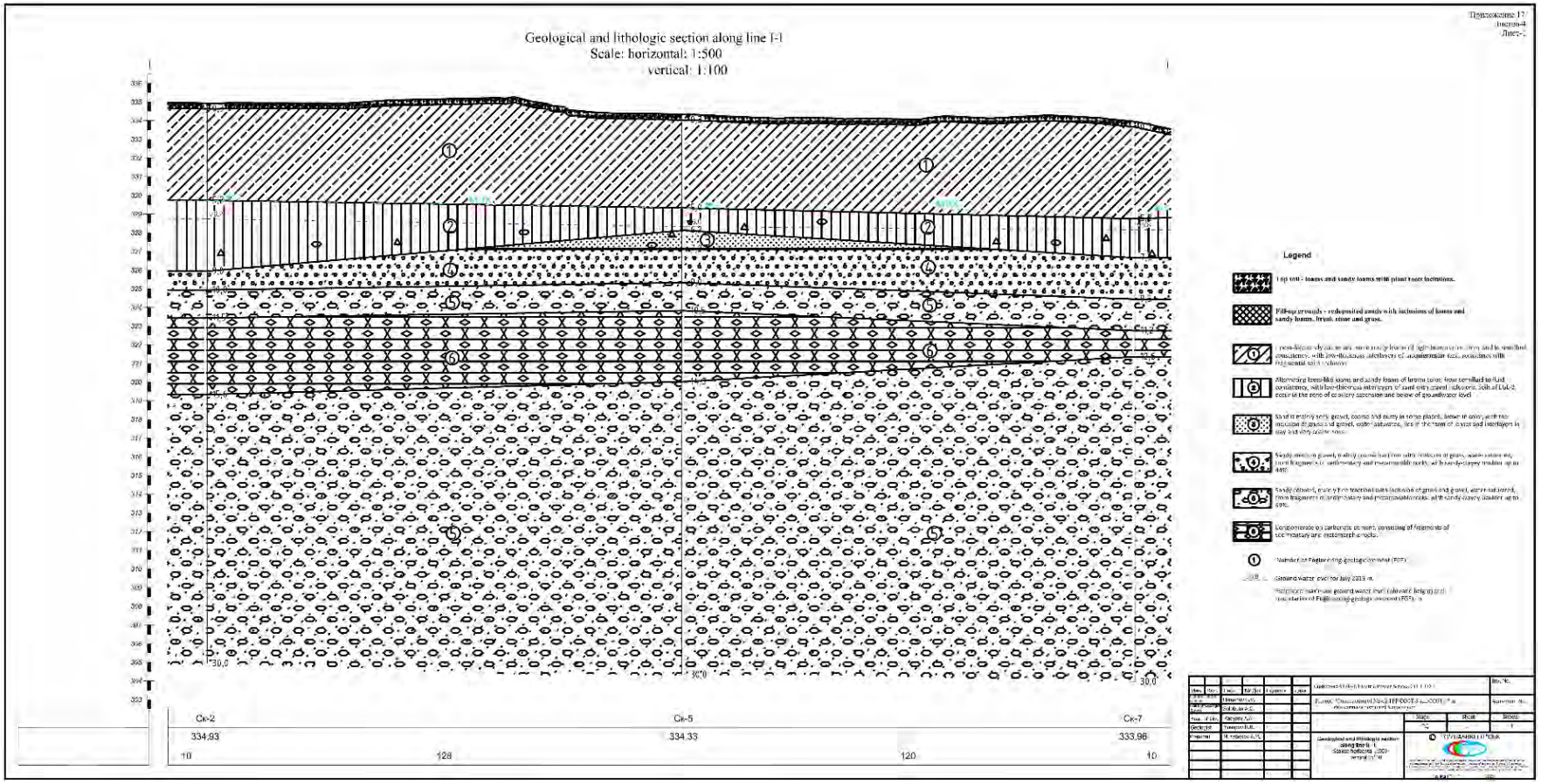
(4) Soil profile

Soil profile is made based on theresults of soil investigation in the power plant site.
Location of soil profile and section are shown below.



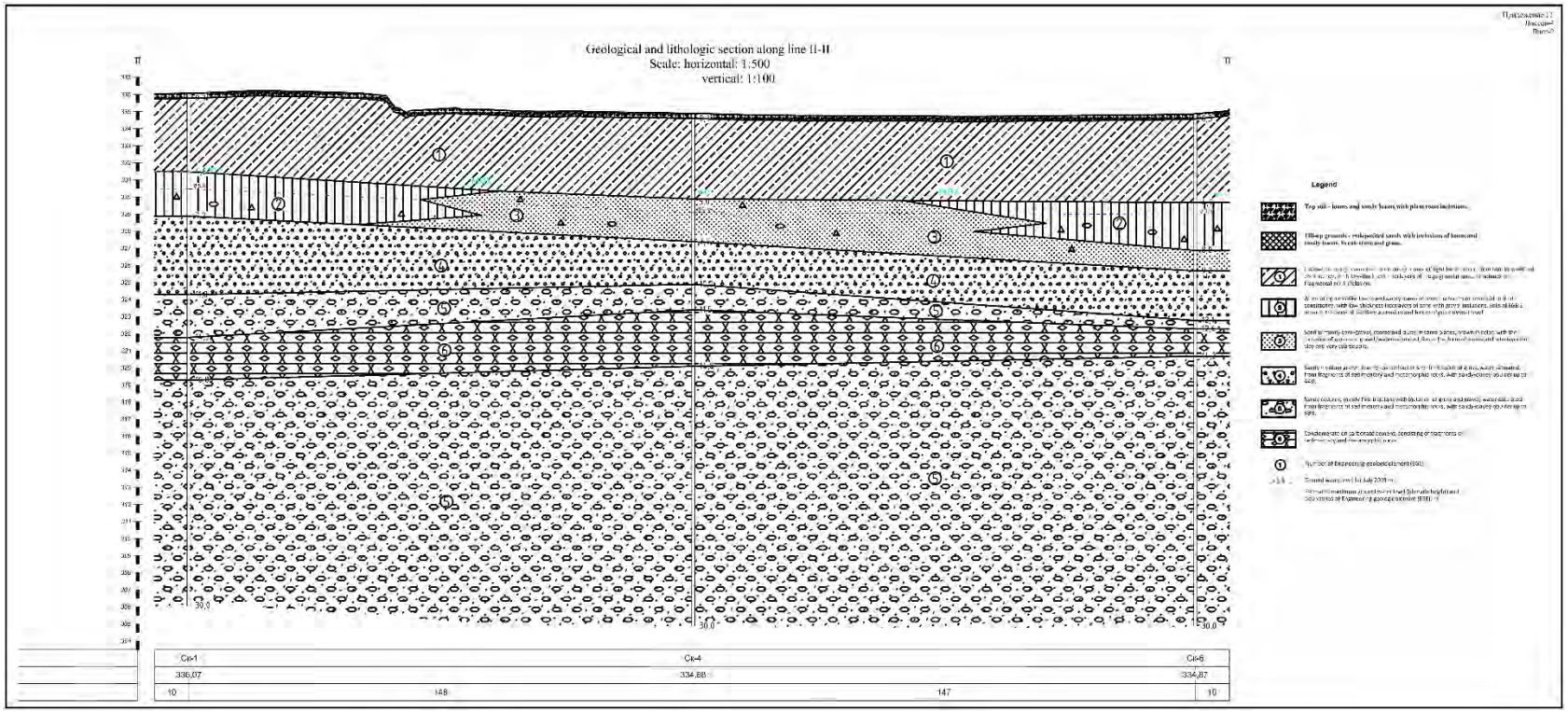
(Source : JICA survey team)

Figure 7.3.11-17 Location of soil profile



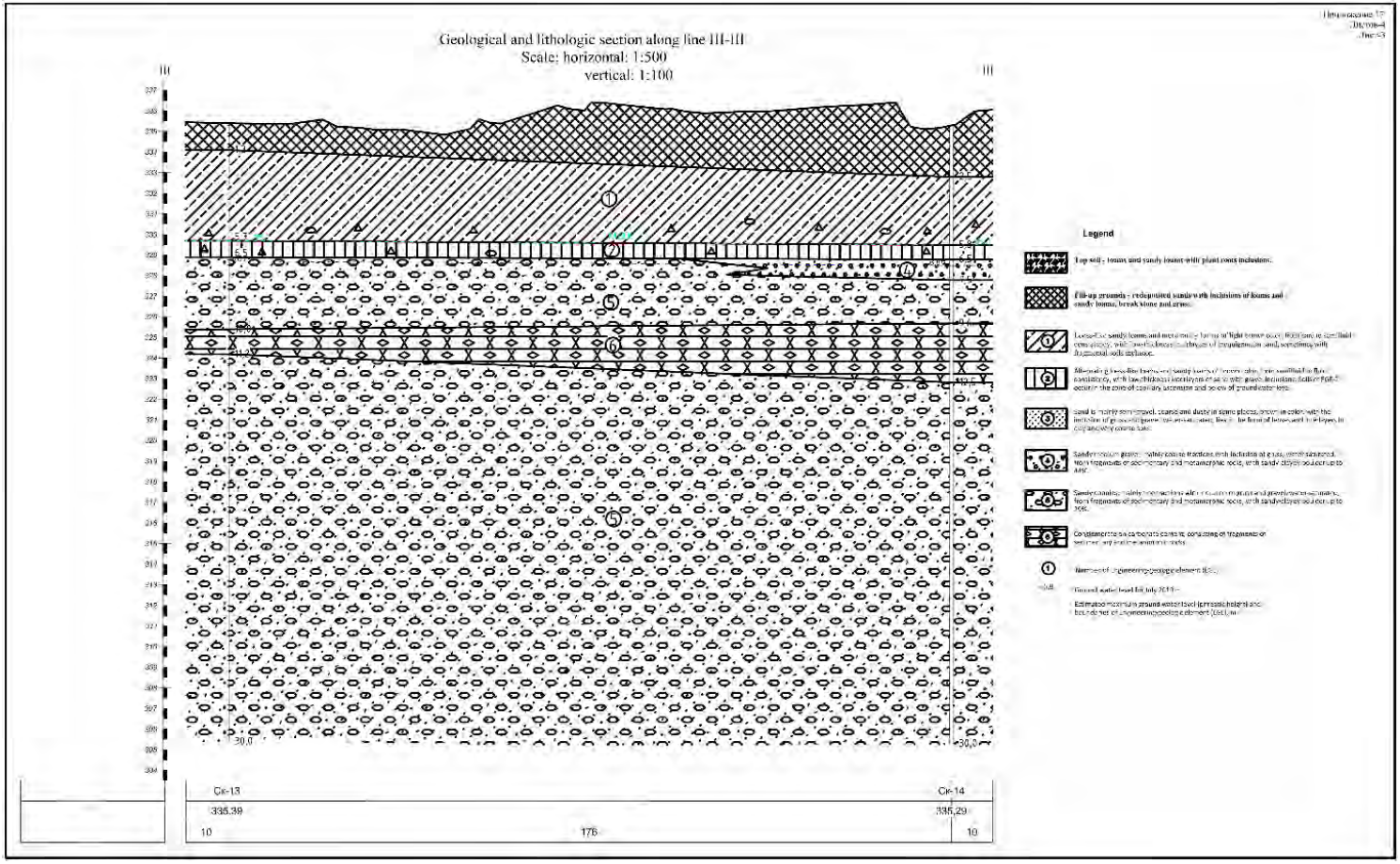
(Source: JICA survey team)

Figure 7.3.11-18 Ⅰ - Ⅰ Sectional Drawing



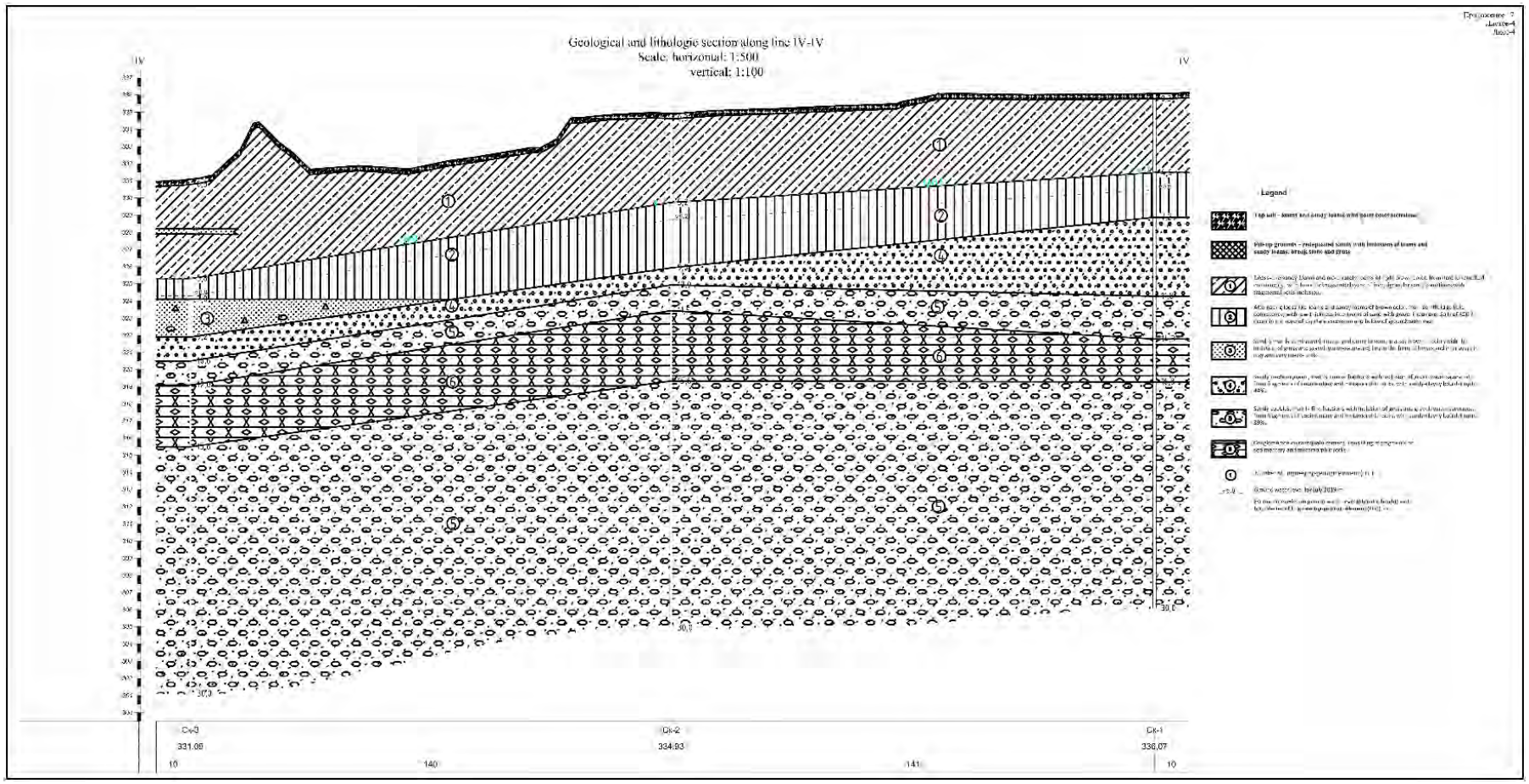
(Source: JICA survey team)

Figure 7.3.11-19 Ⅱ-Ⅱ Sectional Drawing



(Source: JICA survey team)

Figure 7.3.11-20 Ⅲ-Ⅲ Sectional drawing



(Source: JICA survey team)

Figure 7.3.11-21 Ⅳ-Ⅳ Cross section drawing

(5) Soils characteristics

Main soils characteristics of each soil layer (① to ⑥) are indicated in the Table 7.3.11-3 to Table 7.3.11-7.

1) Soil layer①

Table 7.3.11-3 Standard and calculated values of soils characteristics EGE-1

Name of characteristics	Meas. unit	Q-ty	Extreme values	Standard values	Calculated values when α =	
					0.85	0.95
Soil density	t/m^3	40	1,53-1,91	1,72	1,71	1,70
Soil density in dry state	t/m^3	40	1,33-1,61	1,50		
Density of soil particles	t/m^3	40	2,66-2,70	2,68		
Porosity coefficient	-	40	0,658-1,023	0,780		
Natural moisture	-	40	0,074-0,205	0,147		
Degree of humidity	-	40	0,23-0,79	0,51		
Moisture at fluidity point	-	40	0,209-0,296	0,250		
Moister at rolling-out limit	-	40	0,136-0,221	0,185		
Plasticity index	-	40	0,033-0,110	0,065		
-Flow rate	-	40	<0-0,26	<0		
Specific cohesion (consolid.)	kPa	12	10,0-23,9	13,2	11,8	10,9
Angle of internal friction (consolid)	Degree	12	24-27	26	26	25
Modulus of deformation: at natural humidity at water saturation	MPa	28	5,5-16,9 1,4-8,4	8,4 4,3		
Relative subsidence at P = 0,1 MPA P = 0,2 MPa P = 0,3 MPa	-	28	0,004-0,059 0,006-0,096 0,008-0,119	-		
Initial subsidience	MPa	28	0,02->0,30	-		

(Source: JICA survey team)

2) Soil layer②

Table 7.3.11-4 Standard and calculated values of soils characteristics EGE-2

Name of characteristics	Meas. unit	Q-ty	Extreme values	Standard values	Calculated values when α =	
					0.85	0.95
Soil density	t/m3	14	1,83-2,00	1,91	1,90	1,89
Soil density in dry state	t/m3	14	1,46-1,69	1,56		
Density of soil particles	t/m3	14	2,66-2,69	2,67		
Porosity coefficient	-	14	0,574-0,842	0,714		
Natural moisture	-	14	0,182-0,256	0,228		
Degree of humidity	-	14	0,81-0,92	0,85		
Moisture at fluidity point	-	14	0,205-0,269	0,239		
Moister at rolling-out limit	-	14	0,164-0,201	0,183		
Plasticity index	-	14	0,032-0,077	0,057		
-Flow rate	-	14	0,22->1,0	0,79		
Specific cohesion	kPa	6	13,0-17,0	14,8	14,2	13,7
Angle of internal friction	Degree	6	25-27	26	26	25
Modulus of deformation: at water saturation	MPa	8	4,0-7,0	5,3		

(Source: JICA survey team)

3) Soil layer③

Table 7.3.11-5 Standard and calculated values of soils characteristics EGE -3

Name of characteristics	Meas. unit	Q-ty	Extreme values	Standard values	Calculated values when α =	
					0,85	0,95
Soil density	t/m3	6	1,85-1,97	1,89	1,87	1,86
Soil density in dry state	t/m3	6	1,46-1,62	1,52		
Density of soil particles	t/m3	6	2,65	2,65		
Porosity coefficient	-	6	0,636-0,815	0,743		
Natural moisture	-	6	0,213-0,269	0,247		
Degree of humidity	-	6	0,85-0,92	0,88		
Angle of internal friction	Degree	-	-	32	30	29
Specific cohesion	кPa	-	-	0,0		
Modulus of deformation:	MPa	-	-	9,0		
Gradient of slope nat/wat	Degree	-	-	35/31		

(Source: JICA survey team)

4) Soil layer④

Table 7.3.11-6 Normative values of EGE-4 charactristics

Name of characteristics	Meas. unit	Norm. value
Soil density	t/m3	1,95
Angle of internal friction	degree	36
Modulus of deformation:	MPa	50

(Source: JICA survey team)

5) Soil layer⑤

Table 7.3.11-7 Normative values of EGE-5 charactristics

Name of characteristics	Meas. unit	Norm. value
Soil density	t/m3	2,05
Angle of internal friction	degree	38
Modulus of deformation:	MPa	55

(Source: JICA survey team)

6) Soil layer⑥

Density of soils of this element is 2,36 t/m3.

Strength of conglomerates (R_c) is 30,0 MPA in air-dry condition.

(6) Topographic Map

Каталог координат СКВ SLE coordinate catalog			
Строительства ТЭС Навои ПГУ-3 и ПГУ-4» Construction of TPP Navoi PGU-3 and PGU-4 " в Карманинском районе Навоийской области			
№	№№	X	Y
1	С к -1	4449809.890	697734.570
2	С к -2	4449940.640	697681.890
3	С к -3	4450080.110	697667.840
4	С к -4	4449843.910	697878.403
5	С к -5	4449969.213	697806.680
6	С к -6	4449882.505	698020.449
7	С к -7	4449993.901	697924.456
8	С к -8	4450151.183	697930.527
9	С к -9	4450423.286	697983.328
10	С к -10	4450926.904	698377.710
11	С к -11	4451599.495	697384.488
12	С к -12	4452019.546	696765.483
13	С к -13	4449693.212	697967.893
14	С к -14	4449733.179	698138.920

Каталог координат долглвременний репера Long term reference coordinate directory			
Строительства ТЭС Навои ПГУ-3 и ПГУ-4» Construction of TPP Navoi PGU-3 and PGU-4 в Карманинском районе Навоийской области			
T-1	4449792.031	698372.295	336.262
T-2	4449804.307	698171.394	336.909
T-3	4449759.018	698011.970	336.073
T-4	4449665.465	697750.664	336.744
T-5	4449751.501	697716.613	336.650
T-6	4449794.445	697897.536	336.180
T-7	4450000.933	698007.206	334.518
T-8	4449943.898	698153.873	334.071
T-9	4449880.872	698192.145	336.334
T-10	4449875.652	698420.334	333.752

(Source: JICA survey team)

Figure 7.3.11-22 Topographic Map

(7) Topographic survey

Topographic survey had been conducted in thepower plant site.. However, since soil investigation on the north side of river has not been conducted, it is necessary to measure the altitude when detail design will been conducted.

(8) Remarks

From the above, it is necessary to pay attention to the following points for civil engineering facilities and architectural facilities.

- Based on the results of detail soil investigation in implementation phase, determine the foundation system of each facility.（direct foundation, pile foundation）
- Based on the results of the detail soil investigation in implementation phase, judge the necessity of ground improvement as measures for liquefaction of each facility.
- To determine the foundation system, confirmation of the foundation system of the existing structure is necessary.

Chapter 12

Environmental and Social Consideration

Chapter 12. Environmental and Social Consideration

12.1 Outline of Project

12.1.1 Background

In Uzbekistan, the rated capacity exceeds the demand. However, the power generation facilities are generally deteriorated and the actual power generation capacity has dropped by approximately 30% from the rated capacity of 10 thermal power stations in the country. Therefore, actual supply capacity does not catch up with demand.

In the Intended Nationally Determined Contribution (hereinafter called “INDC”) based on the Paris Agreement, the Government of Uzbekistan set a goal that it would reduce emissions of greenhouse gases (hereinafter called “GHG”) against their GDP by 10 % by 2030, compared to emission levels in 2010 and will take the following measures to achieve this goal.

· Installation of new production facilities with advanced energy efficiency and energy-saving technologies

· Reduction of fuel consumption in the production and use of electrical energy

· Construction of large-scale solar power plants and large-scale wind power generation

As part of this, high-efficiency gas-fired power plants are planned for 8,000 MW at Navoi, Tashkent, Talimardjan, etc., and 3,000 MW at 12 solar power generation sites and 8 wind power generation sites for renewable energy development.

By replacing conventional power plants with mainly natural gas thermal plants with high efficiency, the Government plans to ensure stable electricity supplies and reduce emissions of CO_2 and NOx by reducing fuel consumption as top priority and then to develop renewable energies in the future.

Under these circumstances, it is urgently necessary to secure power supply capacity and improve the reliability of power generation facilities by upgrading facilities. At the same time, it is desired to introduce high-efficiency power generation facilities to suppress GHG emissions.

On the occasion of the visit to Uzbekistan by Prime Minister Abe in October 2015, the ongoing cooperation to the power sector was declared in the joint statement by the top-leaders of the both countries.

In these situations, the Government of Uzbekistan issued the request for conducting the preparatory survey of finance and cooperation for the construction of GTCC3 in the Navoi old. The capacity of GTCC3 would be 600 MW using a high-efficiency gas turbine.

In this project, the output increased from initial proposed 450 MW to 600 MW, but the technology adopted is that the power generation efficiency is 60 % (LHV) and highest efficiency shown in Best Available Technology (hereinafter called "BAT") announced by of the Ministry of the Environment and the Ministry of Economy, Trade and Industry of Japan in February 2017.

This technology enables reduction of fuel consumption per unit of power generation as much as possible, and of emissions of nitrogen oxides (NOx) and carbon dioxide (CO_2).

The EIA procedure in Uzbekistan for this project is being conducted as a project that includes GTCC3 and an additional power generation facility (GTCC4) with generation capacity equivalent to GTCC3, and the EIA report for two units was approved in May 2019.

From here on, this report is focus on only GTCC3, including the outline of the facility, the alternatives, scoping, survey results and impact assessment, environmental management plan, monitoring plan. It is to be noted that the chapters on the survey result of the environmental and social conditions and are described collectively for GTCC3 and GTCC4, as it is difficult to describe them respectively.

12.1.2 Survey Area

The main target areas of this survey are the Navoi-old, the north area in the premises of the power station and its surrounding areas. Figure 12.1.2-1 shows the positional relationship of the Metropolitan City of Tashkent and Navoi City in Uzbekistan. The project site is located 6 km to the north-west from Navoi city.

Figure 12.1.2-2 shows the Navoi old, the surrounding areas of the planned construction sites of GTCC3, existing GTCC1, GTCC2, and the candidate construction site of the 220kV transmission line.

Units 1, 2 and 6 in Navoi old have already been decommissioned, and Units 3 and 8 will also be decommissioned when GTCC2 will put into operation in the end of 2019. When GTCC3 will put into operation in the end of 2023, Units 4, 5 and 11of Navoi old will be stopped.

(Source: Google Map, added by JICA Survey Team)

Figure 12.1.2-1 Positional Relationship Map of Metropolitan City of Tashkent and Navoi City

(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.1.2-2 Air Photography of GTCC3 and Related Facilities

12.1.3 Main Facilities and Process

(1) Power Generation System

Combined cycle power generation facility supplying both heat and electricity (600 MW+200 Gcal×1 unit)

(2) Fuel

Fuel of GTCC3 would be natural gas and fuel supply system is to be considered based on the existing gas pipelines and additional installation of gas pipelines accompanied with GTCC2 construction.

(3) Cooling Methods

Air cooled condenser cooling system will be installed for GTCC 3.

(4) Water Intake and Discharge

Water is taken for the Navoi old by installing an intake dam in the Zeravshan River. Units 3, 4, 8, and 9 of the Navoi old (manufactured by the former Soviet Union) adopted once-through condenser cooling systems and use river water taken for cooling condenser through the intake canal from the intake dam.

Thermal effluent is discharged to the Zeravshan River through a water discharge point located about 1 km downstream from the water intake point. Since the intake dam is installed as described above, there is no concern about recirculation of thermal effluent.

The water intake point for GTCC3 is planned to be branched from the existing water intake canal and the wastewater will be discharged in the Zerashvan River from the discharge point in the east side of the site.

(5) Stack

A multi-shaft combined cycle system is adapted to GTCC3 and a by-pass stack for simple cycle operation will not be installed.

The height of the stack of the GTCC3 for combined cycle operation is expected to be about 110 m, which is higher than the GTCC1 and GTCC2.

(6) Transmission Facilities and Substation

Transmission line connecting between GTCC3 and Substation will be about 6 km long with 11 transmission towers. The area of all towers and substation are estimated about 0.3 ha and 22.5 ha. These areas are not residential land and mainly farm land.

Transmission line and substation are also considered to be financed by JICA ODA loan and thereby is the main target of the examination of the environmental and social consideration in this survey.

12.1.4 Associated Facilities

The environmental and social consideration needs to be examined for associated facilities in accordance with JICA Guidelines.

(1) Access Road

The Project will improve the existing road in the north of Navoi PS and use it as access road.

(2) Gas Pipeline

Gas pipelines are to be branched from existing pipelines of GTCC2 and installed through existing power plant sites.

The pipeline will not be installed outside the site.

(3) Other

Site temporally used for construction work, such as materials and equipment storage areas, will be secured by leveling the grounds within the power station premises.

Workers camp will not be constructed for the construction of GTCC3. In addition, neither borrow pit nor quarry are necessary as earth and sand generated by excavation of the site will be used for leveling.

12.2 Environmental and Social Status

The environmental and social status of the project site and the surrounding area basically were described in the final EIA report of GTCC3 and 4. The final EIA report was approved by the State Ecology Committee (Goskomekologiya) on May 3, 2019 and provided to the Survey Team.

Some environmental and social status of the project site are described by additional survey and past F/S report of GTCC2.

12.2.1 Air Quality

(1) Navoi City

Table 12.2.1-1 describes the result of the annual continuous atmospheric survey in 2010 and 2018 at three measurement points in Navoi City by Uzgidromet. The measurement points are shown in Figure 12.2.1-1.

The nitrogen dioxide (hereinafter called "NO_2") concentration is 15 ~ 110 μg/m^3 (30 minutes average), higher than the maximum acceptable concentration (hereinafter called "MAC") of 85μg/m^3 at the maximum level, whereas IFC/WB EHS Guidelines value is satisfied.

Whereas SO_2 (1 ~ 11 μg/m^3)is compliant with MAC (500 μg/m^3)and IFC/WB EHS Guidelines value (500 μg/m^3 at 10 minutes and 125 μg/m^3 at 24 hour), suspended particles/dust (62 ~ 700 μg/m^3) is not compliant with MAC (150 μg/m^3) and IFC/WB EHS Guidelines value (150 μg/m^3 at 24 hour).

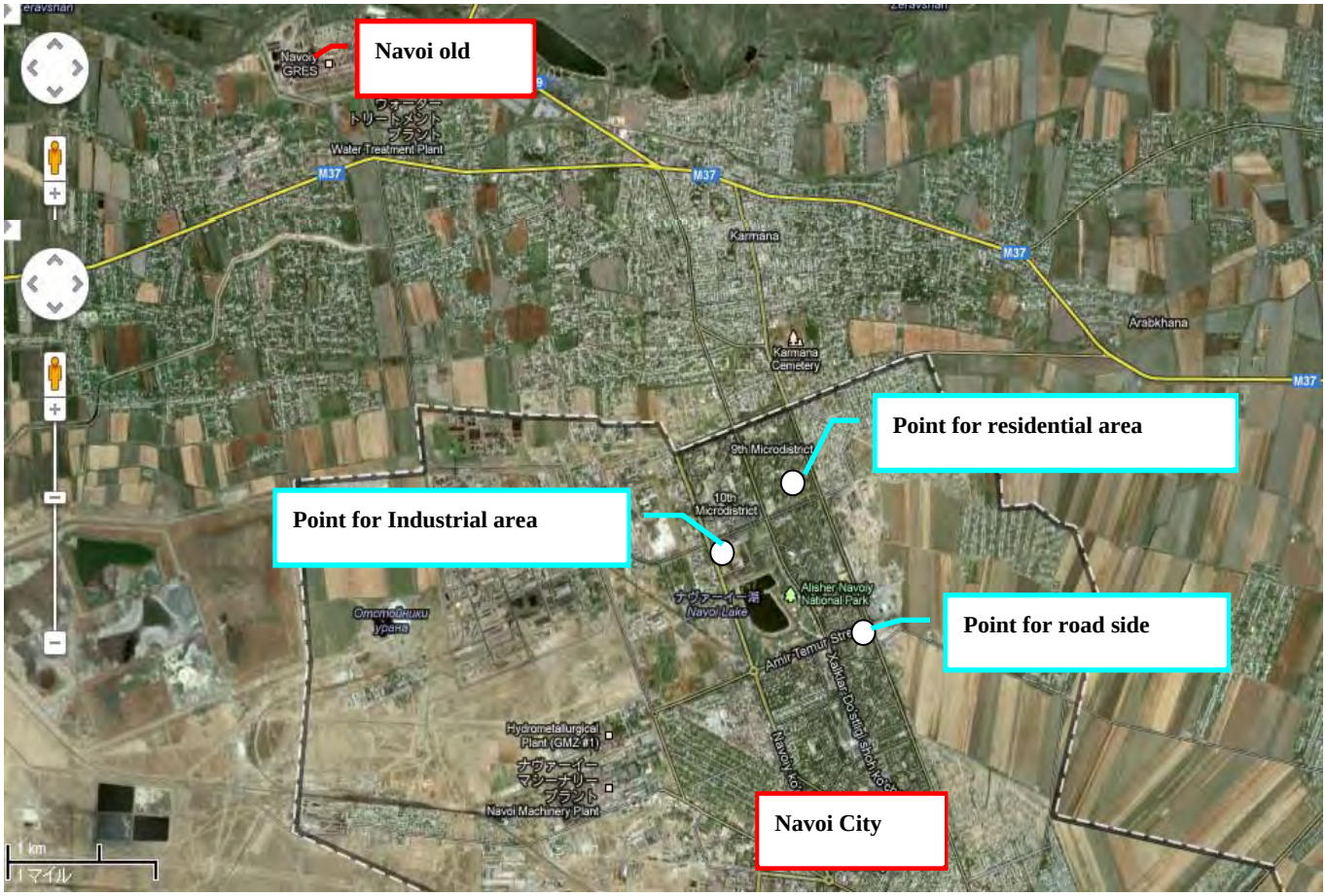
The concentration of NO_2, SO_2 and dust in 2018 does not show any significant deterioration compared to 2010.

Table 12.2.1-1 Comparison of Air quality in Navoi city with the Environmental Standard (μg/m^3)

Pollutant	Year	Area	Current value in Navoi City		UzbekistanMaximum acceptable concentration (MAC)(30 min)	IFC/WB EHS General Guidelines (2007)
			Minimum~maximum (30 min)	Annual average (1year)		
Nitrogen dioxide (NO_2)	2010	Residential	15~90	40	85	200 (1hour) 40 (1year)
	2018		<110	40		
	2010	Industrial	16~110	40		
	2018		<110	40		
	2010	Roadside	16~100	40		
	2018		<90	50		
Nitrogen oxide (NO)	2010	Residential	14~90	30	600	—
	2018		-	-		
	2010	Industrial	9~14	30		
	2018		-	-		
Sulfur dioxide (SO_2)	2010	Residential	1~8	2	500	500 (10min) 125 (24hours)
	2018		<11	3		
	2010	Industrial	~8	2		
	2018		<10	3		
	2010	Roadside	2~9	3		

Pollutant	Year	Area	Current value in Navoi City		UzbekistanMaximum acceptable concentration (MAC)(30 min)	IFC/WB EHS General Guidelines (2007)
			Minimum~maximum (30 min)	Annual average (1year)		
	2018		<9	2		
Suspended particles (dust)	2010	Residential	62~500	100	150	150 (24hours) 70 (1year)
	2018	Roadside	<700	100		

（Source: JICA Survey Team）



(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.2.1-1 Measuring Location of Air Quality in Navoi City

(2) Surrounding Area of Navoi PS

In order to confirm the impacts from the construction of GTCC2, air quality was measured in 2018 at 2 points shown in Figure 12.2.1-2. The results are indicated as Table 12.2.1-2. The concentration of NO_2 was 12~42 μg/m^3 (30 minutes average), lower than the MAC of 85 μg/m^3 and IFC/WB EHS Guidelines value of 200 μg/m^3.

Concentration of suspended particles (dust) does not meet MAC and IFC/WB EHS Guidelines value. The cause of this excess is mainly that wind generates dust in the dry area around the project site. Environment Pollution and Monitoring Department of Navoi set regionally original standards for dust,

i.e. 500 μg/m^3 at 30-minute average and 350 μg/m^3 at daily average, which are less stringent than standards set nationally to manage such anthropogenic pollutions. All measurement values were below these regional standards.

Since the numbers of vehicles and industry plants, which are the generation source of NO_2, around the power plant site are much lower than those in Navoi City.

Table 12.2.1-2Air Quality in the Construction Area of GTCC2

Pollutant	Time	Points	Current value (μg/m^3)		Uzbekistan MAC (μg/m^3)	IFC/WB EHS General Guidelines (2007) (μg/m^3)
			Minimum ~maximum (30 min)	Average (24hr)		
Nitrogen dioxide (NO_2)	20.April	West-residential area①	20~34	27	85 (30 min) 60 (24hrs)	200 (1hour) 40 (1year)
		South-residential area②	12~42	20		
	16.May	West-residential area①	22~32	27		
		South-residential area②	20~28	24		
	14.Aug	West-residential area①	20~32	27		
		South-residential area②	20~42	31		
Suspended particles (dust)	20.April	West-residential area①	120~190	150	150 (30 min) 100 (24hrs)	150 (24hours) 70 (1year)
		South-residential area②	190~260	220		
	16.May	West-residential area①	130～170	150		
		South-residential area②	110～160	140		
	14.Aug	West-residential area①	130～190	160		
		South-residential area②	110～180	140		

(Source: Navoi Thermal Power Station Modernization Project Environmental Monitoring Report Quarter III, 2018)

Locations of monitoring stations at and around the construction site (● air quality, ▲ noise)

(Source: Navoi Thermal Power Station Modernization Project Environmental Monitoring Report Quarter III, 2018)

Figure 12.2.1-2 Measuring Locations of Air Quality and Noise in the Construction Area of GTCC2

12.2.2 Water Quality

(1) Zeravshan River

Final EIA report of GTCC3 and 4 describes yearly average values of water quality of Zeravshan River conducted at two points in Navoi City by Uzgidromet in 2012.

The chemical composition of Zeravshan river water is formed under the influence of pollutants coming with sewage water from industrial enterprises of the cities of Samarkand, Kattakurgan, Navoi and farmland.

Heavy metals and phenols are part of many fertilizers and pesticides and can get into reservoirs along with runoff from agricultural land.

The result shows that water is considerably contaminated while flowing into Navoi city. Despite pollution, waters of Zeravshan River are used for domestic and drinking purposes of Navoi city and Region.

When approaching the city, water contains above the permissible values of ions of magnesium, calcium, sulfates, phenol, chromates, and iron.

In its downstream of Navoi city, waters of Zeravshan River are characterized with increased content of suspended particles, especially, great mass of debris passes through the river during the period of high-water level; its formation takes place due to washout of roots of cotton, bush and other debris

with rain storm waters from ploughed slopes of the river developed under agricultural fields. One of the causes of high suspended solids could be that particle matters in the air is settling into the River. The highest turbidity reaches 11,000 to 13,000 mg/ℓ in the spring and summer period. The smallest is 32 mg/ℓ in the autumn-winter period. (final EIA report of GTCC3 and 4 p.37)

Table 12.2.2-1 Water Quality of Zeravshan River near Navoi city

Item	Unit	Upstream of Navoi	Downstream of Navoi	Environmental standards in Uzbekistan (San Pin No.0056-98)
Dissolved Oxygen (DO)	mg/ℓ	10.2	10.55	Summer: 4.0 or higher Winter: 6.0 or higher
Biochemical Oxygen Demand (BOD)	$mgO_2/ℓ$	1.86	2.36	3.0
Chemical Oxygen Demand (COD)	$mgO_2/ℓ$	12.59	14.32	15
Suspended Solid (SS)	mg/ℓ	**388.5**	**325.4**	15
Oil	mg/ℓ	0.02	0.02	0.05
Ammonia (NH_4)	mg/ℓ	0.05	0.14	0.5
Nitrite (NO_2)	mg/ℓ	0.019	0.037	0.02
Nitrate (NO_3)	mg/ℓ	1.9	2.1	40
Phenol	mg/ℓ	**0.004**	**0.004**	0.001
Iron (Fe)	mg/ℓ	0.02	0.04	0.5
Copper (Cu)	mg/ℓ	**1.1**	**1.0**	0.001
Zinc (Zn)	mg/ℓ	**1.6**	**2.2**	0.01
Chromium (Cr)	mg/ℓ	**1.0**	**1.0**	0.5

*According to data from Yearbook of Quality of Surface Waters on Area of Activity of Uzgidromet for 2012. Tashkent, 2013 (average values).

（Source: final EIA report of GTCC3 and 4 p.38）

Water quality of Inlet Chanel of Navoi-old from Zeravshan River for 2012-2018 is shown in Table 12.2.2-2. The water quality exceeds the standard value in SS, Sulfate, Nitrite, Iron Petroleum products.

Table 12.2.2-2 Water Quality Monitoring Result at Inlet Chanel of Navoi-old

Parameters	Unit	2012	2013	2014	2015	2016	2017	2018	Environmental standard in Uzbekistan (San Pin No.0056-98)
Temperature	°C	6~30	6~29	6~29	8~29	11～33	7～30	6.5～27	—
pH	-	8.1~8.3	8.0~8.3	8.1~8.4	8.2~8.3	8～8.2	8～8.2	8～8.2	6.5- 8.5
Suspended Solid (SS)	mg/l	**51~4,190**	**88~11,590**	**106~11,311**	**115~14,020**	**158～4538**	**89～2380**	**94～1524**	15
Chlorine (Cl)	mg/l	29~130	62~122	56~118	85~130	65～106	64～102	68～101	300
Sulfate (SO_4)	mg/l	**230~699**	**403~672**	**6~672**	**384~768**	**425～566**	**455～599**	**480～627**	100
Nitrite (NO_2)	mg/l	0.015**~0.25**	**0.095~0.3**	**0.1~0.25**	**0.09~0.26**	**0.13～0.32**	**0.14～0.4**	**0.08～0.21**	0.02
Nitrate (NO_3)	mg/l	3.0~10.0	4.0~10.0	5.0~11.0	8.5~9.5	4～13	6.5～18.8	1.7～10.2	40
Iron (Fe)	mg/l	**1.8~6.7**	**1.2~7.5**	**1.0~8.4**	**3.1~6.4**	**1.2～8.4**	**1.2～8.6**	**2～12.5**	0.5
Petroleum products (Oil)	mg/l	**0.11~0.46**	**0.09~0.38**	0.05~**0.33**	**0.09~0.44**	**0.14～0.29**	**0.14～0.29**	**0.25～0.49**	0.05

(Source: Report of Zaravshan River Water Quality 2015, JICA survey team)

The monitoring results at the water inlet and waste water of Navoi-old for 2018 are presented in Table 12.2.2-3 below.

Water quality at the discharge is not very different compared to the inlet, but as in the power station water is treated to remove the SS, SS concentration at the discharge is lower than at the inlet.

Table 12.2.2-3 Water Quality Monitoring Result at Outlet of Wastewater of Navoi-old

Item	Water inlet channel	Waste water				Effluent standard for Navoi -old	IFC/WB EHS guideline values (thermal power station)
		No. 1	No. 2	No.4	No. 5		
Approved Volume (m^3/h)	−	67,361	35	5	344	-	-
Temperature	19.0	20.0	21.1	17.3	20.3	Not more than by 3°C	-
pH	8.25	8.25	8.23	7.9	8.15	6.5-8.5	6 –9
SS	791	**759**	192	181	183	487	50 mg/ℓ
Oil	0.24	**0.24**	**0.29**	ND	ND	0.234 (No.1) 0.1 mg/ℓ (No.2-4) - (No.5-6)	10 mg/ℓ
Nitrite	0.156	0.186	0.124	ND	ND	3.3 mg/ℓ	-
Nitrate	7.6	7.8	6.25	ND	ND	45 mg/ℓ	-
Sulfate	545	**545**	496	ND	634	500 mg/ℓ (No.1～4) 1000 mg/ℓ (No 5～6)	-
Mineralization	1516	1516	1410	ND	**1671**	1500 mg/ℓ	-
Chloride	91	90.3	86	ND	94.2	350 mg/ℓ	-
Remark	-	Thermal effluent from Unit 1-10 once-through system	Rain water from Unit 8-12 after oil-treatment	Rain water from Unit 1-7 after oil-treatment	Effluent from water treatment facility	—	—

Note: 1.Existing Unit 1-2 was decommissioned.

2. ND: Not detected

(Source: JICA Survey Team)

(Source: Google Map, added by JICA Survey Team)

Figure 12.2.2-1 Locations of Inlet and Outlet of Navoi-old

12.2.3 Noise

Noise levels around GTCC2 were monitored at 5 points in 2018 shown in Figure 12.2.1-2 to confirm the impacts from construction of GTCC2. The results monitored inside of residential area (two locations) are shown in Table 12.2.3-1.

Noise level at west residential area is 48-54 dB(A) in the daytime and 49-51 dB(A) in the night and that of south is 53-61 dB(A), 45-51 dB(A), respectively. These results slightly exceed the Uzbekistan standards and the IFC EHS Guidelines values.

During the time of measurements from April to August intensive works during night occurred which were reduced significantly in the second half of August. Thus the noise situation at night should improve now.

Table 12.2.3-1Noise Level Compared with the Uzbekistan and Other Environmental Standards

Points	Time		Measurement value (dB(A))	Standard in Uzbekistan (residential area) (dB(A))	IFC /WBEHS General Guidelines(2007) (residential area) (dB(A))
West-residential area (“①” in Figure 12.2.1-2)	20.April	Day time	54	55 （Day time） 45（Night time）	55 （Day time） 45（Night time）
		Night time	**51**		
	16.May	Day time	52		
		Night time	**48**		
	14.Aug	Day time	48		
		Night time	**49**		
South-residential area (“②” in Figure 12.2.1-2)	20.April	Day time	54		
		Night time	**50**		
	16.May	Day time	53		
		Night time	**51**		
	14.Aug	Day time	**61**		
		Night time	45		

(Source: Navoi Thermal Power Station Modernization Project Environmental Monitoring Report Quarter III, 2018)

12.2.4 Natural Environment

(1) Geography and Geology

Navoi-old is located 6 km to the north-west from Navoi city and height above sea level is 334.2 m. The height of the terrace ledge above the low-water horizon in the river is 6–7 m. Navoi old is located on the third right bank above flood-plain terrace of the Zeravshan river This is a flat plain with a slight bias towards the river. (Final EIA report of GTCC3 and 4, p.5, 39).

(2) Geology

Within the area from the surface, a stratum of quaternary deposits is developed, underlain everywhere by continental tertiary deposits — a layer of interbedded sand, argillite clay, sandstones, and conglomerates. More ancient Paleozoic and Cretaceous rocks spread far beyond the industrial site.

Quaternary deposits of the Golodnostep complex are represented by alluvial-proluvial loams and sandy-brownish sandy loams, moist, dense, plastic, macro porous, imbedding as a layer with a thickness of 5-6 to 10 m and more, which decreases with distance from the river. Sandy cobbles with gravel and clay filler, with interlayers and lenses of sand, rotted rock and less often conglomerates, lie below. Pebbles are small, mostly flat, from shale, sandstone, limestone, etc. The gravel-pebble layer reaches 20-25 m and more.

The layer of the project area consists of quaternary deposit of alluvial clayey loam and sandy loam, 5m to 10m thick. A gravel layer of 20 to 25m thick lies underneath (Final EIA report of GTCC3 and 4 p.39).

According to the hearing survey from the power plant official, the existing power plant has never experienced any large-scale earthquakes or damages caused by earthquakes before.

According to the database of United States Geological Survey, seven earthquakes have occurred within the 100 km radius of the Navoi-old since 1973 (Table 12.2.4-1). All of these earthquakes were below the magnitude of 5. Therefore, earthquakes that have potential to give significant impact to the power plant are not expected to occur.

Table 12.2.4-1Record of Earthquakes in Navoi Region

Date	focal depth (km)	Magnitude	Distance from power plant (km)
8th, May, 1977	33	4.5	34
7th, Jun, 1979	33	4.3	37
29th, Mar, 1980	37	4.2	85
26th, Apr, 1980	33	4.2	88
3rd, Apr, 1984	33	4.7	68
18th, Jan, 1998	33	3.8	84
3rd, Jun, 2007	10	4.0	71

(Source: JICA GTCC2 Report)

(3) Meteorology

The meteorology of Navoi City measured by Uzgidromet in 2018is described below.

1) Air Temperature

The average annual temperature is plus 15.9 °C. The average monthly temperature of the coldest month (January) is plus 3.0 °C, the average temperature of the hottest month (July) is 30.9 °C.

The average minimum temperature for a year is plus 9.2 °C, the average maximum temperature is 22.8 °C.

The maximum temperature for a year is plus 40.0 °C, the minimum is - 13.4 °C. (Final EIA report of GTCC3 and 4, p. 6-7).

2) Precipitation and Humidity

Precipitation in Navoi falls all year round, the average annual precipitation is 180.54 mm.

Monthly maximum precipitation occurs in February, the minimum falls in July.

Fogs are very rare, 10 hours a year. Most often fogs are observed in the winter months, the average frequency of fogs does not exceed 0.5 %.

The average monthly relative humidity during a year varies from 41 to 82 %. The maximum values are observed in the winter months, the minimum - in June-July. (Final EIA report of GTCC3 and 4, p.8-9).

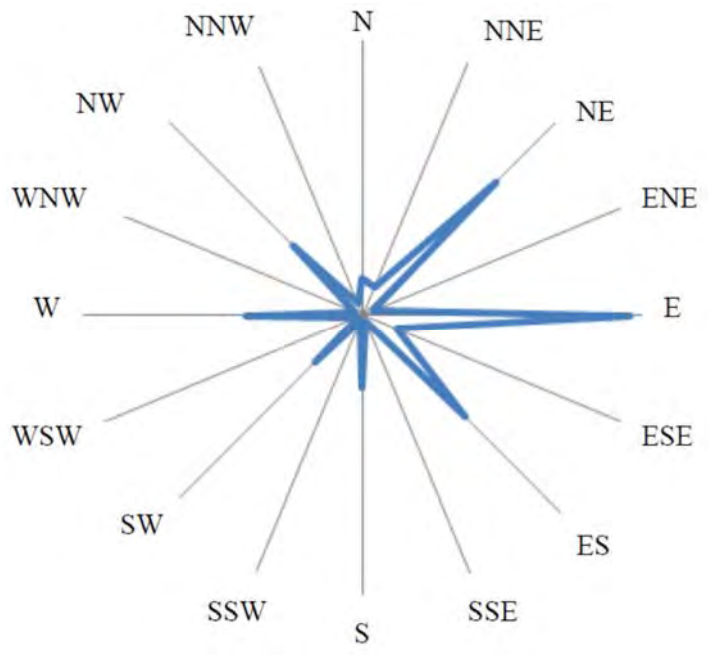
3) Wind Direction/Speed

During a year, eastern (23.9 %) and northeastern (16.8 %) winds are characteristic for the area under consideration.

In the study area, the average wind speeds during a year vary from 2.7 to 5.1 m/s. Their highest values fall on July, the smallest - on September, November, December. The average annual wind speed is 3.6 m/s, the maximum is 30 m/s.

The city of Navoi, in general, is characterized by small values of average monthly wind speeds. The recurrence of winds at a speed of 0-1 m/s is 41.8 %, which contributes to the accumulation of pollutants in the surface layer of the atmosphere.

Winds with a slightly higher speed (2–3 m/s, 27 %), serving as a cleansing factor, are most frequent from March to July. Strong winds (8–9 and 10–13 m/s) are quite rare (4.6 and 4.96 % frequency, respectively). Squally winds with speeds of 14-15 m/s (1.16 %), 16-17 m/s (0.6 %) and 18-20 m/s (0.16 %) are even less frequent. (Final EIA report of GTCC3 and 4, p.9).



(Source: Final EIA report of GTCC3 and 4, p.10)

Figure 12.2.4-1Wind Rose

(4) Hydrology

Navoi-old is located on the bank of the Zeravshan river. Its waters are used entirely for national economic needs.

The Zeravshan river basin extends in the latitudinal direction from east to west and has a length of 750 km.

When entering the Zeravshan valley, the branches again merge into one canal, 60 km downstream from the confluence of the branches, the water intake of the Navoi-old is located.
The Zeravshan River is fed by glaciers and snow. It is formed by the confluence of the rivers Matchi and Fandarya.
The waters of the Zeravshan River are used entirely to irrigate the land of Tajikistan, the and Samarkand and Bukhara regions of Uzbekistan.

The flow of the Zeravshan River is largely regulated by the Katta-Kurgan Reservoir, built in 1947, with a capacity of 500 million m^3.
Four irrigation canals take water from the Zeravshan river in the section from Zaatdin to Navoi: Kanimekh, Kalkon-Ata, Kasoba and Khanym with a maximum total withdrawal of up to 56 m^3/h.

The residual flow of the river of Zaravshan is used to fill the Kuymazar reservoir located below the thermal power plant. In its lower reaches the Zeravshan river belongs to low rivers. Throughout the length of the river to the city of Navoi, an intensive water intake takes place.

The river flow depends on the season. Low flow (minimum flow) occurs from October to May. In June and July there is a flood, and in August-September there is a slow decline in the water level.

There is a tendency to a decrease in the value of the minimum flow, which is associated with increased water intake for agricultural needs during the low-flow periods. (Final EIA report of GTCC3 and 4, p.37).

12.2.5 Protected Areas

No protected areas are located around Navoi-old. The nearest protected area is Kyzylkum State Reserve (Bukhara, designated in 1971) 185 km southwest of the power plant, and Zeravshan State Reserve (Samarkand, designated in 1975) 405 km northwest of the site.
(Source: JICA GTCC2 Report)

12.2.6 Biology

(1) Terrestrial Vegetation

Vegetative cover in Navoi-old is presented as ephemeroid-wormwood (*Artemisia*) communities and agricultural plantations. Glasswort (*Salicornia europaea*), Bluegrass (*Poa pratensis*), awn, one-year astragals (*Astragalus*), foxtail (*Setaria*), and iris (*Iris*) are observed.

Salt marsh and meadow with tamarisk (*Tamarix tenuissima*) and Alhagi genus are recorded in lowland (Final EIA report of GTCC3 and 4 p.48).

As vegetation of trees, there are mulberry (*Morus alba*), poplar (*Populus*)、Siberian elm(*Ulmus pumila*), Bollé poplar and Canadian poplar, oleaster (*Elaeagnus angustifolia* L.), box-elder (Acer negundo) and white willow from Pennsylvanian ash (*genus Fraxinus)*, sycamore tree (*Quercus robur*)., English oak (*Quercus*), and stone fruit trees such as peaches, cherry, apricot are planted (Final EIA report of GTCC3 and 4 p.38).

A total of 78 fruit trees and trees will be removed before with the construction. 17 poplars, 22 juniper, 33 apricots, and 6 willows are included, which were all artificially planted (Final EIA report of GTCC3 and 4, p.48).

JSC Navoi TPP/JSC TPP is planning to plant trees in the site as much as possible.

Around of the transmission line route, Chinara (sycamore), elm, white mulberry, poplar, maple, willow, ash, oak and fruit trees - peaches, cherries, apricots, apples. In addition, there is an artificial planting of grapes, roses and other decorative flowers. From the grass - ephemeroid-wormwood species, as well as weeds - adraspan and cousins.

(Source: JICA Survey Team)

Any endangered and threatened species designated by International Union for Conservation of Nature and Natural Resources (hereinafter called “IUCN”) and by the Uzbekistan Red Data Book are not observed.

(2) Terrestrial Animals

Around the Navoi-old, as reptiles, desert lidless skink (*Ablepharus deserti*), rapid french-toed lizard (*Uma*), water snake (*Homalopsidae*), Central Asian tortoise (*Agrionemys horsfieldii*) are observed.

As birds, tree sparrow (Tree sparrow), laughing dove (*Spilopelia senegalensis*), common starling (*Sturnus vulgaris*), barn swallow (*Hirundo rustica*), common swallow (*Hirundo rustica*), red-rumped swallow (*Cecropis daurica*), black swift (*Apus pacificus*), my-lady’s-belt, magpie (*Pica pica*), mynah (*Gracula sp.*), as amphibians, ground toads (*Bufo*), frogs (*Salientia*), as mammals, mouse, mole

lemming, common pipistrelle (*Pipistrellus pipistrellus*), tamarisk gerbil (*Meriones tamariscinus*), are observed (Final EIA report of GTCC3 and 4 p.50).

Around of the transmission line route, as reptile, desert gologlaz, Central Asia tortoise are observed. As birds, field sparrow, little turtle dove, common starling, orc swallow, with black, Swift, Maina, forty are observed.

As amphibians, toads and frogs are settled and as mammals, domestic mouse, hare, dwarf bat, gerbil, an eared hedgehog and a small shrew are observed.

(Source: JICA Survey Team)

Any endangered and threatened species designated by IUCN and by the Uzbekistan Red Data Book are not observed.

(3) Aquatic Organisms

Table 12.2.6-1 shows the list of aquatic organisms observed in Zeravshan River and the water reservoir in the basin.

30 species from 7 families of aquatic organisms are observed in Zeravshan River, of which *Cyprinidae* family is the largest with 19 species. Most of the aquatic organisms in Zeravshan River are local species. There are several non-native species, such as *Rhinogobius* sp., Balkhash perch (*Perca schrenki*), Spotty gubach, Korean and common sawbelly (*Hemicuter leucisculus*) (Final EIA report of GTCC3 and 4 p.50-51).

Comparing fish species observed in Zeravshan River with IUCN List (February 2012), 4 species are categorized as Least Concern (LC): *Leuciscus leuciscus*, *Aspius aspius*, *Silurus glanis*, and *Stizostedion lucioperca*.

Table 12.2.6-1 List of Aquatic Organisms in Zeravshan River and Reservoir or Other Water Body in the River Shed

Species	Zeravshan r.	Water reservoirs						Lakes			Amu-Bukharskij Channel
		Akdarinskoe	Karaultepnnskoe	Kattakurganskoe	Kuyumazarskoe	Tudakulskoe	Shorkulskoe	Tuzgan (Solenoe)	Dengizkul	Karakyl	
Acipenseridae											
Spine	-	-	-	-	+	+	-	+	+	-	+
Pseudoscaphirhynchus kaufinanii	-	-	-	-	+	+	+	+	+	+	+
Cyprinidae											
Rutilus rutilus aralensis	+	-	-	-	+	+	+	+	+	+	+
Zarafshan dace (*Leuciscus leuciscus*)	+	+	-	-	-	-	-	-	-	-	-

Species	Zeravshan r.	Water reservoirs						Lakes			Amu-Bukharskij Channel
		Akdarinskoe	Karaultepnnskoe	Kattakurganskoe	Kuyumazarskoe	Tudakulskoe	Shorkulskoe	Tuzgan (Solenoe)	Dengizkul	Karakyl	
Ctenopharyngodon idella	+	-	-	+	+	+	+	+	+	-	+
Aspius aspius taenatus nidiliodes	+	-	-	-	+	+	+	+	+	-	+
Ston morocos (Pseudorasbora)	+	+	+	+	+	+	+	+	+	-	-
Pseudogobio rivularis	+	+	-	+	-	-	-	-	-	-	-
Gudgeon	+	-	-	-	-	-	-	-	-	-	-
Khramulya (Varicorhinus)	+	+	+	-	-	-	-	-	-	+	-
Barbus capito conocephalus	+	+	-	+	+	+	+	+	+	+	+
Barbus brachycephalus	-	-	-	-	+	+	-	+	+	-	+
Schizothorax intermedius	+	+	+	-	-	-	-	-	-	-	-
Chaicalburnus chalcoides aralensis	-	-	-	+	+	+	+	+	+	+	-
Alburnoides bipunctatus	+	+	+	-	-	-	-	-	-	+	-
Alburnoides taeniatus	+	+	+	-	-	-	-	-	-	+	-
Abramus brama orientalis	+	-	-	-	+	+	+	+	+	+	-
Abramis sapa	+	-	-	-	+	+	-	+	-	-	-
Capoetobrama kuschakewitschi	+	-	-	-	-	-	-	-	-	-	+
Hemicuter leucisculus	+	-	+	+	+	+	+	+	+	-	-
Iculter lucidus	+	-	+	+	+	+	+	+	+	-	-
Pelecus cultratus	-	-	-	-	+	+	-	+	+	-	+
Carassius auratus gibelio	+	+	+	+	+	+	+	+	+	+	-
Carpio	+	+	+	+	+	+	+	+	+	+	-
Hypophthalmichthys molitrix	-	+	-	+	+	+	+	+	+	-	+
Hypophthalmichthys nodilis	-	-	-	+	+	+	+	+	+	-	+
Cobitidae											
Noemacheilus strauch	+	+	-	-	-	-	-	-	-	-	-
Noemacheilus pardalis	+	-	-	-	-	-	-	-	-	-	-
Noemacheilus oxianus	+	-	-	-	+	+	-	+	+	-	+
Noemacheilus amudarjensis	+	-	-	-	-	-	-	-	-	-	+
Noemacheilus sp.	+	-	-	-	-	-	-	-	-	-	-
Barbus brachycephalus	+	-	-	-	+	-	-	-	-	-	+
Siluridae											
Silurus glanis	+	+	-	+	+	+	+	+	+	+	+
Poecelidae											
Gambusia affinis holbrockii	+	+	-	+	+	+	+	+	+	+	+
Channidae											
Channa argus warpa chowskii	+	+	-	-	-	+	+	+	+	+	+
Percidea											
Stizostedion lucioperca	+	-	-	-	+	+	+	+	+	-	-
Perca schrenki	-	-	-	+	-	-	-	-	-	-	-
Gobiidae											
Rhinogobius sp.	+	-	-	-	+	+	-	+	+	-	-

Species	Zeravshan r.	Water reservoirs						Lakes			Amu-Bukharskij Channel
		Akdarinskoe	Karaultepnnskoe	Kattakurganskoe	Kuyumazarskoe	Tudakulskoe	Shorkulskoe	Tuzgan (Solenoe)	Dengizkul	Karakyl	
Total - Presence	30	15	9	14	24	24	17	24	23	12	15

Note: + presence, - absence
Reference: The document obtained at the survey

12.2.7 Social Environment

(1) Land Use

The boundaries of the Navoi-old are located 6 km to the north-west from Navoi city and the height above sea level is 334.2 m. The station occupies an area of 100 ha.:
The boundaries of the station are:

- from the north: agricultural land and garden plots;
- from the south: the integrated energy service of the Navoi MMC and Tashkent - Bukhara highway;
- from the east: “Michurin” village, the Zeravshan river and Navoi – Uchkuduk highway;
- from the west: agricultural land.

The land plot for GTCC3 is planned on the eastern side of the territory of the Thermal Power Station, on lands not used in agriculture, at the present time, fallow and free from buildings and wood vegetation.
The boundaries of the construction site are: the territory of Navoi-old from the west, Zeravshan River from the east, abandoned weekend cottages from the north, and the auxiliary facilities of the Thermal Power Station from the south (Final EIA report of GTCC3 and 4 p. 5).

Distance to residential buildings located in the south–east from the territory of the construction site of the GTCC3 is 400 m “Michurin” village.
Distance from the nearest residential buildings to the stack of GTCC3 amounts to 550m that conforms to requirements of SanPiN No. 0350-17 of Uzbekistan (final EIA report of GTCC3 and 4 p.5).

The transmission line area is located in the western part of the Zeravshan Valley, which is a piedmont plain, rising from west to east with a slight slope towards the Zeravshan River. From the west, the project site is bounded by sandy areas of the southeastern Kyzylkum, from the north by the spurs of

the Nurata range, from the east and south by the spurs of the Turkestan and Zeravshan ranges, and from the south, the Karnabkul and Karshinsky steppes.

The transmission line will start from GTCC3 and will run across the Navbahor district of the Navoi region of the Republic of Uzbekistan to the external 220/500 kV substation. The transmission line route will cross several ditches, collectors, canals, the Zeravshan River, grazing land in the banks of Zeravshan River, field, gravel, asphalt roads, including the A379 Highway, and agricultural land. Basically, the route follows cultivated land for cotton and wheat cultivation.

From the power station, the route goes eastward, crosses the dacha plots, the road in the area of corner No.1, turns to the northwest, then again crosses the dacha plots, pastures in the Zeravshan River banks, the Zeravshan River, again follows the pasture lands. Then it crosses the road, pasture land, a water canal extending from the Zeravshan River, and further to corner No.2, follows wheat cultivation land. From the corner No.2, the route turns west and passes through wheat and cotton cultivation lands, crosses the water canal, field roads and the edge of an orchard with apple trees (110 m). In the area of corner No. 3, the highway turns north and, on the way to corner No. 4, crosses the cotton field, the A379 Navoi-Uchkuduk highway, two water canals, and four gravel roads. By the corners No.4 to No.7, the route goes around the east part of Urgench village, following the cotton and wheat cultivation lands, crossing eight field roads. Further, the route passes in the northeast direction along cotton plantings up to the corner No.8, from which it turns to the east and goes through agricultural fields to the substation.

The nearest residential development is Urgench village, 120 m from the corner No. 7. This distance meets the regulatory requirements for establishing safety distance for newly designed transmission lines in accordance with “Sanitary standards and rules for the protection of atmospheric air in populated areas of the Republic of Uzbekistan”.

As with the implementation of the project, demolition of residential buildings is not expected.

Tree plantings in the form of poplars, mulberry trees and fruit trees are found in the grazing land, along canals, collectors and ditches crossed by the projected route. The project considers maximum preservation of trees. In order to reduce additional logging, trees before construction and during operation of the transmission line are supposed to be pruned to the permissible height indicated in the project plan.

The substation will be built about 2km north from GTCC3 and 4. The boundaries of the construction site on all sides are agricultural land of wheat and cotton with a total area of 25 hectares.

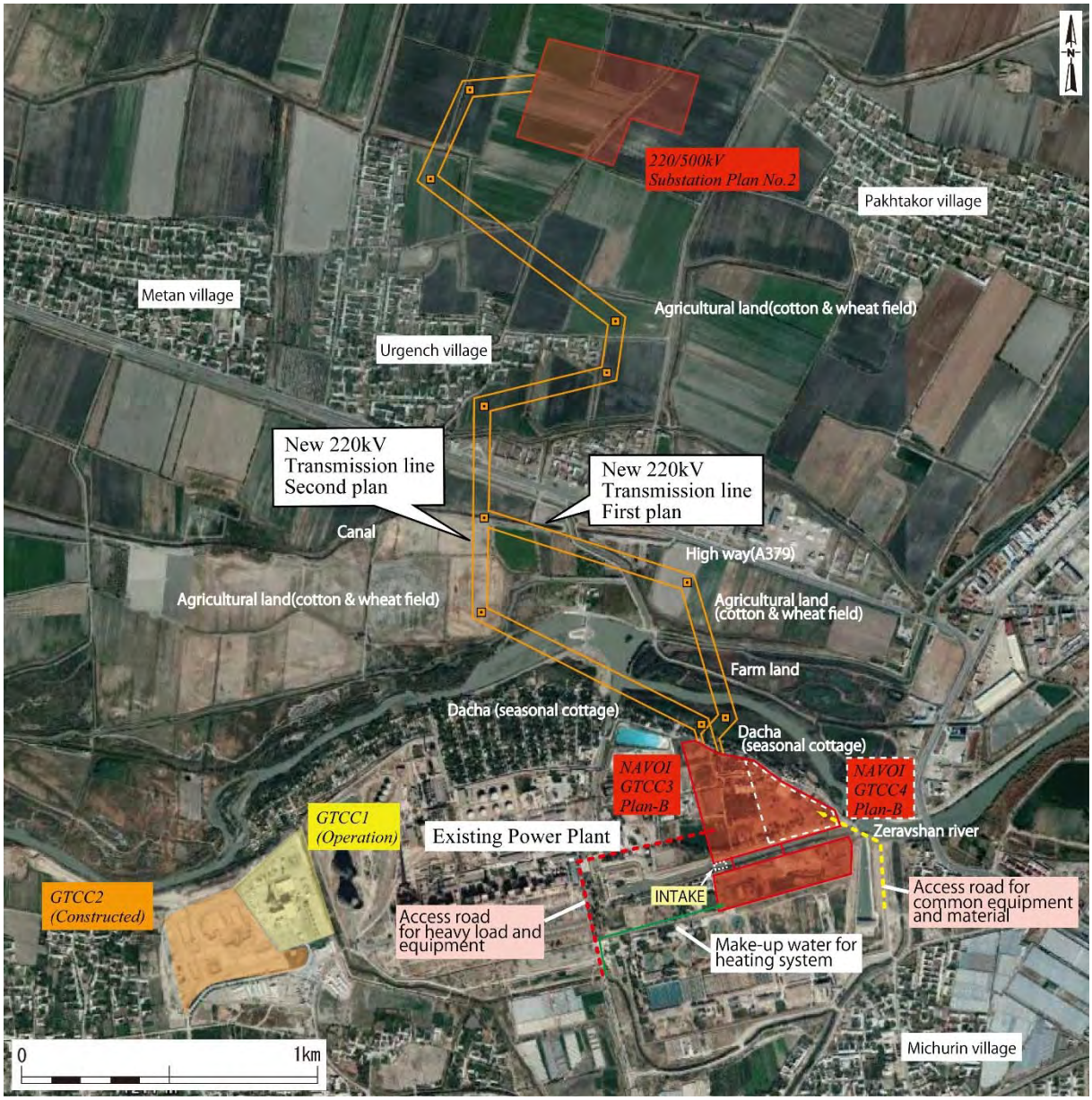
The closest residential development is Urgench settlement, 330m southwest of the substation. This distance meets the regulatory requirements for the establishment of sanitary - protective gaps for

newly designed transmission lines according to "Sanitary standards and rules for the protection of atmospheric air in populated areas of the Republic of Uzbekistan”

Other residential developments are Pakhtakor village, located to 490m to the east, and Metan village, located to the south-west, is 810 m.

As with the implementation of the project, demolition of residential buildings is not expected.

There are no tree plantations and surface watercourses in the construction site area.



(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.2.7-1 Land Use in the Surrounding Area of GTCC3 and Related Facilities

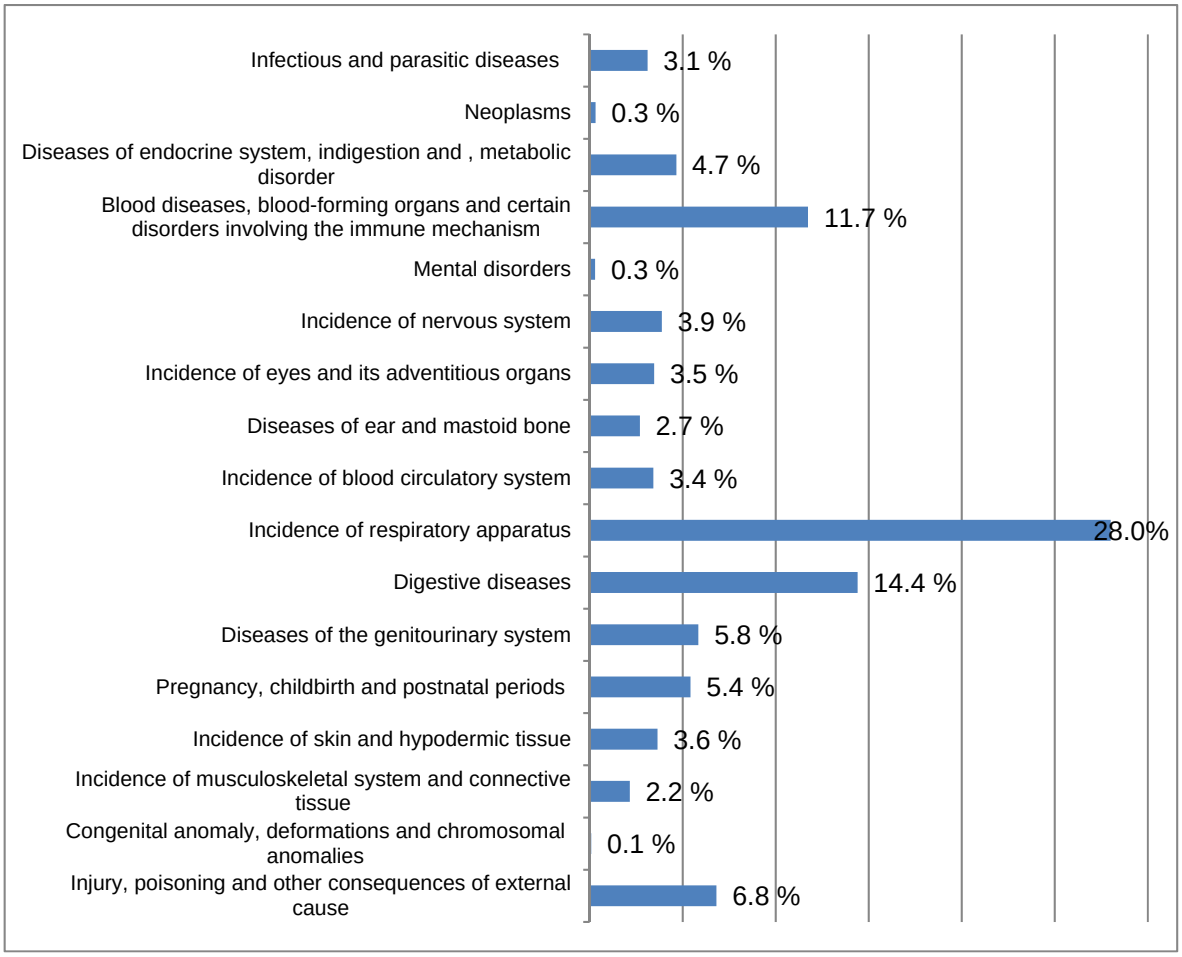
(2) Public Health

There is a decrease of number of diseases for the period of 2012-2015 by -7.6 thousand cases per 100 000 population. The largest share of diseases of the population in Navoi region falls on incidence of respiratory apparatus (28%), digestive diseases (14.4%) and blood diseases, blood-forming organs and certain disorders involving the immune mechanism (11.7%).

Table 12.2.7-1 Number of Diseases of Navoi Region between 2012 and 2017

	2012	2013	2014	2015	2016	2017
Total number of diseases per 100,000 population (people)	62086.7	58063.3	59749.9	57237.3	55693.9	54485.9

(Source: State committee on statistics of the Republic of Uzbekistan)



(Source: State committee on statistics of the Republic of Uzbekistan)

Figure 12.2.7-2 Sickness Rate of Population of Navoi Region in 2017

Number of hospitals in the region in 2017 amounts at 29 units that is 3% of total number of hospitals of Uzbekistan. Number of outpatient-and-polyclinic institution makes up 5 % of total polyclinics of

Uzbekistan. In Navoi region, 239 patients fall on a doctor; 72 patients fall on paramedical personnel respectively. 239 patients fall on one hospital bed.

Table 12.2.7-2 Health Development of Navoi Region between 2012 and 2017

Indicator	2012	2013	2014	2015	2016	2017
Number of hospitals, units	37	29	29	29	28	29
Number of hospital beds:						
Total, thousand units.	3,9	3,8	3,7	4	4	4
Per 10 000 population	44,2	45,5	41	42,9	42.5	41.9
Number of people on one hospital bed	226	236	244	233	236	239
Number of outpatient-and-polyclinic institution, units	280	291	279	291	299	246
Number of doctors						
Total, thousand people	2,5	2,5	2,5	2,6	2,7	2.7
Per 10 000 population	28,6	27,7	27,6	28,1	28.3	28.4
Number of people on a doctor	349	361	363	356	353	239
Number of people on one paramedical personnel	75	76	75	74	72	72

(Source: State committee on statistics of the Republic of Uzbekistan)

(3) Population and Demography

3% of total population of Uzbekistan falls on Navoi region, namely 958.0 thousand people. Population in Navoi region has increased by +1. 4 % per year (+12.8 thousand people) for the period of 2012-2018. The share of male population amounts at 51.2 %, female population – 48.8 % of total population of the region respectively. The population in Navoi region is mostly concentrated in rural area. The share of rural and urban population is 51.2 % and 48.8%, respectively in 2018. The density of the population in the region in 2018 amount at 8.6 persons per km^2.

These data between 2012 and 2018 is shown in Table 12.2.7-3.

Table 12.2.7-3 Demographic Characteristics of Navoi Region between 2012 and 2018

(thousand people)

Indicators	2012	2013	2014	2015	2016	2017	2018
Population	881.2	888.4	901.1	913.2	927.9	942.8	958.0
Including:							
Male	434.8	438.2	444.0	450.0	470.6	478.2	485.5
Female	446.4	450.2	457.1	463.2	457.3	464.6	472.5
Urban	429.0	445.2	448.2	448.5	455.7	460.9	467.6
Rural	452.2	443.2	452.9	464.7	472.2	481.9	490.4
Density of population, persons per 1 km2	7.9	8.0	8.1	8.2	8.4	8.5	8.6

(Source: State committee on statistics of the Republic of Uzbekistan)

According to the data available for 2018, the largest concentration of population is in the capital of the region, Navoi city (14.2 %). Among the project districts, there are 12.9 % in Karmana district and 11.3 % - in Navbakhor district as shown in Table 12.2.7-4.

Table 12.2.7-4 Population by District in Navoi Region at the Beginning of 2018

(thousand people)

Area	Population	%	Urban population	Rural population
Navoi region	958	100 %	467,6	490,4
Khatyrchi District	191,7	20,0 %	43,9	147,8
Kyzyltepa District	146,8	15,3 %	47,3	99,5
Navoi city	135,6	14,2 %	135,6	-
Karmana District	**123,4**	**12,9 %**	**43,3**	**80,1**
Navbakhor District	**108,6**	**11,3 %**	**15,8**	**92,8**
Nurata District	89,5	9,3 %	53,3	36,2
Zeravshan city	81,4	8,5 %	81,4	-
Uchkuduk District	37	3,9 %	31,9	5,1
Kanimekh District	29,7	3,1 %	10,5	19,2
Tamdy District	14,3	1,5 %	4,6	9,7

(Source: State committee on statistics of the Republic of Uzbekistan)

The birth rate in 2017 was 21.6 per mille. It decreased by -0.7 per mille in comparison with the birth rate in 2016 (22.3 per mille). Decrease of the birth rate is caused by the governmental policy to decline in the birth rate and improve health of mother and child.

The death rate amounted at 4.7 per mille in 2017. The average annual growth of death rate is +1.6% per year (+68 people). Number of born people is more than the number of dead people in the region by 4.6 times.

The average natural growth of the population, including the migration impacts for the period of 2012-2017, amounts at +19.4% per year. (+1.6 thousand people).

Table 12.2.7-5 Vital Statistics of Navoi Region between 2012 and 2017

Indicators	Unit	2012	2013	2014	2015	2016	2017
Birth rate per 1000 people	Per mille	20.4	21.6	25.8	26.2	22.3	21.6
Number of born people	People	18 067	19 300	20 116	20 259	20 837	20 573
Mortality rate per 1000 people	Per mille	4.7	4.6	4.6	4	4.7	4.7
Number of dead people	People	4 153	4 103	4 188	4 110	4 401	4 495
Natural increase rate per 1000 people	Per mille	15.7	17.0	17.6	17.5	16.4	16.9
Maternal mortality*	People	3	8	4	5	5	6
Infant mortality rate (number of children died before the age of 1 year, per 1000 births)	People	7.6	7.4	9.2	9.8	8.9	9.6
Total growth of population	People	7 189.0	12 714.0	12 083.0	14 666.0	14 881.0	15 251.0

* Number of dead women due to complications of pregnancy, childbirth and the puerperal period
Source: State committee on statistics of the Republic of Uzbekistan

The migration balance is negative. The departed population is higher than arrived population for labor migration. The data is shown in Table 12.2.7-6.

Table 12.2.7-6 Statics on Migration of Navoi Region between 2012 and 2017

(People)

Indicators	2012	2013	2014	2015	2016	2017
Arrived	12 134	12 321	13 001	11 752	12 104	13 047
Departed	18 859	14 804	16 846	13 235	13 659	13 887
Migration balance	-6 725	-2 483	-3845	-1483	-1555	-840
Number of immigrants	408	189	193	147	128	107
Number of emigrants	9 343	5 459	5 446	2 832	2312	2320
Migration balance	-8 935	-5 270	-5 253	-2 685	-2184	-2213

(Source: State committee on statistics of the Republic of Uzbekistan)

In 2017 share of labor resources makes up 58.0 % of total population of the region. 81.4 % of labor recourses are economically active population in the region; 18.6 % of labor resources are economically inactive respectively.

In 2017, 94.8 % of economically active population are employed. The unemployment rate makes up 5.2%. The average annual growth rate of unemployment for the period of 2012-2017 is +1.4 % per year (0.3 thousand people). For the whole studied period the number of employed population annually has grown, on average, by +0.2 % that is +0.9 thousand people.

Table 12.2.7-7 Statics on Migration of Navoi Region between 2012 and 2017

(Thousand people)

Indicators	2012	2013	2014	2015	2016	2017
Labor resources	544.1	546.8	543.1	540.3	543.5	547.2
Economically active population	440	442.4	443.7	443.6	444.2	445.7
Employed population	418.5	419.6	420.6	421.2	421.8	422.4
Unemployed population	21.5	22.8	23.1	22.4	22.4	23.3
Economically inactive population	104.1	104.4	99.4	96.7	99.3	101.5

(Source: State committee on statistics of the Republic of Uzbekistan)

(4) Education

As shown in Table 12.2.7-8, in Navoi region, there are 356 schools in 2017. On average, 434 pupils fall on one school (2017). Total number of specialized secondary educational establishments in the region amounts at 51 units. 598 students fall on one specialized education establishment. Number of

higher educational institutes in the region amounts at 2 units that servicing 10.0 thousand students. On average, there are 5.0 thousand students studying in one institute.

Table 12.2.7-8 Educational Institution of Navoi Region between 2012 and 2017

Indicator	Unit	2012	2013	2014	2015	2016	2017
Number of comprehensive secondary schools	units	360	356	355	355	354	356
Number of colleges	units	47	47	47	47	47	46
Number of academic lyceums	units	4	4	4	4	4	5
Number of institutions of higher education	units	2	2	2	2	2	2
Number of pupils at comprehensive secondary school	Thousand people	126.8	128.1	131.6	135.7	140.2	154.8
Number of students at colleges	Thousand people	49.6	44	40.2	37	35.9	27.8
Number of students at academic lyceums	Thousand people	3.5	3.5	3.4	3.2	3.1	2.7
Number of students at institution of higher education	Thousand people	8.4	8.1	8.5	8.4	8.8	10.0

(Source: State committee on statistics of the Republic of Uzbekistan)

(5) Economy

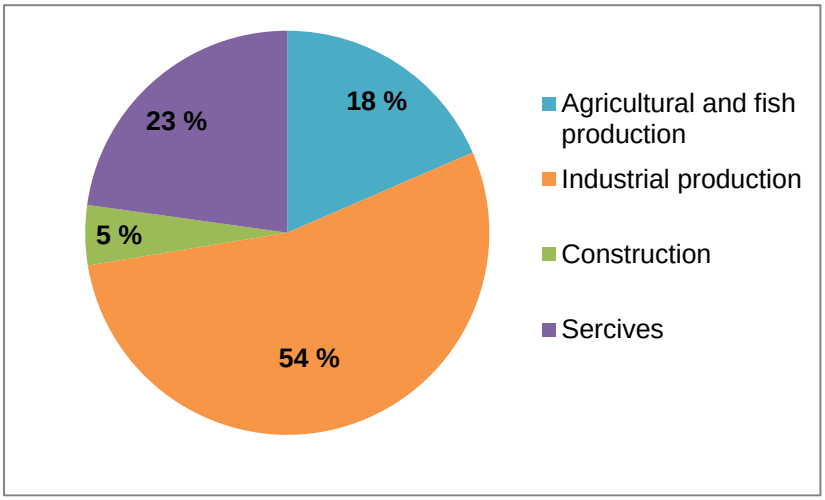
6% of GDP of Uzbekistan falls on Navoi region. The average growth rate of gross regional product of Navoi region makes up + 1342.8 billion UZS per year. The GRP of the region for the last 6 years has increased by 2.2 times.

Table 12.2.7-9 Gross Regional Product for 2012-2018 in Navoi Region

Indicators	Unit	2012	2013	2014	2015	2016	2017	January – September 2018
Gross regional product	Billion UZS	5603.5	6438.1	8376.6	8981.4	10542.0	12317.4	13270.8
Gross regional product per capita	Thousand UZS	6333.0	7756.3	8349.9	9754.9	11271.0	12961.6	13620.9

(Source: State committee on statistics of the Republic of Uzbekistan)

The largest share of GRP falls on industrial sector - 53.9 %, especially production of nonferrous metallurgy industry. 22.8 % of GRP falls on production of servicing sector; agricultural and fish products make up 18.5 % of GRP. Construction sectors amounts at 4.8% respectively.



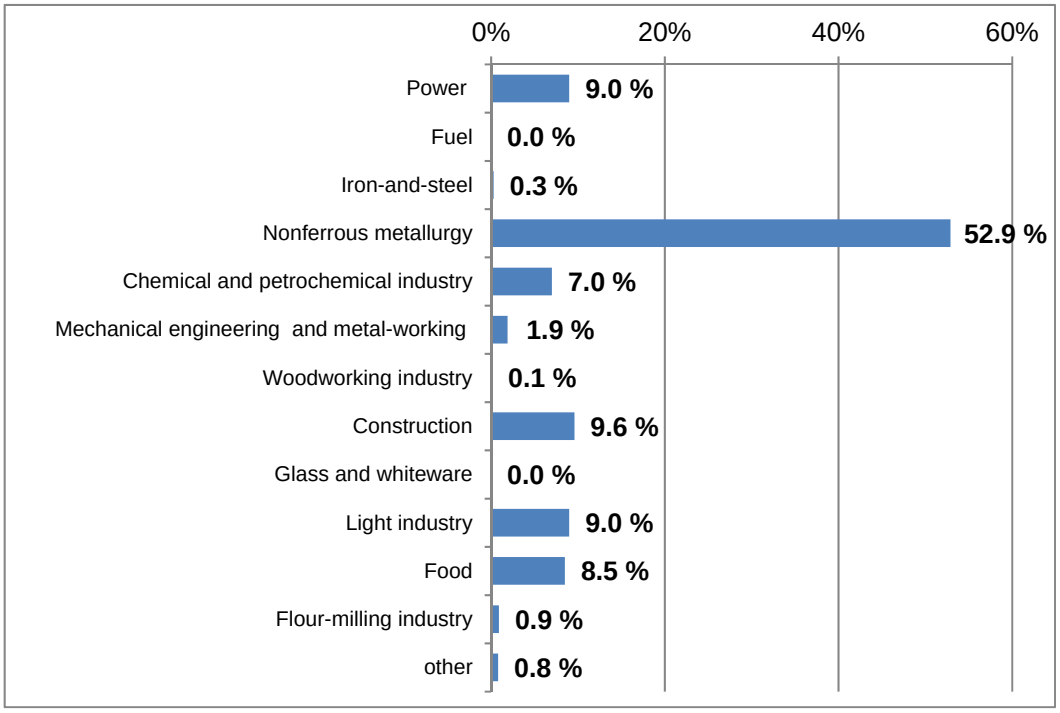
(Source: State committee on statistics of the Republic of Uzbekistan)

Figure 12.2.7-3 Structure of Gross Regional Product in Navoi Region in 2017

(6) Industry

Navoi region is one of the largest industrial centers of the country. In 2008, Free Industrial Economic Zone (hereinafter called “FIEZ”) Navoi was established on the territory of the region. The term of its operation is 30 years, with the possibility of subsequent extension. FIEZ Navoi is located in the territory of Navoi region, on the land plot of the Karmana district. FIEZ Navoi is an industrial center of regional and international importance, which provides business opportunities for international producers. The main goal of creation of FIEZ Navoi is attraction of foreign investments and manufacture of products capable to compete in the world market.

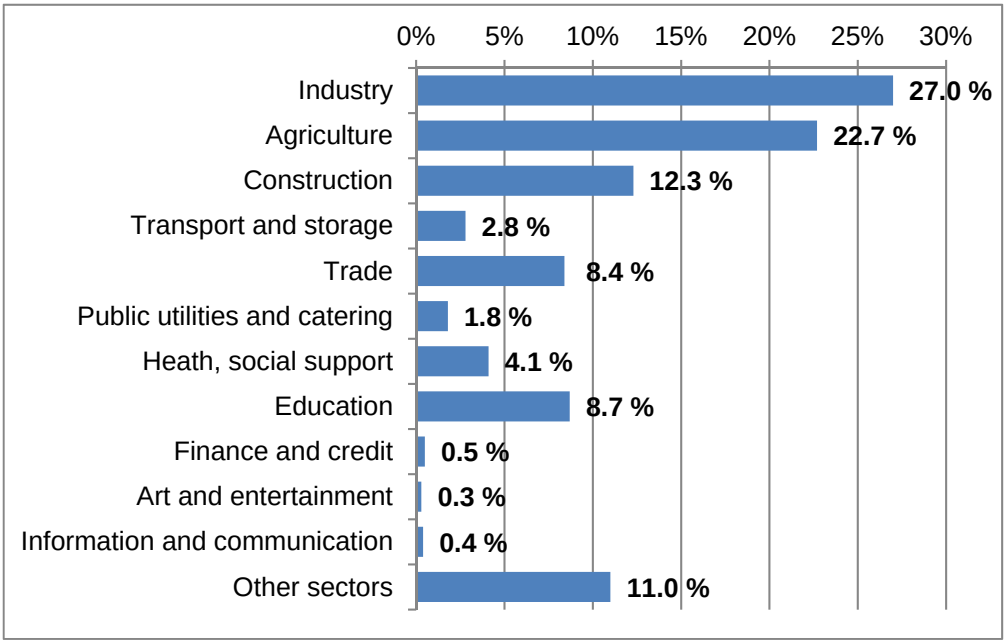
Mining metallurgical combine, machine-building plant, gold extracting, electromechanical, cement, chemical plant, food industry enterprises and power station operate in the region.



(Source: State committee on statistics of the Republic of Uzbekistan)

Figure 12.2.7-4 Structure of Industrial Production in Navoi Region in 2017

The largest share of the people in Navoi region is employed in industrial sector (27.0 %), agricultural sector (22.7 %), and construction (12.3 %) as shown in Figure 12.2.7-5.



(Source: State committee on statistics of the Republic of Uzbekistan)

Figure 12.2.7-5 Number of People Employed in Various Sectors of Economy in Navoi Region in 2017

The main branches of agriculture in Navoi region are karakul, a famous species of sheep in Central Aia, and cotton growing. The region is the leading region in the country in the desert livestock. Large specialized karakul farms were established in the Kyzyl Kum desert. Effective measure is being implemented to provide pastures with water as well as phyto-meliorative measures to increase their productivity.

The northern part of the region is suitable only for grazing livestock. All the year round, karakul sheep are grazing there. Foothills in the southeastern part of the region are also suitable for sheep breeding. The Zeravshan valley and the southern part of the region, which are fed from the Amu Darya, are used for irrigated agriculture.

6 % of agricultural production of Uzbekistan falls on Navoi region. The agricultural production for the period of 2012-2017 has increased by 2.9 times that is +2521.5 billion UZS for the period. The average annual growth rate of agricultural production is +25.6 % per year or +504.3 billion UZS.

59.6 % of agricultural production falls on crop farming. 40.4 % are livestock production respectively.

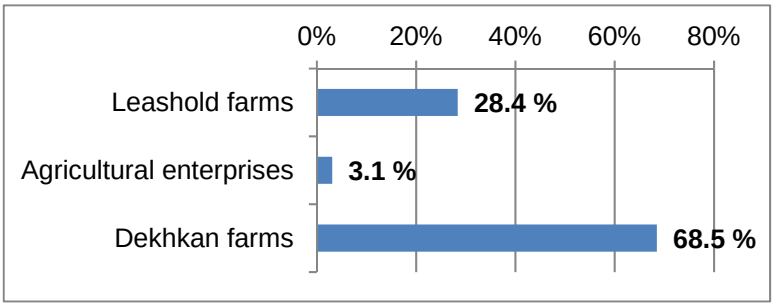
The main crops are grain (wheat) and industrial crops (cotton).

Table 12.2.7-10 Agricultural Development of Navoi Region between 2012 and 2017

Indicator	2012	2013	2014	2015	2016	2017
Production of agricultural and forestry, fishery products (billion UZS)	1332.4	1780.4	2094.2	2081.9	2330.2	3853.9
Including						
Crop farming	647.9	917	1111.5	994.4	1186.6	2295.9
Livestock	684.5	863.4	982.7	1087.5	1143.4	1558
Structure of sowing area of agricultural crops in farms of all categories, %						
Grain crops	50.0 %	49.2 %	49.2 %	50.6 %	50.6 %	51.1 %
Industrial crops	36.3 %	37.1 %	36.8 %	37.1 %	36.2 %	36.0 %
Of these, cotton	36.2 %	35.0 %	34.8 %	34.8 %	34.0 %	35.5 %
Potatoes and Vegetable	6.4 %	6.5 %	6.9 %	6.9 %	7.4 %	7.7 %
Forage crops	7.3 %	7.2 %	7.1 %	5.4 %	5.8 %	5.2 %
Number of livestock, thousand head						
Cattle	355.9	366.4	384.0	417.7	440.9	469.0
Cows	159.2	162.4	170.4	170.8	173.4	187.5
Sheep and goats	1706.8	1731.8	1782.6	1869.0	1834.0	1875.0
Poultry	1505.8	1668.9	1858.1	2028.8	2272.5	2312.7

(Source: State committee on statistics of the Republic of Uzbekistan)

The largest share of agricultural products is produced by dekhkan farmers (private subsidiary farm / homestead land plots) – 68.5 % in 2017. 28.4 % of agricultural products are produced by leasehold farmers. 3.1 % - are produced by agricultural enterprises respectively.



(Source: State committee on statistics of the Republic of Uzbekistan)

Figure 12.2.7-6 Production of Agricultural Product in Navoi Region by Type of Producers in 2017

(7) Income

The incomes of the population in Uzbekistan grow up due to the implementation of state programs directed on improvements in households living conditions, living level standards as well as strong social addressing policy. As the result the incomes and social benefits are increased.

The average income of the population for 2012-2017 has increased by 2.1 times that is +4872.6 thousand UZS for the period. The average growth rate of incomes makes up +964.9 thousand UZS per year that is +16.5 % per year. In 2017 the largest share of income falls on income from labor activity (81.7 %). The income from transfer amounts at 15.3 %. Incomes from services and production for own consumption as well as incomes from property make up 1.9 % and 1.1 % respectively.

Thus, the average income per capita in 2017 is 9036.3 thousand UZS in Navoi region. The average old-aged pension in Uzbekistan is 724.5 thousand UZS.

Table 12.2.7-11 Aggregate Income of Population of Navoi Region between 2012 and 2017

Indicators	Unit	2012	2013	2014	2015	2016	2017
Average income per capita	Thousand UZS	4211.6	5050.1	5794.3	6576.5	7918.6	9036.3
Income from labor activity	%	81.0	80.4	81.3	82.9	84.1	81.7
Income from services and production for own consumption	%	1.6	1.6	1.7	1.8	1.9	1.9
Income from property	%	1.1	1.0	1.1	1.1	1.1	1.1
Income from transfer	%	16.3	17.0	15.9	14.2	12.9	15.3

(Source: State committee on statistics of the Republic of Uzbekistan)

(8) Vulnerable Groups

Information on vulnerable groups describes statistical data only for disabled people. There is no available data on minorities, poor population as well as war veterans.

12 % of population of Navoi region is pensioners and beneficiaries of social benefits, 115.2 thousand people. 2 2 % of people receiving pensions and social benefits are disable people.

Interviews regarding the poor were conducted during the LARAP survey. As a result, there are no poor people in the project site as shown in 12.10.3 (2) 3).

Since project site and surrounding area are located in mountainous area, there are no ethnic minorities.

Table 12.2.7-12 Indicators on Social Vulnerable Groups in Navoi Region between 2012 and 2017

Indicator	2014	2015	2016	2017
Number of people receiving pensions and social benefits (thousand people)	105.5	106.5	110.1	115.2
Per 10 000 population	1155	1148	1168	1202
Number of disable persons who receive pensions and social benefits, (thousand people)	25.7	24.4	24.1	25.4
Per 10 000 population	281.5	263.3	256.0	265.0

(Source: State committee on statistics of the Republic of Uzbekistan)

12.3 Environmental Impact Assessment (EIA) and Other Legal Systems

12.3.1 Environmental Administration and Related Legal Systems

(1) Environmental Administration

1) Administrative Boundary

The following governmental agencies play primary roles regarding the Environmental Administration in the Republic of Uzbekistan.

- ✓ The President:
  Act as a decision maker on major environmental issues and also a leader to promote international cooperation on environmental conservation.
- ✓ The Diet:
  Clarifying the environmental conservation policies, making decision in the Diet, acting as liaison with the State Committee for Nature Protection, establishing sanctuary and disaster area, and developing legal systems.
- ✓ The Cabinet:
  Implementing environmental conservation policy, making decision and supervising operation on environmental conservation plan, and allocating natural resources.

2) Implementing Agencies

Based on the above role-sharing, the actual implementing body mainly managing the environment issue is the State Committee for Nature Protection “Goskomekologiya”. Also as local organization of the State Committee for Nature Protection, the local Committee for Nature Protection exists in each province and major cities.

State and local Committee for Nature Protection implements and manages environmental conservation.

The primary responsibilities held by the State Committee for Nature Protection are as follows.

- ✓ Legal surveillance regarding environmental conservation
- ✓ Promotion on environmental conservation plan
- ✓ Guidance on environmental tests implemented by the state
- ✓ Approval of environmental standards
- ✓ Issue and nullification of license for emission/storage of pollutant and industrial waste
- ✓ Implementation of environmental measurement
- ✓ System for international cooperation on environmental issues

Other than the State Committee for Nature Protection, the environmental management is conducted by Ministry of Health, Ministry of Agricultural Water Utilization under the scope of each jurisdiction respectively. Also, State Land Use Committee, State Forestry Committee, Uzbek Hydro meteorological Institution "Uzgidromet" are in charge of conducting environmental conservation. Monitoring on air /water quality in the general environment is actually measured by Uzbek Hydro Meteorological Institution "Uzgidromet" under State Nature Conservatory Committee.

(2) System of Legal Restriction on the Environment

Laws regarding nature conservation, utilization of natural resources, environmental conservation are composed of act, presidential decree, legislative decree, and enactment.

Followings are the Basic Laws and the established years.

- ✓ The Law of the Republic of Uzbekistan "On Nature Protection" (9 December 1992 ref, 754-XII)
- ✓ The Law of the Republic of Uzbekistan "On Water and Water Use" (6 May 1993, ref. 837-XII)
- ✓ The Law of the Republic of Uzbekistan "On Ambient Air Protection" (27 December 1996, ref. 353-I)
- ✓ The Law of the Republic of Uzbekistan "On Fauna Use and Protection" (26 December 1997, ref. 545-I)
- ✓ The Law of the Republic of Uzbekistan "On Flora Use and Protection" (26 December 1997, ref. 543-I)
- ✓ Land Code of the Republic of Uzbekistan (30 April 1998, ref. 599-I)
- ✓ The Law of the Republic of Uzbekistan "On Forest" (15 April 1999, ref. 770-I)

- ✓ The Law of the Republic of Uzbekistan "On Protection of Population and Areas from Emergency Conditions of Natural and Technogenic Character" (20 August 1999, ref. 824-I)
- ✓ The Law of the Republic of Uzbekistan "On Environmental Audit" (25 May 2000, ref. 73-II)
- ✓ The Law of the Republic of Uzbekistan "On Radiation Safety" (31 August 2000, ref. 120-II)
- ✓ The Law of the Republic of Uzbekistan "On Protection of Agricultural Plants from Pests, Diseases and Agrestals" (31 August 2000, ref. 116-II)
- ✓ The Law of the Republic of Uzbekistan "On Solid Waste Disposal" (5 April 2002, ref. 362-II)
- ✓ The Law of the Republic of Uzbekistan "On Subsoil" (new edition), (13 December 2002, ref. 444-II)
- ✓ The Law of the Republic of Uzbekistan "On Preserved Natural Territories" (3 December 2004, ref. 710-II)

12.3.2 The EIA in Uzbekistan

In Uzbekistan, in the implementation of business activities having potential environmental and human impact such as a power station project, the EIA should be implemented, which applies to this project.

(1) The Procedure for EIA

In Uzbekistan, the EIA should be implemented according to the Law on Nature Preservation (enacted in December 9, 1992).

The specific procedure is regulated by Law on Environmental Audit (2000) as well by the Resolution of the Cabinet of Ministers no.949 about state environmental impact assessment in the Republic of Uzbekistan (year 2018).

In the case of thermal power plant, the required document, the reviewing organization, the expense and the period differ depending on the generation capacity (Table 12.3.2-1).

The project of power plant is categorized in Category I and Transmission line and Substation are categorized in Category II.

The submission of the EIA to Goskomekologiya for review and approval is required.

Table 12.3.2-1 Outline of the Environmental Impact Assessment Procedure concerning Thermal Power Plant

Item	Category I	Category II	Category III	Category IV
Generation capacity	＞300 MW	＜300 MW ＞100 MW	<100 MW	---
Required	**Stage 1**: EIA Draft	EIA	EIA	SEE

Item	Category I	Category II	Category III	Category IV
document	**Stage 2**: Environmental Impact Assessment (EIA) developed on demand of Goskomekologiya **Stage 3**: Statement of environmental effects (SEE)			
Reviewing organization	Goskomekologiya	Goskomekologiya	Regional Goskomekologiya	Regional Goskomekologiya
Review expense	Minimum salary of 25 people	Minimum salary of 15 people	Minimum salary of 7.5 people	Minimum salary of 0.5 people
Review period	30 days (not more than 2 months)	30 days (not more than 2 months)	20 days	10 days

(Source: Resolution of the Cabinet of Ministers no. 949 about state environmental impact assessment in the Republic of Uzbekistan (2018))

The outline of the EIA procedure is described below.

1) EIA Procedure

As determined in Section 10 of The Law of the Republic of Uzbekistan "On Environmental Audit", 3 steps of EIA procedure as described below: 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.

(a) Planning Phase

a) Development of the Environmental Impact Assessment (EIA)

The draft EIA is developed in the planning phase of the project and submitted to the State Committee for Nature Protection.

b) Reflection of the Result of the Review

Following the review of the EIA, additional survey, in-situ investigation, special analysis, and model simulation are conducted as necessary to determine the appropriate environmental protection measures before approval issued by the State Committee for Nature Protection.

EIA report for GTCC3 and 4 already was approved by the State Committee for Nature Protection on the third of May.

EIA report for Transmission line and Substation was approved by the State Committee for Nature Protection on the 18th and 23th of July.

(b) Pre-operation Phase

Statement of Environmental Consequences should be prepared and submitted to the State Committee for Nature Protection prior to the commercial operation of the project facility. This procedure is almost equivalent to the procedure of approval application in pre-operation phase in Japan.

(c) Public Meeting

The Environmental Impact Assessment Regulations (the Resolution of the Cabinet of Ministers No.491, 2001) stipulates that the public meeting shall be held at the demand from the resident. The meeting based on the said Regulations was not held during the EIA procedure concerning GTCC3, but the stakeholder meetings were conducted during JICA cooperation preliminary survey period, to explain and consult with the local people on the subject including the scoping plan, land acquisition, overview of the EIA, and JICA guidelines.

The public meeting is basically held at the demand of the residents as part of the environmental impact assessment in case of the project in urban area.
The meeting is planned and conducted by JSC Navoi TPP. The procedure consists of five steps:

Step 1, the notification of the meeting to the relevant people;
Step 2, the preparation of the summary of the EIA, distribution to the relevant people, and the EIA being made available to the public for reference;
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 relevant organization.

Table 12.3.2-2 shows the basic scheme of implementation of EIA public meeting.

Table 12.3.2-2 Basic Scheme of Implementation of EIA Public Meeting

Step	Procedure
1	Notification of conducting the meeting with the local administration, local residents, local community
2	Preparation of the summary of the draft EIA, its distribution to the relevant people, and the EIA is made available for reference within the power plant and the local community
3	Opening meetings to explain the EIA to local residents;
4	Collection and analysis of the opinions of local residents through questionnaire
5	Report of the result of the meeting to the relevant organization.

（Source: JICA Survey Team）

The meeting schedule should be widely notified using newspaper and other mass media and the relevant website.

The EIA summary is made in Uzbek and Russian and distributed to the relevant people. 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 should consist of the explanation of the overview of the project, including the advantage of the new facility and potential environmental impact, from JSC Navoi TPP, 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 summary of the result of the meetings is reported to the relevant organization by JSC Navoi TPP, and the result is also publicized through the mass media.

The opinion from the local residents will be reflected in the final Statement of Environmental Consequences.

(2) The Content of the EIA

Article 11 of the Law of the Republic of Uzbekistan "On Environmental Audit" stipulates the content of the EIA and the Statement of Environmental Consequences as follows.

1) EIA

- ✓ Environmental analysis of the environmental status, population, land development before the project installation.
- ✓ The current status of the residential area, farmland, transmission line, and life infrastructure.
- ✓ The construction plan including the environmental impact of the equipment, technologies, materials used in construction and their mitigation measures.
- ✓ The analysis of the alternatives for the project plan and technical decisions regarding natural protection, in view of the latest technologies.
- ✓ Technical countermeasures to avoid and mitigate negative environmental impact.
- ✓ Situation analysis of negative impact in the emergency case, assessment of preventive measures.
- ✓ Prediction of environmental change after project installation.

2) The Statement of Environmental Consequences

- ✓ The modification reflecting the result of the review of the EIA and the public consultation.

- ✓ The regulating standard applied at the operation phase of the facility (maximum acceptable concentration, maximum acceptable emission, maximum acceptable storage, etc.)
- ✓ Environmental mitigation measures and the organizational structure at the operation
- ✓ Major policy of the environmental mitigation measures

12.3.3 Gaps with JICA Environmental Guidelines (April 2010)

The content of the EIA is stipulated in Law on Environmental Audit and the Environmental Impact Assessment Regulations (the Resolution of the Cabinet of Ministers no.491 (2001) and no. 152(2009)).

The comparison between the content of the EIA with the requirement of JICA Guideline on Environmental and Social Consideration seems to show no significant gap.

However, there are still some gaps: the description concerning mitigation measures and monitoring plan during construction phase is not required in the above-described regulations, for example.

The gap regarding the EIA report of this project will be examined upon acquisition of EIA. The gap between the content of the approved EIA report for GTCC3 project in 2019 and JICA Guideline on Environmental and Social Consideration is shown in Table 12.3.3-1.

Table 12.3.3-1 Gaps between the EIA Content of this Project and JICA Guideline

Items	JICA Guidelines	EIA system in Uzbekistan	Existence of gap and how to cope with it
Basic issues	➢ In the implementation of the project, the survey and the examination of the environmental and social impact of the project shall be conducted in the planning stage of the project in order to consider the alternative or the mitigation measure to prevent or minimize the impact and to reflect the findings in the project plan.	➢ In a major development project, the implementation of the EIA survey in the stage of pre-feasibility study is required. ➢ Analyze the alternatives for the project plan and technical decisions regarding natural protection, in view of the latest technologies.	➢ There is no significant gap.
Information Disclosure	➢ EIA reports shall be disclosed to all local stakeholders, residents, etc. Also, the reports shall be disclosed on the JICA web site.	➢ The public meeting is basically only held at the demand of the residents as part of the environmental impact assessment in case of the project in urban area.	➢ Since there is a gap, the result of scoping and review of EIA will be disclosed to stakeholders in stakeholder meetings.

Items	JICA Guidelines	EIA system in Uzbekistan	Existence of gap and how to cope with it
Participation of residents	➢ Information on the Project shall be disclosed to project proponents and discussions with local residents and stakeholders (particularly with local residents who can be affected directly) shall be encouraged. ➢ In the case of category A projects, project proponents shall make an explanation to local residents and stakeholders at an early stage about the necessity of development, predicted negative environmental and social impacts, and analytical results of alternative plans. ➢ In the case of category A projects, explanatory meetings for local residents shall in principle be held twice in total, one when the scoping is made and another when EIA reports are being prepared. In the case of category B projects, it is provided that explanatory meetings shall be held as required.	➢ No related provision is in place.	➢ Since there is a gap, stakeholder meetings will be held at the phases of scoping and Final EIA during this preparatory survey, to offer explanation concerning the necessity of development, predicted negative environmental and social impacts, analytical results of alternative plans, etc.
Examination of mitigation measures	➢ Multiple alternatives shall be examined in order to avoid or minimize adverse impacts. ➢ In the examination of measures, priority is to be given to avoidance of adverse impacts on the environment; when this is not possible, minimization and reduction of impacts must be considered next. ➢ Compensation measures shall be examined only when impacts cannot be avoided with any of the aforementioned measures. ➢ Appropriate follow-up plans and systems, such as monitoring plans and environmental management plans, shall be prepared; the costs of implementing such plans and systems, and the financial methods to fund such costs shall be determined. Plans for projects with particularly large potential adverse impacts shall be accompanied by detailed environmental management plans.	➢ Analyze the alternatives for the project plan and technical decisions regarding natural protection, in view of the latest technologies. ➢ Indicate technical countermeasures to avoid and mitigate negative environmental impact. ➢ Conduct situation analysis of negative impact in the emergency case, assessment of preventive measures. ➢ Predict the environmental change after project installation.	➢ Description of impact assessment and mitigation measures during construction and operation were confirmed. ➢ As a countermeasure, management plan and monitoring plan during construction and operation will be conducted according to JICA environmental and social consideration guidelines.

Items	JICA Guidelines	EIA system in Uzbekistan	Existence of gap and how to cope with it
Assessment items of the environmental and social consideration	➢ The scope of the impact to be investigated and examined with regard to environmental and social considerations include the impact on human health and safety and the natural environment (including transboundary or global environmental impact) through the atmosphere, water, soil, waste, accident, water use, climate change, ecosystem and biota, and social considerations. ➢ Population migration including involuntary resettlement, Local economy including employment and means of livelihood, land use and local resource use, social organization including social infrastructure and regional decision-making organizations, the existing social infrastructure and social services, socially vulnerable group including poor people and indigenous people, fairness in distribution of damage and benefits and development process, gender, right of children, cultural heritage, conflict of interests within the local area, infectious diseases such as HIV / AIDS, and labor environment（including working safety). ➢ In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent. It is also desirable that the impacts that can occur at any time throughout the project cycle should be considered throughout the life cycle of the project.	➢ Analyze the environmental status, population, land development before the project installation. ➢ Cumulative impacts such as air quality and water quality are evaluated in EIA of power plant.	➢ Short description of social economical items is found in the EIA of this country. ➢ As a countermeasure, social economical items will be evaluated according to JICA environmental and social consideration guidelines.
Monitoring, grievance redress system	➢ Appropriate follow-up plan or system such as environmental management plan and monitoring plan, including the necessary expense and fund-rising method, shall be developed. Detailed environmental management plan should be prepared especially for the project with larger impact expected. ➢ In case an adequate monitoring is presumed to be essential for an appropriate environmental and social consideration, such as a project where the mitigation measures should be implemented while examining the effect of the mitigation measures at the same time, it should be ensured that the monitoring plan is included in the project plan and that the feasibility of the plan is confirmed. ➢ The grievance redress system to address grievance from the affected people and community.	➢ Prepare the construction plan including the environmental impact of the equipment, technologies and materials used in construction on the environment and their mitigation measures.	➢ Some description on the environmental management plan and monitoring plan during construction and operation in EIA of transmission line and substation. ➢ No description on the environmental management plan and monitoring plan during construction and operation in EIA of power plant. ➢ As a countermeasure, management plan and monitoring plan during construction and operation will be conducted according to JICA environmental and social consideration guidelines.

Items	JICA Guidelines	EIA system in Uzbekistan	Existence of gap and how to cope with it
Ecosystem and biota	➢ The project should not cause significant alteration or significant deterioration of the precious natural habitat or precious forest.	➢ Analyze the Ecosystem and biota before the project installation.	➢ There is no significant gap.
Indigenous people	➢ The impact of the project on the indigenous people should be avoided with all possible measures considered. In case the impact cannot be avoided through such consideration, a viable countermeasure for such people should be developed in order to minimize and compensate for the possible impact	➢ No regulation exists.	➢ The land use of the indigenous people is determined in the survey and the response will be considered as necessary.

(Source: JICA Survey team)

12.3.4 Standards Related to This Project

(1) Air Quality

1) Ambient Air Quality Standards

In the Republic of Uzbekistan, MAC for protecting human health is established for each danger classes of hazardous substances, according to the atmospheric and working environment as in Table 12.3.4-1. IFC/WB General EHS Guidelines value is also described for comparison (the standard value is mostly similar).

Table 12.3.4-1 MAC for Atmosphere and in a Working Area

Pollutant	MAC (μg/m^3)			Danger class***	[Reference]**** IFC/WB EHS General Guidelines (2007) (μg/m^3)
	30-minute value*	24-hour value*	Work area**		
Nitrogen dioxide (NO_2)	85	60	5,000	2	200 (1-hour value) 40 (1year value)
Nitrogen oxide (NO)	600	250	-	3	—
Sulfur dioxide (SO_2)	500	200	10,000	3	500 (10-minute value) 125 (24-hour value)
Carbon oxide (CO)	5,000	4,000	20,000	4	—
Dust (particulate matter)	150	100	-	3	150 (24-hour value) 70 (1year value)

(Source: JICA Survey Team)

Notes:* MAC of air pollutant in atmosphere
Sanitary norms, rules and hygienic regulations of the Republic of Uzbekistan (* San PiN No. 0293-11 Hygienic standards list of maximum acceptable concentration (MAC) of pollutants in the ambient air of populated areas on the territory of the Republic of Uzbekistan

**Maximum acceptable concentration of hazardous substance in a working area
San PiN No. 0294-11 "Hygienic standards of MAC of harmful substances in the air of the working area

*** Class of danger is categorized as follows
1- Pollutant of extreme danger
2- Pollutant of high danger
3- pollutant of medium danger
4- pollutant of low danger
Sanitary norms, rules and hygiene normative documents of the Republic of Uzbekistan. San Pin No. 0015-94

****IFC/WB EHS (Environmental, Health, and Safety) General Guidelines (2007)
The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice in view of environment, health and safety, established by IFC (International Finance Corporation), a member of World Bank group. Version 2007 is the latest one.

2) Emission Standard

In the Republic of Uzbekistan, the standard for the pollutant in the exhaust gas is not applied in a single uniform way. Instead, ground concentration of air pollutant discharged from each stack is estimated by a designated method, and it should not exceed concentration standard value calculated from each area / danger factor shown in the Table 12.3.4-2, against the MAC shown in the Table 12.3.4-1.

Table 12.3.4-2 Pollutant Factors for Danger/Territorial Area Class

Territorial category**	Danger Class*			
	1	2	3	4
Province: Tashkent, Fergana, Andizhan, Namangan City: Navoi, Samarkand, Bukhara	0.17	0.20	0.25	0.33
Province:Bukhara, Djizak, Kashkadaria, Navoi***, Samarkand, Syrdaria	0.20	0.25	0.33	0.50
Republic of Karakalpakstan the Khorezm Province	0.25	0.33	0.50	1.00

(Source: JICA Survey Team)

Notes:*Danger classes are described in the notes of Table 12.3.4-1.
**Pollutant factors for each territorial category are established following "Instructions for pollution emission inventory and evaluation of sources of pollutants in the ambient air for the enterprises of the Republic of Uzbekistan"(Ministry of Justice. 1533.3 January 2006).
***This project is located in the suburbs of Navoi City and corresponds to Navoi Province.

Table 12.3.4-3 Maximum Ground Concentration (μg/m^3) of Pollutant (Navoi old)

Pollutant	①MAC*	②Territorial rate**	MAC×Territorial rate (①×②)	Danger class*
Nitrogen dioxide (NO_2)	85	0.25	21	2
Nitrogen oxide (NO)	600	0.33	200	3
Sulfur dioxide (SO_2)	500	0.33	63	3
Carbon oxide (CO)	5000	0.50	2,500	4
Dust (particulate matter)	150	0.33	50	3

(Source: JICA Survey Team)

Notes: *Danger classes are described in the notes of Table 12.3.4-1.
**Pollutant factors for each territorial category are described in Table 12.3.4-2.

In this project, as is the case in GTCC1 and GTCC2, NOx concentration will be compliant to the Russian standard (GOST 29328-92) in Table 12.3.4-4. This standard value is equivalent to the guideline value for thermal power plant stipulated in IFC/WB EHS Guideline.

Table 12.3.4-4 Emission Standard for Exhaust Gas

Pollutant	GOST 29328-92	IFC/WB EHS Guidelines for Thermal power plant (2008)
NOx	51 mg/Nm^3 (25 ppm)	51 mg/Nm^3 (25 ppm)

(Source: JICA Survey Team)

(2) Water Quality

1) Acceptable Concentration

There is a water quality standard for drinking water and other water usage facilities at water intake station as an environmental standard in Republic of Uzbekistan shown in Table 12.3.4-5.

MAC in Zeravshan River, where water used in the power plant is taken and discharged, is established as shown in Table 12.3.4-6.

Table 12.3.4-5 Environmental Standards for Drinking Water and Water Usage

Pollutant	Drinking water supply	Non-drinking water (recreational use)
Suspended solid (SS)	Suspended matters content shall not exceed:	
	0.25 mg/dm^3	0.75 mg/dm^3
	For ponds that contain more than 30 mg/ℓ of mineral substances during low water an increase of the content of suspended matters is allowed within 5 %	
	Clouds with rate of sedimentation more than 0.4 mm/s for flowing pond and more than 0.2 mm/s for reservoirs are prohibited for discharge	
Floatable impurities (substances)	Floating films, spots of mineral oils and accumulations of other impurities shall not be detected on the surface of a pond	
Odor	Water shall not obtain alien smells with intensity more than mark (point) 2 detected:	
	Chlorination or disinfection with chlorine equivalent to chlorination.	Immediate chlorination
Color	Shall not be detected in the column:	
	20 cm	10 cm
Water temperature	Summer temperature of water as a consequence of discharge of wastewater shall not be more than 3°C higher comparing to the average temperature of the hottest month of a year for the last 10 years.	
pH	Shall not exceed 6.5-8.5	
Mineral content	Shall not exceed 1,000 mg/ℓ of dry residue, including: Chlorides (Cl-) – 350 mg/l ; Sulfates (SO_4^{2-}) – 500 mg/l	
Dissolved oxygen(DO)	Shall not be less than 4 mg/ℓ at any period of the year in a sample taken before 12:00 a.m.	
Biochemical oxygen demand (BOD)	Should not exceed at 20 °C with no exceeding:	
	3.0 mgO_2/dm^3	6.0 mgO_2/dm^3
Chemical oxygen demand (COD)	Should not exceed at 20°C with no exceeding:	
	15.0 mgO_2/dm^3	30.0 mgO_2/dm^3
Substances liable to cause infection	Shall not contain any.	
Bacillus coli	Not more than 10,000 per litter (not applied to decentralized water source)	Not more than 5,000 per litter
Coliform	Not more than 100 per litter (not applied to decentralized water source)	Not more than 100 per litter
Teleorganic eggs of worms, cysts of Bacillus coli	Shall not contain per litter	
Chemical substances	Shall not contain in concentrations exceeding MAC	

Notes:

1) Water quality standard is regulated in two categories: “drinking water” mainly used for drinking, and “non-drinking water (recreational use)” mainly used for recreational purpose such as fishing and play in water.
2) Floatable substances do not include nylon, polyester synthetic fabric, glass fiber, particulate of asbestos and others, metal hydroxide generated from the waste water treatment facility.
3) Water quality condition for water supply for clean water or water supply for clean water through disinfection.

(Source: San PiN No. 0318-15.Gigienicheskie (Hygienic) and anti-epidemic requirements for the protection of water reservoirs on the territory of the Republic of Uzbekistan)

Table 12.3.4-6 Water Quality Standards for Zeravshan River Water (MAC)

Item	Unit	Maximum acceptable concentration [MAC]
pH	—	6.5- 8.5
DO	mg/L	Summer: ＞4.0 Winter ＞6.0
BOD	mgO_2/ L	3.0
COD	mgO_2/ L	15
SS	mg/ L	15
Oil	mg/ L	0.05
NH_4^+	mg/ L	0.5
NO_2^-	mg/ L	0.02
NO_3^-	mg/ L	40
SO_4^{2-}	mg/ L	100
Phenol	mg/ L	0.001
Cl	mg/ L	300
Ca	mg/ L	180
Na	mg/ L	120
K	mg/ L	50
$.PO_4^{3-}$	mg/ L	0.01
Fe	mg/ L	0.5
Cu	mg/ L	0.001
Zn	mg/ L	0.01
Cr	mg/ L	0.5
Pb	mg/ L	0.03

(Source: Ecologist expert guide, Tashkent, Republic of Uzbekistan State Committee for Nature Protection, the State Ecological Expertise of the State Committee of Uzbekistan. 2011, Volume 2, p. 371-372)

2) Effluent Standard

In Uzbekistan, the effluent standard for the power plant is established so as to meet the water quality standard for water usage shown in the tables above, considering other effluent sources. That is, instead of a unified effluent standard (pollutant concentration) like international standards, the discharge rate and pollutant concentration are determined for respective project prior to the operation, pursuant to Decree №14 of the Cabinet of Ministers on 01.21.2014. Therefore, the effluent standards for GTCC3 cannot be obtained in this survey period.

GTCC2 will be constructed in the adjacent site, which also plans to discharge effluent into Zeravshan River, and the information on the planned effluent standard of this unit should be confirmed in this survey as much as possible for reference purpose.

Table 12.3.4-7 Effullent Standard of GTCC1, GTCC2 and Navoi-old

Items	Unit	Effluent standard for Navoi-old	Effluent standard for GTCC1	Effluent standard for GTCC2	IFC/WB EHS guideline values (thermal power station)
Approved volume of wastewater	m^3 / h	Exit No 1: 67361 Exit No 2: 35 Exit No 3: 255 Exit No 4: 5 Exit No 5: 344 Exit No 6: 785	200	50	-
pH	-	6.5－8.5	8.1	8.2	6 –9
SS	mg/L	487	-	-	50
Oil	mg/L	0.234 (No.1) 0.1 (No.2-4) - (No.5-6)	0.2	0.6	10
Nitrite	mg/L	3.3	0.3	0.2	-
Nitrate	mg/L	45	13	13	-
Sulfate	mg/L	500(No.1-4) 1000(No.5-6)	980	760	-
Chloride	mg/L	350	150	115	-
Zinc	mg/L	-	-	-	1
Cadmium	mg/L	-	-	-	0.1
Lead	mg/L	-	-	-	0.5
Mercury	mg/L	-	-	-	0.005
Copper	mg/L	-	-	-	0.5
Chrome	mg/L	-	-	-	0.5 (Total Cr)
Cadmium	mg/L	-	-	-	0.1
Chlorine	mg/L	-	-	-	0.2
Arsenic	mg/L	-	-	-	0.5

Note: Existing Unit 1-2 was decommissioned.
Exit No.1: Thermal effluent from Unit 3-10 one-through system
Exit No.2: Rain water from Unit 8-12 after oil-treatment
Exit No.3: Blow-down from the cooling tower of Unit 11-12
Exit No.4:: Rain water from Unit 1-7 after oil-treatment
Exit No.5: Effluent from waste water treatment facility
Exit No.6: Emergency Effluent from No.5 at failure of pumps.
(Source: EIA of GTCC3 and 4 p.16-20 and the document obtained at the survey.
Rules for protection of surface water from contamination by discharge water. (San Pin No.0056-98))

(3) Noise and Vibration

1) Noise

In Uzbekistan, noise standard (KMK 2.01.08-96) is established as shown in Table 12.3.4-8 according to land use category. Also, sound pressure level for each octave band is regulated as shown in Table 12.3.4-9.

Table 12.3.4-8 Noise Level Standard (1)

Category	Environmental standard in Uzbekistan		IFC EHS General Guidelines (2007)	
	Day	Night	Day	Night
Residential area	55 dB(A)	45 dB(A)	55 dB(A)	45 dB(A)
Commercial area	60 dB(A)	60 dB(A)	70 dB(A)	70 dB(A)
Industrial area	---	---	70 dB(A)	70 dB(A)

(Source: Building Regulations Protection against noise. KMK 01.02.08-96(The State Committee of Uzbekistan for Architecture and Construction Tashkent in 1996.)

Table 12.3.4-9 Noise Level Standard (2)

Octave band (Hz) / Sound pressure level(dB)	31.5	63	125	250	500	1,000	2,000	4,000	8,000
Residential area	84	67	57	49	44	40	37	35	33
Commercial area	93	79	70	63	58	55	52	50	49

(Source: Building Regulations Protection against noise. KMK 01.02.08-96(The State Committee of Uzbekistan for Architecture and Construction Tashkent in 1996.))

2) Vibration

There is no environmental standard for vibration level in Uzbekistan. The allowable vibration is established in San PiN No. 0122-01 in view of safety in working environment pursuant to Decree of the Cabinet of Ministers of 12 July 2000 N 267.

The vibration standard value is not established either in IFC/WB EHS Guideline which is adopted in EU and other major industrialized countries.

The vibration standard in Japan is shown in Table 12.3.4-10 just for reference for impact estimation.

Table 12.3.4-10 Vibration Standard Value of Japan (dB)

Category	**Daytime** (05:00-19:00 or 08:00-22:00)	**Nighttime** (19:00-05:00 or 22:00-8:00)
Residential area	60～65	55～60
Residential area + commercial area + industrial area	65～70	60～65

(Source: Vibration Regulation Law, 1976(4) Odors)

(4) Waste

In Uzbekistan, waste is classified into the categories as shown in Table 12.3.4-11, according to the Resolution of the Cabinet of Ministers No.14, 21.01.2014.

Table 12.3.4-11 Categories of Waste

class	Waste type
I	Extreme danger
II	High danger
III	Medium danger
IV	Low danger
V	No danger

(Source: The Resolution of the Cabinet of Ministers No.14 ot21.01.2014)

Standard value for maximum allowable amount of waste is calculated through the consumption amount of materials used from the production to the final process at the current production facilities through the most appropriate manufacturing method. Every waste material must have the following displayed; the name of the waste material, generation source, physical /chemical

characterization, and danger level. Maximum allowable storage amount is established for every waste material taking into account disposal amount, treatment of waste material and usage schedule.
Transportation of waste to disposal site or reuse is delegated to the licensed company. Final disposal is conducted at the licensed disposal facility.
The status of waste during transportation and treatment is assessed through a manifest system.
In the existing power plant, scrap metal and oil are reused by a special company, and sludge is disposed of at a designated disposal site.
Domestic waste is disposed of at a disposal site of private company "Stimul Navoiy" in Navoi.

Table 12.3.4-12 describes the types of main waste, amount of generation and disposal situation in the existing power plant.

Table 12.3.4-12 Types and Amount of Main Waste Generated at the Existing Power Plant

Description of waste	products (t/y)	Hazard class	Placements
Ferrous scrap	253	IV	Temporary storage in the territory of entity, repair workshops. The bulk of it accumulates in centralized maintenance workshop. Always supply to scrap recycling entity "Vtorchermet" in Navoi
Waste transformer oil	22	II	Used oil is pouring out into oil box Part of it is used again and part of which is supplied to petroleum storage depot for recovery.
Used car tires	1.7	IV	Temporary storage in the territory of Vehicle Workshop. Always supply to recycling entity "Vtorsyryo"
Oily sludge	17	III	Taking out for use in coating plant DAEWOO "Magistral" in asphalt production.
Sludge from wastewater of water treatment unit	2,467	III	Temporary storage in sedimentation tanks 1 and 2 and after cleaning of sedimentation tanks is taken out to special designated place in landfill for construction waste materials – private company "Barno"
Sludge from pretreated raw water	2,103	III	After cleaning of sedimentation tanks is taken out to special designated place in landfill for construction waste materials – private company "Barno"
Mud from river water clarification	2,219	III	Temporary storage in sedimentation tanks and bowls of cooling tower. Then taken out to landfill for construction waste materials – private company "Barno" in Navoi
Sediment form chemical cleaning of condensers and pipes of screening system	9	III	Is sent to sludge remover units 1,2 (pond of vaporizer) at treating facilities of industrial wastewater where water evaporates and sediment settles and stores until filling of pond.
Waste lime	59	IV	Upon accumulation is taken out in special tight vehicle to landfill for construction waste materials – private company "Barno" in Navoi.
Wastes of process salt	44	IV	Temporary storage in the territory of chemical workshop and upon accumulation is taking out to landfill for construction waste materials – private company "Barno" in Navoi
Used fluorescent lamps	5.6	I	Temporary storage in corrugated boxes and transferred to a specialized organization.
Wastes of thermo-insulating materials	11	III	60% of generated wastes are sent to recycling plant "Electroizolit" for recycling and the remaining parts unusable for recycling, are sent in special tight vehicle to landfill for construction waste materials – private company "Barno" in Navoi
Waste paper	1.0	IV	Temporary storage in special room, always take out to waste paper receiving centers.
Food waste	56	V	Store in special vessel and taken out everyday for cattle feed

(Source: final EIA report of GTCC3 and 4 p.32-33 and (Source: JICA GTCC2 Report))

12.3.5 Laws and Regulations on Safety

The laws and regulations concerning working safety in Uzbekistan are as follows.

- ✓ Uzbekistan's Constitution, Article 37, 40
  _Stipulates the right of selection of work, equality of working conditions, protection of unemployed persons, penalty for violation, right of receiving medical treatment.

- ✓ The Law "On labor protection" from 06.05.1993, in the new edition of 2016
  _Established for worker's safety and health.

- ✓ Labor Code of the Republic of Uzbekistan, 21.12 1995 (Last modified: Bulletin of Oliy Majlis, 2016, №17, Article 173.)
  _Code aiming at effective implementation of cultural and qualitative improvement of people, improvement of working environment, and worker's safety and health.

- ✓ The Law "On Countering the spread of disease caused by a virus human immunodeficiency (HIV) "(2013)
  _Established for the prevention of spread of infection of virus human immunodeficiency and precaution.

- ✓ The Law "On the State Sanitary Inspection" (1992)
  _Law aiming at ensuring epidemiologic measures and sanitation for the well-being of the people, based on the international treaty.

- ✓ The Law "On Industrial Safety of Hazardous Industrial Facilities", 2006
  _Established for the effective management of disaster and accident at hazardous industrial facilities and emergency response and preventive measures. It also stipulates the social and economic framework facilitating the safe operation of the hazardous facilities.

- ✓ Resolution of the Cabinet of Ministers №271 from 10.12.2008 "On additional measures for the implementation of the Law of Uzbekistan" On industrial safety of hazardous production facilities"
  _Regulates the additional measures regarding the implementation of the Law on industrial safety of hazardous production facilities.

- ✓ Resolution of the Cabinet of Ministers №413 from 27.11.2002 "On measures for further development of the insurance market"
  _Law aiming at enhancing capital strength of the insurance organizations, improvement of service, and establishment of trust from the people on the insurance market.

- ✓ Regulations on the investigation and recording of accidents and other damage to the health of workers at work ", approved by the Cabinet of Ministers № 286 from June 6, 1997
  _Regulates investigation and recording of registration of labor accident due to inappropriate management, compensation and care for injuries due to disease of workers.

The following safety regulations specify distances to secure between the facilities of this project and residential areas. Table 12.3.5-1 shows the distances depending on the facility. No residential structures are allowed within the areas.

- ✓ San PiN No. 0350-17 "Sanitary Norms and Rules for the Protection of Atmospheric Air in Populated Areas of the Republic of Uzbekistan"

_Prohibits the construction of residential structures around power plants and substations

- ✓ The Rules for the protection of electric grid facilities approved by PKM RUz No. 1050 of 12/26/2018

_Prohibits the construction of residential structures along transmission line

Table 12.3.5-1 Regulations of Distance between Facilities and Residential Areas

Facility	Area where residential structures are prohibited
Power plant	500 m from the stack
Transmission line	220 kV - Both side 25 m from the center of the line 500 kV - Both side 30 m from the center of the line
Substation 220 / 500kV	25-30 m from all sides of the perimeter substation fence

(Source: JICA Survey Team)

12.3.6 Land Use and Compensation

There are no laws or legislation in Uzbekistan that specifically address matters related to involuntary resettlement. Rather land acquisition is governed by the following laws and resolutions:

- ✓ The Civil Code.

_ This Code was enacted by Oliy Majlis of Uzbekistan No.163-I of December 21, 1995 and No. 256-I of August 29, 1996.
_ Amended in August 30, 2003 and December 3, 2004.

- ✓ The Land Code.

_ This Code was approved by the Statute of Uzbekistan No. 598-I of April 30, 1998.
_ Amended according to Division XIX of the Statute of Uzbekistan of August 30, 2003, item 41 of the Statute of Uzbekistan of December 3, 2004.

- ✓ The State Land Cadastre.

_ This Law was approved by the Statute of Uzbekistan No. 666-I of August 28, 1998.
_Amended according to different laws of Uzbekistan of 2002-2004.

- ✓ The State Cadastre.

_ This Law was approved by the Statute of Uzbekistan No. 171-II of December 15, 2000.
_Amended according to different laws of Uzbekistan of 2002-2011.

- ✓ Law of the Republic of Uzbekistan "On Evaluation Activity"

_ This Law was approved by the Statute of Uzbekistan No. 811-I of August 19, 1999.

- ✓ Decree of the President of the Republic of Uzbekistan "On further improvement of activity of evaluation companies and increases of their responsibility for the quality of rendered services"

_ This Decree was approved as No. PP-843 of April 24,2008.

- ✓ Cabinet of Ministers Resolution on “Order of realization into private property of objects of trade and public services together with land plots where they are located, and land plots into life inheritance tenure”.

_ This Resolution No. 126 was adopted of April 11, 1995.

_ Amended according to Resolution of CM No. 202 of April 30, 1999.

- ✓ Cabinet of Ministers Resolution on "Order of compensation of citizens' and legal entities' losses due to land plots acquisition for state and public needs".

_This Resolution No. 97 was adopted of May 29, 2006.
_Amended according to Resolutions of CM No. 248 of November 9, 2010 and No. 146 of May 25, 2011.

- ✓ Annex to Cabinet of Ministers Resolution No. 97.

_ This was approved in May 29, 2006.
_ This Annex includes all prime rules and regulation that assign the order of compensation.

Collectively, these regulations provide a sound basis for acquiring land for public purposes and for compensating land users according to the registered use of the land.

In this survey, the latest information will be checked focusing on the laws and regulations on land use and compensation applicable to GTCC3.

12.4 Consideration of Alternatives

12.4.1 In Case of the Project Is Implemented and Not Implemented

(1) Power Plant, Transmission Line and Substation

In Uzbekistan, wear and tear of the power plants is proceeding, with the average heat efficiency approximately as low as 30 percent. Navoi old includes a heat and power supply station in service for more than 50 years, and mechanical reliability and the possibility of accident is a serious concern.

The project relates to the construction of a high-efficiency power plant and will satisfy the peak demand and support for the decommissioning and renewal of the existing power plant as a standby facility.

In this regard, this project is essential in the improvement of reliability in electric supply and reduction of greenhouse gas emission in Uzbekistan and the power plant will contribute to the region. Construction of power plant and zero option are compared as described in Table 12.4.4-1.

Table 12.4.1-1 Comparison of Case When the Project Is Implemented or Not Implemented

Item	In case the project is implemented	Not implemented
Technical aspect	・ A power plant with higher efficiency than the existing plants will be constructed in the project site. ・ A Transmission line and substation will be constructed in the project site and will enable electricity generated at the plant to be transmitted.	・ The existing power plants with lower efficiency than the proposed plant will remain operational. ・ Electricity generated at the plant will not be transmitted.
Economic aspect	・ The project will purchase construction materials and equipment in the local area and also offer working opportunities to local people, contributing to the local economy. ・ Some of the existing power plants will be closed down and energy efficiency and fuel cost savings will be promoted. ・ Although it requires construction costs, the project will contribute to economic development in Navoi Region.	・ No construction project will offer neither working opportunities to local people nor contribute to the local economy. ・ No construction cost will need. However, the economic growth in Navoi region will slow down or be negative due to the power supply shortage. ・ Because the existing power plant cannot be closed down, promotion of energy efficiency or fuel cost savings will be delayed.
Environmental and social consideration	・ The new project will be constructed, which needs appropriate measures to relieve environmental impact. ・ Land needs to be acquired.	・ Nothing in particular. ・ No land needs to be acquired.

(Source: JICA Survey team)

12.4.2 Consideration of Alternative Project Sites

(1) Power Plant

As shown in Table 12.4.2-1 and (Source: Google Earth/Map, added by JICA Survey Team)
Figure 12.4.2-1, there are two candidate project sites

In terms of land use, according to JSC TPP, the site for both Plan-A and Plan-B is owned by the power plant, in a similar natural condition and no significant difference is observed.

In regard to social environmental aspects (land acquisition, resettlement) as well, the project site is owned by the power plant.
Even in the past, land acquisition has not been conducted for the project in both project sites. It should be noted that there are dacha in both sites and farmland in Plan-B. Farmland is classified in 2 categories, land leased to the public by contract with the power plant, and land cultivated by the power plant personnel.
The current plan is to operate GTCC 3 and 4 while the existing plant would be shut down and decommissioned, Site B is large enough but Site A lacks space. Moreover, the existing facility needs to be dismantled in Site A. Therefore, Site B was recently chosen as the project site and the EIA report for Site B was developed and approved.

Table 12.4.2-1 is the summary of the characteristics of the project site in respective plan based on the collected information currently available.

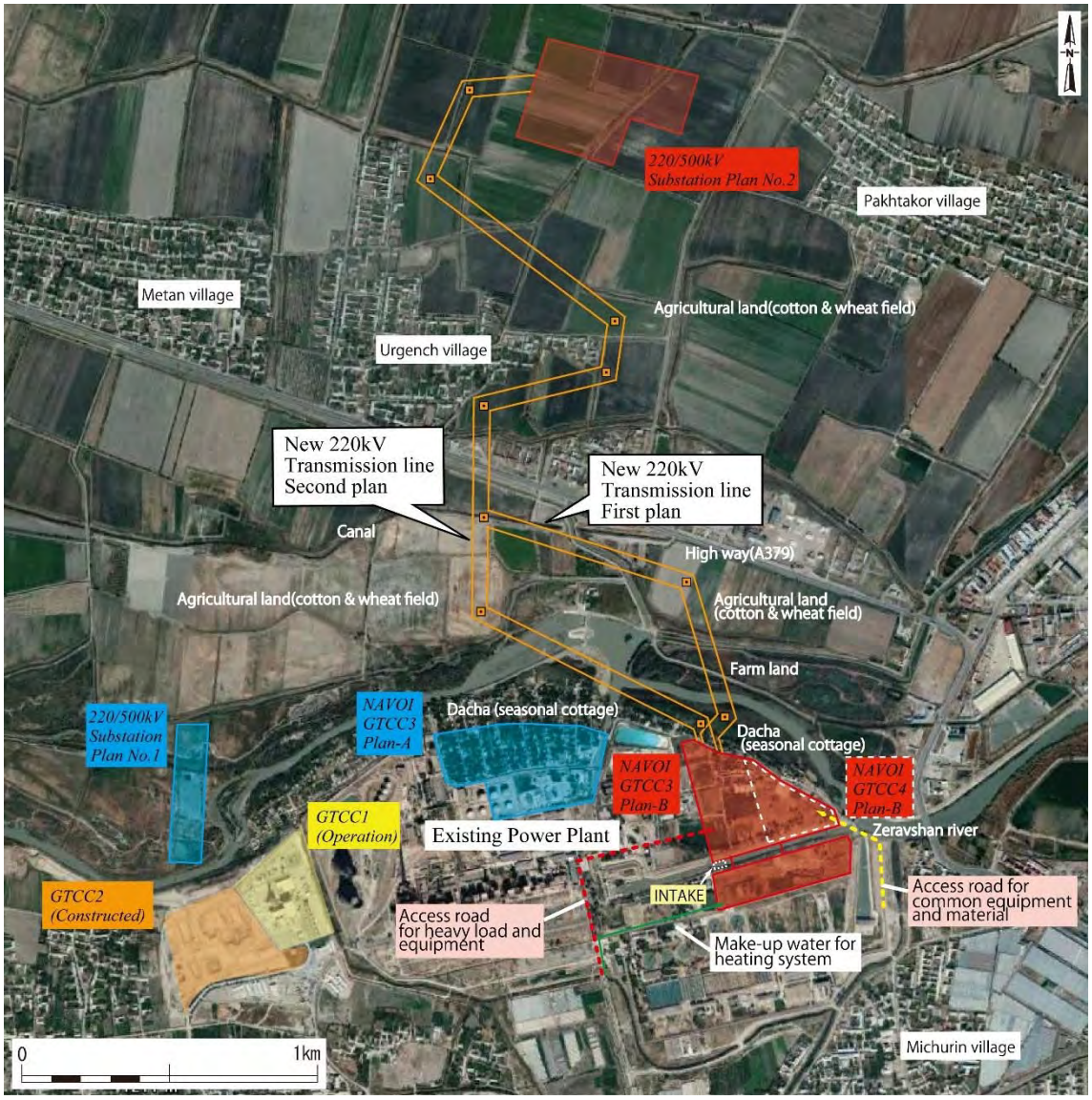
Table 12.4.2-1 Characteristics of the Project Site

No.	Items	Plan-A		Plan-B	
1	Site Area (for GTCC 3 and 4)	△	Approx. 15ha Not enough area to arrange predetermined power generation equipment (including the case of air-cooled condenser is accepted)	○	Approx. 21ha Enough area to arrange predetermined power generation equipment (including the case of air-cooled condenser is accepted)
2	Intake & Discharge routes	△	Since there is a possibility that the intake canal passes through the area of existing Navoi old, it's necessary to adjust with the existing facilities. Possible to make the length of both canals *long*.	○	The needed water inlet and discharge canals will be installed near the project site. There are no structures that are particularly obstacles for both intake and discharge canals. Possible to make the length of both canals *short*.
3	Connection with power transmission line	-	The connecting distance to the transmission line (new) is *equal* between two plans.	-	The connecting distance to the transmission line (new) is *equal* between two plans.
4	Fuel (Natural gas) line route	○	Fuel (Natural gas) is expected to be branched / extended from the supply line to GTCC 1 and 2(west side), so the length of the connecting pipe becomes relatively *short*. All the pipelines will be installed inside the existing power plant.	○	Fuel (Natural gas) is expected to be branched / extended from the supply line to GTCC 1 and 2 (west side), so the length of the connecting pipe becomes relatively *long*. However, all the pipelines will be installed inside the existing power plant.
5	Heat supply piping route	○	The pipeline connection length with the existing factory steam supply piping and the district heating warm water supply piping can be made *short*.	△	The pipeline connection length with the existing factory steam supply piping and the district heating warm water supply piping become *long*.

No.	Items	Plan-A		Plan-B	
6	Difficulty of construction	△	Construction difficulty level is higher than Plan B for the following reason, ·In the case of a once-through cooling system, there is a possibility that the intake canal passes through the existing Navoi-old (formerly Soviet plant), adjustment with existing facilities and investigation of existing buried items are necessary.	○	Construction difficulty level is lower than Plan A for the following reasons, ·In the case of the once-through cooling system, there are no large obstacles on the intake/discharge canal route, and the length of the both canals is short.
7	Construction period	△	·Removal / relocation of existing facilities in the site are necessary, and the construction period becomes longer than Plan B accordingly.	○	·There are no particularly obstructive structures in the premise, and the site is flat. Therefore, construction period is expected to shorter than Plan-A.
8	Access Road	-	Access road can be laid from the main road on the south side of the site (JSC TPP's opinion).	-	Access road can be laid from the main road on the south side of the site (JSC TPP's opinion).
9	Equipment material storage during construction	-	Possible to secure a place for materials in the premises.	-	Possible to secure a place for materials in the premises.
10	Environmental and social consideration	-	<Overall> The predicted impact on the natural and social environments is almost the same as Plan-B. <Natural Environment> The site is an artificially prepared land and natural vegetation does not exist <Social Environment> The site is owned by the power plant, and the planned construction site is used for the existing power plant site or dacha. The specific survey of the present status of the site should be conducted.	-	<Overall> The predicted impact on the nature and social environment is almost the same as Plan-A. <Natural Environment> Same as plan A <Social Environment> The site is owned by the power plant, and the planned construction site is used for the existing power plant site or dacha. The specific survey of the present status of the site should be conducted.
12	Rough Project cost	△	Although the construction cost of the plant is *equal* to Plan-B, the project cost is high as the cost of removing and relocating existing facilities is required.	○	The plant construction cost is *equal* to Plan-A, but there is no removal / transfer cost of existing facilities, so the project cost is expected to be *low* compared to Plan-A.

Note: ○advantage／△disadvantage ／－equivalence

(Source : JICA Survey Team)



(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.4.2-1 Candidate Site of Power Plant and Transmission Line

(2) Transmission line and Substation

1) Transmission line

The route of the first proposal was made by the survey team at scoping stage. However, district public facility will be constructed, this facility must be relocated by this project.

Therefore, new candidate routes were considered based on the route of the second proposal of the survey team for EIA report of transmission line.

Figure 12.4.2-1 and Table 12.4.2-2 shows the result of examining the transmission line plan for connecting GTCC3 under construction plan to the Navoi thermal power plant in Uzbekistan.

First plan seems to be superior as aspect of technical in comparing with Second plan of the EIA report.

The ROW of transmission line and site of substation are mainly farm land and not residential area. The area of basis for towers and substation are estimated about 0.3 ha and 22.5 ha.

Table 12.4.2-2 Characteristics of Transmission Line

Item	1st plan		2nd plan	
Outline	-	・The 1st plan is about 6km.	-	・The 2nd plan is about 6km
Technical	○	・The transmission line crosses the river at one point.	△	・The transmission line crosses the river at two points. ・One of the proposed foundations in the 2nd plan is closer to the river than those in the 1st plan. Therefore, piling might be necessary for this foundation. This will be technically more difficult and need more cost.
Social	-	・The transmission line passes through small area of north side of Dacha	-	・The transmission line passes through small area of north side of Dacha
Environmental scale	-	・.These areas are mainly farm land.	-	・.These areas are mainly farm land.

Note: ○ advantage／△ disadvantage ／－equivalence

(Source: JICA Survey Team)

2) Substation

As shown in Figure 12.4.2 1 and Table 12.4.2-23 there are two candidate project sites for new substation

In terms of land use, according to JSC Navoi PS, the site for both Plan No.1 and No.2 are similar natural condition and no significant difference is observed.

In regard to social environmental aspects, both sites are farmland and not residential area.
Plan No.1 is large enough but Plan No. lacks space .
Table 12.4.2-13 is the summary of the characteristics of the project site in respective plan based on the collected information currently available.

Table 12.4.2-3 Characteristics of the Project Site for New substation

No.	Items	Plan No.1		Plan No.2	
1	Site Area (for GTCC 3 and 4)	△	Approx. 10ha Not enough area to arrange predetermined power generation equipment (including the case of air-cooled condenser is accepted)	○	Approx. 25ha Enough area to arrange predetermined power generation equipment (including the case of air-cooled condenser is accepted)
2	Connection with power transmission line	○	The connecting distance to the transmission line (new) is shorter than plan No.2	△	The connecting distance to the transmission line (new) is longer than plan No.1
3	Construction period	-	・There are no particularly obstructive structures in the premise, and the site is flat.	-	・There are no particularly obstructive structures in the premise, and the site is flat.
4	Access Road	△	・New access road will be required to be laid from the main road.	○	・New access road will not be required to be laid from the main road.

No.	Items	Plan No.1		Plan No.2	
5	Environmental and social consideration	-	<Overall> The predicted impact on the natural and social environments is almost the same as Plan No.2. <Natural Environment> The site is an artificially prepared land and natural vegetation does not exist <Social Environment> These areas are mainly farm land., not be residential area,	-	<Overall> The predicted impact on the nature and social environment is almost the same as Plan No.1. <Natural Environment> Same as plan No.1
6	Risk by flood of river	△	The site is near from Zerafshan river, about 200m.	○	The site is far from Zerafshan river, about 1km.

Note: ○advantage／△disadvantage ／－equivalence

（Source : JICA Survey Team）

12.4.3 Consideration of Fuel Type

Natural gas is already used in GTCC1 in operation and in GTCC2 in commissioning as well. The gas supplier is already nearby, and the supply line has already been established, which ensures an easy fuel supply and a lower cost for facility construction. Natural gas also has advantages from an environmental standpoint, with lower emission of SO_2, CO_2, and dust compared to coal (Table 12.4.3-1).

In INDC based on the Paris Agreement, the Government of Uzbekistan set a goal that it would reduce emissions of GHG against GDP by 10% by 2030 compared to emission level in 2010. By replacing conventional power plants with mainly natural gas thermal plants with high efficiency, it plans to ensure stable electricity supplies and reduce emissions of CO_2 and NOx by reducing fuel consumption as top priority and then to develop renewable energies in the future.

Under these circumstances, it is urgently necessary to secure power supply capacity and improve the reliability of power generation facilities by upgrading facilities. At the same time, it is desired to introduce high-efficiency power generation facilities to suppress GHG emissions.

<Reference>

CO_2 emissions (CO_2 emissions per kWh) for each type of power source in Japan are as follows. That for combined cycle power generation is smaller than other types of thermal power generation.

- Coal-fired power: 943 (g-CO_2 / kWh)
- Oil-fired thermal power: 738
- LNG thermal power: 599
- LNG thermal power (combined cycle): 474

Table 12.4.3-1 Consideration of Fuel for Power Plant

Item	Natural gas	Oil	Coal	Renewable energy
Technical aspect	The existing gas pipeline running near the project site makes fuel supply easy.	Installation of fuel storage and supply facility such as light oil tank is necessary.	- Installation of facility for storage and procurement is needed. - Ash disposal site should also be constructed.	Renewable energy, though does not consume resources, is low in energy density and vulnerable to restrictions of natural conditions (seasonal changes, wind, etc.) and geographic conditions. A backup power plant would be needed for the case power is not generated.
Economic aspect	- This country has natural gas abundantly. It is economical to use natural gas as fuel for plant. - Cost for construction of gas supply facility is low.	Cost for supply facility construction is also expensive.	- Cost for construction of the supply facility. - Land acquisition is necessary to install a coal storage site and an ash disposal site.	-High facility cost. -Power generation of 600MW expected in this project requires a vast area of land (ex.: more than 700 ha for solar power generation).
Environmental-social consideration	As fuel used here contains very little ash and sulfur, soot and SOx are not generated.	Dust collector and desulfurization equipment is necessary to treat ash and sulfur in the fuel.	- A dust collector shall be installed as fuel contains much ash. A desulfurization system is needed depending on sulfur content. - Since large-sized land acquisition is occurred, a significant impact on the local society is predicted.	Air pollutant and CO_2 are not emitted in the process of power generation. CO_2 may be generated depending on the type of backup power plant.

(Source: JICA Survey Team)

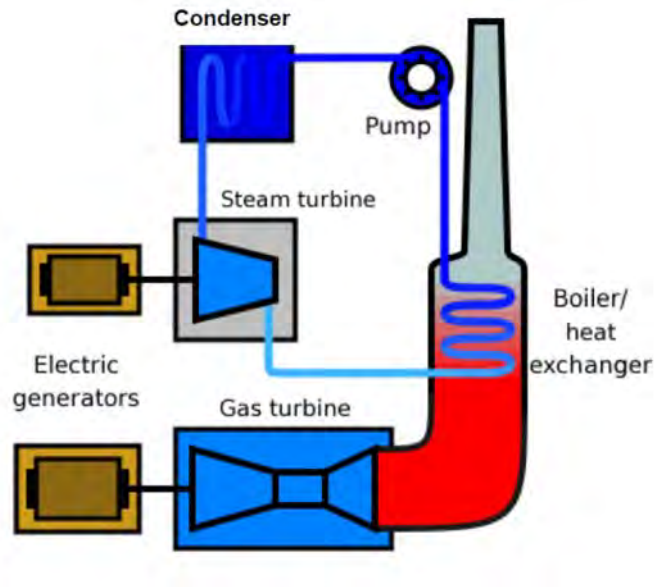
12.4.4 Consideration of the Power Generation Method

In the case natural gas is used for fuel, combined cycle power generation uses steam power with exhaust heat from internal-combustion power generation and has high power generation efficiency and advantages in obtaining power sources compared to a conventional power plant such as gas-fired thermal power generation (Table 12.4.4-1, Figure 12.4.4-1). In addition, high generation efficiency reduces CO_2 emission intensity, making combined cycle power generation more advantageous in view of environment protection.

Table 12.4.4-1 Consideration of Power Generation Method

Item	Combined cycle thermal power generation	Conventional thermal power generation
Technical aspects	Gas turbine generation is also possible in case of employing a bypass system, which makes construction period shorter, while power output is comparatively smaller.	Construction period of conventional thermal power plant is longer than that of combined cycle thermal power generation by the number and kind of equipment. Plant cannot be put into operation until the plant is completed.
Economic aspect	Generation efficiency is high and cost per unit generation amount is lower.	Lower generation efficiency and higher cost per unit generation compared to the combined cycle.
Environmental-social consideration	High generation efficiency results in lower CO_2 generation per unit generation amount.	Lower generation efficiency and higher CO_2 emission per unit generation amount compared to the combined cycle.

(Source: Preparatory Survey on Turakurgan Thermal Power Plant Construction Project, JICA)



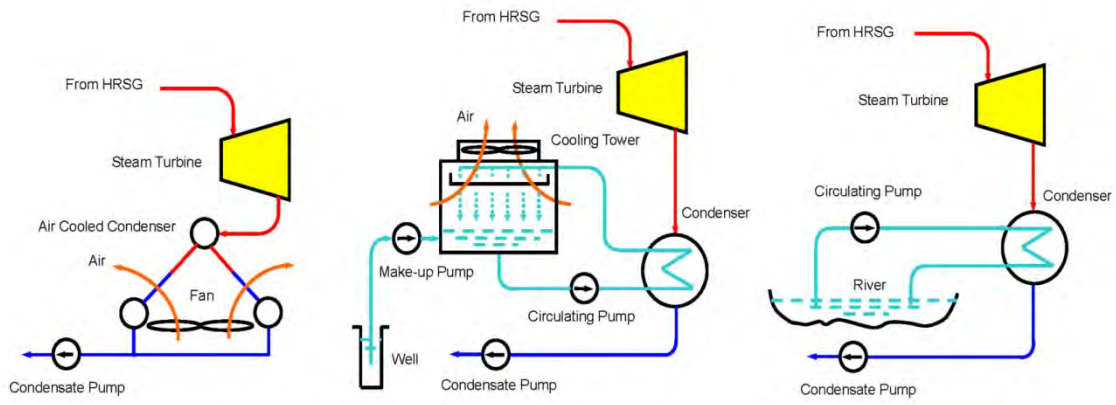
(Source: combined cycle (http://ja.wikipedia.org))

Figure 12.4.4-1 Outline of Combined Cycle Generating Plant

12.4.5 Consideration of Cooling System

As shown in Figure 12.4.5-1, three types of cooling system for steam turbine may be considered. Table 12.4.5-1 is the summary of the characteristics of three cooling systems.
For GTCC3, (1) Forced draft air cooling system and (3) Once-through cooling system are considered for adoption. In case of (3), generation efficiency of power plant will be higher than case of (1) but flow rate and water level of Zeravshan River may be not sufficient in dry season.

As a result of discussions with Uzbekenergo, forced draft air cooling system shown as (1) in Figure 12.4.5-1 is adopted in order to eliminate the adverse effect on the water quality and water volume of Zeravshan River by thermal effluent and intake of cooling water.



(1) Forced-draft air cooling system **(2) Forced-draft cooling tower system** **(3) Once-through cooling system**

(Source: JICA Survey Team)

Figure 12.4.5-1 Outline of the Major Condenser Cooling System

Table 12.4.5-1 Comparison of Cooling System

Items	(1) Forced draft air cooling system	(2) Forced-draft cooling tower system	(3) Once-through cooling system
Cost for installation	Not determined Estimated to be higher than (2).	Not determined	Not determined Estimated to be lower than (1)(2).
Cooling water (condenser)	Not necessary	Necessary	Necessary
Installation space	[Base]	[compared to Base] smaller	[compared to Base] smaller
Water management	Not necessary	Necessary	Necessary
Generation efficiency	[Base]	[compared to Base] slightly higher	[compared to Base] higher
Thermal effluent	Not discharged	Discharged Estimated to be smaller than (3).	Discharged Estimated to be larger than (2).
Noise	[Base]	[compared to Base] slightly lower	[compared to Base] lower
Adoption example in Uzbekistan	GTCC2（under construction）	GTCC1（operating）	Unit1, 2, 3, 4, 6, 8, 9 of Navoi old and many other thermal power stations

(Source: JICA Survey Team)

12.5 Scoping and TOR of the Survey

12.5.1 Draft Scoping

(1) Predicted Environmental Impacts

The predicted environmental impact items and the aspect of the environmental impact is assumed and summarized in Table 12.5.1-1 for power plant and Table 12.5.1-2 for transmission line, respectively, according to the items cited in JICA Guidelines and based on the available information including the EIA report of GTCC3 and 4, 220kV transmission line and 220kV/500kV substation.

As for access roads, existing roads will be modified and used for carrying heavy equipment and materials under construction, but there are no plans for widening. The gas pipeline will be installed in the power plant site, land acquisition or land modification are not expected. Intake facilities will be installed along existing intake channels, and drainage facilities will be installed on the east side of the site, but will be implemented as part of the construction of the power plant facilities.

Expected adverse effects of access roads, gas pipelines and water intake / drainage facilities to environment and social condition are air pollution, noise and waste during construction, but the number and type of machines used is less than that of power plant construction.

For this reason, environment and social impact caused by these associated facilities are included in the scope and TOR of the Power Plant.

EMP and EMoP of these facilities are included in those of the Power Plant.

Table 12.5.1-1 Scoping Result for Power Plant

No.	Item	Assessment				Reasons for assessment
		Construction phase		Operation phase		
		Positive	negative	Positive	negative	
Pollution Control						
1	Air pollution	D	B	D	B	**Construction phase:** - Emission of air pollutant (NOx, PM) is expected by operation of construction vehicles and equipment, but the impact will be limited only in the adjacent area. **Operation phase:** - NOx is generated from the exhaust gas used for fuel, but SO2 and soot generation will be insignificant. - Since cumulative effects with new and existing facilities are assumed as a result of the implementation of this project, it is necessary to confirm the impacts, including the reduction of emissions due to the suspension or decommissioning of deteriorated facilities.

No.	Item	Assessment				Reasons for assessment
		Construction phase		Operation phase		
		Positive	negative	Positive	negative	
2	Water pollution	D	B	D	B	**Construction phase**: - Turbid water, concrete waste water and oil-containing waste water, and domestic waste water of construction workers is generated. **Operation phase**: - Since cumulative effects with new and existing facilities are assumed as a result of the implementation of this project, it is necessary to confirm the impacts, including the reduction of emissions due to the suspension or decommissioning of deteriorated facilities. - Cooling system is air cooled condenser cooling system and therefore lowering level of the river caused by large amount of water usage is not assumed. - Wastewater is generated, but the amount is not so large.
3	Wastes	D	B	D	B	**Construction phase**: - General waste and hazardous waste will be generated by the construction work. **Operation phase**: - General waste and hazardous waste will be generated.
4	Soil contamination	D	B	D	B	**Construction phase**: - Possibility of soil pollution caused by leakage of lubricant from construction activity s. **Operation phase**: - Possibility of soil pollution caused by leakage of lubricant, fuel oil and chemical material from operation.
5	Noise and vibration	D	B	D	B	**Construction phase**: - Impact of noise and vibration is predicted caused by operation of heavy machines and trucks, but only temporarily **Operation phase**: - Some equipment in the power plant generates noise or vibration. - Since cumulative effects with new and existing facilities are assumed as a result of the implementation of this project, it is necessary to confirm the impacts, including the reduction of noise and vibration due to the suspension or decommissioning of deteriorated facilities.
6	Land subsidence	D	D	D	D	**Construction phase and Operation phase**: - No ground water will be pumped.
7	Odor	D	D	D	D	**Construction phase and Operation phase**: - Substances generating bad odor will not be used.
8	Bottom sediment	D	B	D	B	**Construction phase**: - Leakage of untreated effluent may cause sediment pollution. **Operation phase** - Leakage of untreated effluent may cause sediment pollution.
Natural environment						
1	Protected area	D	D	D	D	**Construction phase and Operation phase:** - There is no protected area in and around the project site.

No.	Item	Assessment				Reasons for assessment
		Construction phase		Operation phase		
		Positive	negative	Positive	negative	
2	Terrestrial ecosystem and valuable species	D	D	D	D	**Construction phase**: - The project site is an artificially cleared and prepared land and little impact on terrestrial organisms is predicted. No valuable species of flora/fauna is observed within the project site. **Operation phase**: - The surrounding area is used for human activity and potentially affected ecosystem is very small. The site is not of ecological importance.
3	River ecosystem and valuable species	D	B	D	B	**Construction phase**: - Water turbidity caused by effluent from construction work may have potential impact on river ecosystem. **Operation phase**: - Since cumulative effects with new and existing facilities are assumed as a result of the implementation of this project, it is necessary to confirm the impacts, including the reduction of emissions due to the suspension or decommissioning of deteriorated facilities. - Cooling system is air cooled condenser cooling system and therefore lowering level of the river caused by large amount of water usage is not assumed. - Wastewater is generated, but the amount is not so large.
4	Hydrology (river)	D	D	D	B	**Construction phase**: - Water intake from construction work is not predicted. **Operation phase**: - The river water will be taken for water usage. - Since cumulative effects with new and existing facilities are assumed as a result of the implementation of this project, it is necessary to confirm the impacts, including the reduction of emissions due to the suspension or decommissioning of deteriorated facilities. - Cooling system is air cooled condenser cooling system and therefore lowering level of the river caused by large amount of water usage is not assumed.
5	Hydrology (ground water)	D	D	D	D	**Construction phase and Operation phase**: - Ground water pumping is not conducted.
6	Geography and geology	D	D	D	D	**Construction phase and Operation phase**: - The site is already prepared for power plant use, and the alteration of geographical features will be very limited.
Social environment						
1	Involuntary resettlement and land acquisition	D	B	D	D	**Preconstruction**: - Involuntary resettlement is not predicted at present. The site is partly used for dacha and farmland and compensation may be required. Detailed survey and appropriate measures are necessary.

No.	Item	Assessment				Reasons for assessment
		Construction phase		Operation phase		
		Positive	negative	Positive	negative	
2	Poor peoples	D	C	D	D	**Preconstruction**: - Involuntary resettlement is not predicted at present. The site is partly used for dacha and farmland and compensation may be required. Detailed survey and appropriate measures are necessary.
3	Minorities and indigenous people	D	D	D	D	**Preconstruction, Construction phase and Operation phase**: - There are no minority group and indigenous people living around the project site.
4	Local economy including employment and means of livelihood	B	B	B	D	**Preconstruction**: - Involuntary resettlement is not predicted at present. The site is partly used for dacha and farmland and compensation may be required. Detailed survey and appropriate measures are necessary. **Construction phase and Operation phase**: - The employment of local people as project workers, and purchase of project equipment and material from the local business will activate local economy.
5	Land Use and Utilization of Local Resources	D	D	D	D	**Construction phase and Operation phase**: - The site is a land for power plant use and use of land and local resources will not be affected.
6	Water use	D	D	D	B	**Construction phase:** -Water intake from construction work is not predicted. **Operation phase:** - The river water will be taken for water usage. - Zeravshan River around the power plant is not used for fishery or river traffic. - Detailed survey of river water use for agriculture are necessary - Since cumulative effects with new and existing facilities are assumed as a result of the implementation of this project, it is necessary to confirm the impacts, including the reduction of emissions due to the suspension or decommissioning of deteriorated facilities. - Cooling system is air cooled condenser cooling system and therefore lowering level of the river caused by large amount of water usage is not assumed.
7	Existing Social Infrastructure and Services	D	B	D	B	**Construction phase**: - Increased number of workers and their family may lead to the need for improvement of infrastructure (houses, medical facility, school, sewage). - The commute for power plant workers will temporarily increase the traffic volume of the surrounding roads. **Operation phase**: - Increased traffic may cause damage to the road.

No.	Item	Assessment				Reasons for assessment
		Construction phase		Operation phase		
		Positive	negative	Positive	negative	
8	Social bodies including society-related capitals and social organizations that make local decisions	D	D	D	D	**Preconstruction, Construction phase and Operation phase**: - Compensation process for land acquisition and crops shall be conducted according to the relevant regulations. Consequently, social bodies including local decision-making organization should not be affected.
9	Unfair distribution of loss and benefit	D	B	D	B	**Preconstruction phase**: - The site is a power plant site partly used for dacha and farmland, and misdistribution of benefits and loss regarding compensation or assistance is predicted. **Construction phase**: - If employing local people and/or outsourcing contracts are not fair, benefit may be unfairly distributed. **Operation phase:** - If employing local people and/or outsourcing contracts are not fair, benefit may be unfairly distributed.
10	Local Conflicts of Interest	D	B	D	D	**Preconstruction and construction phase:** - The site is a power plant site partly used for dacha and farmland, and local conflicts of interest may occur by inadequate compensation. - Numbers of construction workers from outside is expected, and lack of understanding of local customs may lead to conflicts with local residents. **Operation phase**: - Workers from outside will be limited in number, and the little conflict between the local people and outside workers arising from difference in custom is not anticipated.
11	Cultural heritage	D	D	D	D	**Construction phase and Operation phase**: - Historical, cultural and/or archaeological property and heritage does not exist around the project site.
12	Landscape	D	D	D	D	**Construction phase and Operation phase**: - There is no scenic area around the project site.
13	Gender	D	C	D	C	**Preconstruction phase:** - The site is a power plant site partly used for dacha and farmland, and the affected people may include females. **Construction phase**: - Inequality of employment condition due to gender may occur. **Operation phase** : - Inequality of employment condition due to gender may occur.
14	Children's Rights	D	C	D	D	**Pre-construction phase**: - The site is a power plant site partly used for dacha and farmland, and the affected people may include children. **Construction phase**: - The possibility of negative impact such as child workers on the construction site is necessary. **Operation phase**: - Recruiting children for workers is not anticipated.

No.	Item	Assessment				Reasons for assessment
		Construction phase		Operation phase		
		Positive	negative	Positive	negative	
15	HIV/AIDS and other infectious diseases	D	B	D	D	**Construction phase**: - Influx of migrant workers may increase the risk of spread of infectious diseases. **Operation phase**: - Workers from outside will be limited in number and spread of infectious disease will be prevented by regular health checkup and other means.
16	Work environment (including labor safety)	D	B	D	B	**Construction phase**: - Risk of labor accident is relatively high. **Operation phase**: - Labor accident may affect the workers
Others						
1	Accidents	D	B	D	B	**Construction phase**: - Possibility of traffic accident by operation of construction vehicles. **Operation phase**: - Possibility of traffic accident by project vehicles and fire of the facility.
2	Cross-boundary Impact and Climate Change	D	D	D	C	**Construction phase**: - Although CO_2 will be produced by construction work, construction period is limited and cross-boundary pollution and impact on climate change is predicted to be insignificant. **Operation phase**: - The existing steam turbine power generation facilities constructed in Soviet Union is to be suspended when ODA loan is financed to this Project and the operation of GTCC 3 commences. - Therefore, the effect of reducing GHG emissions through the implementation of this project is expected.

Notes: The categorization criteria are as follows.
A: Significant positive/negative impact is expected.
B: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown.
(A further examination is needed, and the impact may be clarified as the study progresses.)
D: No impact is expected.

(Source: JICA Survey Team)

Table 12.5.1-2 Scoping Result for Transmission Line and Substation

No.	Item	Assessment				Reasons for assessment
		Construction period		Operation period		
		Positive	Negative	Positive	Negative	
Pollution control						
1	Air pollution	D	B	D	D	**Construction phase:** - Although heavy equipment and trucks are likely to generate air pollutants (including NOx and PM), there shall be very few of these so the quantity of emissions should be low. Thus, impact from the emission is likely to be limited to the vicinities of the construction areas. Also, the construction period of each tower is short and the impact is temporary. **Operation phase:** - No air pollutants will be generated.
2	Water pollution	D	B	D	D	**Construction phase:** - The transmission line route and substation are located mainly in a flat area with very little slope, and the soil run-off from earth cuts and the resulting turbidity is not expected. The impact should be temporary. - Domestic waste water, concrete-containing waste water and oil-containing waste water is likely to be generated. However, since the quantity of workers and construction work is limited, the scope of impact should be limited and temporary. **Operation phase:** - No water pollutants will be generated.
3	Waste	D	B	D	D	**Construction phase:** - Construction work will generate general waste and hazardous waste. However, since the quantity of workers and construction work is limited, generation of waste is likely to be little. **Operation phase:** - Waste will hardly be generated.
4	Soil contamination	D	B	D	B	**Construction phase:** - Lubrication oil, fuel oil and chemical material spilled by from c construction activity are likely to cause contamination to the soil. However, since the quantity of construction work is limited, impact should be little and temporary. **Operation phase:** - In the substation, Leakage of oil in the transformer may be occurred.

No.	Item	Assessment				Reasons for assessment
		Construction period		Operation period		
		Positive	Negative	Positive	Negative	
5	Noise and vibration	D	B	D	B	**Construction phase:** - The operation of heavy equipment and trucks will probably cause a temporary impact from the noise and vibrations. However, there shall be very few equipment and trucks so the quantity of noise and vibrations should be low. Thus, impact will be limited to the vicinities of the construction areas. **Operation phase:** - In the substation, noise of transformer will be generated.
6	Land subsidence	D	D	D	D	**Construction and operation phase:** - Water will not be drawn up from underground.
7	Odor	D	D	D	D	**Construction phase:** - The transmission towers will be built on the flat floor. Therefore, soil of some embankments and earth cuts may not overflow into the river. **Operation phase:** - Waste will hardly be generated.
Natural environment						
1	Protected area	D	D	D	D	**Construction phase and operation phase:** - The transmission line will not pass through wild life preservation area and there is no such nearby area.
2	Terrestrial ecosystem and valuable species	D	D	D	B	**Construction phase:** - The transmission line route will be along the road and be surrounded by agricultural land. Therefore, terrestrial ecosystem and rare species are not expected to be affected. **Operation phase:** - There are neither rare species of birds However impact of bird strikes will may be occurred.
3	River ecosystem and valuable species	D	D	D	D	**Construction phase:** - The transmission towers will be built on the flat floor. Therefore, soil of some embankments and earth cuts may not overflow into the river. **Operation phase:** - The transmission line route is located mainly in a flat area with very little slope, and the soil run-off from earth cuts and the resulting turbidity is not expected.
4	Hydrology (river)	D	D	D	D	**Construction phase and Operation phase:** - River water will not be taken in.
5	Hydrology (ground water)	D	D	D	D	**Construction phase and Operation phase:** - Water will not be drawn up from underground.
6	Geography and geology	D	B	D	D	**Construction phase:** - The transmission line route is located mainly in a flat area with very little slope, and the soil run-off from earth cuts is not expected. The impact should be temporary. **Operation phase:** - Soil flowage will not occur.

No.	Item	Assessment				Reasons for assessment
		Construction period		Operation period		
		Positive	Negative	Positive	Negative	
Social environment						
1	Involuntary Resettlement and Land acquisition	D	B	D	D	**Preconstruction:** - Involuntary resettlement is not predicted at present. The site is partly used for farmland and compensation may be required. Detailed survey and appropriate measures are necessary.
2	Poor peoples	D	B	D	D	**Preconstruction:** - Involuntary resettlement is not predicted at present. The site is partly used for farmland and compensation may be required. Detailed survey and appropriate measures are necessary.
3	Minorities and indigenous people	D	D	D	D	**Construction phase and Operation phase:** - There is no minority group living around transmission line route.
4	Local economy including employment and means of livelihood	D	B	D	D	**Pre-construction**: - Involuntary resettlement is not predicted at present. The site is partly used for farmland and compensation may be required. Detailed survey and appropriate measures are necessary. **Construction phase:** - The construction will not lead to purchasing material and equipment items in the local area and also not offer employment to local people. **Operation phase:** - The operation will not lead to purchasing material and equipment items in the local area and also not offer employment to local people.
5	Land use and utilization of local resources	D	B	D	D	**Construction phase** - Land acquisition will take place in tower of transmission and substation site and is likely to result in temporary losses of farm land. **Operation phase:** - There is no impact for Land use around transmission line and substation.
6	Water use	D	B	D	D	**Construction phase:** - The transmission line route and substation are located mainly in a flat area with very little slope, and the soil run-off from earth cuts and the resulting turbidity is not expected. The impact should be temporary. - Domestic waste water, concrete-containing waste water and oil-containing waste water is likely to be generated. However, since the quantity of workers and construction work is limited, the scope of impact should be limited and temporary. **Operation phase:** - The transmission line and substation will hardly generate waste water.

No.	Item	Assessment				Reasons for assessment
		Construction period		Operation period		
		Positive	Negative	Positive	Negative	
7	Existing social infrastructure and social service	D	B	D	D	**Construction phase**: - Inflow of the limited number of workers is expected. - Traffic is expected to increase during construction but is limited. **Operation phase:** - The very few numbers of workers are expected at periodical inspections.
8	Social bodies including society-related capitals and social organizations that make local decisions	D	D	D	D	**Pre-construction, Construction phase and Operation phase**: - Compensation process for land acquisition and crops shall be conducted according to the relevant regulations. Consequently, social bodies including local decision-making organization should not be affected.
9	Unfair distribution of loss and benefit	D	B	D	D	**Preconstruction phase**: - The site is partly used for farmland, and misdistribution of benefits and loss regarding compensation or assistance is predicted. **Construction phase:** - If employing local people and/or outsourcing contracts are not fair, benefit may be unfairly distributed. **Operation phase:** - The local people for the operation of the transmission line will not be employed.
10	Local Conflicts of Interest	D	B	D	D	**Pre-construction phase:** - The site is used for farmland, and local conflicts of interest may occur by inadequate compensation. **Construction phase:** - The construction will not lead to purchasing material and equipment items in the local area and will not offer employment to local people. **Operation phase:** - The operation will not lead to purchasing material and equipment items in the local area and will not offer employment to local people.
11	Cultural heritage	D	D	D	D	**Construction phase and Operation phase:** - Since the surroundings of the transmission line route have no historical, cultural and religious precious heritages, no impact is expected.
12	Landscape	D	D	D	D	**Construction phase and Operation phase:** - Since the surroundings of the transmission line route have no scenic spots, no impact is expected.
13	Gender	D	D	D	D	**Construction phase and Operation phase:** - No particular impact is expected to take place on the gender.
14	Rights of children	D	D	D	D	**Construction phase and Operation phase:** - No particular impact is expected to take place on the rights of children.

No.	Item	Assessment				Reasons for assessment
		Construction period		Operation period		
		Positive	Negative	Positive	Negative	
15	HIV/AIDS and other infectious diseases	D	D	D	D	**Construction phase**: - Inflow of the limited number of workers is expected. **Operation phase:** - The very few numbers of workers are expected at periodical inspections.
16	Work environment (including labor safety)	D	B	D	B	**Construction phase**: - Risk of labor accident is relatively high. **Operation phase**: - Labor accident may affect the workers
Others						
1	Accident	D	B	D	B	**Construction phase:** - Traffic accidents may occur during construction **Operation phase:** - Steel towers may fall down due to a storm, heavy rain, etc. - The health impact of electro shock may be occurred
2	Cross-boundary Impact and Climate Change	D	D	D	D	**Construction phase:** - Although CO_2 is generated during construction, the impact is quite limited to a temporal period and hardly expected to take place across the borders and on climatic change. **Operation phase:** - No particular impact is expected to take place across the borders and on climatic change.

Notes: The categorization criteria are as follows.
A: Significant positive/negative impact is expected.
B: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown.
(A further examination is needed, and the impact may be clarified as the study progresses.)
D: No impact is expected.

(Source: JICA Survey Team)

(2) Items that will Potentially Receive Negative Impact and that will Not Be Affected

Table 12.5.1-3 and Table 12.5.1-4 show items that contain negative impacts predicted and the extent of positive/negative impact unknown in the draft scoping in Table 12.5.1-1 and Table 12.5.1-2 and that therefore need further survey.

Table 12.5.1-3 Items of Negative Impact for Power Plant

Item	Construction phase (including pre-construction)	Operation phase
- Items expected to receive certain degree of negative impact - Items whose level of impact is unknown (need additional survey and the impact may become clear in the course of survey).	Pollution Control	
	- Air pollution - Water pollution - Waste - Soil pollution - Noise/vibration - Bottom sediment	- Air pollution - Water pollution - Waste - Soil pollution - Noise/vibration - Bottom sediment
	Natural environment	
	- Terrestrial ecosystem and valuable species - River ecosystem and valuable species	- Terrestrial ecosystem and valuable species - River ecosystem and valuable species - Hydrology (river)
	Social environment	
	- Involuntary resettlement and land acquisition - Poor peoples - Local economy including employment and livelihood - Water use - Existing Social Infrastructure and Services - Unfair distribution of loss and benefit Local Conflicts of Interest - Gender - Children's right - HIV/AIDS and other infectious diseases - Working environment (including working safety)	- Local economy including employment and livelihood - Water use - Existing social infrastructure and services - Unfair distribution of loss and benefit - Gender - Working environment (including working safety)
	Others	
	- Accident	- Accident - Cross-boundary Impact and Climate Change

(Source: JICA Survey Team)

Table 12.5.1-4 Items of Negative Impact for Transmission Line and Substation

Item	Construction phase (including pre-construction)	Operation phase
- Items expected to receive certain degree of negative impact - Items whose level of impact is unknown (need additional survey and the impact may become clear in the course of survey).	Pollution Control	
	- Air pollution - Water pollution - Waste - Soil contamination Noise/vibration	- Soil pollution - Soil contamination - Noise/vibration
	Natural environment	
	- Geography and geology	- Terrestrial ecosystem and valuable species
	Social environment	
	- Involuntary Resettlement and Land acquisition - Poor peoples - Local economy including employment and livelihood - Land use and utilization of local resources - Water use - Existing Social Infrastructure and Services - Unfair distribution of loss and benefit - Local Conflicts of Interest - Working environment (including working safety)	- Working environment (including working safety)
	Others	
	- Accident	- Accident

(Source: JICA Survey Team)

12.5.2 Term of Reference for the Survey

(1) Review of the EIA

Considering the scoping results described in Table 12.5.1-1 and Table 12.5.1-2, which is mainly based on the information from Final EIA report for GTCC3 and 4 , GTCC3 and 4, 200 kV transmission line and 220 kV/500 kV substation.

The survey items, survey method and predicted assessment method for the environmental impact assessment shall be described as cited in Table 12.5.2-1 for power plant and Table 12.5.2-2 for transmission line.

Table 12.5.2-1 Survey Item and Method, Prediction Assessment and Mitigation Measure for Power Plant

Item	Check item	Survey method	Prediction assessment and mitigation measure
Air pollution	- Conditions of residential land and agricultural area - Meteorological condition - Atmospheric condition	- Existing documents - On-site survey and hearing - Acquirement of the existing data （temperature, humidity, wind direction and speed） - Existing documents	**Construction phase:** - Existing documents - On-site survey and hearing - Consideration of air pollution prevention measure **Operation phase:** - Consideration of air pollution mitigation measures - Consideration of compliance with gas emission standard - Consideration of compliance with ambient air quality standard using air diffusion simulation of exhaust gas - Assessment of cumulative impact on air quality caused by existing power plants and GTCC3.
Water pollution	- Water quality	- Existing documents - On-site survey and hearing	**Construction phase:** - Consideration of waste water treatment measure **Operation phase:** - Consideration of waste water treatment measure - Consideration of compliance with water discharge standard - Assessment of cumulative impact on water quality caused by existing power plants and GTCC3.
Waste	- Waste treatment and disposal plan	- On-site survey and hearing	**Construction phase:** - Consideration of waste treatment **Operation phase:** - Same as construction phase

Item	Check item	Survey method	Prediction assessment and mitigation measure
Soil contamination	- Hazardous substances management and storage plan	- On-site survey and hearing	**Construction phase:** - Consideration of oil leakage mitigation measures **Operation phase:** - same as construction phase
Noise and vibration	- Conditions of residential land and agricultural land - Noise and vibration	- Existing documents - On-site survey and hearing	**Construction phase:** - Consideration of noise and vibration prevention measures of construction vehicles and machines. - Confirmation of compliance with the environmental standard using prediction formula based on propagation theory **Operation phase:** - Consideration of noise and vibration prevention measures - Confirmation of compliance with the environmental standard using prediction formula based on propagation theory - Assessment of cumulative impact on noise caused by existing power plants and GTCC3.
Bottom sediment	Management plan of Waste water treatment facility	- On-site survey and hearing	**Construction phase:** - Consideration of waste water treatment measures **Operation phase:** - same as construction phase
River ecosystem and valuable species	- Habitat and growth of river flora and fauna	- Existing documents - On-site survey and hearing	**Construction phase:** - Consideration of waste water **Operation phase:** - same as construction phase - Assessment of cumulative impact on water quality caused by existing power plants and GTCC3.
Hydrology (river)	- River flow	- Existing documents - - On-site survey and hearing	**Operation phase:** Assessment of cumulative impact on water intake caused by existing power plants and GTCC3.

Item	Check item	Survey method	Prediction assessment and mitigation measure
Resettlement and land acquisition	- Income condition - Land use - Resettlement status (scale and others)	- Existing documents - On-site survey and hearing	**Preconstruction:** - Development of abbreviated resettlement plan and implementation of compensation based on the plan
Poor peoples	- Income condition - Status of people in poverty among affected people	- On-site survey and hearing	**Preconstruction, Construction phase and Operation phase:** - Consideration of necessary mitigation measures
Local economy including employment and means of livelihood	- Income condition - Local employment status and income - Local economy	- Existing documents - Hearing	**Construction phase:** - Consideration of employment of local residents **Operation phase**: - same as construction phase
Water use	- Agriculture use - River flow	- Existing documents - - On-site survey and hearing	**Operation phase:** Assessment of cumulative impact on water intake caused by existing power plants and GTCC3.
Existing Social Infrastructure and Services	- Infrastructures including hospital, school	- Existing documents - Hearing	**Construction phase:** - Consideration of necessity of mitigation for increase in traffic volume and establishment of infrastructure **Operation phase:** - same as construction phase
Unfair distribution of loss and benefit	- Local employment status - Local economy	- Existing documents - Hearing	**Construction phase:** - Consideration of employment of local residents **Operation phase:** - same as construction phase
Local Conflicts of Interest	- Local employment status and income - Local economy	- Existing documents - Hearing	**Construction phase:** - Consideration of educational method of local customs
Gender	- Status of women's right	- Existing documents - Hearing	**Preconstruction, Construction phase and Operation phase:** - Consideration of necessary mitigation measures
Children's right	- Educational status	- Existing documents - Hearing	**Construction phase:** - Consideration of child labor prevention

Item	Check item	Survey method	Prediction assessment and mitigation measure
HIV/AIDS and other infectious diseases	- Public sanitation - Status of disease	- Existing documents - Hearing	**Construction phase:** - Consideration of public sanitation measures
Labor Environment (Including Work Safety)	- Planning of work environment and working safety improvement	- Existing documents - Hearing	**Construction phase:** - Consideration of working safety measures **Operation phase:** - same as construction phase
Accidents	- Working safety plan	- Existing documents - Hearing	**Construction phase:** - Consideration of traffic accident prevention measures **Operation phase:** - Consideration of traffic accident prevention measures - Consideration of fire-fighting facility
Cross-boundary Impact and Climate Change	- CO_2 emission rate	- Existing documents - Hearing	**Construction phase:** - Consideration of necessary mitigation measures **Operation phase:** - Reduction of CO_2 emission rate and calculation of CO_2 discharge

(Source: JICA Survey Team)

Table 12.5.2-2 Survey Item and Method, Prediction Assessment and Mitigation Measure for Transmission Line and Substation

Item	Check item	Survey method	Prediction assessment and mitigation measure
Air pollution	- Conditions of residential land and agricultural area - Meteorological condition	- Existing documents - On-site survey and hearing	**Construction phase:** - Existing documents - On-site survey and hearing - Consideration of air pollution prevention measure
Water pollution	- Conditions of river and canal	- Existing documents - On-site survey and hearing	**Construction phase:** - Consideration of soil runoff countermeasures
Waste	- Waste treatment and disposal plan	- On-site survey and hearing	**Construction phase:** - Consideration of waste treatment
Soil contamination	- Hazardous substances management and storage plan	- On-site survey and hearing	**Construction phase:** - Consideration of oil leakage mitigation measures **Operation phase:** -same as construction phase
Noise and vibration	- Conditions of residential land and agricultural land - Noise and vibration	- Existing documents - On-site survey and hearing	**Construction phase:** - Consideration of noise and vibration prevention measures of construction vehicles and machines.
Terrestrial ecosystems and rare species	- - Habitat status of birds	- Existing documents	**Operation period:** - -Bird strike countermeasures
Geography and geology	- Conditions of land and River	- Existing documents	**Construction period:** - Consideration of soil runoff countermeasures
Involuntary Resettlement and Land acquisition	- Income condition Land use - Resettlement status (scale and others)	- Existing documents - On-site survey and hearing	**Preconstruction:** - Development of abbreviated resettlement plan and implementation of compensation based on the plan
Poor peoples	- Income condition Land use - Resettlement status (scale and others)	- Existing documents - On-site survey and hearing	**Preconstruction:** - Development of abbreviated resettlement plan and implementation of compensation based on the plan
Local economy including employment and means of livelihood	- Income condition Local - employment status and income - Local economy	- Existing documents - Hearing	**Construction phase:** - Consideration of employment of local residents

Item	Check item	Survey method	Prediction assessment and mitigation measure
Land use and utilization of local resources	- Income condition Land use - Resettlement status (scale and others)	- Existing documents - On-site survey and hearing	**Preconstruction:** - Development of abbreviated resettlement plan and implementation of compensation based on the plan
Water use	- Conditions of river and canal	- Existing documents - - On-site survey and hearing	**Construction phase:** - Consideration of soil runoff countermeasures
Existing social infrastructure and social service	- Infrastructures including hospital, school	- Existing documents - Hearing	**Construction phase:** - Consideration of necessity of mitigation for increase in traffic volume and establishment of infrastructure
Unfair distribution of loss and benefit	- Local employment status - Local economy	- Existing documents - Hearing	**Construction phase:** - Consideration of employment of local residents
Local Conflicts of Interest	- Local employment status and income - Local economy	- Existing documents - Hearing	**Construction phase:** - Consideration of educational method of local customs
Work environment (including labor safety)	- Planning of work environment and working safety improvement	- Existing documents - Hearing	**Construction phase:** - Consideration of working safety measures **Operation phase:** - same as construction phase
Accidents	- Working safety plan	- Existing documents - Hearing	**Construction phase:** - Consideration of traffic accident prevention measures **Operation phase:** - Consideration of towers falling down and electro shock preventive measures

(Source: JICA Survey Team)

There is any gap in the EIA content from JICA Environmental Guidelines or WB Safeguard Policy OP4.01, additional content will be discussed with JSC TPP.

In the development of the environmental management plan and the environmental monitoring plan (implementation system and method, expense) in construction and operation phase, the support and suggestion will be provided to JSC TPP as necessary.

12.6 Results of the Survey

12.6.1 Review of Environmental Impact in the EIA Report for Power Plant, Transmission Line and Substation

(1) Power Plant

1) Construction Stage

(a) Air Pollution

Emission of air pollutant (NOx, PM) is expected by operation of construction vehicles and equipment, but the impact will be limited only in the adjacent area.

Mitigation measure such as watering of road and the deposit area and vehicle speed restrictions on roads are described similarly in Final EIA (Final EIA of GTCC3 and 4, p.62). However, it was considered appropriate to examine additional mitigation measures and carry out reassessment.

(b) Water Pollution, Bottom Sediment, River Ecosystem and Valuable Species, and Water Use

Turbid water, concrete waste water and oil-containing waste water, and domestic waste water of construction workers is generated and may have potential impact on river ecosystem. Leakage of untreated effluent may cause sediment pollution.

There is little description on waste water treatment during construction and reassessment will be conducted.

(c) Wastes

General waste and hazardous waste will be generated by the construction work.

Final EIA describes that soil contaminated by fuel leakage is stored in a special container and disposed of as waste. All excavated soil will be disposed within the site.

Construction waste is stored in an appropriately-equipped place, and then entrusted to a specialized contractor for disposal according to the contract. Domestic waste disposal will also be entrusted to the contractor with fully responsibility from a hygienic point of view, and the assessment result and mitigation measures are considered appropriate (Final EIA of GTCC3 and 4 p.62-63).

(d) Soil Contamination

Possibility of soil pollution caused by leakage of lubricant from construction vehicles and machines.

As described above,

Final EIA describes following proper disposal of soil contaminated by fuel leakage and, therefore, the evaluation and mitigation measures are considered appropriate (Final EIA of GTCC3 and 4 p. 62-63).

- Due to poor solubility, petroleum products will have a low migration capacity and will not pose a danger to groundwater.
- In general, during the construction period, soils and groundwater polluted with oil products will have an insignificant risk to the environment and personnel safety.
- In order to further minimize the environmental impact of oil-polluted soils, it is recommended to collect contaminated soil layers into a specially provided container for subsequent disposal.

(e) Noise and Vibration

Impact of noise and vibration is predicted caused by operation of heavy machines and trucks, but only temporarily

Although there is a description that construction work that generates noise, excavation work for example, will be limited to the daytime (Final EIA of GTCC3 and 4 p. 64), more quantitative estimation and execution of additional countermeasures and assessment is concluded to be appropriate.

(f) Involuntary Resettlement and Land Acquisition, Poor People, Local Economy including Employment and Means of Livelihood, Unfair Distribution of Loss and Benefit, Local Conflicts of Interest, Gender, and Children's Rights

Involuntary resettlement is not predicted at present. The site is partly used for dacha and farmland, and a detailed survey and appropriate measures are necessary.
There is also little description about the impact on people in poverty, local economy such as employment and livelihood means, misdistribution of benefits and loss, local conflicts of interest, gender, children's rights resulting from the involuntary resettlement. For this reason, the effects associated with land acquisition will be evaluated based on the findings referred in Chapter 12.10, regarding appropriate compensation and support including mitigation measures and monitoring.

Workers shall be within working age limit (16 years old or over) according to the labor law of Uzbekistan, and child labor is therefore not predicted during the construction and operation.

Also, there are following descriptions that the local laborers are to be employed during the construction and operation, the training during employment is conducted and the employment of women will be secured as much as possible. The evaluation and mitigation measures are considered appropriate (Final EIA of GTCC3 and 4 p. 64-65).

- All workers involved must be of working age, in accordance with the labor legislation of Uzbekistan.
- Specific construction tasks will be carried out within the age limit in accordance with the labor legislation of Uzbekistan.
- As much as possible, attract local labor force for employment in the construction work, carry out a constant check of the original passports at the same time.

(g) Existing Social Infrastructure and Services

Increased number of workers and their family may lead to the need for improvement of infrastructure (houses, medical facility, school, sewage).
The commute for power plant workers will temporarily increase the traffic volume of the surrounding roads.
There is little description on mitigation measures for vehicles during construction and, therefore, reassessment will be conducted.

(h) HIV/AIDS and Other Infectious Diseases

Influx of migrant workers may increase the risk of spread of infectious diseases.
Final EIA states that following programs for prevention and enlightenment regarding human trade will be developed, and at the same time the implementation of enlightenment of HIV/AIDS will be conducted. The evaluation and mitigation measures are considered appropriate (Final EIA of GTCC3 and 4 p.65).

- Develop and implement the program for prevention of and awareness on human trafficking (can be carried out simultaneously with HIV/AIDS awareness).

(i) Labor Environment (Including Work Safety)

Risk of labor accident is relatively high. There is little description on mitigation measures for work safety during construction and, therefore, reassessment will be conducted.

(j) Accidents

Possibility of traffic accident by operation of construction vehicles. There is little description on mitigation measures for accident of construction vehicles during construction and, therefore, reassessment will be conducted.

2) Operation Stage

(a) Air Pollution

NOx is generated from the exhaust gas used for fuel, but SO_2 and soot generation will be insignificant.

The Navoi-old is not equipped with exhaust gas treatment system. The existing boilers adopted multi-stage boilers to reduce nitrogen oxide emissions, but the effects have not been fully achieved (Final EIA of GTCC3 and GTCC4, p. 20).

The power generation efficiency of the existing power generation facility is 34 to 37% (Final EIA of GTCC3 and 4 p.57).

Since cumulative effects with new and existing facilities are assumed as a result of the implementation of this project, it is necessary to confirm the impacts, including the reduction of emissions due to the suspension or decommissioning of deteriorated facilities.

Final EIA predicted and assessed the following mitigation measures and cumulative impacts (Final EIA of GTCC3 and GTCC4, p.58,66-70,84).

- The NOx concentration in exhaust gas will comply with the emission standard of 25 ppm.
- A stack of 112m height is installed to conform to the Uzbekistan environmental standard.
- The comparison of the current and future emission of air pollutants is shown in Table 12.6.1-1. The current amount of NO_2, NO and CO emission is approximately 3,484 tons/year, 578 tons/year and 874 tons/year, but after the decommission of the existing facilities, it will decrease to approximately 2,697 tons/year, 481 tons/year and 708 tons/year which is the total emission from GTCC1 to GTCC4.
- Total emission of all pollutants is 4,977 tons/year at present. After the decommission of the existing facilities, it will decrease to about 3,906 tons/year which is the total emission from GTCC1 to GTCC4.
- The maximum ground concentration of NO_2, which is the pollutant with large emission, is 1.03 (MAC) at present, but will decrease to 0.87 MAC at the operation of GTCC2, and further to 0.24 MAC at the operation of GTCC3 and 4.

However, the impact at the time of both the existing facilities and GTCC3 in operation has not been predicted, and the impact evaluation including the background concentration shall be conducted as it is not conducted in Uzbekistan.

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Table 12.6.1-1 Comparison of the Current and Future Emission of Air Pollutants (t/year)

Operation status of the generation facilities	Current status	Status during operation of GTCC2	Status during operation of GTCC3 and 4 (after the shutdown of the existing Navoi facilities)	Main source
	Existing Unit3-5, Unit 7-12, GTCC1 in operation	Existing Unit4, 7, Unit 9-12, GTCC1-2 in operation	GTCC1-4 in operation	
Capacity of power generation/heat supply facility	1,618 MW 641 Gcal/h	1,758 MW 808 Gcal/h	1,928 MW 643 Gcal/h	-
Nitrogen oxide	578.1	581.6	480.8	Boiler Gas turbine
Nitrogen dioxide	3484.2	3581.8	2696.8	Boiler Gas turbine
Carbon oxide	873.7	908.8	708.2	Boiler Gas turbine
Sulfur dioxide	21.2	18.0	1.1	Boiler (under oil use) Chemical tank for water treatment
Sulfuric acid aerosol	10.0	10.0	10.0	Chemical tank for water treatment
Hydrocarbon	6.9	6.9	6.9	Oil tank
Hydrogen chloride	2.1	2.1	2.1	Chemical tank for water treatment
Others	0.5	0.5	0.4	Welding Chemical tank for water treatment Maintenance
Total	4976.6	5109.6	3906.3	

(Source: JICA Survey Team)

(b) Water Pollution, Bottom Sediment, River Ecosystem and Valuable Species, and Water Use

Since cumulative effects with new and existing facilities are assumed as a result of the implementation of this project, it is necessary to confirm the impacts, including the reduction of effluent due to the suspension or decommissioning of deteriorated facilities.
Cooling system is air cooled condenser cooling system and therefore lowering level of the river caused by large amount of water usage is not assumed.
Wastewater is generated, but the amount is not so large.
The amount of thermal effluent is predicted to decrease due to the adoption of air-cooling fans and the shutdown of all the existing facilities (Final EIA of GTCC3 and 4, p. 60).
However, the impact at the time of the existing facilities and GTCC3 in operation need to be evaluated since it has not been estimated.

(c) Wastes

General waste and hazardous waste will be generated.
Regarding the disposal of waste from the existing facilities, Final EIA states that it is treated according to the danger class based on the laws and regulations of Uzbekistan, and that the amount of waste generation will not change after the shutdown of the existing facilities.

In basic, the GTCC project consumes less water than the conventional steam turbines, and the amount of sludge generated from water treatment is also small. In addition, the amount of waste oil generated around the fuel oil tank are small, the assessment and mitigation measures are considered appropriate (Final EIA of GTCC3 and 4, p. 31-33, 65).

(d) Soil Contamination

Possibility of soil pollution caused by leakage of lubricant and fuel oil from operation.
Although there is no description of mitigation measures in the EIA, installation of large-scale fuel oil tanks is not planned.
The examination of additional mitigation measures and the reassessment will be conducted.

(e) Noise and Vibration

Some equipment in the power plant generates noise or vibration.
Since cumulative effects with new and existing facilities are assumed as a result of the implementation of this project, it is necessary to confirm the impacts, including the reduction of noise and vibration due to the suspension or decommissioning of deteriorated facilities.
Noise from GTCC units meets the noise standard in residential area (45 dB). Monitoring will be carried out for confirmation.
The vibration from the GTCC units does not exceed 50 dB at the site boundary and is at the unperceivable level (Final EIA of GTCC3 and 4, p. 72).
The following noise and vibration reduction measures are described. (Final EIA of GTCC3 and 4, p. 72-73)

- In order to prevent noise, the wind speed in the duct will be optimized, and the main noise source will be stored inside the building, and anti-vibration materials will be installed to the fan of the exhaust gas discharge system and the air conditioning system.
- Monitoring will be conducted to determine the significance of impact on residential areas.

The quantitative evaluation of the impact including the existing facilities has not been conducted, and the examination of mitigation measures and the reassessment need to be conducted

(f) Local Economy Including Employment and Means of Livelihood, Unfair Distribution of Loss and Benefit, and Gender

The employment of local people as project workers, and purchase of project equipment and material from the local business will activate local economy.
There is little description on the positive effect of employment and economic activities during operation, and the examination of additional mitigation measures and the reassessment will be conducted.

(g) Existing Social Infrastructure and Services

Increased traffic may cause damage to the road.
There is little description on the impact of damage caused by increased traffic during operation, and the examination of additional mitigation measures and the reassessment will be conducted.

(h) Labor Environment (Including Work Safety)

Labor accident may affect the workers.
Regarding working safety in operation phase, personal safety gear will be provided. There is little description on the labor environment except the use of noise prevention tools (headphones, earplugs) in the high noise level environment, and the examination of additional mitigation measures and the reassessment will be conducted （Final EIA of GTCC3 and 4, p.84）.

(i) Accidents

Possibility of traffic accident by project vehicles and fire of the facility.
The following firefighting measures are described in Final EIA. (Final EIA of GTCC3 and 4, p. 77-78)

- Automatic carbon dioxide (CO_2) fire extinguishing system is installed.
- Alarm system, manual fire detectors, sensors and alarms to ensure employee safety.
- The valves of the gas supply system are explosion-proof.
- Securing of evacuation route from all the fire hazard areas and of the passage for firefighting

However, as there is little description of traffic countermeasures, the examination of mitigation measures and the reassessment will be carried out.

(j) Cross-boundary Impact and Climate Change

The existing steam turbine power generation facilities constructed in Soviet Union is old and be suspended when ODA loan is financed to this Project and the operation of GTCC3 commences.
Therefore, the effect of reducing GHG emissions through the implementation of this project is expected.
The J class 650 MW GTCC unit to be introduced has high power generation efficiency (more than 60%) and consumes less fuel per power generation output than existing facilities. The implementation of the project will save 587 million m^3 of natural gas annually and reduce greenhouse gases (Final EIA of GTCC3 and 4, p.71).
Details will be described in Chapter 12.11.

(2) Transmission Line and Substation

1) Construction Stage

(a) Air Pollution

Heavy equipment and trucks are likely to generate air pollutants (including NOx, and PM), there shall be very few of these so the quantity of emissions should be low. Thus, impact from the emission is likely to be limited to the vicinities of the construction areas.

The result of air diffusion simulation assuming emission from construction machineries etc., shows that the contribution of pollutants concentration in the air is extremely low and remains the same as current level.
The following is described as main mitigation measures.

- Inspection of vehicles and diesel equipment etc. before the usage
- Watering during strong wind
- Covering vehicles transporting earth and sand

The evaluation and mitigation measures are considered appropriate (Final EIA of transmission line p.50, 61, 64, Final EIA of substation p.62, Annex Environmental management plan of these Final EIA).

(b) Water Pollution, Soil Pollution, River Ecosystem and Valuable Species, Geography and Geology, Water use

The transmission line route and substation are located mainly in a flat area with very little slope, and the soil run-off from earth cuts and the resulting turbidity is not expected. The impact should be temporary.

Domestic waste water, concrete-containing waste water and oil-containing waste water is likely to be generated. However, since the quantity of workers and construction work is limited, the scope of impact should be limited and temporary.

The following is described as the main mitigation measures.

- No construction of towers within 100 m range from Zeravshan River
- Implementation of erosion prevention measures within 50 m from waterway before construction works
- Storage of lubricant and fuel in dedicated tanks more than 50 m away from water area
- Storage of excavated earth and sand in a place where there are not affected by flood
- Compression of earth and sand after backfilling
- Control soil erosion using appropriate drainage system and vegetation
- Use of mobile septic tank for workers

Also, there are no water canals or rivers near the substation, Zeravshan River is about 1.2 km away.

The evaluation and mitigation measures are considered appropriate (Final EIA of transmission line p.61, Final EIA of substation p.4, Annex Environmental management plan of these Final EIA).

(c) Waste

Construction work will generate general waste and hazardous waste. However, since the quantity of workers and construction work is limited, generation of waste is likely to be very little.

The following is described as the main mitigation measures.

- Submission of a waste disposal plan and reception of its approval one month before start of construction works
- Securing safe disposal and storage area
- Recovery and reuse of waste oil and lubricant and prohibition of combustion
- Prevention of leakage by the maintenance of equipment
- Collection and disposal of solid waste and life waste under the agreement with local government (Khokimiyat)

The evaluation and mitigation measures are considered appropriate (Final EIA of transmission line, Final EIA of substation, Annex Environmental management plan of these Final EIA).

(d) Noise and Vibration

The operation of heavy equipment and trucks will probably cause a temporary impact from the noise and vibrations. However, there shall be very few equipment and trucks so the quantity of noise and vibrations should be low. Thus, impact will be limited to the vicinities of the construction areas.

Installation works of towers near residential buildings, including excavation is limited during the daytime, and noise related to construction activity is temporary and periodic, therefore noise level around the residential area will not exceed environmental standard. Vibration is also temporary therefore it will not extend outside the working area.

The following is described as the main mitigation measures.

- Attachment of silencer to heavy construction machineries and equipment, and introduction of enclosed equipment

- Installation of noise prevention wall when necessary
- Maintenance of vehicles and implementation of speed limitation

The evaluation and mitigation measures are considered appropriate (Final EIA of transmission line p.59, Final EIA of substation p.63, Annex Environmental management plan of these Final EIA).

(e) Involuntary Resettlement and Land Acquisition, Poor People, Local Economy Including Employment and Means of Livelihood, Unfair Distribution of Loss and Benefit, Local Conflicts of Interest

Involuntary resettlement is not predicted at present. The site is partly used for farmland and compensation may be required. and local conflicts of interest may occur by inadequate compensation. The construction will not lead to purchasing material and equipment items in the local area and also not offer employment to local people.

The area of land acquisition at the base of steel tower will be 0.284 ha, which is mainly used as agricultural lands for wheat away from residential area.

The following is described as the main mitigation measures.

- Implementation of compensation along with the compensation plan and schedules
- Implementation of compensation of trees under the market price before construction
- Selection of routes along with the boundary of cultivated lands to minimize loss
- Implementation of construction after harvesting agricultural products

Also, the following measures for workers and employments will be conducted.

- Employment of local workers and drivers
- Purchase of local goods and use of local service

The evaluation and mitigation measures are considered appropriate (Final EIA of transmission line p.50, 61, 64, Final EIA of substation p.5, Annex Environmental management plan of these Final EIA).

There is also little description about the impact to people in poverty, local economy such as employment and livelihood means, misdistribution of benefits and loss, local conflicts of interest, gender, children's rights resulting from transmission line. For this reason, the effects associated with land acquisition will be evaluated based on the findings referred in Chapter 12.10, regarding appropriate compensation and support including mitigation measures.

(f) Work Environment (Including Labor Safety)

Workers may have accidents during construction and maintenance.
The following is described as the main mitigation measures.

- Implementation of all appropriate measures for safety according to laws and appropriate technology practices
- Compliance of guidelines related to detailed regulations and construction safety standards for industrial safety and health
- Maintenance of health condition of workers
- Supply of safety protective equipment (helmet)
- Implementation of training related to safety

The evaluation and mitigation measures are considered appropriate (Final EIA of transmission line, Final EIA of substation, Annex Environmental management plan of these Final EIA).

(g) Accidents

Traffic accidents may occur during construction.
The following is described as the main mitigation measures.

- Select the route of the vehicle taking into account of the vicinity between the school and hospital
- Installation of traffic signs and compliance of traffic rules
- Confirmation of conditions of roads and bridges

The evaluation and mitigation measures are considered appropriate (Final EIA of transmission line, Final EIA of substation, Annex Environmental management plan of these Final EIA).

2) Operation Stage

(a) Soil Contamination

In the substation, Leakage of oil in the transformer may be occurred.
The following is described as the main measures.

- Installation of leakage prevention walls to prevent leakage at damage to transformer
- Installation of tanks to store all amount of oil leaked

The evaluation and mitigation measures are considered appropriate (Final EIA of substation p.77, Annex Environmental management plan).

(b) Noise and Vibration

In the substation, noise of transformer will be generated.
Noise level generated by the transformer is far from residential area and is in compliance with the environmental standard. The evaluation is considered appropriate (Final EIA of substation p.77).

(c) Terrestrial Ecosystems and Valuable Species

There are neither rare species of birds. However, impact of bird strikes may occur.
The following is described as the main measures.

- Attachment of fluorescent or colorful ribbons to transmission lines
- Respect of sufficient height of the transmission line above the ground

The evaluation and mitigation measures are considered appropriate (Final EIA of transmission line p.63, Annex Environmental management plan).

(d) Accidents

Steel towers may fall down due to a storm, heavy rain and the health impact of electric shock is expected. -The health impact of electro shock may be occurred.
The main mitigation measures mentioned are as follows:

- Respect of the safety norms for the construction of the towers
- Selection of the base ground area, construction and materials according to a detailed soil quality survey
- Installation of earth connection equipment to ensure the safety of the distribution line
- Carrying out trainings for the workers and the local population about the risks of the power distribution line
- Carrying out periodical check-ups and maintenance of the power distribution line

The evaluation and mitigation measures are considered appropriate (Final EIA of transmission line p.60, Annex Environmental management plan of these Final EIA).

12.6.2 Reassessment of the Prediction

(1) **Power Plant**

1) Construction Stage

(a) Air Pollution

According to the Beaufort scale, when wind speed exceeds about 6 m/s, dust on the ground may be lifted up. The occurrence ratio of wind speed exceeding about 6 m/s around the project site is low throughout the year, whereas it occurs slightly more often in winter.

Dust caused by the strong winds in the dry season will be reduced with periodic watering in the site and road.

Emission of air pollutants (NOx, PM) from construction machinery and vehicles may affect air quality of the surrounding site.
Periodic maintenance and management of all the construction machinery and vehicles will be conducted to reduce pollutant emission. Adjustment of the construction schedule shall be considered in advance in order to avoid the concentration of machinery and vehicles in one specific period.

The impact of the project on the atmospheric air quality will be minimized by the mitigation measures cited above, although air quality monitoring in the busiest construction period will still be necessary.

(b) Water Pollution, Bottom Sediment, River Ecosystem and Valuable Species

Domestic wastewater and excretion from workers, concrete effluent and oil-containing effluents are generated and may affect the water quality of river in the surrounding area.
Concrete-generated waste water and oil-containing effluent are treated at a neutralization and oil-separation system installed within the construction area.

Treated waste water is finally sent to the river and is reused within the site as much as possible. Waste water that could not be reused will be discharged into the river.
These measures will minimize the impact of contamination of the river water. Water quality monitoring of waste water and the river canal will still be necessary.

(c) Noise and Vibration

Quantitative noise prediction during construction phase is not conducted in EIA for GTCC 3. Since the nearest residential area is located in 300m south west from site, prediction was conducted during this survey mission and environmental impact is confirmed.
Noise level caused by operation of construction equipment was estimated.

Operation of heavy equipment and vehicles for transporting materials will cause noise and vibration impacts. There are no households in the direct neighborhood of the site, but some households are located in on the north and south of the project site, and sufficient consideration must be given to minimizing any noise impact.

a) Noise

The level of noise resulting from the operation of the construction machinery was simulated using the following estimation model.
Noise level estimation model
Noise predictions were carried out in accordance to International Standard ISO 9613, Acoustics-Attenuation of Sound during Propagation Outdoors.

$LPA = LWA - 20 \cdot 1ogR - 8 - A\gamma - AE$

In which
LPA：Sound pressure level by A-weighted (dBA)
LWA：Sound power level by A-weighted (dBA)
R　：Distance (m)
Aγ　：Barrier attenuation (dBA)
AE　：Atmospheric absorption (dBA)
Noise level data of noise source

Major construction machines used for construction include cranes used for loading basic materials and the like, concrete mixers and pump cars in foundation construction works, backhoes for excavation, power generators, air compressors, etc.

Considering the ground condition, piling operation which generates high noise will not be necessary.
Table 12.6.2-1 shows the noise level of the main construction machinery and the number of machines.

Table 12.6.2-1 Noise Level of Major Construction Machinery

Work stage	Machine type	Specification	Noise level (dB)	Number of equipment
Installation of electric transformer equipment	Crawler crane	25-650 t	97	1
	Truck crane	45-300 t	102	1
Installation of gas turbine building	Crawler crane	25-650 t	97	1
	Truck crane	45-300 t	102	1
	Forklift	800 t	105	1
	Trailer	30-50 t	113	1
	Truck	2-11 t	109	1
Installation of heat recovery steam generator	Crawler crane	25-650 t	97	1
	Truck crane	45-300 t	102	1
	Forklift	800 t	105	1
	Truck	2-11 t	109	1
Installation of the cooling tower (cooling fan)	Backhoe	1.0-4.0 m^3	102	1
	Air compressor	10.6 m^3/min	106	1
	Generator	60-600 kVA	101	2
Steam turbine building	Truck crane	45-300 t	102	1
	Backhoe	1.0-4.0 m^3	102	1
	Concrete pumping vehicle	100 m^3/h	110	1
	Concrete mixer	4 m^3	101	1

Note: Data based on the example of gas turbine power plant of similar-scale in Japan

(Source: JICA Survey Team)

[Calculation conditions]
The calculation was conducted on the assumption that all the aforementioned machines were operating simultaneously. However, construction activities will be carried out based on a step-by-step construction schedule so that all the machinery is not operated simultaneously.

6 measurement points (No.1 ~ No.6) on the boundary of power plant site and other 3 points (No.7~ No.9) in the residential area located near the power plant were selected for simulation.

(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-1 Location of Simulation Points

[Prediction result]
Table 12.6.2-2 shows the result of simulation of the noise level (contribution, current, and future level) related to the operation of the construction equipment. Figure 12.6.2-2 shows the distribution of noise levels.
The contribution noise level was 58 ~ 64dB(A) at the boundary of the site, and 52 ~ 54 dB(A) in the residential area.

As the current level of noise, the minimum noise level of 45 dB is selected in residential areas for monitoring GTTC2.
Future noise level was simulated through the addition of the current noise level and the contribution noise level. Future noise level is 58 ~ 64 dB(A) at the boundary, and 53 ~ 55 dB(A) in the residential area.

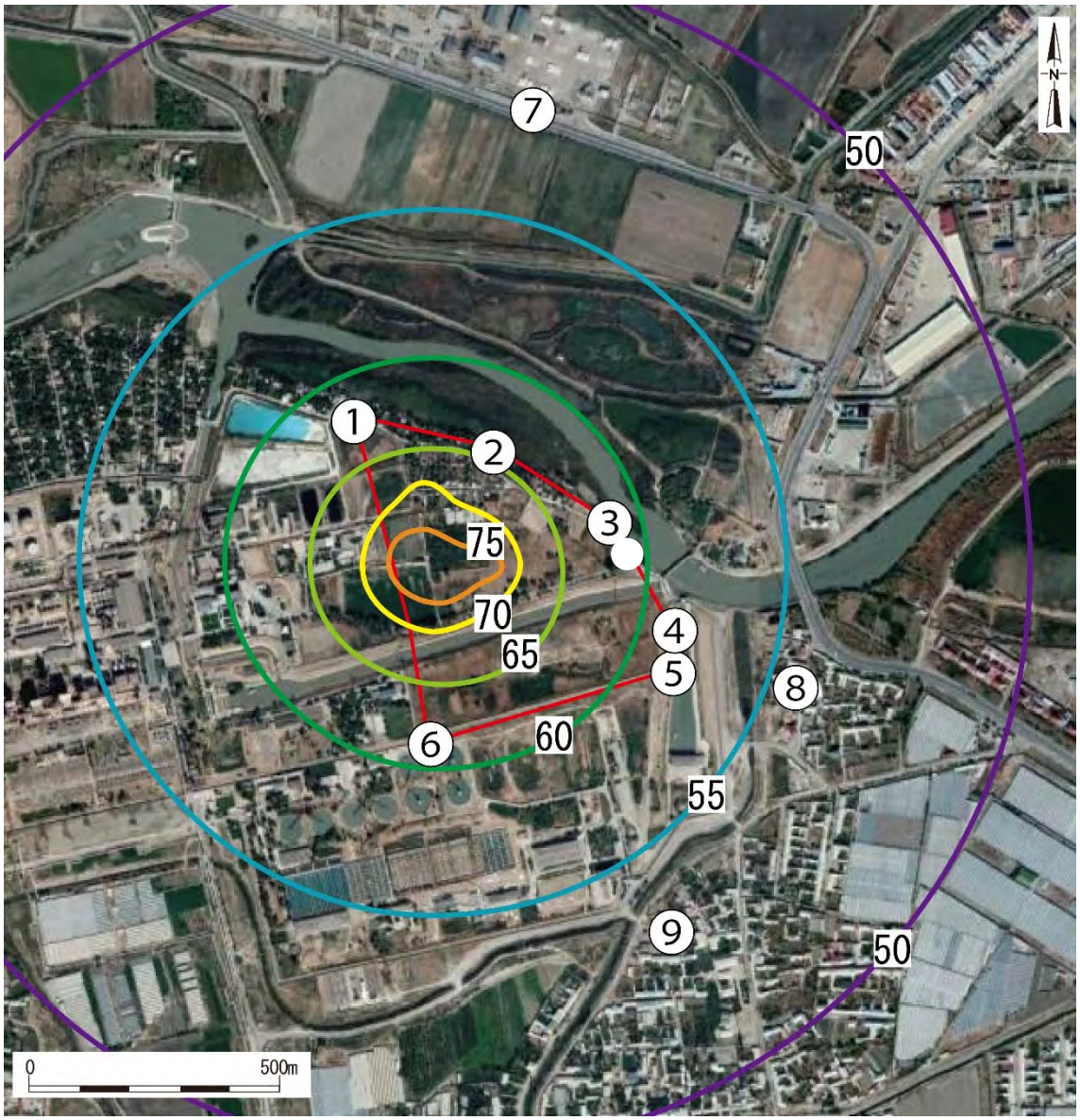
The estimated future noise levels at all the measuring points of boundary comply with

Uzbekistan and IFC/WB guideline value (industrial area, daytime). Also, the future noise levels at the residential area satisfy the standard value of Uzbekistan and IFC/WB guideline value (residential area, daytime). The future noise level does not satisfy the noise standard for nighttime, but increase from the current noise level is not expected.

Table 12.6.2-2 Results of Simulating Noise Levels from Construction Work

Location	Point	Contribution noise level (dBA)	Current noise level(dBA)	Future noise level (dBA)	Noise standard of Uzbekistan (dBA)	IFC/WB/WB EHS Guideline General
Project Boundary	No. 1	62	45	62	–	Industrial zone: Day 70 Night 70
	No. 2	64		64		
	No. 3	62		62		
	No. 4	58		59		
	No. 5	58		58		
	No. 6	61		61		
Residential area	No. 7	52		53	Residential zone: Day 55 Night 45	Residential zone: Day 55 Night 45
	No. 8	54		55		
	No. 9	53		54		

(Source: JICA Survey Team)



(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-2 Distribution of Noise Levels during Construction Phase

Noise impact caused by construction activities will be mitigated by managing the construction schedule in order to level out the construction amount and scale.

Low noise equipment will be used as much as possible and regular maintenance will be conducted.
Measures for reducing generation of noise, such as speed reduction of large vehicles in residential areas, will be taken, whereby vehicle noise impact will be minimized.

Construction work will be conducted in daytime to the possible extent. Considering the high bearing power of the ground, piling work producing high noise will not be conducted.

Thus, all efforts will be made to minimize the noise impact. Monitoring on noise levels in the busiest construction period will still be necessary.

b) Vibration

Quantitative vibration prediction during construction phase is not conducted in EIA for GTCC3 and 4. Since the residential area is located close, prediction was conducted during this survey mission and environmental impact is confirmed.

The major construction machinery used in the construction work includes a dump truck, bulldozer and back hoe for excavation, a hydraulic hammer used for pile driving, a truck crane for transportation of the equipment and material, and a mixer for producing concrete.
Table 12.6.2-3 shows the vibration level of the construction machinery at different distance in the example of GTCC project in Japan. Vibration level at the residential area 300m from the plant site is below 40 dB which is very low.

Table 12.6.2-3 Vibration Level of Construction Power Plant Machinery

Machine type	Scale	Vibration level by distance (dB)			
		5m	100m	200m	300m
Truck crane (hydraulic)	50t	69	47	36	25
Dump truck	11t	69	47	36	25
Back hoe	0.6m^3	80	59	47	37
Bulldozer	11t	75	64	53	42
Hydraulic hammer	4.5t	80	59	47	37

(Source: JICA Survey Team)

(d) Involuntary Resettlement and Land acquisition, People in Poverty, Local Economy Such as Employment and Livelihood Means, Misdistribution of Benefits and Loss, Local Conflicts of Interest, Gender, Children's Rights

To construct the power plant, 14ha of the land will be acquired. This land is currently used for houses, dachas, and agricultural land. 36 households will lose their houses/dacha and 2 leasehold farmers will lose their agricultural land. Affected households include female-headed ones but not people in poverty.
Their livelihood will be affected. If compensation will not be appropriately made to affected households that will lead to misdistribution of benefits and loss and also local people may have conflicts of interests.
A-LARAP is prepared in accordance with Uzbek legislation and JICA Guidelines and local district governments (khokimiyat) will make compensations to affected people before the relocation as planned in A-LARAP. It will be confirmed that affected people agree with the compensation and relocation, before the compensation.
Details will be described in Chapter 12.10.

(e) Existing Social Infrastructure and Services

In the nearest city of Navoi, there are enough accommodation, schools and sewerage system so there is no need to install new facilities to accommodate the workers and their families.
Traffic jam caused by increasing traffic is expected during construction.
The project proponent will conduct the traffic control plan including route-setting and operation schedule. Bus for transportation of workers will be operated to minimize traffic and the route and schedule of operation will be discussed with the relevant organizations.

(f) Labor Environment (Including Work Safety)

Workers may have accidents during construction service.
The construction company will develop the safety and sanitation management plan including safety education and training and obtain approval from TTPH. Safety gears including helmet, safety shoes and earplugs shall be installed following the safety management plan. The storage

of hazardous materials shall be marked with a sign board. A manual for safe handling of machinery shall also be prepared and checked by Project Implementation Unit (PIU) for approval.
In case of an accident, monitoring shall be conducted.

(g) Accidents

Traffic accidents may occur during operation of vehicles. As prevention measures for land traffic accidents, observation of traffic regulations, and training and education on safe driving will be implemented, as well as an appropriate vehicle operation route and schedule.

2) Operation Phase

(a) Air Pollution

a) Emission from GTCC3

Gas will be used for fuel in the power plant and nitrogen oxide (NOx) will be generated, but sulfur oxide (SOx) and particulate matter (PM) are not emitted.

Regarding NOx emission, as nitrogen (N_2) is barely contained in fuel, N_2 contained in air reacts chemically with oxygen (O_2) and produces nitrogen monoxide (NO) and nitrogen dioxide (NO_2). It is mostly NO at the time of emission of exhaust gas, and is converted into NO_2 through photoreaction with ozone (O_3) in the air at the dispersion stage.

With the mitigation measures described above, the emission concentration of air pollutant in the exhaust gas will meet the emission standard of Uzbekistan and the standard value of IFC/WB EHS guidelines (Thermal Power Plant, 2008) as described in Table 12.6.2-4
Standard values for pollutant concentrations in exhaust gas are not established in Uzbekistan, and the Russian standard (GOST 29328-92) is applied, which is equivalent to IFC/WB EHS Guidelines values. The project will comply with both.

Table 12.6.2-4 Emission Concentration and Emission Standard

Fuel	Item	Unit	Proposed Concentration	Emission Standards of Russian (GOST 29328-92)	IFC/WB EHS guidelines (Thermal Power Plant; 2008)
Gas	NOx	mg/Nm^3	51	51	51

Note: O_2＝15% equivalent

(Source: JICA Survey Team)

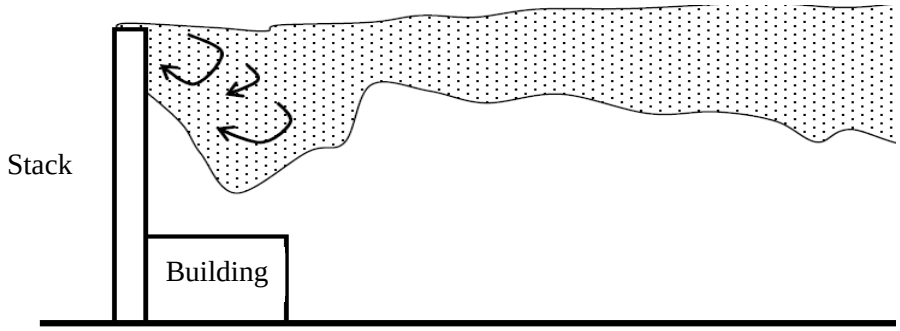
b) Condition for Prediction of Atmospheric Dispersion

It is necessary to ensure that the compliance of the environmental standard will continue to be secured in future and to take appropriate measures for the compliance.

The dispersion calculation will be conducted to understand the contribution concentration of the new power plant through simulation and the cumulative impact of the existing facility including contribution concentration. It is also important to take into account the downdraft and downwash described below where high concentration occurs in the calculation.

[Downwash]
In general, downwash reportedly occurs with a wind speed 1.5 times or more than the exhaust gas speed. The assumed exhaust gas speed in this project being 19 m/s, downwash may occur in case wind speed at the stack outlet is more than 13 m/s.

According to the meteorological survey data of the area, the occurrence of the above-described wind speed is very low, and the occurrence of downwash will be extremely small.



(Source: "Nitrogen oxides total amount control manual" (Ministry of the Environment, 2000))

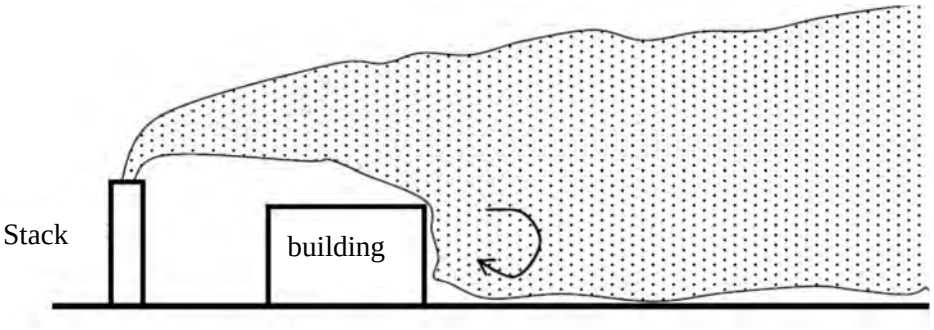
Figure 12.6.2-3 Diagram of Downwash

[Downdraft]
In a case where the stack height is low, downdraft may occur due to the presence of the surrounding building. By using the formula shown below, if the HG value is shown to be higher than the stack height, it is necessary to consider the impact of downdraft.

$$HG = H + 1.5L$$

H = Building height (m)
L = Building height or the value for the building with the lowest diameter (m)

In this project, the stack height is 110m and the turbine building and HRSG are only 23m and 28m height, respectively, and the planned stack height is 110m which is much higher than the required height of 70m for downwash prevention.



(Source: "Nitrogen oxides total amount control manual" (Ministry of the Environment, 2000))

Figure 12.6.2-4 Diagram of Downdraft

c) Selection of Modelling

The impact evaluation model for this project was selected from plume models commonly adopted in the U.S., Europe and Japan in the environmental impact assessment. AERMOD, in particular, is an evaluation model recommended by the US-EPA and is suitable for the impact evaluation of the area including elevated area, as is the case in this project. This model is widely adopted abroad in the EPA and is a reference model of IFC/WB EHS guidelines. AERMOD is published as Appendix W to 40 CFR Part 51 (as revised).

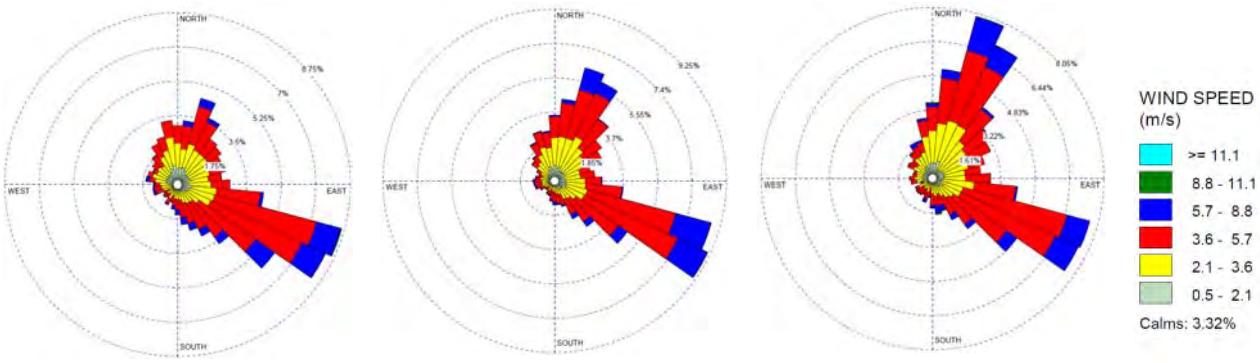
d) Meteorological Conditions

AERMOD dispersion model requires one-hour value of meteorological data (air temperature, wind speed and wind direction, etc) of at least one year's span to conduct appropriate estimation. However, Qazvin meteorological station near the project site measures wind speed and wind direction only three times a day, which are the essential meteorological data in the dispersion modeling. This is insufficient for an appropriate evaluation.

Therefore, the one-hour values in the meteorological data from the meteorological model (MM5 (The Mesoscale Model)) from 2016 to 2018 will be used for calculation. MM5 is Fifth-Generation Penn State/NCAR Mesoscale Model* developed by Pennsylvania State University and National Center for Atmospheric Research. It encompasses existing data from each region around the world and is very efficient in air quality simulation.

*The meteorological models in Mesoscale is applicable to the grid of several kilometers to several ten kilometers, is therefore suitable for the air quality simulation for this project.

The estimated frequency of wind direction and wind speed based on the weather model (MM5) is shown in Figure 12.6.2-5. It indicates that east wind is dominant, followed by south-south-east and north-north-east wind, mainly eastern wind. Wind speed is mostly within the range of 1 to 6 m/s, with low occurrence of wind speed exceeding 6m/s, similar to the meteorological data in Chapter 12.2.4. MM5 provides on one-hour basis data and these data adopted for calculation in this project.



2016 2017 2018

(Source: JICA Survey Team)

Figure 12.6.2-5 Simulated Frequency of Wind Direction/Speed Level Based on the Weather Model (MM5) (32 Wind Directions, 2016~2018)

The NOx calculation with gas fuel using data of 2016, 2017 and 2018 indicated no significant difference. All calculation was conducted with one-hour basis with the data of 2017 when NOx concentration was the highest.

e) Emission Specification

Table 12.6.2-5 and Table 12.6.2-6 show the volume, temperature, speed of exhaust gas and emissions of NOx, contained in gas emission from the new and existing power plants.

Table 12.6.2-5 Emission Specification of the New Gas Turbine Plant

Item	Unit	GTCC 3
Output	MW	600MW+200Gcal
Fuel	-	Gas
Emission volume (wet)	m^3/s	1047
Exhaust temperature	ºC	120
Exhaust speed	m/s	18.45
Stack diameter	m	8.5
Stack height	m	112
NOx emission	g/s	36.19

(Source: JICA Survey team)

When GTCC 4 in operation, all the existing facilities will be shut down. However, as it is unclear which unit will be shut down when GTCC 3 is in operation, It was assumed that the existing Unit 4, 5, 7 and 9 to 12 will remain during the operation of GTCC2 and the existing Unit 7, 9, 10 and 12 will remain during the operation of GTCC3.

Table 12.6.2-6 Emission Data from Stack of Power Plant

Items	Unit	Existing units				Gas-combined	
		Stack2	Stack 3	Stack4	Stack 5	GTCC 1	GTCC 2
		Unit 4	Unit 5, 7	Units 9, 10	Units 11, 12		
Emission volume (wet)	m^3/s	328.0（0）	402.1（201.05）	442.7	701.9（350.05）	691.2	752.9
Exhaust temperature	°C	140.4（0）	117.0	140.4	154.0	126.0	126.0
Exhaust speed	m/s	5.0 （0）	6.1（3.05）	6.7	24.8（12.4）	12.2	13.3
Stack diameter	m	9.2	9.2	9.2	6.0	8.5	8.5
Stack height	m	56	56	56	180	60	60
NO_x emission	g/s	14.9（0）	17.5（8.7）	23.2	83.1（41.6）	23.6	23.2

Note: The values in brackets above are emission data associated with the shutdown of the existing facilities during GTCC 3 operation.

(Source: Final EIA of GTCC 3 and 4)

f) Prediction Result

The prediction was conducted in following three patterns. Outcomes are the ground concentrations of nitrogen dioxide (NO_2) in the maximum one-hour value and 24-hour value, and the annual average value.

- Impact of GTCC 3 only
- Impact of the existing power plants in operation, GTCC 1 and GTCC 2
- Cumulative impact of the existing power plants in operation, GTCC 1, GTCC 2, GTCC 3

The prediction result of each pattern will be explained below.

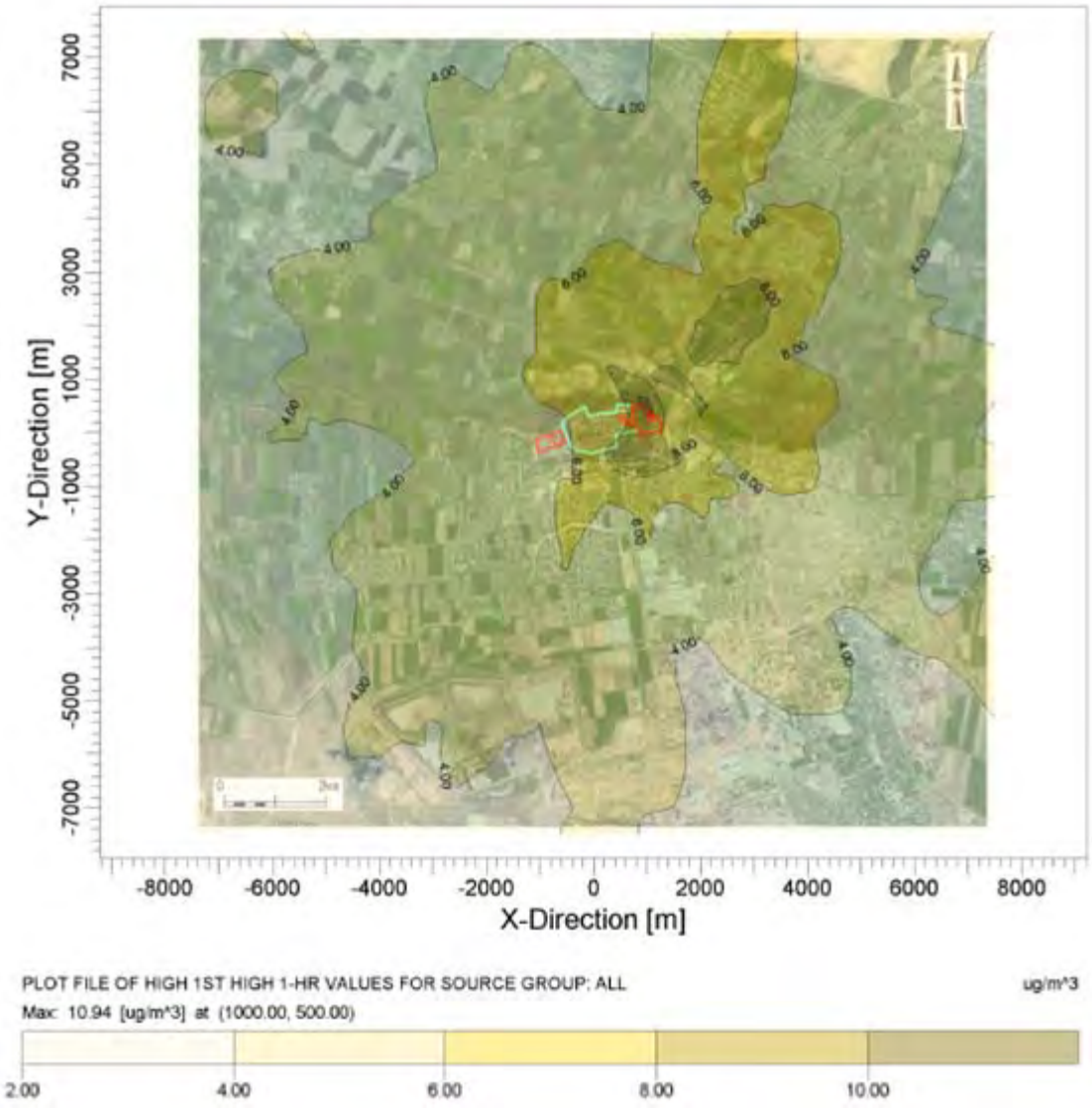
➢ Prediction Result of Impact of New Plant (GTCC 3) only

As fuel used in this project is basically gas, the diffusion simulation of NO_2 generated in case of gas fuel is conducted. The prediction results of the contribution ground concentration are as shown in Figure 12.6.2-6 to Figure 12.6.2-8. Also, Table 12.6.2-7 describes the overview.

The maximum ground level concentrations were predicted to be 10.94μg / m^3 for one-hour value, 3.15μg / m^3 for 24-hour value, and 0.59μg / m^3 for the annual average. These are approximately 12.9% (one-hour) and 5.3% (24-hour) of the environmental standard value of Uzbekistan (30 min value: 85μg / m^3, 24-hour value: 60μg / m^3) and 5.5% and 1.5% of IFC/WB guideline values (one-hour value: 200μg / m^3, annual average value: 40μg / m^3).

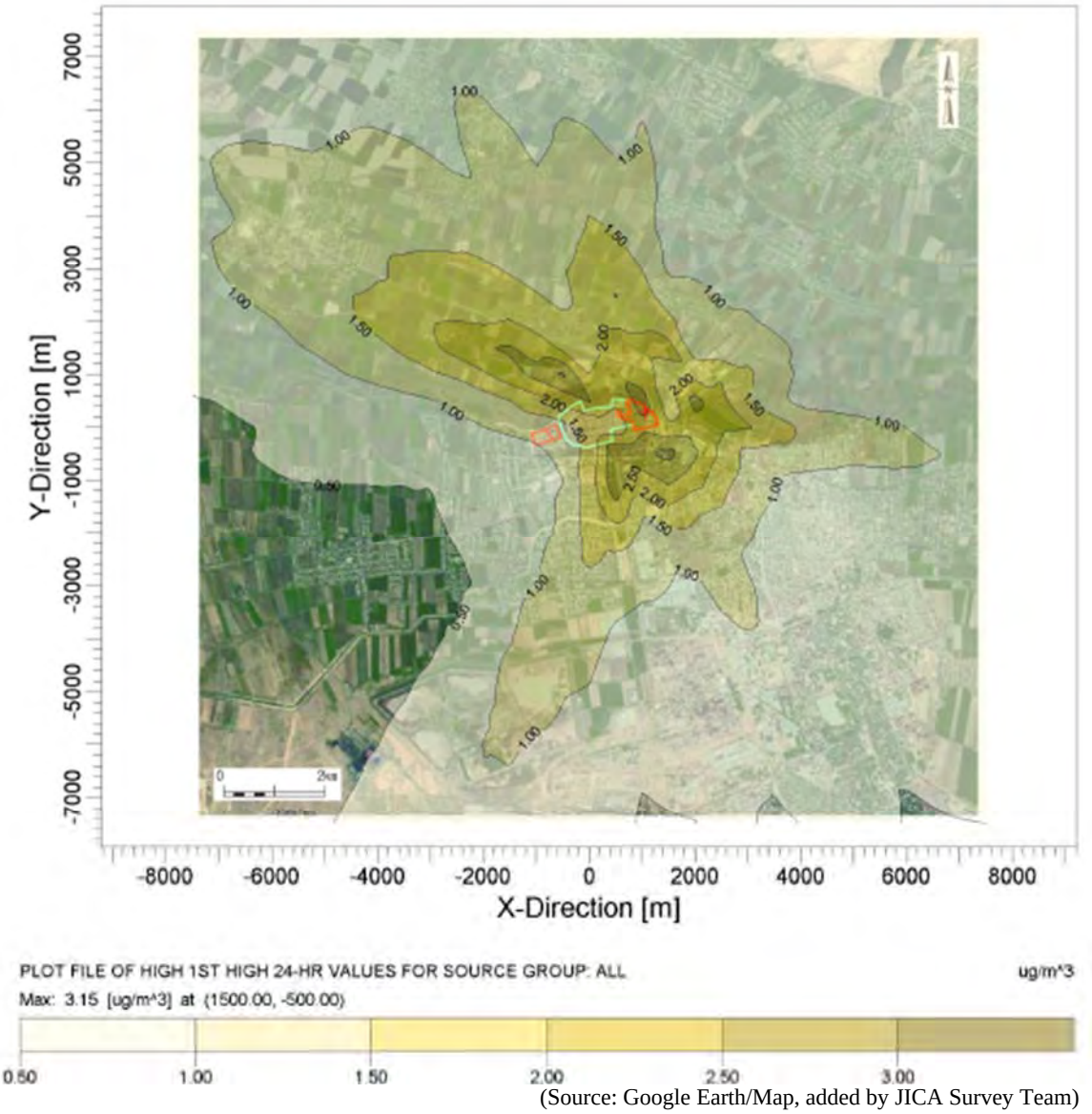
According to the IFC/WB Guidelines (General), a single project is required not to contribute more than 25% of the applicable ambient air quality standards. Compared to this threshold, the present project has an extremely low contribution.

Additionally, regarding the future concentration obtained by adding the current concentration to the predicted value, the maximum future concentration calculated with the highest concentration obtained in the current monitoring data, which are sufficiently lower compared with the Uzbekistan's environmental quality standard and the IFC/WB guidelines.



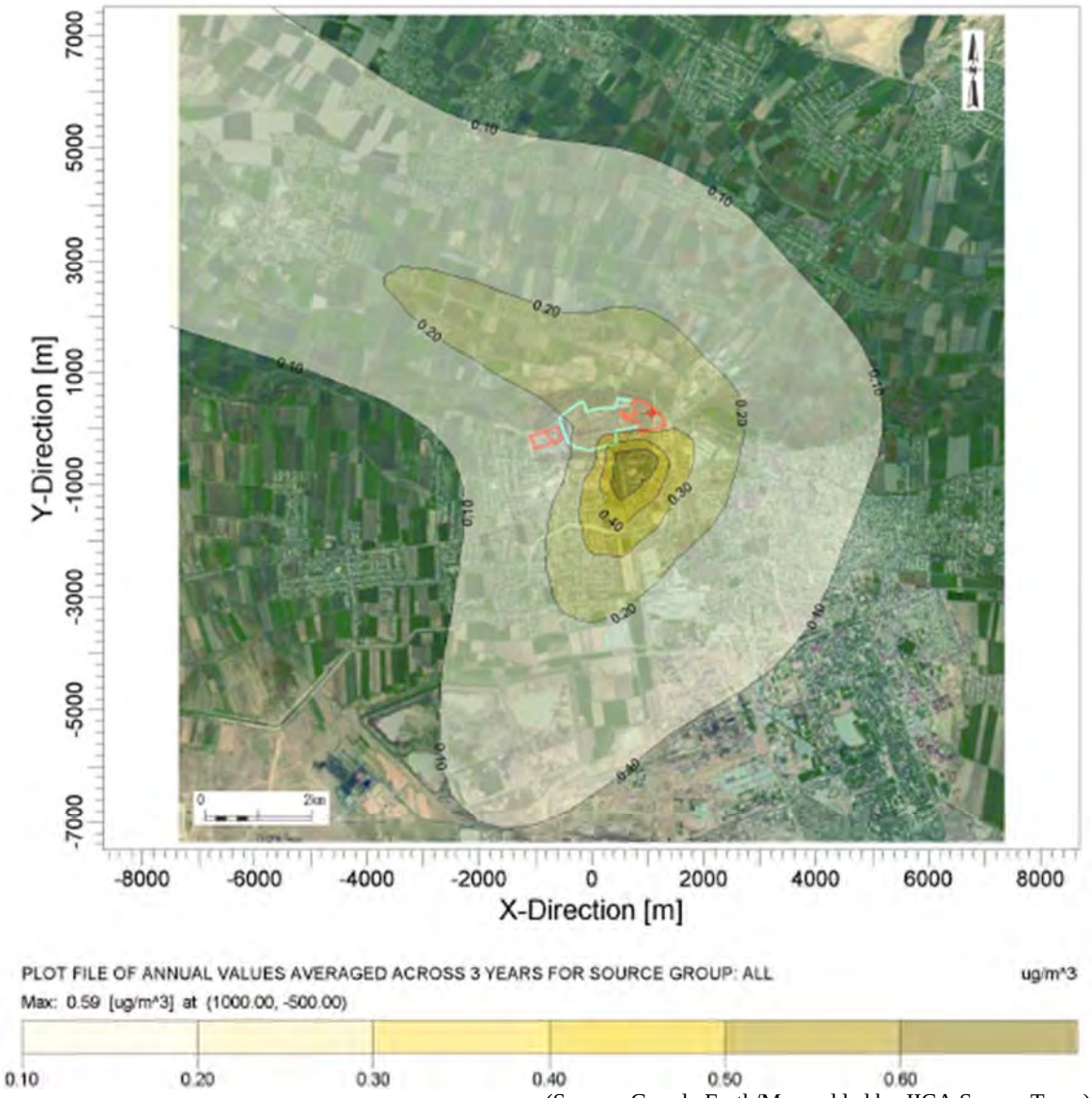
(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-6 Contribution Concentration of the New Power Plant of NO_2 at the Ground Level (1 Hour Value)



(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-7 Contribution Concentration of the New Power Plant of NO_2 at the Ground Level (24 Hour Value)



(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-8 Contribution Concentration of the New Power Plant of NO_2 at the Ground Level (1-year Value)

Table 12.6.2-7 Prediction Result of the Contribution of NO_2 Concentration of the Operation of the New Power Plant (GTCC3)

Time category	Unit	A	b	a + b	Uzbekistan air quality standard	International standard value and standard value in each country (IFC/EU/Japan)
		Background concentration	Maximum predicted concentration	Background concentration + Maximum concentration		
1-hour	μg/ m^3	42	10.94	52.94	85 (30mins)	200/200/-
24-hour	μg/ m^3	31	3.15	34.15	60	-/-/113
Annual average	μg/ m^3	26	0.59	26.59	-	40/40/-

Note: The current concentration of 1hr value and 24-hour value (a) was referred max measured under the condition that existing Navoi thermal power plants and GTCC1 are in operation (p.12-6).
The 1-year background concentration (a) was calculated with all 24-hour averaged data measured
(Source: JICA Survey Team)

- Cumulative Impact of the Existing Power Plants in Operation with GTCC 1, GTCC 2, and GTCC 3

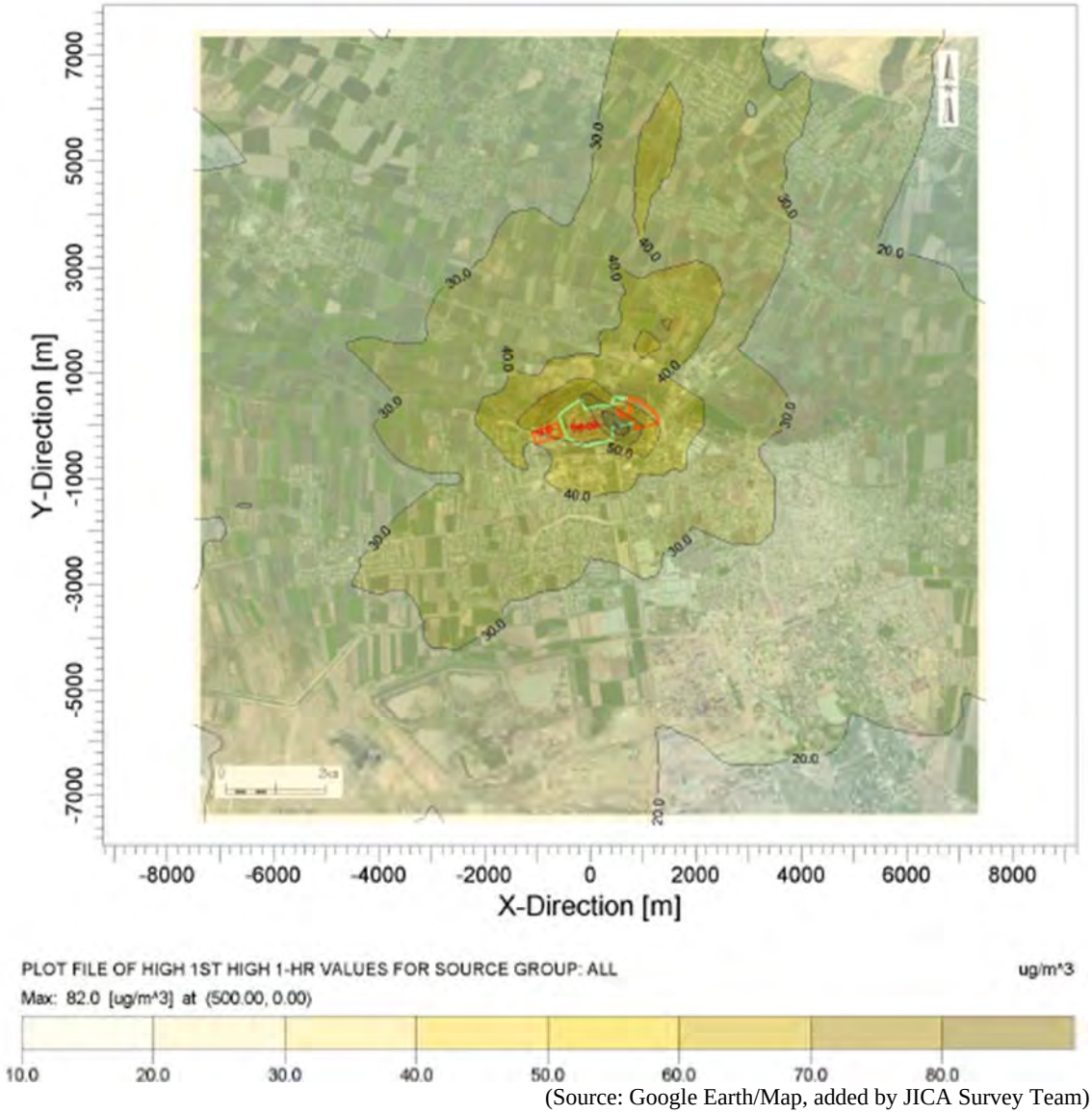
The current contribution concentration of nitrogen dioxide (NO_2) of the existing facility and the predicted contribution concentration after the new facility is installed are described below. The comparison of the current status of pollutant concentration and the future concentration of the new facility with the environmental standard is described below.

The maximum ground level concentration of the existing facilities (the existing power plants in operation, GTCC1 and GTCC2) is 81.95 μg / m^3 for one-hour value, 29.12 μg / m^3 for 24-hour value, and 4.28 μg / m^3 for the annual average. These are approximately 41.0 % (one-hour) and 4.3 % (24-hour) of the environmental standard value of Uzbekistan (30 min value: 85 μg/m^3, 24-hour: 60 μg/m^3) and 41.0 % and 10.7 % of IFC/WB guideline values (one-hour value: 200 μg / m^3, annual average value: 40 μg / m^3). The prediction results are shown from Figure 12.6.2-9 to Figure 12.6.2-11 .

The maximum future ground level concentration of the existing facilities (the existing power plants in operation, GTCC1 and GTCC2) and the new power plant (GTCC3) is 60.05 μg / m^3 for one-hour value, 22.25 μg / m^3 for 24-hour value and 3.31 μg / m^3 for annual average, which is approximately 70.6 % (one-hour) and 37.1 % (24-hour) of the environmental standard value of Uzbekistan and 30.0 % and 8.3 % of IFC/WB guideline values (one-hour value: 200 μg / m^3, annual average value: 40 μg / m^3), which shows no significant difference compared to the current status. The prediction results are shown from Figure 12.6.2-12 to Figure 12.6.2-14.

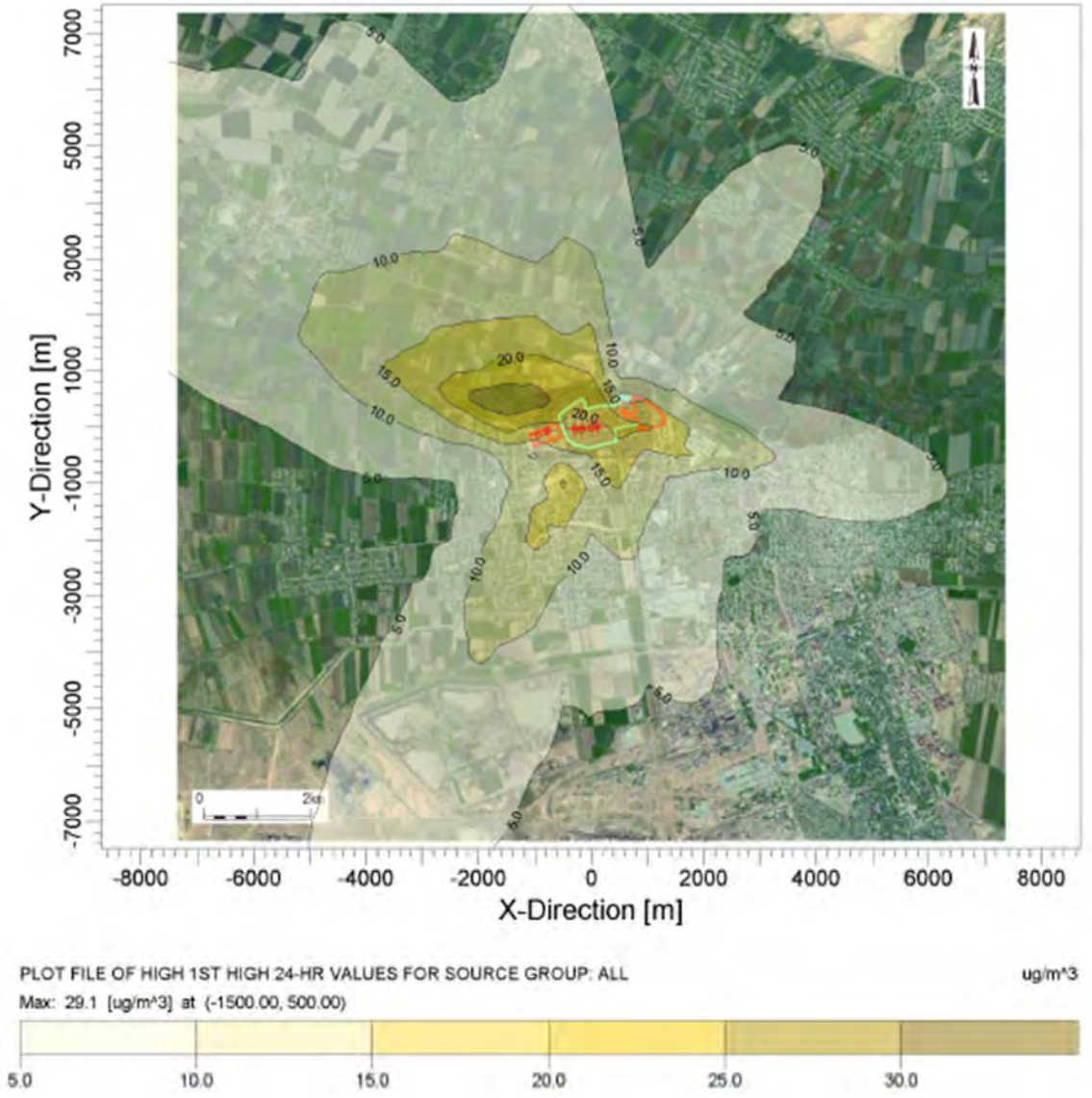
Regarding of the future concentration, which is the addition of the prediction concentration of the existing facilities (the existing power plants in operation, GTCC1 and GTCC2) and the new power plant (GTCC3) and the background concentration, the future concentration is 82.05 μg / m^3 for one-hour value, 43.25 μg / m^3 for 24-hour value and 19.31 μg / m^3 for annual average value, which is in compliance with Uzbekistan's environmental quality standards, EU environmental standard and the IFC/WB guidelines value. The overview of the result is shown in Table 12.6.2-8.

NO_2 concentration will decrease after the shutdown of the existing power plant with the operation of GTCC3.



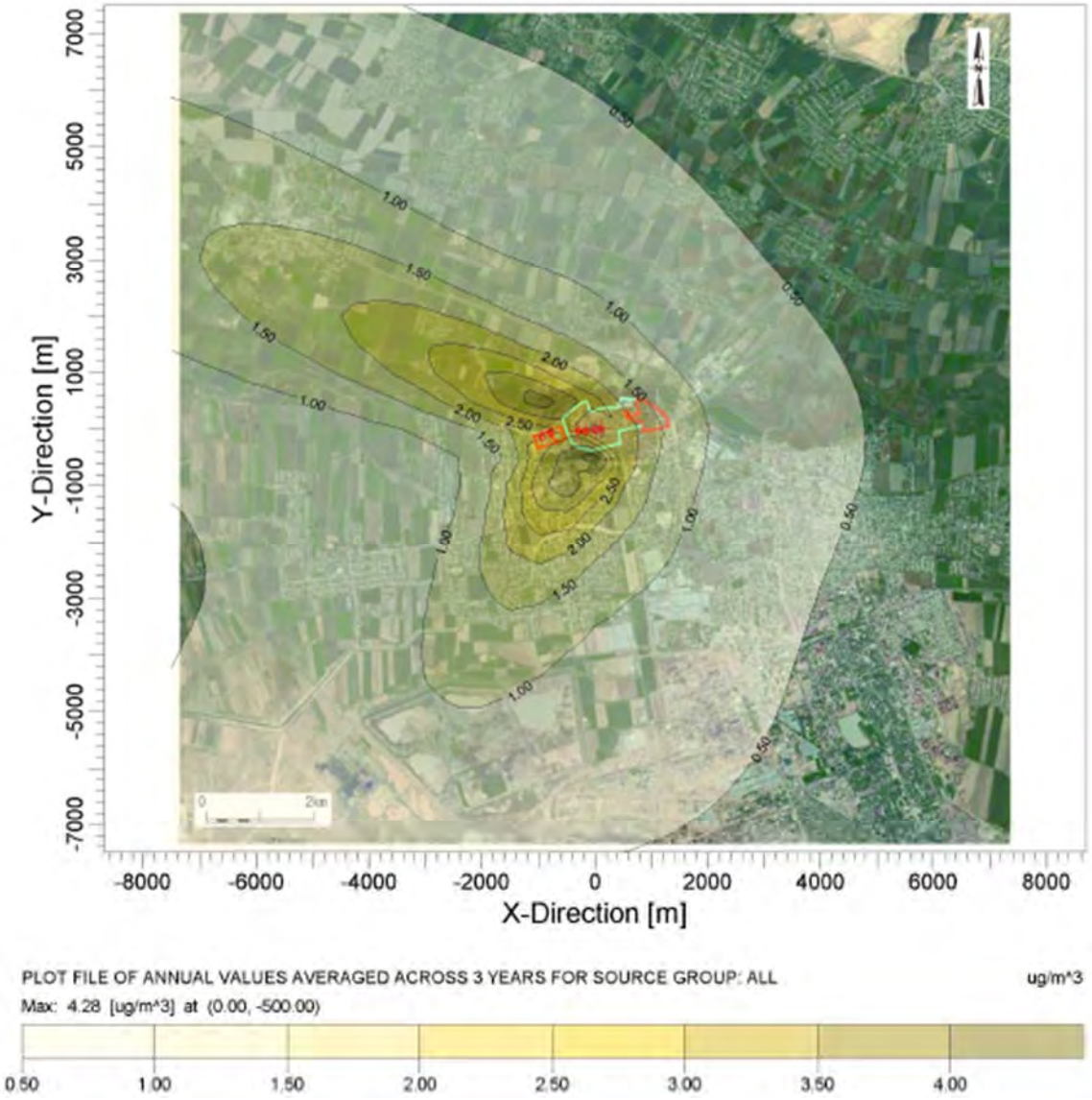
(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-9 Ground Level Concentration of NO2 in the Current Status (existing Unit 4, 5, 7 and 9 to 12 + GTCC 1 &2) (1 Hour Value)



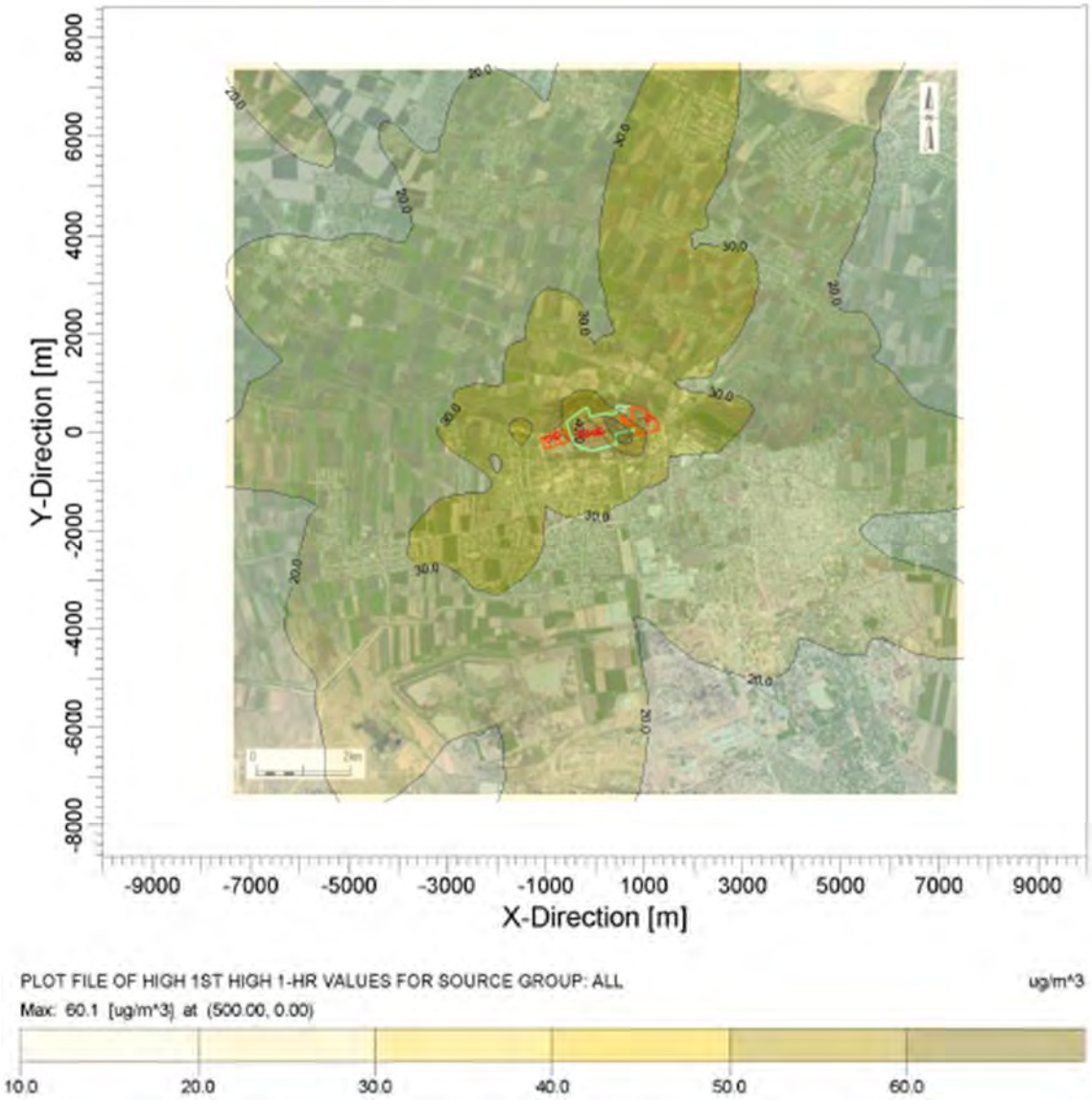
(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-10 Ground Level Concentration of NO_2 in the Current Status (existing Unit 4, 5, 7 and 9 to 12 + GTCC 1 &2) (24 Hour Value)



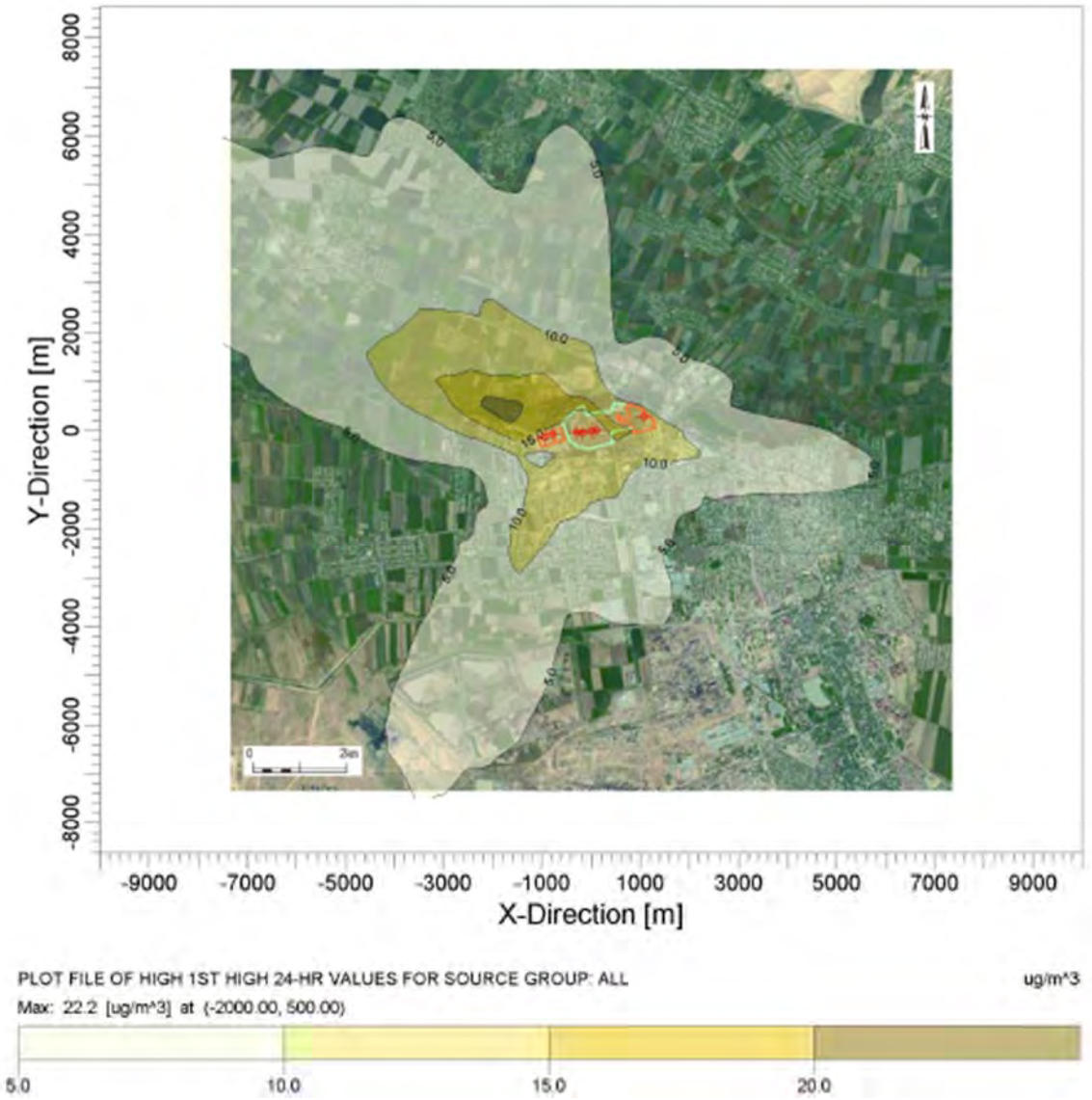
(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-11 Ground Level Concentration of NO_2 in the Current Status (existing Unit 4, 5, 7 and 9 to 12 + GTCC 1 &2) (Annual Average)



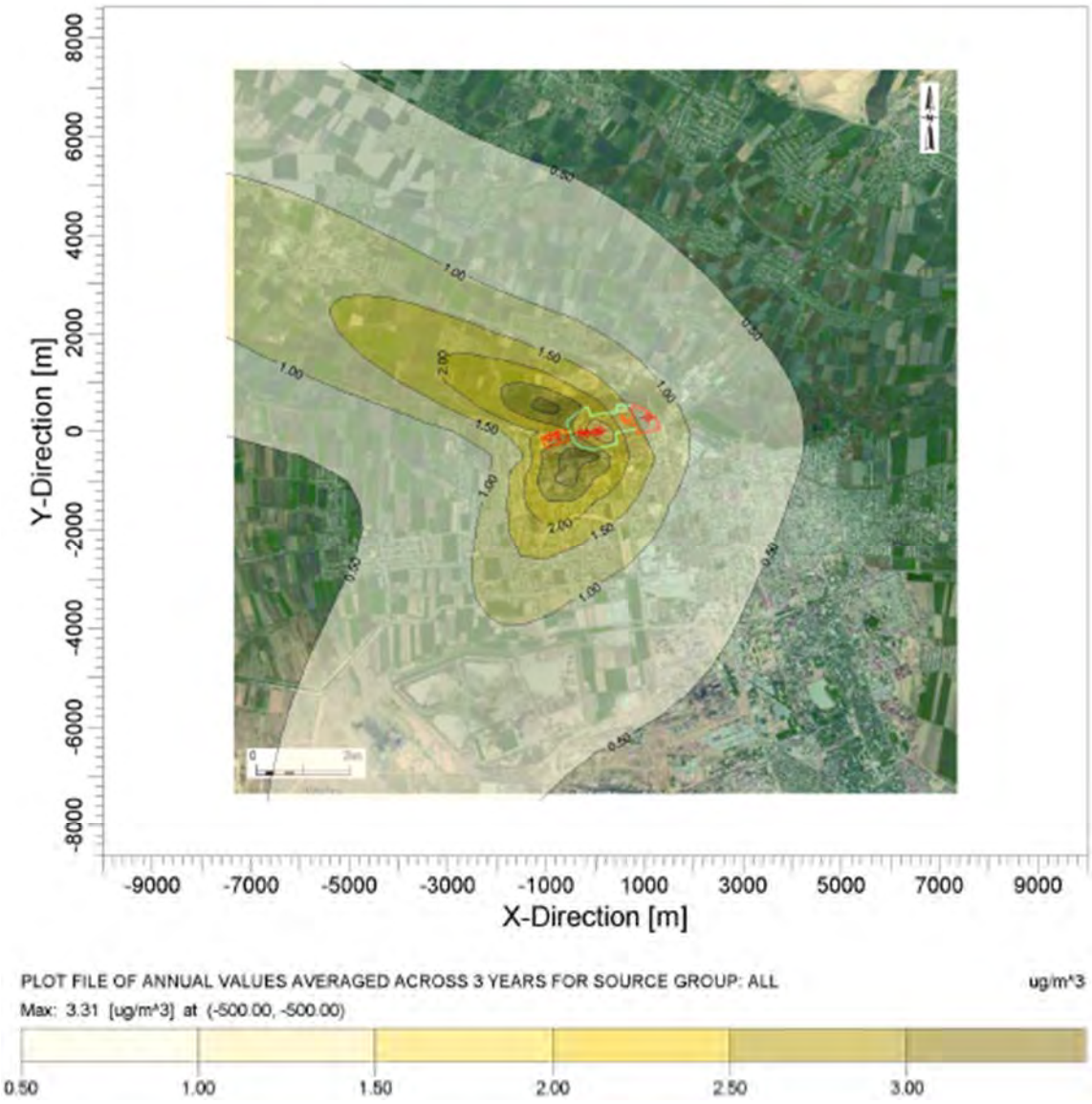
(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-12 Ground Level Concentration of NO_2 in the Future Condition (existing Unit 7, 9,10 and 12 + GTCC 1 &2 +GTCC3) (1 Hour Value)



(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-13 Ground Level Concentration of NO_2 in the Future Condition (existing Unit 7, 9,10 and 12 + GTCC 1 &2 +GTCC3) (24 Hour)



(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-14 Ground Level Concentration of NO_2 in the Future Condition (existing Unit 7, 9,10 and 12 + GTCC 1 &2 +GTCC3) (Annual Average)

Table 12.6.2-8 Prediction Result of the Contribution Concentration of the Existing Power Plant Facility and of the New Power Plant

Time category	Unit	A	b	c	b + c	Uzbekistan air quality standard	International standard value and standard value in each country (IFC/EU/Japan)
		Maximum concentration of the existing facility	Maximum concentration of the existing facility and the new facility	Background concentration	Maximum future concentration		
1-hour	μg/m^3	81.95	60.05	22	82.05	85 (30mins)	200/200/-
24-hour	μg/m^3	29.12	22.25	21	43.25	60	-/-/113
Annual average	μg/m^3	4.28	3.31	16	19.31	-	40/40/-

Note: The current concentration of 1hr value and 24-hour value (a) was measured under the condition that existing Navoi thermal power plants and GTCC1 are in operation.
Specifically, in consideration of the impacts of the existing facilities shown in p.12-89 to 91, the value was settled by subtracting 20 μg/m^3 from the maximum measurement value for one hour value, and subtracting 10 μg/m^3 for 24 hour value.
The 1-year background concentration (a) was established by the average of the subtraction of 10μg/ m^3 from the 24-hour value described above.

(Source: JICA Survey Team)

(b) Water Pollution, Bottom Sediment, River Ecosystem and Valuable Species, Hydrology, and Water Use

In the operation of the power plant, wastewater from the power plant, oil-containing wastewater and domestic sewage will be generated and the potential environmental impact is predicted.
Zeravshan River around the power plant is not used for fishery or river traffic and is used for irrigation channel of agriculture.
In case once-through cooling system is adopted, water recession area may occur, but decommissioning of the existing facilities is expected.

Waste water mainly consists of regeneration waste water from demineralization plant and from Boilers Heat Recovery Steam Generators (HRSG), which are not large in amount in a normal operation. Oily drainage wastewater from the condenser and the light oil tank will be generated accompanying to domestic sewage from office and accommodation for staff and rain water.

The total amount of waste water will be approximately 56m^3/h at the maximum.
Main items associated with water quality are as follows:

- Oily drainage wastewater: oil
- Domestic sewage: SS, organic matter
- Wastewater from water purification system: SS, Acid, Alkaline
- Waste washing water from the exhaust heat recovery boiler: SS, Acid, Alkaline

Wastewater from water purification system and waste water from the exhaust heat recovery boiler is treated with neutralization and sedimentation treatment system and is examined for compliance with waste water quality standards of Uzbekistan and the IFC/EHS Guideline for thermal power plants (2008).

Oily drainage wastewater will be collected in the wastewater treatment system for oil separation to comply with Uzbekistan standard and IFC/EHS Guideline values for thermal power plants (2008). Domestic wastewater will be discharged to sewage system of Navoi city.
With the above-described measures, the impact on water quality by the power plant operation is minimized.

The largest thermal wastewater from the existing Navoi old is discharged by the cooling water of the condenser, with the discharge volume of up to about 106,000 m^3/h. Other waste water includes the regeneration drainage of the water treatment equipment with 35 m^3/h volume, and the blow drainage of the wet cooling tower for Unit 11-12 with 255 m^3/h volume.

Combined cycle power plant generation generates smaller amount of drainage compared with the existing power plant, 200 m^3/h for GTCC1 and 50 m^3/h for GTCC2.
In GTCC3, similar to GTCC2, cooling water will not be required through forced-draft air cooling system and thermal waste water will not be discharged and cooling water will not be taken.
For this reason, the amount of drainage is small, approximately 56 m^3/h in GTCC3 assumed in comparison with GTCC2 in terms of output.

The thermal wastewater generated from the existing power plant will be reduced to about 71,000 m^3/h by the shutdown of the existing equipment at the time of GTCC2 operation, and further reduced to about 24,000 m^3/h at the time of GTCC3 operation. At the time of GTCC 3 operation, the blowout drainage of the cooling tower will also be reduced by about 125 m^3/h by the shutdown of the existing facility.
From the above, with the operation of GTCC3, the impact of drainage on the river will be reduced.

Of the water intake from the rivers, the largest amount used in the existing power plant is for cooling water for condenser, which is discharged directly as thermal effluent.
In the a wet-type cooling tower of Unit 11 and Unit 12 , water evaporates to the atmosphere and about 1,100 m^3/h of makeup water as consumed water is needed, and the impact of water intake on the river flow is most significant.

Forced-draft air cooling system for GTCC3 is adopted and cooling water including make-up water will not be taken.
In the operation of GTCC3, consumed water is about 500 m^3/h (intake: 560 m^3/h, discharged: 56 m3/h) is assumed for GTCC3 considered from the case of GTCC2.

The makeup water is reduced by about 550 m^3/h after the shutdown of Unit 11 of the existing facilities, and consumed water and impact to river flow will be reduced.
From the above, no significant impact on water quality, bottom sediment, river ecosystem and valuable species, hydrology, and water use for agriculture is expected.

(c) Soil Contamination

There is a possibility of soil contamination caused by spill of lubricant oil, fuel oil and chemical material which will be used for operation of the facilities.
Tank for oil will be settled in the place with concrete pavement and oil dyke around the tank.
As the above measures will be taken, the occurrence of soil contamination is minimized.

(d) Noise

Quantitative noise prediction during operation phase is not conducted in EIA for 3. Since

the residential area is located close by, prediction was conducted during this survey mission and environmental impact is confirmed.

Noise level was simulated according to the same theoretical formula as in case of construction phase.
Likewise, the extent of prediction area is set to 1,000m radius from the project site.

a) Data of Noise Source

The major machinery of noise source in operation phase includes turbine, pumps, air compressors, and cooling fan at GTCC 3.
The noise level of power generation facility calculated from GTCC project of J-class in Japan.

The main noise generation source in the operation of the power plant include gas compressors, stacks, air compressors, cooling fans and ducts.
Table 12.6.2-9 shows the noise level of each equipment.

Table 12.6.2-9 Noise Level of Main Equipment

Equipment	Noise Level (dB)
Unit Transformer	75
Gas compressor	85
Heat recovery steam generator	78
Stack	90
Steam turbine	70
Gas turbine	70
GT Enhanced Air Compressor	85
Air cooled condenser	87
Condensate Pump House For ACC	70
Cooling Water Pump House	70

Note Calculation under the condition that gas turbine and steam turbine are equipped with a cover.
(Source: JICA Survey team)

[Calculation Conditions]
6 measurement points (No.1 ~ No.6) on the boundary of power plant site and other 3 points (No.7 ~ No.9) in the residential area located near the power plant were selected for simulation as in case of construction phase.

Regarding the cumulative effects of the existing power plants, the distance between GTCC 3 and Unit 3 to Unit 12 of the existing Navoi old is more than 600 m, and approximately 1 km to GTCC 1 and GTCC 2.
The noise from the existing power plants is attenuated to below 30 dB at the GTCC3 site, extremely low compared to the above-mentioned GTCC3 noise level, and cumulative effects on the residential area near GTCC3 are not expected.
Similarly, cumulative effects on the residential areas around GTCC2 side are not expected.

b) Prediction Result

Table 12.6.2-10 shows the result of the estimation of noise level (contribution, current, and future level) for each sampling point during the operation of the plant equipment. Figure 12.6.2-15 shows the noise level distribution.

Noise level generated by power plant operation is 38- 43dB (A) at the boundary of the power plant site, and 31-34 dB (A) at the residential area near the site.
As for the current noise level at the prediction point, the current noise level during construction

is adopted. The future noise level at the prediction points was estimated based on the current noise level and contribution noise level.

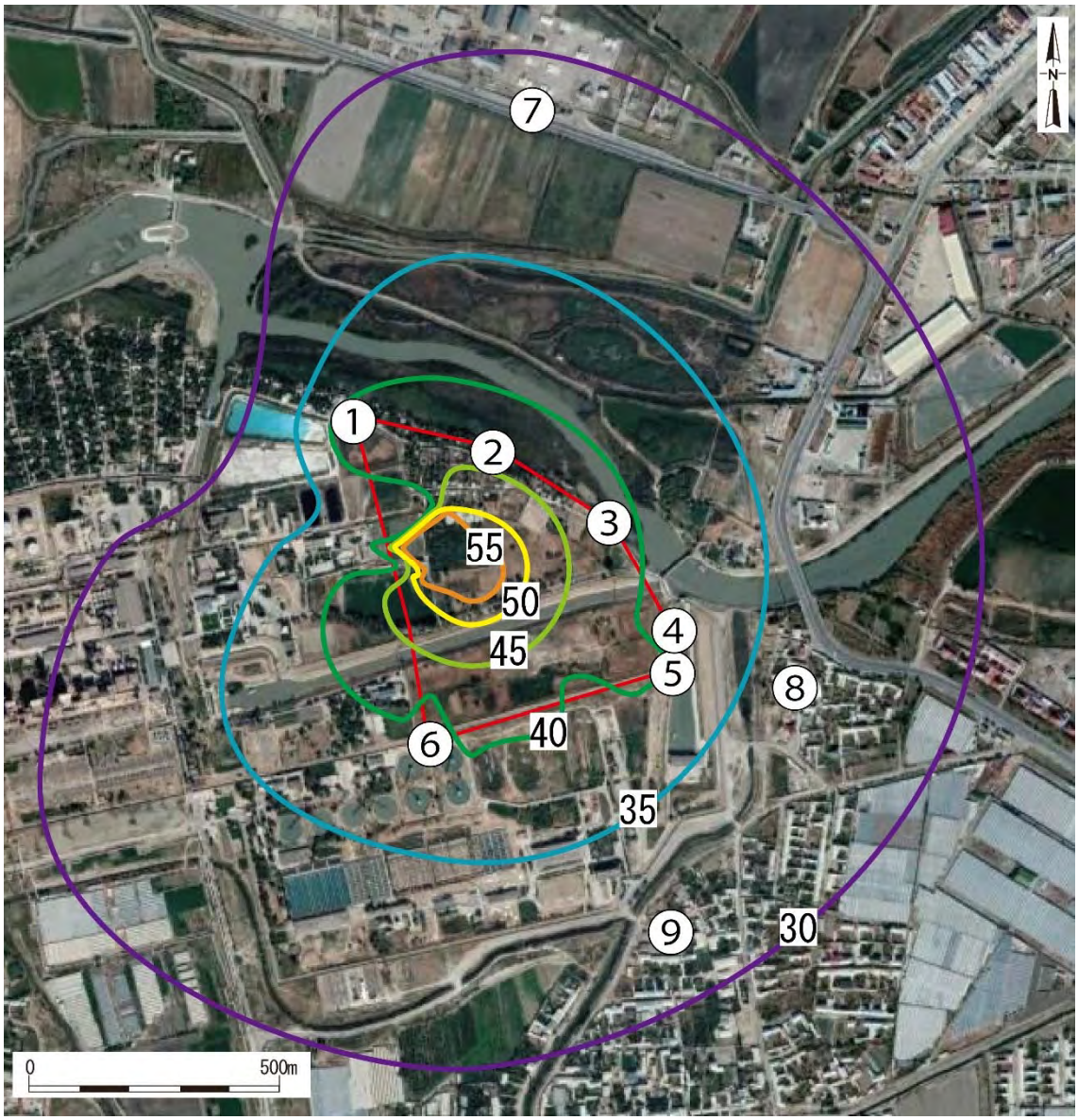
The future noise level was 46 ~ 47 dB(A) at the boundary, and 45 dB(A) at the nearby residential area.
The noise levels at all boundary comply with the environmental standard of IFC/WB guideline value (70 dB(A), industrial area). Also, the noise levels at the residential area satisfy the environmental standard of Uzbekistan and IFC/WB guideline value (45 dB(A), residential area, night time).

Noise-generating equipment will be enclosed as much as possible and low noise type equipment will be installed. Periodic maintenance of equipment will be conducted.

Table 12.6.2-10 Results of Simulating Noise Levels during Operation Phase

Location	Point	Contribution noise level (dBA)	Current noise level(dBA)	Future noise level (dBA)	Noise standard of Uzbekistan (dBA)	IFC/WB/WB EHS Guideline General
Project Boundary	No. 1	43	45	47	—	Industrial zone: Day 70 Night 70
	No. 2	43		47		
	No. 3	41		47		
	No. 4	38		46		
	No. 5	36		46		
	No. 6	38		46		
Residential area	No. 7	31		45	Residential zone: Day 55 Night 45	Residential zone: Day 55 Night 45
	No. 8	34		45		
	No. 9	32		45		

(Source: JICA Survey Team)



(Source: Google Earth/Map, added by JICA Survey Team)

Figure 12.6.2-15 Distribution of Noise Levels during Operation Phase

(e) Vibration

Quantitative vibration prediction during operation phase is not conducted in EIA for GTCC3 and 4. Since the residential area is located close by, prediction was conducted during this survey mission and environmental impact is confirmed.

Machinery of vibration sources in the power plant is basically installed on a strong foundation, and therefore vibration level attenuates with distance.

Table 12.6.2-11 describes the vibration level of a circular water pump, a gas turbine, a steam turbine and a gas compressor by distance from the example of GTCC project in Japan. Vibration level at the residential area 300m from the project site is 30dB, a sufficiently low level.

Table 12.6.2-11 Vibration Level of Power Plant Machinery

Machine type	Vibration level by distance (dB)		
	1m	100m	300m
Circulation water pump	67	38	16
Gas turbine	80	51	29
Steam turbine	74	45	23
Gas compressor	58	29	2

(Source: JICA Survey Team)

Regarding the cumulative effects of the existing power plants, the distance between GTCC3 and Unit 3 to Unit 12 of the existing Navoi old is more than 600 m, and approximately 1 km to GTCC1 and GTCC2.
The vibration from the existing power plants is attenuated to below 20 dB at the GTCC3 site, extremely low compared to the above-mentioned GTCC3 vibration level, and cumulative effects on the residential area near GTCC3 are not expected.
Similarly, cumulative effects on the residential areas around GTCC2 side are not expected.

(f) Local Economy including Employment and Means of Livelihood, Unfair Distribution of Loss and Benefit, Gender

Local people may be employed as workers by the power plant, and increased purchase of local materials and equipment items, use of local restaurants and catering service will activate local economy.
There are 1,545 employees at the existing Navoi old consisting of 1,277 men and 268 women. Among these, local employment includes 1,260 men and 267 women except for managerial positions.
In GTCC3, most of the employees will be also hired from the local people, and about 10% will be women.
The employment of the local people shall be conducted under publicized employment conditions to prevent unfair competition.

(g) Existing Social Infrastructure and Services

The project proponent will conduct the traffic control plan including route-setting and operation schedule. Bus for transportation of workers will be operated to minimize traffic and the route and schedule of operation will be discussed with the relevant organizations.
Traffic accident mitigation measures will be implemented including development of appropriate driving routes and schedule, traffic safety education and safe driving training for workers. In a period of regular maintenance when an increased number of vehicles is expected, appropriate instruction shall be provided for the maintenance company.

(h) Labor Environment (Including Work Safety)

It is necessary to develop the safety and sanitation management plan including safety education and training. Safety gears including helmet, safety shoes and earplugs shall be provided following the safety management plan. The storage of hazardous materials shall be marked with a sign board.

(i) Accident

Traffic accident mitigation measures will be implemented including development of appropriate driving routes and schedule, traffic safety education and safe driving training for workers. In a period of regular maintenance when an increased number of vehicles is expected, appropriate instruction shall be provided for the maintenance company.

(j) Cross-boundary Impact and Climate Change

The baseline emission is 3,332,342 t-CO_2/y, and the project emission is 1,919,000 t-CO_2/y, and consequently the reduction of emission is 1,413,342 t-CO_2/y.

12.6.3 Environmental assessment

The results of environmental and social impact assessment are summarized in Table 12.6.3-1 and Table 12.6.3-2.

Table 12.6.3-1 Results of Environmental Impact Assessment for Power Plant

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
Pollution prevention										
1	Air pollution	D	B	D	B	D	B	D	B	**Construction phase:** - Emission of air pollutant (NOx, PM) is expected by operation of construction vehicles and equipment, but the impact will be limited only in the adjacent area. - According to the Beaufort scale, when wind speed exceeds about 6 m/s, dust on the ground may be lifted up. The occurrence ratio of wind speed exceeding about 6 m/s around the project site is low throughout the year, whereas it occurs slightly more often in winter. **Operation phase:** - NOx is generated from the exhaust gas used for fuel, but SO_2 and soot generation will be insignificant. The decommissioning of the old facilities is also expected. - The emission concentration of air pollutant in the exhaust gas will meet the emission standard of Uzbekistan or the standard value of IFC/WB EHS guidelines (thermal power plant, 2008). - Wind speeds exceeding 10m/s are extremely rare, so downwash is expected to rarely occur. - Around the stack, there is no building causing occurrence of downdraft. - The maximum concentration at the ground level of the pollutants released by the project is extremely low compared to the Uzbekistan's standard and IFC/WB guidelines. - Future maximum concentration at ground level obtained by adding the predicted concentration of the existing power plants and the new facility to the background concentration is sufficiently low as compared with Uzbekistan's standards and the EU and the IFC/WB guidelines. - NO_2 concentration will decrease after the shutdown of the existing power plant with the operation of GTCC3.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
2	Water pollution	D	B	D	B	D	B	D	B	**Construction phase**: - Turbid water, concrete waste water and oil-containing waste water, and domestic waste water of construction workers is generated. - Waste water will be checked to comply with the environmental standard of Uzbekistan and IFC/WB EHS guideline value. **Operation phase**: - Plant waste water is generated, but some units of existing facilities will be decommissioned. - In the operation of GTCC3, the impact of drainage on the river will be reduced. - Forced-draft air cooling system will be adopted and thermal waste water will not be discharged. - Domestic waste water of workers is generated. - The waste water is treated with oil separator, neutralization and sedimentation treatment system and is examined for compliance with waste water quality standards of Uzbekistan and of the IFC/EHS Guideline for thermal power plants (2008).
3	Waste	D	B	D	B	D	B	D	B	**Construction phase**: - General waste and hazardous waste will be generated by the construction work. **Operation phase**: - General waste and hazardous waste will be generated. - There is a description that waste from the existing facilities is treated according to the danger class based on the laws and regulations of Uzbekistan, and that the amount of waste generation will not change after the shutdown of the existing facilities.
4	Soil pollution	D	B	D	B	D	B	D	B	**Construction phase**: - Possibility of soil pollution caused by leakage of lubricant oil, fuel oil and chemical material from construction work. **Operation phase**: - Possibility of soil pollution caused by leakage of lubricant oil, fuel oil and chemical material from operation.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
5	Noise and vibration	D	B	D	B	D	B	D	B	**Construction phase**: - Impact of noise and vibration is predicted caused by operation o of heavy machines and trucks, but only temporarily - All estimated noise levels at the boundary in the residential area meet the environmental standard of Uzbekistan and IFC/WB EHS guideline standards (day time) . **Operation phase**: - Some equipment in the power plant generates noise or vibration. All estimated noise levels at the boundary in the residential area meet the environmental standard of Uzbekistan and IFC/WB EHS guideline standards (night time). - The noise and vibration from the existing power plants is low compared to GTCC3 vibration level and cumulative effects on the residential area near GTCC3 are not expected.
6	Land subsidence	D	D	D	D	D	D	D	D	**Construction phase and Operation phase**: - No ground water will be pumped.
7	Odor	D	D	D	D	D	D	D	D	**Construction phase and Operation phase**: - Substances generating bad odor will not be used.
8	Bottom sediment	D	B	D	B	D	B	D	B	**Construction phase**: - Leakage of untreated effluent may cause sediment pollution. **Operation phase** - Leakage of untreated effluent may cause sediment pollution. - The waste water is treated with oil separator, neutralization and sedimentation treatment system and is examined for compliance with waste water quality standards of Uzbekistan and of the IFC/EHS Guideline for thermal power plants (2008). - Plant waste water is generated, but some units of existing facilities will be decommissioned. - In the operation of GTCC3, the impact of drainage on the river will be reduced.
Natural environment										
1	Protected area	D	D	D	D	D	D	D	D	**Construction phase and Operation phase:** - There is no protected area in and around the project site.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
2	Terrestrial ecosystem and valuable species	D	D	D	D	D	D	D	D	**Construction phase**: - The project site is an artificially cleared and prepared land and little impact on terrestrial organisms is predicted. No valuable species of flora/fauna is observed within the project site. **Operation phase**: - The surrounding area is used for human activity and potentially affected ecosystem is very small. The site is not of ecological importance.
3	River ecosystem and valuable species	D	B	D	B	D	B	D	B	**Construction phase**: - Water turbidity caused by effluent from construction work may have potential impact on river ecosystem, but only temporarily. **Operation phase**: - Forced-draft air cooling system will be adopted and thermal waste water will not be discharged and cooling water will not be taken from river. - Plant waste water and domestic waste water may cause adverse effect on river ecosystem. - The waste water is treated with oil separator, neutralization and sedimentation treatment system and is examined for compliance with waste water quality standards of Uzbekistan and of the IFC/EHS Guideline. - Plant waste water is generated, but some units of existing facilities will be decommissioned. - In the operation of GTCC3, the impact of drainage and intake on the river will be reduced.
4	Hydrology (river)	D	D	D	B	D	D	D	B	**Construction phase**: - Water intake from construction work is not predicted. **Operation phase**: - Forced-draft air cooling system is adopted and cooling water will not be taken from river. - Process water will be intake from river but some units of existing facilities will be decommissioned. - In the operation of GTCC3, the impact of intake from the river will be reduced.
5	Hydrology (ground water)	D	D	D	D	D	D	D	D	**Construction phase and Operation phase**: - Ground water pumping is not conducted.
6	Topography and geology	D	D	D	D	D	D	D	D	**Construction phase and Operation phase**: - The site is already prepared for power plant use, and the alteration of geographical features will be very limited.
Social environment										

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
1	Involuntary resettlement and land acquisition	D	B	D	D	D	B	D	D	**Pre-construction**: - 14ha of land will be acquired permanently for construction of GTCC3&4. 36 households will lose their houses/summer cottages and 2 leasehold farmers will lose their agricultural land. - A-LARAP was prepared in accordance with Uzbek legislation and JICA Guidelines. The affected people will be compensated in accordance with the A-LARAP.
2	Poor People	D	C	D	D	D	D	D	D	**Pre-construction**: - It was confirmed that there are no poor people out of the affected people by the land acquisition.
3	Minorities and indigenous people	D	D	D	D	D	D	D	D	**Pre-construction, Construction phase and Operation phase**: - There is no minority group and indigenous people living around the project site.
4	Local economy including employment and means of livelihood	B	B	B	D	B	B	B	D	**Pre-construction**: - Leasehold farmers will lose sources of their livelihood. They will be compensated in accordance with Uzbek legislation and JICA Guidelines. **Construction phase and Operation phase**: - The employment of local people as project workers, and purchase of project equipment and material from the local business will activate local economy.
5	Land Use and Utilization of Local Resources	D	D	D	D	D	D	D	D	**Construction phase and Operation phase**: - The site is a land for power plant use and use of land and local resources will not be affected.
6	Water use	D	D	D	B	D	D	D	B	**Construction phase :** - Water intake from construction work is not predicted. **Operation phase**: - Zeravshan River around the power plant is not used for fishery or river traffic and is used for irrigation channel of agriculture. Forced-draft air cooling system is adopted and cooling water will not be taken. - Plant waste water is generated, but decommissioning of the existing facilities is expected. - In the operation of GTCC3, the impact of drainage and intake on the river will be reduced.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
7	Existing Social Infrastructure and Services	D	B	D	B	D	B	D	B	**Construction phase**: - In the nearest city of Navoi, there is enough accommodation, schools and sewerage system capacity to accommodate the workers and their families, so the installation of new facilities is not necessary. - The commute for power plant workers will temporarily increase the traffic volume of the surrounding roads. **Operation phase**: - Increased traffic may cause damage to the road.
8	Social bodies including society-related capitals and social organizations that make local decisions	D	D	D	D	D	D	D	D	**Pre-construction, Construction phase and Operation phase**: - The site is a land for power plant, and social infrastructure and local decision-making institutions will not be affected.
9	Unfair distribution of damage and benefit	D	B	D	B	D	B	D	B	**Pre-construction phase**: - The site is a power plant site partly used for dacha and farmland, and misdistribution of benefits and loss regarding compensation or assistance is predicted. - A-LARAP was prepared in accordance with Uzbek legislation and JICA Guidelines. The affected people will be compensated in accordance with the A-LARAP. Therefore, unfair distribution will be prevented and implementation of A-LARAP will be monitored internally and externally. **Construction phase**: - There may be inequality of employment of the local residents and contract outsourcing which may lead to misdistribution of benefits. **Operation phase**: - There may be inequality of employment of the local residents and contract outsourcing which may lead to misdistribution of benefits.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
10	Local Conflicts of Interest	D	B	D	D	D	B	D	D	**Pre-construction:** - The site is a power plant site partly used for dacha and farmland, and local conflicts of interest may occur. - A-LARAP was prepared in accordance with Uzbek legislation and JICA Guidelines. The affected people will be compensated in accordance with the A-LARAP. Therefore, compensation will be made fairly. **Construction phase:** - Numbers of construction workers from outside is expected, and lack of understanding of local customs may lead to conflicts with local residents. **Operation phase**: - Workers from outside will be limited in number, and the little conflict between the local people and outside workers arising from difference in custom is not anticipated.
11	Cultural heritage	D	D	D	D	D	D	D	D	**Construction phase and Operation phase**: - Historical, cultural and/or archaeological property and heritage does not exist around the project site.
12	Landscape	D	D	D	D	D	D	D	D	**Construction phase and Operation phase**: - There is no scenic area around the project site.
13	Gender	D	C	D	C	D	B	D	B	**Pre-construction phase:** - The site is site partly used for dacha and farmland, and the affected people may include females. - In accordance with A-LARAP, additional support will be provided to female-headed households. **Construction phase**: - Inequality of employment condition due to gender may occur. **Operation phase**: - Inequality of employment condition due to gender may occur.
14	Children's Rights	D	C	D	D	D	D	D	D	**Pre-construction phase**: - The site is partly used for dacha and farmland, and the affected people may include children. **Construction phase**: Recruiting children for workers is not anticipated. **Operation phase**: - Recruiting children for workers is not anticipated.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
15	Infectious Diseases such as HIV/AIDS	D	B	D	D	D	B	D	D	**Construction phase**: - Influx of migrant workers may increase the risk of spread of infectious diseases. **Operation phase**: - Workers from outside will be limited in number and spread of infectious disease will be prevented by regular health checkup and other means.
16	Labor Environment (Including Work Safety)	D	B	D	B	D	B	D	B	**Construction phase**: - Risk of labor accident is relatively high. **Operation phase**: - Labor accident may affect the workers
Others										
1	Accidents	D	B	D	B	D	B	D	B	**Construction phase**: - Possibility of traffic accident by operation of construction vehicles. **Operation phase**: - Possibility of traffic accident by project vehicles and fire of the facility.
2	Cross-boundary Impact and Climate Change	D	D	D	C	D	D	D	C	**Construction phase**: - Although CO_2 will be produced by construction work, construction period is limited and cross-boundary pollution and impact on climate change is predicted to be insignificant. **Operation phase**: - The existing steam turbine power generation facilities constructed in Soviet Union is to be suspended when ODA loan is financed to this Project and the operation of GTCC 3 commences. - Therefore, the effect of reducing GHG emissions through the implementation of this project is expected. - The baseline emission is 3,332,342t-CO_2/y, and the project emission is 1,919,000 t-CO_2/y, and consequently the reduction of emission is 1,413,342 t-CO_2/y.

(Source: JICA Survey Team)

Notes: The categorization criteria are as follows.
A: Significant positive/negative impact is expected.
B: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown.
(A further examination is needed, and the impact may be clarified as the study progresses.)
D: No impact is expected.

Table 12.6.3-2 Results of Environmental Impact Assessment for Transmission line and Substation

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
Pollution prevention										
1	Air pollution	D	B	D	D	D	B	D	D	**Construction phase:** - Although heavy equipment and trucks are likely to generate air pollutants (including NOx and PM), there shall be very few of these so the quantity of emissions should be low. Thus, impact from the emission is likely to be limited to the vicinities of the construction areas. Also, the construction period of each tower is short and the impact is temporary. **Operation phase:** - No air pollutants will be generated.
2	Water pollution	D	B	D	D	D	B	D	D	**Construction phase:** - The transmission line route and substation are located mainly in a flat area with very little slope, and the soil run-off from earth cuts and the resulting turbidity is not expected. The impact should be temporary. - Domestic waste water, concrete-containing waste water and oil-containing waste water is likely to be generated. However, since the quantity of workers and construction work is limited, the scope of impact should be limited and temporary. **Operation phase:** - No water pollutants will be generated.
3	Waste	D	B	D	D	D	B	D	D	**Construction phase:** - Construction work will generate general waste and hazardous waste. However, since the quantity of workers and construction work is limited, generation of waste is likely to be little. **Operation phase:** - Waste will hardly be generated.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
4	Soil contamination	D	B	D	B	D	B	D	B	**Construction phase:** - Lubrication oil and fuel spilled by from construction vehicles and machinery are likely to cause contamination to the soil. However, since the quantity of construction work is limited, impact should be little and temporary. **Operation phase:** - In the substation, leakage of oil in the transformer may be occurred.
5	Noise and vibration	D	B	D	B	D	B	D	B	**Construction phase:** - The operation of heavy equipment and trucks will probably cause a temporary impact from the noise and vibrations. However, there shall be very few equipment and trucks so the quantity of noise and vibrations should be low. Thus, impact will be limited to the vicinities of the construction areas. **Operation phase:** - In the substation, noise of transformer will be generated.
6	Land subsidence	D	D	D	D	D	D	D	D	**Construction and operation phase:** - Water will not be drawn up from underground.
7	Odor	D	D	D	D	D	D	D	D	**Construction phase:** - The transmission towers will be built on the flat floor. Therefore, soil of some embankments and earth cuts may not overflow into the river. **Operation phase:** - Waste will hardly be generated.
Natural environment										
1	Protected area	D	D	D	D	D	D	D	D	**Construction phase and operation phase:** - The transmission line will not pass through wild life preservation area and there is no such place nearby area.
2	Terrestrial ecosystem and valuable species	D	D	D	B	D	D	D	B	**Construction phase:** - The transmission line route will be along the road and be surrounded by agricultural land. Therefore, terrestrial ecosystem and rare species are not expected to be affected. **Operation phase:** - There are neither rare species of birds However impact of bird strikes will may be occurred.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
3	River ecosystem and valuable species	D	D	D	D	D	D	D	D	**Construction phase:** - The transmission towers will be built on the flat floor. Therefore, soil of some embankments and earth cuts may not overflow into the river. **Operation phase:** - The transmission line route is located mainly in a flat area with very little slope, and the soil run-off from earth cuts and the resulting turbidity is not expected.
4	Hydrology (river)	D	D	D	D	D	D	D	D	**Construction phase and Operation phase:** - River water will not be taken in.
5	Hydrology (ground water)	D	D	D	D	D	D	D	D	**Construction phase and Operation phase:** - Water will not be drawn up from underground.
6	Geography and geology	D	B	D	D	D	B	D	D	**Construction phase:** - The transmission line route is located mainly in a flat area with very little slope, and the soil run-off from earth cuts is not expected. The impact should be temporary. **Operation phase:** - Soil flowage will not occur.
Social environment										
1	Involuntary Resettlement and Land acquisition	D	B	D	D	D	B	D	D	**Pre-construction:** - 22.92ha of land will be acquired permanently and 16.52ha will temporally for two years for construction of transmission line and substation. Permanently, 3 leasehold farmers will lose their agricultural land, and 2 commercial structure will be removed. Temporally, 19 leasehold farmers cannot use their agricultural land. - A-LARAP was prepared in accordance with Uzbek legislation and JICA Guidelines. The affected people will be compensated in accordance with the A-LARAP.
2	Poor peoples	D	B	D	D	D	B	D	D	**Pre-construction:** - It was confirmed that there are no poor people out of the affected people by the land acquisition.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
3	Minorities and indigenous people	D	D	D	D	D	D	D	D	**Construction phase and Operation phase:** - There is no minority group living around transmission line route.
4	Local economy including employment and means of livelihood	D	B	D	D	D	B	D	D	**Pre-construction phase:** - Leasehold farmers will lose sources of their livelihood. They will be compensated in accordance with Uzbek legislation and JICA Guidelines. **Construction phase:** - The construction will not lead to purchasing material and equipment items in the local area and also not offer employment to local people. **Operation phase:** - The operation will not lead to purchasing material and equipment items in the local area and also not offer employment to local people.
5	Land use and utilization of local resources	D	B	D	D	D	B	D	D	**Construction phase and Operation phase:** - Since the transmission line route is governmental land and not been used for farmland and residential area, the construction and operation will have no impact.
6	Water use	D	B	D	D	D	B	D	D	**Construction phase:** - The transmission line route and substation are located mainly in a flat area with very little slope, and the soil run-off from earth cuts and the resulting turbidity is not expected. The impact should be temporary. - Domestic waste water, concrete-containing waste water and oil-containing waste water is likely to be generated. However, since the quantity of workers and construction work is limited, the scope of impact should be limited and temporary. **Operation phase:** - The transmission line and substation will hardly generate waste water.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
7	Existing social infrastructure and social service	D	B	D	D	D	B	D	D	**Construction phase**: - Inflow of the limited number of workers is expected. - Traffic is expected to increase during construction but is limited. **Operation phase:** - The very few numbers of workers are expected at periodical inspections.
8	Social bodies including society-related capitals and social organizations that make local decisions	D	D	D	D	D	D	D	D	**Construction phase and Operation phase:** - Since the transmission line route is governmental land and not been used for farmland and residential area, no impact is expected on society-related capitals and social bodies such as local bodies that make decisions on local affairs.
9	Unfair distribution of loss and benefit	D	B	D	D	D	B	D	D	**Preconstruction phase**: - The site is partly used for farmland, and misdistribution of benefits and loss regarding compensation or assistance is predicted. - A-LARAP was prepared in accordance with Uzbek legislation and JICA Guidelines. The affected people will be compensated in accordance with the A-LARAP. Therefore, unfair distribution will be prevented and implementation of LARAP will be monitored internally and externally. **Construction phase:** - If employing local people and/or outsourcing contracts are not fair, benefit may be unfairly distributed. **Operation phase:** - The employment of local people for the operation of the transmission line will not be generated.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
10	Local Conflicts of Interest	D	B	D	D	D	B	D	D	**Pre-Construction phase:** - The site is used for farmland, and local conflicts of interest may occur by inadequate compensation. - A-LARAP was prepared in accordance with Uzbek legislation and JICA Guidelines. The affected people will be compensated in accordance with the A-LARAP. Therefore, compensation will be made fairly. **Construction phase:** - The construction will not lead to purchasing material and equipment items in the local area and also not offer employment to local people. **Operation phase:** - The operation will not lead to purchasing material and equipment items in the local area and also not offer employment to local people.
11	Cultural heritage	D	D	D	D	D	D	D	D	**Construction phase and Operation phase:** - Since the surroundings of the transmission line route have no historical, cultural and religious precious heritages, no impact is expected.
12	Scenery	D	D	D	D	D	D	D	D	**Construction phase and Operation phase:** - Since the surroundings of the transmission line route have no scenic spots, no impact is expected.
13	Gender	D	D	D	D	D	D	D	D	**Pre-construction phase** - The site is site partly used for farmland, and the affected people may include females. - In accordance with A-LARAP, additional support will be provided to female-headed households. **Operation phase:** - No particular impact is expected to take place on the gender.
14	Rights of children	D	D	D	D	D	D	D	D	**Construction phase** - The site is partly used for farmland, and the affected people may include children. **Operation phase:** - No particular impact is expected to take place on the rights of children.

No.	Item	Assessment at the scoping				Assessment based survey results				Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
15	HIV/AIDS and other infectious diseases	D	D	D	D	D	D	D	D	**Construction phase**: - Influx of migrant workers may increase the risk of spread of infectious diseases. **Operation phase**: - Workers from outside will be limited in number and spread of infectious disease will be prevented by regular health checkup and other means.
16	Work environment (including labor safety)	D	B	D	B	D	B	D	B	**Construction phase**: - Risk of labor accident is relatively high. **Operation phase**: - Labor accident may affect the workers
Others										
1	Accidents	D	B	D	B	D	B	D	B	**Construction phase:** - Traffic accidents may occur during construction **Operation phase:** - Steel towers may fall down due to a storm, heavy rain, etc. - The health impact of electro shock may be occurred
2	Impact across the borders and on climatic change	D	D	D	D	D	D	D	D	**Construction phase:** - Although CO_2 is generated during construction, the impact is quite limited to a temporal period and hardly expected to take place across the borders and on climatic change. **Operation phase:** - No particular impact is expected to take place across the borders and on climatic change.

(Source: JICA Survey Team)

Notes: The categorization criteria are as follows.
A: Significant positive/negative impact is expected.
B: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown.
(A further examination is needed, and the impact may be clarified as the study progresses.)
D: No impact is expected.

12.7 Environmental Management Plan (Mitigation Measures)

12.7.1 Power Plant

(1) Implementation System

1) Construction Phase

At the construction phase, Project Implementation Unit (PIU) of Navoi old shall carefully consider all construction activities with the supervision consultant, and encourage the EPC contractor to fully understand the necessary mitigation measures and implement them.

In this regard, PIU shall be organized prior to the start of construction and an expert environmental management administrator in the PIU shall be employed. The unit will discuss and prepare mitigation measures with the supervision consultant and the EPC contractor prior to the start of construction.

A large inflow of workers is expected once construction begins. The PIU shall also function as a grievance organization seeking to understand and address any grievances from local people during the construction phase, and conduct appropriate mitigation measures.

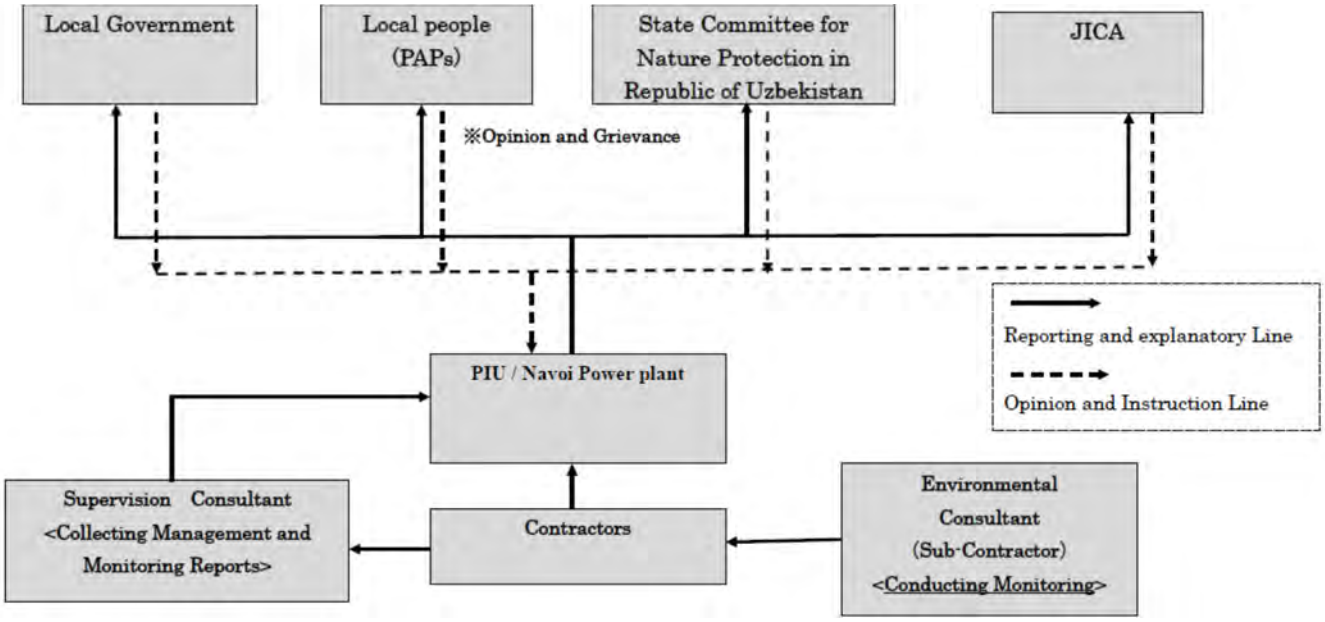
The PIU shall improve the understanding of the surrounding community regarding construction details, schedule and mitigation measures, and shall obtain local people's opinions and correct the mitigation measures as appropriate.

In order to confirm the implementation of environmental management and to consider further mitigation measures, the contractor should submit regular reports to the supervisory consultant and the PIU on the implementation status of the management plan.

The administrator of the PIU shall regularly hold explanation sessions with the local community, continuously listen to their grievances, submit reports to JICA and other relevant organizations regarding those grievances, as well as the implementation status of environmental management and environmental monitoring (described hereinafter).

If environmental problems occur due to construction work, the PIU shall confirm the cause with the contractor as soon as possible.
In order to resolve these problems, the administrator of the PIU shall instruct the contractor and consultant regarding necessary measures. If the problem is serious, PIU may order the contractor to halt construction work until the problem is resolved.

Figure 12.7.1-1 outlines the environmental management and monitoring implementation structure in accordance with the reporting flow during the construction phase.



(Source: JICA Survey Team)

Figure 12.7.1-1 Environmental Management Plan and Monitoring Implementation Structure in Construction Phase for Power Plant

2) Operation Phase

The PIU and power plant are responsible to develop and implement an environmental management plan that includes mitigation measures. An expert environmental management administrator in the PIU and power plant shall be employed to ensure the environmental management plan is appropriately implemented.

The administrator shall encourage the project staffs to familiarize themselves with the environmental management plan prior to the start of plant operation, and shall regularly educate them regarding ongoing matters during the operation phase.

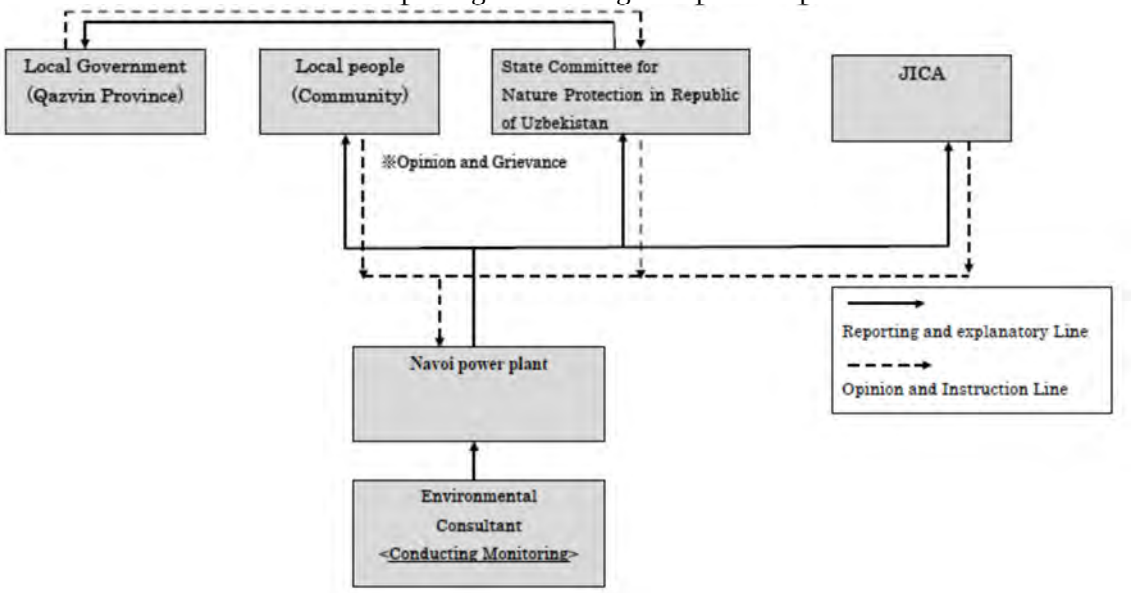
The administrator shall also function as a grievance organization and will strive to understand and address any grievances from the local people during the operation phase, and conduct appropriate mitigation measures.

The basic function of the environmental management plan is to closely cooperate with the local community, and to provide them with sufficient explanations based on positive mitigation measures, which is very important.

The administrator shall report the contents and implementation status of the environmental management plan and environmental monitoring plan described below to the director of the plant and the director of the responsible section, with the director of power plant taking final responsibility.

The administrator shall regularly provide explanations to the local community, continuously listen to their grievances, submit reports to JICA and other relevant organizations regarding those grievances, as well as on the implementation status of environmental management and environmental monitoring activities (described hereinafter).

Figure 12.7.1-2 outlines the environmental management and monitoring implementation structure in accordance with the reporting flow during the operation phase.



(Source: JICA Survey Team)

Figure 12.7.1-2 Environmental Management Plan and Monitoring Implementation Structure in Operation Phase for the Power Plant

(2) Environmental Management Plan

Table 12.7.1-1 describes the environmental impact, mitigation measure, responsible organization and cost for each environmental item in construction and operation phase.

Table 12.7.1-1 Environmental Management Plan (Power Plant)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Construction Stage									
1	Air Pollution	1) Generation of fine particles from land preparation and other civil engineering work. 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment	1)-2) - Ambient air quality standards (Uzbekistan) - IFC guideline values for ambient air quality (General/ 2007)	1) –2) - Prevention of air pollution in the surrounding area	1) Dust - Generation of dust due to strong wind will be reduced with periodic watering (dry season) - Conduct washing of equipment and vehicles - The soil and sand-transport trucks shall be covered. 2) Preventing exhaust gas emissions - Conduct periodical maintenance in the construction equipment and vehicles - Turn off engines on standby 1)-2) - Monitoring of ambient air in the residential area compared to the standard of Uzbekistan and IFC/WB EHS guidelines.	1) - 2) - Construction area	1) - 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor
2	Water Pollution	1) Muddy water after rain 2) Wastewater from concrete 3) Oily wastewater 4) Wastewater from the construction site	1) - 4) - Water quality standards (Uzbekistan) - IFC/WB EHS guideline values for waste water quality (General/ 2007)	1) - 4) - Prevention of water pollution of the irrigation canal	1) Installation of temporary sedimentation pond or evaporation pond and rainwater drainage, if need. 2) Installation of a neutralization tank 3) Installation of a provisional oil separator 4) Installation of a septic tank and temporary toilets for the workers 1)-4) Monitoring of river water quality compared to the standard of Uzbekistan	1) -4) - Construction area	1) - 4) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
3	Waste	1) General waste generated in the construction phase (packaging, organic, etc.) 2) Hazardous waste generated in the construction phase (such as waste oil, exhausted batteries etc.)	1) – 2) - Waste management regulation (official name yet to be included in this document)	1)-2) Prevention of soil and water pollution, malodors and hygiene issues	1) - 2) - Development of waste management program -Implement a waste management and disposal plan including education of site workers addressing waste reduction, recycling and inadequate waste disposal. -Litter separation and storage in an appropriate place and method. -Compliance with legislation regarding general waste and hazardous waste, and assuring they are adequately transported and treated in the facilities authorized by authority, as in the case of the existing facility.	1) - 2) Construction area	During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor
4	Soil pollution	Leakage of lubricants, fuels and chemical material from construction activity (such as chemical material)	-Hazardous material regulation	Prevent soil pollution in the project site	Storage of oil and chemical materials in an appropriate storage site and method to prevent permeation into the ground (for examples, a concrete layer covered soil)	Construction area	During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor
5	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	1)- 2) - Noise level standards - IFC EHS guideline, noise level values (General/ 2007)	1)- 2) - Reduction of noise level from construction activities	1) Construction machinery - Perform construction work during daytime - Using low-noise/ low vibration equipment 2) Mobilization - Limit truck speed 1)- 2) -Periodic checks and regular maintenance of construction equipment and vehicles -Monitoring of Noise level at site boundary and the residential area compared to the standard of Uzbekistan and IFC/WB EHS guidelines. - Temporary soundproof wall around the project site, if need.	1)- 2) - Construction area	1)- 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
6	Bottom sediment	1) Wastewater from concrete 2) Oily wastewater 3) Domestic waste water from the site workers	1)- 3) Same as "2) Water Pollution"	1)-3) Minimize the impact to fishery by preventing water pollution	1)- 3) Same as "2) Water Pollution"	1)-3) - Construction area	1)-3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by Contractor and PIU
7	River ecosystem and valuable species	1) Wastewater from concrete 2) Oily wastewater 3) Domestic waste water from the site workers	1)- 3) Same as "2) Water Pollution"	1)-3) Minimize the impact to fishery by preventing water pollution	1)- 3) Same as "2) Water Pollution"	1)-3) - Construction area	1)-3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by Contractor and PIU
8	Involuntary resettlement and land acquisition	1) Loss of private land 2) Loss of farms a 3) Loss of residential/ commercial structures 4) Loss of trees and fruit	1) - 4) - The acquisition and requisition of immovable property ordinance of 1982 - JICA guideline (2010)	1) Consideration for land owners 2) Consideration for persons losing their homes 3), 4) Consideration for persons losing their property	1)-4) - Development of livelihood restoration measure with appropriate compensation and support. - Monitoring of the local residents shall be conducted. - Establishment of grievance system.	1) - 4) -Construction area	1) - 4) - During land acquisition process	- District Office - PIU	Expenses to be paid by PIU
9	Poor People	- Poor households among those who are to be resettled.	- JICA guideline (2010)	- Consideration for poor people	- Same as "8) Involuntary resettlement and land acquisition"	-Construction area	- During land acquisition process	- District Office - PIU	Expenses to be paid by PIU

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
10	Local economy including employment and means of livelihood	1) Loss of private land, farms, residential/ commercial structures and trees etc. 2) Employment for local residents	-	1) Consideration for land owners, persons losing their homes and persons losing their property 2) - Activation of the local economy - Increase the standard of living of the local population	1) Same as "8) Involuntary resettlement and land acquisition" 2) - Employ as many local residents as possible - Use the services (i.e., laundry and catering services, etc.) and products offered by the local community	1) Construction area 2) - Construction area and the surrounding area	1) During land acquisition process 2) During construction phase	1) - District Office - PIU 2)Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	1) Expenses to be paid by PIU 2)Expenses included in contract cost by Contractor and PIU
11	Existing Social Infrastructure and Services	- Traffic jam caused by increasing traffic	-	-Maintaining the usability of the roads	- the traffic control plan including route-setting and operation - Bus for transportation of workers	- Construction area and traffic route	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by Contractor and PIU
12	Unfair distribution of loss and benefit	1) Loss of private land, farms, residential/ commercial structures and trees etc. 2)Employment distribution in the area could be unfair	-	1) Consideration for land owners, persons losing their homes and persons losing their property 2)Promote local employment and avoiding a feeling of unfairness within the community	1) Same as "8) Involuntary resettlement and land acquisition" 2) Present employment opportunities with clearly explained pre-requisites that are not related to gender	1) Construction area 2) - Construction area and the surrounding area	1) During land acquisition process 2) During construction phase	1) - District Office - PIU 2)Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	1) Expenses to be paid by PIU 2)Expenses included in contract cost by Contractor and PIU

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
13	Local Conflicts of Interest	1) Loss of private land, farms, residential/ commercial structures and trees etc. 2)Conflict between the local population and manpower coming from other regions	-	1) Consideration for land owners, persons losing their homes and persons losing their property 2)Cooperation with the local population	1) Same as "8) Involuntary resettlement and land acquisition" 2) - Employ as many local residents as possible - Respect local habits and traditions - Promote cultural exchange with the local population (for instance, participating in a local event)	1) Construction area 2)Construction area and the surrounding area	1) During land acquisition process 2)During construction phase	1) - District Office - PIU 2) - Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	1) Expenses to be paid by PIU 2)Expenses included in contract cost by Contractor and PIU
14	Gender	1) Loss of private land, farms, residential/ commercial structures and trees etc. 2)Employment for local residents	-	1) Consideration for land owners, persons losing their homes and persons losing their property 2) Activation of the local economy - Increase the standard of living of the local population	1) Same as "8) Involuntary resettlement and land acquisition" 2) Present employment opportunities with clearly explained pre-requisites that are not related to gender as possible	1) Construction area 2)Construction area and the surrounding area	1) During land acquisition process 2)During construction phase	1) - District Office - PIU 2) - Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	1) Expenses to be paid by PIU 2)Expenses included in contract cost by Contractor and PIU

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
15	Children's rights	1) Loss of private land, farms, residential/ commercial structures and trees etc. 2)Potential increase in school abandonment due to child labor	-	1) Consideration for land owners, persons losing their homes and persons losing their property 2) Prohibit child labor	1) Same as "8) Involuntary resettlement and land acquisition" 2) - Prohibit labor contracts with children - Conduct periodical inspections regarding child labor	1) Construction area 2)Construction area and the surrounding area	1) During land acquisition process 2)During construction phase	1) - District Office - PIU 2) - Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	1) Expenses to be paid by PIU 2)Expenses included in contract cost by Contractor and PIU
16	Infectious Diseases such as HIV/AIDS	- Temporary influx of migrant labor during construction may increase risk of infection	-	- Consideration of sanitation of local residents	- Development of safety and sanitation management plan and implementation of regular medical checkup. - Education and training on workers' infectious disease and health care - Installation of medical facility and medical staff. - Implementation of periodic medical check-ups	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by Contractor and PIU

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
17	Work environment (Including Work safety)	High risk of labor accidents in construction work: - Handling heavy loads - Working at heights - High-noise work	- Work safety standards established in Uzbekistan - EHS Guidelines on the IFC/WB (General, 2007)	- Labor safety and prevention of health problems	- Development of safety and sanitation management plan and implementation of regular medical checkup. - Prepare a manual for labor accident prevention including safety education and training: - Provide workers with appropriate protective equipment such as a helmet, safety boots, safety belt, mask, electric shock prevention equipment, earplugs, etc. - Establish clear signs to identify the location of hazardous or toxic material - Create a “User Manual” for equipment such as cranes -Provide of medical facility on the working site with nurse.	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by Contractor and PIU
18	Accidents	Traffic accidents	-	Prevent traffic accidents	- Checking of traffic regulations -Installation of traffic signs - Driving safety education, speed restriction -Checkup of vehicle equipment (brake, klaxon).	Roads surrounding the construction area	During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by Contractor and PIU
Operational Stage									

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
1	Air Pollution	Operation of gas turbine generates emissions of NOx in case gas fuel is used	- Gas emission standards (Uzbekistan) - IFC/WB EHS guideline emission gas standard (Thermal power plant, 2008) -Air quality standards (Uzbekistan) -Air quality standards of IFC/WB EHS guideline (General, 2007)	- Prevention of air pollution in the surrounding area	- Introduction of Low NOx combustion technology to reduce the total emission of NO_2. - Install high stack(110m) for promotion of dispersion and reduction of concentration on the ground level - A continuous emission monitoring system (CEMS) will be installed in the duct, and emissions will be compared with international emissions standards and Uzbekistan's standards - Monitoring of ambient air in the residential area compared to the standard of Uzbekistan and IFC/WB EHS guidelines.	- Power plant	- During operational phase	- PIU/ Environmental Consultant	Expenses of equipment included in contract cost by PIU and Contractor. Other expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
2	Water Pollution	1) Process waste water and Oily water including rain water 2) domestic waste water	1) -2) - IFC/WB EHS guideline effluent standard (Thermal power plant, 2008) -Uzbekistan's effluent standards - IFC/WB EHS guideline domestic wastewater standard (General, 2007)	1)-2) - Prevention of river pollution	1) - Wastewater will be collected, and its related neutralization, sedimentation and oil separation equipment will be installed. Treated wastewater will be periodically checked against the IFC/WB EHS standards 2) -Wastewater treatment for domestic water will be installed. The treated water will be periodically checked against IFC/WB EHS guideline and Uzbekistan's standard. -- Monitoring of waste water and river water compared to the standard of Uzbekistan and IFC/WB EHS guidelines.	1) - 2) - Power plant	1) - 2) - During operational phase	- PIU/ Environmental Consultant	Expenses of equipment included in contract cost by PIU and Contractor. Other expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
3	Waste	1) Hazardous waste from wastewater treatment (sludge, oils) 2) Domestic waste from workers	1) - 2) - Waste management regulation	1) - 2) - Prevention of inadequate waste disposal	1) - 2) - Development of waste management program -- Implement a waste management and disposal plan including education of site workers addressing waste reduction, recycling and inadequate waste disposal. -Litter separation and storage in an appropriate place and method. -Compliance with legislation regarding general waste and hazardous waste -Adequately transported and disposal in authorized method and place.	1) - 2) - Power plant	1) - 2) - During operational phase	- PIU/ Environmental Consultant	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost)
4	Soil pollution	Leakage of lubricants and fuels used for operation of the facilities	-Hazardous material regulation	Prevent soil pollution in the project site	Storage of oil and chemical materials in an appropriate storage site and method to prevent permeation into the ground (for examples, a concrete layer covered soil)	Power plant	During operational phase	PIU/ Environmental Consultant	Expenses of equipment included in contract cost by PIU and Contractor. Other expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
5	Noise and vibration	1) Noise and vibration caused by equipment	1)-2 - IFC/WB EHS Guidelines noise level standards (General, 2007)	1)-2) - Mitigation of noise from the power plant - Mitigation of vibration from the power plant	1)-2) - Introduction of low noise type or enclosed type equipment - Introduction of low vibration equipment - Reduction of vibration by selecting a solid foundation - Maintaining equipment by periodical check -- Monitoring of Noise level at site boundary and the residential area compared to the standard of Uzbekistan and IFC/WB EHS guidelines.	1) - 2) - Power plant	1) - 2) - During operational phase	- PIU/ Environmental Consultant	Expenses of equipment included in contract cost by PIU and Contractor. Other expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
6	Bottom Sediment	1) Process waste water and Oily water including rain water 2) domestic waste water	1)- 2) Same as "2) Water Pollution"	1)-2) Minimize the impact to fishery by preventing water pollution	1)- 2) Same as "2) Water Pollution"	1) - 2) - Power plant	1) - 2) - During operational phase	- PIU/ Environmental Consultant	Expenses of equipment included in contract cost by PIU and Contractor. Other expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
7	River ecosystem and valuable species	1) Process waste water and Oily water including rain water 2) domestic waste water	1)- 2) Same as "2) Water Pollution"	1)-2) Minimize the impact to fishery by preventing water pollution	1)- 2) Same as "2) Water Pollution"	1) - 2) - Power plant	1) - 2) - During operational phase	- PIU/ Environmental Consultant	Expenses of equipment included in contract cost by PIU and Contractor. Other expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
8	Local economy including employment and means of livelihood	- Employment for local residents - Local supply and machinery	-	- Activation of the local economy - Increase the standard of living of the local population	- Employ as many local residents as possible - Use the services (i.e., laundry and catering services, etc.) and products offered by the local community	- Villages around the site - Power plant	- During operational phase of the power plant	- PIU/ Environmental Consultant	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
9	Existing Social Infrastructure and Services	-Traffic jams caused by increased vehicles	-	-Minimization of increasing traffic volume	- Minimizing traffic volume by using buses for employees	- Villages near the site	- During the operation of power plant	- PIU/ Environmental Consultant	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
10	Water use	- In case once-through cooling system is adopted, water recession area may occur	-	Protection for water use of irrigation channel of farm	-Forced-draft cooling fan system is adopted	- Power plant	- During operational phase	- PIU/ Environmental Consultant	Expenses of equipment included in contract cost by PIU and Contractor. Other expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
11	Unfair distribution of loss and benefit	Employment distribution in the area could be unfair.	-	Promote local employment and avoiding a feeling of unfairness within the community	- Present employment opportunities with clearly explained pre-requisites	- Power plant	- During operational phase	- PIU/ Environmental Consultant	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
12	Gender	1)Employment for local residents 2)Inequality of employment condition	-	1) - Activation of the local economy - Increase the standard of living of the local population 2) avoiding a feeling of unfairness for female	1)) Same as “8) Local economy including employment and means of livelihood” 2) Present employment opportunities with clearly explained pre-requisites that are not related to gender as possible	1)-2) - Power plant	1)-2)- During operational phase	1)-2)- PIU/ Environmental Consultant	1)-2) Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
13	Work environment (Including Work safety)	Labor accidents involving: Working at heights - High-noise work	- Occupational standards established in Uzbekistan - IFC/WB EHS Guidelines (General, 2007)	- Labor safety and prevention of health problems	- Prepare a manual for labor accident prevention including safety education and training: -Provide workers with appropriate protective equipment such as a helmet, safety boots, safety belt, mask, electric shock prevention equipment, earplugs, etc. - Establish clear signs to identify the location of hazardous or toxic material -Construction of medical facility on the working site with nurse. - Establishment of cooperative relationship with the local medical facilities.	- Power plant	- During operational phase	- PIU/ Environmental Consultant	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
14	Accidents	1)Fire 2) Gas-leakage 3) Traffic accidents (especially at periodic maintenance)	-	1) Fire prevention and fire extinguishing 2)Gas-leakage prevention 3) Prevention of traffic accidents	1) Fire - Implement plan to prevent oil leakages - Installation of fire extinguishers - Installation of fire alarm systems - Establishment of fire brigade and training 2) Gas-leakage - Development of gas-leakage prevention management plan - Gas-leakage alarm system - Inspection of equipment 3) Traffic accidents - Investigate adequate traffic rules - Education to promote safe driving	1) Power plant 2) Gas pipeline and power plant 3) Roads surrounding the power plant	1) - 3) During operational phase	- PIU/ Environmental Consultant	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
15	Transboundary effects and climate change	CO_2 emissions	Amount of CO_2 emissions	Reduction of CO_2 emissions per kW	Utilization of high-efficiency gas turbine	Power plant	During operational phase of the power plant	- PIU/ Environmental Consultant	Expenses of equipment included in contract cost by PIU and Contractor. Other expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

(Source: JICA Survey Team)

12.7.2 Transmission Line and Substation

(1) Implementation System

1) Construction Phase

At the construction phase, Project Implementation Unit (PIU) of Transmission company shall carefully consider all construction activities with the supervision consultant, and encourage the EPC contractor to fully understand the necessary mitigation measures and implement them.

In this regard, PIU shall be organized prior to the start of construction and an expert environmental management administrator in the PIU shall be employed. The unit will discuss and prepare mitigation measures with the supervision consultant and the EPC contractor prior to the start of construction.

A large inflow of workers is expected once construction begins. The PIU shall also function as a grievance organization seeking to understand and address any grievances from local people during the construction phase, and conduct appropriate mitigation measures.

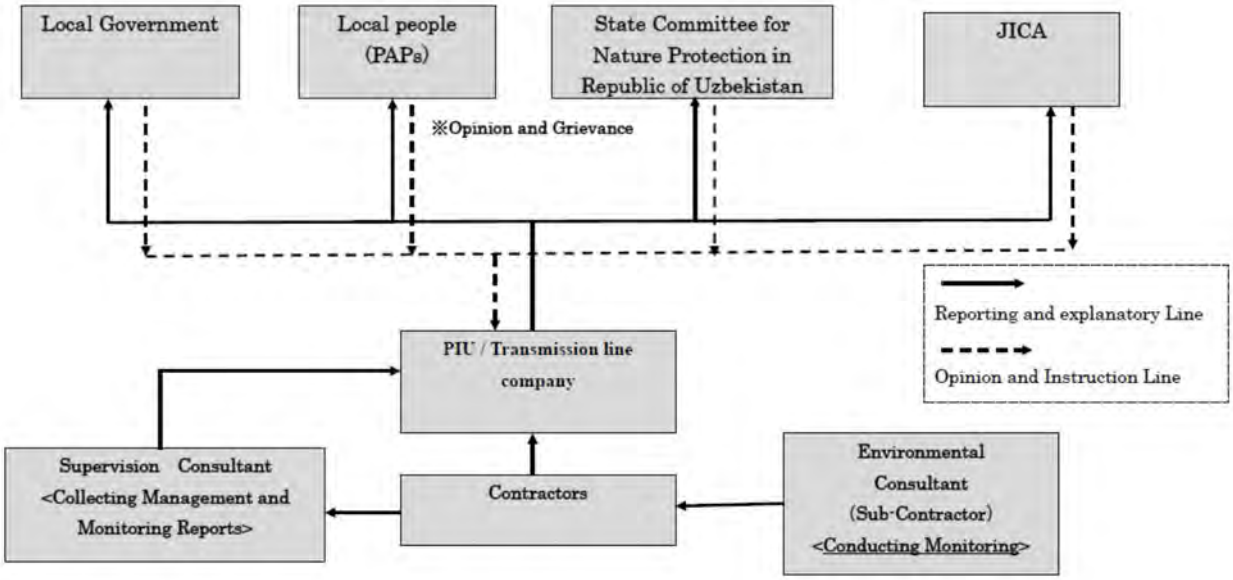
The PIU shall improve the understanding of the surrounding community regarding construction details, schedule and mitigation measures, and shall obtain local people's opinions and correct the mitigation measures as appropriate.

In order to confirm the implementation of environmental management and to consider further mitigation measures, the contractor should submit regular reports to the supervisory consultant and the PIU on the implementation status of the management plan.

The administrator of the PIU shall regularly hold explanation sessions with the local community, continuously listen to their grievances, submit reports to JICA and other relevant organizations regarding those grievances, as well as the implementation status of environmental management and environmental monitoring (described hereinafter).

If environmental problems occur due to construction work, the PIU shall confirm the cause with the contractor as soon as possible.
In order to resolve these problems, the administrator of the PIU shall instruct the contractor and consultant regarding necessary measures. If the problem is serious, PIU may order the contractor to halt construction work until the problem is resolved.

Figure 12.7.2-1 outlines the environmental management and monitoring implementation structure in accordance with the reporting flow during the construction phase.



(Source: JICA Survey Team)

Figure 12.7.2-1 Environmental Management Plan and Monitoring Implementation Structure in Construction Phase for Transmission Line and Substation

2) Operation Phase

The PIU and power plant are responsible to develop and implement an environmental management plan that includes mitigation measures. An expert environmental management administrator in the PIU and power plant shall be employed to ensure the environmental management plan is appropriately implemented.

The administrator shall encourage the project staffs to familiarize themselves with the environmental management plan prior to the start of plant operation, and shall regularly educate them regarding ongoing matters during the operation phase.

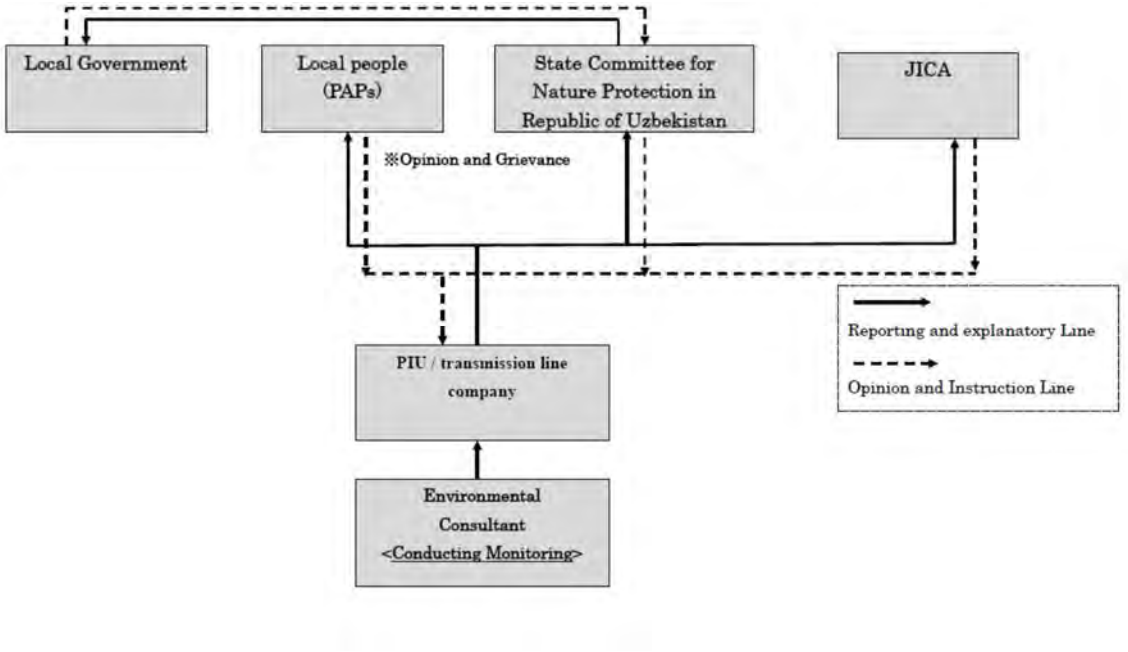
The administrator shall also function as a grievance organization and will strive to understand and address any grievances from the local people during the operation phase, and conduct appropriate mitigation measures.

The basic function of the environmental management plan is to closely cooperate with the local community, and to provide them with sufficient explanations based on positive mitigation measures, which is very important.

The administrator shall report the contents and implementation status of the environmental management plan and environmental monitoring plan described below to the director of the plant and the director of the responsible section, with the director of power plant taking final responsibility.

The administrator shall regularly provide explanations to the local community, continuously listen to their grievances, submit reports to JICA and other relevant organizations regarding those grievances, as well as on the implementation status of environmental management and environmental monitoring activities (described hereinafter).

Figure 12.7.2-2 outlines the environmental management and monitoring implementation structure in accordance with the reporting flow during the operation phase.



(Source: JICA Survey Team)

Figure 12.7.2-2 Environmental Management Plan and Monitoring Implementation Structure in Operation Phase for Transmission Line and Substation

(2) Environmental Management Plan

Table 12.7.2-1 describes the environmental impact, mitigation measure, responsible organization and cost for each environmental item in construction and operation phase.

Table 12.7.2-1 Environmental Management Plan (Transmission Line and Substation)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Construction Stage									
1	Air Pollution	1) Generation of fine particles from land preparation and other civil engineering work. 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment	1)-2) - Ambient air quality standards (Uzbekistan) - IFC guideline values for ambient air quality (General/ 2007)	1) – 2) - Prevention of air pollution in the surrounding area	1) Dust - Generation of dust due to strong wind will be reduced with periodic watering (dry season) - Conduct washing of equipment and vehicles - Cover with the car for soil transportation 2) Preventing exhaust gas emissions - Conduct periodical maintenance in the construction equipment and vehicles-1)-2) - Monitoring of ambient air in the residential area compared to the standard of Uzbekistan and IFC/WB EHS guidelines.	1) - 2) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
2	Water Pollution	1) Increase in water turbidity due to soil runoff 2) - Domestic waste water, concrete-containing waste water and oil-containing waste water	1)-2) - Water quality standards(Uzbekistan)	1)-2) Prevention of water pollution of the rivers in the lower reaches of the basin	1) Preparation of soil erosion measures – - ・Storage of excavated earth and sand in a place where there are not affected by flood ・Compression of earth and sand after backfilling 2) Prevention of wastewater - Using mobile septic and adequate reserve of oil - Not construction of tower nearby river and channel 1)-2) Monitoring of river water quality compared to the standard of Uzbekistan	1)-2)- River or channel near construction area	1)-2)- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor
3	Waste	1) General waste generated in the construction phase (packaging, organic, etc.) 2) Hazardous waste generated in the construction phase (waste oil)	1) – 2) - Waste management regulation (official name yet to be included in this document)	1)-2) Prevention of soil and water pollution, malodors and hygiene issues	1) - 2) - ・Submission of a waste disposal plan and reception of its approval one month before start of construction works - Implement a waste management and disposal plan including education of site workers addressing waste reduction, recycling - Compliance with legislation regarding general waste and hazardous waste, and assuring they are adequately transported and treated in the facilities authorized by authority, as in the case of the existing facility.	1) - 2) Construction area	During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
4	Soil contamination	Leakage of lubricants , fuels and chemical from construction activity	-Hazardous material regulation	Prevent soil pollution in the project site	Prevention of leakage by the maintenance of equipment	Construction area	During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor
5	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	1)- 2) - Noise level standards - IFC EHS guideline, noise level values (General/ 2007)	1)- 2) - Reduction of noise level from construction activities	1) Construction machinery - Perform construction work during daytime - ・Attachment of silencer to heavy construction machineries and equipment, and introduction of enclosed equipment 2) Mobilization - Limit truck speed 1)- 2) - Periodic checks and regular maintenance of construction equipment and vehicles -Monitoring of Noise level at site boundary and the residential area compared to the standard of Uzbekistan and IFC/WB EHS Installation of noise If need, prevention wall guidelines...	1)- 2) - Construction area	1)- 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
6	River ecosystem and rare species	1) Increase in water turbidity due to soil runoff 2) - Domestic waste water, concrete-containing waste water and oil-containing waste water	-	1)-2) Prevention of water pollution of the rivers in the lower reaches of the basin	Same as "2) Water Pollution"	1)-2)- River or channel near construction area	1)-2)- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor
7	Topography and geography	- Soil erosion	-	Prevention of Soil erosion	・Preparation of soil erosion measures based on geological survey. (for example, using concrete and grassing)	1)-2)- River or channel near construction area	1)-2)- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor
8	Involuntary resettlement and land acquisition	1) Loss of private land 2) Loss of farms 3) Loss of residential/ commercial structures 4) Loss of trees and fruit	1) - 4) - The acquisition law- JICA guideline (2010)	1) Consideration for land owners 2) Consideration for persons losing their homes 3), 4) Consideration for persons losing their property	1) - 4) - Developing an appropriate "Land acquisition and resettlement action plan" - Land acquisition should be conducted in compliance with the relevant laws and regulations - The cost related to relocation will be given to relocated residents	1) - 4) - At the route	1) - 4) - During land acquisition process	- District Office - PIU	Expenses to be paid by PIU
8	Poor peoples	- Poor households among those who are to be resettled.	- JICA guideline (2010)	- Consideration for poor people	- Same as "7) Involuntary resettlement and land acquisition"	-Construction area	- During land acquisition process	- District Office - PIU	Expenses to be paid by PIU

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
9	Local economy including employment and means of livelihood	1) Loss of private land, farms, residential/ commercial structures and trees etc. 2) Employment for local residents	-	1) Consideration for land owners, persons losing their homes and persons losing their property 2) - Activation of the local economy - Increase the standard of living of the local population	1) Same as "8) Involuntary resettlement and land acquisition" 2) - Employ as many local residents as possible - Use the services (i.e., laundry and catering services, etc.) and products offered by the local community	1) Construction area 2) - Construction area and the surrounding area	1) During land acquisition process 2) During construction phase	1) - District Office - PIU 2)Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	1) Expenses to be paid by PIU 2)Expenses included in contract cost by Contractor and PIU
10	Land use and utilization of local resources	Loss of private land, farms, residential/ commercial structures and trees etc.	-	Consideration for land owners, persons losing their homes and persons losing their property	Same as "8) Involuntary resettlement and land acquisition"	Construction area	During land acquisition process	- District Office - PIU	Expenses to be paid by PIU
11	Water use	1) Muddy water after rain 2) Wastewater from concrete 3) Oily wastewater 4) Wastewater from the construction site	1) - 4) - Water quality standards (Uzbekistan) - IFC/WB EHS guideline values for waste water quality (General/ 2007)	1) - 4) - Prevention of water pollution of the irrigation canal	Same as "2) water pollution"	1) -4) - Construction area	1) - 4) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by PIU and Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
12	Existing social infrastructure and social service	- Traffic jam caused by increasing traffic	-	-Maintaining the usability of the roads	- the traffic control plan including route-setting and operation - Bus for transportation of workers	- Construction area and traffic route	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by Contractor and PIU
13	Unfair distribution of loss and benefit	1) Loss of private land, farms, residential/ commercial structures and trees etc. 2)Employment distribution in the area could be unfair	-	1) Consideration for land owners, persons losing their homes and persons losing their property 2)Promote local employment and avoiding a feeling of unfairness within the community	1) Same as "8) Involuntary resettlement and land acquisition" 2) Present employment opportunities with clearly explained pre-requisites	1) Construction area 2) - Construction area and the surrounding area	1) During land acquisition process 2) During construction phase	1) - District Office - PIU 2)Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	1) Expenses to be paid by PIU 2)Expenses included in contract cost by Contractor and PIU
14	Local Conflicts of Interest	Loss of private land, farms, residential/ commercial structures and trees etc.	-	Consideration for land owners, persons losing their homes and persons losing their property	Same as "8) Involuntary resettlement and land acquisition"	Construction area	During land acquisition process	- District Office - PIU	Expenses to be paid by PIU

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
15	Work environment (Including Work safety)	High risk of labor accidents in construction work: - Handling heavy loads - Working at heights - High-noise work	- Work safety standards established in Uzbekistan - EHS Guidelines on the IFC/WB (General, 2007)	- Labor safety and prevention of health problems	- ・Implementation of all appropriate measures for safety according to laws and appropriate technology practices ・Compliance of guidelines related to detailed regulations and construction safety standards for industrial safety and health ・Maintenance of health condition of workers ・Supply of safety protective equipment (helmet) ・Implementation of training related to safety	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by Contractor and PIU
16	Accidents	Traffic accidents	-	Prevent traffic accidents	・Select the route of the vehicle taking into account of the vicinity between the school and hospital ・Installation of traffic signs and compliance of traffic rules ・Confirmation of conditions of roads and bridges	Roads surrounding the construction area	During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in contract cost by Contractor and PIU
Operational Stage									
1	Soil contamination	Leakage of oil in the transformer in the substation	-	Prevent oil contamination by leakage of oil	・Installation of leakage prevention walls to prevent leakage at damage to transformer ・Installation of tanks to store all amount of oil leaked	Substation	During operational phase	- PIU/ Environmental Consultant	Expenses included in contract cost by Contractor and PIU Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
2	Noise and vibration	noise of transformer in the substation	- Noise level standards - IFC EHS guideline, noise level values (General/ 2007)	- Reduction of noise level from	- Introduction of low noise type, as passible - Reduction of vibration by selecting a solid foundation - Maintaining equipment by periodical check - Monitoring of Noise level at site boundary and the residential area compared to the standard of Uzbekistan and IFC/WB EHS guidelines.	Substation	During operational phase	- PIU/ Environmental Consultant	Expenses included in contract cost by Contractor and PIU Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
3	Terrestrial ecosystem and valuable species	bird strikes will may be occurred.	-	prevention of bird strikes	・Attachment of fluorescent or colorful ribbons to transmission lines ・Respect of sufficient height of the transmission line above the ground	Transmission line route	- During operational phase	- PIU/ Environmental Consultant	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
3	Work environment (including labor safety)	Labor accidents involving: Working at heights - High-noise work	- Occupational standards established in Uzbekistan - IFC/WB EHS Guidelines (General, 2007)	- Labor safety and prevention of health problems	- Prepare a manual for labor accident prevention including safety education and training: -- Provide workers with appropriate protective equipment such as a helmet, safety boots, safety belt, mask, electric shock prevention equipment, earplugs, etc. - Establish clear signs to identify the location of hazardous or toxic material	Substation	- During operational phase	- PIU/ Environmental Consultant	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
5	Accidents	1) towers fall down 2) electro shock		1) prevention of towers fall down 2) prevention of electro shock	1) ・Respect of the safety norms for the construction of the towers ・Selection of the base ground area, construction and materials according to a detailed soil quality survey 2) ・Installation of earth connection equipment to ensure the safety of the distribution line ・Carrying out trainings for the workers and the local population about the risks of the power distribution line ・Carrying out periodical check-ups and maintenance of the power distribution line	1) Transmission line route 2) Substation	1) - 2) During operational phase	- PIU/ Environmental Consultant	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

(Source: JICA Survey Team)

12.8 Environmental Monitoring Plan (Mitigation Measures)

12.8.1 Power plant

An Environmental Monitoring Plan will be prepared to provide guidelines for environmental management plan during construction and operation of the power plant.

The environmental components that will be monitored are those which will be negatively affected by the construction activities and to determine that the effectiveness of mitigation measures should be confirmed.

Environmental management is a sustainable way of planning, arranging, supervising, organizing, and developing the environment for the maintenance of the preservation of natural resources and the prevention or reduction of damage to the environment.

The major environmental impact, monitoring method, responsible organizations, and expenses for each environmental item in the construction and operation phases for the power plant are listed in Table 12.8.1-1.

Table 12.8.1-1 Environmental Monitoring Plan (Power plant)

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
Construction Phase							
1	Air pollution,	Ambient air quality - PM_{10}, NO_2 - Ambient air quality standard of Uzbekistan - IFC/WB EHS guideline, ambient air quality standard (General/ 2007)	Analyzing air quality	Air quality of the surrounding area - 2 point: Residential area in (north-west and west of the site)	- Quarterly	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor. Measurement of air quality:6,000USD
2	Water pollution, Bottom Sediment, River ecosystem and valuable species	1) Waste water - pH, SS, Oil, BOD, COD, Total nitrogen, Total phosphorus, Total coliform - IFC/WB EHS guideline, wastewater standard (General / 2007) 2) Ambient water -DO,BOD SS, Oil, Ammonia, Nitrite, Nitrate, Sulfate Phenol Chloride Calcium Potassium, Fe, Cu, Zn, Cr, Pb - Uzbekistan water quality standard	- Evaluation of effect of the mitigation measure of water pollution	1) Wastewater -Discharged point 2) Ambient water quality - 2 point at river:	1) -Discharged time 2) - Quarterly	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor. Measurement of water quality3,000USD
3	Waste	- Type and volume of waste as well as disposal method - Waste management regulation	- Record of type and volume of waste as well as disposal method	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
4	Soil contamination	- Management record of oil and chemical substances. - Leakage accident	- Record of type and volume of oil and chemical substances.	Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
5	Noise and Vibration	Noise level - Uzbekistan noise standards - IFC/WB EHS guideline, noise level standard (General/2007))	- Measurement using noise level meter	- 4 points: On the border of the site (2 points), the residential area near the site (2 point)	- Quarterly	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor. Measurement of noise level:5,000USD/year
6	Local economy including employment and means of livelihood, Unfair distribution of loss and benefit, Conflict of interests within the local area, Gender, Children's rights	-Number of workers employed from the local area and the number of the subcontractor in the local area. (Total, male female, under 15year)	-Information from the relevant organizations -Interview with the local people	-Contractor's office -Construction area	- Continuously	Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
7	Existing Social Infrastructure and Services	-Record of traffic volume	-Record of traffic volume	-Contractor's office	- monthly	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
8	HIV/AIDS and other infectious diseases	-Record of training -Record of health check -Record of medical treatment	-Record of training -Record of health check	-Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
9	Work Environment (Including Work Safety)	Record of accidents - Handling heavy loads - Working at heights - Electric shock	- Record of accidents	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
10	Accident	-Record of accidents(Construction and driving of vehicles	-Record of accidents	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
11	Grievances	The numbers, contents, and processing results of grievances	Record	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
Operation Stage							
1	Air pollution	1)Exhaust gas -NOx - Emission gas standards of Uzbekistan - IFC/WB EHS guideline, emission gas standard (Thermal power plant/ 2008) 2)Ambient air of the area: NO_2 - Ambient air quality standards of Uzbekistan - IFC/WB EHS guideline, e Ambient air quality standards (General / 2007)	1) Exhaust gas - CEMS (Continuous Emission Monitoring System) 2) Ambient air quality analysis	1) Gas duct 2) 3 points in the surrounding residential area (north-west, west and south of the site)	1) Continuous measurement of gas emission 2) Quarterly (24 hours, one week) for the first 3 years of operation	- PIU/ Environmental Consultant	- CEMS Expense of CEMS installation included in cost by PIU and contract cost by the Contractor. Management and measurement of CEMS included in the operation/maintenance cost of PIU (2%/year of project cost). Air quality measurement:60,000USD$/year
2	Water pollution, Bottom Sediment, River ecosystem and valuable species	1) Waste water -pH, SS, Oil, Nitrite, Nitrate, Sulfate, Chloride, Zinc, Cadmium, Lead, Mercury, Copper, Chrome, Cadmium, Chlorine, Arsenic - Wastewater discharge standards of Uzbekistan for GTCC2 - IFC/WB EHS Guideline, wastewater standard (Thermal Power plant, 2008) 2) Ambient water quality	- Evaluation of effect of the mitigation measure of water pollution	1) Discharged water - 1 point: outlet point of wastewater treatment plant 2) water quality of the surrounding area - 2 point at	1)-2) Discharged water and river Water - Quarterly	- PIU/ Environmental Consultant	Water quality measurement: 8,000USD$/year

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		-DO, BOD, SS, Oil, Ammonia, Nitrite, Nitrate, Sulfate Phenol Chloride Calcium Potassium, Fe, Cu, Zn, Cr, Pb - Ambient water quality standards of Uzbekistan		river:			
3	Waste	- Type and volume of waste as well as disposal method - Waste management regulation	- Record of type and volume of waste as well as disposal method	- Power plant office	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
4	Soil contamination	- Management record of oil and chemical substances. ・Leakage accident	- Record of type and volume of waste as well as disposal method	- Power plant office	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
5	Noise and Vibration	Noise level - Noise standards - IFC/WB EHS guideline, noise level standard (General/2007))	- Measurement using noise level meter	- 4 points: On the border of the site (2 points), the residential area near the site (2 point)	- Quarterly	- PIU/ Environmental Consultant	Noise level measurement:20,000USD$/year
6	Local economy including employment and means of livelihood, Unfair distribution of loss and benefit, Conflict of interests within the local area, Gender	-Number of workers employed from the local area (Total, male female)	-Record of employment	-Power plant office	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
7	Work Environment (Including Work Safety)	- Labor accidents - Handling heavy loads - Working at heights - Electric shocks	- Record of accidents	-Power plant	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
8	Accident	- Record of fire accidents	-Record of accidents	- Power plant office	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
9	Transboundary effects and climate change	- Amount of CO_2 emissions	- Calculation of CO_2 emission based on the fuel consumption.	- Power plant office	- Once a year	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
10	Grievances	The numbers, contents, and processing results of grievances	Record	- Power plant office	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

(Source: JICA Survey Team)

12.8.2 Transmission Line and Substation

An Environmental Monitoring Plan will be prepared to provide guidelines for environmental management plan during construction and operation of the transmission line.

The environmental components that will be monitored are those which will be negatively affected by the construction activities and to determine that the effectiveness of mitigation measures should be confirmed.

Environmental management is a sustainable way of planning, arranging, supervising, organizing, and developing the environment for the maintenance of the preservation of natural resources and the prevention or reduction of damage to the environment.

The major environmental impact, monitoring method, responsible organizations, and expenses for each environmental item in the construction and operation phases for the power plant are listed in Table 12.8.2-1.

Table 12.8.2-1 Environmental Monitoring Plan (Transmission line and Substation)

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
Construction Phase							
1	Air pollution	Ambient air quality - PM_{10}, NO_2 - Ambient air quality standard of Uzbekistan - IFC/WB EHS guideline, ambient air quality standard (General/ 2007)	Analyzing air quality	- nearest residential at 10 tower section of construction	- 1 sample in 1 section	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor. Measurement of air quality:20,000USD
2	Water pollution, Bottom River ecosystem and valuable species, Topography and geography	River water quality - DO, BOD SS, Oil, Ammonia, Nitrite, Nitrate, Sulfate Phenol Chloride Calcium Potassium, Fe, Cu, Zn, Cr, Pb - Ambient water quality standards of Uzbekistan	- Evaluation of effect of the mitigation measure of water pollution	nearest river at 10 tower section of construction	- 1 sample in 1 section	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor. Measurement of water quality7,500USD
3	Waste	- Type and volume of waste as well as disposal method - Waste management regulation	- Record of type and volume of waste as well as disposal method	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
4	Soil contamination	- Management record of oil and chemical substances. - Leakage accident	- Record of type and volume of waste as well as disposal method	Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
5	Noise and Vibration	Noise level - Uzbekistan noise standards - IFC/WB EHS guideline, noise level standard (General/2007))	- Measurement using noise level meter	nearest resident at 10 tower section of construction	- 1 sample in 1 section	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor. Measurement of noise level:10,000USD/year
6	Local economy	-Number of workers employed from	-Information from	-Contractor's	- Continuously	Implementation:	Expenses included in cost by PIU

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
	including employment and means of livelihood, Unfair distribution of loss and benefit, Conflict of interests within the local area, Gender, Children's rights	the local area and the number of the subcontractor in the local area. (Total, male female, under 15year)	the relevant organizations -Interview with the local people	office -Construction area		Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	and contract cost by the Contractor.
7	Existing Social Infrastructure and Services	-Record of traffic volume	-Record of traffic volume	-Contractor's office	- monthly	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
8	Work Environment (Including Work Safety)	Record of accidents - Handling heavy loads - Working at heights - Electric shock	- Record of accidents	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
9	Accident	-Record of accidents (Construction and driving of vehicles	-Record of accidents	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
10	Grievances	The numbers, contents, and processing results of grievances	Record	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PIU/ Supervision Consultant	Expenses included in cost by PIU and contract cost by the Contractor.
Operation Stage							
1	Soil	- Management record of oil	- Record of accident	- Substation	- Continuously	- PIU	Expenses included in the

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
	contamination	Leakage accident		office			operation/maintenance cost of PIU (2%/year of project cost).
2	Noise and Vibration	Noise level - Noise standards - IFC/WB EHS guideline, noise level standard (General/2007))	- Measurement using noise level meter	- 2 points: On the border of the site (2 points), the residential area near the site (1 point)	- Quarterly	- PIU/ Environmental Consultant	Noise level measurement:15,000USD$/year
3	Terrestrial ecosystem and valuable species	bird strikes will may be occurred.	-Record of bird strikes	- Substation office	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
4	Work Environment (Including Work Safety)	- Labor accidents - Handling heavy loads - Working at heights - Electric shocks	- Record of accidents	- Substation office	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
5	Accident	1) Record of towers fall down 2) Record of electro shock	-Record of accidents	- Substation office	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).
6	Grievances	The numbers, contents, and processing results of grievances	Record	- Substation office	- Continuously	- PIU	Expenses included in the operation/maintenance cost of PIU (2%/year of project cost).

(Source: JICA Survey Team)

12.9 Stakeholder Meeting and Others

Stakeholder meetings were held by JSC TPP twice for this project, and JSC TPP received support for the meetings.

12.9.1 First Stakeholder Meeting

The first stakeholder meeting was held on April 12, 2019, outlined below in accordance with JICA Guidelines.

Date and Time: 10.00 a.m. – 11.45 a.m. April 12, 2019
Language: Uzbek and English
Participants:
Ergashev Dilmurad (Deputy khokim of Karmana district office)
Juraev Rustam (Head of Enterprise Thermal Power Network, Karmana district office)
Alisher Nurmatov (Head of Cadaster and Land Resources Department, Karmana district office)
Davron Abdullayev (Head of Khokimiyat Construction Department, Karmana district office)
Sharipov Muzaffarp (Head of Investment Department, Karmana district office)
Kim Juliet (Chairman of the cottages community named after Michurin)
Ganiev Kakhramon (General Director of JSC Navoi TPP)
Dostov Shukhrat (PIU leading engineer, Navoi TPP)
Hofiz Komil (Engineer of the department of capital construction, Navoi TPP)
Jamshid Mirzaev (Environmental protection engineer (ecologist), Navoi TPP)
Koichi Ikeda (Representatives of JICA)
Norihiko Fukazawa (JICA Survey team)
Mizuki Kitagawa (JICA Survey team)
Maria Malinovskaya (Al Mar Consulting LLC)
Veronika Cherdikudi (Al Mar Consulting LLC)
Agenda: - Greeting by General Director of Navoi TPP
- Purpose of the meeting
- Explanation of project outline, JICA Guidelines, and scope of the study

Questions and /or comments were raised and answers were given to them as followings.

Table 12.9.1-1. Question/Comments and Answers Discussed in the First Stakeholder Meeting

No.	Questions/Comments	Answers
1	There are around 90 households within and along the proposed project site, which can potentially be affected. (by Chairman of the cottages community)	At this stage of the impact assessment, about 12-14 households are assumed to be affected, which will be surveyed in detail on the process of preparation of A-LARAP. According to the experience of land acquisition for GTCC2, the project, the affected persons will be provided with a housing complex with all the conditions for living, no worse than before the project level.
2	The community are worried whether they cannot use a water line which they built from Zeravshan River for irrigation at their own expense. (by Chairman of the cottages community)	At this stage of the impact assessment, it is already clear that the water line will not be affected.

(Source: JICA Survey Team)

Figure 12.9.1-1 First Stakeholder Meeting on April 12, 2019

Though some local people from the surrounded communities were invited to this stakeholder meeting, only one (community leader) attended it. Therefore, information on the project was explained to affected people and opinions were collected from them as Chapter 12.9.2 describes.

12.9.2 Interview and Other Meeting

Interviews were made during social survey for A-LARAP. Details will be shown in Chapter 12.10.11.

12.9.3 Second Stakeholder Meeting

The first stakeholder meeting was held on August 2, 2019, outlined below in accordance with JICA Guidelines.

Date and Time: 10.00 a.m. – 11.30 a.m. August 2, 2019
Language: Uzbek and English
Participants: 46 people

Umarov F.S. (Khokim of Karmana district)
Ergashev D. (Deputy khokim of Karmani district)
Akhmedov A. (Chief specialist, khokimiyat of Karmana district khokimiyat)
Jumaev K. (Deputy Head of the District Electricity Supply Enterprise)
Nazarov U. (Deputy khokim of Novbakhor district)
Isinov R. (Head of the department of cadastre and land resources, khokimiyat of Novbakhor district)
Tursunov I. (Head of the department of capital construction, khokimiyat of Novbakhr district)
Yuldashev O. (Branch office of land, property and cadaster, Novbakhr district)
Ganiev Kakhramon (General Director of JSC Navoi TPP)
Dostov Shukhrat (PIU leading engineer, JSC Navoi TPP)
Khudoyorov O. (Director of production department, JSC Navoi TPP)
Kim Juliet (Chairman of the cottages community named after Michurin (Dacha GRES))
Jalilov A. (Chairman of community «Pakhtakor», Novbakhr district)
Rakhmonov H. (Chairman of community «Yangiyul», Novbakhr district)
Ergashev A. (Chairman of community «Novbakhor»)
Bahronov Sh. (Chairman of community «Uyrot», Karmana district)
Project affected people of Karmana district -19 owners of summer cottages, representative of «Tamirlash kurilish montaj LLC».
Project affected people of Novbakhr district - 10 leasehold farmers.
Norihiko Fukazawa (JICA Survey team)
Mizuki Kitagawa (JICA Survey team)
Veronika Cherdikudi (Al Mar Consulting LLC)

Agenda:
- Greeting by Khokim of Karmana district
- Greeting by General Director of JSC Navoi TPP
- Purpose of the meeting
- Explanation of project outline, JICA Guidelines, and scope of the study

Questions and /or comments were raised and answers were given to them as followings.

Table 12.9.3-1. Question/Comments and Answers Discussed in the Second Stakeholder Meeting

No.	Questions/Comments	Answers
1	Where will land plots for summer households be allocated?	The representative of khokimiyat of Karmana district informed the affected people about the current stage of consideration of the issue on land allocation. According to preliminary data, it is planned to consider the option of using lands in this village of other cottages, the owners of which are interested in selling their land. All summer cottages that agree to receive compensation in exchange for the land will be compensated.
2	How will compensation for losses be calculated?	Almar Consulting's resettlement specialist explained that all compensation calculations and property evaluation will be carried out by an independent appraisal company. Property evaluation will be based on the market value of the property loss. In order to minimize inconvenience of the affected people, khokimiyats will provide possible assistance to attract an independent appraisal company for evaluation. All costs for evaluation process will be covered by the project costs.
3	How will compensation for lost trees be calculated on the land plot? How will the costs of growing trees that bring crops be compensated? Will there be compensation for those summer households that sell their crops and receive income from this?	Almar Consulting's resettlement specialist explained that the assessment of all trees will be carried out taking into account the age and productivity of the tree. The specialist emphasized that the costs of growing trees in each summer house are covered by the harvest from these trees received by owner. This harvest is used by households for their own consumption. Finally, the expenses for consumption of HH food are reduced. Regarding the opportunities of earning income from growing products on the territory of the summer cottage. The specialist noted the attention of affected persons to the fact that the sale of agricultural products is allowed to farmers, dekhkan farms and agricultural firms that pay the corresponding mandatory tax payments. Their products are examined to comply with sanitary standards for growing products. Agricultural products that are grown in gardens and dachas should be used for personal consumption of HH. Such products are not allowed to sell at the markets.
4	How will the issue of land acquisition and compensation be addressed?	The representative of Karmana khokimiyat explained to affected people that an inventory of summer households in the cadastre department has already begun. These documents are necessary for the preparation the appraisal report of property and trees of summer cottages by an independent appraisal company. After calculating the compensation, compensation payments and “land for land” compensation will be made. Only after this the land acquisition and resettlement stage will be carried out.

(Source: JICA Survey Team)

12.10 Land Aquisition and Compensation

The details are described in A-LARAP attached to this Report.

12.10.1 Necessity of Land Aqcuisition and Resettlement

(1) Power Plant

As described in Chapter 12.4.2, two candidate sites were examined. As a result of comprehensive examination, Plan-B (east of the existing power plants) was selected as it is more likely to accommodate in the future as well as GTCC3 than Plan-A (north of the existing power plants). The number of dacha does not seem to differ significantly between Plan-A and Plan-B.

(2) 220kV Transmission Line and Substation

According to Decree of the Cabinet No.1050/2018 on regulations of protection zones for electric power facilities, the Right of Way (ROW) of the 220kV transmission line shall be 25m in both sides from immediately beneath the transmission line. In Uzbekistan, no building is allowed within the ROW for safety reasons. The transmission line route was selected from two options to cross the existing transmission line at less points for technical reason avoid dacha areas as much as possible as described in Chapter 12.4.2. Consequently, resettlement of the residents living within the ROW of the proposed transmission line route did not happen, but two commercial structures will be demolished within ROW.

12.10.2 Analysis of the Legal Framework concerning Land Acquisition and Resettlement

(1) Relevant Provisions for Land Acquisition and Resettlement in the Republic of Uzbekistan

Table 12.10.2-1 presents the normative and legal documents of Uzbekistan concerning resettlement. These documents provide guarantee of the rights of the project affected persons and the order of compensations payment to these persons in case of loss of property and other objects of property.

Table 12.10.2-1 Key National Legislation Related to Land Acquisition and Resettlement

Name	Date of approval and amendments	Description
Land Code of the Republic of Uzbekistan	Code was approved by the Law of the Republic of Uzbekistan as for 30.04.1998, considering amendments as for 30.08.2003 and 03.12.2004.	Code regulates the issues of withdrawal and provision of land plots for nonagricultural needs and compensation of losses of agricultural production.
Civil Code of the Republic of Uzbekistan	Code approved by the Laws of the Republic of Uzbekistan as for 21.12.1995 No.163-I and as for 29.08.1996 No.256-I according to the last amendments as for 22.09.2010 No. ZRU-260.	Code provides definition of the property, main concepts to property objects, basics of termination of the property rights and the right for compensation payments in view of the property right loss.
Decree of the CM of the Republic of Uzbekistan № 146	25.05.2011	"On measures for improvement of the order of provision of the land plots for town-planning and other nonagricultural needs"
Decree of the CM of the Republic of Uzbekistan № 97	29.05.2006	"On the order of compensations payment to the citizens and legal entities in view of withdrawal of the land plots for the state and public needs"

(Source: JICA Survey Team)

As a rule, these standard and legal documents provide general basis for acquisition of lands for public and social needs and compensation to land tenants, users or lessees according to the registered use of land.

To improve the guarantees of rights of people affected by the land acquisition and resettlement the following decrees are adopted and the following amendments are made:

i. **Law "On privatization of lands"**, No ZRU 552, dated August 13, 2019, which guarantees the rights of owner of lands in case of land acquisition. The land plots under residential houses are permitted to be private.

ii. **Decree of President of RUz "On additional measures to strengthen the protection of private property and guarantee the rights of owners, majorly improve the organization of work to support entrepreneurial initiatives, as well as expand the access of business entities to financial resources and production infrastructure"** No PD –5780 dated August 13, 2019. In compliance with this decree since January 1, 2020, the ken gash of people's deputies will be given the powers of the chairman of the Council of Ministers of Karakalpakstan, khokims of regions and Tashkent city, districts and cities to acquire and transfer agricultural land from one farm to another in cases stipulated by law, as well as to acquire the lands, owned, used and leased by individuals and legal entities, for public and state needs.

   According to this decree, work to seize land and demolish real estate of citizens and business entities will be carried out in three stages.

   At the first stage, a package of materials in the territories where demolitions are planned is submitted by khokims to the Cabinet of Ministers. Then, a conclusion is prepared in the government - according to town-planning requirements and financial calculations. After the conclusion, it is submitted to the Prime Minister for consideration and decision. The document approved the composition of the Republican coordination working group and territorial working groups on inventory of the amount of damage caused to citizens and businesses during the seizure of land.

Within implementation of this project the order of compensations payment to these persons in case of loss of property and other objects of property is also governed by the following standard and legal documents:

i. Law of the Republic of Uzbekistan "On Evaluation Activity" as for 19.08.1999. No. 811-I;

ii. Decree of the President of the Republic of Uzbekistan "On further improvement of activity of evaluation companies and increases of their responsibility for the quality of rendered services" (No. PP-843 dated 24.04.2008 with amendments dated 2014).

(2) Scope of the Republic of Uzbekistan's Right to Land Acquisition and Resettlement

According to the Land Code, all land in the republic is state property and permits for use of land are granted and monitored by the State through the district and provincial administrations. National legislation specifies two types of land transfers:

i. for use, lease, or ownership by legal entities dealing with various trades and services for life long inheritable use (with housing), and
ii. use or lease by individuals. Because all land ultimately belongs to the RU, it cannot be sold without the buildings on that land.

In the case of individual land uses, land can be purchased only with the residence located on that land. A similar provision applies to land used by legal entities (owners of trade or service facilities).

All land occupied by permanent structures required for the project, specifically, power plant facilities and transmission line and related protection perimeters ("sanitary zones") is allocated by the Republic of Uzbekistan government through the local authorities and will remain the property of the Republic of Uzbekistan government upon completion of the Project. Legislation envisages compensation for damages to land users in full, including lost income, in the following instances:

i. seizure, purchase, or temporary occupation of land;
ii. limitation of the rights of users; and
iii. deterioration of land quality due to the effects of construction works, and servicing and other activities that lead to decreases in the quantity or quality of agricultural products.

In the case of acquisition of agricultural lands, in addition to compensation for damages, the legislation envisages compensation for the loss of agricultural production.

The Land Code identifies the following categories of arable land users, who are eligible for compensation for losses and damages in connection with land acquisition:

- **Land owners**: Citizens who were allocated land plots for individual housing construction and/or farming on the basis of lifetime ownership with right of inheritance.
- **Lessees (leaseholders)**: Farmers, who were allocated land plots for agricultural production purposes, on the basis of a long-term lease.
- **Land users**: Users of land plots occupied by tradesmen and services, which are used as private property.
- **Other land users**: All other enterprises, organizations and institutions, which are entitled to use of non-agricultural lands. This is the largest category, which includes enterprises and institutions of all types (private and public). Examples are hospitals, schools, private enterprises, and factories

(3) JICA's Policy on Involuntary Resettlement

The key principle of JICA policies on involuntary resettlement is summarized below.

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

II. When, after such an examination, avoidance is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected.

III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

IV. Compensation must be based on the full replacement cost as much as possible.

V. Compensation and other kinds of assistance must be provided prior to displacement.

VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.

IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principle based on World Bank OP 4.12 is as follows.

X. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.

XI. Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

XII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.

XIII. Provide support for the transition period (between displacement and livelihood restoration.

XIV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

XV. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared

In addition to the above core principles on the JICA policy, it also laid emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc.

Table 12.10.2-2 shows the gaps between the Uzbekistan legal framework for resettlement and JICA's Policy on Involuntary Resettlement, and the correspondence of the Project.

Table 12.10.2-2 Comparison of JICA Guidelines and Uzbekistan Policy Related to Compensation for Land Acquisition

No.	JICA guidelines	Uzbekistan Law	Gap between JICA GL and Uzbekistan Law	Correspondence of the Project
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	No specific policy	Because there is not the policy in the national regulations, there is a gap.	The project site was selected so as to avoid physical displacement.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	Department of the State Committee of the RU* on Land Resources, Geodesy, Cartography and State Cadastre conducts the estimation of loss of land and production means, and consideration of restoration means of agricultural land and alternative land.	There is no gap.	The project site was selected so as to avoid physical displacement.
3	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	National law has social policies for all citizens. No specific policy directed to displace persons.	There is no gap.	Compensation will enable affected households to restore their pre-project incomes and standard of living following the implementation of A-LARAP

No.	JICA guidelines	Uzbekistan Law	Gap between JICA GL and Uzbekistan Law	Correspondence of the Project
4	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	State Committee will assess value of agricultural land, loss of crop/tree income, and market value for lands appropriated.	There is no gap.	Affected households are entitled to be compensated at full replacement cost (excluding depreciation) for their lost assets, including temporary losses or impacts.
5	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	Compensation will be paid prior to construction of works.	There is no gap.	Compensation will be fully provided before land can be acquired for civil works or demolition.
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	No specific policy	Because there is not the policy in the national regulations, there is a gap.	This project will cause involuntary resettlement but it is not large-scale. A-LARAP will be prepared.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL)	No specific policy	Because there is not the policy in the national regulations, there is a gap.	Affected households will be consulted with in course of the preparation and implementation of the A-LARAP.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	No specific policy	Because there is not the policy in the national regulations, there is a gap.	Affected households will be fully informed of their compensation option.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Grievance redress committee includes local community leaders and farmers.	Because representative of affected people is not included in the committee, there is a gap.	Affected households will consulted with in the course of the preparation and implementation of the A-LARAP
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	Resettlement has a standard mechanism to address grievances.	There is no gap.	Grievance redress mechanism will be established.

No.	JICA guidelines	Uzbekistan Law	Gap between JICA GL and Uzbekistan Law	Correspondence of the Project
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12 Para.6)	Department of the State Committee of the Republic of Uzbekistan on Land Resources, Geodesy, Cartography and State Cadastre conducts the estimation of loss of land and production means.	There is a gap.	In creating the A-LARAP, JSC TPP interviewed the affected households whose orchards within the project site will all be acquired and confirmed their other farmland, the occupation, the income, etc.
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	All houses/ building/ shops which are registered under Land Code are valued at respective province/ district level People apply for registration for a particular land use. Untitled land use is ineligible for compensation.	Because untitled land use is ineligible for compensation, there is a gap.	All affected households will be received compensation regardless of the legal status of the land and land use rights.
13	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	Since land is owned by state, Land Code does not recognize individual ownership of land, but only permits use of land	There is no gap.	Provision of equivalent land is the preferred compensation for lost land, unless the affected household chooses cash compensation.
14	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	No specific policy, but all citizen's life is covered under the national social policy.	There is no gap.	This is not applied the Project.
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	The national policy relates to compensation only. Living standard improvement applies to all citizens	There is no gap.	Compensation will be provided giving equal consideration to women and men.
16	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	No specific policy	Because there is not the policy in the national regulations, there is a gap.	A-LARAP is established in this project.

(Source: JICA Survey team)

(4) Policies on the Project

I. The Government of the Republic of Uzbekistan will use the Project Resettlement Policy (the Project Policy) for the Navoi Thermal Power Station Modernization Project (Phase 2) specifically because existing national laws and regulations do not cover all the requirements to address involuntary resettlement according to international practice, including JICA's policy. The Project Policy is aimed at filling-in any gaps in what local laws and regulations cannot provide in order to help ensure that PAPs are able to rehabilitate themselves to at least their pre-project condition. This section discusses the principles of the Project Policy and the entitlements of the PAPs based on the type and degree of their losses. Where there are gaps between the Uzbekistan legal framework for resettlement and JICA's Policy on Involuntary Resettlement, practicable mutually agreeable approaches will be designed consistent with Government practices and JICA's Policy. These approaches will be agreed with the Government of the Republic of Uzbekistan.

II. Land acquisition and involuntary resettlement will be avoided where feasible, or minimized, by identifying possible alternative project designs that have the least adverse impact on the communities in the project area.

III. Where displacement of households is unavoidable, all PAPs (including communities) losing assets, livelihoods or resources will be fully compensated and assisted so that they can improve, or at least restore, their former economic and social conditions they had at pre project level.

IV. Compensation and rehabilitation support will be provided to any PAPs, that is, any person or household or business which on account of project implementation would have his, her or their:

- Standard of living adversely affected;
- Right, title or interest in any house, interest in, or right to use, any land (including premises, agricultural and grazing land, commercial properties, tenancy, or right in annual or perennial crops and trees or any other fixed or moveable assets, acquired or possessed, temporarily or permanently;
- Income earning opportunities, business, occupation, work or place of residence or habitat adversely affected temporarily or permanently; or
- Social and cultural activities and relationships affected or any other losses that may be identified during the process of resettlement planning.

V. All affected people will be eligible for compensation and rehabilitation assistance, irrespective of tenure status, social or economic standing and any such factors that may discriminate against achievement of the objectives outlined above. Lack of legal rights to the assets lost or adversely affected tenure status and social or economic status will not bar the PAPs from entitlements to such compensation and rehabilitation measures or

resettlement objectives. All PAPs residing, working, doing business and/or cultivating land within the project impacted areas as of the date of the latest census and inventory of lost assets(IOL), are entitled to compensation for their lost assets (land and/or non-land assets), at replacement cost, if available and restoration of incomes and businesses, and will be provided with rehabilitation measures sufficient to assist them to improve or at least maintain their pre-project living standards, income-earning capacity and production levels.

VI. PAPs that lose only part of their physical assets will not be left with a portion that will be inadequate to sustain their current standard of living. The minimum size of remaining land and structures will be agreed during the resettlement planning process.

VII. People temporarily affected are to be considered PAPs and resettlement plans address the issue of temporary acquisition.

VIII. Where a host community is affected by the development of a resettlement site in that community, the host community shall be involved in any resettlement planning and decision-making. All attempts shall be made to minimize the adverse impacts of resettlement upon host communities.

IX. The resettlement plans will be designed in accordance with Uzbekistan's National Involuntary Resettlement Policy Land Code and JICA's Policy on Involuntary Resettlement.

X. The Resettlement Plan will be translated into local languages and disclosed for the reference of PAPs as well as other interested groups.

XI. Payment for land and/or non-land assets will be based on the principle of replacement cost.

XII. Compensation for PAPs dependent on agricultural activities will be land-based wherever possible. Land-based strategies may include provision of replacement land, ensuring greater security of the lease right, and upgrading livelihoods of people without legal land titles. If replacement land is not available, other strategies may be built around opportunities for re-training, skill development, wage employment, or self-employment, including access to credit which will be included in Livelihood Restoration Program. Solely cash compensation will be avoided as an option if possible, as this may not address losses that are not easily quantified, such as access to services and traditional rights, and may eventually lead to those populations being worse off than without the project.

XIII. Replacement lands, if the preferred option of PAPs, should be within the immediate vicinity of the affected lands wherever possible and be of comparable productive capacity and potential. As a second option, sites should be identified that minimize the social disruption of those affected; such lands should also have access to services and facilities similar to those available in the lands affected. If not, the access to services and facilities similar to the pre-project level will be provided to all PAPs.

XIV. Resettlement assistance will be provided not only for immediate loss, but also for a transition period needed to restore livelihood and standards of living of PAPs. Such support could take the form of short-term jobs, subsistence support, salary maintenance, or similar arrangements.

XV. The resettlement plan must consider the needs of those most vulnerable to the adverse impacts of resettlement (including the poor, those without legal title to land, ethnic minorities, women, children, elderly and disabled) and ensure they are considered in resettlement planning and mitigation measures identified. Assistance should be provided to help them improve their socio-economic status.

XVI. PAPs will be involved in the process of developing and implementing resettlement plans through the public consultations and meetings as well as the rights to submit their addresses, suggestions and complaints in compliance with the project-designed Grievance Redress Mechanism.

XVII. PAPs and their communities will be consulted about the project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to the extent possible be involved in the decisions that are made concerning their resettlement.

XVIII. Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition (including compensation and income restoration measures) within the agreed implementation period. The funds for all resettlement activities will come from the Government.

XIX. Displacement does not occur before provision of compensation and of other assistance required for relocation. Sufficient civic infrastructure must be provided in resettlement site prior to relocation. Acquisition of assets, payment of compensation, and the resettlement and start of the livelihood rehabilitation activities of PAPs, will be completed prior to any construction activities, except when a court of law orders so in expropriation cases. (Livelihood restoration measures must also be in place but not necessarily completed prior to construction activities, as these may be ongoing activities.)

XX. Organization and administrative arrangements for the effective preparation and implementation of the resettlement plan will be identified and in place prior to the commencement of the process; this will include the provision of adequate human resources for supervision, consultation, and monitoring of land acquisition and rehabilitation activities.

XXI. Appropriate reporting (including auditing and redress functions), monitoring and evaluation mechanisms, and grievance redress mechanism will be identified and set in place as part of the resettlement management system. An external monitoring group will be hired by the project and will evaluate the resettlement process and final outcome. Such groups may include qualified NGOs, research institutions or universities.

(5) Cut-off-date of Eligibility

The cut-off-date of eligibility refers to the date prior to which the occupation or use of the project area makes residents/users of the same eligible to be categorized as PAPs and be eligible to Project entitlements.

In the regulation of the Republic of Uzbekistan, the cut-off date is defined as the date in which the district division of the State Committee on Land Resources, Geodesy, Cartography and State Cadastre signs Certificate of Agreement for land acquisition.

However, In the Project, cut-off dates was declared on t the beginning date of the population census; , i.e. 1 August, 2019. This date has been disclosed to each affected community by the relevant local governments and the communities have disclosed to their populations. In addition, this date has been addressed in the stakeholder meeting held on 2 August, 2019. The establishment of the eligibility cut-off date is intended to prevent the influx of ineligible non-residents who might take advantage of Project entitlements

(6) Principles of Replacement Cost

All compensation for land will be based on land for land compensation as the land is the property of the Government of Republic of Uzbekistan. Therefore, here the compensation against non-land assets owned by households/ business owners will be described and those who meet the cut-off-date will be based on the principle of replacement cost for non-land assets. Replacement cost is the amount calculated before displacement which is needed to replace an affected asset without depreciation and without deduction for taxes and/or costs of transaction as follows:

a. Existing local government regulations listed in 12.10.2(1) for compensation calculations for building, crops and trees will be used where ever available.
b. *Houses and other related structures* based on actual current market prices of affected materials;
c. *Annual crops* equivalent to current market value of crops at the time of compensation for all agricultural lands;
d. *For perennial crops,* cash compensation at replacement cost that should be in line with local government regulations, if available, is equivalent to current market value given the type and age at the time of compensation and scope of harvest losses.
e. *For timber trees,* cash compensation at replacement cost that should be in line with local government regulations, if available, will be equivalent to current market value for each type, age and relevant productive value at the time of compensation based on the diameter at breast height of each tree.

   For fruit trees, cash compensation at replacement cost that should be in line with local government regulations, if available. It will be equivalent to current market value for each type, age and relevant productive value at the time of compensation based on the diameter at breast height of each tree and scope of harvest losses.

12.10.3 Scope of Land Acquisition

(1) Size of Land Acquisition

The project is expected to acquire 36.92 ha of land permanently for the construction of thermal power station (GTCC 3 and stock and mobilization area during construction) and transmission lines and 16.52ha temporally, for two years, for the construction activities along the transmission line route Location and features of the required land plots are given in Table 12.10.3-1. These areas were defined by several decrees which khokimiyats of Karmana and Novbahor districts issued on 29 July 2019 to allocate the land to the Project.

Table 12.10.3-1 Overview of Land Acquisition for Power Plant and Transmission Line

Permanency	Project component	Size of land plot	Current land use	Location in Navoi region	Affected household/ leasehold farmer/entities
Permanent	Combined cycle gas turbine and boiler facility	5.65 ha	Irrigated agriculture	Uyrot community, Karnama district	1 leasehold farmer (green house and orchard)
		2.6 ha	Dacha	Michurin community, Karnama district	36 households / cottages
		1.35 ha	Roads, aryks etc.	Michurin community, Karnama district	Public roads and other public lands inside the affected community
	Chemical department and power network	4.4 ha	Irrigated agriculture	Uyrot community, Karnama district	1 leasehold farmer (orchard)
	220/550kV substation	22.5ha	Irrigated agriculture	Novbahor district	2 leasehold farmers (wheat farming)
	ROW of transmission lines	0.06ha	Irrigated agriculture	Novbahor district	1 leasehold farmer (orchard)
	Towers for transmission lines	0.36ha	Irrigated agriculture	Novbahor district	3 Leasehold farmers *(identical to the 2 farmers affected by substation and the 1 farmer affected by ROW mentioned above)* 2 commercial structures (fuel station and private company "Akfa window frames")
	TOTAL	36.92ha	-	2 districts	36 households 5 leasehold farmers 2 commercial entities
Temporary	Transmission line	16.52ha	Irrigated agriculture	Novbahor district	19 leasehold famers
	TOTAL	16.52 ha	-	1 district	19 leasehold farmers
GRAND TOAL		53.44ha	-	2 districts	36 households 24 leasehold farmers 2 commercial entities

(Source: JICA Survey team)

Overall, 36 households using dachas and two leasehold farmers are expected to be affected for land acquisition for power plant facilities and chemical department.

These cottages / dacha houses are mainly used as seasonal living houses for summer period. All of these households will lose their cottages / dacha houses. In the detailed design stage, JSC TPP will make an effort to minimize its land use for the Project to avoid disturbance of the cottages / dacha houses as much as possible.

One of the lease holders is “Kurilishgassuv-kran montaj” Ltd. which uses the land to be acquired for power plant facilities for greenhouse and growing agricultural products (leasehold farm). This land plot was allocated to “Kurilishgassuv-kran montaj” Ltd. in 2009 as unused land plot. The period of using the land plot for 10 years was stated by the Decree of Karmana district khokimiyat #910-K dated August 20, 2009. The period of using of leased land ends in 2019. The land plot is considered as reserve lands of Karmana district.

(2) Socio-economic Profile of the Affected People

The socio-economic analysis of the affected households covered 36 households of seasonal households. The social survey was conducted in the period of August 1-8, 2019. Resettlement specialist conducted face-to-face interviews with the affected households to obtain information on socio-economic data through a structured socio-economic questionnaire.

1) Affected Population

In all, 36 households will be affected by the resettlement. The average household size is 4 members per household. 42% of affected people (most of them are pensioners) live at the cottages during all seasons in a year. They live at their cottages for all seasons at their own wish, 58% of affected people use their cottages only as seasonal dachas. 67% of heads of households are male, 23% are female (see Table 12.10.3-2). 81% of heads of households are married. All of heads of households graduated from secondary schools or higher (see Table 12.10.3-3).

Table 12.10.3-2 Affected People by Gender

Disctrict	Affected households	Affected persons	Male head of households	Female head of households	Average household size
Karnama district	36	153	24	12	4
Total	36	153			

(Source: A-LARAP for the Project)

Table 12.10.3-3 Education Level of Households’ Heads

Education level	%
Secondary	33%
Higher	17%
College	36%
University	14%

(Source: A-LARAP for the Project)

2) Income and Expenses

About 36% of the surveyed heads of households depend on white-collar jobs, such as work in the Government sector. Agriculture is the main economic activities for 23% of the affected households. 23% are retired people. 11% are stated that private sector (private enterprise and small business) is their main economic activity. Approximately 4% of the surveyed households are businessmen.

Table 12.10.3-4 Sources of Income of Households' Heads

Main Source of Income	%
Agriculture	23%
Business	4%
State companies	36%
Private companies	11%
Daily work	3%
Pension	23%
Total	100%

(Source: A-LARAP for the Project)

Governmental sector is the highest contributor to the annual income of the affected households. The survey data shows the average income of the households affected by the project. As can be seen in table below, the average income for a household is US$ 357.3 per month per family. Average daily income per capita of affected households is US$89.3 per capita per month or US$2.9 per day. According to the legislation social requirements all the affected households are above the poverty line[1].

Table 12.10.3-5 Household Monthly Income (UZS)

Disctrict	Affected HHs	Affected persons	Income for per family, UZS			Income for per family, US$		
			Min	Average	Max	Min	Average	Max
Karmana	36	153	1,000,000	3,099,636	8,450,000	115.4	357.3	975.3
TOTAL	36	528	1,000,000	3,099,636	8,450,000	115.4	357.3	975.3

(Source: A-LARAP for the Project)

The main share of households falls on food needs that are 42% of total expenses of AHHs. 15% spend clothes. 11% of incomes go to health needs of households (see Table 12.10.3-6).

[1] The poverty line is taken as**:** monthly per capita income is less than the equivalent of UZS 334,500, which is close to the internationally accepted income poverty line of US$1.28 per capita, per day.

Table 12.10.3-6 Household Expenses (UZS)

Item	%
Food	42%
Communal services	6%
Clothes	15%
Health	11%
Education	10%
Communications	4%
Social needs	0
Agriculture	3%
Other	8%
TOTAL	100%

(Source: A-LARAP for the Project)

3) Vulnerability Status of the Affected Households

Based on the census data, it was noted that 1 HH of the 36 affected households comprised of vulnerable households. This household is considered themselves as low income household. Total number of family of these household is 7 persons, including 5 children. The income per month amounts at US$ 673. They have a credit payments for the cottage house, which is 10% of their income. According to the legislation of Uzbekistan this household is no considered as low income family.

The poverty criteria based on income for Uzbekistan is equivalent to US$ based on Resolution # 165 of Cabinet of Ministers of Uzbekistan (as for 07.06.2012) and calculated as 1.5 times minimum salary wage per person in the family, less than US$ 38 per capita per month. Due to US$ exchange rate fluctuations this data is subject for fluctuations accordingly, but minimum flat rate is accepted as US$ 1.28.

According to the legislation of Uzbekistan this household is no considered as low income family.

(3) Affected Land, Structures and Trees

The land acquisition will affect a number of seasonal cottages (summer houses, gardens, sheds, baths other building attachments and structures), agricultural lands (farmer lands) and commercial structures. Table 12.10.3-7, Table 12.10.3-8 and Table 12.10.3-9 show house the loss for land, structures and trees of affected households, leasehold farmers and commercial entities, respectively.

Table 12.10.3-7 Loss of Assets of Households

Name	Number of household members	Type of affected structure	Land (m2)			Structures Lost		Affected crops/ trees	Number of affected trees/crops	Area of affected crops (m2)
			Total	Lost	%	No.	Area m2			
Household 1	1	Garden	875	875	100%	-	-	Fodder	-	400
		Cottage				-	-	Trees	78	-
Household 2	4	House	650	25	100%	1	25	Fodder	-	500
		Cattle house		30		1	30	Trees	14	-
		Garden		595		-	-	-	-	-
Household 3	3	Garden	820	820	100%	-	-	Fodder	-	500
		Cottage				-	-	Trees	7	-
Household 4	2	House	300	300	100%	1	40	Trees	3	-
		Cattle house				1	6	-	-	-
Household 5	5	House	624	160	100%	1	160	fodder	-	230
		Garden		464		-	-	Trees	32	-
Household 6	2	House	510	30	100%	1	30	Trees	28	-
		Metal barn		3		1	3	Crops	20	-
		Toilet		3		1	3	-	-	-
		Garden		474		-	-	-	-	-
Household 7	5	House	650	45	100%	1	45	Fodder		500
		Garden		605		-	-	Trees	18	-
Household 8	4	House	797	49	100%	1	49	Fodder	-	200
		Barn		20		1	20	Crops	-	50
		Chicken house		10		1	10	Trees	76	-
		Bath house		10		1	10	-	-	-
		Garden		708		-	-	-	-	-
Household 9	3	House	509	70	100%	1	70	Fodder	-	100
		Cattle house		30		1	30	Crops	-	150
		Barn		6		1	6	Trees	41	-
		Chicken house		4		1	4	-	-	-
		Garden		399		-	-	-	-	-
Household 10	1	House	896	50	100%	1	50	Fodder	-	400
		Summer kitchen		20		1	20	Trees	26	
		Garden		826		-	-	-	-	-
Household 11	4	House	511,2	72	100%	1	72	Trees	16	
		Cattle house		120		1	120	-	-	-
		Garden		274,2		-	-	-	-	-
		Barn		28		1	28	-	-	-
		Water well/pump		17		1	17	-	-	-
Household 12	1	House	1200	20	100	1	20	Trees	5	
		Garden		1180		-	-	-	-	-
Household 13	6	House	500	50	100	1	50	Fodder	-	200
		Bath house		12		1	12	Trees	23	-
		Water pool		10		1	10	-	-	-
		Garden		428		-	-	-	-	-
Household 14	4	Cottage	989	42	100%	1	42	Trees	1440	
		Garden		947		-	-	-	-	-
Household 15	7	Cottage	985	42	100%	1	42	Crops	-	500
		Garden		943		-	-	Trees	187	-
Household 16	7	House	823	40	100%	1	40	Crops	-	600
		Water pool		21		1	21	Trees	32	-
		Shower		9		1	9	-	-	-

Name	Number of household members	Type of affected structure	Land (m2)			Structures Lost		Affected crops/ trees	Number of affected trees/crops	Area of affected crops (m2)
			Total	Lost	%	No.	Area m2			
		Garden		753		-	-	-	-	-
Household 17	5	House	850	50	100%	1	50	Fodder	-	200
		Structure		10		1	10	Crops	-	310
		Cattle house		28		1	28	Trees	35	-
		Cattle house		10		1	10	-	-	-
		Garden		752		-	-	-	-	-
Household 18	4	House	448	160	100%	1	160	Trees	103	-
		Garden		288		-	-	-	-	-
Household 19	2	House	700	70	100%	1	70	Crops	-	400
		Cattle house		56		1	56	Trees	192	-
		Barn		56		1	56	Trees (saplings)	121	-
		Bath house		15		1	15	-	-	-
		Garden		503		-	-	-	-	-
Household 20	13	Garden	693	693	100%	-	-	Crops	-	450
						-	-	Trees	44	-
Household 21	6	House	400	60	100%	1	60	Crops	-	100
		House		20		1	20	Trees	51	-
		Garden		320		-	-	-	-	-
Household 22	3	Cottage	400	64	100%	1	64	Lucerne	-	200
		Barn		24		1	24	Trees	8	-
		Water pool		4		1	4	-	-	-
		Garden		308		-	-	-	-	-
Household 23	17	House	1189	192	100%	1	192	Crops	-	900
		Barn (foundation)		16		1	16	-	-	-
		Garden		981		-	-	-	-	-
Household 24	4	House	594	30	100%	1	30	Crops	-	250
		Cattle house		32		1	32	Trees	8	-
		Veranda		30		1	30	-	-	-
		Garden		502		-	-	-	-	-
Household 25	2	House	618	72	100%	1	72	Crops	-	150
		Barn		10		1	10	Trees	84	-
		Chicken house		5		1	5	-	-	-
		Garden		531		-	-	-	-	-
Household 26	2	Garden	1482	1482	100%	-	-	Trees	31	-
Household 27	6	House	563	37	100%	1	37	Crops	-	350
		Kitchen		15		1	15	Trees	51	-
		Cattle house		6		1	6	-	-	-
		Chicken house		6		1	6	-	-	-
		Garden		499		-	-	-	-	-
Household 28	1	House	800	64	100%	1	64	Fodder	-	500
		Bath house		16		1	16	Crops	-	150
		Chicken house		32		1	32	Trees	25	-
		Garden		688		-	-	-	-	-
Household 29	4	House	624	36	100%	1	36	Crops	-	120
		Garden		588		-	-	Trees	80	-
Household 30	1	House	850	20	100%	1	20	Fodder	-	800
		Garden		830		-	-	Apricot	1	-

Name	Number of household members	Type of affected structure	Land (m2)			Structures Lost		Affected crops/ trees	Number of affected trees/crops	Area of affected crops (m2)
			Total	Lost	%	No.	Area m2			
Household 31	4	House	396	70	100%	1	70	Crops	-	250
		Cattle house		20		1	20	Trees	35	-
		Barn		21		1	21	-	-	-
		Garden		285		-	-	-	-	-
Household 32	4	House	810	70	100%	1	70	Crops	-	600
		Garden		740		-	-	Trees	56	-
Household 33	3	House	800	44	100%	1	44	Crops	-	100
		Garden		756		-	-	Fodder	-	600
						-	-	Trees	50	-
Household 34	4	House	628	96	100%	1	96	Crops	-	50
		Cattle house and chicken house		60		1	60	Trees	55	-
		Garden		472		-	-	-	-	-
Household 35	5	Garden	620	620	100%	-	-	Fodder	-	300
						-	-	Trees	10	-
Household 36	4	House	960	30	100%	1	30	Fodder	-	500
		Barn		20		1	20	Trees	24	
		Garden		910		-	-	-	-	-
Total	153		26064,2				2771		3110	9980

(Source: A-LARAP for the Project)

Table 12.10.3-8 Loss of Assets of Leasehold Farmers

Name of leasehold farm	District	Total area, ha	Affected area, ha	Losses, %	Trees	Crops	Workers	Structures
Leasehold farmer 1	Karmana	5,65	5,65	100%	531 trees	0,44 ha	19	4
Leasehold farmer 2	Karmana	4,4	4,4	100%	500 planting stocks		25	0
Leasehold farmer 3	Novbahor	4	0,3	8%	72 trees	0	30	0
Leasehold farmer 4	Novbahor	88,6	3,9	4%	0	Cotton/ Wheat	48	0
Leasehold farmer 5	Novbahor	107	18,30	17%		Cotton/ Lucerne	70	0
Leasehold farmer 6	Novbahor	186	0,06-0,012	0.1%	0	0	4	0
Leasehold farmer 7	Novbahor	60	0,12-0,018	0.1%	0	Barley/Mung bean	8	0
Leasehold farmer 8	Novbahor	28	0,06-0,12	0.1%	30 trees	Corn/ Lucerne	3	0
Leasehold farmer 9	Novbahor	142	0,06-0,12	0.1%	30 trees	Cotton/ Wheat	37	0
Leasehold farmer 10	Novbahor	11,3	0,12-0,18	0.1%	35 trees	Corn/Wheat/Barley	3	0
Leasehold farmer 11	Novbahor	86	0,06-0,12	0.1%	30 trees	Corn/Cotton	19	0
Leasehold farmer 12	Novbahor	937	0,12-0,18	0.1%	35 trees	Cotton/ Wheat	25	0
Leasehold farmer 13	Novbahor	13	0,49	0.1%	42 trees	Lucerne/Barley/ Garlic/Tomatoes/Potato	15	0
Leasehold farmer 14	Novbahor	76	0,06-0,12	0.1%	0	Cotton/ Wheat	35	0
Leasehold farmer 15	Novbahor	200	0,06-0,12	0.1%	0	Cotton/ Wheat	3	0
Leasehold farmer 16	Novbahor	90	0,12-0,018	0.1%	0	Cotton/ Wheat	36	0
Leasehold farmer 17	Novbahor	102,7	0,18	0.1%	37 trees	Cotton/ Wheat	15	0
Leasehold farmer 18	Novbahor	61,8	0,12-0,18	0.1%	20 trees	Cotton/ Wheat	25	0
Leasehold farmer 19	Novbahor	10	0,15-0,18	0.1%	38 trees	Barley	21	0

Name of leasehold farm	District	Total area, ha	Affected area, ha	Losses, %	Trees	Crops	Workers	Structures
Leasehold farmer 20	Novbahor	18	0,06-0,12	0.1%	0	Carrot/Onion	19	0
Leasehold farmer 21	Novbahor	77	0,18	0.1%	0	Wheat	57	0
Leasehold farmer 22	Novbahor	82	0,06-0,12	0.1%	30 trees	Cotton	39	0
Leasehold farmer 23	Novbahor	108	0,12-0,18	0.1%		Cotton	52	0
Leasehold farmer 24	Novbahor	107	0,06-0,12	0.1%	28 trees	0	18	0

(Source: A-LARAP for the Project)

In total the following impact on trees and agricultural crops are expected because of land acquisition:
In total, fruit trees 4338 fruit trees (2253 planting stocks) and 202 Timber trees

- Fruit trees at farmers 1228 fruit trees including 500 planting stocks and Timber 202 trees
- Cottages trees - 3110 fruit trees (including 1753 planting stocks)
- Farmers crops:
- Cotton / wheat at 22,53-22,74 ha
- Barley / mung bean / corn / carrot / onion etc . - 0.55-0.58 ha

Table 12.10.3-9 Loss of Structures of Commercial Entities

Name	District	Total area, ha	Affected area, ha	Losses, %	Structures
Commercial structure 1	Novbahor	0.06	0.06	100%	Shop - Private company “Akfa window frames”
Commercial structure 1	Novbahor	0.03	0.03	100%	Fuel station – Asil Ziyda

(Source: A-LARAP for the Project)

(4) **Impact on Income and Livelihood of All Project Affected Households**

According to the results of census affected households living in Michurin community will lose their seasonal cottages with gardens and some structures only. These cottages are not place of permanent residence of them. No one of the affected households will lose their source of income and need to restore their livelihood because of relocation.

According to the results of census, 4 affected people loss 100% of their assets and their income:

- Commercial structure 1 – shop - Private company “Akfa window frames”
- Commercial structure 2 - Fuel station – Asil Ziyda
- Leasehold farmer - “Kurilishgassuv-kran montaj” Ltd. (agricultural lands for greenhouse and growing agricultural products).
- Leasehold farmer - “Tammirlash Qurilish montaj” Ltd. (intensive orchard).

The mitigation measures for these losses are in the entitlement matrix.

12.10.4 Compensation for Lost Assets

(1) Methodology of valuation

Acquisition of land and involuntary resettlement of persons affected by the project, as well as compensation of their lost assets (granting the housing of equal worth or money equivalent for the

acquired property cost) will be considered within the project implementation. So, the valuation of losses is held in order to calculate the approximate amount of losses that households of project area will suffer due to their involuntary resettlement.

Consequently, with the aim of developing of the appropriate LARAP, assessment of the property market value is held. During the evaluation process the assessor adheres to the concepts and methods of the National Standards for Property Assessment (NSPA) adopted on 14.06.2006 by the resolution of the State Property Committee and developed on the basis of the law of the RUz “On valuation activity” (dated 1999, with amendments dated August 20, 2015).

In accordance with the NSPA №2 “Market value as the base for assessment”, the market value is calculated by application of the evaluation methods and procedures which reveal the sort of the property and conditions for its selling in the open market. The most commonly used ways of the market value calculation are the sales comparative approach, the capitalization-of-income method or the discounted cash flow technique and the cost plus method.

As provided by NSPA No.10 “Appraisal value of the fixed property”, the selection of established methods within the bounds of each approach to the assessment is conducted by the assessor in accordance with the purpose of assessment, specificity and development perspectives of the evaluated object, as well of the restrictive conditions, information database availability and completeness.

Calculation of orchard / garden value is implemented in accordance with the Collector №4 of the “Aggregative indexes of the replacement values” and on the basis of the replacement value of one tree (in Uzbek sums). Diameter of the tree, its replacement value, inflation index and reappraisal coefficient was taken into consideration as well.

- To make the evaluation and appraisal of the affected objects the appraisal company makes a revision of the appraisal objects and its inspection and collects all necessary data on its features and actual condition of development. Thereby it is determined:

1. Type of basic engineering structures / buildings;
2. Type of basic construction materials;
3. Geometry features;
4. Actual state of engineering structures and buildings.

Identification of the object is implemented by the appraiser on the basis of the documentation provided by the owner of the object as follows:

1. State Registration Certificate for the building / structure;
2. Cadastral documents.

In case of availability of construction documents, the verification of actual design concepts, used construction materials and volumes of civil and erection works is implemented. If construction

documents not available, the geometry features of the evaluation object is determined by means of physical measuring.

The evaluating process of the affected structure / building or trees includes list of all objects, photographing and other necessary actions for the object identification confirming the actual condition of construction elements, engineering systems and equipment defined by visual inspection.

According to the results of the evaluation, the appraisal company provides an appraisal report that includes all the detailed information of the inspected object and the value of property, which is considered as the amount of the established compensation for lost property / assets.

(2) Census of the Assets of Affected People

The census of the assents of the losses and damages of project affected people is carried out preliminary at the market replacement cost of their losses.

At the stage of evaluation and compensation the independent appraisal company (third independent party) will carry out the required evaluation of the impacted assets of all project affected people. The proper appraisal reports will be provided to the project affected people as well as local authorities to compensate the losses and damages.

At this stage of preparatory studies of project impact the preliminary evaluation is carried out by the Cadastral departments of khokimiyat at the current market prices.

Once the feasibility study / detailed design is prepared and detailed design of the project is developed, the exacted lands required for the project is approved, the list of affected households and their losses will be updated. Currently the feasibility study of the project is not prepared. The project design of the required lands is preliminary

(3) Entitlement Matrix

Table 12.10.4-1 shows “type of loss”, “entitled persons”, and “detail of compensation” of the affected households by construction of GTCC3, substation, and transmission line).

During the preparation of LARAP Consultant found out that there are no illegal households affected by the project. Local government (khokimiyat) has already started the process of registration of project affected households at cottages at Michurin community. Previously they were illegal owners of cottages and land users. Due to the project implementation activities all these owners are officially registered at cadaster department of khokimiyat. All of them are entitled for right of compensation as legal owners of property.

Table 12.10.4-1 Entitlement Matrix

Losses	Application	Determination of owner	Compensation policy	Implementation issues	Responsible organization
Agricultural lands	Loss of land regardless of impact degree Permanent losses	Lessee / leaseholder	a) - Compensation "land for land" is being provided to all households (including farmers/orchard). Affected persons to be provided opportunity to harvest standing crop prior to land acquisition. If not, compensation for standing crop to be provided. - *For lost agricultural crops:* Monetary compensation is based on market replacement cost by providing compensation for loss of the right of land use, equal to 4 years of average net profit calculated for the last 3 years (the affected annual crops) - *For fruit trees:* Monetary compensation is based on market replacement cost by providing compensation for loss harvest equal to 4 years of average net profit calculated for the last 3 years (the affected tree) and full replacement cost of the tree. - *For timber trees:* Monetary compensation is based on market replacement cost by full replacement cost of the tree. b) Not covered plots of affected arable land will be also compensated if after impact they are unsuitable for use.	- Payment of compensations will be carried out on the basis of full replacement cost of affected assets in local markets for the actual moment of compensation, taking into account inflation and market fluctuation in prices in the real estate sphere, including all payments taxes and fees related to it. - Commissions consisting of representatives of khokimiyats, departments of cadastral service and other departmental structures on selection of the similar (equivalent) land plots of the equal value / productivity, of comparable location and additional agricultural means (or compensation for provision of similar means) will be created.	- Khokimiyat (local authority) - Ministry of agriculture (local department) - Farmer Council - JSC TPP
	Additional provision in case of strong impact (loss of more than 10% of production		Allowance equal to the net profit from annual harvesting (including summer and winter crops) in addition to the provision the land plot and compensation for crops / trees. - In case the PAP is unable to harvest the crop prior to land acquisition additional		- Khokimiyat (local authority); - Ministry of agriculture (local department) - Farmer Council

Losses	Application	Determination of owner	Compensation policy	Implementation issues	Responsible organization
	capacities)		compensation for standing crop will be is paid for the seasonal harvest losses.		- JSC TPP
	Loss of land regardless of impact degree Temporary losses	Lease / leaseholder	- *For lost agricultural crops:* Monetary compensation is based on market replacement cost by providing compensation for loss of the right of land use, equal to period of temporary losses based on average net profit calculated for the last 3 years (the affected annual crops) - *For fruit trees:* Monetary compensation is based on market replacement cost by providing compensation for loss harvest equal to period of temporary losses based on average net profit calculated for the last 3 years (the affected tree) and full replacement cost of the tree. - *For timber trees:* Monetary compensation is based on market replacement cost by full replacement cost of the tree.		-
Loss of residential structures of the households	Losses of the inhabited structures, adjacent to the territory and the objects located in this territory	Legal owners of houses including farmers who have their residential houses at their farms	- Full compensation of the inhabited structures (full replacement cost of affected assets in local markets), adjacent territories and objects in this territory. Calculation of compensation is based on the results of the market estimation of cost of the specified objects, including all the related payments - Compensation for moving; - Rental allowance for temporary accommodation (rental allowance sufficient to get accommodation equivalent to their current homes) in the form of 1 to 24 months' rent in cash for those who plan to construct a new house themselves).	- Payment of compensations will be carried out on the basis of full replacement cost of affected assets in local markets for the actual moment of compensation payment, taking into account inflation and market fluctuation in prices in the real estate sphere, including all payments related to it; - The commissions consisting of representatives of khokimiyats, departments of cadastral service and other departmental structures on selection of the similar (equivalent) land plots and inhabited structures will be created. Valuation will be undertaken by an appraisal company, which is non-governmental and independent. - The rental allowance will be provided for the period up to 24 months. The household can rent the house in the relocation area or area of the current residence.	- Khokimiyat (local authority); - Department for Land Use and State Cadastre (Goscomzemgeodezcadastre) - JSC TPP

Losses	Application	Determination of owner	Compensation policy	Implementation issues	Responsible organization
				The rent will be sufficient to get accommodation equivalent to their current homes. During this period household will construct the new house.	
		Householder / officially rented house	- Full compensation of the inhabited structures (full replacement cost of affected assets in local markets), adjacent territories and objects in this territory to owner of the property. Calculation of compensation is based on the results of the market estimation of cost of the specified objects, including all the related payments.	- Payment of compensations will be carried out on the basis of full replacement cost of affected assets in local markets for the actual moment of compensation payment, taking into account inflation and market fluctuation in prices in the real estate sphere, including all payments related to it; - The commissions consisting of representatives of khokimiyats, departments of cadastral service and other departmental structures on selection of the similar (equivalent) land plots and inhabited structures will be created. Valuation will be undertaken by an appraisal company, which is non-governmental and independent.	- Khokimiyat (local authority); - Department for Land Use and State Cadastre (Goscomzemgeodezcadastre) - JSC TPP
		Informal owner (no cadastral documents for houses)	- Assistance in registration the rights for inhabited structures; - Full compensation of the inhabited structures (full replacement cost of affected assets in local markets), adjacent territories and objects in this territory. Calculation of compensation is based on the results of the market estimation of cost of the specified objects, including all the related payments; - Compensation for moving.		- Khokimiyat (local authority) - Department for Land Use and State Cadastre (Goscomzemgeodezcadastre) - JSC TPP
Losses of summer houses / cottages	Losses of the seasonal structures / cottages / summer houses	Legal owners of houses	- Land for land compensation - Full compensation of the seasonal structures (full replacement cost of affected assets in local markets), adjacent territories and objects in this territory	- Payment of compensations will be carried out on the basis land for land compensation OR full replacement cost of affected assets in local markets for the actual moment of compensation payment, taking into account inflation and market fluctuation in prices in the real estate sphere, including all payments related to it; - The commissions consisting of representatives of khokimiyats, departments of cadastral service and other departmental structures on selection of the	- Khokimiyat (local authority) - Department for Land Use and State Cadastre (Goscomzemgeodezcadastre) - JSC TPP
		Householder / officially rented house	- Land for land compensation to owner of the land - Full compensation of the seasonal structures (full replacement cost of affected assets in local markets), adjacent territories and objects in this		

Losses	Application	Determination of owner	Compensation policy	Implementation issues	Responsible organization
			territory to the owner of the property.	similar (equivalent) land plots and inhabited structures will be created. Valuation will be undertaken by an appraisal company, which is non-governmental and independent.	
		Informal owner (no cadastral documents for houses)	- Assistance in registration the rights for inhabited structures; - Full compensation of the seasonal structures (full replacement cost of affected assets in local markets), adjacent territories and objects in this territory.		
Losses of trees / perennials	Losses of trees inside the owned land plot or adjacent to the territory and the objects located in this territory	Persons with legal use of the land	- *For fruit trees:* Monetary compensation is based on market replacement cost by providing compensation for loss harvest equal to 4 years of average net profit for the last 3 years (the affected tree) and full replacement cost of the tree. - *For timber trees:* Monetary compensation is based on market replacement cost by providing compensation for full replacement cost of the tree.	- Payment of compensations will be carried out on the basis of full replacement cost of affected assets in local markets for the actual moment of compensation.	- Khokimiyat (local authority); - Department for Land Use and State Cadastre (Goscomzemgeodezcadastre) - JSC TPP
		Socially recognized owner / Informal occupant of trees / perennials			
Loss of commercial, business and industrial objects	Losses of the industrial structures, adjacent to the territory and the objects located in this territory	The owner of commercial, business and industrial activity	- Full compensation of the structures, adjacent territories and objects at replacement cost of affected assets in local markets, including all payments related to it, including compensation of losses for 2 years based on average annual profit. Compensation for movement	- Khokimiyats of the respective districts will notify and consult with the owners of residential, production and other buildings, structures and plantings on the made decision in writing for the signature not later than in six months prior to demolition, attaching to the notice copies of the relevant decisions on withdrawal of the land plot, demolition of residential, production and other buildings, structures and plantings located in the land plot. Withdrawal of the land plots and the real estate in them will be made only after receiving of compensation by these subjects.	- Khokimiyat (local authority); - Makhalla committee, - Ministry of employment and labour relations - JSC TPP
	Loss of permanent employment from affected	Employees losing their wage as a result of impact on business enterprises	- Full compensation in cash for lost wages up to 6 months (including fixed by oral agreement with employer) paid for the period of wage interruption	- Payment of compensations will be carried out on the basis of size of wage of affected employees paid at the enterprise at moment of compensation. Compensation will be provided to the affected	

Losses	Application	Determination of owner	Compensation policy	Implementation issues	Responsible organization
	businesses		- Assistance in seeking a job and training	business and transferred to its employees.	
	Loss of seasonal employment from affected businesses	Employees losing their wage as a result of impact on business enterprises	- Full compensation in cash for lost wages up to 3 months paid for the seasonal period of wage interruption - Assistance in seeking a job and training	- JSC TPP is responsible for assisting affected employees in seeking a job and training for 2 years after the payment of compensation. Khokimiyat will monitor their livelihood 2 years later and, as necessary, provide tailored assistance to them.	
Any	Vulnerable Affected Households	Low income households, female-headed households with fewer than two adult income-earners, the elderly headed households with unemployed family members and disabled)	- Inclusion in existing safety net programs to ensure the continuation, or increase, of previous income. - One-time additional allowance equivalent to their 3-month average household. - Priority for employment in project-related jobs, training opportunities, self-employment and wage employment assistance. - Livelihood restoration measures such as training to ensure that continuation, or increase, or previous income (if required). (More detailed measures are described below in Section Livelihood restoration and rehabilitation).		- Khokimiyat (local authority); - Makhalla committee, Ministry of employment and labour relations - JSC TPP
Rehabilitation and reclamation of the affected land	Agricultural lands, orchard, state reserve lands (roads, canals etc.), pastures and other classified as agricultural land	The state (Special account of rational/regional Department for Land Use and State Cadastre of Goscomzemgeodezcadastre). *The calculated compensations are for the affected lands that remain under the state owned (ex. Reserve lands, greeneries along roads/highways, orchards, agricultural lands, pastures, and*	- Compensations are to be paid to rehabilitate lands through irrigation and agro-irrigation activities in order to maintain the fertility/productivity of existing lands in accordance with the unit rate - Calculations of compensations are done according to the Cabinet of Ministers Decree # 146. In case of absence of such value category of agricultural land such as pasture, reserve land and others will be calculated by application of special unit rate set by this Decree. - The compensations are paid to the local Khokimiyats and relevant agencies that are responsible to rehabilitate and develop affected land. - All losses to economic trees, crops, pasture land, and/or other economic activities will be compensated based on the entitlement matrix.		- Khokimiyat (local authority); - Department for Land Use and State Cadastre (Goscomzemgeodezcadastre)

Losses	Application	Determination of owner	Compensation policy	Implementation issues	Responsible organization
		other classified as agricultural lands).			
Loss of livelihood	Losses of livelihood / sources of incomes	Farmers that lost a season of planting due to restrictions on planting In case if households are identified during project implementation as losing livelihoods as a result of the project.	Livelihood restoration measures: - Employment assistance. - Provisional of financial support and allowance for persons who are for the first time seeking for work; - Additional guarantees would be provided by creation of additional workplaces for work of disabled people, organization of special programs of training, establishment in the enterprises of the minimum quantity of workplaces for employment etc. - Social support and provision of state social insurance. - Safety net programs including additional assistance from the local authorities such as social benefits (cash income according to the welfare system); provision of foodstuff (oil, flour, meal) etc. Assistance in transportation, construction, celebration and other activity.		- Khokimiyat (local authority); - Makhalla committee, Employment support center, - Ministry of employment and labour relations - JSC TPP
Loss of services (utilities such as electricity, gas, etc.)	Losses of access to public utilities	Households relocated to the new communities	The State Unitary Enterprise Housing and Communal Services enterprises under its control are the suppliers of public utilities, together with the self-funding enterprise, operating at district and city levels as well as local authorties (khokimiyats) will: - Assess the needs and develop facilities (gas, electricity, water supply etc.) as well as provide enhancement of carrying capacity of common civic amenities/utilities of new communities; - Provide investment in the new area to improve health, education, and other public services; - Conduct afforestation in the new area. Utilities will be provided in temporary and permanent housing prior to relocation of affected persons.		- Local authorities / State Unitary Enterprise Housing and Communal Services (gas, electricity, water supply etc.)
Any unanticipated Impacts: Any unanticipated impacts identified during Project implementation will be compensated in full at replacement rate or the entitlements listed in the Resettlement Framework prepared for this Project.					

(Source: A-LARAP)

(4) Livelihood Restoration and Rehabilitation

The livelihood restoration and improvement plan will be implemented based on consultation with possible affected people and their socio-economic profile, living environment, level of education, etc. which were identified in the socioeconomic survey. Project Implementation Unit will consider the opportunities to incorporate the following measures into livelihood restoration program:

The livelihood restoration and rehabilitation plan includes efforts to assist displaced persons to restore livelihoods at par or better than pre-project conditions when their livelihoods are adversely affected by the project.

The following measures will be provided to the affected households as special assistance over and above the compensation for affected assets in order to ensure that they are able to restore or improve their pre-project standard of living. Thus, these measures are provided in order to improve the living conditions of vulnerable affected households in compliance with Entitlement Matrix:

- **Employment:** Affected households/persons would get preferences for employment. Vulnerable households would have benefit for employment in project-related jobs, self-employment and wage employment assistance; Employment in the Resettlement Site construction would be an added source of income in the livelihood restoration processes.
- **Human development measures:** Provisional of financial support and allowance for persons who are for the first time seeking for work as well as persons interested to resume their work after a long break;
- **Additional guarantees** would be provided by creation of additional workplaces, the specialized enterprises, including the enterprises for work of disabled people, organization of special programs of training, establishment in the enterprises of the minimum quantity of workplaces for employment etc.
- **Social support**: Provision of state social insurance. Vulnerable households will be provided with additional conditions to reduce their expenses to get the working place, medical point, educational institution (school/ college etc.), local authorities as well as adequate quality of social and public infrastructure (gas, water, electricity etc.).
- **Safety net programs** for the affected households would include additional assistance from the local authorities such as social benefits (cash income according to the welfare system); provision of foodstuff (oil, flour, meal etc) etc. Assistance in transportation, construction, celebration and other activity.

For the commercial and farming affected structures:

- Assistance in provision of fertilizers and auxiliary materials, as well as allocation of additional soft financing.
- Support with registration of documents.
- Reconsider crediting conditions for the existing business.

At this stage of assessment, there are 4 project affected people (2 farmers in Karmana district and 2 business structures in Navbahor district) who loss 100% of their incomes. The compensation in compliance with the Entitlement Matrix covers their losses and gives them the opportunity to restore their incomes after relocation.

JSC TPP is responsible for assisting affected employees in seeking a job and training for 2 years after the payment of compensation. Taking into account the period of mitigation measures such as compensation for losses of income, the monitoring of restoration process of their incomes will be as a part of monitoring of LARAP. In case if these affected people have no restored their income up to pre-project level, the detailed livelihood restoration program will be developed for them. Khokimiyat will also monitor their livelihood 2 years later and, as necessary, provide tailored assistance to them.

Any way assessment of income restoration shall be based on comparison their incomes the project and period of time required for restoration income with the provided compensation.

12.10.5 Grievance System

Grievance Focal Point (GFP) is an organization handling all the complaints from the local inhabitants, and is established within Makhalla which is an organization of the inhabitants, and within districts which is an administrative organization.

The GFP will be assisted and supported by members of the District Land and Resettlement Committee (LARC) who will maintain a register of complaints, keep track of their status and report to the PIU's Head. They will regularly track complaints received, actions taken and the status of resolution. Complaint forms will be distributed to the heads of local makhalla's and the District GFP to facilitate recording of complaints.

The Affected Persons should be informed in prepared brochures on all contacts and contacts persons (GFP) responsible for the realization of the resettlement project. They will be able to call or submit personally any complaints to these persons. There should also be envisaged a possibility of a GFP's visit directly to a place of resettlement.

The duration for redressing all the complaints or requests submitted by the APs is 15 working days. If there is no reaction to the APs' complaints within this period, APs should be able to turn to District GFP (e.g. in writing a complaint, faxing it, etc.) if necessary.

The District GFP will have 15 working days from the day of submission of a complaint to provide a well-reasoned reply to APs and take an appropriate decision. The written complaint and attempts will be registered to be solved it. If complaint is not resolved in one week, it is passed by the GFP to the District LARC for resolution.

In the event that a satisfactory answer cannot be provided, the written complaint and attempts with the AP will be registered in the Land Acquisition and Resettlement Committee (LARC) the District Khokimiyat to be resolved it. If a solution is not reached within 15 working days, the LARC refers it to JSC TPP PIU.

JSC TPP PIU will assist the activities of the GFP and LARC to resolve the complaints and makes a decision within 15 working days. If the District is not able to resolve the dispute within the elapsed time, the JSC TPP PIU will have further two weeks to resolve the issue. If the decision is still unacceptable to the AP, the APs can take it to the District Court although all court costs (preparation and representation) will be paid for by the project – no matter the outcome.

The District Court will make a final decision. The decision will bind on all parties. Table below shows the summary of grievance procedure.

Table 12.10.5-1 Summary of Grievance Procedures

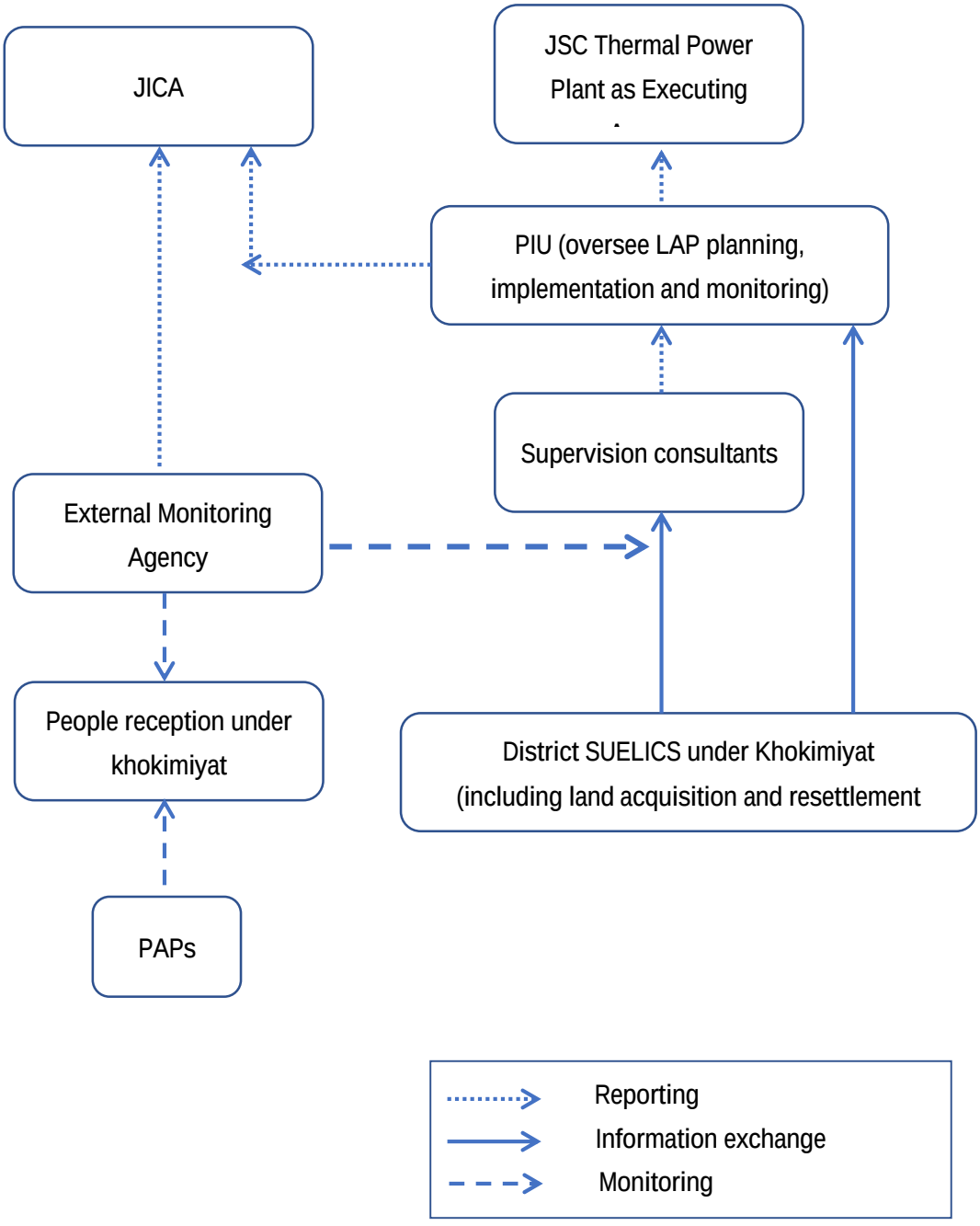
Step	Stage in Response Handling	Required Activities
1	GFP at cottages community	Verbally responds to questions and/or complaints. If no response within one week, or response is unsatisfactory, AP prepares a grievance in writing (utilize standard forms where possible).
2	District GFP	Registers the written complaint and attempts to solve it. If complaint is not resolved in 15 working days, it is passed by the GFP to the District LARC for resolution
3	District Land Acquisition and Resettlement Committee (LARC)	Registers the written complaint and attempts to resolve it with the AP within 15 working days. If a solution is not reached, the LARC refers it to UE PIU.
4	JSC TPP PIU	Assists in the activities of the GFP and LARC in the resolution of complaints. Makes a decision within 15 working days. In the event that the District is not able to resolve the dispute within the elapsed time, the UE PIU will have further two weeks to resolve the issue. If the decision is still unacceptable to the AP, they make take it before the District Court, with all costs paid for by the project.
5	District Court of Law	The District Court hears the case and makes a final decision that is binding on all parties. The application to the people reception is allowed at any stage of complaints from all project affected people.
6	People reception under khokimiyat	General office of grievance redress mechanism for all types of complaints. The application to the people reception is allowed at any stage of complaints from all project affected people.

(Source: A-LARAP)

12.10.6 Implementation System

The main institutions that will be involved in LAR activities are JSC TPP as executing agency, PIU (Project Implementation Unit), Design Institute (DI), Project Consultants (PC), Provincial (Province) and District (District) and municipal town authorities, State Unitary Enterprise Land and Immovable Cadastre Service (SUELICS) at district level. Roles of each organization are described below. Their relations are shown in (Source: A-LARAP)

Figure 12.10.6-1.



(Source: A-LARAP)

Figure 12.10.6-1 Project Implementation Diagram

(1) JSC TPP

The JSC TPP will have overall responsibility for all aspects of the project. The Project Implementation Unit (PIU) within JSC TPP will be responsible for the day to day management of the Project including cross-agency coordination for LARAP implementation and monitoring the compensation and disbursement.

The PIU will be directly involved in all LAR related planning, implementation, inter-agency coordination, monitoring and reporting.

(2) Project Implementation Unit (PIU)

The Project Implementation Unit (PIU) will be in charge of elaborating the design and construction documents for the project. It will work to:

- Look for measures and alternatives to avoid and minimize land acquisition and resettlement impacts.
- Assemble all documents required for compensation.
- Carry out topographic surveys of the expropriated land and replacement lands.
- Elaborate layouts indicating the location of the worksites and the permanent infrastructures and the perimeter of the required surfaces differentiating the land use patterns in the areas being occupied to serve as a base for the selection of compensation land.
- Conduct land marking and pegging of the land assigned for temporary use and permanent occupation of acquired land.
- Conduct the internal monitoring according to LARAP.
- Select the independent valuation agencies and independent monitoring agencies for external monitoring.

(3) District State Unitary Enterprise Land and Immovable Cadastre Service (SUELICS)

This is a permanent committee at District level. However, it plays an enhanced role throughout implementation. It is responsible for:

- Identifying land losses incurred by land owners and land users plus agricultural output losses.
- Determining the need for protective sanitary and water protection zones around constructions.
- Preparing proposals on allocation of land plots of equal value under land for land.
- Approving the Implementation Act and the attached plan.
- Amending government edicts on land use and land ownership as well as other cadaster documents.

(4) District Government

Local district government involved in the LARAP review and implementation. It will form a district land acquisition and resettlement committee (LARC) which will undertake the following:

- Outline locations of constructions and structures affected by the project.
- Select land for construction sites.
- Prepare and approve legislation for the right (title) to use land plots.

- Approve the Act for the right to use the land plot.

In addition to permanent members, the Committee may include representatives of JSC TPP, as well as affected legal entities and individuals (DPs).

The LARC will also estimate losses of land owners and land users in accordance with JICA specifications in addition to losses resulting from land acquisition based on data provided by the independent valuation agency. The Committee will prepare Acts for the right to specific plots of land specifying the acquired land area and losses and allowances as determined under the LARAP entitlement matrix. It is proposing that LARC will compose of the following members:

- JSC TPP PIU.
- District Department of SUELICS.
- District Department of Agriculture and Water Resources.
- District Department of Environmental Protection.
- Makhallas' leaders.
- Representatives of the affected people.

All affected legal parties and individual persons (or their legal representatives) will have representation on the committee. Besides state organizations and structures and makhalla authorities will be involved in resettlement activities to ensure the legal rights and interests of land users who are subject to land acquisition and resettlement.

(5) District Grievance Redress Committee (GRC)

This is a permanent committee at District level based at GFP (see Chapter VI.2) that has to function during all period of the resettlement process. It is responsible for:

- Reception and reviewing questions and/or complaints on the part of DPs.
- Informing for the District SUELICS on the questions/complaints for resolution.

(6) Supervision Consultants (Internal Monitoring)

The Supervision Consultants should be selected by PIU. They are responsible for:

- Supervision and information exchange with District SUELICS regarding to the resettlement process.
- Monthly reporting to the PIU regarding to the resettlement process.

(7) External Monitoring Agency (EMA)

The External Monitoring Agency (EMA) should be selected by PIU and approved by JICA. It is responsible for:

- Monitoring of the activities of District Grievance Redress Committee.
- Monitoring of the activities of District SUELICS.

- Monitoring of the activities of Supervision Consultants.
- Monthly reporting to JICA regarding to the resettlement process and activities of all institutions involved to the resettlement process.

12.10.7 Implementation Schedule

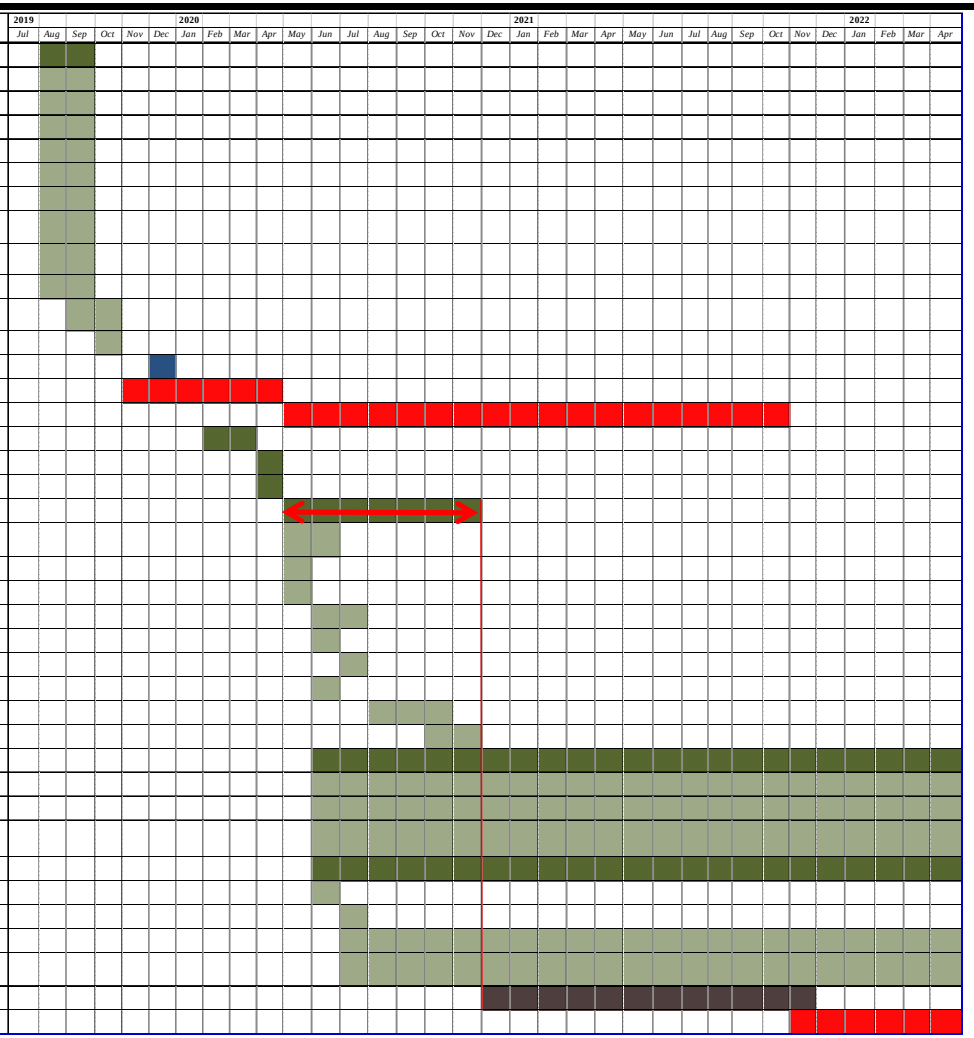
A timeline for A-LARAP preparation, implementation and post implementation is summarized in Table and Figure below.

Table 12.10.7-1 RAP Implementation schedule

Step	Action	Responsibility	Timing
A)	**COMPLETING A-LARAP PREPARATION**		
	Evaluation of project impacts	Resettlement Consultant	June - July 2019
	Identification of compensation amounts	Resettlement Consultant, District Land Acquisition and Valuation Committee, Independent evaluating company, Khokimiyat	July 2019
	Stakeholder meeting 2 / Disclosure of A-LARAP through public consultation / consultations on compensation policy	Resettlement Consultant, Khokimiyat	August 2019
B)	**A-LARAP IMPLEMENTATION**		
	Preparation of new resettlement sites / relocation sites	District Land Acquisition and Valuation Committee, Mahalla, Khokiniyats, Farmers Association and Resettlement Consultant, PIU	April 2020
	Detailed schedule for compensation action plan	District Land Acquisition and Valuation Committee, Khokiniyats, and Resettlement Consultant ,PIU	May 2020
	Preparation of plan for payment of each affected asset / compensation payments (before construction starts)	District Land Acquisition, and Resettlement Committee Khokiniyats and Resettlement Consultant, EA/ PIU	May 2020
	Monitoring of payments compensation according to the Entitlement Matrix.	District Land Acquisition, and Resettlement Committee Khokiniyats and Resettlement Consultant, EA/ PIU	June 2020
	Public consultation and information sharing on A-LARAP activities	District Land Acquisition and Valuation Committee, Khokiniyats and Resettlement Consultant ,PIU	July 2020
	Demolition and Relocation of Affected Structures/Assets (After compensation paid and temporary place to live is provided)	Contractor	September – November 2020
	Reinstallation of public utilities / roads / re-cultivation of lands	District Land Acquisition and Valuation Committee, Khokiniyats, PIU, Contractor	After construction
C)	**POST-IMPLEMENTATION TASKS**		
	Independent evaluation of A-LARAP	Independent Monitoring	Start in June- July 2020
D)	**ITERATIVE TASKS**		
	Internal monitoring. Semi-annual reporting to JICA	Resettlement Consultant ,PIU	Start in June- 2020

(Source: A-LARAP)

ID	Task Name	Responsibility
1	**LARAP MAKING**	
2	Implement census survey	UE supported by Expert ALMAR
3	Compensation rates fixed	UE supported by Expert ALMAR
4	Identification of replacement plots	UE supported by Expert ALMAR
5	Legalization of illegal APs	UE supported by Expert ALMAR
6	Identification of vulnerable APs	UE supported by Expert ALMAR
7	Valuation of asset based on full replacement cost	UE
8	Determination of induvidual entitlement (land compensation/ monetary compensation)	UE
9	Preparation of the LARAP	UE supported by Expert ALMAR
10	Information distribution/ Stakeholder consultation	UE
11	Review/Approval of LARAP and issuance no-objection/LARAP Disclosure	JICA
12	Approval and Disclosure Uzbekenergo	UE
13	**LOAN AGREEMENT**	UE and JICA
14	**SELECTION OF CONSULTANT**	UE and JICA
15	**SELECTION OF CONTRACTOR**	Consultant
16	**SELECTION OF RESETTLEMENT CONSULTANT**	UE
17	**UPDATE LARAP**	UE and/or Consultant
18	**REVIEW LARAP BY JICA**	UE and/or Consultant
19	**LARAP IMPLEMENTATION**	
20	Allocation of LARAP funds, including those for relocation and rehabilitation assistance	UE
21	Official Notification of DPs	UE
22	Preparation of vouchers	UE
23	Registration of new plots	District LARC
24	Opening of Bank Account for compensation payment	UE/District LARC/DPs
25	Delivery of compensation	District LARC
26	Establishment of Grievance Redress Committee	UE/District LARC
27	Construction of housing	DPs
28	Relocation	DPs
29	**MONITORING (internal monitoring)**	
30	Monitoring	UE
31	Preparation of compliance report	UE
32	Review of compliance report and issuance of no-objection for civil works	UE
33	**MONITORING (external monitoring)**	
34	Employment of external monitoring agency	UE/Consultant
35	EMA mobilization/Action plan preparation	EMA
36	Monitoring	EMA
37	Advicing project management regarding possible improvements in the implementation of the RP	EMA
38	**RELOCATION of EXISTING TRANSMISSION LINE**	**to be confirmed**
39	**CONSTRUCTION PERIOD**	**to be confirmed**



(Source: A-LARAP)

Figure 12.10.7-1 Tentative LARAP Implementation and Monitoring Schedule

12.10.8 Alternative Land

The District LAR Committee assesses options for relocation of affected 36 seasonal households. It is expected that in all cases they will be reallocated land close to their current plots.

Currently khokimiyat considers the option of using lands within the existing site of seasonal cottages. Representatives of khokimiyat will discuss the opportunity to allocate the lands of other cottages to the affected households in case of other owners are interested in selling their land. All owners of summer cottages who agree to receive compensation in exchange for the land, will be compensated for the lost land plots.

The land plots for leasehold farmers will be allocated within the affected districts from the reserved agricultural lands.

12.10.9 Cost and Funding

In order to ensure that sufficient funds are available for LAR tasks, JSC TPP will have to allocate 100% of the cost of compensation at replacement cost and expected allowances estimated in each LARAP plus contingencies before LARAP implementation. JSC TPP will be responsible for timely allocating the funds to implement the LARAP. Allocations will be reviewed bi-annually based on budget requirements indicated in the LARAP/RP.

PIU will ensure that compensation for lost assets and other allowances are provided in accordance with the entitlements agreed in the LARAP and reflected in the Entitlement Matrix.

JSC TPP will be responsible for including LAR funds for project activities in each fiscal years government budget. The budget for LARAP/RP will be disbursed by UE via the District LAR Committee which will in turn distribute the compensation to APs.

The compensation and other related resettlement costs for permanent land acquisition due to LARAP amount to UZS 4,719,093,408.84 or US$ 544,508.10. This amount includes 10% contingency to cover the cost of complaints and cost of future monitoring of LARAP. The summary of the preliminary budget for LARAP is provided in the following table.

Table 12.10.9-1 Preliminary Estimated Costs of the Land Acquisition and Resettlement Issues

Item of expenses	Total, UZS	Total, US$
Compensation for land	LAND for LAND compensation	
Compensation for structures	386,216,172.0	44,563.20
Compensation for agricultural lands	2,910,526,728.20	335,828.40
Compensation for commercial structures	69,229,574.0	7,987.90
TOTAL	3,365,972,474.20	388,379.50
Contingencies (20%)	673,194,494.84	77,675.90
M&E	679,926,439.80	78,452.70
GRAND TOTAL	4,719,093,408.84	544,508.10

(Source: A-LARAP)

Note: Calculations of compensation are carried out preliminary by the estimated rate of the losses at the current market prices

12.10.10 Monitoring System

(1) Internal Monitoring

All activities in LAR are time bounded. Internal monitoring will be carried out by the PIU and the LARC in the District khokimiyat. Process indicators will relate to implementation outputs and deliverables. These will be collected directly from the field, and will be reported monthly to the PIU to assess the LARAP implementation progress and adjust the work plan if necessary. These reports will be quarterly consolidated and submitted to JICA.

Specific internal monitoring benchmarks will be:

- Information campaign and consultation with APs.
- Status of land acquisition and payments on land compensation.
- Compensation for affected structures and other assets.
- Relocation of APs.
- Payments for loss of income.
- Selection and distribution of replacement land areas.
- Income restoration activities.
- Ensure the gender mitigation measures are adhered to during the internal monitoring and reporting process.

Upon the completion of resettlement, the PIU will prepare a post-LARAP implementation evaluation report that will assess both the permanent and temporary land acquisition activities and impacts of the Project focusing on the restoration of impacted lands and conditions of DPs especially those who were identified as vulnerable.

In addition, the PIU will update the LARAP and particularly the JICA's policy matrix, with a view to aligning Uzbekistan's CSS and reducing LARAP reporting requirements. Internal monitoring and reporting will continue for two years since the all affected households finish relocating to the new place.

(2) External Monitoring

The External Monitoring Agency (EMA) should be selected by PIU and approved by JICA. It is responsible for:

- Monitoring of the activities of District Grievance Redress Committee.
- Monitoring of the activities of District SUELICS.
- Monitoring of the activities of Supervision Consultants.
- Monthly reporting to JICA regarding to the resettlement process and activities of all institutions involved to the resettlement process.

Monitoring will be conducted during two years on continuing basis. The budget for external monitoring is US$ 78 452.6 and included into the preliminary resettlement budget. The report will be prepared on the results of M&E quarterly.

12.10.11 Public Consultation

Public consultations were held twice in April and August 2019 to explain the project and anticipated impacts to affected people. Details are described in Chapter 12.9.

(1) Inventory Survey

During the face to face interviews all affected people were informed about the objectives and tasks of the project, planned project implementation period, their rights for compensation their losses, procedures of land acquisition, evaluation and compensation. APs also informed in details on designed GRM allowing them submit their addresses, complaints and suggestions within the project.

The key question APs concerned about is compensation for their losses. Affected individuals worried on cases if their losses are not fully covered by the compensation. They think that probably they will have more losses than it will be evaluated at the preparatory stage of project implementation. Due to this, Consultant explained them the details of evaluation the losses and mechanism of redress grievance for such cases.

Consultant also noted that appraisal specialist are experienced in evaluation of existing and potential losses of the assets. This fact allow cover all the potential impacts as well.

Proper reports will be prepared for the appraisal of losses. The separate LARAP is preparing to assess the project impacts as well. There is a monitoring stage of project implementation in the project. Monitoring Consultant will assess the process of LARAP implementation. No civil works will start before all the compensation are paid fully.

(2) Strategies for Future Consultations

Meaningful consultations will be conducted throughout the project implementation cycle. An additional round of consultation with affected persons will be held at the stage of LARAP disclosure, stage of updating LARAP and implementation stage. For future consultations, the project includes the following steps:

- Public meetings in order to inform community members about the compensation paid and the assistance provided to the project affected households;
- Collection of information on complaints, proposals of affected persons on the issues of compensation and project mitigation measures;
- All monitoring and evaluation reports of the A-LARAP components of the project will be disclosed to the public in the same way as A-LARAP itself.
- Attempts will be made to ensure that vulnerable groups understand the process of compensation taken into account their specific needs.
- Affected persons will receive information on corrective measures, if any required, in accordance with the A-LARAP implementation procedures.

(3) Disclosure of Information

The A-LARAP will be disclosed after the endorsement the final report with JICA Team and JSC TPP. As noted above the A-LARAP will be disclosed to the project affected persons during the public consultation meetings. The A-LARAP will be available at the local municipality (district level), provincial khokimoyats, PIU as well as JSC TPP. The relevant agencies and organization involved in project implementation will disclose the A-LARAP at their web-sites.

12.11 Estimation of Greenhouse Gas (GHG) and Air Pollutants

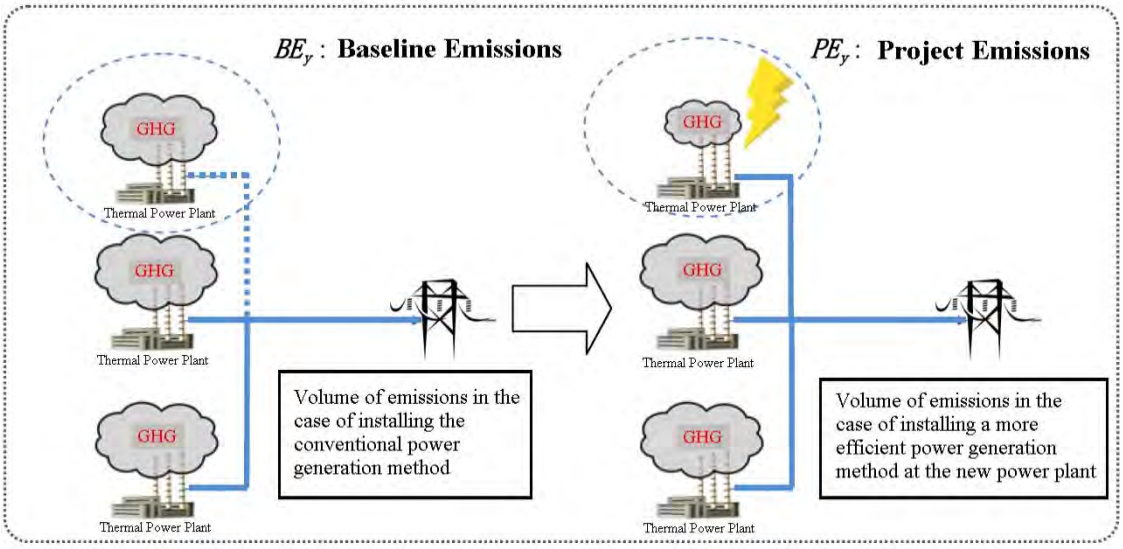
12.11.1 Methodology

This project is identified as a climate change mitigation project, and its mitigation effect was calculated in reference to "JICA Climate-FIT (Mitigation) Climate Finance Impact Tool for Mitigation, 2011". The calculation method for greenhouse gas (GHG) emission reduction is shown below ().

ER_y: GHG emission reduction in year y achieved by project (t-CO_2/y)

BE_y: GHG emission in year y with low-efficiency power generator (t-CO_2/y) (Baseline emission)

PE_y: GHG emission in year y after efficiency improvement (t-CO_2/y) (Project emission)



(Source: JICA Climate-FIT (Mitigation) Climate Finance Impact Tool for Mitigation, 2011)

Figure 12.11.1-1 Images of Emissions Reductions

(1) Baseline Emission

Since the amount of power output in the grid before the start of the project is supposed not changed after the completion of the project, the power output reduced by the existing power plant shall be equivalent to the power out generated by the new power plant.

$$BE_y = EG_{BLy} \times EF_{BLy}$$

Where,

BEy: Baseline emission (GHG emission with low-efficiency existing power plants), (t-CO_2/y)

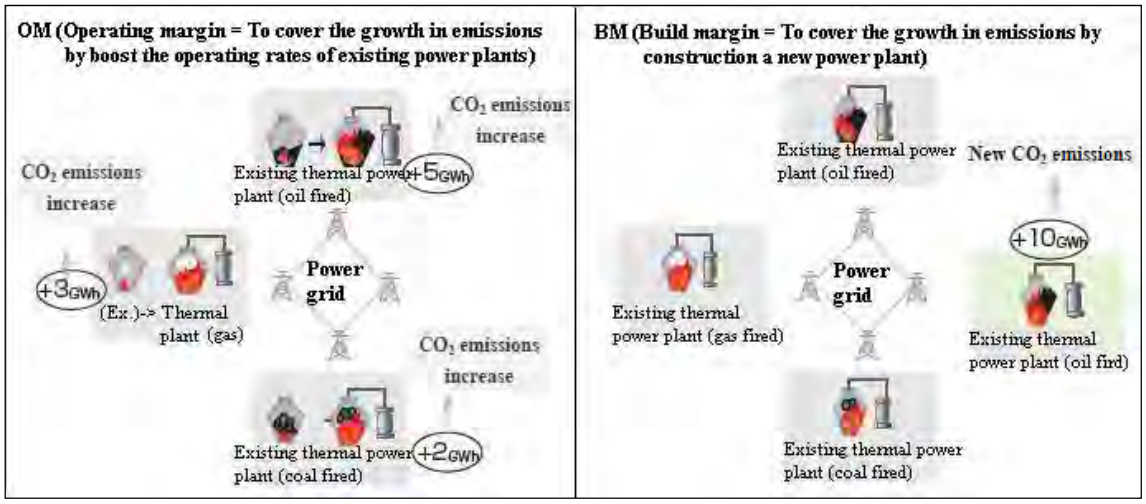
EG_{BLy}: Reduction of net electrical output by the existing power plants, which shall be equivalent to the power output of new power plant EG_{PJy}, (MWh/y)

EF_{BLy}: CO_2 emission factor of the electricity for the low-efficiency power plant, (t-CO_2/MWh)

There are three options for calculations of baseline emission coefficient (t-CO_2/MWh)

Option 1 : the build margin emission coefficient (t-CO_2/MWh)
Option 2 : the combined margin emission coefficient (using a 50/50 operating margin/build margin weight)
Option 3 : emission coefficient (t-CO_2/MWh) identified as the most likely baseline scenario

The images of operating margin (OM) and build margin (BM) emissions coefficient are shown in Figure 12.11.1-2.



(Source: http://gec.jp/gec/jp/Activities/cdm_meth/pACM0002-old-080414.pdf)

Figure 12.11.1-2 Images of OM and BM

(2) Project Emission

Project emission shall be determined by multiplying the net power output produced by the new power plant and the CO_2 emission factor of electricity for the new power plants.

$$PE_y = EG_{PJy} \times EF_{PJy}$$

Where,

$PE_{PJ,y}$: Project emission (GHG emission after project activity (t-CO_2/y))

$EG_{PJ,y}$: Yearly electricity generating capacity after the project (transmission end efficiency) (MWh/y)

$EF_{PJ,y}$: CO_2 emission coefficient of electricity generation (t-CO_2/MWh)

12.11.2 Calculation of Project CO_2 Emission Factor of Electricity: EFPJy

CO_2 emission coefficient of electricity for the new power plant is calculated using the planned data of CO_2 emission factor of fuel and generation efficiency and power output for the new power plant before the project starts, and the measured data shall be used after the project is completed.

CO_2 emission factor of fuel "i" shall be the same as of the baseline, since the fuel properties are the same for the both cases.

$$EF_{PJ,y} = \{COEFi / (\eta_{PJ,y/100}) \} x\ 0.0036$$

Where,

EF_{PJy}: Project CO_2 emission factor of electricity, (t-CO_2/MWh)

$COEF_i$: CO_2 emission coefficient of fuel "i" per calorific value, (t-CO_2/TJ)

$\eta_{PJ,y}$: Planned value of generation efficiency after improvement, (%)

0.0036: Conversion factor of electric energy (megawatt hour) to thermal energy (tera-jule), (TJ/MWh)

12.11.3 Estimation of Effect of Greenhouse Gas Emissions Reductions

(1) Baseline Emission

IGES (Institute for Global Environmental Strategies) of Japan provides three emission factors as below for Uzbekistan.

Table 12.11.3-1 Grid CO_2 Emission Factors in Uzbekistan

Margin	Unit	Average
Combined Margin (CM)	t-CO_2/ MWh	0.585
Operation Margin (OM)	t-CO_2/ MWh	0.577
Build Margin (BM)	t-CO_2/ MWh	0.590

Source: http://pub.iges.or.jp/modules/envirolib/view.php?docid=2136

Since not only combined cycle power plants but also conventional thermal power plants are programmed for the future plan in Uzbekistan, using combined margin (CM) as baseline emission seems to be more conservative and appropriate than using build margin (BM). Therefore, we adopt here combined margin (CM) as baseline emission factor.

Baseline Emission Coefficient: 0.585 (t-CO_2/ MWh)

(2) Project Emission

Regarding GTCC3, the CO_2 emission factor of fuel i: COEFi and CO_2 emission factor of electricity: $EF_{PJ,y}$ can be calculated using the same equations as for the old power plants by only changing the figure of generation efficiency. The results are as shown in Table 12.11.3-2.

Table 12.11.3-2 Calculation of CO_2 Emission Coefficients for GTCC3 Project

Item	Unit	Value	Remarks
Total power generation	MW	622.8	
Gas turbine	MW	467.2	
Steam turbine	MW	155.6	
Capacity factor (CF)	%	91.3	
Higher heating value, HHV	kJ/kg	53,363	
Lower heating value, LHV	kJ/kg	48,802	
Carbon content in fuel, C%	weight%	73.2	
CO_2 emission coefficient of fuel, COEFi	t-CO_2/TJ	73.2	Note-1)
Net generation efficiency of new power plant, $\eta_{PJ/y}$	%	52.0	
Conversion factor of electric energy (megawatt hour) to thermal energy (tera-jule)	TJ/MWh	0.0036	
CO_2 emission coefficient of electricity generation, $EF_{PJ,y}$	t-CO_2/MWh	0.450	Note-2)

Note:
1) CO_2 emission factor of fuel i,
COEFi = (C%/100) / LHV x (44.01/12.011) x 10^6
2) CO_2 emission factor of electricity, $EF_{PJ,y}$={COEFi / (η_{PJy} / 100)} x 0.0036

(Source: JICA Survey team)

(3) Trial Calculation of GHG Reduction

Table 12.11.3-3 shows a trial calculation result of CO_2 emission reduction of the project based on the expected performance data for the combined cycle plant The baseline emission BEy is 2,913,931t-CO_2/y, and the project mission PEy is 1,919,000 t-CO_2/y, and consequently the reduction of emission is 994,931 t-CO_2/y.

Table 12.11.3-3 Production and CO_2 Emission by GTCC3

Item	Unit	Value	Remarks
Gross power output of GTCC	MW	622.8	
Gross thermal efficiency	%	52.0	
Capacity factor	%	91.3	CF
Electricity generation	MWh	4,981,079	MWx8760x(CF/100)
Annual CO_2 emission	ton	1,919,000	Fx8760*(CF/100)x(C%/100)
Baseline CO_2 emission factor of electricity	ton/MWh	0.585	
Project CO_2 emission factor of electricity	ton/MWh	0.3852	
Baseline emission, BEy	t-CO_2/y	2,913,931	
Project emission, PEy	t-CO_2/y	1,919,000	
Reduction of emission,	t-CO_2/y	1,413,342	

(Source: JICA Survey team)

12.12 Other

12.12.1 Environmental Checklist

Table 12.12.1-1 and Table 12.12.1-2 shows the result of environmental and social consideration for power plant and for transmission line and Substation, respectively, reviewed according to the checklist attached to JICA Guidelines.

Table 12.12.1-1 Environmental Checklist for Power Plant

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
1. Permits and Explanation		
(1) EIA and Environmental Permits		
(a) Have EIA reports been officially completed?	**The EIA report was completed.** ・ The EIA of this project has been officially completed in accordance with the laws of Uzbekistan.	**Y**
(b) Have EIA reports been approved by authorities of the host country's government?	**The EIA report has been approved by the Uzbekistan government** ・ The EIA was approved on May 3, 2019 by the State Ecology Committee.	**Y**
(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?	**JSC Navoi TPP/JSC TPP will follow the conditions.** ・ Conditions for the EIA is followings: - JSC Navoi TPP/JSC TPP shall submit State of Environmental Effects (SEE) to Goskomekologiya and receive the approval of SEE prior to the commissioning; and - SEE shall develop environmental standards for all types of environmental impacts of the project. - JSC Navoi TPP/JSC TPP will follow the conditions.	**Y**
(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	**Environmental permits other than EIA have not been obtained yet, and these will be approved by the commencement of operation.** ・ JSC Navoi TPP/JSC TPP is required to obtain approval of Environmental Effects (SEE) prior to the commissioning. In this procedure, all permit will be obtained.	**N**
(2) Explanation to the Stakeholder		
(a) Are contents of the project and the potential impacts adequately explained to the stakeholder based on appropriate procedures, including information disclosure? Is understanding obtained from the stakeholder?	**The public consultation shall be conducted.** ・ JSC Navoi TPP/JSC TPP held a stakeholder meeting to explain this project on April 12, 2019 at the Khokimiyat of Karmani district, Karmana city, Navoi region. 15 people attended the meeting including the chairman of dacha community around the site. ・ Through the interview survey for preparing Abbreviated Land Acquisition and Resettlement Action Plan (A-LARAP) in August 2019, JICA Survey team will explain project overview, JICA Guidelines and scope of JICA Study. ・ 2nd Stakeholder meeting was be held in August 2, 2019.	**Y**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(b) Are proper responses made to comments from the stakeholder and regulatory authorities?	**The comments of the local people collected at the public consultation were all answered by JSC Navoi TPP/JSC TPP.** ・ At the meeting held on April 12, 2019 for local residents, the chairman of dacha community expressed concerns about resettlement and water use but JSC Navoi TPP/JSC TPP explained that compensation would be paid to the affected people including illegally occupants based on national regulations and the living level would not be worse than that before the resettlement. ・ 2nd Stakeholder meeting was held in August 2, 2019.	**Y**
(3) Alternatives		
(a) Were any alternatives of the project plan, including the environmental social items, examined	**JICA Survey team examined alternatives concerning the zero option and site selection.** **1. Zero option** ・ In a case where GTCC 3 is not constructed and the existing old-type power plants continue operation, the efficiency will not be higher, the fuel cost will not be lower, the reliability of the facility will decrease, and the risk of accident will increase. **2. Site selection** ・ Two options were considered from various perspectives such as area size, intake and discharge routes, difficulty of construction, and environmental and social consideration: Plan-A in the north of the existing power plant and Plan-B in the east of the existing plant. ・ As a result of examination, Plan-B was selected is considered the most favorable alternative, even though resettlement of around 36 households is predicted.	**Y**
2. Mitigation Measures		
(1) Air Quality		
a) 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 cause areas that do not comply with the country's ambient air quality standards?	・ NOx is generated from the exhaust gas used for fuel, but SO2 and soot generation will be insignificant. The decommissioning of the old facilities is also expected. ・ The emission concentration of air pollutant in the exhaust gas will meet the emission standard of Uzbekistan and the standard value of IFC/WB EHS guidelines (thermal power plant, 2008). ・ Wind speeds exceeding 10m/s are extremely rare, so downwash is expected to rarely occur. ・ Around the stack, there is no building causing occurrence of downdraft. ・ The maximum concentration at the ground level of the pollutants released by the project is extremely low compared to the Uzbekistan's standard and IFC/WB guidelines. ・ Future maximum concentration at ground level obtained by adding the predicted concentration of	**Y**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
	the existing power plants and the new facility to the background concentration is sufficiently low as compared with Uzbekistan's standards and the EU and the IFC/WB guidelines. ・ NO2 concentration will decrease after the shutdown of the existing power plant with the operation of GTCC3	
(b) 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?	**GTCC 3 is not a coal-fired power plant.**	**Y**
(2) Water Quality		
(a) 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 standards or cause a significant temperature rise in the receiving waters?	**Wastewater from Navoi-old into Zeravshan River will be minimal and will be appropriately treated in compliance with IFC/WB EHS Guidelines. As cooling water will be reused through forced-draft cooling fan system, thermal wastewater will not be discharged.** ・ Main wastewater caused by the operation of the new power plant and treatment for each wastewater will be the followings: - Oily drainage wastewater – oil separator; - Domestic sewage – septic tank; - Wastewater from water purification system - neutralization and sedimentation treatment; and - Waste washing water from the exhaust heat recovery boiler - neutralization and sedimentation treatment. ・ Total amount of wastewater will be approximately 56m3/h at the maximum. ・ All wastewater will be treated in compliance with IFC/EHS Guidelines (General and Thermal Power Plants). ・ Cooling water from the condenser will be reused through forced-draft cooling fan system and thermal waste water will not be discharged and cooling water will not be taken ・ The total discharge volume from Navoi Thermal Power Plant was 78,000m3/h prior to the operation of GTCC1, 71,000m3/h prior to the operation of GTCC2. Compared to the total discharge volume, that from GTCC3 will be minimal at 56m3/h. Furthermore, after some of the	**Y**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
	existing units stop operation associated with the operation of GTCC3, the total and discharge volume will decrease significantly.	
(b) 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?	**GTCC 3 is not a coal-fired power plant.**	**N/A**
(c) Are adequate measures taken to prevent contamination of surface water, soil, groundwater, and seawater by the effluents?	**Waste water will be appropriately treated by introducing a treatment system or other mitigation measure and serious water pollution is not predicted.** ・ Wastewater from water purification system and waste water from the exhaust heat recovery boiler will be treated with neutralization and sedimentation treatment system and will be examined for compliance with waste water quality standards of Uzbekistan and the IFC/EHS Guideline for thermal power plants (2008). ・ Oily drainage wastewater will be collected in the wastewater treatment system for oil separation to comply with Uzbekistan standard and IFC/EHS Guideline values for thermal power plants (2008). ・ Domestic wastewater from worker's camp is treated in the septic tank to comply with Uzbekistan standard and IFC/EHS Guideline values (General, 2007).	**Y**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(3) Wastes		
(a) 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?	**Industrial waste generated from the power plant operation will be correctly collected and treated by authorized treatment business according to the Uzbekistan regulation, so no significant environmental impact is predicted.** **1. Disposal Waste in Navoi-old** ・ Standard for treatment of waste shall be established for all economical activities regardless of the types of industry in Republic of Uzbekistan. ・ Transportation of waste for disposal site or reuse is delegated to the licensed company. Final disposal is conducted at the licensed disposal facility. ・ In Navoi-old, scrap metal and oil are reused by a special company, and sludge is disposed of at a designated disposal site. Domestic waste is disposed of at a disposal site in Navoi. ・ Waste oil from the equipment and oil-separating system of the waste-water treatment system and sludge from the precipitation system of the waste-water treatment system will be generated but may be diminished after stopping of the existing facilities. ・ As river water, not public water, will be used for boiler feed water and make-up water for cooling tower, sludge will be generated from the water treatment system. Sludge will be treated and disposed of as in the case of the existing power plant. **2. Mitigation measures** ・ Development of waste management program including education of workers to encourage reduction and reuse of waste. ・ Prohibition of illegal dumping. ・ Separation of waste by hazard level, storage in an appropriate storage site and legal disposal in an appropriate disposal site.	**Y**
(4) Noise and Vibration		
(a) Do noise and vibrations generated by the power plant operations comply with the country's ambient standards, and occupational health and safety standards?	**Mitigation measures for noise will be conducted, complying with the regulation standard of environmental noise level as well as working environment of Uzbekistan.** **1. Noise** ・ All estimated noise levels at the boundary in the residential area meet the environmental standard of Uzbekistan and IFC/WB EHS guideline standards. ・ Following mitigation measures are considered to be taken:	**Y**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
	- Introduction of low noise type or enclosed type equipment; and - Maintaining equipment by periodical check. **2. Vibration** ・ Vibration level at the residential area 300m from the project site is predicted to be 30dB, a sufficiently low level. ・ Following mitigation measures are considered to be taken: - Introduction of low vibration equipment - Reduction of vibration by selecting a solid foundation - Maintaining equipment by periodical check	
(5) Subsidence		
(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	**There is no possibility that land subsidence may arise because ground water will not be used.** ・ Groundwater will not be taken at the power plant.	**N**
(6) Odor		
(a) Are there any odor sources? Are adequate odor control measures taken?	**Substances generating odor will not be used.**	**N**
3. Natural Environment		
(1) Protected Areas		
(a) 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?	**There is no protected area in near and around project site.** ・ The project site is adjacent to the residential area and the power plant already under influence of human activity.	**N**
(2) Ecosystem and biota		
(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	**Project site does not encompass primeval forests, tropical rain forests and ecologically valuable habitats.** ・ The project site is adjacent to the residential area and the power plant is already under influence of human activity.	**N**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	**Project site does not encompass habitats of endangered species.** ・ Precious species designated by IUCN (International Union for Conservation of Nature and Natural Resources) and by the Uzbekistan Red Data Book are not observed in the land around site.	**N**
(c) If significant ecological impacts are anticipated, are adequate environmental protection measures taken to reduce the impacts on ecosystem?	**Air pollution will be mitigated by shutdown of the existing power plant.** ・ The project site is adjacent to the residential area and the power plant is already under influence of human activity. ・ Air pollution will be mitigated by shutdown of the existing power plant.	**Y**
(d) 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 aquatic organisms?	**Intake water from Zeravshan River will be decreased because once-through cooling system of the existing power units will be shut-down and forced-draft air cooling system which does not require cooling water will be adopted for the new plant.** ・ Since exhaust steam from the steam turbine is cooled by forced-draft air cooling system, cooling water will not be taken. ・ The total intake water at Navoi PS will be decrease when some of the existing power units with once-through cooling systems will be shut-down.	**Y**
(e) 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?	**The intake and discharge water volume will decrease when the new plant (GTCC3) with forced-draft air cooling system will start operating and some of the existing power units using once-through cooling system will shut down.** ・ Since exhaust steam from the steam turbine is cooled by forced-draft air cooling system, cooling water will not be taken and thermal wastewater will not be discharged. ・ The total intake and discharge water volume at Navoi-old will decrease when some of the existing power units with once-through cooling systems will be shut-down.	**Y**
4. Social Environment		
(1) Resettlement		
(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement?	**Yes.** ・ 36.92ha of land will be acquired permanently and 16.52ha will temporally for two years for construction of transmission line and substation. Permanently, 36 households will lose their house/dacha, 5 leasehold farmers will lose their agricultural land, and 2 commercial structure will be removed. Temporally, 19 leasehold farmers cannot use their agricultural land. ・ Alternative study for project site was conducted to reduce the impact of land acquisition and	**Y**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
	resettlement.	
(b) Is adequate explanation on relocation and compensation given to affected persons prior to resettlement?	**Yes.** ・ During social survey for A-LARAP and 2nd stakeholder meeting, explanation was made to the affected people. Further consultation will be held as necessary.	**Y**
(c)Is the resettlement plan, including compensation by the replacement cost, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	**Yes.** ・ Social survey was conducted in August 2019 and based on the results, A-LARAP is prepared. A-LARAP covers compensation by replacement cost, restoration of livelihoods and living standards.	**Y**
(d)Is payment of compensation made prior to resettlement?	**Yes.** ・ Payment of compensation will be made prior to resettlement.	**Y**
(e)Is the compensation plan formulated in documents?	**Yes.** ・ Please refer to Chapter 12.10.4.	**Y**
(f)Does the resettlement plan pay particular attention to vulnerable group or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	**Yes.** ・ Additional support will be provided to vulnerable people in accordance with the entitlement matrix developed in A-LARAP.	**Y**
(g)Are agreements with the affected persons obtained prior to resettlement?	**Yes.** ・ Agreements with the affected persons will be obtained prior to resettlement.	**Y**
(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	**Yes.** ・ Project Implementation Unit established within JSC Navoi TPP/JSC TPP will be mainly responsible for the resettlement in coordination with local district governments (khokimiyat). ・ JSC Navoi TPP/JSC TPP are capable as they experienced resettlement for Navoi GTCC2 in accordance with JICA Guidelines before. ・ JSC Navoi TPP/JSC TPP will secure the budget.	**Y**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(i)Is a plan developed to monitor the impacts of resettlement?	**Yes.** ・ Internal monitoring and external monitoring are planned.	**Y**
(j)Is the structure of grievance mechanism established?	**Yes.** ・ Affected persons will be informed on all contacts and contacts persons. Grievance focal point will be Makhalla which is an administrative organization. ・ Makhalla will be assisted and supported by District Land and Resettlement Committee (LARC) who will maintain a register of complaints, keep track of their status and report to the Project Implementation Unit's Head. ・ If affected people is not satisfied with what Makhalla and District LARC handle, they can register their grievance to JSC TPP will assist the activities of LARC to resolve the complaints. ・ The District Court will make a final decision.	**Y**
(2) Living and Livelihood		
(a) 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?	**There seems to be a positive impact that local people will be preferentially employed for this project.** ・ Local people may be employed as workers by the power plant, and increased purchase of local materials and equipment items, use of local restaurants and catering service will activate local economy. Therefore, positive impacts are expected. ・ Pollution control described in 2. Pollution Control in this check list will be taken. Therefore, no significant impacts are not expected to disturb the living conditions.	**Y**
(b)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?	**Social infrastructures are fully available, and access roads had already been constructed.** ・ In the time of constructing GTCC1 and 2, necessary access roads had already been constructed. ・ The construction site will be near Navoi City. Thus, hospitals and other social infrastructure are fully available.	**Y**
(c)Is there a possibility that large vehicle traffic associated with the project will affect road traffic in the surrounding areas? Are adequate measures considered	**Adequate mitigation measures are provided during construction period.** ・ National road is wide and traffic volume is not so large. ・ JSC Navoi TPP/JSC TPP will conduct the traffic control plan including route-setting and operation schedule. Bus for transportation of workers will be operated to minimize traffic and the route and	**Y**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
to reduce the impacts on traffic, if necessary?	schedule of operation will be discussed with the relevant organizations. ・ The following mitigation measures will be taken: - Development of appropriate driving routes and schedule; and - Traffic safety education and safe driving training for workers	
(d)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?	**Adequate mitigation measures are provided during construction period.** ・ The following mitigation measures will be taken; - Education and training on workers' infectious disease and health care - Installation of medical facility and medical staff. - Implementation of periodic medical check-ups	**Y**
(e)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)?	**The intake and discharge water volume will decrease when the new plant (GTCC3) with forced-draft air cooling system will start operating and some of the existing power units using once-through cooling system will shut down.** ・ Since exhaust steam from the steam turbine is cooled by forced-draft air cooling system and cooling water will not be taken and thermal waste water will not be discharged. ・ The total intake and discharge water volume at Navoi-old will decrease when some of the existing power units with once-through cooling systems will be shut-down.	**N**
(3) Heritage		
(a)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?	**There is no historical, cultural, religious monument in the project site.** ・ The site is not known to have any precious archeological, historical, cultural and religious heritages and monuments.	**N**
(4) Landscape		

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(a)Is there a possibility that the project will adversely affect the local landscape, if there is any aesthetic landscape near the site? Are necessary measures taken?	**Serious influence on landscape is not assumed** ・ The construction site is a place where people have many activities bound to power plant and houses. ・ There is no particular scenery of which to give consideration (2nd local survey).	**N**
(5) Ethnic Minorities and Indigenous Peoples		
(a)Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?	**The project site is not an area for minorities to live around.** ・ The project site is a place where a minority group live together.	**N**
(b)Are the rights about the land and resources of an ethnic minority and indigenous people respected?	**The project site is not an area for minorities to live around.** ・ The project site is a place where a minority group live together (2nd local survey).	**N**
(6) Working conditions		
(a)Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?	**JSC Navoi TPP/JSC TPP will compliance with the national laws and ordinances associated with working conditions.** ・ JSC Navoi TPP/JSC TPP will implement the project in accordance with the labor law of the country.	**Y**
(b)Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?	**Measures to individuals involved in the project on tangible safety considerations will be developed and conducted.** ・ The following prevention and mitigation measures will be taken: - Provide workers with appropriate protective equipment such as a helmet, safety boots, safety belt, mask, electric shock prevention equipment, earplugs, etc. - Establish clear signs to identify the location of hazardous or toxic material	**Y**
(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the	**Measures to individuals involved in the project on intangible safety considerations will be planned and conducted.** ・ The following prevention and mitigation measures will be taken:	**N**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
establishment of a safety and health program, and safety training (including traffic safety and public sanitation) for workers etc.?	- Prepare a manual for labor accident prevention including safety education and training:	
(d)Are appropriate measures being taken to ensure that security guards involved in the project do not violate safety of other individuals involved, or local residents?	**Security guards will be placed from the security company** ・ JSC Navoi TPP/JSC TPP will subcontract a security firm to deploy security guards. The security personnel trained by the security firm will be deployed.	**N**
5. Others		
(1) Impacts during Construction		
(a)Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?	**Adequate mitigation measures are provided during construction period.** ・ The following prevention and mitigation measures will be taken: **1. Noise and Vibration** - Perform construction work during daytime - Use low-noise/ low vibration equipment - Limit truck speed - Periodic checks and regular maintenance of construction equipment and vehicles - Adjust schedule so as to prevent the concentration of transporting vehicles on the site **2. Water pollution** - Install a neutralization tank - Install a provisional oil separator - Install a septic tank and temporary toilets for the workers **3. Air pollution** - Conduct periodic watering (dry season) - Conduct washing of equipment and vehicles - Conduct periodical maintenance in the construction equipment and vehicles - Turn off engines on standby - Distribute construction work within schedule preventing concentration of work in short periods	**N**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
	4. Waste Solid waste - Conduct the lubricants and oils collection in area where soil permeation does not occur (for examples, a concrete layer covered soil)	
(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts?	**Adequate mitigation measures for Air pollution, water pollution, etc. are provided during construction period.** ・ The prevention and mitigation measures described above will be taken.	**Y**
(c)If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	**Adequate mitigation measures are provided during construction period.** **1. Employment and Business** ・ The following prevention and mitigation measures will be taken: - Employ as many local residents as possible - Present employment opportunities with clearly explained pre-requisites - Use the services (i.e., laundry and catering services, etc.) and products offered by the local community **2. Local community** ・ Access roads had already been constructed. ・ In near Navoi City, hospitals and other social infrastructure are fully available. ・ The following prevention and mitigation measures will be taken: - Promote cultural exchange with the local population (for instance, participating in a local event) - Education and training on workers' infectious disease and health care - Installation of medical facility and medical staff. - Implementation of periodic medical check-up	**Y**
(2) Accident Prevention Measures		
(a)In the case of coal-fired power plants, are adequate measures planned to prevent spontaneous combustion at the coal piles? (e.g., sprinkler systems).	**GTCC 3 is not a coal-fired power plant.**	**N/A**
(3) Monitoring		

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?	**Monitoring during construction and operation phase will be conducted in order to assure the environmental impacts caused by the project.** ・ Monitoring plan about potential impacts during construction and operation phase is prepared.	**Y**
(b)How are the item of a monitoring plan, a method, frequency, etc. defined?	**Environmental monitoring is appropriately planned.** ・ Environmental monitoring is appropriately planned as described in Chapter 12.8.1.	**Y**
(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?	**Monitoring framework including organization and equipment will be established, and adequate budget will be secured.** ・ Organization structure for environmental monitoring implementation during construction and operation phase is described in Chapter 12.8.1. ・ Same as the existing power plant, monitoring framework including equipment will be established, and adequate budget will be secured.	**Y**
(d)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?	**Regular reporting to the regulatory authorities will be conducted.** ・ The environmental management administrator shall regularly conduct explanation to the local people and regularly report to the State Ecology Committee, JICA and other relevant organizations about the environmental monitoring.	**Y**
Reference to Checklist of Other Sectors		
(a)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).	**New transmission lines for this project will be small in scale but the checklist was checked in Table 12.12.1-2.**	**Y**
(b)Where necessary, pertinent items described in the Ports and Harbors checklist should also be checked (e.g.,	**This project will build no port and harbors.**	**N**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
projects including construction of port and harbor facilities).		
6. Note		
Note on Using Environmental Checklist		
(a)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).	・ Adoption of high-efficiency combined cycle power generation system and maintenance of capacity of the facility. ・ The project mission PEy is 1,919,000 t-CO_2/y, and consequently the reduction of emission is 994,931 t-CO2/y.2 emission concerning this project compared with an average power generation facility in Uzbekistan is 2,913,931 t-CO_2/y.	**N**

(Source: JICA Survey team)

Table 12.12.1-2 Environmental Checklist for Transmission Line and Substation

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
1. Permits and Explanation		
(1) EIA and Environmental Permits		
(a) Have EIA reports been already prepared in official process?	**EIA was prepared and approved in accordance with Uzbekistan legislation.** ・ EIA for the transmission line and substation was prepared separately in accordance with Uzbekistan legislation. ・ EIA for transmission line was approved in 18 July, 2019 and the one for substation was in 23 July, 2019. ・ Conditions for the EIA is following and this will be followed by Transmission Line Company: - Transmission Line Company shall submit State of Environmental Effects (SEE) to Goskomekologiya and receive the approval of SEE prior to the commissioning	**Y**
(b) Have EIA reports been approved by authorities of the host country's government?		**N**
(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?		**N**
(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	**Environmental permits other than EIA have not been obtained yet, and these will be approved by the commencement of operation.** ・ Transmission Line Company is required to obtain approval of Environmental Effects (SEE) prior to the commissioning. In this procedure, all permit will be obtained.	**N**
(2) Explanation to the Stakeholder		
(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is the understanding obtained from the Local stakeholders?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(3) Alternatives		

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(a) Have alternative plans of the project been examined with social and environmental considerations?	**1. Zero option** ・ In a case where transmission line is not constructed, the electricity generated from GTCC3 will not be transmitted. ・ Construction of transmission line will contribute to economic development on Navoi region. **2. Site selection** ・ Two candidate routes of transmission line were considered from various perspectives such as cost, impact on construction GTCC3, social impact, and environmental scale. First plan seems to be superior as aspect of technical in comparing with Second plan of the EIA report. ・ There are two candidate project sites for new substation. The site for both Plan No.1 and No.2 are similar natural condition and no significant difference is observed. Plan No.1 is large enough but Plan No. lacks space .	**N**
2. Mitigation Measures		
(1) Water Quality		
(a) Is there any possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? If the water quality degradation is anticipated, are adequate measures considered?	**Since the transmission line and substation will be built on a flat floor, soil of some embankments and earth cuts may not overflow into the river.**	**N**
3. Natural Environment		
(1) Protected Areas		
(a) 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?	**No protected areas and national parks are within the proposed transmission line route and substation area.**	**N**
(2) Ecosystem and biota		

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	**The project site does not encompass primeval forests, tropical rain forests, ecologically valuable habitats.** ・ Therefore, there are no primeval forests, tropical rain forests, ecologically valuable habitats in the transmission line corridor and the substation area.	**N**
(b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	**The project site does not encompass the protected habitats of endangered species designated by both Uzbekistan laws and IUCN.** ・ No precious species designated by IUCN and by the Uzbekistan Red Data Book are observed in the land around site.	**Y**
(c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem?	**No significant impact including bird strike is anticipated.** ・ There are neither rare species of birds and migratory birds observed around the site and transmission line will be short (3-5km). Therefore, impact of bird strikes will not be serious.	**N**
(d) Are adequate measures taken to prevent disruption of migration routes and habitat fragmentation of wildlife and livestock?	**There are no migratory birds and wildlife and the livestock can cross under the transmission line.** ・ The transmission line will be built along the public road and. Therefore, there are no migratory birds and wildlife. The livestock can cross under the transmission line.	**N/A**
(e) Is there any possibility that the project will cause the negative impacts, such as destruction of forest poaching, desertification, reduction in wetland areas, and disturbance of ecosystem due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered?	**The project will not cause the negative impacts, such as destruction of forest poaching, desertification, reduction in wetland areas, and disturbance of ecosystem due to introduction of exotic species and pests.** ・ The transmission line will be built along the public road. In addition, the transmission line will be very short, 3-5 km. Therefore, construction of transmission line will not case destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystem due to introduction of exotic (non-native invasive) species and pests	**N/A**
(f) In cases where the project site is located in undeveloped areas, is there any possibility that the new development will result in extensive loss of natural environments?	**The project site is located in developed area.** ・ Proposed sites of tower foundation and transmission line route are almost all in the developed land, namely the public road.	**N/A**
(3) Topography		

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(a) Is there any soft ground on the route of power transmission and distribution lines that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed?	・ According to visual observation, soils on the route are mainly sand and loamy sand interbeds, weak-moist, of semi-hard and hard consistency.	**Y**
(b) Is there any possibility that civil works, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides?	**Civil works will not cause slope failures or landslides as the route is in a flat area.** ・ The route is in a flat area. Thus, landslides will not occur.	**N**
(c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	**Soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites as the route is in a flat area.** ・ The route is in a flat area and sediment runoff will not occur.	**N**
4. Social Environment		
(1) Resettlement		
(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**N**
(b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(d) Are the compensations going to be paid prior to the resettlement?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(e) Are the compensation policies prepared in document?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(g) Are agreements with the affected people obtained prior to resettlement?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(i) Are any plans developed to monitor the impacts of resettlement?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(j) Is the grievance redress mechanism established?	・ Same as the checklist for Power Plant (See Table 12.12.1-1)	**Y**
(2) Living and Livelihood		
(a) 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?	**Neither positive nor negative impacts on living conditions of inhabitants are not anticipated because of the transmission line.** ・ The operation will not lead to purchasing material and equipment items in the local area and also not offer employment to local people.	**N**
(b) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary?	**Workers from outside will be limited and, therefore, diseases will not be brought.** ・ Workers from outside will be limited in number and spread of infectious disease will be prevented by regular health checkup and other means.	**N**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(c) Is there any possibility that installation of structures, such as power line towers will cause a radio interference? If any significant radio interference is anticipated, are adequate measures considered?	**The transmission towers will not cause a radio interference because it will no encompass the residential area.** ・ The transmission line route and substation area avoids running through residential areas.	**N**
(d) Are the compensations for transmission wires given in accordance with the domestic law?	**Yes.** ・ Compensation for RoW (25m each) of transmission line will be given in accordance with the domestic law.	**N**
(3) Heritage		
(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	**There are no historical, cultural and archaeological property and heritage.** ・ Historical, cultural and archaeological property and heritage does not exist around the proposed transmission line route and substation area.	**N/A**
(4) Landscape		
(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	**There is no scenic area around the proposed transmission line route and substation area.**	**N/A**
(5) Ethnic Minorities and Indigenous Peoples		
(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?	**There is no minority group living around transmission line route and substation area.**	**N/A**
(b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?		**N/A**
(6) Working conditions		

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?	**Transmission Line Company will comply and will oblige the EPC contractor to comply the national laws and ordinances associated with working conditions.**	**Y**
(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?	**Measures to individuals involved in the project on tangible safety considerations will be developed and conducted.** ・ The following prevention and mitigation measures will be taken: - Provide workers with appropriate protective equipment such as a helmet, safety boots, safety belt, mask, electric shock prevention equipment, earplugs, etc. - Establish clear signs to identify the location of hazardous or toxic material	**Y**
(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?	**Measures to individuals involved in the project on intangible safety considerations will be planned and conducted.** ・ The following prevention and mitigation measures will be taken: - Prepare a manual for labor accident prevention including safety education and training - Create a “User Manual” for equipment such as cranes	**Y**
(d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	**Security guards will not be deployed for the transmission line.**	**Y**
5. Others		
(1) Impacts during Construction		
(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?	**Significant impacts related to noise, vibrations, turbid water, dust, exhaust gases and wastes are not expected.**	**N/A**
(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce the impacts?	**Construction of transmission line will not affect the natural environment.** ・ The transmission line will be constructed in the public road and will not affect natural environment during construction.	**N/A**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts?	**Adequate measures are considered for accident prevention.** ・ The following measures related to accidents will be taken by JSC "National Electric Networks of Uzbekistan" and EPC Contractor. - Consider adequate traffic rules and timing - Compliance with local traffic rules and safe driving training	**Y**
(2) Monitoring		
(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?	**Monitoring during construction and operation phase will be conducted in order to assure the environmental impacts caused by the project.** ・ Monitoring plan about potential impacts during construction and operation phase was prepared.	**Y**
(b) What are the items, methods and frequencies of the monitoring program?	**Environmental monitoring is appropriately planned.** ・ Environmental monitoring is appropriately planned as described in Chapter 12.8.1.	**Y**
(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?	**Monitoring framework including organization and equipment will be established, and adequate budget will be secured.** ・ Organization structure for environmental monitoring implementation during construction and operation phase is described in Chapter 12.8.1. ・ Same as the existing power plant, monitoring framework including equipment will be established, and adequate budget will be secured.	**Y**
(d) 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?	**Regular reporting to the regulatory authorities will be conducted.** ・ There are no regulatory requirement regarding monitoring reports but JSC "National Electric Networks of Uzbekistan" will regularly report to JICA and other relevant organizations about the environmental monitoring.	**N**
Reference to Checklist of Other Sectors		
(a) Where necessary, pertinent items described in the Road checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	**This project will use the existing roads.**	**N**

Main Check Items	Confirmation of Environmental Considerations (Reason, Justify, Counter Measures, etc.)	Yes: Y No: N
6. Note		
Note on Using Environmental Checklist		
(a) If necessary, the impacts to trans boundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as trans boundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	・ CO_2 will be generated during the construction, but the impact is limited to a temporal period. Periodic checkup and maintenance of heavy machine and vehicles will be conducted.	**N**

(Source: JICA Survey team)

12.12.2 Associated Projects

The environmental and social consideration for transmission line and Substation which are to be financed by JICA was examined above. There are no other associated facilities which are to be financed by JICA and need to be examined.

12.12.3 Monitoring Form

Items that require monitoring shall be decided on according to the sector and nature of the project, with reference to the following list of items.

(1) Construction Phase for Power Plant

1) Air Pollution

(a) Ambient Air quality

Location: 2points (north-west and west of the site)

Regulation: Sanitary norms, rules and hygiene normative documents of the Republic of Uzbekistan. San Pin No.0015-94

Monitoring Form:

Location: _____

Parameter: NO_2 ($\mu g/m^3$)

Date	Measured Value		Uzbkistan maximum permissible concentration (MAC)		IFC/ EHC Guidelines (General;2007)
	30min Min－Max	24hr Average Min－Max	30min	24hr	1hr
			85	60	200

(Source: JICA Survey team)

Location: _____

Parameter: PM_{10} ($\mu g/m^3$)

Date	Measured Value		Uzbkistan maximum permissible concentration (MAC)		IFC/ EHC Guidelines (General; 2007)
	30min Min－Max	24hr Average Min－Max	30min	24hr	24hr
			150	100	150

(Source: JICA Survey team)

2) Water Pollution

(a) Wastewater

Location: Discharged point

Regulation: No regulation of waste water for construction.

Monitoring Form:

Date	Item	Unit	concentration	IFC/WB EHS guidelines (general)
	pH	－		6－9
	SS	mg/L		50
	COD	mg/L		125
	Oil & Grease	mg/L		10
	Total nitrogen	mg/L		10
	Total phosphorus	mg/L		2
	Total coliform bacteria	MPN/100ml		400

(Source: JICA Survey team)

(b) Ambient Water Quality

Location: 2 points (100m upstream and 100m downstream of the outlet of waste water from temporary sedimentation pond in Zeravshan River)

Regulation: Rules for protection of surface water from contamination by discharge water. (San Pin No.0056-98)

Monitoring Form:

Location: _____

Sampling Date: _____

Item	Unit	Min－Max	Environmental standard in Uzbekistan	Remarks
pH	－		6.5- 8.5	
DO	mg/ℓ		Summer: 4.0 or higher Winter: 6.0 or higher	
BOD	mgO2/ℓ		3.0	
SS	mg/ℓ		30	
Oil	mg/ℓ		0.05	
Ammonia	mg/ℓ		0.08	
Nitrite	mg/ℓ		0.08	
Nitrate	mg/ℓ		40	
Sulfate	mg/ℓ		100	
Phenol	mg/ℓ		0.001	
Chloride	mg/ℓ		300	
Calcium	mg/ℓ		180	
Potassium	mg/ℓ		50	
Fe	mg/ℓ		0.5	
Cu	mg/ℓ		0.001	
Zn	mg/ℓ		0.01	
Cr	mg/ℓ		0.5	
Pb	mg/ℓ		0.03	

(Source: JICA Survey team)

3) Waste

Location: Contractor's office

Regulation: RD 118,0027714.60-97 Nature protection. Treatment of waste from production and consumption. Terms and definitions. Goskomekologiya of Uzbekistan. Tashkent. 1997.

Monitoring Form:

Date; _____

Unit: t or kg

Item	Hazardous Class	Place of generated waste	Storage amount	Disposal amount	Disposal method and place

(Source: JICA Survey team)

4) Noise

Location: 4 points (2 points: project site north and south boundary, 2 points north: and south residential area in the vicinity)

Regulation: Protection from noise (State committee of Uzbekistan for architecture and construction. Tashkent. 1996) (Norms for household construction)（KMK 2001.08-96）

Monitoring Form:

Date: _____

Unit: dBA

Location	Min－Max	Uzbekistan Noise standards	IFC/EHC Guidelines (General; 2007)	Remarks
Site north boundary		Residential area day: 55 night: 45	Residential area day: 55 night: 45	
Site south boundary				
Site north residential area				
Site south residential area				

(Source: JICA Survey team)

5) Employment

Location: Contractor's office

Monitoring Form:

Date; _____

Unit: person

Item	Sex	Locals	From Uzbekistan	From other countries	Remarks
Number of employees	Male				Continuously
	Female				
	under 15year				

(Source: JICA Survey team)

6) HIV/AIDS and Other Infectious Diseases

Location: Contractor's office

Monitoring Form:

Date; _____
Unit: person

Item	Total number of diseases	Total number of infectious diseases	Provision	Remark
Health check				Continuously

(Source: JICA Survey team)

7) Work Environment and Accidents

Location: Contractor's office

Monitoring Form:

Date; _____
Unit: person

Construction Contents	Inspection Item	Contents	Status	Provision	Remarks
					Continuously

(Source: JICA Survey team)

8) Grievance

Location: Contractor's office

Date	Name	Contents	Status	Results	Remarks

(Source: JICA Survey team)

(2) Construction Phase for Transmission Line and Substation

1) Air Pollution

(a) Ambient Air Quality

Location: nearest residential at 10 tower section of construction

Regulation: Sanitary norms, rules and hygiene normative documents of the Republic of Uzbekistan. San Pin No.0015-94

Monitoring Form:

Location: _____
Parameter: NO_2 ($\mu g/m^3$)

Date	Measured Value		Uzbkistan maximum permissible concentration (MAC)		IFC/ EHC Guidelines (General;2007)
	30min Min－Max	24hr Average Min－Max	30min	24hr	1hr
			85	60	200

(Source: JICA Survey team)

Location: _____
Parameter: PM_{10} ($\mu g/m^3$)

Date	Measured Value		Uzbkistan maximum permissible concentration (MAC)		IFC/ EHC Guidelines (General; 2007)
	30min Min－Max	24hr Average Min－Max	30min	24hr	24hr
			150	100	150

(Source: JICA Survey team)

2) Water Pollution

(a) Ambient Water Quality

Location: nearest river at 10 tower section of construction

Regulation: Rules for protection of surface water from contamination by discharge water. (San Pin No.0056-98)

Monitoring Form:

Location: _____

Sampling Date: _____

Item	Unit	Min－Max	Environmental standard in Uzbekistan	Remarks
pH	－		6.5- 8.5	
DO	mg/ℓ		Summer: 4.0 or higher Winter: 6.0 or higher	
BOD	mgO2/ℓ		3.0	
SS	mg/ℓ		30	
Oil	mg/ℓ		0.05	
Ammonia	mg/ℓ		0.08	
Nitrite	mg/ℓ		0.08	
Nitrate	mg/ℓ		40	
Sulfate	mg/ℓ		100	
Phenol	mg/ℓ		0.001	
Chloride	mg/ℓ		300	
Calcium	mg/ℓ		180	
Potassium	mg/ℓ		50	
Fe	mg/ℓ		0.5	
Cu	mg/ℓ		0.001	
Zn	mg/ℓ		0.01	
Cr	mg/ℓ		0.5	
Pb	mg/ℓ		0.03	

(Source: JICA Survey team)

3) Waste

Location: Contractor's office

Regulation: RD 118,0027714.60-97 Nature protection. Treatment of waste from production and consumption. Terms and definitions. Goskomekologiya of Uzbekistan. Tashkent. 1997.

Monitoring Form:

Date; _____

Unit: t or kg

Item	Hazardous Class	Place of generated waste	Storage amount	Disposal amount	Disposal method and place

(Source: JICA Survey team)

4) Noise

Location: nearest resident at 10 tower section of construction, - 1 sample in 1 section

Regulation: Protection from noise (State committee of Uzbekistan for architecture and construction. Tashkent. 1996) (Norms for household construction)（KMK 2001.08-96）

Monitoring Form:

Date: _____

Unit: dBA

Location	Min－Max	Uzbekistan Noise standards	IFC/EHC Guidelines (General; 2007)	Remarks
		Residential area day: 55 night: 45	Residential area day: 55 night: 45	

(Source: JICA Survey team)

5) Employment

Location: Contractor's office

Monitoring Form:

Date; _____

Unit: person

Item	Sex	Locals	From Uzbekistan	From other countries	Remarks
Number of employees	Male				Continuously
	Female				
	under 15year				

(Source: JICA Survey team)

6) HIV/AIDS and Other Infectious Diseases

Location: Contractor's office

Monitoring Form:

Date; _____

Unit: person

Item	Total number of diseases	Total number of infectious diseases	Provision	Remark
Health check				Continuously

(Source: JICA Survey team)

7) Work Environment and Accidents

Location: Contractor's office

Monitoring Form:

Date; _____

Unit: person

Construction Contents	Inspection Item	Contents	Status	Provision	Remarks
					Continuously

(Source: JICA Survey team)

8) Grievance

Location: Contractor's office

Date	Name	Contents	Status	Results	Remarks

(Source: JICA Survey team)

(3) Operation Phase for Power Plant

1) Air Pollution

(a) Exhaust Gas

Location: Gas duct

Regulation: GOST 29328-92

Monitoring Form:

Parameter: NOx (mg/Nm^3)

Date	Min –Max	Excess period of the standard	GOST 29328-92	IFC/ WBEHC Guidelines (Thermal Power Plant; 2008) <Gas fuel>
			51	51

Note dry gas base,O_2=15%

(b) Ambient Air Quality

Location: 3point (north-west, west and south of the site)

Regulation: Sanitary norms, rules and hygiene normative documents of the Republic of Uzbekistan. San Pin No. 0015-94

Monitoring Form:

Parameter: NO_2 (μg/m^3)

Date	Measured Value			Uzbkistan maximum permissible concentration (MAC)		IFC/WB EHC Guidelines (General;2007)	
	30min Min－Max	24hr Average Min－Max	All Average	30min	24hr	1hr	1year
				85	60	200	40

(Source: JICA Survey team)

2) Water Pollution

(a) Wastewater

Location: Outlet of waste treatment facility

Regulation: Rules for protection of surface water from contamination by discharge water. (San Pin No.0056-98)

Monitoring Form:

Sampling Date: _____

Parameter	Unit	Min－Max	Uzbekistan Standard for Navoi Power plant *(To be confirmed before operation)*	IFC/WB EHC Guidelines (Thermal Power Plant; 2008)	Remarks
pH	—			6.5－9.0	
SS	mg/ℓ			50	
Oil	mg/ℓ			10	
Dissolved inorganics	mg/ℓ			—	
Nitrite	mg/ℓ			—	
Nitrate	mg/ℓ			—	
Sulfate	mg/ℓ			—	
Chloride	mg/ℓ			—	
Calcium	mg/ℓ			—	
Magnesium	mg/ℓ			—	
Residual chlorine	mg/ℓ			0.2	
Total chromium	mg/ℓ			0.5	
Copper	mg/ℓ			0.5	
Iron	mg/ℓ			1.0	
Zinc	mg/ℓ			1.0	
Lead	mg/ℓ			0.5	
Cadmium	mg/ℓ			0.1	
Mercury	mg/ℓ			0.005	
Arsenic	mg/ℓ			0.5	

(Source: JICA Survey team)

(b) Ambient Water Quality

Location: 2 points (100m upstream and 100m downstream of the existing outlet of wastewater in Zeravshan River)

Regulation: Rules for protection of surface water from contamination by discharge water. (San Pin No.0056-98)

Monitoring Form:

Location: _____

Sampling Date: _____

Item	Unit	Min－Max	Environmental standard in Uzbekistan	Remarks
pH	—		6.5- 8.5	
DO	mg/ℓ		Summer: 4.0 or higher	

Item	Unit	Min－Max	Environmental standard in Uzbekistan	Remarks
			Winter: 6.0 or higher	
BOD	mgO2/ℓ		3.0	
SS	mg/ℓ		30	
Oil	mg/ℓ		0.05	
Ammonia	mg/ℓ		0.08	
Nitrite	mg/ℓ		0.08	
Nitrate	mg/ℓ		40	
Sulfate	mg/ℓ		100	
Phenol	mg/ℓ		0.001	
Chloride	mg/ℓ		300	
Calcium	mg/ℓ		180	
Sodium	mg/ℓ		120	
Potassium	mg/ℓ		50	
Phosphate	mg/ℓ		0.01	
Fe	mg/ℓ		0.5	
Cu	mg/ℓ		0.001	
Zn	mg/ℓ		0.01	
Cr	mg/ℓ		0.5	
Pb	mg/ℓ		0.03	

(Source: JICA Survey team)

3) Waste

Location: Power plant office

Regulation: RD 118,0027714.60-97 Nature protection. Treatment of waste from production and consumption. Terms and definitions. Goskomekologiya of Uzbekistan. Tashkent. 1997.

Monitoring Form:

Date; _____

Unit: t or kg

Item	Hazardous Class	Place of generated waste	Storage amount	Disposal amount	Disposal method and place

(Source: JICA Survey team)

4) Noise

Location: 4 points: On the border of the site (2 points), the residential area near the site (2 point)

Regulation: Protection from noise (State committee of Uzbekistan for architecture and construction. Tashkent. 1996) (Norms for household construction)（KMK 2001.08-96）

Monitoring Form:

Date: _____

Unit: dBA

Location	Min－Max	Uzbekistan Noise standards	IFC/ EHC Guideline (General; 2007)	Remarks
Site north boundary		Residential area	Residential area	

Site south boundary		day: 55 night: 45	day: 55 night: 45	
Site north residential area				
Site south residential area				

(Source: JICA Survey team)

5) Employment

Location: Power plant office

Monitoring Form:

Date; _____

Unit: person

Item	Sex	Locals	From Uzbekistan	From other countries	Remarks
Number of employees	Male				Continuously
	Female				

(Source: JICA Survey team)

6) Work Environment and Accidents

Location: Power plant office

Monitoring Form:

Date; _____

Unit: person

Construction Contents	Inspection Item	Contents	Status	Provision	Remarks
					Continuously

(Source: JICA Survey team)

7) Grievance

Monitoring Form:

Date	Name	Contents	Status	Results	Remarks

(Source: JICA Survey team)

(4) Operation Phase for Transmission Line and Substation

1) Noise

Location: 4 points: On the border of the site (2 points), the residential area near the site (1 point)

Regulation: Protection from noise (State committee of Uzbekistan for architecture and construction. Tashkent. 1996) (Norms for household construction)（KMK 2001.08-96）

Monitoring Form:

Date: _____

Unit: dBA

Location	Min－Max	Uzbekistan Noise standards	IFC/ EHC Guideline (General; 2007)	Remarks
Site north boundary		Residential area day: 55 night: 45	Residential area day: 55 night: 45	
Site south boundary				
Site north residential area				
Site south residential area				

(Source: JICA Survey team)

2) Terrestrial Ecosystem and Valuable Species (Bird Strike)

Location Substation office

Monitoring Form:

Date	species	death	trouble	Remarks

3) Work Environment and Accidents

Location: Substation office

Monitoring Form:

Reporting Date; _____

Inspection Item	Contents	Status	Provision	Remarks

(Source: JICA Survey team)

4) Grievance

Location: Substation office

Monitoring Form:

Date	Name	Contents	Status	Results	Remarks

(Source: JICA Survey team)