Uzbekenergo Joint-stock Company
The Republic of Uzbekistan

PREPARATORY SURVEY (F/S)
FOR
TASHKENT THERMAL POWER COGENERATION PLANT CONSTRUCTION PROJECT
AND
MASTER PLAN STUDY
IN
THE REPUBLIC OF UZBEKISTAN

Vol.2

MASTER PLAN STUDY

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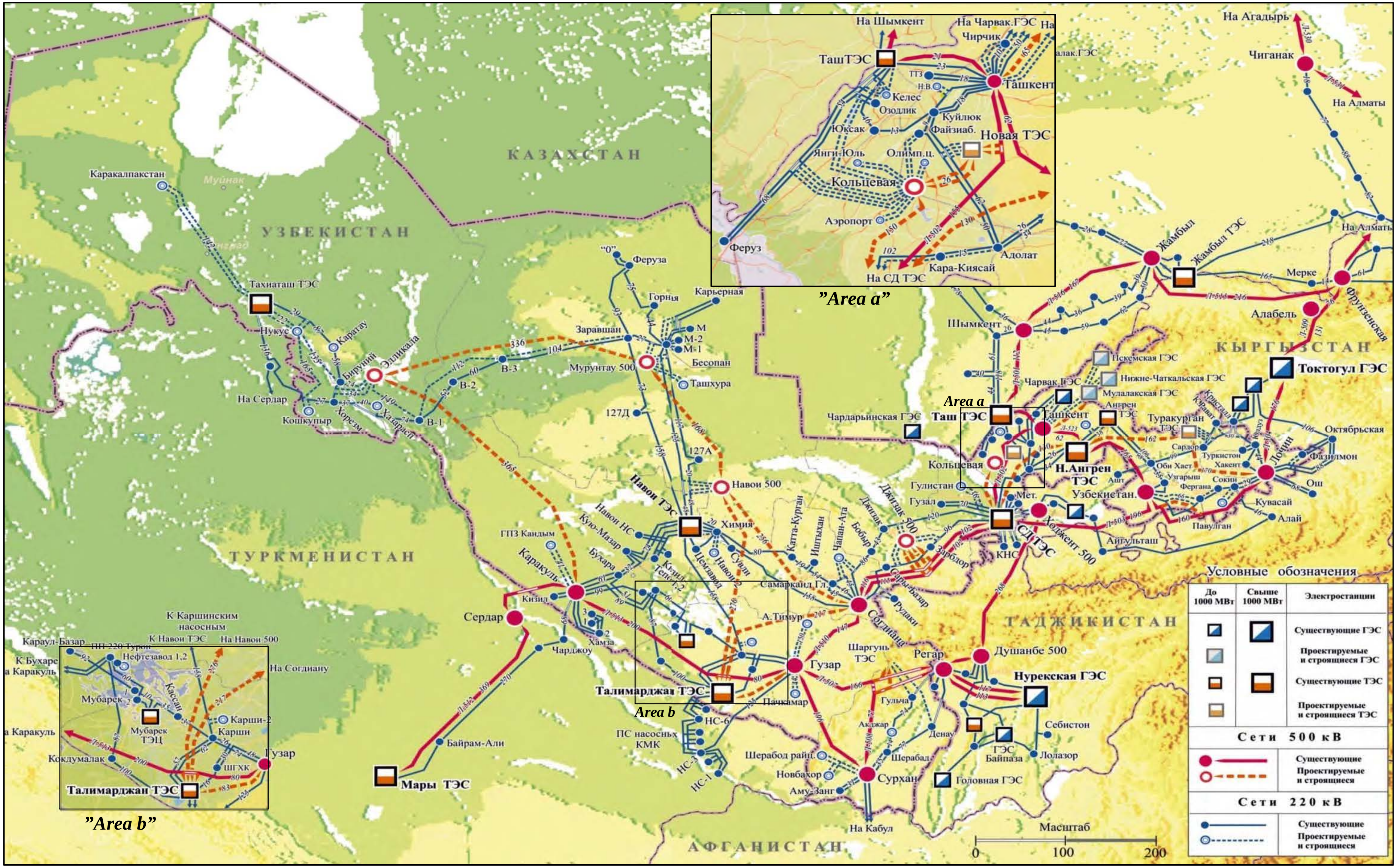

Source: Prepared by JICA Study Team on the basis of materials provided by Uzbekenergo JSC

Power network map of the Republic of Uzbekistan

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ABBREVIATIONS

ADB	Asian Development Bank
AS	Steel-Aluminum
ASO	Steel-Aluminum Lightweight structure
ASTM	American Society for Testing and Materials
BAU	Business As Usual
BP	British Petroleum
CEB	Ceylon Electricity Board
CHP	Combined Heat and Power Plants
DSS	Daily Start and Stop
EIA	U. S. Energy Information Administration
EIA	Environmental Impact Assessment
F/S	Feasibility Study
FAO	Food and Agriculture Organization
GDE	Gross Domestic Expenditure
GDP	Gross Domestic Product
GTCC	Gas Turbine Combined Cycle
GTCS	Gas Turbine Cogeneration System
GTG	Gas Turbine Generator
HPP	Hydro Power Plant
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IFMR	Institute of Forecasting and Macroeconomic Research
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
JSC	Joint-Stock Company
L/A	Loan Agreement
LFC	Load Frequency Control
LOLP	Loss Of Load Probability
NDC	National Dispatch Center
NEDO	New Energy and Industrial Technology Development Organization
NERC	North American Electric Reliability Corporation
NPV	Net Present Value
PLN	Perusahaan Listrik Negara
PTE	*Pravila Tekhnicheskoy Ekspluatatsii Elektricheskikh Stantsiy i Setey* [Rules of technical operation of power plants and grids]
PUE	*Pravila Ustroystva Elektroustanovok* [Rules for electric installations]
R/P ratio	Reserves to Production Ratio

SPES	*Spravochnik po Proyektirovaniyu Elektricheskikh Setey* [Handbook for designing of electrical grids]
UFRD	Uzbekistan Fund for Reconstruction and Development
UNSTAT	United Nations Statistics Division
WASP	Wien Automatic System Planning package, version-IV
WSS	Weekly Start and Stop

Chapter 1 Review of the Power Development Concept

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1.1 The content of the power development concept

The power development concept for the next 16 years, from 2015 to 2030, proposes a power development model that meets the energy demand and requirements for power supply reliability and which is based on minimum cost requirements. This model comprises development projects based on the scope of works and generation capacities for each year.

Unlike the common Master Plan for power development, the power development concept used within the framework of this Study does not provide for simultaneous implementation of the power development plan. Therefore, in the absence of system restrictions, the plan will be prepared based on minimum cost requirements. Accordingly, prior to implementing the proposed power development concept, it is recommended to perform power system analysis and ensure that no problems in the system will be used. In case any problems occur, it is advisable to take the necessary measures to expand the system.

1.2 Flow of the power development concept planning.

The flow of the power development concept planning is shown in Figure 1.2-1.

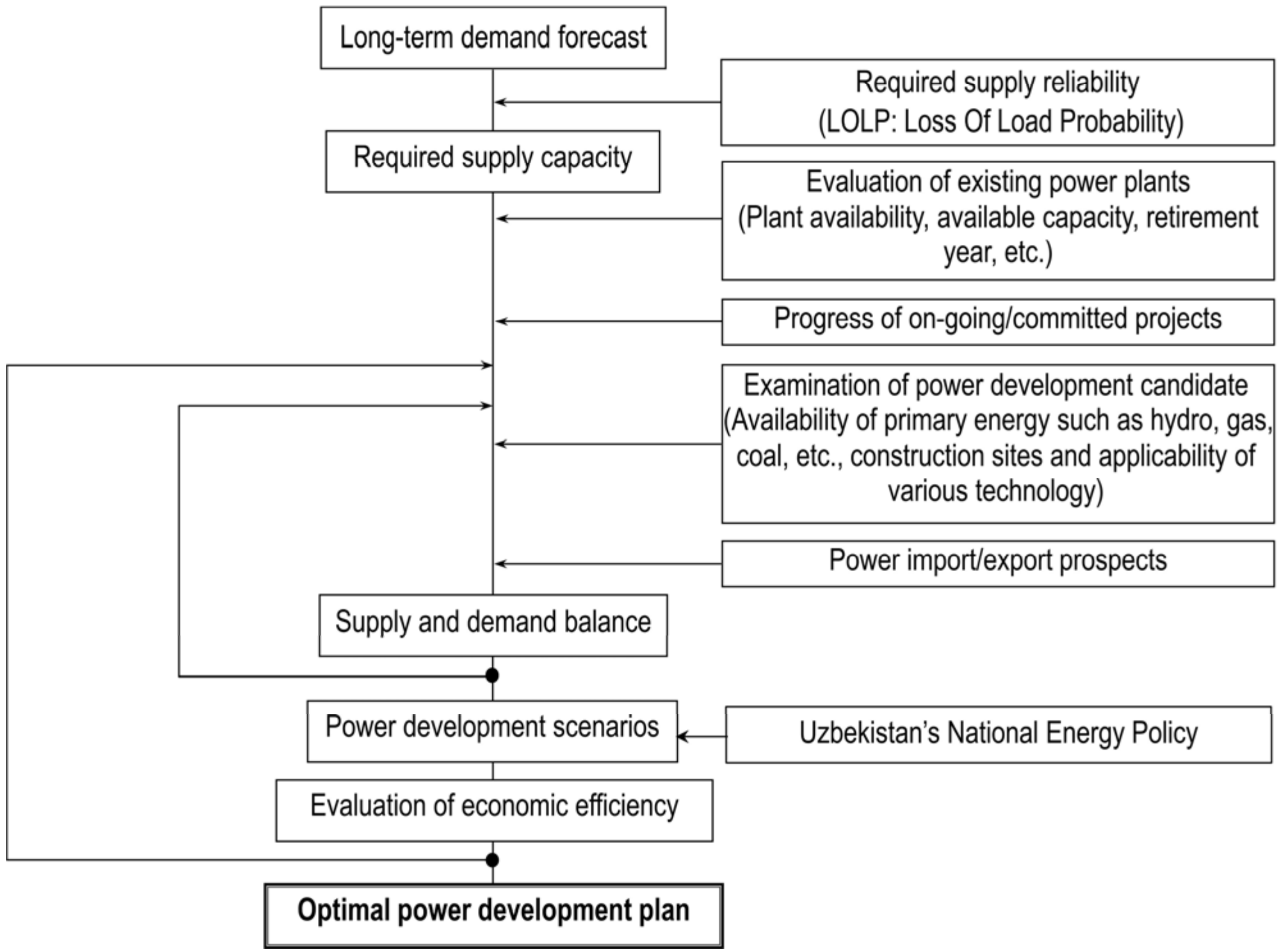


Figure 1.2-1 Flow of power development concept planning

<Step 1> Create a future provisional system configuration and project flow

Create a system configuration for each year to be investigated based on the results of power demand projections, power source development plans and proposed system plans shown in existing plans; acquire flow projections; review the need to strengthen transmission facilities over the medium- and long-term, and envision multiple alternative scenarios.

<Step 2> Evaluate the system configuration, flow, etc. in terms of system analysis for each year to be investigated

Evaluate system structure for each year to be investigated in terms of power quality, overload situations and short-circuit capacity in normal circumstances and in N–1 situations.

<Step 3> Identify places to strengthen system configuration for each year to be investigated based on the system analysis evaluation

Use the results from Step 2 to examine and identify places to strengthen system configuration for each year to be investigated.

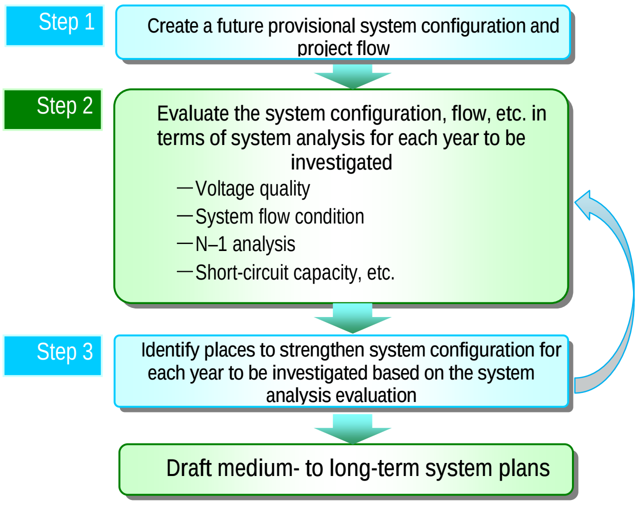


Figure 1.2-2 Flow of network development planning

Chapter 2 Fuel Supply Plan

Chapter 2 Fuel Supply Plan

2.1 Overview of primary energy

This Chapter looks at whether natural gas and coal can be supplied stably as fuels required to meet the power source development plan up to 2030, as prepared by Uzbekenergo JSC. First, the supply and demand situation on primary energy and reserves are reviewed, whereupon the status of natural gas and coal in primary energy are investigated to confirm the supply potential of natural gas and coal used to generate power.

(1) Supply and demand situations on primary energy

The supply and demand situations, etc. of all primary energy sources, including oil, coal as well as natural gas, are to be reviewed using mainly IEA and BP data sources in which relatively substantial data are available. This is because it was impossible to obtain information and data on natural gas and oil from Uzbekistan directly. The reliability and accuracy of the data was inspected as follows:

Firstly natural gas - IEA's data on fuel consumption to generate power and those on fuel purchase obtained from Uzbekenergo JSC were compared. The average deviation was as low as 1.6% for the 9 years from 2004 to 2012 between both data for natural gas, meaning there is no problem to utilize IEA's data. Though the data of BP and EIA differed slightly from those of the IEA, the average deviation between the data of IEA and BP was 8.6 % and that between the data of IEA and EIA was 0.6 %[1], when data for 13 years from 2000 to 2012 were compared.

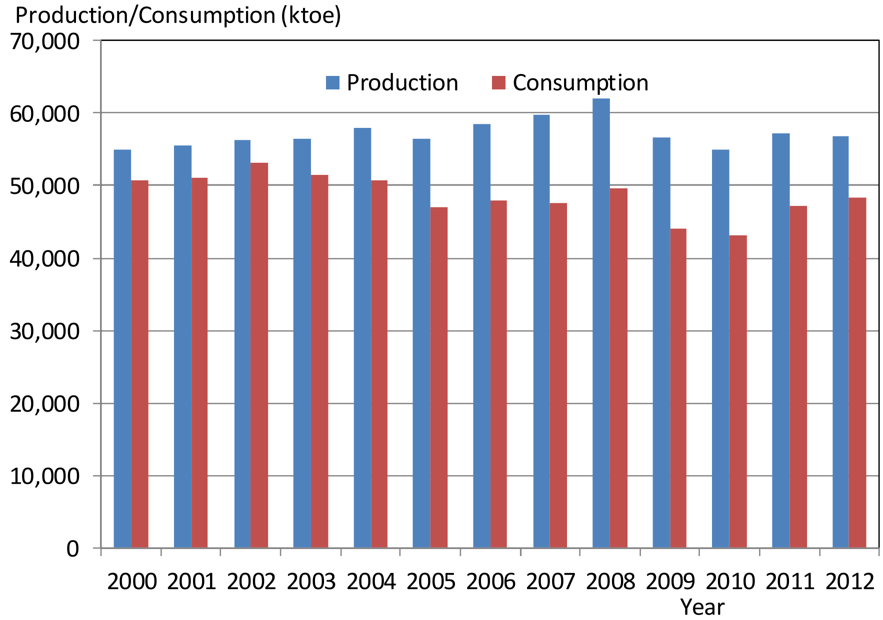
Data for Uzbekenergo JSC and the IEA were also compared for oil and coal as well as natural gas and it emerged that the average deviation over 9 years was 25.9 % for oil and 3.3 % for coal. According to Uzbekenergo JSC data, however, the average proportional purchase volume of oil and coal against natural gas was as small as 3.7 and 8.3 % respectively in terms of calorific value. Accordingly, even in the event of a significant deviation[2] for oil and coal (data on coal matches considerably well between IEA and Uzbekenergo JSC), the impacts in terms of a deviation of total energy are relatively smaller than the impact of natural gas.

Figure 2.1-1 represents the primary energy production and consumption in Uzbekistan (the latter of which is equal to primary energy supply.) According to Figure 2.1-1, production exceeds consumption, which means that Uzbekistan has export potential as far as primary energy is concerned. Though primary energy production increased slightly up to 2008, it decreased to level in 2004 to 2006 after that year. Primary energy consumption also showed slight growth from 2000 to 2002, but decreased continuously until 2010, before growing again, although fluctuating slightly since 2002. Figure 2.1-2 represents the production and consumption of natural gas that comprises the largest share of primary energy. Natural gas is also a self-sufficient and exportable resource.

[1] EIA data are basically quoted from IEA data.

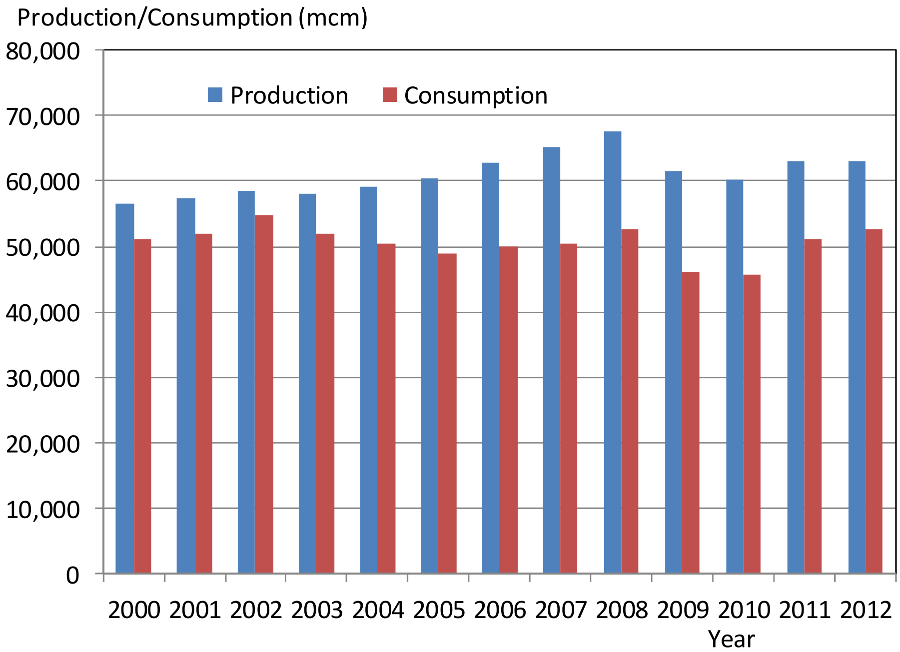
[2] Since oil consumption is as small as 3.7 % compared with natural gas consumption (in terms of calorific value), the deviation would increase when estimated with accuracy equivalent to that of natural gas consumption.

However, both primary energy and natural gas are on a downward trend in terms of export potential, since production growth is small compared to consumption. When Figures 2.1-1 and 2.1-2 are compared, conversely, it emerges that both trends almost coincide, clearly showing that natural gas supply and demand trends dominate those of primary energy.



Source: IEA

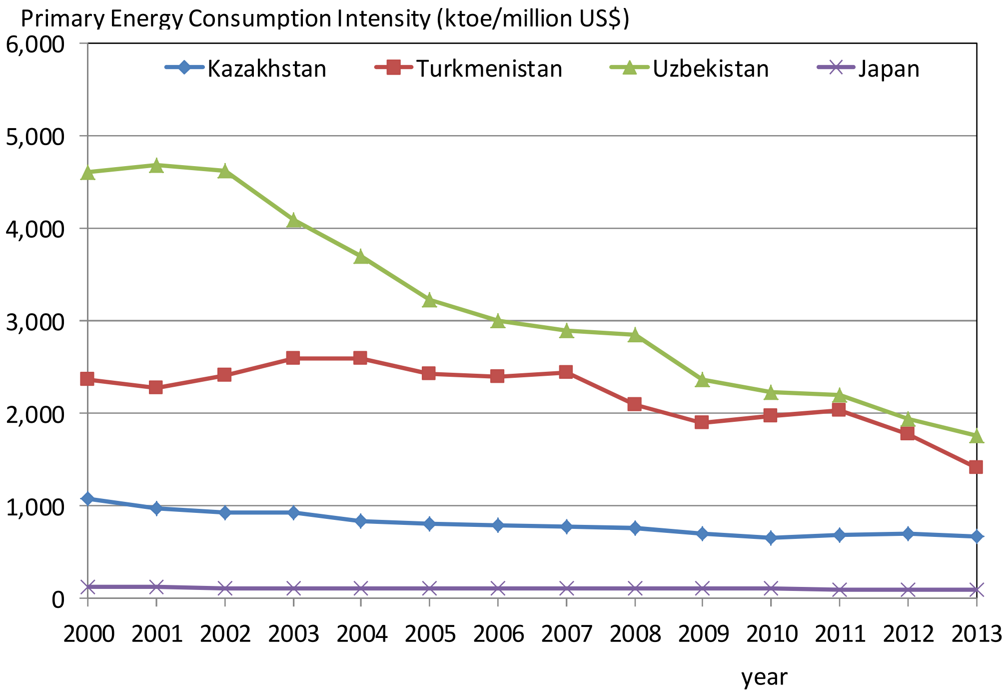
Figure 2.1-1 Primary energy production and consumption



Source: IEA

Figure 2.1-2 Natural gas production and consumption

Figure 2.1-3 represents primary energy consumption intensity in terms of GDP (primary energy consumption divided by GDP[3]) to determine the economic efficiency of primary energy consumption compared to neighboring countries, including Japan. Although the previous energy consumption intensity in Uzbekistan was extremely high compared to neighboring countries, it has declined significantly since 2000. It is considered that such decline was attributable to a history in which the share of primary industry represented by cotton growing with low added value, left over from the planned economy during the USSR period, remained high in the early 2000s, whereupon the shares of secondary and tertiary industries with relatively high added value have increased.

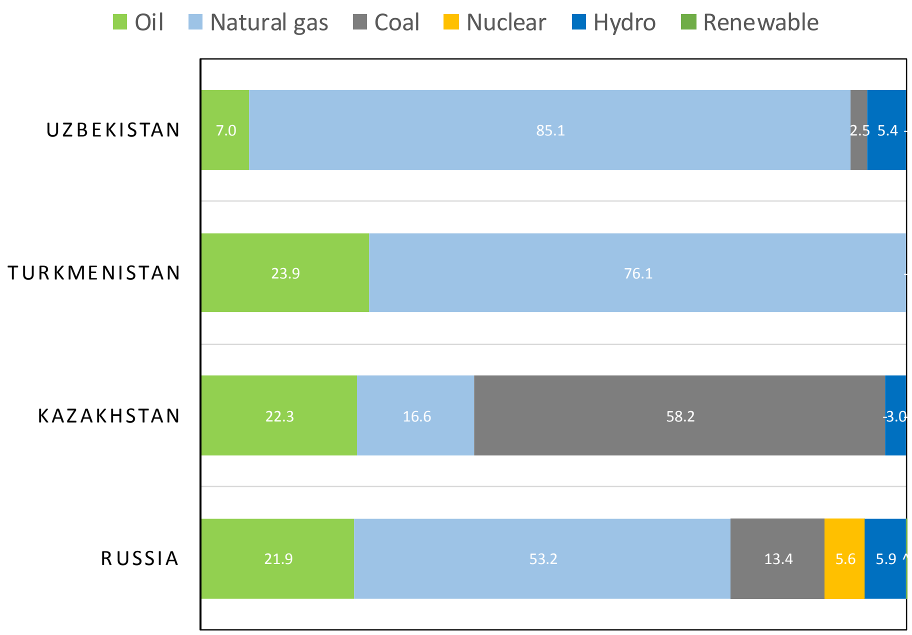


Source: JICA study team based on data from BP and the World Bank

Figure 2.1-3 Primary energy consumption intensity in terms of GDP

Figure 2.1-4 represents primary energy consumption structure by fuel type compared to that among neighboring countries. It is clear that Uzbekistan is significantly dependent on natural gas compared to neighboring countries.

[3] Real GDP in year 2005 US dollars



Source: BP

Figure 2.1-4 Primary energy consumption structure of neighboring countries by fuel type (%, as of 2013)

(2) Energy reserves situation

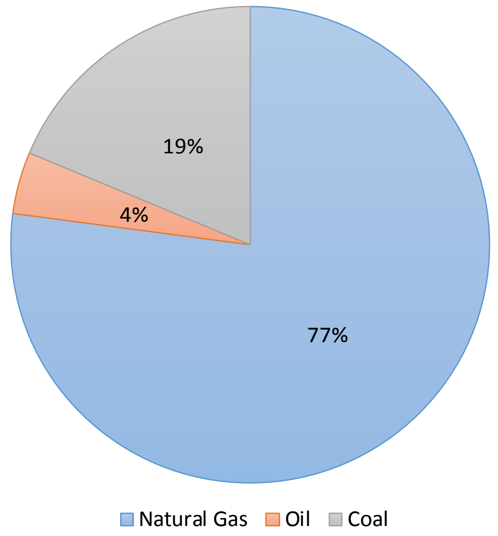
Table 2.1-1 represents the oil, natural gas and coal reserves in Uzbekistan. According to this table, data of the World Bank and BP coincide for oil and coal but data of BP show a far lower figure compared to the World Bank data for natural gas. As the data of the World Bank coincide with that of the IEA as widely quoted by international energy research organizations, etc., the data of the World Bank will be utilized hereinafter for natural gas reserves.

Table 2.1-1 Fossil fuel reserves

Organization	Year	Fuel type	Unit	Proven reserves	Estimated undiscovered reserves
World Bank	2012	Oil	million bbl	594	5,700
		Natural gas	billion cm	1,841	4,000
		Coal	million ton	1,900	4,700
BP	2014	Oil	million bbl	594	-
		Natural gas	billion cm	1,086	-
		Coal	million ton	1,900	-

Source: World Bank and BP

Figure 2.1-5 represents the structure of these reserves in terms of calorific value. According to 2.1-5, although the share of natural gas is as much as 77 %, it should be noted that the share of coal reaches 19 %[4] and that of oil is as small as 4 %.



Source: Prepared by the JICA study team based on World Bank data

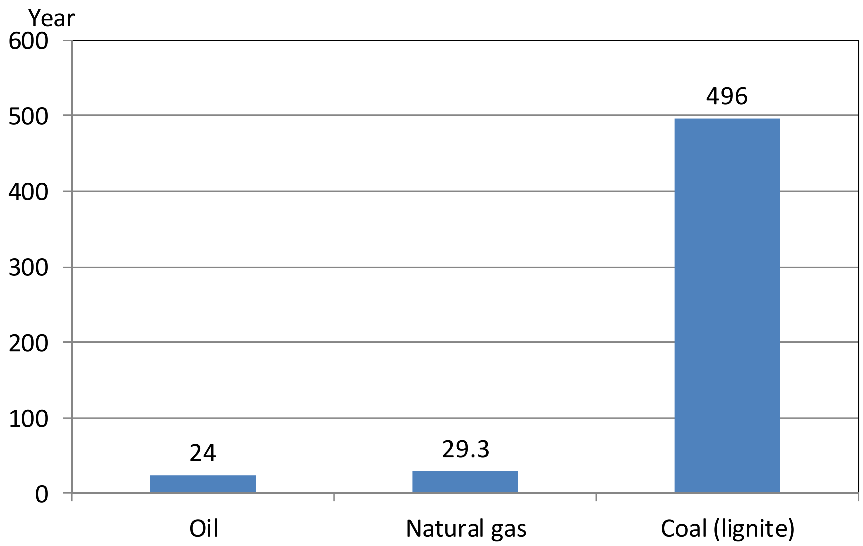
Figure 2.1-5 Fossil fuel reserves structure

(3) Supply potential of primary energy

Next, it is investigated whether or not natural gas, oil and coal have supply potential as fuels to generate power. Figure 2.1-6 represents the recoverable years of oil, natural gas and coal as of 2012. Recoverable yeas (R/P ratio) refer to the figure obtained by dividing reserves by production in a certain year and is the figure dictating the number of years for which production will be able to continue as of that time.

As reserves increase when new oil, gas and coal fields are developed or technology progresses, the years shown in Figure 2.1-6 do not necessarily indicate the actual number of years within which resources will be exhausted but are guideline figures. Accordingly, it is clear that lignite has sufficient potential in terms of a resource as far as recoverable years are concerned.

[4] According to BP, the breakdown of proven reserves for coal of 1,900 million tons comprises 47 million tons of anthracite and bituminous coal and 1,853 million tons of sub-bituminous and lignite coal. As only the latter is used to generate power, the latter will be treated as proven reserves of coal to generate power.



Source: Prepared by the JICA study team based on data from the World Bank, IEA and Uzbekgol

Figure 2.1-6 Recoverable period of fossil fuel (as of 2012)

2.2 Supply potential of natural gas to generate power

(1) Investigation of the supply potential of natural gas to generate power and its evaluation method

In this section, the following procedures are to be applied to investigate and evaluate the supply potential of the fuel to generate power (natural gas in this section) in future:

i. Natural gas demand in the transformation sector except power generation (including heat and power generation) and final energy consumption sector is to be predicted.
ii. Demand except power generation and export and possible production are to be compared, whereupon the possible supply volume of natural gas allocable to generate power is to be investigated and evaluated.
iii. Assuming that the natural gas production applied to item ii above is to be determined based on the protection facility capacity rather than demand, information required to predict production is sought, whereupon investigation and evaluation will be conducted by analyzing said information.
iv. Whether or not natural gas resources that guarantee future production exist as proven reserves will be investigated and evaluated, when natural gas production is made by the volume investigated and predicted on item iii above.

However as the information and data on natural gas are classified as confidential and unavailable, the following investigation and evaluation are approximated.

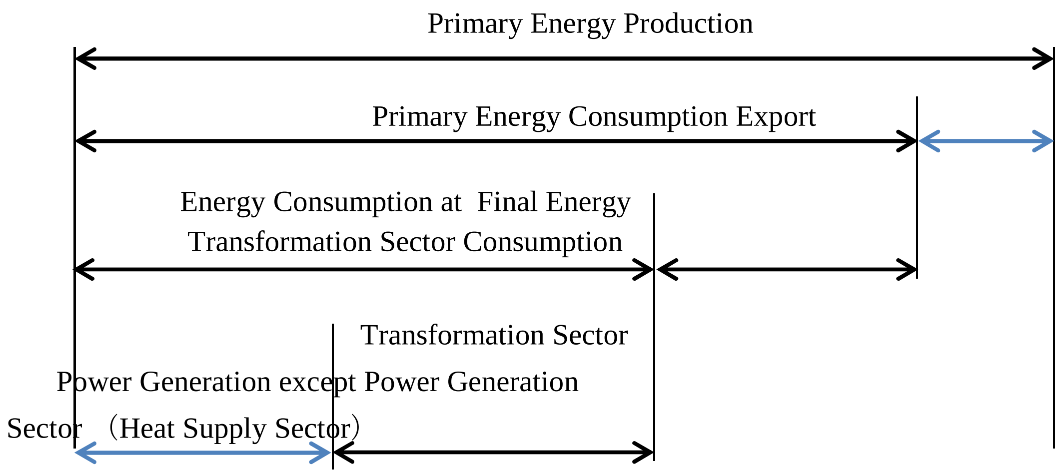
(2) Natural gas demand forecast

Natural gas demand forecast is to be undertaken by integrating the natural gas demand econometrics model into power demand econometrics model for three cases comprising Base, Saving and Low Cases set for forecasting a power demand. Base case is that in which a forecast is made, assuming the economic growth rate in Uzbekistan is to be increased to 8-something percent by implementing an expanded fiscal policy on a continuous basis and maintaining average annual growth of 13.5 % in terms of government expenditures until 2030. Saving Case is that in which a forecast is to be made assuming considerable energy conservation potential for the Base Case, given the high energy consumption intensity in Uzbekistan as shown by Figure 2.1-3. Low Case is that in which a forecast is to be made assuming current economic, social and energy consumption structure changes based on past records as the so-called BAU Case. In this section, the natural gas demand forecast was made based on the Base Case forecast result, which leads to energy consumption peaking (annual growth rate of power demand is 3.6 %.) As other cases result in smaller power demand growth than the Base Case and lower natural gas demand, the total natural gas demand does not exceed that of the Base Case, meaning issues concerning the natural gas supply are less serious compared to the Base Case.

Natural gas demand in all sectors except power generation and export is equal to that in the final energy consumption and transformation sectors, except for the power generation sector. According to the IEA energy balance table, the energy consumption structure concerning natural gas and coal in Uzbekistan comprises five items, namely power generation plants, combined heat and power (CHP) plants, heat supply plants, energy industry own use and losses. Among them, four items except heat supply are summarized in the power generation sector[5].

Consequently, natural gas demand in the transformation sector, except that used to generate power, is equal to that of heat supply plants. Accordingly, the natural gas to be allocated to generate power and export can be obtained by deducting the consumption in the final energy consumption sector and heat supply plants from primary energy consumption. This structure is represented in Figure 2.2-1.

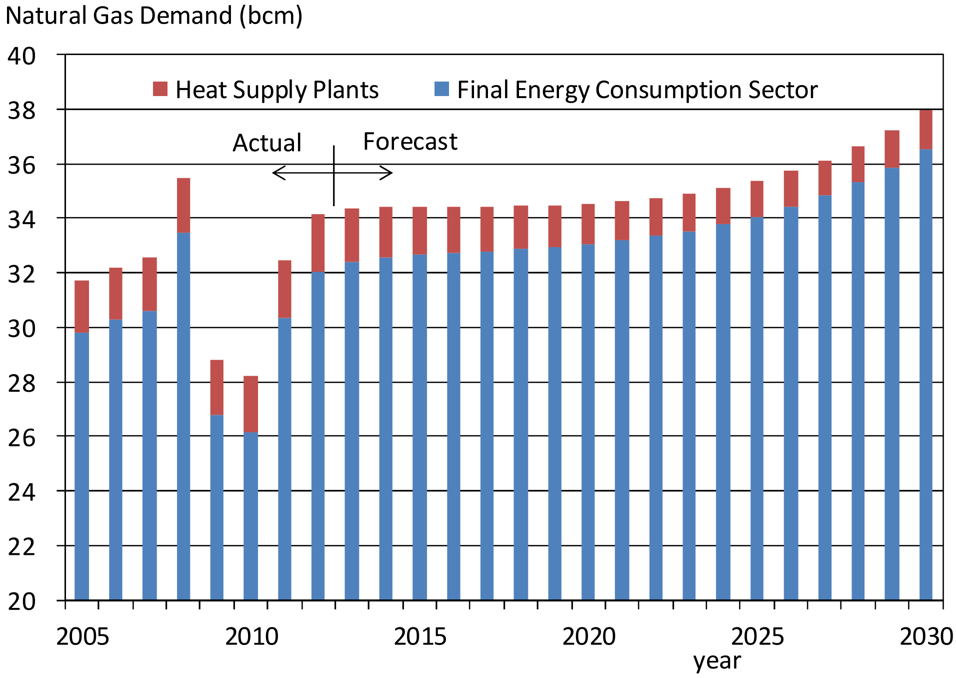
[5] In a strict sense, energy industry own use includes that at heat supply plants but as its share is considered small compared with that at power generation and CHP plants, all the own use is assumed to be included in the power generation sector only.



Source: JICA study team

Figure 2.2-1 Energy supply and demand structure (natural gas)

Figure 2.2-2 represents the natural gas demand forecast, except to generate power and exports, which was obtained using the same assumptions, preconditions, etc. as those for the Base Case of the power demand forecast model (original model) described on Section 3.2.1 in Chapter 3 and by incorporating the fuel demand forecast model into the original model. The assumptions and preconditions comprise three items, namely the population, foreign and government factors. As the population factor, the growth rate in the United Nations Population Prospect result is introduced into the model, since fluctuations in population affect energy supply and demand. The foreign factor mainly comprises economic trends in trading partner countries, exchange rates and international energy prices. The economic trend in trading partner countries affects imports and exports of Uzbekistan and consequently also affects energy supply and demand. Since the share of imports and exports with Russia and China is large, economic growth in both countries is integrated into the model. Since exchange rates and international energy prices are important factors to evaluate domestic energy price and energy price taking the exchange rate into consideration and energy supply and demand are closely interrelated, these factors are also integrated into the model.



Source: JICA study team

Figure 2.2-2 Natural gas demand forecast except to generate power and exports

The government factor is key for the model analysis and energy supply and demand are closely related to economic growth. Since government financial expenditure is an effective macro-economic political measure for Uzbekistan's economy and government expenditure and investigation drive economic growth, these are integrated into the model as variables. An energy supply demand forecast is implemented assuming the economic growth of 8- something percent is maintained by changing the government expenditure and investigation as variables (refer to footnote15.)

Natural gas production prediction is necessary to investigate and evaluate the supply potential as described below. In this chapter, the supply potential of natural gas to generate power until 2030 is investigated and evaluated, but investigation on supply potential for 2030 onward is limited within qualitative terms without any quantity.

(3) Natural gas production prediction

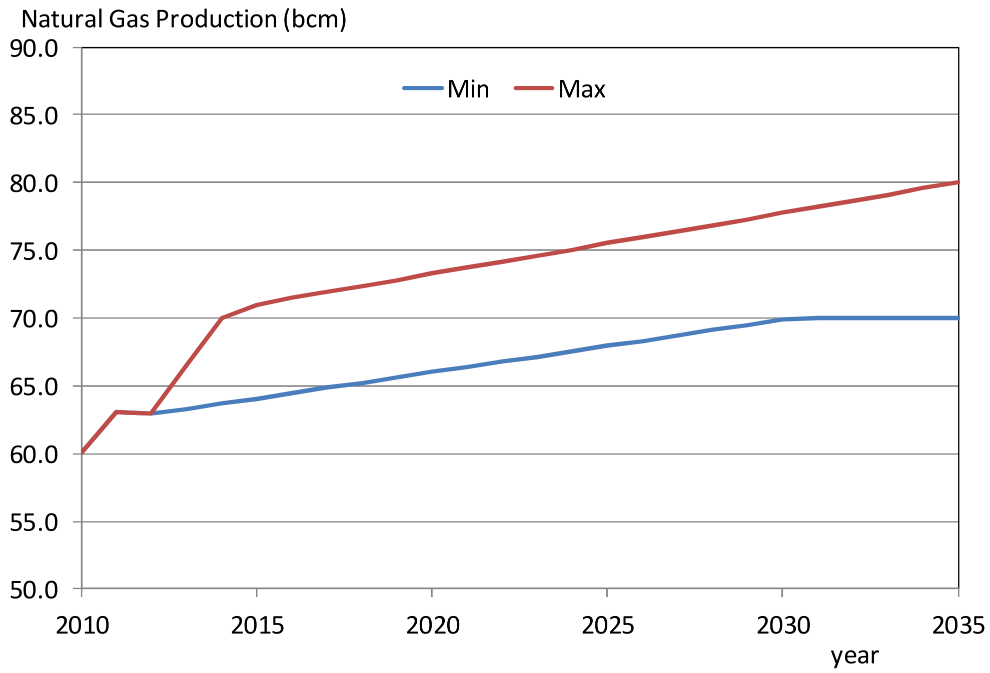
Natural gas production is influenced by the introduction of new gas fields and decreased productivity due to ongoing depletion in old fields, etc. It is not impossible to build an econometrics-based forecast model, in which these factors are taken into consideration. However, information and data for forecasting such production capacity are insufficient and classified as confidential, making it impossible to evaluate with guaranteed accuracy. Accordingly, an evaluation was made using information announced on production capacity. The following information on the production capacity or amount has been announced to date:

i. According to Uzbekneftegas, Uzbekistan intends to increase natural gas production to 66 bcm by 2020[6] (production in 2012 was 62.9 bcm)

ii. According to Eagle ford formation, recently (as of 29 December, 2013) the capacity of Uzbekneftegas allowed it to produce around 70 bcm of natural gas[7]

iii. According to ADB, intensified exploration and production efforts in the southwestern Gazli region will boost natural gas production, from 60 bcm in 2010 to 71 bcm in 2015 and 80 bcm in 2035[8]

While item iii covers the period from 2010 to 2035, items i and ii cover only a partial period, namely item i - from 2012 to 2020 and item ii - as of 2013 (actual capacity enhancement considered to be implemented slightly later.) Accordingly, it was assumed that for item i, the same annual growth rate from 2012 to 2020 would apply to that of the period until 2035 and for item ii, increased production would also apply to that of the same period. Namely, it is assumed that the production will increase by 0.39 bcm annually from 2020 to 2035 for item i and production will remain at a constant 71 bcm up to 2035. The year-to-year production for these three cases is compared and the maximum and minimum levels in each year are sought. Figure 2.2-3 represents the predicted maximum and minimum production levels.



Source: JICA study team

Figure 2.2-3 Prediction of natural gas production

[6] Natural Gas Asia, http://www.naturalgasasia.com/uzbekistan-expects-gas-output-to-reach-66-bcm-by-2020-12478
[7] https://eaglefordtexas.com/news/id/89/oil-gas-uzbekistan/
[8] Energy Outlook for Asia and the Pacific, October 2013, ADB

Production in 2015 is predicted to be 71 bcm but as production in 2012 was 62.9 bcm, it means that the production increases by 8.1 bcm only for three years. According to Figure 2.1-2, as production increased by 7.3 bcm from 60.3 bcm in 2005 to 67.6 bcm in 2008, a production increase of 8.1 bcm seems achievable. However, another figure shows 2014 production of 57.3 bcm[9]. If this is the case[10], production in item iii would have to increase by as much as 13.7 bcm for one year from 2014 to 2015, which is considered unlikely.

Of the three kinds of data, item iii comprises the maximum value throughout the entire period from 2010 to 2035, but as item iii is unlikely, item i or ii should be adopted as the predicted production value. It is desirable to adopt a smaller value for item i or ii so that production prediction would not be overestimated. However, even if a smaller value is adopted, actual production would undeniably be smaller than the minimum planned value. When consumption including to generate power in 2012 and 2025 is compared for example, it was 52.7 bcm (actual record) in 2012 but it is expected that consumption would decrease to 48.2 bcm (prediction) due to the contribution of improvement in generating efficiency. Conversely, as the minimum planned value in 2025 is 67.9 bcm, the difference between planned value and demand reaches 19.7 bcm. Furthermore, it is not theoretically impossible to adjust the exported volume. Accordingly, there is not considered to be any problem, even if actual production is smaller than the minimum planned value to some extent.

Therefore, it is considered appropriate to apply the minimum level to Figure 2.2-3 to predict natural gas production but the maximum level is also shown for reference. Table 2.2-1 represents the maximum and minimum production figures for every five years from 2015 to 2030. Though production based on item ii comprises the minimum level from 2031 onward, there may be restrictions on production in the 2030s, since the depletion of natural gas resources may have an impact. Accordingly, it is considered reasonable to apply the minimum level as a means of predicting natural gas production.

Table 2.2-1 Maximum and minimum values of natural gas production prediction

Year	2015	2020	2025	2030
Max.	71.0	73.3	75.5	77.8
Min.	64.1	66.0	67.9	69.9

Source: JICA study team

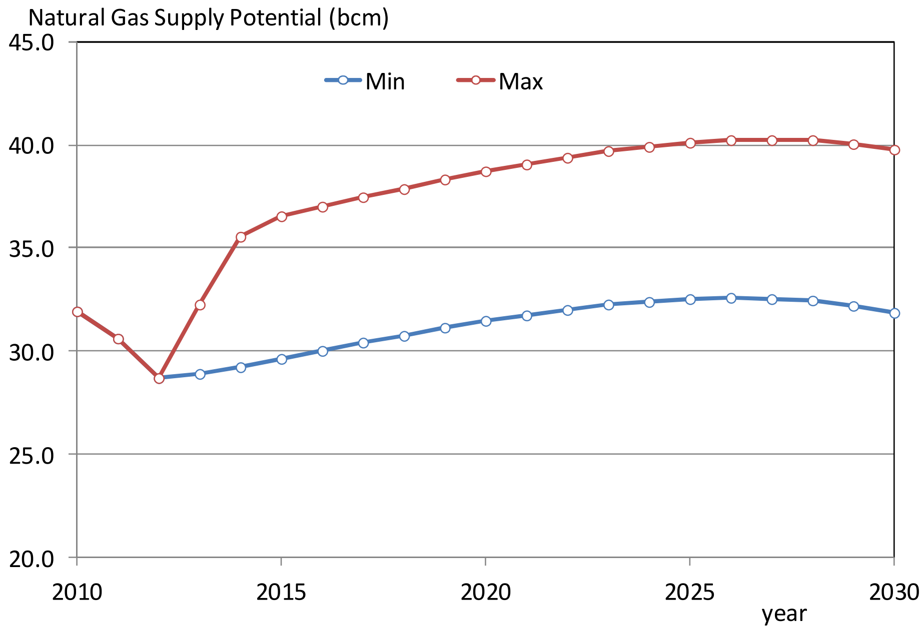
(4) Supply potential of natural gas to generate power

The amount of natural gas to generate power and exports can be calculated by deducting natural gas demand except power generation and exports as shown in Figure 2.2-2 from the prediction of natural gas production shown in Figure 2.2-3. Figure 2.2-4 also represents the case where natural gas will be produced at a peak level for reference.

[9] http://www.globalnote.jp/post-2856.html?cat_no=302

[10] Production in 2014 was 57.3 bcm in “BP Statistical Review of World Energy June 2015”, which is identical to the figure on footnote 9 above. In addition, according to “Country Analysis Note Uzbekistan” of EIA, the production in the same year was about 2 Tcf, which is equivalent to 56.6 bcm.

According to Figure 2.2-4, where the minimum amount of natural gas is allocated to generate power and exports increase slightly from 2012 to around 2025 and then subsequently decline. In the maximum case, natural gas allocated to generate power and export will soar due to the rapid increase in production from 2012 to 2014 but the upward and downward trends are almost identical to the minimum case. As the natural gas shown in Figure 2.2-4 includes that for export, if the security of natural gas to generate power is prioritized, it will be possible to secure the natural gas necessary to generate power fully and there will be no problem with supply potential, because the power generation system introduced in future is mainly a gas turbine combined cycle with higher efficiency.



Source: JICA study team

Figure 2.2-4 Supply potential of natural gas to generate power and export

Introducing a more efficient power generation facility means that future natural gas consumption to generate power will decrease compared to current consumption. In other words, comparing natural gas consumption to generate power between 2013 and 2025, for example, shows that in 2025, average generation efficiency is estimated at 48.4 % (though the generating efficiency of 450 MW class combined cycle was estimated at 53.2 %, combined cycle plants are operated at partial load with lower efficiency periodically and in addition some conventional steam plants will be still in service at that time. Therefore, overall efficiency drops) and natural gas consumption at 13,789 mcm with power generation of 59,758 GWh for scenario 1 in Chapter 3, while in 2013 average generating efficiency was 34 % for whole plants and natural gas consumption was 14,915 mcm[11] with 45,076 GWh. Consequently, total generating efficiency becomes lower than that of the combined cycle, meaning natural gas consumption in 2025 will decrease compared to that in 2013.

[11] According to Table 3.4.2-1 of Chapter 3 natural gas consumption for power generation is estimated at 12,848 mNcm, but in Uzbekistan natural gas volume is counted at standard gas temperature condition of 20 deg. C but not 0 deg. C.

(5) Evaluation of proven reserves

In this clause, we investigate how many years it will take before natural gas reserves are exhausted, when natural gas is produced at the maximum and minimum predicted levels as shown in Figure 2.2-3. As the optimum power source planning covers the period up to 2030, the evaluation criterion is whether or not calculated proven reserves will exist in 2060. If a power generation facility enters into service in 2030, it will be operated for 30 years.

Proven natural gas reserves are presented in Table 2.1-1. Though the figures between the World Bank and BP differ, the former is selected because it is consistent with IEA data from which other energy research organizations quote frequently, namely proven reserves as of 2012 were 1,841 bcm. As natural gas production in 2012 was 62.9 bcm, the number of recoverable years (R/P ratio) is 29.3. Accordingly, if proven reserves do not increase from now on, proven reserves will gradually decline with no further increase in natural gas production and it can be calculated that production will become impossible some 30 years later from 2012, i.e. around after 2040.

However, proven reserves will increase through new discovery of gas fields and decrease when production rises. In addition, there is the potential for reserves to increase alongside price and improved exploration and development technology. Accordingly, current recoverable years do not necessarily mean expiry of resources. According to Business Monitoring International (BMI[12]), the following outlook for reserves is presented; "Some discoveries and exploration activity would keep gas reserves stagnant at about 1,800 bcm through to 2018, though Uzbekistan would need to accelerate the rate of exploration and discovery should it wish to prevent a fall in gas reserves to about 1,700 bcm by 2023"[13]. Though proven reserves decrease through production as mentioned above, it is unclear what level of production from 2012 to 2018 will trigger a decrease from 1,841 to 1,800 bcm. The same applies for the period from 2018 to 2023. As a matter of fact, changes in proven reserves cannot be calculated without knowing production.

Accordingly, production in 2023 is assumed to be the same as 62.9 bcm, namely the production level in 2012. This is an assumption on the safe side, because if production increases from 2012 onward and proven reserves result in 1,800 bcm, proven reserves in this case should exceed the case where production is constant.

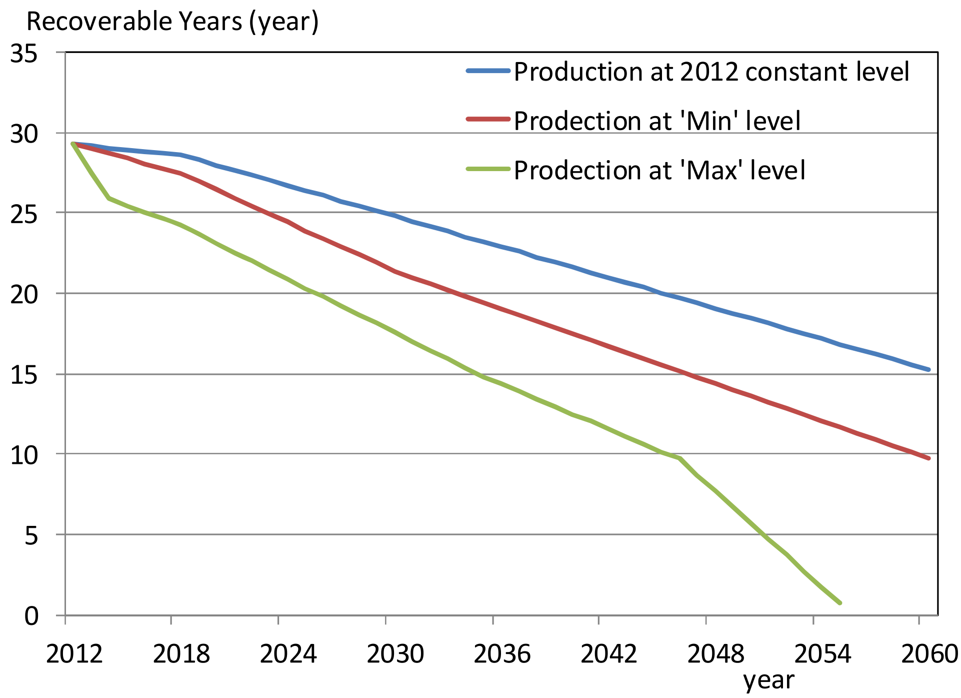
It is assumed that production at the minimum level shown in Figure 2.2-3 will increase every year until 2031 and then become constant. It is assumed that peak production will increase until 2035 and then become constant. As proven reserves decline with increasing production, for both maximum and minimum level cases, proven reserves decrease by the difference between production in each case and production in 2012 compared to the case where production is equivalent to the 2012 level. Accordingly, proven reserves are deducted by the increase in production from the 2012 level and

[12] BMI is a research firm that provides macroeconomic, industry and financial market analysis. It was founded in 1984.
[13] Oil and Gas: Uzbekistan Oil and Gas Report Q3 2014, BMI Research, June 4, 2014

defined as revised proven reserves. The revised recoverable years can be calculated by dividing the revised proven reserves by production at each level. Figure 2.2-5 represents the calculation result.

According to Figure 2.2-5, the recoverable years will become 10 years in 2060 for the case of minimum level production. As said, judging from the long history of the oil industry in the USA, when there are fewer than ten recoverable years, no further production increase is possible and reserves start to decline[14], which means they will be exhausted in around 2070. Conversely, the recoverable years will go below ten years in 2046 for maximum level production and reserves will be exhausted in around 2055, a decade after 2046. This means any generation facility that enters into service in 2030 will not be operable for 30 years. However, as mentioned above, the maximum production case is unlikely.

As mentioned above, the proven reserve prediction as of 2023 is based on assumptions that Uzbekistan would need to accelerate the rate of exploration and discovery should it wish to prevent a decline in gas reserves. The time limit when reserves will be exhausted can be postponed by accelerating the rate of exploration and discovery.



Source: JICA study team

Figure 2.2-5 Comparison of recoverable years

[14] Dictionary of oil/natural gas terms, JOGMEC

(6) Consideration

As mentioned in clause (4) above, he following points should be noted with respect to the supply potential of natural gas for power:

Firstly, the use of such fuel to generate power is to be prioritized over exports. If this is the case, the supply of natural gas to generate power is not considered problematic.

Even if there is no problem to supply natural gas, conversely, it is necessary to confirm whether or not the transportation capacity for supplying such volumes of natural gas to power stations and other consumers would accept an increase in production. For example, though the total transportation capacity of the three trunk pipelines connected to Tashkent city includes sufficient room on a year-round basis, there is a possibility of a potential shortage of transportation capacity in winter with higher demand. It is necessary to investigate whether or not pipelines elsewhere, particularly trunk pipelines connected to power stations, have sufficient room in transportation capacity in winter. However, to do so, data must be collected on the transportation capacity of trunk pipelines connected to each power station, including those newly built in future and actual data on current monthly transportation volume.

As the annual growth rate in electricity demand is 3.6 % for the Base Case, electricity demand growth must be controlled first. It is generally unlikely to implement energy conservation in which the increased consumption of fossil fuels such as oil and natural gas can be controlled without reducing growth in electricity demand. Accordingly, an energy demand structure with high electricity demand growth will inevitably bring with it high fossil fuel demand.

In the model used for the forecast shown in Figure 2.2-3 for example, natural gas demand as primary energy will be 73.6 bcm in 2030. Conversely, natural gas demand will increase by 1.7 % in terms of the annual growth rate according to the forecast undertaken by ADB (refer to footnote 8.) When this annual growth rate is applied, natural gas demand is calculated at 71.4 bcm, which differs slightly from the figure forecast by the JICA study team. However, the annual growth rate of electricity demand is 0.8 % according to ADB's forecast and 3.6 % for the Base Case as mentioned above[15]. Accordingly, the figure of 73.6 bcm is considered reasonable compared to ADB's figure of 71.4 bcm.

As described in clause 2.2(4) it is expected that natural gas demand to generate power would rather decrease in future and in addition it is possible to transfer the natural gas from export to power generation use in an emergency. In conclusion, it is considered that the supply potential of natural gas to generate power by 2060 would not be problematic, even taking resource restrictions into consideration.

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[15] In this study, power demand forecast was undertaken based on the economic growth forecast implemented by the Institute of Forecasting and Macroeconomic Research (IFMR) in Uzbekistan. The economic growth forecast by IFMR shows an economic growth rate up to 2030 of 8.3 to 9 percent. Conversely, according to the power demand forecast by ADB, the economic growth rate will be 8.0 % between 2010 and 2020 and 5.3 % between 2020 and 2035. Consequently, the difference in the economic growth forecast is considered the main reason for the difference in power demand.

2.3 Supply potential of coal to generate power

(1) Investigation of the supply potential of coal to generate power and its evaluation method

Data on production, consumption and reserves, etc. were given by Uzbekugol for coal and some data were also given by Uzbekenergo JSC. An investigation followed by comparing these data with IEA data, etc. in this section. In Uzbekistan, coal reserved and consumed includes a small amount of bituminous coal as well as lignite (including sub-bituminous coal.) The investigation was undertaken by focusing on lignite, because the coal used to generate power is lignite only[16] according to the IEA's energy balance table.

Figure 2.3-1 represents coal production, consumption (equal to domestic supply) and imports. Unlike natural gas, Uzbekistan is a net importer of coal, albeit in small amounts. Coal is produced by three companies[17], Uzbekugol, Apartak and Shargukumir (all of which Uzbekenergo JSC subsidiaries.) The companies who produce lignite (whose low calorific value is 1,910 kcal/kg) are Uzbekugol and Apartak and Shargukumir mainly produces bituminous coal. Uzbekugol had a 94.0 % share of lignite production from 2010 to 2014 and Apartak 6.0 %[18]. It was confirmed that bituminous coal is not used to generate power according to the data obtained from Uzbekenergo JSC.

Figure 2.3-2 represents a comparison between IEA data and data arranged by Uzbekugol. These data effectively match except for the Uzbekugol data for 2009, where a mistake occurred when copying. As described in clause 2.1(1), the average deviation for nine years was as small as 3.3 % for coal consumption to generate power. However, as for natural gas, IEA data was mainly used to analyze and evaluate the same, given the lack of available data related to coal demand due to the nature of Uzbekugol as a coal production company.

According to Figure 2.3-1, while coal production rose since 2000, despite fluctuating slightly, consumption showed a milder upward trend than overall production, despite fluctuating slightly. Consequently, net imports since 2005 were almost zero. According to the IEA, the breakdown of coal consumption by application type is as follows: that to generate power (including heat supply) is 68 % and for uses other than power generation is 32 % as of 2012. Furthermore, the breakdown of consumption for applications other than power generation is as follows: that for heat supply plants 0.5 %, for industry 21.2 %, for households 3.7 %, for agriculture/fishery 1.1 % and unspecified 73.5 %, when the total is set at 100 %[19].

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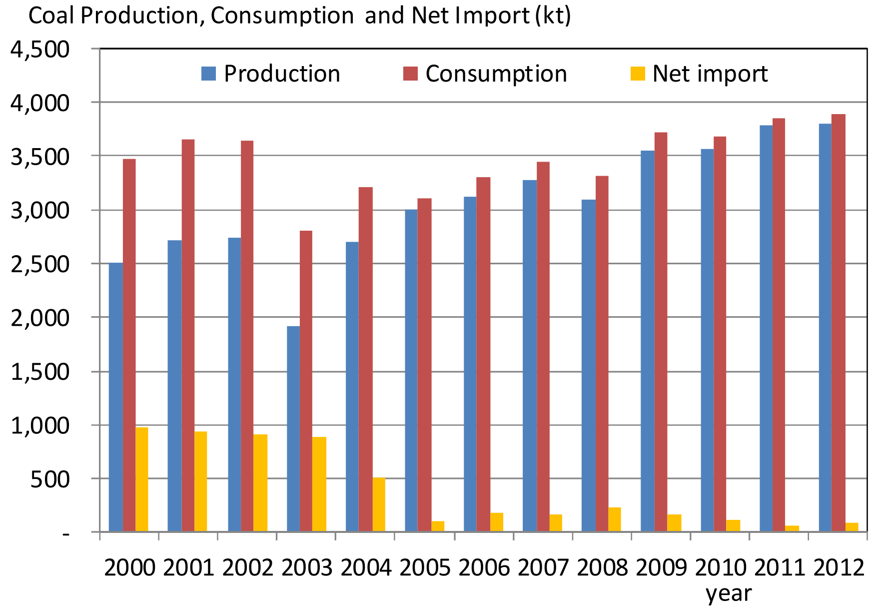
[16] Strictly speaking, Uzbekenergo JSC consumes charcoal as well as lignite. However the share of charcoal is a few percentage points in terms of calorific value compared with that of lignite. In addition, as there were many years when no charcoal at all was consumed at all according to Uzbekenergo JSC, the focus was solely on lignite.

[17] There is also a company named Erostigaz in addition to these three companies, which produces coal mine gas. However as coal mine gas is excluded from IEA data, it is also excluded from this section.

[18] "Production from 2004 to 2014", Uzbekugol's response to the additional questionnaire "Questionnaire on primary energy (coal)" asked during the third site visit.

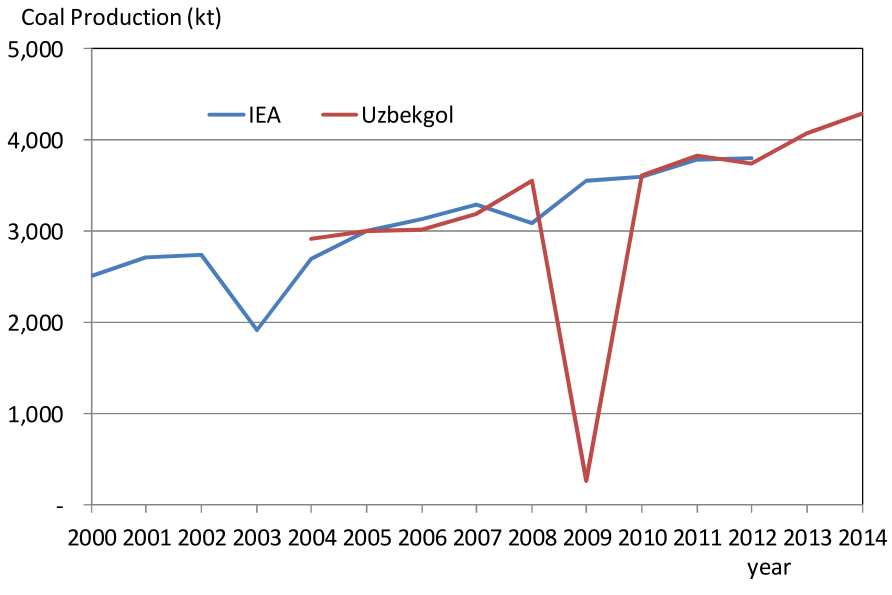
[19] http://www.iea.org/countries/non-membercountries/uzbekistan/

The supply potential of coal to generate power is investigated and evaluated below and the procedure for investigation and evaluation follows, as applied to those of natural gas described in the previous section.



Source: IEA

Figure 2.3-1 Coal production, consumption and import



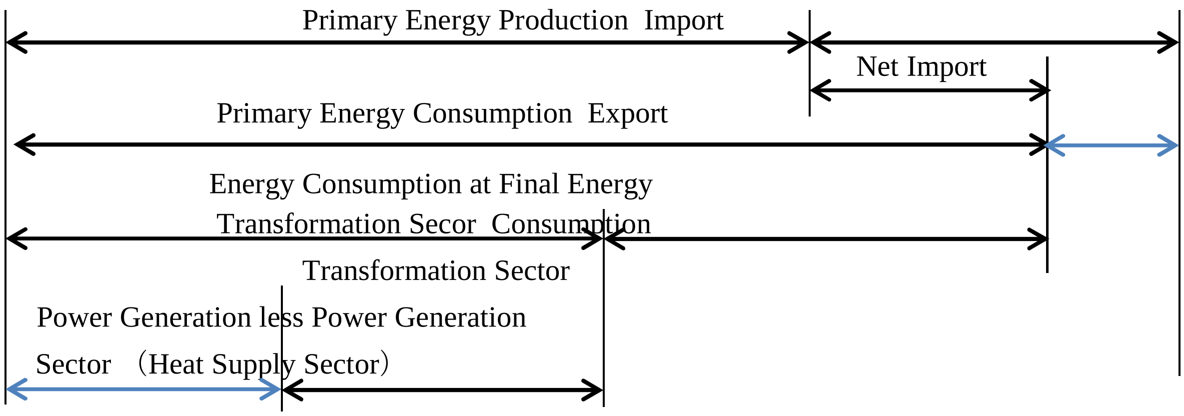
Source: JICA study team based on data from the IEA and Uzbekugol

Figure 2.3-2 Comparison of coal production data between IEA and Uzbekugol[20]

[20] The reason for the decrease in production in 2009 is that part of the production data (of the Uzbekugol data for three companies) is missing among series of data obtained through Uzbekugol, which means an actual decrease in production is considered unlikely.

(2) Coal demand forecast

The coal demand forecast was also undertaken by the econometric model established to forecast the demand to generate power as well as natural gas. Figure 2.3-3 represents the coal demand except the power generation sector for the Base Case. Domestic demand is represented as the sum of demand in the transformation and final energy consumption sectors, similar to natural gas, while for the transformation sector, the coal to be allocated to generate power can be obtained by deducting the consumption at heat supply plants from that in the transformation sector. Unlike natural gas, coal has been in a situation of net import (imported volume exceeds that exported) to date. As this means that domestic demand exceeded production, it could not be allocated for export[21]. Applying Figure 2.2-1 representing supply and demand structure of natural gas to coal, its supply and demand structure is as represented in Figure 2.3-3.

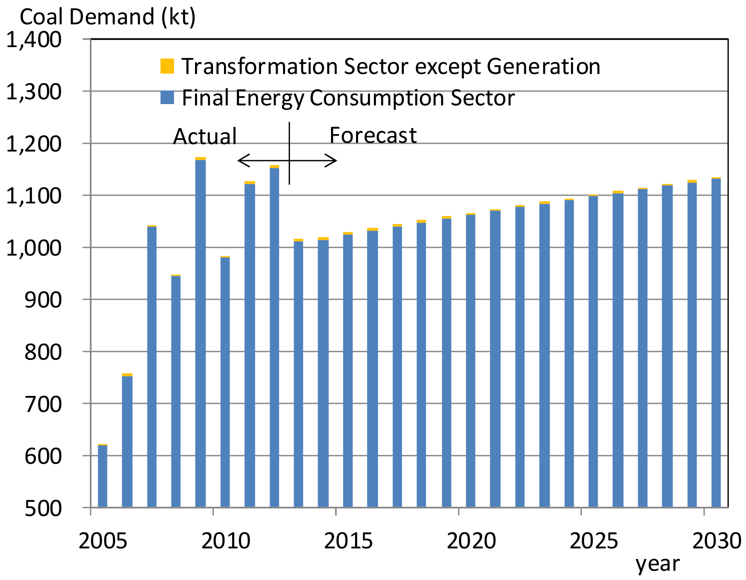


Source: JICA study team

Figure 2.3-3 Energy supply and demand structure (coal)

Figure 2.3-4 represents the resulting demand forecast except for the power generation sector. As shown, almost all the coal is consumed in the final energy consumption sector except for power generation but its consumption is extremely small.

[21] According to IEA, some 1 % of the production volume was exported as of 2012 (imported volume is 3.4 %).



Source: IEA

Figure 2.3-4 Coal demand forecast except to generate power

The supply potential of coal to generate power until 2030 is first investigated and evaluated but investigation on the supply potential for 2030 onward is limited to a qualitative scope, without any quantitative analysis, similar to natural gas. The following coal production prediction is made prior to investigating and evaluating the supply potential:

(3) Coal production prediction

Information on coal production can be obtained via the Internet, etc. as well as the production planning announced by Uzbekugol and the following are publicly disclosed:

i. Uzbekugol announced a production plan from 2011 to 2020[22].

ii. The Government planned to increase lignite production to 6.4 million tons (mt)/yr by 2014 and 16.3 mt/yr by 2021[23]. In addition, Uzbekugol planned to increase production to 11.5 mt/yr by 2018 and Apartak to 1.82 mt/yr. Though not all the information clarified the starting point, it is assumed to be 2012, since the source document describes the situation in 2012.

iii. According to the World Bank, the Government planned to increase coal production from the current level of 3.6 mt/yr to 17 mt/yr by 2020[24]. Although the starting point is "current", it is assumed to be 2010, since 3.6 mt/yr was the 2010 production according to the data of Uzbekugol shown in Figure 2.3-2. As this production figure is the total of that of lignite and bituminous coal, it is only necessary to estimate lignite production.

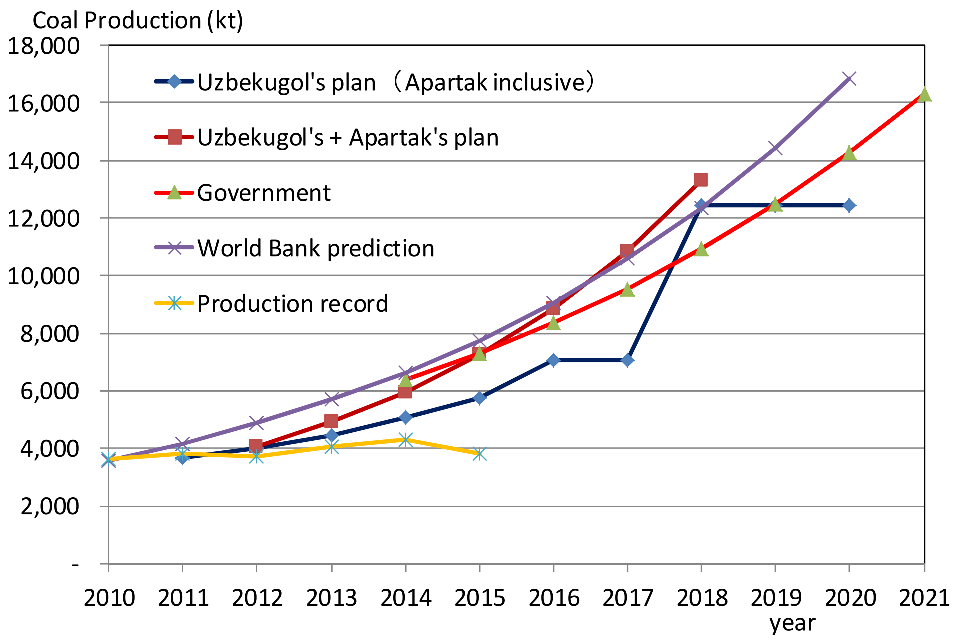
[22] Joint-stock Publish Company "Uzbekcoal", Brochure published by Uzbekugol

[23] "2012 Minerals Yearbook Uzbekistan", U.S. Department of the Interior & U.S. Geological Survey

[24] "Uzbekistan Energy/Power Sector Issues Note", June

There is a breakdown comprising total production and that of Uzbekugol and Apartak in Uzbekugol data that are the source of Figure 2.3-2 (footnote 18) concerning item i. As for the average production share of each company from 2010 to 2014, Uzbekugol's share is 94.0 % and that of Apartak is 6.0 %. Accordingly, total production can be assumed by dividing the figures shown on Uzbekugol's production plan by 0.94 for item i. Furthermore, Uzbekugol data on which Figure 2.3-4 is based include a breakdown of lignite[25] production and bituminous coal[26] production and the average share of each coal type from 2010 to 2014, as 99.1 and 0.9 %, respectively. Accordingly, lignite production can be assumed by multiplying coal production by 0.991.

Figure 2.3-5 represents a coal production prediction, in which production is calculated based on items i to iii and organized. Figure 2.3-5 also includes a production record from 2010 to 2015 based on Uzbekugol data. The Uzbekugol data cover the period 2010 to 2014 only. However, according to the latest information on coal production, it decreased by 11.4 % during the period January to June 2015 compared to the same period in 2014[27]. The production record shown in Figure 2.3-5 showed a decrease of 11.4 % assumed to be applicable; not only to the first half but also year-round. According to Figure 2.3-5, it is obvious that the production record has not been able to keep pace with various production plans.



Source: JICA study team

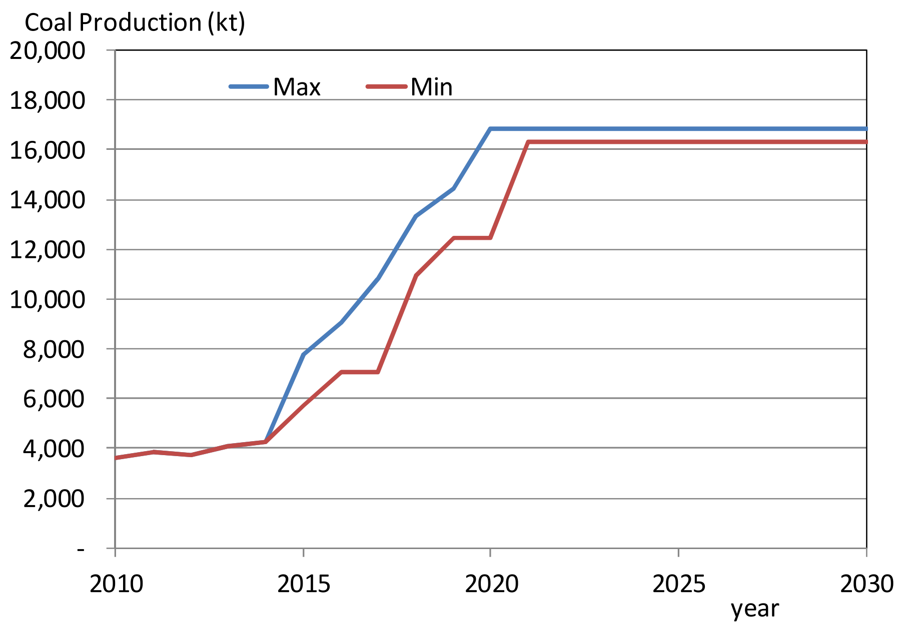
Figure 2.3-5 Coal production prediction (Part 1)

[25] Lignite is formed from peat at shallow depths and at temperatures lower than 100 deg. C. It is the first product of coalification. Lignite has a calorific value lower than 4,610 kcal/kg according to ASTM's standard. (ASTM: American Society for Testing and Materials)

[26] Bituminous coal has far higher coalification than lignite and is rich in volatile hydrocarbons. Bituminous coal has a calorific value exceeding 6,390 kcal/kg according to ASTM's standard.

[27] http://en.trend.az/business/economy/2425894.html

Figure 2.3-6 represents the predicted production up to 2030. Figure 2.3-6 was prepared based on assumptions of pre-2014 production from the production record and the production at maximum and minimum levels shown in Figure 2.3-5 applied after 2015 but prediction at the minimum level in 2021 is to be continued unchanged until 2030 and prediction at the maximum level in 2020 is to be continued until 2030. Such assumptions were made for the following reasons: the pace of actual production increase has been extremely slow to date and little scope is seen to achieve the production plan target, which requires a considerable and prompt production increase by 2020 or 2021, judging from the production increase record in other coal producing countries[28]. it will not be easy to increase production further after achieving the planning target during this period, because such production increases will involve significant investment in the coal industry for example but long-term concentration of investment in the coal industry appears difficult. In particular, since 2015 production is scheduled to decline compared to that in 2014, this will further exacerbate the difficult situation.



Source: JICA study team

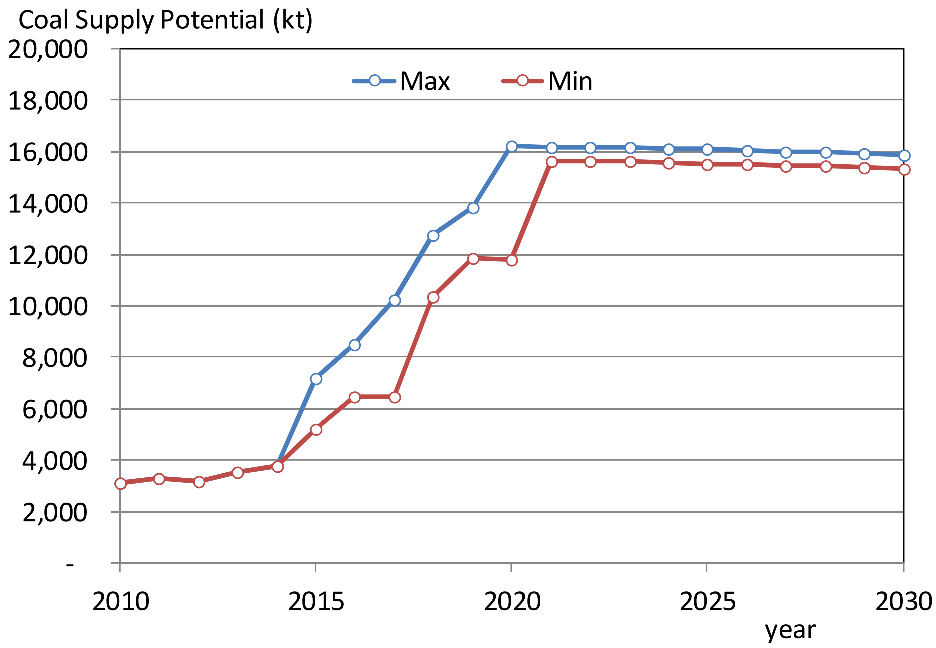
Figure 2.3-6 Coal production prediction (Part 2)

As described later, the current introduction plan for coal-fired power plants as drafted by Uzbekenergo JSC requires only 600 MW by 2030. Even if existing coal-fired plants are added to those newly introduced, total coal consumption to generate power is expected to be some 1,300 to 1,400 thousand tons as of 2024 according to a rough calculation. Accordingly, no significant production increase is considered necessary, since any increase in coal demand up to 2030 is forecast to be limited.

[28] A transition of production increase in main coal producing countries from 2000 on was checked using BP statistics. Indonesia achieved a maximum increase of 2.5 times for 6 years from 77 million tons (mt) in 2006 to 193.8 mt in 2006, but no countries achieved a production increase of four times during the same period, as planned by the Uzbekistan government.

(4) Supply potential of coal to generate power

The amount of coal allocable to generate power can be calculated by deducting coal demand except power generation shown on Figure 2.3-4 from the coal production prediction shown in Figure 2.3-6 and represented in Figure 2.3-7.



Source: JICA study team

Figure 2.3-7 Supply potential of coal to generate power

The supply potential shown in Figure 2.3-7 is subject to the achievement of production according to the prediction shown in Figure 2.3-6. However, the past production record showed that production was progressing with a slightly upward trend, as mentioned above. The key question is whether or not the rapid production increase from 2015 to 2020 will inevitably be achieved. If the production increase is delayed during that period, coal imports are likely to increase from the current low level.

Coal is transported by railroad (up to 69 tons per wagon) and dump trucks with a payload capacity from 20 to 40 tons. Though the thermal power generation sector accommodates most coal consumption, coal-fired power stations, including those newly built, are located in and around Angren, hence problems with coal transportation are considered minor compared to natural gas. However, in case production does not increase as predicted and imports must be accelerated owing to the tight domestic supply and demand situation, the railway transportation capacity from Kazakhstan must be checked as imported coal is basically transported by railroad.

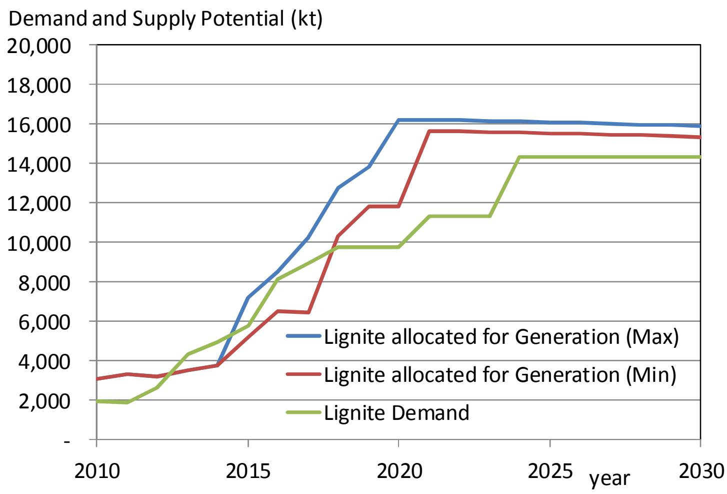
(5) Evaluation of proven reserves

As described in clause 2.1(3), coal reserves are relatively abundant in terms of recoverable years compared to natural gas and oil (Figure 2.1-6.) Current proven reserves of lignite amount to 1,853 mt as described in footnote 4. Even if proven reserves do not increase in future and production peaks at some 17,000 thousand tons (kt) as shown in Figure 2.3-6, the recoverable period will still exceed a century. This means any issues with lignite in Uzbekistan are extremely minor in resource terms compared to natural gas.

(6) Consideration

According to the current power generation facility expansion plan of Uzbekenergo JSC, a coal-fired power plant with 150 MW capacity will go into service in 2015, one with 150 MW in 2021 and one with 300 MW in 2024 at Angren. Furthermore, there is also a program in which five existing natural gas/coal (mixed) fuel-fired power plants with total available capacity of 943 MW will be converted to year-round coal-fired plants. The retirement program does not include these five plants before 2030. However, it is assumed that existing plants currently burn mixed fuel, with 40 % natural gas and 60 % coal in terms of calorific value, judging from the 2014 coal consumption. If the coal share is increased by 10 % every year, these plants will be converted to completely coal-fired ones in 2018.

Under the above precondition, assuming that the low calorific value of lignite is 1,910 kcal/kg as shown above and the capacity factor of existing pants is 60.4 % (the average value of the record for 5 years from 2009 to 2014), generating efficiency is 31.4 % (refer to Table 4.2-1) and for newly introduced plants 60.4 % (identical to existing ones), 35.7 % (refer to Table 3.2.6-1), respectively, coal demand required for operating coal-fired plants up to 2030 was approximately calculated first, whereupon lignite demand was calculated by adding other demand except that to generate power shown by Figure 2.3-4. The calculated demand was compared to coal that can be supplied to generate power and the result is represented in Figure 2.3-8.



Source: JICA study team

Figure 2.3-8 Comparison between coal power generation demand and its supply potential

According to Figure 2.3-8, coal demand soared and exceeded production in 2013 and a shortage of coal is considered to have been covered by imports, provided the Uzbekugol production data are correct. Demand is also expected to exceed production during the period 2014 to 2017 and must be covered by imports, to slow down the pace of fuel conversion from natural gas to coal, or postpone the operational launch of the new plant, which was originally scheduled to go into service in 2015. Conversely, no problem is considered to have emerged provided the production increase plans settled by the Government and coal production companies are implemented from 2018 onward, even at a slightly slower pace.

Thus, although there is a certain period when the supply and demand situation will be tight, countermeasures exist as mentioned above and proven reserves include sufficient room for the foreseen supply and demand level up to 2030. Consequently, it is considered that supply potential of coal would not become an issue.

2.4 Supply potential of alternative energy

The development of hydraulic resources, renewable energy such as photovoltaics, wind power and biomass, etc. are considered realistic and alternative energy sources. Table 2.4-1 represents power mix in 2013 and 2030[29]. According to Table 2.4-1, the growth of hydraulic power is small for the period between 2013 and 2030 and the share of renewable energy except hydraulic power is as small as 7 %. Though photovoltaic and wind power account for the majority of renewable energy, these sources bring considerable fluctuations in generated power depending on the weather and hence have little effect on decreasing the power generation capacity of thermal power plants due to the need for a backup power source. Thus, it is also impossible to scale down gas supply infrastructure (transportation capacity, etc..), which limits the potential of these energies as an alternative energy source for natural gas.

Table 2.4-1 Power mix (actual record and planning)

	Electric Power in 2013		Electric Power in 2030	
	MWh	%	MWh	%
Thermal Power Plant	48,600	88.5	80,900	77
Hydraulic Power Plant	6,270	11.5	16,800	16
Renewable Energy	-	-	7,400	7
Total	54,900	100	105,000	100

Source: "Republic of Uzbekistan Energy Policy", Ministry of Economy of Uzbekistan

However, from another perspective, solar radiation is considered one of the most promising renewable energy sources among alternative energies. Nationwide, Uzbekistan has more than 300 sunny days a year and approximately 75 % of the country is desert. Solar radiation of 176.8 mtoe is said to be technically exploitable[30]. This figure equates to three times the primary energy production shown by Figure 2.1-1 (some 57 mtoe in 2012), representing very high photovoltaic potential[31].

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[29] The figure for 2030 in Table 2.4-1 shows the plan prepared by the Uzbekistan government as obvious from the source and differs from the figure of power source development plan in Chapter 3.

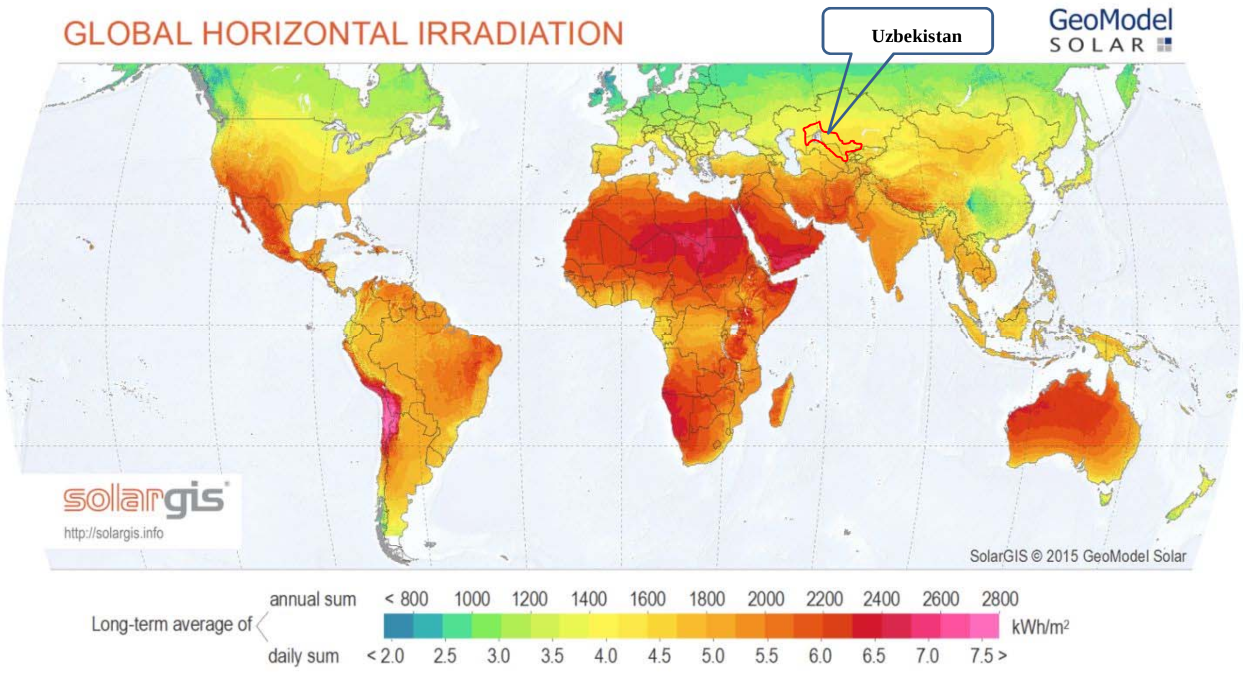
[30] Potential of Renewable Energy Source in Uzbekistan, Journal of Knowledge Management, Economics and Information Technology, Issue 7 December 2011

[31] The solar radiation potential and photovoltaic power potential are not the same. As the efficiency of photovoltaic power

As photovoltaic (PV) power, as mentioned above, is a relatively unstable power source and involves high generating cost, its large-scale introduction is problematic. However, PV power can play a role as alternative energy and help improve the current balance by transferring the natural gas saved through the operation of PV power system to export. In this sense, it necessary to investigate the economic feasibility of PV power by relating the increased exports of saved natural gas to economic effects but not by comparing its unit generation cost with that of existing power sources. It is considered fully likely that PV power would become economically feasible depending on the export price of natural gas.

As shown in Figure 2.4-1 below, Uzbekistan receives a good amount of insolation at 5kWh/m^2/day and there are many clear days, which collectively indicate the high potential of solar energy as a renewable energy source. Conversely, the potential of wind energy is limited because Uzbekistan is a double land-locked country with no seashore. As for biomass, Uzbekistan is a leading cotton producer and generates 3 million tons of cotton stalk as leftover each year. If all of this could be used to produce electric energy 1.5 TW/year would be produced, but there are some issues: (1) cotton stalk is used as a fuel for cooking and heating in countryside homes, (2) a supply chain for collecting, drying and storing the biofuel will need to be established, (3) existing gas burning boilers will need to be converted into biomass burning.

In conclusion, solar radiation can be considered to have the highest potential among renewable energy sources in Uzbekistan.



Source: Solargis homepage, http://solargis.info

Figure 2.4-1 Global horizontal irradiation map

generation is 15 to 20 percent, photovoltaic potential is 15 to 20 percent of solar radiation potential.

Chapter 3 Power Development Concept

Chapter 3 Power Development Concept

To determine the most economical power development plan on the basis of the Electric Power Development Plan up to 2030 developed by Uzbekenergo JSC, a comparative analysis of power development scenarios has been made, and the optimal type and capacity of power development required up to 2030 has been determined. Software for power development planning at minimum cost (WASP, Wien Automatic System Planning Package, Version–IV) was used.

3.1 Optimal Power Development Concept selection method

To select the most economical power development plan combining different types of power source and development principles, the WASP software was used, as developed by the International Atomic Energy Agency (IAEA).

This software meets constraints such as power supply reliability (LOLP, Loss of Load Probability), reserve capacity, fuel limitations, limits on the permissible pollutant emissions and others, thus helping to choose the optimal power development plan up to 2030. The most appropriate plan is one including the minimum total cost, based on calculations of Net Present Value using the discount rate. Below is the outline of a model developed in WASP.

The mix of power sources meeting constraints and combined in an electronic system (power development plan) is estimated based on the cost function (Objective Function), to include the following items:

- Investment costs, which may be repaid: cost of equipment and installation (I)
- Liquidation value of investment costs (S)
- Investment costs, which may not be repaid: fuel reserve, spare parts, etc. (L)
- Fuel cost (F)
- O&M costs in addition to fuel cost (M)
- Costs of delivering electricity (O)

The expenses function evaluated by WASP is shown in the following equation:

$$B_j = \sum_{t=1}^{T} [\,\bar{I}_{j,t} - \bar{S}_{j,t} + \bar{L}_{j,t} + \bar{F}_{j,t} + \bar{M}_{j,t} + \bar{O}_{j,t}\,]$$

Where:

B_j: Expenses function of the Power Development Plan j

t: Year of the Power Development Plan (1, 2, ..., T)

T: Period of the Power Development Plan (all years)

The horizontal bar above the symbols refers to the price discounted by the discount ratio i by a certain point in time. The optimal power development plan has the smallest expenses function Bj among all the development plans j suggested.

Figure 3.1-1 is a short WASP-IV flow chart showing the flow of information between various modules of WASP and related data files.

Table 3.1-1 The Power Development Plan up to 2030, developed by Uzbekenergo JSC (including renovation of existing hydropower plants)

No.	Name of the power plant	Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	[MW]
1	Talimarjan TPP	GTCC		450	450				450	450							450	450	2,700
2	Navoi TPP	GTCC			450				450										900
3	Syrdarya TPP	Steam	50																50
4	Tashkent TPP	GTCC		370								450	450	450	450	450		450	3,070
5	Angren TPP	Steam		150					150										300
6	Novo-Angren TPP	Steam										300							300
7	Takhiatash TPP	GTCC					250	250											500
8	Turakurgan TPP	GTCC			450	450			450	450									1,800
9	Syrdarya province, new TPP	GTCC				450	450												900
10	Mubarek CHPP	GTCS					140												140
11	Ferghana CHPP	GTCC				57,7													57,7
12	Tashkent CHPP	GTCS						2×27											54
13	Tashkent CHPP	GTCS				4×27													108
	Total for CPP		50	970	1350	1,065.7	840	304	1,500	900	-	750	450	450	450	450	450	900	10,880
	Per five (5) years		50	4,529.7					3,600					2,700					
14	Renovation of existing hydropower plants		45	17.3	6.9	8.7	11.8	2.4	10.8	2.1	1.3	0.4	0.3						107
			1HPP	2HPP	3HPP	4HPP	3HPP	3HPP	2HPP	3HPP	3HPP	2HPP	2HPP						
	Per five (5) years		45	47.1					14,9										
15	Kamolot HPP				8														8
16	Irgailiksai HPP									13.6									15
17	Nijne-Koksu HPP										20								20
18	Nijne-Chatkal HPP											100							100
19	Khodjikent HPP												200						200
20	Mullalak HPP														240				240
21	Akbulak HPP															60			60

22	Pskem HPP																404		404
	Total for new HPP			8					333,6					704					1,046
	Grand total for HPP		45	17.3	14.9	8.7	11.8	2.4	10.8	15.7	21.3	100.4	200.3	-	240	60	404	-	1,153
	Per five (5) years		45	55.1					348.5					704					
23	Solar power plant			100			100			100			100			100			500
24	Wind power plant								50			50		50			50		200
	Total for renewable energy			200					300					200					700
	Total for every year Total for power sources		95	1,087.3	1,364.9	1,074.4	951.8	306.4	1,560.8	1,015.7	21.3	900.4	750.3	500	690	610	904	900	12,732
	Per five (5) years		95	4,784.8					4,248.5					3,604					

Source: Uzbekenergo JSC

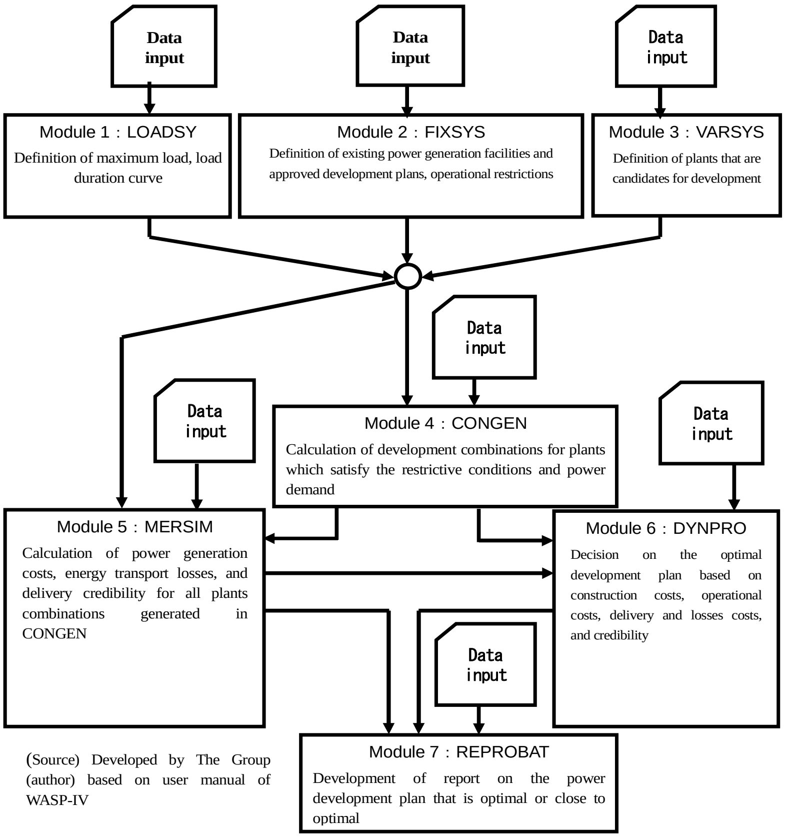


Figure 3.1-1 Flowchart of WASP-IV

3.2 Review conditions

3.2.1 Electric Power Demand Forecasting

(1) Model Configuration

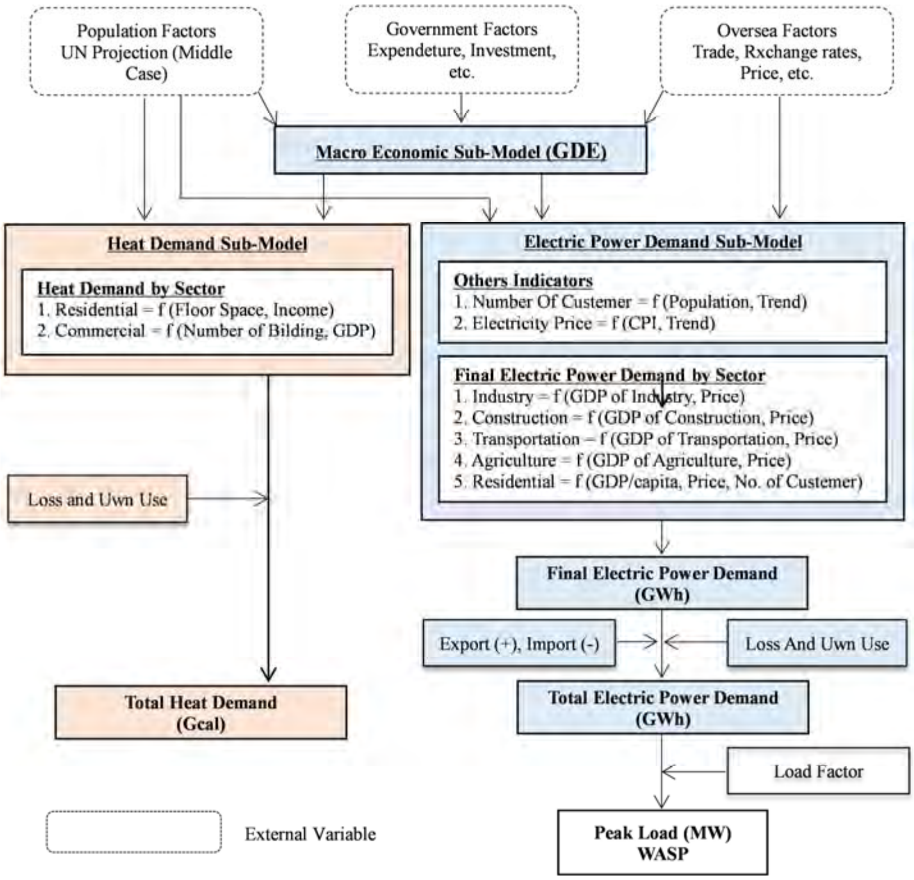
1) Concept and Structure

The Uzbekistan government has been implementing the dissemination of market economy consistently since its independence in December 1991.However, it was hit by runaway inflation and economic turmoil during the 1990s. Nonetheless, the economy stabilized during the first half of the 2000s, and the second half saw a rapid growth in the economy. We recommended that the introduction of the analysis method of econometric model for electric power demand forecast analysis in this project because we expect that the Uzbekistan government will continue to promote the market economy in the future. The reasons are as follows.

① Economic activity since 2000, which is in a relatively stable situation, where inflation has remained somewhere between 6 to 10%.

② Number of samples in statistical data are sufficient to enable the quantitative trend analysis.

③ As Uzbekistan’s economy progresses further, the correlation of macro-economic activity and power demand has become even closer.



Source: JICA Study Team

Figure 3.2.1-1 Structure of Model

The structure of the modeling is composed of the “Macro Economic Sub-Model”, the “Electric Power Demand Sub-Model” and the “Heat Demand Sub-Model”, These three sub-models are shown in the general configuration diagram, Figure 3.2.1-1. The simulation analysis will be based on these three sub-models to estimate the electric power demand and heat demand of Uzbekistan by 2030. This integrated quantitative analysis model can easily verify the correlation between macro-economic indicators and power demand. Furthermore, there is an advantage which is easy to explain the changes of electric power demand in future by economic activity.

Macro-Economy Sub-Model

The Institute of Forecasting and Macroeconomic Research (IFMR) is one of the main institutions that prepare the short-term (2016 - 2018) and long term (until 2030) forecasting for the economy and energy demand in Uzbekistan. IFMR is not entirely relianent on the model, but scenario analysis has also became an important part of the long-term projection process. As a result, the country’s economic growth rate is projected at an average annual rate of 8.3 to 9.0 % by 2030. Gross Domestic Product (GDP) in 2030 is projected to expand 3.7 times compared to now. The population has been estimated to reache 37 million by 2030 at an average annual rate of 1.28%. IFMR also points out that

Uzbekistan is also facing a big challenge in ensuring the stability of the labor force, investment and resources (fuel and water) in order to to maintain high economic growth by 2030[1].

After consideration of the above IFMR forecasting method in the electric power demand projection model study, an econometric analysis method for modeling construction was introduced. The economic model was constructed based on gross domestic expenditures (GDE), and the economic growth rate of Uzbekistan was estimated. Industrial structure analysis on the present point is difficult without the input-output (IO) tables[2], but the GDP by sector is simulated by share functions, which are based on the history of the industrial sector trends and changes in the structure.

The macroeconomic sub-model has been constructed on data from variables such as private consumption, government expenditure (investment), and imports and exports which simulate the gross domestic expenditure (GDE). The main characteristics of the model are trade factors (trade partner's economy change, foreign exchange), government factors (public investment, interest rates, etc.) and population factors, which are given as external variable to simulated the economic growth rate and production by each sector.

Electric Power Demand Sub-model

The core part of the entire model is the "Electric Power Demand Sub-model". As an explanatory variable indicators has obtained from the "Macro-economic Sub-model such as the GDP by sector, electricity tariff, population, income and number of customers is used to determine the electric power demand by sector in final sector. The sum of final sector power demand, transmission loss, own use[3] and net import-export will become the total electric power demand of Uzbekistan. The peak load (MW) can be calculated when multiplying the load factor by the total electric power demand. Power capacity development plan is created based on this peak load. Thepower capacity composition is calculated by optimization the software "WASP".

The electric power demand in each province / region is calculatated according to the ratio of total electric power demand of Uzbekistan.

2) Projection Period and Model Scale

The Model estimation period is over 17 years from 2014 to 2030.The model has a total of 232 equations consisting of 97 function equations and 135 definitional equation. All equation in the model will be calculated by simultaneous equations. The historical data of macro-economics is from 1995 to 2013, and electricity and heat data is from 2000 to 2013.

[1]27th January 2015, by interviews to "Institute of Forecasting and Macroeconomic Research" (IFMR). (Refer to interview minutes)

[2]According to IFMR, the input-output (IO) tables that Uzbekistan has been created now is divided into 36 sectors, and the table has become a relatively simple structure. Although the development of IO table has supported by international organizations, but to reflect fully the real economy to the table is expected to take time.

[3]It means the demand of Generators, Substations and Uzbekenergo JSC offices usage.

3) Data

The historical data sources of macroeconomic are based on data from the International Monetary Fund (IMF) and the United Nations statistic Division (UNSTAT), whereas the data sources of electric power and heat are provided by Uzbekenergo JSC.

(2) Assumptions

1) Population Factor

Uzbekistan's population at the end of 2013 was 30.24 million. In December 1991, the annual growth rate of Uzbekistan was 2.0% compared to the previous year. However, after gaining independence, the growth rate started to drop and slowed down to 1.2% in 2006. Nonetheless, the expansion of economy since 2007 has stimulated a growth in the population. In 2010, for example, the annual growth rate of the population rose to 2.9%. In 2013, the annual growth rate of the population dropped to 1.6%, and this trend is expected to continue in the future. The growth rate of the population, as recorded by the United Nations Statistic Division, has been included in the electric power demand model as an external variable. According to the same population estimation results, the increase rate of the population in Uzbekistan will decelerate gradually from 1.35%after 2013 to 0.61% in 2030.

However, much of the population in Uzbekistan consists of migrant workers from neighboring Kazakhstan and Russia, population factors as explanatory variables might be contained elements of uncertainty.

Table 3.2.1-1 Population Projection of Uzbekistan (2014 - 2030)

Year	Population (Million)	Annual Growth Rate (%)
2014	30.61	1.35
2015	31.01	1.31
2016	31.40	1.27
2017	31.79	1.22
2018	32.16	1.17
2019	32.52	1.13
2020	32.87	1.08
2021	33.21	1.03
2022	33.54	0.98
2023	33.85	0.93
2024	34.15	0.88
2025	34.43	0.83
2026	34.70	0.78
2027	34.96	0.73
2028	35.20	0.69
2029	35.43	0.65
2030	35.64	0.61

Source: United Nations, Department of Economic and Social Affairs, Population Division (2013). "World Population Prospects: The 2012 Revision"

2) Overseas Factor

Overseas factors are mainly economic trends of trading partners, currency exchange rate and international energy prices. The economic trends of Russia and China especially have a high impact to Uzbekistan's economy. The trade balance of Uzbekistan after 2010 has always had a surplus at national level, but has fallen short against Russia and China. In 2012, the share of exports to Russia accounted for 9.0%, and the share of exports to China accounted for 7% in total. When we look at imports, the share from Russia accounted for 21.0% and the share from China accounted for 16.0% in total. The economic growth in both countries became external variables in determining the imports and exports of Uzbekistan.

Exchange rates and international energy prices are important elements for evaluating domestic energy costs. Exporting natural gases to Russia and China are especially important for gaining foreign currency in order to raise the value of net exports.

3) Government Factor

The government factor is the most important key factor in this model analysis. As described above, Uzbekistan is in the process of formatting a market economy, and the government's fiscal spending is an effective macro policy which aims to promote economic growth. In this model government expenditure and investment, as drivers of economic development, have been incorporated as external variables in the macro-economic sub-model. By sensitive analysis in changing this variable to calculate the government budget introduced amount required to maintain the growth of the 8% level.

(3) Scenario Setting

1) Base Case

The Uzbekistani government has implemented a continually expanding fiscal policy to sustain the growth rate at an average annual rate of 13.5% by 2030.Implementation of the structural reform of industry corresponding to this financial expenditure makes it possible to boost the country's economic growth rate of 8%. When calculated based on the exchange rate of dollars in 2013 as a basis year, this fiscal expenditure plan, it is necessary to ensure the financial resources of 75.5 billion USD in 2030.

2) Energy Saving Case

Energy saving case is a case that made the implementation of 20% energy savings policy based on the base case. World bank study reports have pointed out that Uzbekistan's energy intensive industries will remain high for the long term, and therefore there is a high potential for energy saving. According to the same report, the energy-saving potential in the power sector showed the order of about 20%[4]. In Uzbekistan, where energy-related equipment is aging, updating such equipment will have a positive impact on energy saving. In this case, the power plant, cogeneration plants, heat

[4] World Bank, "Uzbekistan Energy Efficiency Strategy for Industrial Enterprises", June 2013, page ix

supply plants, power transmission and distribution equipment is the main energy supply facilities was assumed to be approximately 20% of energy savings can be realized.

3) Low Case

Low case corresponds to the so-called BAU case. In others words, the current economy, in terms of energy consumption has had no structural change, the simulation result is based on the historical trend of the data.

(4) Simulation Results

1) Base Case

The table below shows the projection results of the macroeconomic sub-model. As described above, in base case, the Uzbekistan government has continued to expand the fiscal expansion policy to a total of $75.5 billion USD by 2030 in order to sustain the real economic growth rate at an average annual rate of 8.1%. Through fiscal expansion policy and industrial restructuring, the growth rate of the industry and construction sector has been expanding at an average annual growth rate of 10.9% and 11.0%. On the other hand, the share of service sector (service, transport and communication, etc.) has expanded 2 points compared to 2013, which accounted for 49.4% of the total in 2030. The share of the agricultural sector was a decreasing trend in the past and is expected to continue this way in the future. Its share decreased by 2.7 points compared to 2013, becoming 16.9% of total GDP in 2030. Reform of Uzbekistan's industrial structure will be ongoing, and the expansion of industrialization and service industry will be sustainable.

Table 3.2.1-2 Uzbekistan Macro Economy Sub-model Simulation Results

(Base Case and Saving Case, 2013 - 2030)

Descriptions	Unit	Actual			Estimating				CAGR (%)	
		2005	2010	2013	2015	2020	2025	2030	2020/ 2013	2030/ 2013
Total Population	Million	26.2	28.6	30.2	31.0	32.9	34.4	35.6	1.2	1.0
GDP Growth (Previous)	%	7.0	8.5	7.0	6.7	7.9	8.8	9.7		
Real GDP (2005 Constant)	Billion Sum	15,923	23,918	29,996	33,723	48,315	72,496	113,290	7.0	8.1
Agriculture	Billion Sum	4,193	5,573	6,953	6,463	8,831	12,721	19,175	3.5	6.1
Industry	Billion Sum	3,371	4,342	5,366	8,875	12,907	19,604	30,950	13.4	10.9
Construction	Billion Sum	771	993	1,228	2,303	3,212	4,711	7,218	14.7	11.0
Service	Billion Sum	1,400	2,499	3,163	3,325	4,744	7,093	11,051	6.0	7.6
Transportation	Billion Sum	1,677	2,995	3,792	4,373	6,518	10,093	16,188	8.0	8.9
Others	Billion Sum	4,512	7,516	9,494	8,384	12,103	18,274	28,708	3.5	6.7
GDP by Sector (%)										
Agriculture	%	29.5	19.8	19.6	19.2	18.3	17.5	16.9	-1.0	-0.9
Industry	%	23.7	26.3	26.1	26.3	26.7	27.0	27.3	0.3	0.3
Construction	%	5.4	7.1	6.9	6.8	6.6	6.5	6.4	-0.6	-0.5
Service	%	9.8	10.2	9.9	9.9	9.8	9.8	9.8	-0.1	-0.1
Transportation	%	11.8	12.7	12.7	13.0	13.5	13.9	14.3	0.8	0.7
Others	%	19.8	23.9	24.8	24.9	25.1	25.2	25.3	0.2	0.1
Total	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0		

Source: JICA Study Team

According to “The Institute of Forecasting and Macroeconomic Research” (IFMR), Uzbekistan electric power demand has doubled compared to 2013 became 105,000 GWh in 2030.In present, Uzbekistan have no plans to introduce nuclear power in future. The increase of energy demand in the future will be supplemented by renewable energy and coal. According to the projection result provided by IFMR, the ratio of renewable energy to total energy consumption in 2030 is estimated to reach 6% of the total energy supply. The energy supply and demand modeling simulated by IFMR is based on the software tool “e-views” and “Excel” base optimization model. “e-view” is one of the famous software tool on econometric analysis.

Electric power demand forecast of this study, estimates based on the data of Uzbekenergo JSC. Explanatory variable such as Macro-economic, population, number of households, floor space and electricity tariff will be used to estimate the electric power demand by each sector. The total of projection result by sector became electric power demand of final sector. The total electric power demand for Uzbekistan is calculated by final electricity demand, transmission losses and private use.

In the case of electricity demand, the total power demand is growing at an average annual growth rate of 3.7% from 54,980 GWh in 2013, and is expected to reach 101,271 GWh in 2030.According to the power development plan of Uzbekenergo JSC, the company will continue to promote the power exports to neighboring countries where the target is to reach 3,600 GWh by 2030. Export of power is mainly to Afghanistan, but some of the power exportsare under plans to be supplied to the northern part of Pakistan in the future. Domestic electric power demand is projected to increase at an average annual growth rate of 3.6% in 2030, resulting in 97,671 GWh. The amount of 75,989 GWh will be consumed in the final sector, and the remaining 21,683 GWh will be supplied for power plant private use and transmission loss. According to the Uzbekenergo JSC’s documents, the average transmission line loss is about 15.7% and power plant private use at an average of 5.1% in the past ten years from 2003 to 2012. From the interviews conducted by Uzbekenergo JSC, it has been revealed that about approximately 16% of the total electric supply is transmission and distribution loss. If this is proven, on the assumption that not seen technology improves, the transmission and distribution loss of 2030 will become 18,279 GWh (15.7%) and power plant private use will become 3,404 GWh (5.1%).

In the final sector, the residential sector will become the maximum electric power demand sector in 2030, and its share will reach 43.1% (32,780 GWh), growing to an average annual rate of 4.9% from 2013 to 2030.It will become the second highest growth rate following the 7.5% rate of the construction sector. In total, the residential sector is the main driving force behind the growth of electric power demand in the country. In terms of the industrial sector, the effects of the industry reform have appeared gradually through a long period of adjustment between 1991 (when the country gained independence) and2007. In recent years, and as as an industrial policy, the government has supported the industrial park construction and a special economic zone to each region of small and medium-sized enterprises. It seems that if such a policy is conducted continuously, the electric power demand in the industrial sector will continue the future. The projection results of this model, and electric power demand in the industrial sector will increase at an average annual rate of 3.6 % and reach 30,883 GWh in 2030.

The transportation and agriculture sector have relatively slow growth in electric power demand. In the agricultural sector, diversification of crop cultivation from cotton as a single crop (based on the Soviet Union regime era) is gradually in transition, and the demand for large-area irrigation water is shrinking. According to the data of the Statistics Division in Food and Agriculture Organization (FAO[5]), the area of Uzbekistan's irrigated agriculture land from 1992 to 2012 has reduced by 66,000 hectares. In the same period, rice and cotton cultivation areas have decreased from 21,000 hectares to 185,000 hectares in synchronization. Electric power demand in the agricultural sector is expected to increase by an average annual rate of 1.0% in 2030, and its share in the final sector will decrease from 7.2 points (20.9%) in 2013 to 13.8% in 2030.In the transportation sector, the electrification of railroads has developed on a national level,but an increase in the demand for electric power is not expected without any new construction plan. Moreover, the number of private vehicles and transport trucks is rapidly increasing, and road transport is becoming more important for economic activity, while the demand of liquid fuel is rapidly increasing.

Table 3.2.1-3 Forecast of Final Electric Power Demand by Sector in Uzbekistan

(Base Case, 2013 - 2030)

Descriptions	Actual (GWh)			Estimating (GWh)				CAGR (%)	
	2005	2010	2013	2015	2020	2025	2030	2020/ 2013	2030/ 2013
(1) Final Sector Consumption	36,972	39,477	41,965	42,603	49,140	59,707	75,989	2.3	3.6
Industry	15,830	15,783	16,942	17,822	20,775	25,002	30,883	3.0	3.6
Construction	130	169	171	254	337	437	583	10.2	7.5
Transportation	1,353	1,193	1,214	1,233	1,255	1,262	1,263	0.5	0.2
Agriculture	9,920	8,592	8,792	8,407	8,956	9,643	10,479	0.3	1.0
Residential	9,466	13,449	14,568	14,887	17,816	23,363	32,780	2.9	4.9
(2) Loss and Own Use	10,515	11,294	11,721	11,774	13,755	16,888	21,683	2.3	3.7
(3) Domestic Demand (1) + (2)	47,487	50,771	53,687	54,377	62,895	76,595	97,671	2.3	3.6
(4) Export	149	843	1,293	1,459	1,971	2,664	3,600	6.2	6.2
(5) Total (3)+(4)	48,301	51,935	54,980	55,835	64,866	79,259	101,271	2.4	3.7
Final Sector by Share (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Industry	43.1	40.3	40.6	41.8	42.3	41.9	40.6		
Construction	0.4	0.4	0.4	0.6	0.7	0.7	0.8		
Transportation	3.7	3.0	2.9	2.9	2.6	2.1	1.7		
Agriculture	27.0	21.9	21.1	19.7	18.2	16.2	13.8		
Residential	25.8	34.3	34.9	34.9	36.3	39.1	43.1		

Source: JICA Study Team

[5] Food and Agriculture Organization of the United Nations, Statistics Division, http://faostat3.fao.org/home/E, accessed 28th April 2015.

In 2013, Navoi Province (6,978 GWh) and Tashkent Province (6,447 GWh) were the regions with the highest demand for electric power in Uzbekistan. The main industries for Uzbekistan such as mining, chemical engineering, building materials production, spinning, and food processing are primarily in the Navoi province. Moreover, the industrial economic special zone,whichwas promoted as the industrial policy of the government has been successful enough to attract the foreign investment in the Navoi industrial zone. Tashkent province has been the center of politicaland economic culture in Uzbekistan for a long time. Most of the industry including energy, chemicals, textiles, and food have gathered in Tashkent Province. The two provinces are expected to continue to be the centers of industry for Uzbekistan in the future in order to lead the increase of electric power demand. In this simulation, the average annual growth rate of electric power demand of both provinces is expected to increase by 4.1% and 3.5% respectively, reaching 13,929 GWh and 11,616 GWh by 2030.

On the other hand, the highest growth rate of electric power demand has been projected in Samarkand Province, Syrdarya Province, Fergana Province, and Khorezm Province of Karakalpakstan. These five provinces are expected to experience a 4.0% increase in demand for electric power. The electric power of these five provinces will mainly be consumed by the residential sector (including the service sector). Except for Fergana Province (57.9%) the share of the other four provinces has accounted for 75% of electricity consumption . In other words, growth in the residential sector of the electric power demand has been the main driving force.

Table 3.2.1-4 Forecast results for Electric Power Demand by Provinces / Regions

(Base Case, 2013 - 2030)

Provinces /Regions	Actual (GWh)			Estimating (GWh)				CAGR (%)	
	2005	2010	2013	2015	2020	2025	2030	2020/ 2013	2030/ 2013
Uzbekistan Total	36,699	39,186	41,687	42,603	49,140	59,707	75,989	2.4	3.6
Karakalpakstan	753	778	877	899	1,070	1,366	1,854	2.9	4.5
Andijan	2,121	1,997	2,142	2,081	2,184	2,477	2,992	0.3	2.0
Bukhara	1,785	2,263	2,403	2,447	2,877	3,463	4,283	2.6	3.5
Jizzakh	1,241	1,239	1,289	1,314	1,479	1,742	2,147	2.0	3.0
Kashkadarya	4,368	4,294	4,691	4,722	5,415	6,380	7,710	2.1	3.0
Navoiy	5,842	6,788	6,978	7,417	8,963	11,070	13,929	3.6	4.1
Namangan	2,154	2,102	2,369	2,386	2,742	3,351	4,334	2.1	3.6
Samarkand	2,249	2,573	2,751	2,817	3,305	4,186	5,670	2.7	4.3
Surkhandarya	1,912	1,831	1,887	1,826	1,953	2,215	2,662	0.5	2.0
Syrdarya	903	909	996	1,018	1,183	1,472	1,965	2.5	4.1
Tashkent	5,946	6,262	6,447	6,668	7,673	9,259	11,616	2.5	3.5
Tashkent City	3,672	3,973	4,472	4,500	4,990	6,026	7,839	1.6	3.4
Fargana	2,861	3,284	3,378	3,481	4,099	5,159	6,877	2.8	4.3
Khorezm	892	892	1,008	1,026	1,207	1,541	2,112	2.6	4.4

Source: JICA Study Team

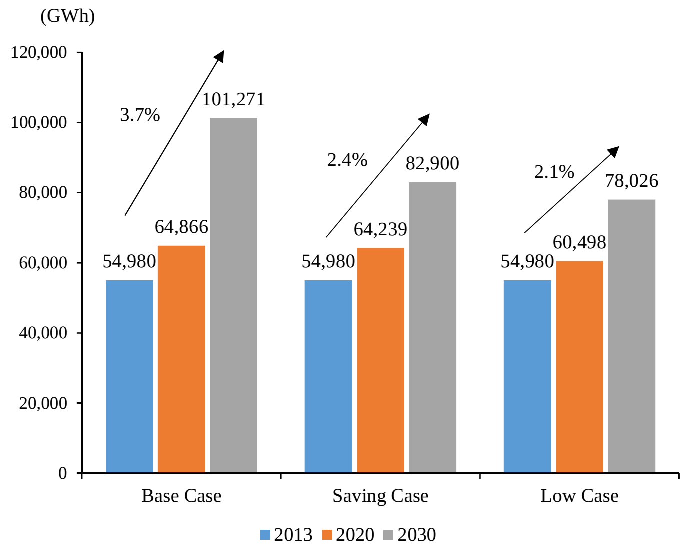
2) Conclusion of the Simulation Result

Figure 3.2.1-2 shows the comparison between the results of the three scenarios. On the basis of these results, the following features have been observed.

① In the base case, the government fiscal expansion policy will maintain high economic growth at 8.1% by 2030. At the same time the demand for electric power will increase at an average annual rate of 3.7% by 2030. The demand for electric power in 2030 will reach 101,270 GWh, which is double that of 2013. Although the GDP elasticity value of the electric power demand of 2013 was abnormally low as 0.35 (the demand for power is not reflected because of the power shortage issue), the value will rise to 0.56 in 2030. It means the relationship between the economic activity and the demand for electric power has become stronger. In the same period, per capita electric power consumption was increased to 2,841 kWh from 1,844 kWh in 2013.

② In the saving case, the growth rate of electric power demand during the forecast period will be loosely 2.4%, if 20% of the energy saving potential of power sector has been reduced. Electric power demand in 2030 has predicted at 82,900 GWh, and if we compare this to the base case amount of 18,371 GWh, then electricity can be saved. In particular, if compared to transmission and distribution losses in developed countries, which is about 6% of total electricity supply, Uzbekistan has high potential on reducing the loss at about 16% at this movement. It also mean that, about 10% reduction can be achieved by improving the transmission and distribution technology.

③ In the low case, electric power demand of Uzbekistan is projected to increase at an average annual rate of 2.1% from 2013to 2030, reaching 78,026 GWh in 2030. This amount of demand at about 77% is compared to the base case of 2030. As a result, the contribution of residential sector is projected more higher than industry sector on electricity demand of Uzbekistan. The demand for electric power for residential sector is projected to increase at an average annual rate of 2.9% by 2030, compared to 1.6% in the industry sector.



Source: JICA Study Team

Figure 3.2.1-2 Simulation Result Comparison by Case (2013, 2020, 2030)

3) Other Simulation Results

Energy Saving Case

Macroeconomic indicator projection results are the same as the base case (see table 3.2.1-2).

Table 3.2.1-5 Forecast of Final Electric Power Demand by Sector in Uzbekistan

(Saving Case, 2013 - 2030)

Descriptions	Actual (GWh)			Estimating (GWh)				CAGR (%)	
	2005	2010	2013	2015	2020	2025	2030	2020/ 2013	2030/ 2013
(1) Final Sector Consumption	36,972	39,477	41,965	43,524	48,650	54,652	61,696	2.1	2.3
Industry	15,830	15,783	16,942	17,580	19,283	21,150	23,198	1.9	1.9
Construction	130	169	171	185	225	273	332	4.0	4.0
Transportation	1,353	1,193	1,214	1,214	1,214	1,214	1,214	0.0	0.0
Agriculture	9,920	8,592	8,792	8,816	8,877	8,939	9,001	0.1	0.1
Residential	9,466	13,449	14,568	15,729	19,051	23,076	27,950	3.9	3.9
(2) Loss and Own Use	10,515	11,294	11,721	12,028	13,618	15,458	17,604	2.2	2.4
(3) Domestic Demand (1) + (2)	47,487	50,771	53,687	55,552	62,268	70,110	79,300	2.1	2.3
(4) Export	149	843	1,293	1,459	1,971	2,664	3,600	6.2	6.2
(5) Total (3)+(4)	48,301	51,935	54,980	57,011	64,239	72,774	82,900	2.2	2.4
Share by Share (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Industry	43.1	40.3	40.6	40.4	39.6	38.7	37.6		
Construction	0.4	0.4	0.4	0.4	0.5	0.5	0.5		
Transportation	3.7	3.0	2.9	2.8	2.5	2.2	2.0		
Agriculture	27.0	21.9	21.1	20.3	18.2	16.4	14.6		
Residential	25.8	34.3	34.9	36.1	39.2	42.2	45.3		

Source: JICA Study Team

Table 3.2.1-6 Forecast results for Electric Power Demand by Provinces / Regions

(Saving Case, 2013 - 2030)

Provinces /Regions	Actual (GWh)			Estimating (GWh)				CAGR (%)	
	2005	2010	2013	2015	2020	2025	2030	2020/ 2013	2030/ 2013
Uzbekistan Total	36,699	39,186	41,687	43,524	48,650	54,652	61,696	2.2	2.3
Karakalpakstan	753	778	877	937	1,110	1,322	1,579	3.4	3.5
Andijan	2,121	1,997	2,142	2,151	2,207	2,304	2,435	0.4	0.8
Bukhara	1,785	2,263	2,403	2,537	2,873	3,221	3,597	2.6	2.4
Jizzakh	1,241	1,239	1,289	1,341	1,481	1,641	1,825	2.0	2.1
Kashkadarya	4,368	4,294	4,691	4,884	5,364	5,855	6,371	1.9	1.8
Navoiy	5,842	6,788	6,978	7,386	8,417	9,486	10,611	2.7	2.5
Namangan	2,154	2,102	2,369	2,473	2,777	3,152	3,611	2.3	2.5
Samarkand	2,249	2,573	2,751	2,911	3,390	3,997	4,753	3.0	3.3
Surkhandarya	1,912	1,831	1,887	1,904	1,977	2,093	2,253	0.7	1.0
Syrdarya	903	909	996	1,049	1,209	1,417	1,682	2.8	3.1
Tashkent	5,946	6,262	6,447	6,698	7,391	8,183	9,088	2.0	2.0
Tashkent City	3,672	3,973	4,472	4,629	5,119	5,757	6,563	1.9	2.3
Fargana	2,861	3,284	3,378	3,559	4,094	4,759	5,576	2.8	3.0
Khorezm	892	892	1,008	1,065	1,239	1,466	1,752	3.0	3.3

Source: JICA Study Team

Low Case

Table 3.2.1-7 Macro Economy Sub-model Simulation Result

(Low Case, 2013 - 2030)

Descriptions	Unit	Actual			Estimating				CAGR (%)	
		2005	2010	2013	2015	2020	2025	2030	2020/ 2013	2030/ 2013
Total Population	Million	26.2	28.6	30.2	31.0	32.9	34.4	35.6	1.2	1.0
GDP Growth (Previous)	%	7.0	8.5	7.0	5.4	5.4	5.6	5.8		
Real GDP (2005 Constant)	Billion Sum	15,923	23,918	29,996	32,993	42,758	55,811	73,687	5.2	5.4
Agriculture	Billion Sum	4,193	5,573	6,953	7,621	9,804	12,719	16,705	5.0	5.3
Industry	Billion Sum	3,371	4,342	5,366	5,802	7,241	9,152	11,747	4.4	4.7
Construction	Billion Sum	771	993	1,228	1,328	1,658	2,097	2,694	4.4	4.7
Service	Billion Sum	1,400	2,499	3,163	3,514	4,650	6,172	8,264	5.7	5.8
transportation	Billion Sum	1,677	2,995	3,792	4,199	5,518	7,286	9,712	5.5	5.7
Others	Billion Sum	4,512	7,516	9,494	10,530	13,887	18,385	24,564	5.6	5.8
GDP by Sector (%)										
Agriculture	%	26.3	23.3	23.2	23.1	22.9	22.8	22.7	-0.2	-0.1
Industry	%	21.2	18.2	17.9	17.6	16.9	16.4	15.9	-0.8	-0.7
Construction	%	4.8	4.2	4.1	4.0	3.9	3.8	3.7	-0.8	-0.7
Service	%	8.8	10.4	10.5	10.7	10.9	11.1	11.2	0.4	0.4
Transportation	%	10.5	12.5	12.6	12.7	12.9	13.1	13.2	0.3	0.2
Others	%	28.3	31.4	31.7	31.9	32.5	32.9	33.3	0.4	0.3
Total	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0		

Source: JICA Study Team

Table 3.2.1-8 Forecast of Final Electric Power Demand of Uzbekistan

(Low Case, 2013 - 2030)

Descriptions	Actual (GWh)			Estimating (GWh)				CAGR (%)	
	2005	2010	2013	2015	2020	2025	2030	2020/ 2013	2030/ 2013
(1) Final Sector Consumption	36,972	39,477	41,965	42,031	45,727	50,952	57,903	1.2	1.9
Industry	15,830	15,783	16,942	17,135	18,439	20,157	22,342	1.2	1.6
Construction	130	169	171	186	217	255	302	3.4	3.4
Transportation	1,353	1,193	1,214	1,233	1,255	1,262	1,263	0.5	0.2
Agriculture	9,920	8,592	8,792	8,693	9,148	9,643	10,191	0.6	0.9
Residential	9,466	13,449	14,568	14,785	16,668	19,636	23,806	1.9	2.9
(2) Loss and Own Use	10,515	11,294	11,721	11,616	12,800	14,412	16,522	1.3	2.0
(3) Domestic Demand (1) + (2)	47,487	50,771	53,687	53,647	58,527	65,364	74,426	1.2	1.9
(4) Export	149	843	1,293	1,459	1,971	2,664	3,600	6.2	6.2
(5) Total (3)+(4)	48,301	51,935	54,980	55,105	60,498	68,028	78,026	1.4	2.1
Share by Sector (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Industry	43.1	40.3	40.6	40.8	40.3	39.6	38.6		
Construction	0.4	0.4	0.4	0.4	0.5	0.5	0.5		
Transportation	3.7	3.0	2.9	2.9	2.7	2.5	2.2		
Agriculture	27.0	21.9	21.1	20.7	20.0	18.9	17.6		
Residential	25.8	34.3	34.9	35.2	36.5	38.5	41.1		

Source: JICA Study Team

Table 3.2.1-9 Forecast results for Electric Power Demand by Provinces / Regions

(Low Case, 2013 - 2030)

Provinces / Regions	Actual (GWh)			Estimating (GWh)				CAGR (%)	
	2005	2010	2013	2015	2020	2025	2030	2020/ 2013	2030/ 2013
Uzbekistan Total	36,699	39,186	41,687	42,031	45,727	50,952	57,903	1.3	1.9
Karakalpakstan	753	778	877	896	1,017	1,189	1,423	2.1	2.9
Andijan	2,121	1,997	2,142	2,061	2,030	2,082	2,201	-0.8	0.2
Bukhara	1,785	2,263	2,403	2,471	2,809	3,197	3,653	2.3	2.5
Jizzakh	1,241	1,239	1,289	1,306	1,411	1,551	1,734	1.3	1.8
Kashkadarya	4,368	4,294	4,691	4,753	5,243	5,820	6,498	1.6	1.9
Navoiy	5,842	6,788	6,978	7,194	8,081	9,119	10,347	2.1	2.3
Namangan	2,154	2,102	2,369	2,383	2,607	2,932	3,375	1.4	2.1
Samarkand	2,249	2,573	2,751	2,787	3,086	3,546	4,197	1.7	2.5
Surkhandarya	1,912	1,831	1,887	1,846	1,903	2,018	2,195	0.1	0.9
Syrdarya	903	909	996	1,015	1,126	1,289	1,518	1.8	2.5
Tashkent	5,946	6,262	6,447	6,478	6,937	7,609	8,510	1.1	1.6
Tashkent City	3,672	3,973	4,472	4,409	4,594	5,023	5,703	0.4	1.4
Fargana	2,861	3,284	3,378	3,417	3,763	4,284	5,013	1.6	2.3
Khorezm	892	892	1,008	1,016	1,122	1,292	1,537	1.5	2.5

Source: JICA Study Team

(5) Electric power demand applied in the power development plan

For future electric power demand applied in the power development plan, we adopted the base case demand forecast from the above-mentioned power demand forecasts. Table 3.2.1-10 shows a comparison of the base case power demand forecast made in this study and that made by Uzbekenergo JSC.

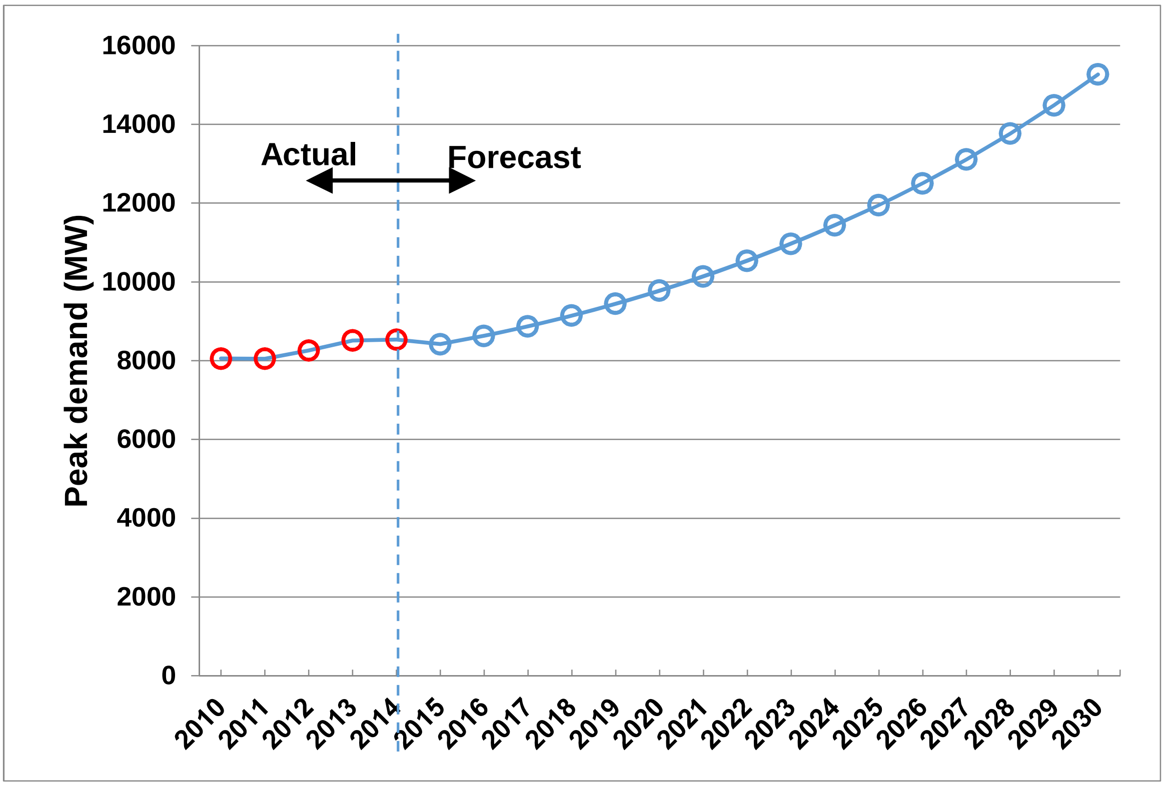
Table 3.2.1-10 Comparison of Power Demand Forecast

(Unit: GW/h)

Year	2015	2020	2025	2030
Uzbekenergo JSC	59,800	71,800	86,800	106,800
JICA Study Team (base load)	55,835	64,866	79,259	101,271

Source: JICA Study Team

In contrast to the demand forecast shown in Table 3.2.1-10 the peak power must be calculated by applying the load factor (0.757), which will be described later. The Figure 3.2.1-3 shows the peak demand forecast.

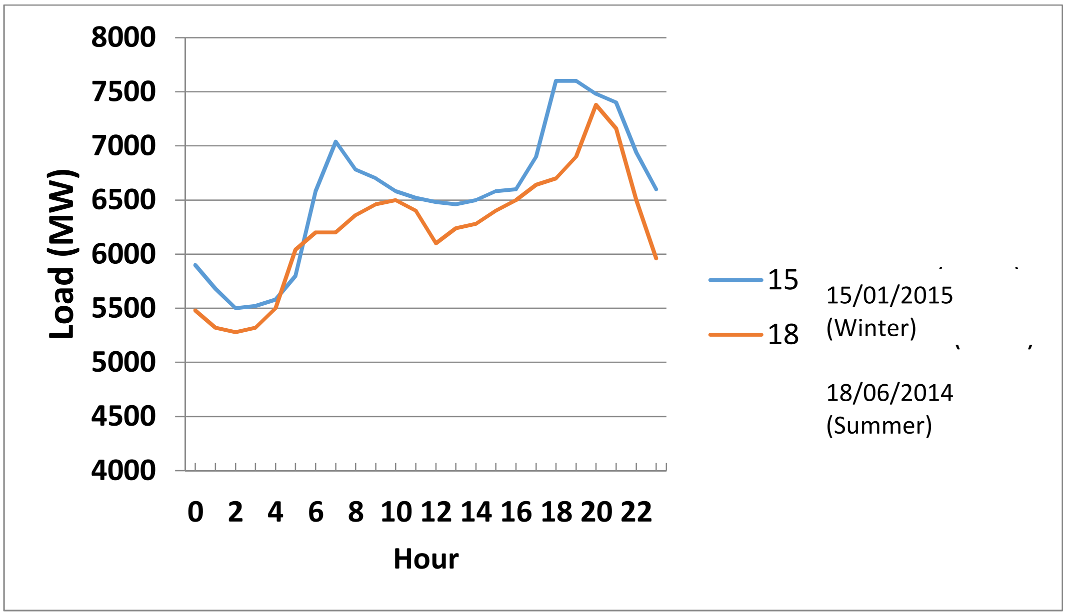


Source: JICA Study Team

Figure 3.2.1-3 Peak Demand Forecast.

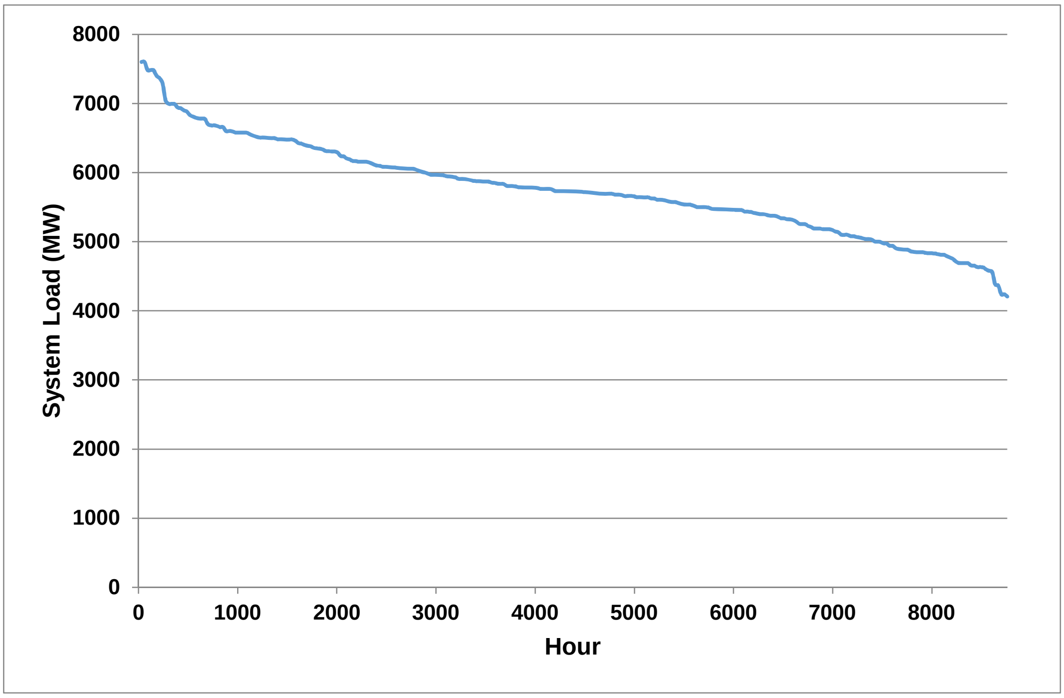
3.2.2 Load duration curve

As data on the load duration curve is not available, the curve has been estimated based on the latest summer and winter period representative daily load curve and monthly power consumption levels. Figure 3.2.2-1 shows representative summer and winter daily load curves, while Figure 3.2.2-2 shows the load duration curve. The load factor for power systems in Uzbekistan is assumed to be 0.757, as calculated from the load duration curve in Figure 3.2.2-2.



Source: Uzbekenergo JSC

Figure 3.2.2-1 Daily Load for Typical Summer and Winter Day



Source: Prepared by the Study Team

Figure 3.2.2-2 Load Duration Curve of Uzbekistan Power System (as proposed by the Study Team)

3.2.3 Supply reliability

The loss of load probability (LOLP) is used as an indicator to evaluate power supply reliability and a power development plan is developed that will have sufficient reserve power to fill the targeted LOLP. LOLP is widely used worldwide as a power supply reliability standard. In the USA (NERC: North American Electric Reliability Corporation), it is one day per decade, in Asian countries, in Indonesia (PLN) – 1 day per year, in Sri Lanka (CEB: Ceylon Electricity Board) – 3 days per year. If we take the GDP per capita as an indicator of the economic level, in Uzbekistan it is 2,046 USD (IMF estimate, 2014, nominal), in Indonesia 3,534 USD (same), in Sri Lanka 3,818 USD (same). Based on a comparison among countries with similar economic levels, it was decided to assume LOLP for Uzbekistan at two days per year. As Uzbekistan's power system is connected with that of Russia via Kazakhstan and also with neighboring Kyrgyzstan, the interconnected system is expected to facilitate adjustment of demand and supply and frequencies. Adjustment of demand and supply and frequencies is currently performed by linking the power system with Russia, Kazakhstan and Kyrgyzstan.

3.2.4 Power sources determined for development

Table 3.2.4-1 shows seven projects that have started at power sources determined for development. Over the next five years, it will be difficult to develop new power sources other than those where works have started or are currently being planned and the sources in the Uzbekenergo JSC Power Development Plan covering the period up to 2020 are called power sources determined for development. As for the development plans for power plants using renewable energy sources such as solar and wind energy, the Power Development Plan developed by Uzbekenergo JSC will be used in this study as it reflects the official energy policy.

Table 3.2.4-1 Power plant construction: projects already under way

Plant name	Capacity (MW), type	Expected year of commissioning	Source of funding
Syrdarya TPP	50 MW steam turbine	2014	UFRD
Tashkent TPP	370 MW GTCC	2015	UFRD, Uzbekenergo JSC's own funds, local banks, foreign investors
Talimarjan TPP	900 MW GTCC （450 MW×2）	2016	UFRD, ADB, JICA, Uzbekenergo JSC's own funds, public capital
Angren TPP	130−150 MW steam turbine	2016	China's credit for SCO member-countries, Uzbekenergo JSC's own funds
Navoi TPP-2	450 MW GTCC	2017	UFRD, JICA, Uzbekenergo JSC's own funds
Turakurgan TPP	900 MW GTCC （450 MW×2）	2017	UFRD, JICA, Uzbekenergo JSC's own funds
Takhiatash TPP	250 MW×2 units GTCC	2020	UFRD, ADB, Uzbekenergo JSC's own funds
Tashkent CHP	30MW× 4 units GTCS	2020	UFRD, JICA, Uzbekenergo JSC's own funds

Source: Uzbekenergo JSC

3.2.5 Existing power plants decommissioning plan

Existing power plants will be discontinued according to the plan shown in Table 3.2.5-1 "Existing Uzbekenergo JSC plants decommission plan".

Table 3.2.5-1 SJSC Uzbekenergo JSC – Existing plants decommission plan

	Power unit	Commissioning Year	Installed capacity (MW)	Proposed year for decommissioning															
				2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tashkent TPP	1	1963	150												Decom.				
	2	1964	150												Decom.				
	3	1965	150										Decom.						
	4	1965	150										Decom.						
	5	1966	150									Decom.							
	6	1967	155									Decom.							
	7	1967	165								Decom.								
	8	1968	165								Decom.								
	9	1969	150						Decom.										
	10	1970	165						Decom.										
	11	1970	155				Decom.												
	12	1971	155				Decom.												
Navoi TPP	3	1964	150					Decom.											
	4	1965	150					Decom.											
	8	1968	160																Decom.
	9	1969	160																Decom.
	11	1980	210																
	12	1981	210																
	1	1963	25	Decom.															
	2	1963	25					Decom.											
	5	1966	50							Decom.									
	6	1967	60							Decom.									
	7	1971	50							Decom.									
Takhiatash TPP	1	1967	100							Decom.									
	2	1968	100							Decom.									
	3	1974	110							Decom.									
Angren TPP	1	1957	52.5			Decom.													
	2	1958	54.5			Decom.													
	3	1958	53			Decom.													
	4	1958	52			Decom.													
	5	1960	68						Decom.										
	6	1961	68						Decom.										
	7	1962	68						Decom.										
	8	1963	68						Decom.										

Source: Uzbekenergo JSC

3.2.6 Power sources proposed for development

The thermal power plants considered as development candidates in the development plans in this study are those for which fuel can be procured from within Uzbekistan and Table 3.2.6-1 shows information on the gas turbine combined cycle, coal-firing and simple cycle gas turbine plants already introduced. As for the basic characteristics of thermal power plants, proposed as development candidates, GTCC is assumed to be similar to those of 450MW class which are being introduced in Uzbekistan. As for the others, the characteristics have been set on the basis of data from Gas turbine world and U.S. Department Of Energy, U.S. Energy Information Administration[6], and Power Development Master Plans of other countries[7].

The candidates for hydropower development based on existing plans are shown in Table 3.2.6-2. As shown in Figure 3.1-1, these various conditions are put into Module-2 FIXSYS, Module-3 VARYSYS of WASP and the combination of development candidates with minimal cost is calculated.

Table 3.2.6-1 Basic Characteristics of thermal power plants, proposed as development candidates

Type	Capacity of one unit	Type	Heat rate (kCal/kW/h)	Heat efficiency	Environmental measures		Construction cost (USD/kW)	Construction phase	Operating life
					Denitration	Desulfurization			
Combined cycle	450 MW	1300 °C Class GT	1,616	53.2%	Yes	No	900	2 years	20 years
Simple cycle gas turbines	140 MW	1100°C Class GT	2,845	30.2%	No	No	900	1 year	20 years
Coal-fired thermal power plants	150 MW	Subcritical	2,115	40.7%	Yes	Yes	2,000	3 years	25 years
	300 MW	High-efficiency, Subcritical	2,050	42.0%	Yes	Yes	2,000	3 years	25 years

Source: JICA Study Team

[6]U.S. Energy Information Administration (April 2013) "Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants"
[7]JICA (March, 2014) " The Project for Formulation of Power System Master Plan in Dar es Salaam and Review of Power System Master Plan"

Table 3.2.6-2 Basic characteristics of hydropower plants, proposed as development candidates

Name of plant	Type	Installed capacity (MW)	Construction cost (USD, kW)
Kamolot HPP	Dam	8 MW	1,512.5
Irgailiksai HPP	Dam	13,6 MW	1,838.2
Nijne-Koksu HPP	Dam	20 MW	2,500.0
Nijne-Chatkal HPP	Dam	100 MW	1,055.0
Khodjikent pumped-storage HPP	Pumped storage	200 MW	1,600.0
Mullalak HPP	Dam	240 MW	1,973.8
Akbulak HPP	Dam	60 MW	1,046.7
Pskem HPP	Dam	404 MW	2,072.3

Source: Uzbekenergo JSC

3.2.7 Fuel price

Selling prices of the second half of 2014 targeted at Uzbekenergo JSC are used as fuel prices for economic calculations in power development plans.

Table 3.2.7-1 Fuel prices

Fuel type	Heat value	Price	Price per unit of heat released
Natural gas	8,200 kCal/Nm³ (normal cubic meters)	181, 620 UZS/1,000 m³	22.1 UZS/MCal*
Coal (lignite)	1,911 kCal/kg	115, 700 UZS/ton	60.5 UZS/MCal*

Source: Uzbekenergo JSC
Note*: M (Mega) –10^6, MCal = 10^6 Cal = 1000 kCal

3.3 Power development scenarios

The following three scenarios were set and a power development plan for each scenario with minimum cost was formulated using WASP:

- Scenario 1: Optimizing Power Development Plan up to 2030 made by Uzbekenergo JSC using WASP.
- Scenario 2: Adding more coal-fired thermal power plants to Scenario 1 (adding 1,500 MW of coal-fired power generation).
- Scenario 3: Adding a pumped-storage hydropower plant to Scenario 1 (adding 200 MW at Khodjikent HPP).

As for Scenario 1, despite the fact Uzbekenergo JSC has already developed a power development plan for this period up to 2030, considering the fact this plan is focused solely on the demand and supply balance and not optimized in terms of minimizing costs and ensuring power supply reliability, it has been decided to optimize this plan within this study using WASP.

As for Scenario 2, considering the fact that natural gas in Uzbekistan is also used for purposes other than power generation, this scenario suggests using alternative fuels for electric power generation. Uzbekenergo JSC has included plans to develop coal-fired power plants with capacity 150 MWx2, 300 MWx1 into its power development plan up to 2030. To verify the impact of further development of such coal-fired power plants on power supply costs, a scenario has been developed that includes even more such plants.

As for Scenario 3, although the power development plan developed by Uzbekenergo JSC includes a plan to construct a pumped-storage hydroelectric power plant, it has been impossible to define the economic benefits of this plant and a scenario has been developed including development of such a plant to compare with other scenarios and define the economic potential.

3.4 Result of WASP simulation

3.4.1 Comparison of the economic efficiency of power development scenarios

Table 3.4.1-1 shows the calculation results of total power generation costs for each scenario. Total power generation costs are equal to the sum of power plants construction costs, the costs of technical maintenance during the operation period and fuel for the target 16-year period from 2015 until 2030. The future prices are shown in the Net Present Value using a discount coefficient of 10 %. Consequently, Scenario 1 has the lowest level of total power generation costs.

However, in Scenarios 2 and 3, unlike Scenario 1, it is possible to reduce the consumption of natural gas and export this saved gas at a price four times higher than the domestic one. Such economic benefit is also worthy of consideration.

As shown in Table 3.4.1-2, the economic benefit of reducing natural gas consumption, if compared to Scenario 1, is 380 million USD in Scenario 2 and 8 million USD in Scenario 3, but the increased total power generation cost is 1,660 million for Scenario 2 and 157 million USD for Scenario 3, which largely exceeds the benefit of gas consumption reduction.

Accordingly, Scenario 1, with the lowest total power generation costs, has been identified as the most economically beneficial[8].

Table 3.4.1-1 Comparison of power development scenarios

	Scenario 1	Scenario 2	Scenario 3
Outline of scenario	Gas, coal and hydro are balanced	More coal than Scenario 1	With pumped-storage hydro
Total generation cost (up to 2030)	$37,811 million	$39,471 million	$37,968 million
Energy balance (Energy share in 2030)	Gas: 76.8 % Coal: 12.6 % Hydro: 9.8 % Renewable: 0.8 %	Gas: 68.1 % Coal: 21.4 % Hydro: 9.8 % Renewable: 0.8 %	Gas: 76.7 % Coal: 12.6 % Hydro: 9.9 % Renewable: 0.8 %
Capacity share (MW and %)	Gas: 14,760 (71 %) Coal: 2,700 (13 %) Hydro: 2,653 (13 %) Renewable: 700 (3.4 %)	Gas: 13,270 (64 %) Coal: 4,200 (20 %) Hydro: 2,653 (13 %) Renewable: 700 (3.4 %)	Gas: 14,760 (70 %) Coal: 2,700 (13 %) Hydro: 2,853 (14 %) Renewable: 700 (3.4 %)

Source: JICA Study Team

Table 3.4.1-2 Economic comparison of power development scenarios

	Scenario 1	Scenario 2 (more coal)	Scenario 3 (with pumped-storage hydro)
Natural gas consumption (2015-30, million ton)	150.62 (Base)	147.17 (Δ 3.75)	150.56 (Δ 0.06)
Cumulative natural gas cost (2015-30, million US$)	14,683 (Base)	14,348 (Δ 335)	14,678 (Δ 5)
Economic benefit of gas saving*1 (million US$)	Base	380	8
Total generation cost*2 (million US$)	37,811 (Base)	39,471 (+1,660)	37,968 (+157)

Source: JICA Study Team

Note: *1: Assuming export of saved gas, the economic benefit was calculated based on the export price: Economic benefit of gas saving = Saved quantity of gas x export gas price

*2: Future benefit is discounted to obtain the Net Present Value (NPV) using a discount rate of 10 %. The total generation cost comprises construction cost, operation and maintenance cost and fuel cost.

Scenario 3 which includes a pumped-storage hydroelectric power plant is not optimal from the economical point of view. However, below we will explain the necessity of pumped-storage hydroelectric power plants for the Uzbekistan electric power system from an operational aspect, especially in terms of their adjustment function. Pumped-storage hydroelectric power plants are needed in conditions such as increased peak power demand, a

[8]The calorific value of bituminous coal quoted at world markets is 6,000kcal/kg, while the calorific value of Uzbekistan coal is about 1,900kcal/kg which is three times less. So, from the standpoint of fuel cost per unit calorific value, coal in Uzbekistan can not compete with gas. As a result, Scenario 1 with large share of gas-fired power plants becomes the most economical scenario.

cheap base load hydroelectric power plant that can become a resource for the pumped-storage power plan and when the cost of power generated at the peak power station exceeds that of power generated at the pumped-storage power plant. As the pumped-storage power plants feature rapid output adjustment and operations can be started/stopped within several minutes, they are used as momentary (hot) reserve and as phase adjustment and frequency control function and help stabilize the power supply system.

Nothing indicates that in Uzbekistan, where the load coefficient is about 75 %, the peak load is increasing. Moreover, as the peak power is generated at reservoir-type power plants, the cost of generating peak power remains low and since Uzbekistan's power grid is linked with Russia's via Kazakhstan and thanks to the larger-scale power grid in Russia, adjustment function can be expected.

The power system adjustment basically includes two functions: frequency control and supply-demand balance. Table 3.4.1-3 shows the types of power system adjustment, while Table 3.4.1-4 shows types of power reserve. The pumped-storage hydroelectric power plants play the role of hot reserve, which contributes to frequency regulation and supply-demand balance.

Table 3.4.1-3 Types of power system adjustment

Time	Power supply-demand fluctuation factors	Types of reserves	Types of adjustment
Short-time ↓ Long-time	• Momentary power supply-demand fluctuation • Power source dropout (momentary response) • Power supply-demand fluctuation due to weather conditions • Error in power supply-demand estimates • Power source troubles (continuous response) • Drought, unscheduled shutdown of power generating unit • Power supply-demand fluctuation due to economic fluctuations	Spinning Reserve Hot Reserve Cold Reserve	Frequency control Power supply-demand balance regulation

Source: Materials of the second meeting of Committee on power adjustment function (June, 2015), "Principles of adjustment function securing and situation regarding supply-demand balance and frequency regulation (prepared by Chubu Electric Power Co., Inc.)"

Table 3.4.1-4 Types of power reserve

Type	Function	Equipment
Spinning Reserve	Starts operation immediately in case of decrease in power system frequency due to load fluctuation and power source dropout, increases the power output (within 10 seconds), ensures continuous automatic power generation till Hot Reserve is put into action.	■ Reserve capacity of governor-free [9] generator operated in partial load mode
Hot Reserve	Power generating units operated in synchronization mode, and units which can be put into action in a short time (within 10 minutes), take over a load, and ensure continuous automatic power generation till Cold Reserve is put into action and takes over a load.	■ Reserve capacity of generator operated in partial load mode ■ **Shutdown or standby hydroelectric power plants**, gas turbines
Cold Reserve	The reserve which requires several hours from start till synchronization and taking over a load.	■ Shutdown or standby thermal power plants

Source: Materials of the second meeting of Committee on power adjustment function (June, 2015), ”Principles of adjustment function securing and situation regarding supply-demand balance and frequency regulation (prepared by Chubu Electric Power Co., Inc.)”

Besides pumped-storage hydroelectric power plants, reserve capacity of generators operated in partial load mode and hydroelectric power plants are used as hot reserve. At the present time in Uzbekistan steam-power generation makes up most of power generation[10]. Steam-power generation units are operated in partial load mode as hot reserve to regulate the power supply-demand balance. As shown in Table 3.4.1-5, steam-power generation units have a wide power output adjustment range. However, the power output change rate is low, and the start-up time is long. On the other hand, as compared to steam-power generation in the case of combined cycle power generation, the power output change rate is high and the start-up time is short. Thus, combined cycle power generation units have high readiness as hot reserves.

In Japan the minimum required hot reserve is 8 % of the maximum expected demand. This value is the sum of error in power supply-demand estimates (5 %) or the largest unit capacity, and short-time demand fluctuations (3 %).

In Uzbekistan the peak power demand in winter of 2020 is forecasted at 9,782 MW, so if hot reserve is assumed to be 8 %, the required hot reserve capacity will constitute 783 MW. In the winter of 2020, available hydroelectric power generation capacity will be 609 MW If about 50 % of this capacity would be used as hot reserve, the remaining 300 MW of hot reserve will be ensured by partial load of operating TPPs. Accordingly, the plans of Uzbekenergo JSC, Navoi-2, Talimardjan, Turakurgan, Tachiatash and other GTCCs will be gradually introduced by 2020.Therefore, installed capacity of GTCC is expected to constitute

[9] Governor-free operation: in order to maintain the generator rotation speed constant regardless of load, depending on the changes in system frequency the generator output is increased or decreased by the governor which automatically controls the volume of working fluid (steam, water).

[10] In 2015 the installed capacity constituted 11,761 MW, of which 9,530 MW (81%) is steam-power generation, 450MW (4%) is combined cycle power generation, and 1,755 MW (15%) is hydroelectric power generation.

4,470 MW. If 300 MW of this capacity is ensured by partial load, the GTCC would be operated at about 93 % rate of capacity. This is considered to be an affordable level for actual operation. Therefore, a necessary regulation function is expected to be ensured by a GTCC governor-free operation and using GTCC as hot reserve without pumped-storage hydroelectric power plants.

Table 3.4.1-5 Power output adjustment range and power output change rate at TPP

Power generation method	Steam-power generation						Combined cycle
Type	Subcritical, drum boiler (350,000 kW class)			Supercritical, once-through boiler (700,000 kW class)			1,300°C class or higher Single-shaft 350,000 kW class
Fuel type	Oil	Gas	Coal	Oil	Gas	Coal	Gas
Governor-free operation	◎	◎	◎	◎	◎	◎	◎
LFC	◎	◎	◎	◎	◎	◎	◎
Power output adjustment capacity	○	◎	○	◎	◎	○	Single-shaft : ○ Sequence : ◎
Power output adjustment range	30-100 %	20-100 %	30-100 %	15-100 %	15-100 %	30-100 %	Single-shaft : 50 to 100% Sequence : 20 to 100%
Power output change rate	3 %/min	3 %/min	1 %/min	5 %/min	5 %/min	3 %/min	10 %/min
Start-up time: WSS	20-30 hours			30-40 hours			12 hours
Start-up time: DSS	3-5 hours			5-10 hours			1 hour 0.5 hours till synchronization

Source: Seminar on Low-carbon power supply system (July, 2009), seminar report "Toward construction of Low-carbon power supply system"

Legend: ◎Excellent, ○: Good

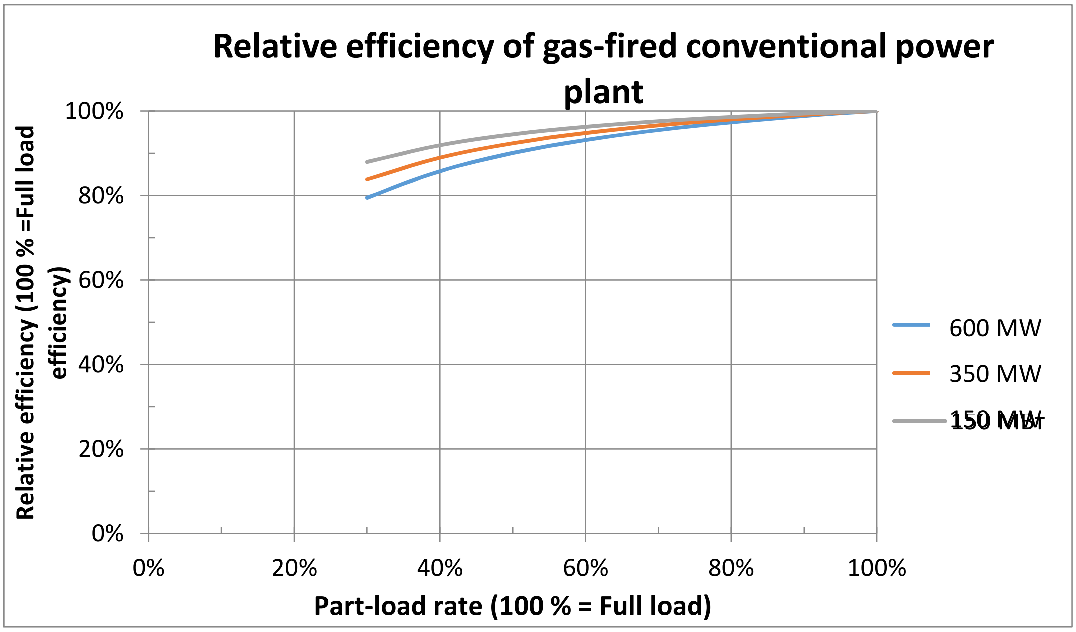
Notes:

DSS (DailyStart and Stop): power generating unit is shut down in nighttime when power demand is low, and start up in the next morning.

WSS (Weekly Start and Stop): power generating unit is shut down in the weekend when power demand is low, and start up in the beginning of the next week.

Start-up time for WSS is time in case of cold start of power generating unit.

The main objective for Uzbekenergo JSC to plan construction of a pumped-storage power plant is to raise the load factor of gas-fired thermal plants and improve the heat efficiency. Usual efficiency of gas-fired conventional thermal plant with partial load is shown in Figure 3.4.1-1. Decrease in efficiency under partial load at conventional thermal plants differs due to unit capacity but at the lowest load is about 10–20 % lower than the nominal efficiency. However, as pumped-storage power plant efficiency is about 70 %, even if the operation of such plant can help boost the load ration at a gas-fired thermal plant and increase its efficiency by 10-20 %, there will be a 30 % loss at the pumped-storage plant, meaning no economic benefit can be obtained.



Source: Kiyono Keiko, Yoji Uchiyama "Economic benefits of the load using energy-storage technologies", Journal "Power sector economic research", No. 24, January, 1988.

Figure 3.4.1-1 Part-load Relative Efficiency of Gas-fired Conventional Power Plant

3.4.2 Gas consumption for power generation

Table 3.4.2-1 shows amount of gas for power generation needed in each development scenario. By 2030 Scenario 2 will help decrease gas consumption by 10 % compared to Scenario 1 and Scenario 3 – by 1 %.

Table 3.4.2-1 Natural gas consumption for each power development scenario

Unit: million Nm³/kW

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Scenario 1	10,948	10,708	11,164	11,033	11,109	11,479	11,266	11,499	12,129	12,211	12,848	13,385	14,070	14,888	15,426	16,321
Scenario 2	10,948	10,708	11,164	11,033	11,109	11,479	11,266	11,499	12,129	12,211	12,848	13,484	13,414	13,842	14,059	14,704
Scenario 3	10,948	10,708	11,164	11,033	11,109	11,479	11,266	11,499	12,129	12,211	12,835	13,371	14,055	14,872	15,414	16,310

Source: JICA Study Team

As for gas consumption per unit of electric energy, it will decrease from 0.291 Nm³/kW/h in 2015 to 0.21 Nm³/kW/h in 2030 in each scenario, which is about 70 % of the 2015 level.

Table 3.4.2-2 Gas consumption per unit of electric energy for each power development scenario

Unit: million Nm³/kW

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Scenario 1	0.291	0.281	0.272	0.264	0.248	0.236	0.225	0.218	0.219	0.216	0.215	0.210	0.211	0.210	0.208	0.206
Scenario 2	0.291	0.281	0.272	0.264	0.248	0.236	0.225	0.218	0.219	0.216	0.215	0.212	0.212	0.211	0.210	0.208
Scenario 3	0.291	0.281	0.272	0.264	0.248	0.236	0.225	0.218	0.219	0.216	0.215	0.210	0.211	0.210	0.207	0.205

Source: JICA Study Team

Regarding the decrease in gas consumption due to more efficient coal-fired power plants, the decreased amount compared to the 2015 levels of gas consumption per unit of electric energy is shown in Table 3.4.2-3. Following the replacement of aging gas-fired thermal plants with the latest combined cycle plants the total decrease in gas consumption from 2015 till 2030 is estimated at 55,900 million Nm^3 for Scenario 1, 53,200 Nm^3 for Scenario 2 and 55,900 Nm^3 for Scenario 3 respectively. Basic characteristics of newly constructed GTCCs are shown in Table 3.2.6-1, year of commissioning is specified in power development plan shown in Table 3.5-1. Heat efficiency of newly constructed GTCCs is 53 %, while heat efficiency of existing aging gas-fired thermal plants is about 20-30 %.

Table 3.4.2-3 Volume of gas saved for each power development scenario (comparison with Base mode in 2015)

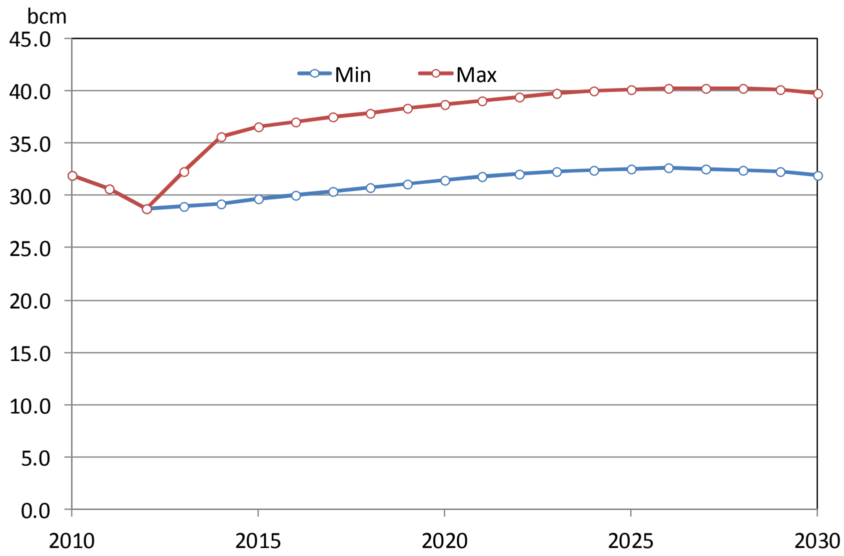
Unit: million Nm^3/kW

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Scenario 1	0	384	752	1,127	1,919	2,644	3,291	3,835	3,997	4,202	4,550	5,122	5,337	5,744	6,181	6,768
Scenario 2	0	384	752	1,127	1,919	2,644	3,291	3,835	3,997	4,202	4,550	5,009	4,947	5,225	5,448	5,841
Scenario 3	0	384	752	1,127	1,919	2,644	3,291	3,835	3,997	4,202	4,564	5,135	5,353	5,761	6,196	6,782

Source: JICA Study Team

3.5 Evaluation of Power Development Concept

After comparing the abovementioned electricity development scenarios, Scenario 1 was evaluated as the most economic, despite having the largest consumption of natural gas among all three scenarios. In Chapter 2 of this report, which explains the fuel supply plan, Figure 3.5-1 shows the amount of natural gas that can be provided for generating and exporting electric power in the period up to 2030. According to Figure 3.5-1, as much as 32 billion m^3 of natural gas can be supplied in 2030 and as this is almost double the consumption from Scenario 1 (16,321 billion m^3), it can be assumed that there will be no problem with supplying natural gas to generate electric power. Table 6.1.4-3 of Chapter 6 shows the comparison of 3 scenarios including zero option. Considering environmental and social considerations there is also no particular problem with Scenario 1. Based on the above power development plan, Scenario 1 is recommended as optimal.



Source: JICA Study Team

Figure 3.5-1 Volume of possible natural gas supply for power generation and export

The yearly power development plan based on Scenario 1 and that developed by Uzbekenergo JSC are shown in Table 3.5-1. In Scenario 1, unlike the plan by Uzbekenergo JSC, the launch of new power sources is leveled and the total generated by 2030 power is less by 510 MW.

In Uzbekistan's energy industry, decommissioning old thermal power plants and replacing them with new and highly effective GTCC is an urgent task from the perspective of energy saving and using natural gas efficiently. A simulation by WASP has shown that the cheapest development pattern requires the launch of many GTCC plants but moving to highly effective power plants is meaningful, not only from an energy-saving perspective but also for economic reasons.

Table 3.5-1 Comparison of Power Development Plans

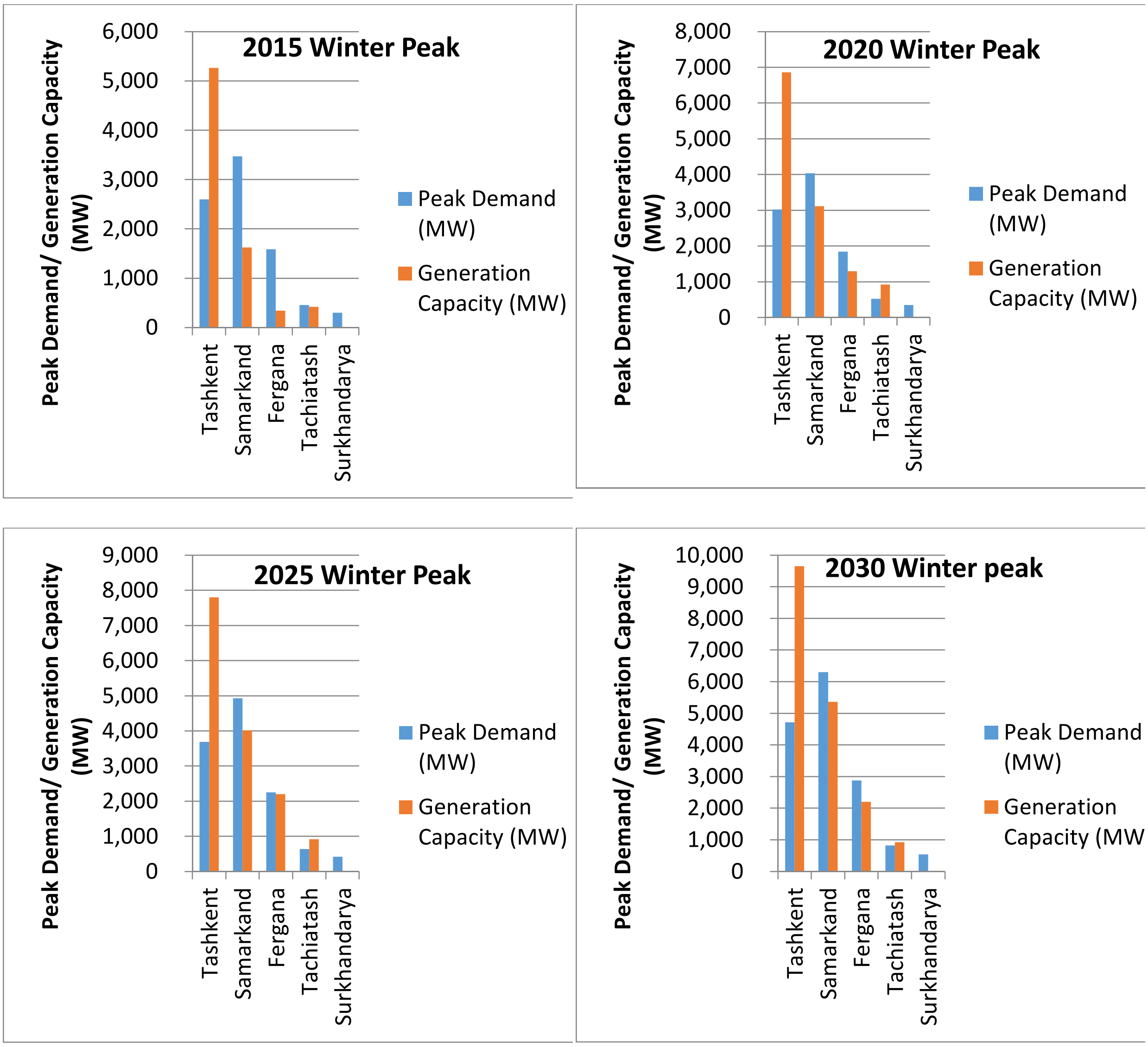
1. Uzbekenergo's Generation Expansion Plan Unit: MW

Year	Plant name	GTCC	Coal	GTCS	Hydro	Other	Total
2015	Sirdarya (Rehabilitation)					50	50
2016	Talimardjan GTCC-1	450					970
	Tashkent GTCC-1	370					
	Angren-9		150				
2017	Talimardjan GTCC-2	450					1,358
	Navoi GTCC-2	450					
	Turakurgan-1	450					
	Kamolot Hydro				8		
2018	Turakurgan-2	450					1,066
	New Sirdarya-1	450					
	Fergana CHPP			57.7			
	TashTETs-2			108			
2019	Tachiatash GTCC-1	250					840
	New Sirdarya-2	450					
	Mubarek CHPP			140			
2020	Tachiatash GTCC-2	250					304
	TashTETs (Expansion)			54			
2021	Talimardjan GTCC-3	450					1,500
	Navoi GTCC-3	450					
	Angren-10		150				
	Turakurgan-3	450					
2022	Talimardjan GTCC-4	450					914
	Turakurgan-4	450					
	Irgailiksai Hydro				13.6		
2023	Nijnekoksuiskaya Hydro				20		20
2024	Tashkent GTCC-2	450					850
	Novo-Angren-8		300				
	Nijnechatkal Hydro				100		
2025	Tashkent GTCC-3	450					650
	Hodjikentskaya Pumped-storage				200		
2026	Tashkent GTCC-4	450					450
2027	Tashkent GTCC-5	450					690
	Mullalakskaya Hydro				240		
2028	Tashkent GTCC-6	450					510
	Akbulakskaya Hydro				60		
2029	Talimardjan GTCC-5	450					854
	Pskemskaya Hydro				404		
2030	Talimardjan GTCC-6	450					900
	Tashkent GTCC-7	450					
Total		9,870	600	360	1,046	50	11,925

2. JICA Study (Scenario-1) Unit: MW

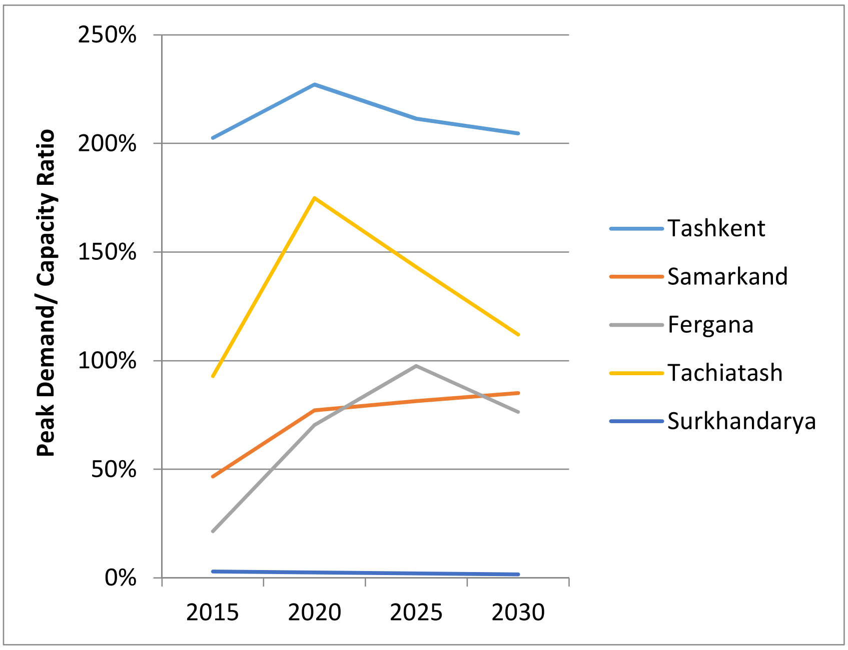
Year	Plant name	GTCC	Coal	GTCS	Hydro	Other	Total	1. - 2. Difference
2015	Sirdarya (Rehabilitation)					50	50	0
2016	Talimardjan GTCC-1	450					970	0
	Tashkent GTCC-1	370						
	Angren-9		150					
2017	Talimardjan GTCC-2	450					1,358	0
	Navoi GTCC-2	450						
	Turakurgan-1	450						
	Kamolot Hydro				8			
2018	Turakurgan-2	450					1,066	0
	New Sirdarya-1	450						
	Fergana CHPP			57.7				
	TashTETs-2			108				
2019	Tachiatash GTCC-1	250					840	0
	New Sirdarya-2	450						
	Mubarek CHPP			140				
2020	Tachiatash GTCC-2	250					304	0
	TashTETs (Expansion)			54				
2021	Angren-10		150				600	900
	Turakurgan-3	450						
2022	Navoi GTCC-3	450					914	0
	Turakurgan-4	450						
	Irgailiksai Hydro				13.6			
2023	Nijnekoksuiskaya Hydro				20		20	0
2024	Tashkent GTCC-2	450					850	0
	Novo-Angren-8		300					
	Nijnechatkal Hydro				100			
2025	Talimardjan GTCC-3	450					450	200
2026	Tashkent GTCC-3	450					900	-450
	Talimardjan GTCC-4	450						
2027	Mullalakskaya Hydro				240		240	450
2028	Tashkent GTCC-4	450					510	0
	Akbulakskaya Hydro				60			
2029	Talimardjan GTCC-5	450					1,444	-590
	Tashkent GTCC-5	450						
	Tashkent (GT)					140		
	Pskemskaya Hydro				404			
2030	Talimardjan GTCC-6	450					900	0
	Tashkent GTCC-6	450						
Total		9,420	600	360	846	190	11,415	510
Difference (1. - 2.)		450	0	0	200	-140		

Figure 3.5-2 shows a comparison of peak demand per region and production levels and the ratio of peak demand per region to production is shown in Figure 3.5-3. In the current year, 2015, in the Samarkand and Fergana regions, demand for electric power largely exceeds production, but as the power industry develops, any imbalance between demand and production levels will ease.



Source: JICA Study Team

Figure 3.5-2 Comparison of peak demand by regions and volume of generated capacity



Source: JICA Study Team

Figure 3.5-3 Peak demand/generation capacity ratio by regions

3.6 Review of Power Development Concept

We have reviewed projects of Uzbekenergo JSC on Talimardjan-3, 4 expansion, Navoi TPP unit №3 (expansion), Turakurgan-3, 4 expansion, Sirdarya (GTCC)-3, 4 expansion from the standpoint of minimum cost plan and power supply-demand balance by regions developed by WASP. The results of review are shown in Table 3.6-1.

As for Talimardjan-3, 4, Navoi-3, Turakurgan-3, 4 expansion projects, it is recommended to delay the launching time. In the case of Uzbekenergo JSC's power development concept (Table 3.1-1)(as shown in Figure 3.6-1) the LOLP, which is the indicator of power supply reliability, will be much below the target level of 2 days per year, i.e. the power supply reliability level will exceed the target level, and excess in installed capacity will occur. Figure 3.6-2 shows the addition of generation capacity for each year between 2021 and 2030. According to Uzbekenergo JSC's plan, 1,500 MW power sources will be launched in 2021 which is 900 MW more than that of the optimum plan from the JICA review. The JICA review plan is a power development concept selected through WASP, which satisfies the power supply reliability needs and requires little cost. By carrying out power development in accordance with this plan, the burden of capital investment can be eased.

In case the volume of power sources to be launched in 2021 (according to Uzbekenergo JSC's plan) will be reduced by 900 MW, the launching of two of the following three units will have to be delayed: Talimardjan-3 (450 MW, Samarkand region), Navoi-3 (450 MW, Samarkand region), Turakurgan-3 (450 MW, Fergana region). According to power supply-demand balance by regions in 2021 shown in Figure 3.6-2 and Table 3.6-2, power generation capacity and demand by regions are almost balanced except for the Tashkent region. In case launching of Talimardjan-3 and Navoi-3 located in Samarkand region is delayed, the power generation capacity/demand ratio in this region will decrease from 97.1 % to 75.6 %. On the other hand, in case launching of Turakurgan-3 in Fergana region is delayed, the power generation capacity/demand ratio in this region will decrease greatly from 87.8% to 64.3%. Therefore, in JICA review the launch of Talimardjan-3 and Navoi-3 planned for 2021 was delayed. Moreover, from the standpoint of the regional power supply-demand balance, the launching times of other power sources were also revised as shown in Table 3.6-1.

Construction of 450 MW GTCC is planned for 2018 and 2019 at Sirdarya TPP. However, further expansion is not necessary. Assuming the expansion of Sirdarya TPP, this may be carried out within the plan of construction and expansion of power plants supplying power to Tashkent region, for instance, carry out Sirdarya TPP expansion instead of Tashkent TPP expansion.

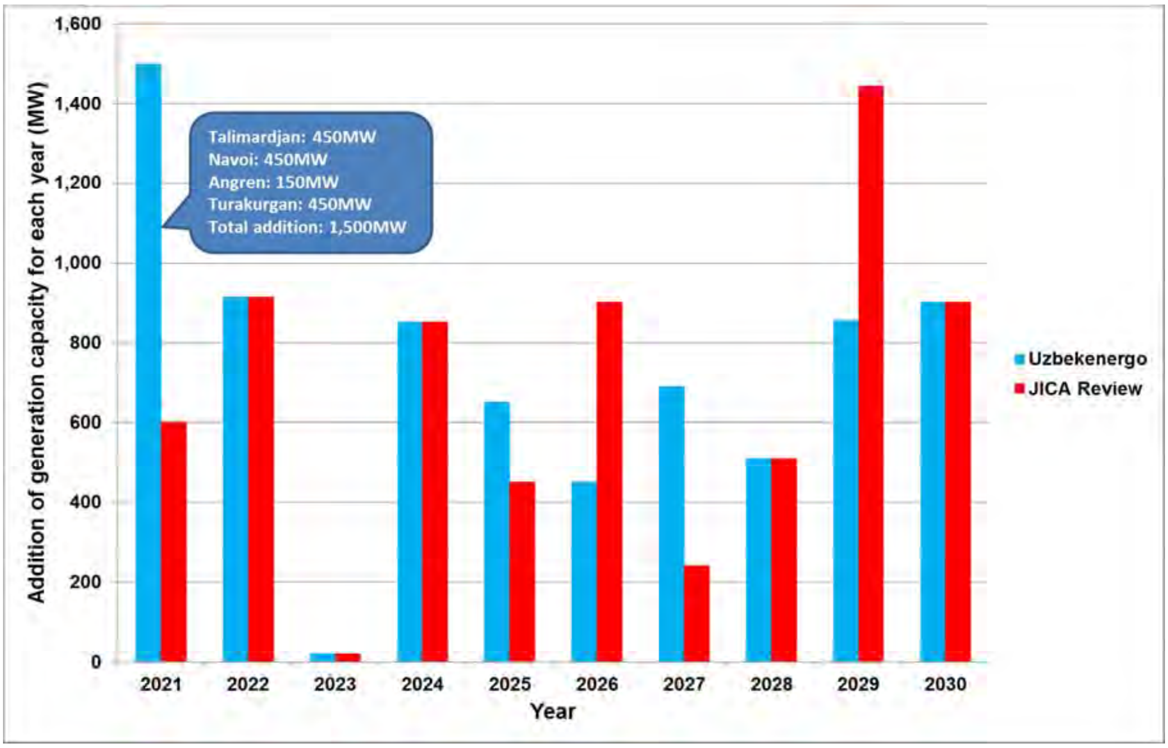
Table 3.6-1 Power Development Concept Review Results

Project	Uzbekenergo JSC's plan (Table 3.1-1)	Review results
Talimardjan-3, 4 expansion	2021: 450 MW 2022: 450 MW	2025: 450 MW 2026: 450 MW
Navoi-3 expansion	2021: 450 MW	2022: 450 MW
Turakurgan-3, 4 expansion	2021: 450 MW 2022: 450 MW	2021: 450 MW 2022: 450 MW
Sirdarya (GTCC)-3, 4 expansion	• Not included	• Not included • Main supply area of Sirdarya TPP is Tashkent region, therefore, in case of carrying out Sirdarya TPP expansion instead of Tashkent TPP expansion, commissioning years are as follows. 2024: 450 MW 2026: 450 MW

Source: JICA Study Team

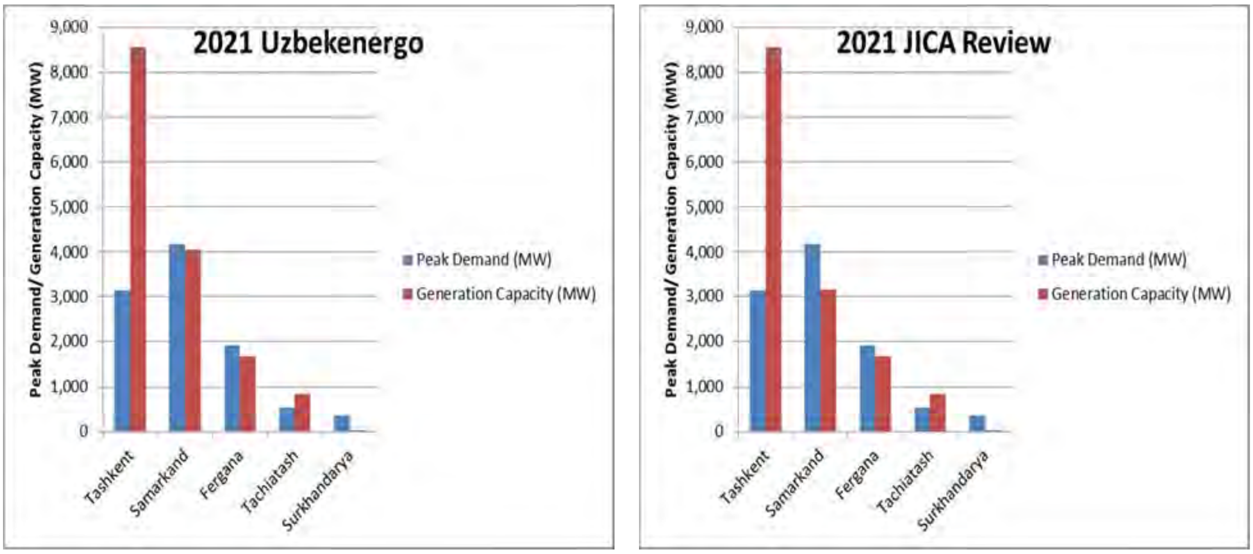
Source: JICA Study Team

Figure 3.6-1 Comparison of LOLP in Uzbekenergo JSC's Plan and JICA Review Plan



Source: JICA Study Team

Figure 3.6-2 Addition of Generation Capacity for Each Year from 2021 till 2030



Source: JICA Study Team

Figure 3.6-3 Generation Capacity and Peak Demand by Regions in 2021

Table 3.6-2 Generation Capacity/ Peak Demand Ratio by Regions in 2021

	2021 Uzbekenergo					2021 JICA Review				
	Tashkent	Samarkand	Fergana	Tachiatash	Surkhandarya	Tashkent	Samarkand	Fergana	Tachiatash	Surkhandarya
Peak Demand (MW)	3,133	4,185	1,912	546	361	3,133	4,185	1,912	546	361
Generation Capacity (MW)	8,553	4,062	1,679	851	9	8,553	3,162	1,679	851	9
Capacity/Demand Ratio	273.0%	97.1%	87.8%	155.7%	2.5%	273.0%	75.6%	87.8%	155.7%	2.5%

Source: JICA Study Team

Chapter 4 Network Development Plan

Chapter 4 Network Development Plan

Reflecting the power development plan shown in Chapter 3, The Team reviewed the network development plan until 2020 formulated by Uzbekenergo JSC. the Team used the network analysis data provided by "EnergoSetProject" Institute, revised them to incorporate recent situation, and conducted the network analysis utilizing network analysis software PSS/E to grasp problems, and then proposed the measures necessary for stable network operation, if any.

4.1 Study method for planning optimal network development

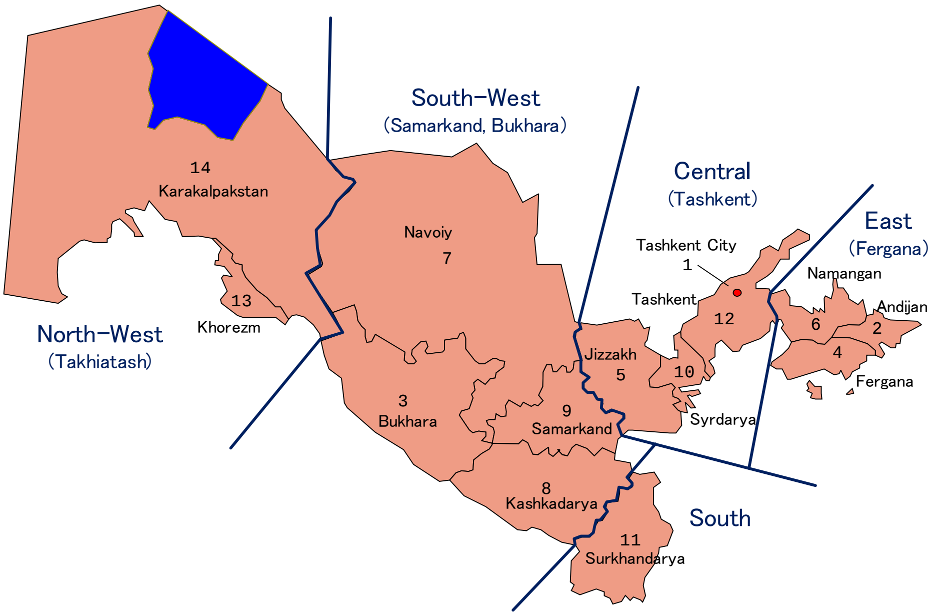
Using network analysis software PSS/E which is de facto standard all over the world, the Team inputed the data regarding power stations including the loads by areas and locations and outputs, those regarding transmission lines including voltages, lengths and transmitting capacities, and those regarding substations including voltages and capacities of transformers. The Team obtained power flows in stations and transmission lines, voltages on busses in all stations, and verified whether they are adequate or not. In the case of not adequate, the Team devised measures to resolve the problems. And also by analyzing fault currents and network stabilities, the Team proposed the network which satisfies three conditions (power flow and voltage, fault current and stability).

4.2 Study Condition

4.2.1 Geographical distribution of load and generation

(1) Areawise classification of network

Uzbekistan has an area of 447 thousand square kilometers, which is 1.2 times of that of Japan. As shown in Figure 4.2.1.1, Uzbekistan is divided into 5 areas, and the network also can be similarly divided into 5 networks: East Network, Central Network (which includes the capital city, Tashkent), South West Network, North West Network and South Network. Since the South network is small, it is actually considered as a part of South West Network. By the way, the terms noted in brackets indicate major cities.



Source: JICA Study Team based on the information provided by Uzbekenergo JSC

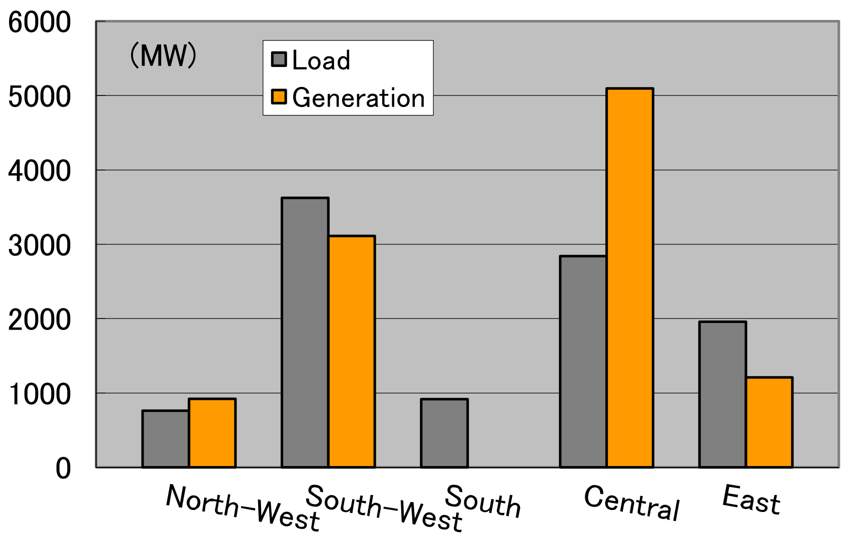
Figure 4.2.1.1 Areawise networks in Uzbekistan

(2) Geographical distribution of load and generation

the Team has investigated the balance of demand of 10,300 MW and supply of 10,550 MW including transmission loss. The distribution of load and generation and the proportional comparison of load and generation are shown in Figure 4.2.1.2 and Figure 4.2.1.3, respectively.

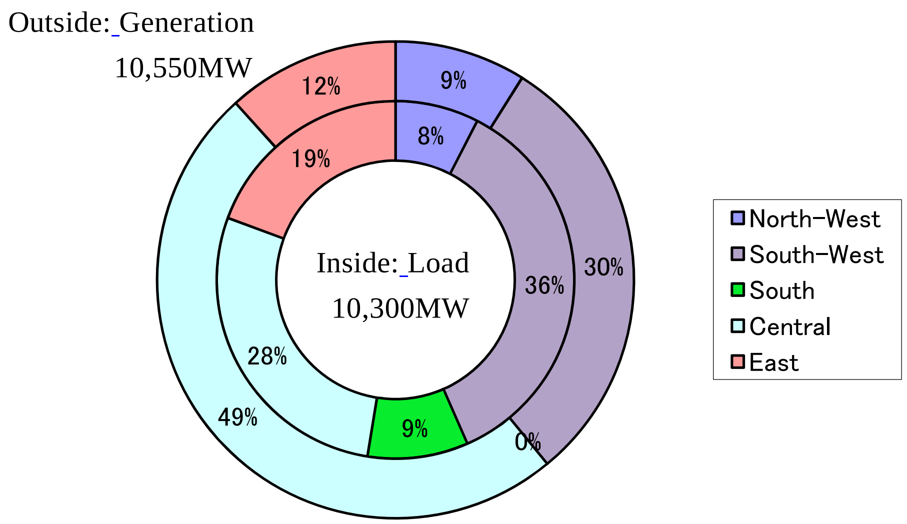
Central Network, to which Tashkent belongs to, accounts for 28% of the total load, almost half of the total generation. South-West Network covers a large area, demand and generation. East Network has 20% of demand and 3% of generation as of 2015; however, the completion of Turakurgan Power Station (output 900 MW by 2020) can significantly improve this unbalanced situation.

It can be said that the demand and supply in each area is moderately balanced, and as a result, it places less burden on the network because of avoiding large and long-distance transmission. But since the largest South-West Network covers an area as almost as large as half of Japan, and the airline distance from east to west end is about 700 km, the demand supply balance within the area should be considered to operate the network stably.



Source: JICA Study Team based on the information provided by "EnergoSetProject" Institute

Figure 4.2.1.2 Distribution chart of load and generation



Source: JICA Study Team based on the information provided by "EnergoSetProject" Institute

Figure 4.2.1.3 Proportional comparison of load and generation

4.2.2 Supply Reliability

(1) Supply Reliability

Uzbekenergo JSC's supply reliability applied for the bulk power network system (500 kV and 220 kV) is that the power supply should be kept under single contingency condition. This concept is adopted in many countries, and referred to as N-1 standard.

(2) Current-carrying capacity

(a) Transmission line

Uzbekenergo JSC uses mainly conductors of AS240, AS300, AS400 and AS500 in bulk power transmission lines, for 500 kV, triple conductor of AS300 or AS400, for 220 kV, single conductor of any of the forementioned conductors except some double conductor lines.

The transmitting capacity of each conductor by voltage, season is indicated in Table 4.2.2.1. The maximum permissible factor (short time capacity) is 1.2 times of the indicated values.

Table 4.2.2.1 Transmitting capacity of lines

Voltage	No.×Conductor	Temp. 25℃	Winter (5℃)	Summer (45℃)
500 kV	3×AS300	2,070 A	2,484 A	1,532 A
	3×AS400	2,475 A	2,970 A	1,832 A
220 kV	AS240	610 A	732 A	451 A
	AS300	690 A	828 A	517 A
	AS400	835 A	1,002 A	618 A
	AS500	945 A	1,134 A	699 A

Source: Uzbekenergo JSC

(b) Transformer

Uzbekenergo JSC adopts the values shown in Table 4.2.2.2 as the short time capacity of transformers. Installing two units of 500 MVA transformer (composed by 3 units of 167 MVA single-phase transformer) in 500/220 kV substation is standardized. An auxiliary 167 MVA single-phase transformer is installed in substation where overloading is expected for replacement in case of one transformer breakdown.

Table 4.2.2.2 Short time capacity of transformers

Oil cooling	Overloading ratio	30%	45%	60%	75%	100%
	Duration time	120 min	80 min	45 min	20 min	10 min
Oilless cooling	Overloading ratio	20%	30%	40%	50%	60%
	Duration time	60 min	48 min	32 min	20 min	5 min

Source : Uzbekenergo JSC

4.2.3 Review of Existing Electricity Network Facilities

(1) Facilities of electricity system used in Uzbekistan

In Uzbekistan voltages of 500 kV and 220 kV are used in main power transmission lines, and electricity distribution is carried out with voltages of 110 kV, 35 kV, 10 kV, 6 kV and 0.4 kV. Voltage classes and stretch of electric grids for each class are presented in Table 3.2.3-1.

Table 4.2.3-1 Voltage classes and stretch of electric grids for each voltage class in Uzbekistan

Voltage class	500 kV	220 kV	110 kV	35 kV	10-6 kV	0.4 kV
OL	2, 257 km[1]	6, 076 km	17, 308 km	13, 025 km	87, 880 km	104, 006 km
Underground cable lines			-[2]	280 km	7, 040 km	3, 504 km

Source: Uzbekenergo JSC SJSC, Uzelectroset UE

Note 1: Data for grids of 500 kV and 220 kV have been obtained from Uzelectroset UE. Other detailed breakdowns are unknown.

Note 2: According to the information of Uzbekenergo JSC SJSC, Tash Gor PES JSC and Sredazenergosetproekt JSC, subsurface lines are currently being used at 3 sites within Tashkent and at some sites of regional cities (towns).

The electrical grids in Uzbekistan are joined together by two or more substations. Large-scale power outages have not happened for the past 10 years. However, due to outdated equipment installed during the Soviet Union, from 1940 to the 70s, problems related to interruptions in electricity transmission and increased maintenance costs occur. Urgent action is needed to replace and improve the reliability of the existing equipment.

In Uzbekistan, networks with voltage above 110 kV usually use overhead lines. Examples of used metal transmission line towers are presented in Tables 7.2.3-2 (1) – 7.2.3-2 (2).

Table 4.2.3-2(1) Metal transmission line towers (220 kV)

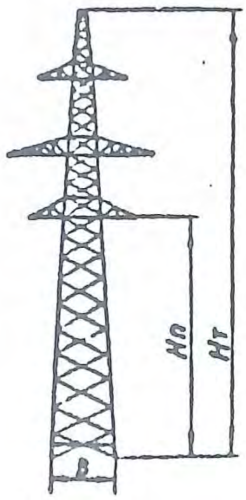
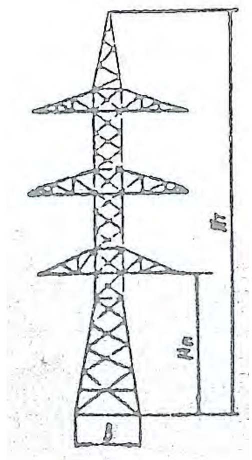
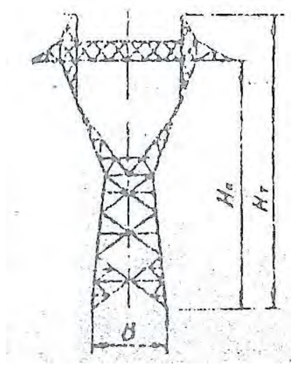
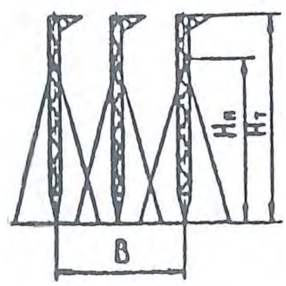
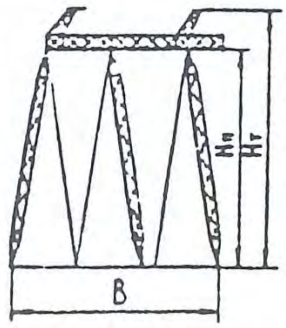
Name	Straight tower	Anchor angle tower
Drawing		
Height (H)	H_T: 41.0 m H_L: 22.5 m	H_T: 31.6 m H_L: 10.5 m
Base width (B)	5.4 m	5.2 m
Maximum wind load	29 m/s	29 m/s
Wires	AS-300/39	AS-300/39
Angle	-	0°–60°
Mass	6.21 tons	14.4 tons

Table 4.2.3-2(2) Metal transmission line towers (500 kV)

Name	Straight tower	Anchor angle tower	Angle tower
Drawing			
Height (H)	H_T:38 m H_L:32 m	H_T: 27.2 m H_L: 22.0 m	H_T: 32.0 m H_L: 27.0 m
Base width (B)	9.05 m	28 m	37.9 m
Maximum Wind load	35 m/s	35 m/s	35 m/s
Wires	3xASO-400, 3xASO-500	3xASO-400, 3xASO-500	3xASO-400, 3xASO-500
Angle	0°	0°-60°	5°-20°
Mass	13.90 tons	15.18 tons	13.274 tons

For overhead transmission lines, steel-aluminum wires of grade AS[1]are mostly used. In addition, wires of grades ASO[2] and ASU[3]are also used. Wire strength increases in the following order: AS → ASO → ASU. In particular, wires of grade ASU are used in deserts and other areas where it is difficult to perform maintenance. In Tashkent, the grids with voltage of 110 kV, 220 kV and 500 kV, sometimes use one-phase two-conductor power transmission lines with conductors section from 95 to 500 mm2.

(2) Regulatory documents regarding electricity grid facilities

Planning, design, construction and operation of electricity grid facilities are carried out in accordance with the following documents and relevant regulations of the Cabinet of Ministers.

- Handbook for designing of electrical grids (SPES[4]) (ed. 2012).

  The content of the handbook includes the following:

  Information on electrical grids of the Russian Federation and other countries; the modern level of electricity consumption and loads (Russia); transmission power lines; electrical grid diagrams; electrical equipment; design of electrical grids; approximate costs, etc.
- Rules for electric installations (PUE[5]), ed. 2007.

  The content of the handbook includes the following:

  Protection of electrical grids; electric grids design (wire types, design conditions, laying methods, etc.); conditions of installation for distribution and transformer equipment; equipment standards, etc.
- Rules of technical operation of power plants and grids (PTE[6]) (ed. 1989).

  The content of the handbook includes the following:

  Rules of technical operation of main equipment, including methods for periodic and daily technical inspection, operational documentation storage rules, rules for firefighting measures, operation rules, environmental standards and norms, etc.

  Standards for power plants including equipment necessary for the implementation of the operation and maintenance (access roads, lightning protection, signs indicating the location of underground utilities, etc.); measures for the protection of the environment (measures to reduce air emissions, wastewater discharges, noise), maintenance of buildings and equipment standards (inspection of premises, etc.).

  Rules for operation and maintenance of hydroelectric power plants, thermal power plants and electrical equipment.

Classes of voltages and the frequency of electric grids of Uzbekistan are presented in Table 4.2.3-3.

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[1]Steel-Aluminum(AS) Wire in English.
[2]Steel-Aluminum Lightweight structure(ASO) Wire in English.
[3]Steel-Aluminum Reinforced structure(ASU) Wire in English.
[4] SPES: *Spravochnik po Proyektirovaniyu Elektricheskikh Setey* [Handbook for designing of electrical grids] in Russian.
[5]PUE: *Pravila Ustroystva Elektroustanovok* [Rules for electric installations] in Russian.
[6] PTE: *Pravila Tekhnicheskoy Ekspluatatsii Elektricheskikh Stantsiy i Setey* [Rules of technical operation of power plants and grids] in Russian.

Table 4.2.3-3 Parameters of electric condition in Uzbekistan

Name	Voltage classes		
Rated voltage	500 kV	220 kV	110 kV
Maximum voltage	525 kV	252 kV	126 kV
Frequency	50 Hz（±0.2 Hz）[1]		

Source: Rules for electric installations, Tash Gor PES JSC.
Note 1: Allowed short-term deviations to ±0.4 GHz.

As can be seen from the table below, Uzbekistan provides large security zone along the high voltage lines, within which there must be no residential houses. However, this does not apply to facilities such as orchards, fields, garages. In the case of highways and railways the rules shown in Table 4.2.3-4 shall be followed. Through the adoption of measures such as erecting high walls between private houses and power lines, the norms of safety distances can be mitigated within the city of Tashkent in exceptional cases.

Rules of safe distances from high voltage lines are shown in Table 4.2.3-4.

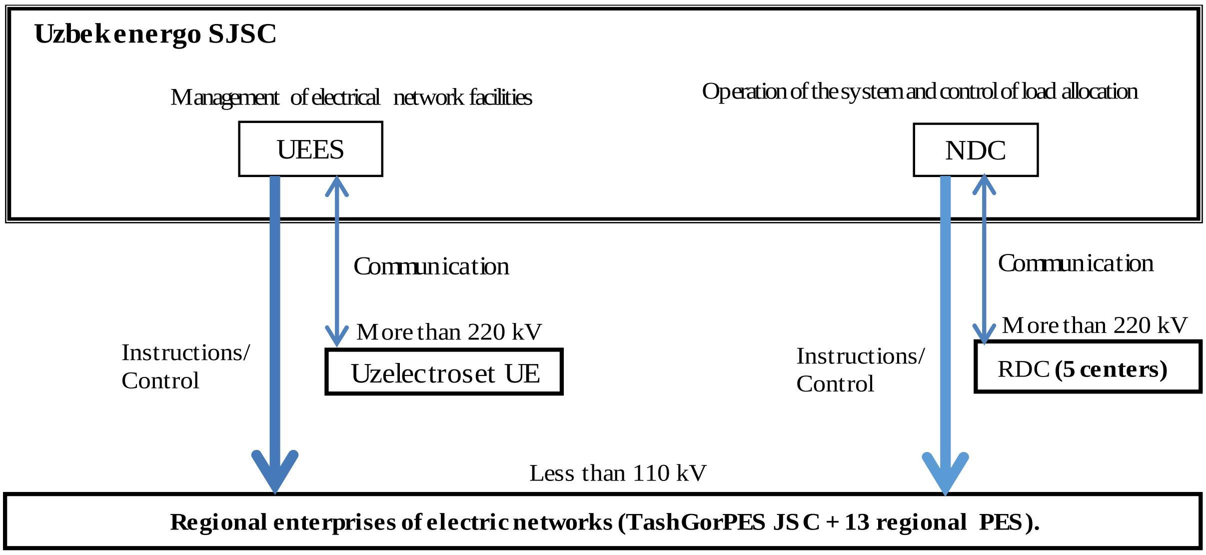
Table 4.2.3-4 Standards for safe distances from high voltage lines

Name	500 kV	220 kV	110 kV	35 kV
(1) Height of power transmission line wires				
Usual places [m]	8	8	7	7
Highways [m]	9	8	7	7
Railways [m]	-	6.5	6	-
Waterways [m]	8	7	6	-
(2) Protection zone (distance from extreme wires)	30	25	20	15
(3) Safe distance from wires to residential houses [m]	-	5	4	3
(4) Safe distance from lines of 500 kV voltage [m]	15	7	5	-
(5) Safe distance from power transmission line towers to the central road line [m]	10	5	5	-
(6) Safe distance from power transmission line towers to railways [m]	9.5	8.5	7.5	7.5

Source: Rules for electrical installations, Decree No. 93 of the Cabinet of Ministers of the Republic of Uzbekistan dated May 17, 2010 on Approval of Rules for Electric Facilities Protection.

(3) Maintenance conditions of existing electricity network facilities

Current maintenance conditions of existing electricity network facilities in Uzbekistan are shown in the figure below.



(4) Operational conditions of existing electricity network facilities

Information on current state of electric grid facilities in 500 kV and 220 kV grids (including 110 kV substation system) was clarified with Uzelectroset UE.

According to information received from Uzelectroset UE, repairs and replacements of equipment are made as and when problems arise, taking into account the potential budget, and when the wear of the equipment increases. Except for the wear and tear of grid facilities, there are currently no technological problems that require urgent solutions.

① Wear and tear

- A large part of transformer equipment was produced in the Soviet times and has already served for 30–40 years. There are also oil circuit breakers (OCB with lifespan of about 50 years.

② Problems in the field of maintenance

- Old equipment, for which it is difficult to get spare parts, is used. Replacement parts have to be produced locally.

  In the event of a breakdown of the oil circuit breaker, it is not repaired but replaced with gas circuit breaker (GCB).

③ Technical inspection plan

- Technical inspection of equipment is carried out periodically in accordance with the rules of technical operation of power plants and grids, which set standards for maintenance of electrical equipment.

④ Repair plan and replacement of equipment

- Due to the presence of a large number of old equipment that requires development of plan for its repair and replacement, Sredazenergosetproekt is attracted additionally. However, due to the limited budget the works do not always run according to the plan, resulting in a situation where it is required to perform an emergency repair at occurrence of malfunctions.
- Selection of old equipment to be replaced is carried out on the basis of competitive bidding. Chinese-made equipment often wins the competitive biddings.

  The most important condition for the admission to biddings is compatibility with the existing equipment.

⑤ Transformers replacement

- The lifespan of the transformers is 25 years. However, many transformers have been served for 30–35 years. Normally, the transformers continue to be used until they come into disrepair.

⑥ Types of switches

- Among the switches for voltages of 110 kV and above, air circuit breaker (ACB) with the lifespan of over 30 years make up a significant portion.
- Retiring switches are replaced by GCB (one of the main suppliers of GCB-Siemens).

⑦ Gas Insulated Switchgear (GIS)

- Since there are no completed projects on site, we can say that the experience is missing.

4.2.4 Uzbekenergo JSC's network development plan

(1) Network development plan from 2015 to 2030 (220 kV and 500 kV system)

500 kV and 220 kV network development plan from 2015 to 2030 drawn up by Uzbekenergo JSC in 2015 is shown in Table 4.2.4.1 and Figure 4.2.4.1 (only No.1to No.5). In 2016, No.5 was postponed to after 2021, and as result, only No.1 to No.4 were selected to be implement until 2020 and approved by the Cabinet.

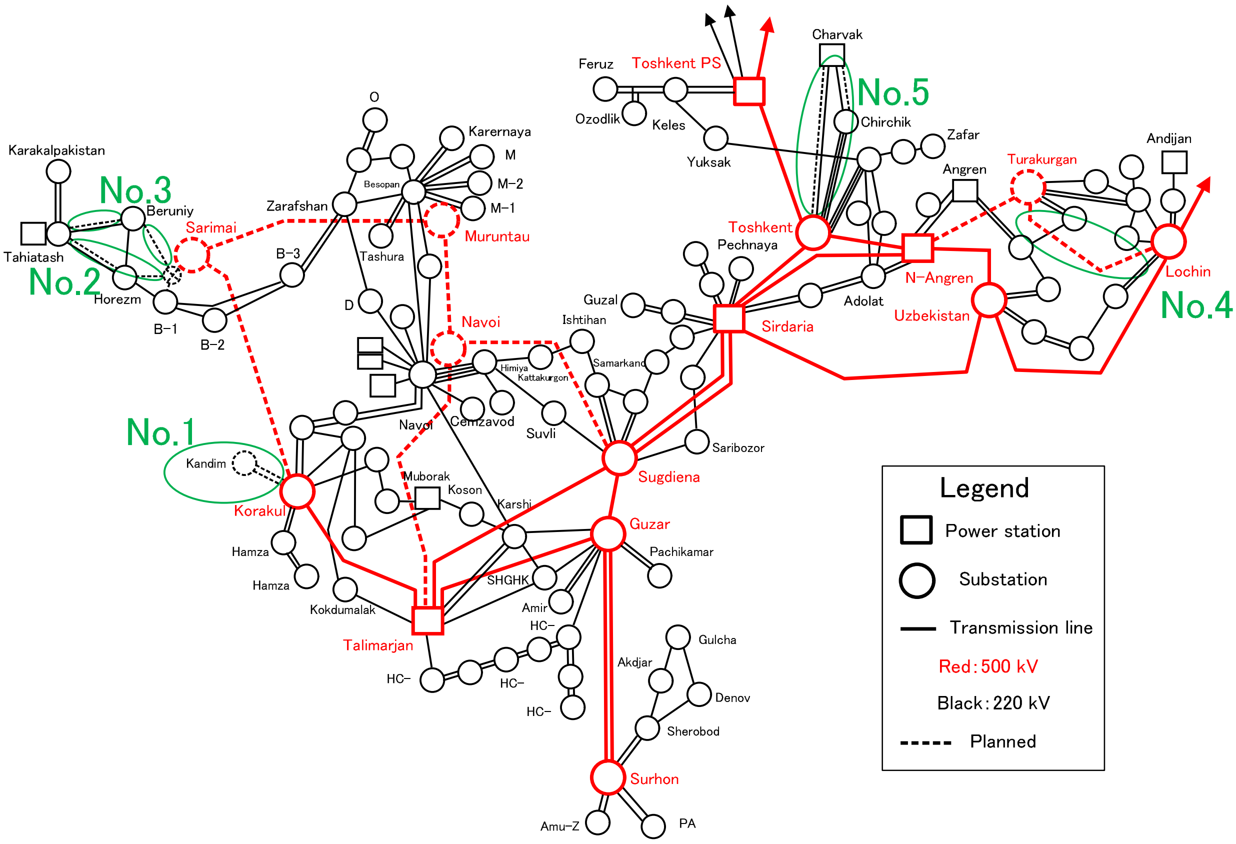
Reflecting No.1 to No.4, the Team made a network analysis.

Table 4.2.4.1 Network development plan (220 kV, 500 kV facility)

No.	Project	Scale	Construction cost (million US$)
Year 2015-2020			
1	220 kV Karakul Substation (SS)–Kandim SS (supply line to Kandym gas processing plant)	2×45 km	58.8
2	220 kV line in Sarimai (Elikala) area Tahiatash thermal power station (PS) –Horezm SS–220 kV switching station	338 km	191.0
3	220 kV Tahiatash thermal PS–Beruni SS–220 kV–B-1 switching station	327 km	109.1
4	500 kVTarakurgan thermal PS –Lochin SS	150 km	144.2
5	220 kV Charvak hydro PS–Tashkent SS	2×52+3+8 km	22.4
Subtotal 500 kV+220 kV (150+870) km			525.5
Year 2021-2025			
6	(2) 220 kV Sarimai switching station – Zaravshan SS	226 km	85.0
7	(1) 220 kV branching point-Tarakurgan thermal PS –Yulduz SS	2×100 km	75.0
8	220 kV Opornaya SS, branch line from Novo-Angren thermal PS–Angren thermal PS	2×200 MVA, 2×0.5 km	36.3
9	220 kV Nukus SS, branch line from Tahiatash thermal PS –Beruni SS	2×63 MVA, 4×1 km	53.1
10	220 kV Amir-Temur SS-Guzar SS	2×125 MVA, 2×150 km	119.8
11	(3) 500 kV Novo-Angren thermal PS –Tarakurgan thermal PS	163 km	166.4
12	(5) 500 kV Talimarjan thermal PS –Surhan SS	270 km	190.0
13	(4) 500 kV NavoiySS, 500 kV Talimarjan thermal PS –Navoi SS	2×501 MVA, 276 km	192.6
14	Installing 500 kV transformer in Tashkent thermal PS	501 MVA	50.0
15	500 kV Samirai (Ellikala) SS, 500 kVKarakul SS–Ellikala SS	2×501MVA, 255 km	171.2

Subtotal 500 kV+220 kV (2,505+776)MVA,(964+731) km			1,139.4
Year 2026-2030			
16	220 kV Gulistan SS, branch line from 220 kV Sirdarya thermal PS –Guzal SS	2×125 MVA, 2×63 km	49.6
17	220 kV Yangiyul SS, 220 kV Kuilyuk SS –Adolat SS	2×125 MVA 2×30 km	48.5
18	220 kV Novo-Vostochnaya SS, branch line from Kuilyuk SS –TashkentSS	2×125 MVA, 2× 5.5 km	34.0
19	220 kV Koshkupir SS, branch line from Tahiatash thermal PS –Horezm SS	2×125 MVA, 2×5 km	36.0
20	220 kV Kuvasaiskaya SS, 220 kV Sokin SS-Kuvasaiskaya SS	2×125 MVA, 2×33 km	38.7
21	220 kV Mullalakskaya hydro PS –Tashkent SS	2×65 km	40.3
22	220 kV Pskemskaya hydro PS – Mullakskaya hydro PS	2×20 km	17.5
23	500 kV Mullalakskaya hydro PS –Tashkent SS	65 km	37.0
24	500 kV Muruntau SS, 500 kV Navoiy SS –Muruntau SS	2×501 MVA, 168 km	143.6
25	500 kV Sarimai(Elliakala) SS –Muruntau SS	226km	90.4
26	500 kV Kolcevaya SS, 500 kV branch line from Sirdarya thermal PS –Tashkent SS	2×501 MVA, 2×26 km	127.1
27	500 kV Sirdarya thermal PS –Kolcevaya SS	150 km	68.0
28	500 kV Navoi SS – Sogdiana SS	256 km	102.4
29	500 kV Djizak SS, 500 kV branch line from Sirdarya therma PS – Sogdiana SS	2×501 MVA, 4×2 km	126.0
30	500 kV Talimarjan thermal PS –Guzar SS	83 km	55.3
Subtotal 500 kV+220 kV (3,006+ 1,250) MVA,(1,008+443) km			1,014.4
Grand total 500 kV + 220 kV (5,511+ 2,026) MVA,(2,122 + 2,044) km			**2,679.3**

Source: Uzbekenergo JSC



Source: JICA Study Team based on the information provided by Uzbekenergo JSC

Figure 4.2.4.1 Network development plan (220 kV, 500 kV facility)

(2) Network development plan by 2020（No.1 to No.4）

According to Uzbekenergo JSC, plans No.1 to No.4 of the Table 4.2.4.1 were modified after the approval. The latest status pf the plans as of February 2016 is described as below. The costs do not include consultant's fee except for plan No.2. For plan No.2, L/A was concluded with ADB and consultants will be procured according to the policy of ADB. For the other projects, procurements of consultants depend on the policy of the donors.

No.1 Bukhara SS - Kandym Gas Plant & Karakul SS: 58. 8MUSD (Material & Construction)	
Outline	・220 kV Transmission line : 83.5 km (AS-400/51, 1 Circuit, New Construction) and 7.6 km (AS-400/51, 1 Circuit, Renovation of Wire) Bukhara SS - Kadym Gas Plant ・Bukhara Substation : 220 kV Switch x 1 Cell (New Construction) ・Karakul Substation: 220 kV Switch x 2 Cells (New Construction)
Note	The F/S implemented by gas plant company, Lukoil (Russia) was approved by the Cabinet and Pre-F/S of Uzbek side will be completed by March 15 and submitted to the Cabinet on April 15. The aim of this Project is to supply power to New Gas Processing Plant at Kandym. The plant is categorized as 1, that is power supply should not be stopped under any circumstances. Through the Project, cells at Bukhara SS and Karakul SS and Transmission Line from Bukhara to Kandym will be prepared by Uzbekenergo JSC, while cells of Kandym will be prepared by the gas plant company, Lukoil. There is enough bus space to install new cell at Bukhara Substation. And there is also enough space at Karakul Substation, and the bus will be extended for the new cells.
No.2 Takhiatash PS – Horezm SS – Sarimai SS: 255 MUSD (incl. Consultant)	
Outline	・220 kV Transmission line : 186.8 km (AS-400/51, 1 Circuit, New Construction) Tahiatash PS – Horezm SS and 151.9 km (AS-400/51, 1 Circuit, New Construction) Horezm SS – Sarimai SS ・Takhiatash PS: 220 kV Switch 1 Cell (New Construction) ・Horezm SS: 220/110 kV, 200 MVA x 2 and 220 kV Switch 10 Cell (Renovation Tr 125MVA→200MVA, ACB→GCB) ・Sarimai SS: 220 kV Switch 5 Cell (New Construction)
Note	L/A was signed by ADB & Uzbekistan on November 12, 2015 The aim of this Project is to improve the reliability of the electricity supply to the North West area, where one of the 220 kV Transmission Lines is located and maintenance is difficult. There is enough space for Takhiatash PS, which is under construction, and 220kV Switch yard of Sarimai SS, while the space for Sarimai 500/220 kV Substation is under consideration. The route for Transmission Line is determined and the land is already prepared.
No.3 Takhiatash PS - Berniy SS - Sarimai SS: 109.1 MUSD (Material & Construction)	

Outline	・220 kV Transmission line : 157.0 km (AS-400/51, 1 Circuit, New Construction) Takhiatash PS – Berniy SS and 170.0 km (AS-400/51, 1 Circuit, New Construction) Berniy SS – Sarimai SS ・Takhiatash PS: 220 kV Switch 1 Cell (New Construction) ・Berniy SS: 220/110 kV, 200 MVA x 2and 220 kV Switch 3 Cell (Renovation Tr 125MVA→200MVA, ACB→GCB) ・Sarimai SS: 220 kV Switch 1 Cell (New Construction)
Note	This Project will be implemented after plan No.2 Project. Ministry of Economics wrote a letter to defer the implementation of the Project to 2018-2020 time frame. Currently this Project is under consideration. The aim of this Project is to improve the reliability of the electricity supply to the North West area, where one of the 220 kV Transmission Lines is located and maintenance is difficult. The spaces for the Project at Takhiatash PS, Berniy SS and Sarimai SS are prepared. At Sarimai, Switching yard will be constructed in the Project No.2 and the space for 1 cell at Sarimai will be prepared for installation in the Project No.3. Regarding Transmission line, the route is not yet determined. Because of the shortage of budget, construction of Nukus SS will be postponed or cancelled at the moment.
No.4 Turakurgan PS – Lochin SS: 165MUSD	
Outline	・500 kV Transmission line : 150.0 km (AS-300 x 3, 1 Circuit, New Construction) Turakurgan PS – Lochin SS ・Turakurgan PS: 500/220 kV, (167 MVA x 3) x 2 and 500 kV Switch 4 Cells ・Lochin SS: 500 kV Switch 2 Cells
Note	The F/S is implemented by Uzbekenergo JSC. The aim of this Project is to improve power supply in East area. There is enough space at Lochin while space at Turakurgan and space for Transmission Line is under consideration.

4.3 Network Analysis

In order to review Uzbekenergo JSC's network development plan, a network analysis on power flow and voltage, fault current and stability was carried out.

4.3.1 Network analysis condition

(1) Network to be reviewed

The analysis data are composed based on the 2020 network data of built by "EnergoSetProject" Institute in 2011.

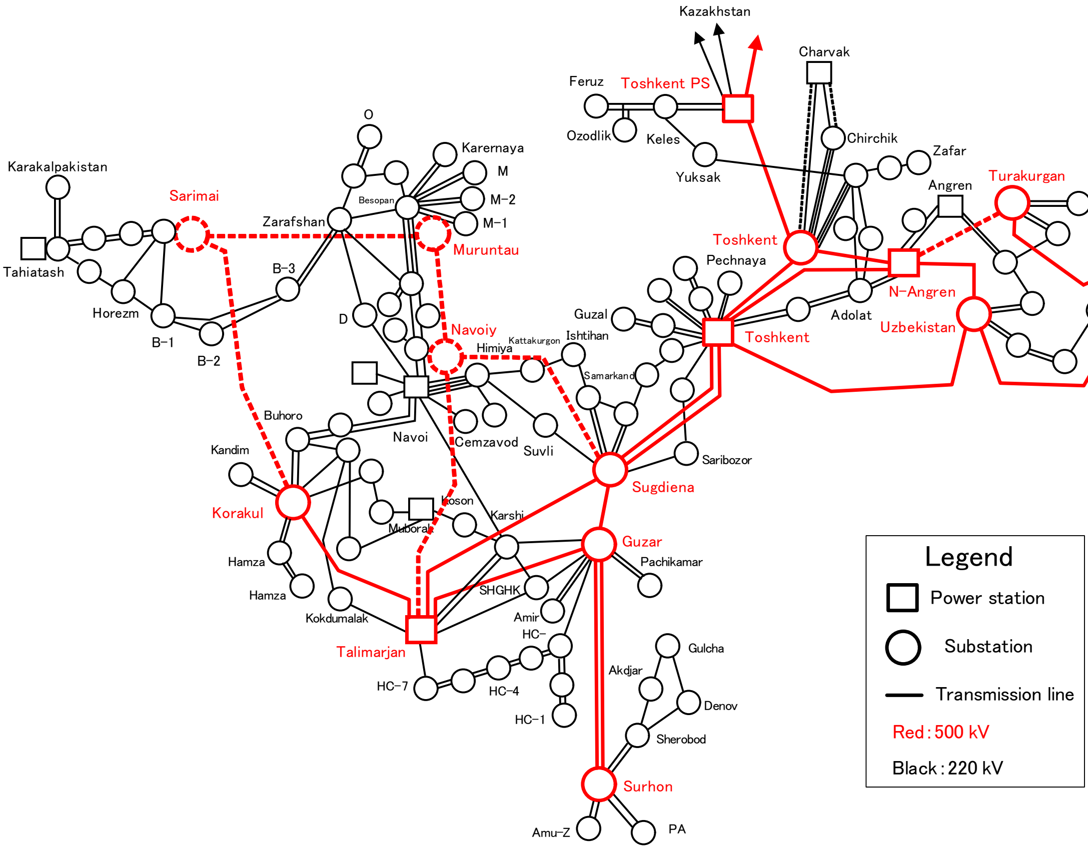
All facilities in 500 kV and 220 kV, and some of 110 kV are simulated, and the simulation scale of the original data is as follows:

Number of busses：208, transmission lines：206, substations：60

The total demand is 10,025 MW similar to 10,297 MW forecasted by the Team.

According to the network configuration of the original data, which were built in 2011, 500 kV network would be distributed around and across the country by 2020, as Figure 4.3.1.1 shows. In this figure, the existing 500 kV network as of 2015 is drawn by solid line and the planned one from 2016 to 2020 by dotted line.

The Team revised the data of loads and power stations. Furthermore, it excluded the 500 kV transmission lines in the western area (Korakul-Sarimai,Sarimai-Muruntau,Muruntau-Navoiy,Navoiy-Talimarjan,Navoiy-Sugdiena), and Novo-Angren-Turakurgan line in the eastern area which will not be completed until 2020. And necessary change was made in 220 kV network.



Source : JICA Study Team based on the information provided by "EnergoSetProject" Institute

Figure 4.3.1.1 Network configuration of the original data

(2) International power interchange

Since Uzbekistan network is interconnected to Kazakhstan and Kyrgyzstan, the value of international power interchange should be confirmed. The southern Kazakhstan, north of Uzbekistan, has a large demand and small generation whereas Kyrgyzstan, east of Uzbekistan, has an affluent hydro power. For this reason, Uzbekistan receives the power from Kyrgyzstan, and sends an equivalent amount of the power to Kazakhstan through the Uzbekistan network.

Since the value of international power interchange in 2020 is not determined, the value is forecasted based on the actual record in the winter of 2015 as follows.

・650 MW of the power is received from Kyrgyzstan at Lochin Substation

・390 MW is sent to Kazakhstan from 500 kV bus and 260 MW from 220 kV bus at Tashkent PS.

4.3.2 Network analysis results

(1) Power flow

(a) Winter peak time

In Uzbekistan, the demand records an annual peak on the time the lights are turned on in the evening of winter. The result of power flow analysis in this period is shown in Figure 4.3.2.1 and the maximum power flow and utilization rate (power flow / transmitting capacity) of each voltage class are shown in Table 4.3.2.1.

The maximum power flow per one circuit of 500 kV transmission line is 706 MW on Novo-Angren-Toshkent line, and the maximum utilization rate is 33.4 % on New-Sirdaria PS-Sugdiena line. Incidentally, the power flow on Toshkent PS-Toshkent line, where the international interchange power of 650 MW flows, is 638 MW and the utilization rate is 26.1 %.

The 220 kV transmission lines have the transmitting capacity of 264 MW– 410MW (820 MW of some line with double conductor), the maximum utilization rate is 64.5 % of Sirdaria-Jizzah line, and the maximum power flow of Novo-Angren-Adolat line is 368 MW. Therefore, there is much allowance against the capacity.

Table 4.3.2.1 Maximum power flow and utilization rate

Line	Capacity * (MW)	Power Flow (MW)	Utiliza-tion rate (%)
500 kV N-Angren-Toshkent	2,443	706	28.9
500 kV N-Sirdaria PS-Sugdiena	2,043	682	33.4
500 kV Toshkent PS-Toshkent	2,443	638	26.1
220 kV Sirdaria-Jizzah	358	231	64.5
220 kV Navoiy-A	298	186	62.4
220 kV Novo-Angren-Adolat	820	368	44.9

Source：JICA Study Team *：Power factor of 0.95 assumed

In order to check the stability network operation under N-1 condition, the power flow analysis is made under the condition that the fault occurs on the line with heavy power flow. The results are shown in Table 4.3.2.2.

In case of opening 500 kV Toshkent PS-Toshkent line after fault occurrence, the power flow in 220 kV Toshkent PS-Toshkent line along the faulted line increases to 537 MW, which exceeds the transmitting capacity of 410 MW. However, almost all of the power flow 638 MW before the fault occurrence is the international interchange power 650 MW. Although the network in Kazakhstan and Kyrgyzstan is not simulated, 500 kV transmission lines exist in the both countries, and since the power flows in these lines as bypass route, overloading does not occur.

Due to the expansion in Navoiy thermal power station (2 units of 450 MW), the power flow in the 220 kV transmission lines around Navoiy area increases and, as a consequence, overloading occurs under N-1 condition. The power flow does not exceed the short time capacity of lines (1.2 times of continuous capacity), and the overloading will disappear after the completion of 500 kV Navoiy-Muruntau line by 2030.

The transmitting capacity of 220 kV lines of Uzbekenergo JSC is relatively small, in the range from 264 MW to 410 MW, and especially, the lines completed early tend to have small capacity. Though the construction of 500 kV lines is a drastic measure, adopting low-sag conductors such as “Gap Type heat resistance Aluminum alloy conductor steel reinforced (GTACSR)” is recommended as effective utilization of existing transmission line. This conductor can double or triplicate the capacity by changing conductor without rebuilding transmission towers.

The power flow in Surhon Substation (2 units of 500/220 kV 500 MVA transformer) is 903 MW; therefore, overloading is expected in case of breakdown of one unit. But a spare mono-pole transformer unit with 167 MVA is installed to replace the damaged unit.

Table 4.3.2.2 Power flow under single contingency condition (N-1 condition)

Faulted Line	Overloaded Line	Capacity (MW)	Power Flow (MW)	Utiliza-tion rate (%)
500 kV N-Angren-Toshkent	None	-	-	-
500 kV N-Sirdaria PS-Sugdiena	None	-	-	-
500 kV Toshkent PS-Toshkent	220 kV Toshkent PS-Toshkent	410	537	131
220 kV Sirdaria-Jizzah	None	-	-	-
220 kV Navoiy-A	220 kV Navoiy-Besopan	298	350	117
220 kV Navoiy-Besopan	220 kV Navoiy-A	298	341	114
	220 kV A-Besopan	298	327	110
220 kV Novo-Angren-Adolat	220 kV Novo-Angren-Adolat	410	442	108

Source：JICA Study Team

(b) Summer peak time

Although the demand in summer is 90% of that of the winter, the capacity of transmission lines decrease to 62% of that of the winter. As the result, transmission lines can be overloaded. For this reason, the study for summer peak time is carried out, and the result is shown in Figure 4.3.2.2.

The maximum power flow in 500 kV line is 563 MW in Toshkent PS-Toshkent line, a value much less than the 1,507 MW transmitting capacity in summer.

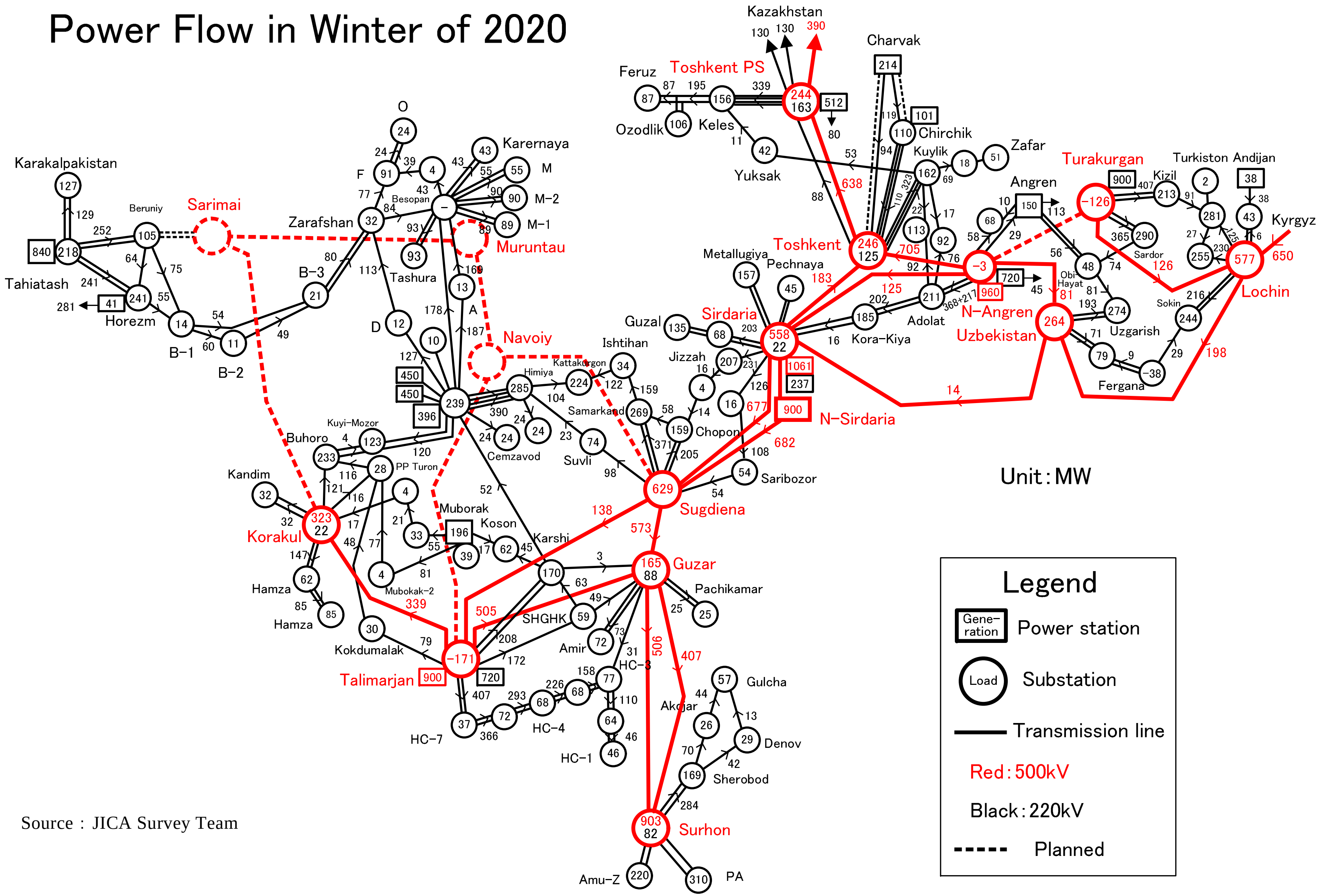
Since the condition that Charvak hydro power station operates at a full capacity, and a power output of 690 MW is assumed, the power flows in 220 kV Charvak-Chirchik line and Charvak-Toshkent line are 382 MW and 307 MW respectively exceeding the 253 MW capacity. These lines were planned to double the circuit by 2020, but this plan was postponed to after 2020, according to the latest update. For this reason, Uzbekenergo JSC will control the output of Charvak hydro power station for the moment. Even in this case, the supply capacity is sufficient to cover the demand which is 90% of that of the winter peak; furthermore, water can be utilized because the power station is a dam plant.

The analysis result indicates that the operation will be at the output of 490 MW, 200 MW less than the capacity, but this will not load to the overloading.

220 kV transmission lines have various capacities with thick and thin conductors; the maximum utilization rate except the above two lines is 84% of Toshkent PS-Toshkent line, and no overloading occurs.

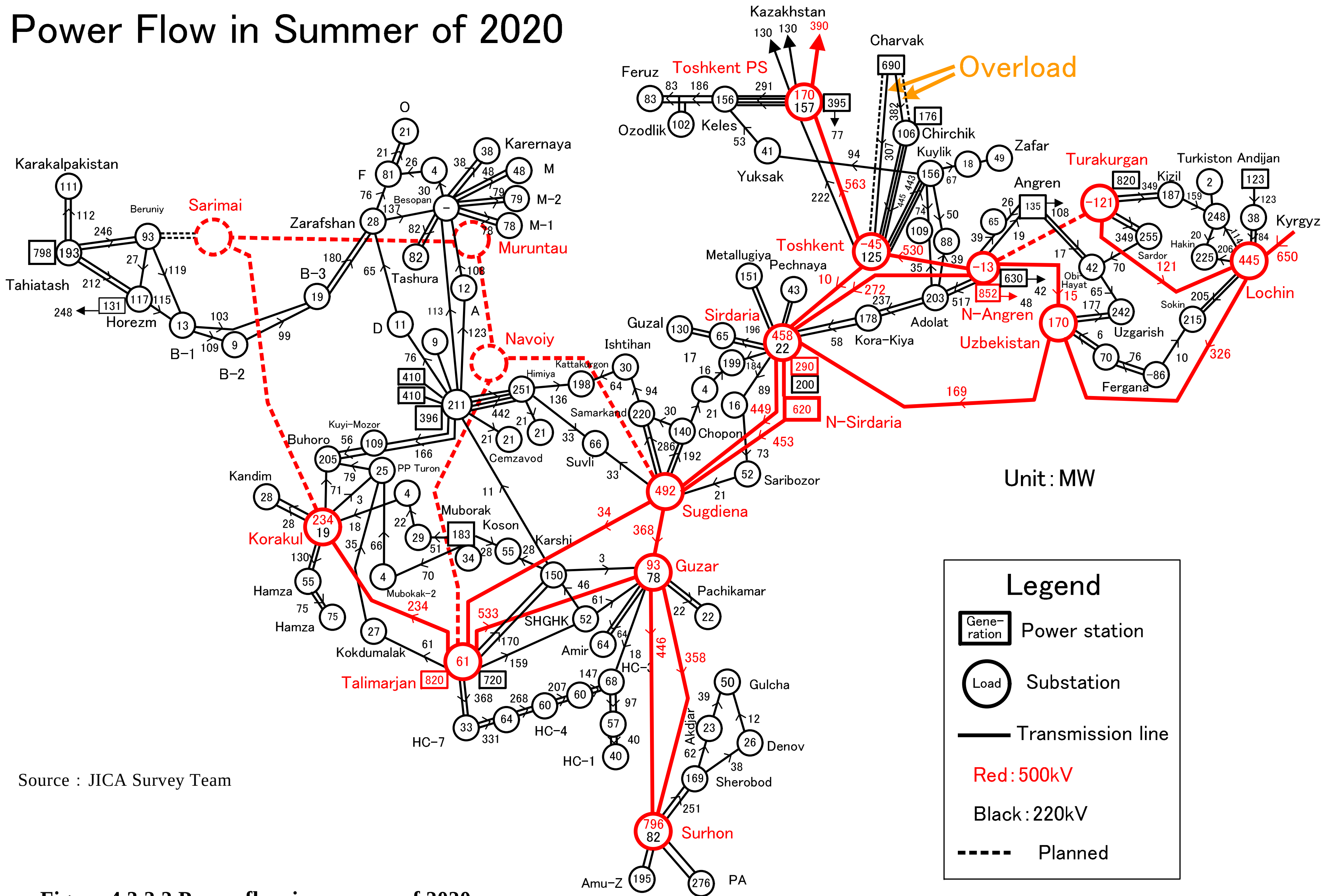
In case of occurrence of overloading under contingency condition, Uzbekenergo JSC controls the outputs of power stations to avoid the overloading problem, and it does not draw up a network development plan responding to the summer peak condition.

Power Flow in Winter of 2020



Source : JICA Survey Team

Figure 4.3.2.1 Power flow in winter of 2020



Source : JICA Survey Team

Figure 4.3.2.2 Power flow in summer of 2020

(2) Voltage

The condition of 220 kV substations with voltages below 90% is shown in Table 4.3.2.3. All these substations exist in the South-West network, far from power stations which can keep voltage. They are influenced by postponement of the development of 500 kV transmission lines, which can supply reactive power to raise the voltage. The voltages also tend to decrease to about 90% in North-West and South networks.

The study to confirm the effect of measures against voltage drop is carried out. The result is shown in Table 4.3.2.3. The proposed measures are installing capacitors (Beruniy 100 MVA, Besopan 200 MVA, Sherobod 100 MVA, Jizza 100 MVA, Keles 100MVA, Yulduz 200 MVA). As Table 4.3.2.3 shows, the measures are effective to recover the voltage at near 100%.

Table 4.3.2.3 220 kV substation below 90% voltage

Station	Voltage (%)		Station	Voltage (%)	
	Before Installation	After Installation		Before Installation	After Installation
B-3	88	100	Zarafshan	85	98
F	82	97	O	82	97
Gornaya	83	98	Karernaya	83	98
M	83	98	M-1	83	98
M-2	83	98	Besopan	83	98
D	89	99	Tashhura	81	97

Source：JICA Study Team

(3) Fault current

Since Uzbekistan network is interconnected to Kazakhstan and Kyrgyzstan networks, the fault current is supplied from these neighboring countries. As this value is not clear, it is assumed as a severe case that 10 kA at Tashkent PS 500 kV bus from Kazakhstan and also 10 kA at Lochin substation 500 kV bus from Kyrgyzstan are supplied. The results are shown in Figure 4.3.2.3 and Table 4.3.2.4. The table also shows the fault currents without that of the neighboring countries also shown.

The fault currents at Tashkent PS and Lochin without that of the neighboring countries are 13.0 kA and 6.9 kA respectively; therefore, it can be said that the 10 kA assumption is sufficiently severe.

The maximum 3 of each voltage class are as follows.

500 kV (permissible value 31.5 kA)：Sirdaria 25.0 kA, Toshkent 23.6 kA, Toshkent PS 23.3 kA

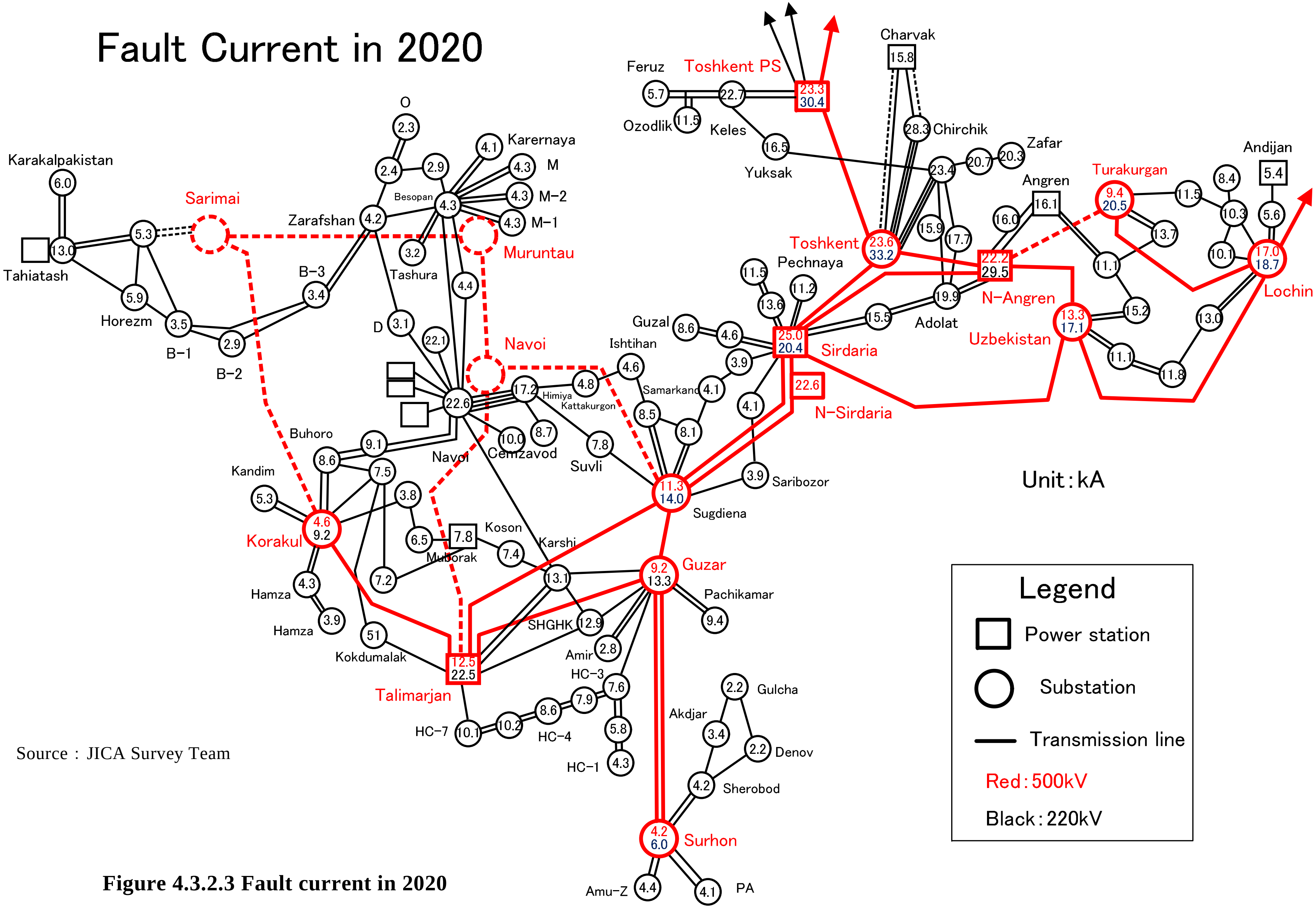
220 kV (permissible value 40.0 kA)：Toshkent 33.2 kA, Toshkent PS 30.4 kA, Novo-Angren 29.5 kA.

Since the maximum values are much less than the permissible values, no problem exists.

Table 4.3.2.4 Fault current

500 kV Station	Fault Current (kA) [ ]: Excluding the current from neighboring countries		220 kV Area	220 kV Station	Fault Current (kA) [ ]: Excluding the current from neighboring countries	
Korakul	4.6	[5.0]	North-West	Tahiatash	13.0	[13.0]
Talimarjan	12.5	[12.4]	South-West	Besopan	4.3	[4.3]
Sugdiena	11.3	[11.0]		Navoiy	22.6	[22.6]
Guzar	9.2	[9.1]		Korakul	9.2	[9.2]
Surhon	4.2	[4.2]		Talimarjan	22.5	[22.5]
Sirdaria	25.0	[22.8]		Sugdiena	14.0	[13.8]
N-Sirdaria	22.6	[20.9]		Guzar	13.3	[13.3]
Toshkent PS	23.3	[13.0]	South	Surhon	6.0	[6.0]
Toshkent	23.6	[15.9]	Central	Sirdaria	20.4	[19.6]
N-Angren	22.2	[18.8]		Toshkent PS	30.4	[25.3]
Uzbekistan	13.3	[10.4]		Toshkent	33.2	[28.6]
Turakurgan	9.4	[7.9]		N-Angren	29.5	[27.9]
Lochin	17.0	[6.9]	East	Uzbekistan	17.1	[14.6]
				Turakurgan	20.5	[17.3]
				Lochin	18.7	[12.6]

Source：JICA Study Team



Source : JICA Survey Team

Figure 4.3.2.3 Fault current in 2020

(4) Stability

The next condition is set for the stability analysis.

Condition：three-phase short circuit fault occurs at 0 ms of a line and the faulted line is opened at 100 ms (220 kV and 500 kV).

The study cases are shown in Table 4.3.2.5.

The severe fault conditions in which the fault occurs at a location very close to the power station are selected.

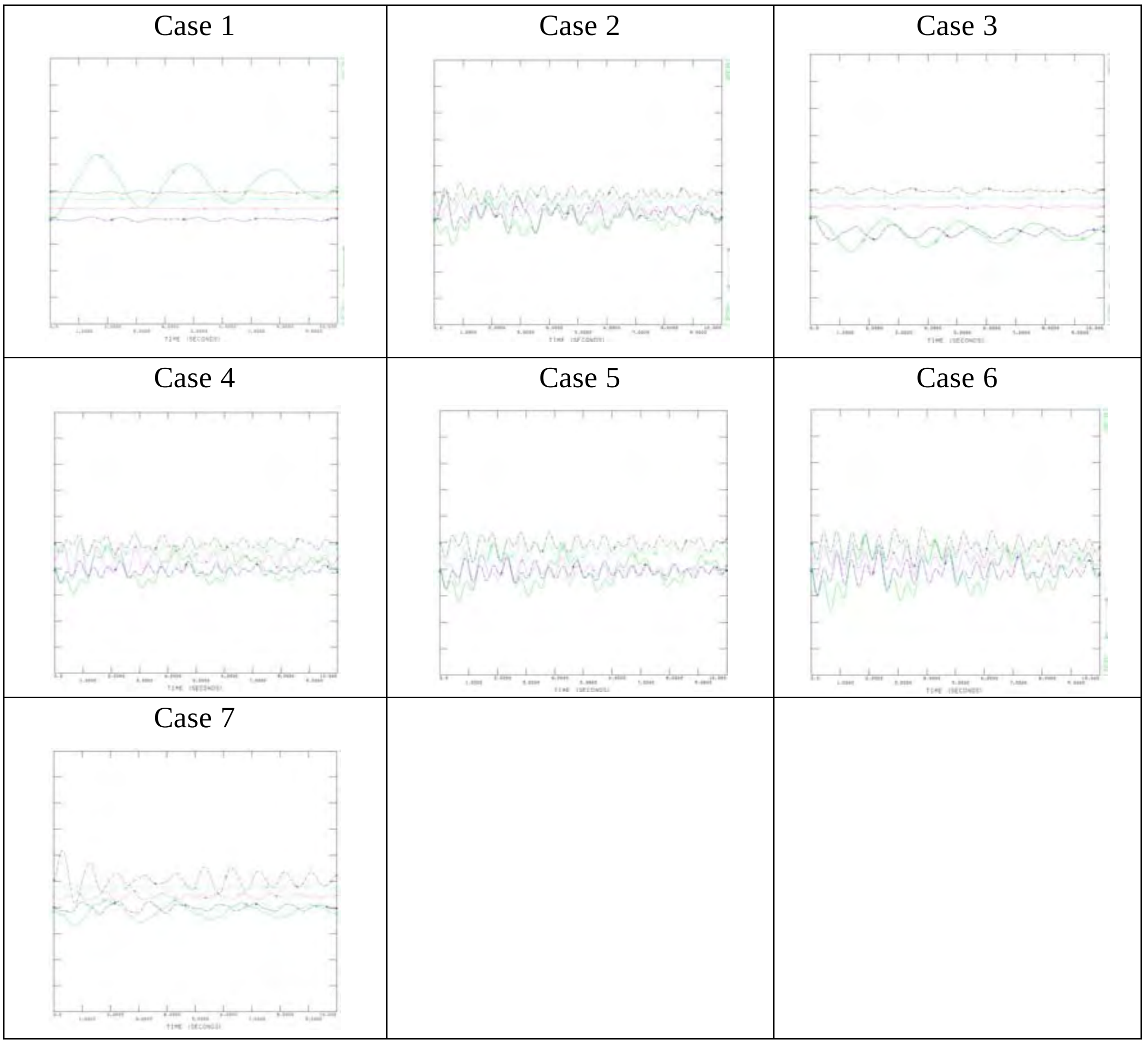
Figure 4.3.2.4 shows the transition of generator voltage angle in a period of 10 sec.

The generator voltage angles fluctuate widely after the fault occurs, but the fluctuation converges with time. Therefore, the stability can be maintained in all cases.

Table 4.3.2.5 Cases for stability study

Case	Voltage	Faulted line	Faulted point	Fault clearing time
Case 1	220 kV	Tahiatash-Koshkupir	Tahiatash	100 ms
Case 2	500 kV	Tarimarjan-Guzor	Tarimarjan	
Case 3	500 kV	Sirdaria-Sugdiena	Sirdaria	
Case 4	220 kV	Toshkent PS-Toshkent	Toshkent PS	
Case 5	500 kV	Toshkent PS-Toshkent	Toshkent PS	
Case 6	500 kV	Novo-Angren-Uzbekistan	Novo-Angren	
Case 7	220 kV	Turakurgan-Kizil-Ravat	Turakurgan	

Source：JICA Study Team



Source：JICA Study Team

Figure 4.3.2.4 Generator internal voltage angle fluctuation

4.3.3 Conclusion

The precise network analysis makes clear that the 2020 network planned by Uzbekenergo JSC can be operated without problems.

Uzbekenergo JSC draws up a network development plan only based on the results of the study on power flow and voltage in winter peak time. The study in summer peak time is not carried out, and even in winter peak time, the study on fault current and stability is not carried out. It is very important for stable network operation to conduct study on power flow and voltage, fault current and stability that are known as three essential elements.

Since the demand in 2030 is expected to be 15,272MW, which is 1.8 times of that of 2015, and there is possibility that problems such as overloading in summer, exceedance of the permissible fault current level and instability may emerge in the future, the master plan study to draw up the long-term development plan is strongly recommended.

Chapter 5 Priority Potential Projects

Chapter 5 Priority Potential Projects

5.1 Outline of thermal power plants in Uzbekistan

According to Uzbekenergo JSC the installed capacity of Uzbekistan power plants as of 2014 is 12,468 MW, 85 % of which is occupied by thermal power stations, 14 % by hydroelectric power stations and the remainder takes the solar power plant in Samarkand.

The main fuel for thermal power plants (TPP) is natural gas (80 %), with coal making up the remaining 20 %. At most power plants, the co-firing of fuel-oil is foreseen as a reserve fuel, when, for instance, examining gas supply equipment. Coal-fired power plants also often use fuel-oil as reserve fuel.

Most Uzbekistan thermal power plants were built in 1950-1970 during the Soviet period 40-60 years ago and are obsolete. Amid peak electricity demand, reaching 8,000 MW, the real ability to supply stopped at 8,200 MW with virtually no spare capacity, given the planned stops during periodic inspections.

Moreover, most of the equipment continues to decline into obsolescence, except for relatively new gas turbine combined-cycle[1] of, Navoi TPP, GTCC of the Talimardjan thermal power plant and the gas turbine Cogeneration System[2] of Tashkent CHP. As shown in Tables 5.1-1 and 5.1-2, the efficiency of gas thermal power plants is low, even compared to Russian data for 1990-1994 years when virtually no combined-cycle plants were introduced. This suggests the need for planned development and renovation of power stations.

Also, Uzbekistan also maintains a mutual turnover of electricity with Kazakhstan, Kyrgyzstan and Afghanistan to recover from electricity shortages and stabilize the power grid. Energy exchanges previously conducted with Turkmenistan and Tajikistan have now been discontinued.

Table 5.1-1 Efficiency of gas thermal power plants

Efficiency of generating side (based on Lower Heating Value) (%)

	USA	Russia	Japan
1990	36.60	34.40	43.20
1991	34.70	30.80	43.40
1992	34.70	31.20	43.40
1993	35.80	32.70	43.10
1994	36.30	30.40	43.50

Source: RITE

[1]GTCC (Gas Turbine Combined Cycle)
[2]GTCS (Gas Turbine Cogeneration System)

Table 5.1-2 Uzbekenergo JSC Thermal power plants (including CHP)

	Type of equipment	No.	Commissioning Year	Installed capacity [MW]	Available capacity [MW]	EFFICIENCY-generating side (%)	
						Station	Block
				11,096	8,242		
Tashkent TPP (main fuel is natural gas)	Steam	1	1963	150	1665	30.3	29.5
		2	1964	150			29.8
		3	1965	150			30.0
		4	1965	150			29.8
		5	1966	150			30.1
		6	1967	155			29.2
		7	1967	165			30.3
		8	1968	165			29.8
		9	1969	150			29.8
		10	1970	165			30.0
		11	1970	155			31.5
		12	1971	155			31.4
Tashkent CHP (natural gas)	Steam	1	1954	30	49.5	85.6	86.2
	GTCS	2	2013	27			67.2
Angren TPP (coal)	Steam	1	1957	52.5	197	31.4	31.4
		2	1958	54.5			31.4
		3	1958	53			31.4
		4	1958	52			31.4
		5	1960	68			31.4
		6	1961	68			31.4
		7	1962	68			31.4
		8	1963	68			31.4
Novo-Angren TPP (coal)	Steam	1	1985	300	1,320	29.5	29.2
		2	1985	300			29.5
		3	1986	300			28.8
		4	1987	300			29.5
		5	1988	300			29.8
		6	1991	300			31.1
		7	1995	300			30.6
Navoi TPP (natural gas)	Steam	3	1964	150			26.6
		4	1965	150			27.3
		8	1968	160	1,300	33.5	27.2
		9	1969	160			28.6
		11	1980	210			24.4
		12	1981	210			25.1
		1	1963	25			16.7
		2	1963	25			16.7
		5	1966	50			33.4
		6	1967	60			33.4
		7	1971	50			33.4
	GTCC	GTCC -1	2012	450			52.1
Syrdarya TPP (natural gas)	Steam	1	1972	300	2,020	33.7	33.0
		2	1973	300			32.7
		3	1974	300			33.3
		4	1975	300			34.3
		5	1976	300			33.6
	Steam	6	1977	300			33.7
		7	1978	300			35.7
		8	1979	300			34.9

	Type of equipment	No.	Commissioning Year	Installed capacity [MW]	Available capacity [MW]	EFFICIENCY-generating side (%)	
						Station	Block
		9	1980	300			33.4
		10	1981	300			32.4
Takhiatash TPP (natural gas)	Steam	1	1967	100	540	26.8	22.3
		2	1968	100			22.3
		3	1974	110			22.3
		7	1987	210			28.4
		8	1990	210			29.1
Fergana CHP (natural gas)	Steam	1	1956	25	250	57.0	No data
		7	1979	55			17.6
		3	1961	60			No data
		4	1966	60			No data
		5	1967	50			15.2
		6	1977	55			16.2
Mubarek CHP (natural gas)	Steam	1	1984	60	120	77.9	44.2
		2	1985	60			48.0
Talimardjan TPP (natural gas)	Steam	1	2004	800	780	37.8	37.8

Source: Uzbekenergo JSC

※ Efficiency of generating side based on Lower Heating Value.

5.2 Overall condition of priority potential project sites

Power plants in the Republic of Uzbekistan are concentrated in the Tashkent region and high electricity demand in most regions is covered by neighboring countries, via the united energy system and central Uzbekistan regions by long distance power transmission. Accordingly, to reduce losses due to power transmission at considerable distance, increase supply security and meet national demand, the construction of several 450 MW GTCCs and decommissioning of obsolete equipment is planned by 2030 as part of the roadmap to develop the electric power industry of Uzbekistan.

The blueprint to develop the electric power industry by 2030 by Uzbekenergo JSC, adopted in this situation, is reflected in Table 5.2-1. It provided that the development period for generating capacities is 3-4 years, construction on the following project sites planned for the post-2018 period. Accordingly, the site for which construction is planned for the post-2018 period was prioritized. Among these, for the highlighted projects, they have been individually studied as priority potential project sites since their funding source of finance is uncertain. The condition of each thermal power plant and combined heat power plant are described from paragraph 4.2.1.

Table 5.2-1 The development concept for the electric power industry until 2030 by Uzbekenergo JSC (TPP&CHP)

Name	Type	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	[MW]
Talimardjan TPP	GTCC		450	450				450	450							450	450	2700
Navoi TPP	GTCC			450				450										900
Syrdarya TPP	GTCC	50																50
Tashkent TPP	GTCC		370								450	450	450	450	450		450	3070
Angren TPP	GTCC		150					150										300
Novo-Angren TPP	GTCC										300							300
Takhiatash TPP	GTCC					250	250											500
Turakurgan TPP	GTCC			450	450			450	450									1800
New Syrdarya TPP	GTCC				450	450												900
Mubarek CHP	GTCS					140												140
Fergana CHP	GTCC				57,7													57.7
Tashkent CHP	GTCS						2×27											54
Tashkent CHP-2	GTCS				4×27													108

Source: Uzbekenergo JSC

※ The red color indicates projects for which a finance source has been defined and construction started or Pre F/S or F/S completed.

The black color indicates projects for which no finance source has been defined, or F/S is not completed or under development. Detailed information on finance sources are presented in Chapter 3, paragraph 3.2.4 "Power sources determined for development"

5.2.1 Navoi TPP

This paragraph shows the results of a study on a potential for further yen loans to construct GTCC 3, which is scheduled for completion by 2021.

(1) Outline of the power plant

Figure 5.2.1-1 Location of Navoi TPP

Navoi TPP has been constructed to provide power to central and western parts of Uzbekistan (Navoi, Bukhara, Samarkand regions). At present, Navoi TPP also supplies heat to the adjacent Navoiyazot (fertilizer plant). Navoi TPP is a cogeneration plant, which includes modern combined-cycle plants of the M701F type produced by MHPS, but the remaining power-generating units were built in the 60s and many have reached the end of their service life. Accordingly, although the total plant capacity is 3,000 MW, the available capacity is 1,300 MW.

On August 22, 2013 the Government of Uzbekistan and the Japan International Cooperation Agency (JICA) signed a loan agreement to grant a yen loan amounting to 34 billion 877 million yen, to cover the total construction cost of 53 billion 195 million yen, for the project to modernize the Navoi Thermal Power Plant. This project aims to increase the efficiency and reliability of heat and electricity supply, develop the economy in the long term and reduce the consumption of natural gas, helping reduce CO_2 emissions by introducing combined-cycle power plants (unit 2) to replace obsolete equipment.

The construction of GTCC 3 at Navoi TPP is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

Pic. 5.2.1-1 Panoramic view of Navoi TPP

Pic. 5.2.1-2 Navoiyazot plant

(2) Power plant operation

Existing equipment: among ten currently operating, units 1, 2 and 6 are temporarily out of service. The remaining units are operated at the maximum possible capacity, while GTCC1 is operated at the rated capacity.

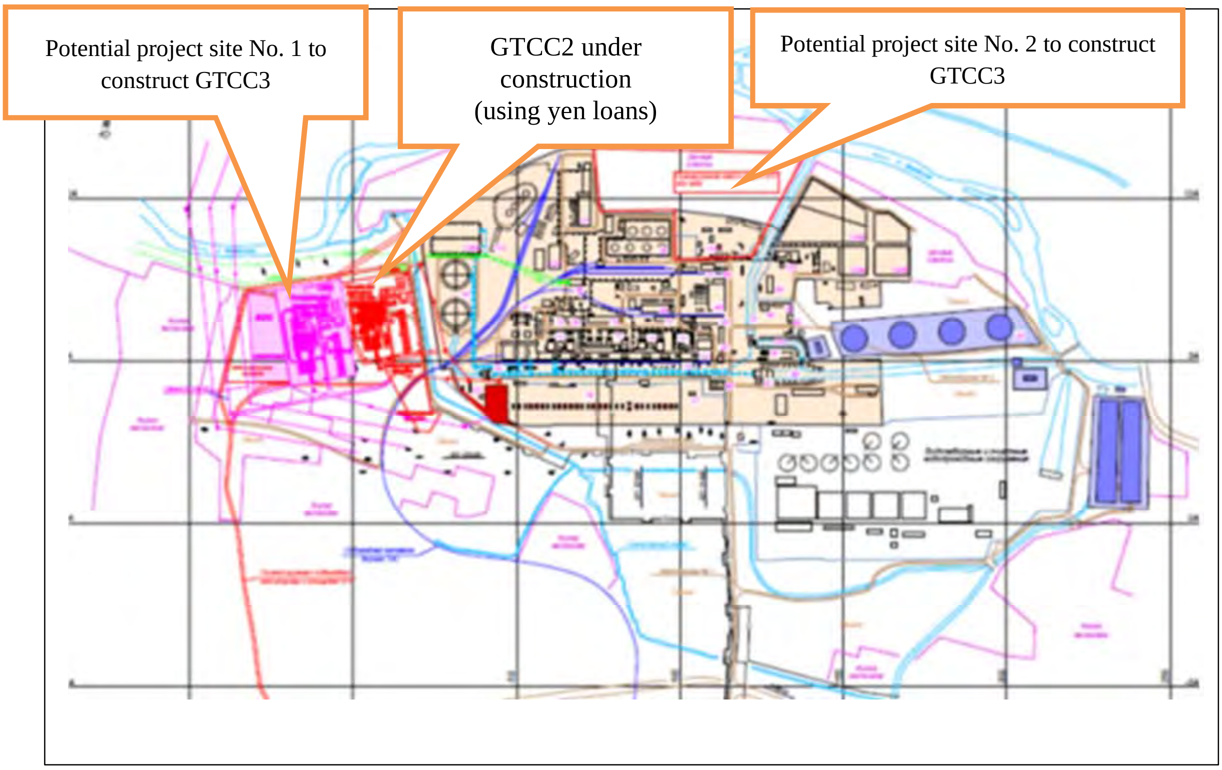
New equipment: GTCC2 which is under construction and GTCC3, construction of which is planned, are planned to be operated at rated capacity.

(3) Allocation of construction site

This issue is under review by TEP[3] and Uzbekenergo JSC.

Two potential project sites are under review. Site No. 1 is located within Navoi TPP, while No. 2 is located in an area adjacent to Navoi TPP, where country houses of Navoi residents are under construction. In case site No. 2 is selected, it will be necessary to relocate or remove these country houses.

[3] TEP (JSC "Teplo electro Proekt")



Source: Uzbekenergo JSC

Figure 5.2.1-2 Potential project sites to construct GTCC3 of Navoi TPP

(4) Fuel supply stability

No problem.

Pipeline: (current situation) 720.8mm diameter, two lines, capacity 400,000m^3/h, (during the construction of GTCC2) there are plans to construct an additional line with capacity exceeding 50,000 m^3/h. On completion to construct unit No. 2, there are plans to decommission the existing unit 3, whereupon sufficient supply capacity should be ensured.

(5) Provision of utilities

Feed water intake for boiler and cooling water is carried out from Zarafshan River flowing near the station and feed water is treated before use. Henceforth, there are plans to conduct F/S and consider expanding facilities before commissioning unit No. 3.

(6) Problems relating to the grid connection

There are plans to carry out the grid connection by two 220 kV lines and no problem with transmission capacity. Henceforth, there are plans to conduct F/S and consider expanding facilities before starting to construct unit No. 3.

(7) Funding for newly constructed equipment

Not determined.

(8) Environmental impact of newly constructed equipment

There is the potential for improvement.

Due to decommissioning of existing unit No. 1, 2 and 6 as well as constructing GTCC3, specific fuel consumption will be improved by 9.2 % (based on calorific value), so CO_2 emissions will be reduced compared to a conventional gas thermal power plant of similar capacity.

(9) Potential for resettlement and alienation of agricultural land

This possibility exists.

The project site among two proposed with the most potential is an area where several country houses of Navoi city residents are under construction. In case the construction is carried out there, it will be necessary to relocate or remove the country houses.

(10) Problems relating to transportation of the equipment

No particular problem.

There are past records of transportation of GTCC1 of the Navoi TPP, which will be used as reference to draw up a transportation plan.

(11) Preparation progress regarding the new construction

The construction of GTCC 3 at Navoi TPP is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan, dated March 4, 2015. However, discussion of technical and other issues remains deadlocked at present.

(12) Challenges to power plant construction

As part of preparation to construct GTCC3, a 110 kV switchyard must be constructed. It will also be necessary to take measures to resettle residents when selecting an area of country houses (potential project site No. 2) as a construction site.

(13) Necessity for and urgency to construct new equipment

The construction of GTCC3 is necessary to address issues such as ensuring the implementation of the state policy of the Republic of Uzbekistan on reducing gas consumption and covering electricity of Uzbekistan. In addition, if constructing new equipment reduces the use of existing equipment, it will provide an opportunity to comply with emission standards; compliance with which is becoming difficult task given the obsolescence of existing equipment.

(14) Evaluation of the construction site

The increased reliability and efficiency of the power supply following the replacement of obsolete equipment via the scrap-and-build method will allow gas consumption to be reduced, in line with the state policy of the Republic of Uzbekistan. Besides, taking into account the fact that existing equipment does not meet emission standards and is incurring penalties, from the perspective of environmental measures in the region, new equipment can be constructed.

5.2.2 Talimardjan TPP

This paragraph shows the results of the study on the potential allocate further yen loans to construct GTCC 3 and GTCC 4, which is scheduled for completion by 2022.

(1) Outline of the power plant

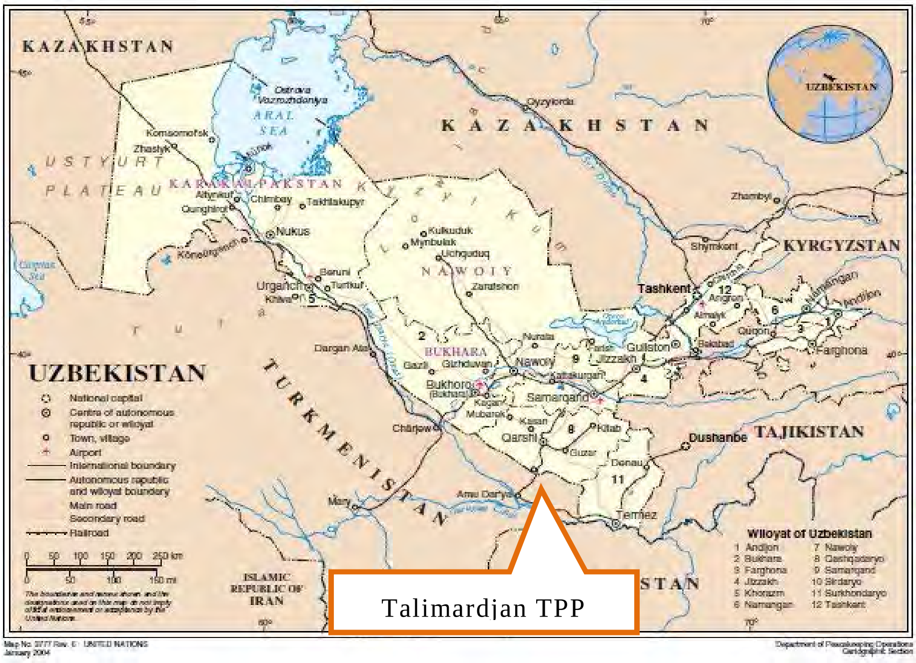


Figure 5.2.2-1 Location of Talimardjan TPP

Talimardjan TPP is located in the South of Uzbekistan and is the newest natural gas power station; put into operation in 2004 and with rated power of 800 MW. Although the original plan was to construct four units, given the low plant efficiency of the first unit, which amounted to 36 %, construction of units 2, 3 and 4 was suspended. In response to the growing electricity demand by the Decree of the President of the Republic of Uzbekistan No. PP-1366 the decision was made to construct GTCC-1 and GTCC-2, followed by GTCC-3 and GTCC-4 by Presidential Decree No. UP-4707.

On May 1, 2010, the Japanese International Cooperation Agency signed an agreement to grant a yen loan amounting to 27 billion 423 million yen for the Talimardjan TPP expansion project. This project, a first in Central Asia, will be implemented according to the Accelerated Co-Financing scheme with the Asian Development Bank (ADB) and there are plans to build two GTCC of 450 MW by 2017.

The construction of GTCC-3 and GTCC-4 (priority potential projects) is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

Pic. 5.2.2-1 Panoramic view of Talimardjan TPP

Pic. 5.2.2-2 Central control room of Talimardjan TPP

(2) Power plant operation

Existing equipment: operation at rated capacity is 800 MW, operation as a mid-load thermal power plant is also possible.

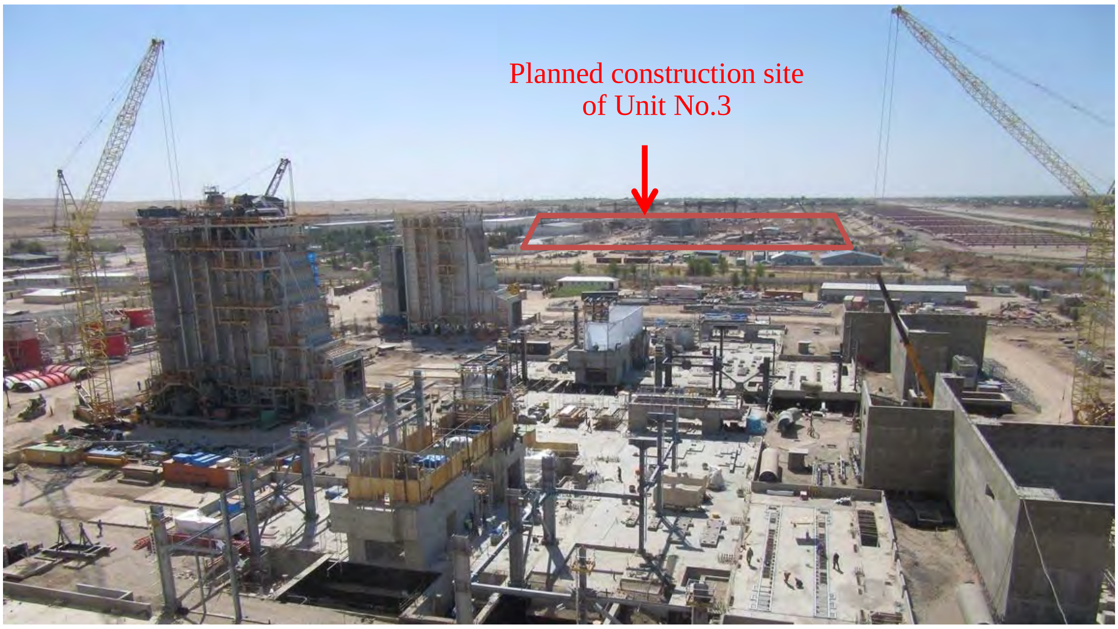
New equipment: there are plans to operate it at rated capacity.

(3) Allocation of construction site

The construction site is determined.

Allocation of Since the construction site is located on the territory of the Talimardjan TPP, there will not be any resettlement or alienation of agricultural land.

At the front of the following picture, GTCC 1 and 2 are under construction, with construction of a third unit on the west side.



Pic. 5.2.2-3 Talimardjan TPP, construction site of GTCC 1 and 2 (in the front) and panned construction site for Unit No. 3

(4) Fuel supply stability

For the new GTCC 1-4, the gas pipeline must be expanded.

Gas supply: gas pipeline, diameter 720 mm, capacity 425,000 m^3/h, two lines.

Gas consumption: on the existing equipment it is 195,000 m^3/h and on newly constructed equipment, 85,000 m^3/h.

(5) Provision of utilities

Feed water intake for boilers and cooling towers is carried out from the Karshi Canal and feed water for the boiler is treated before use. From now, there are plans to conduct F/S and consider expanding facilities.

(6) Problems relating to the grid connection

No particular problem.

There is one 500 kV switchyard (for the new GTCC 1, 2, 3, 4). There are plans to complete the construction of a 500 kV transmission system with the commissioning of units 1 and 2 (2017). No problem with transmission capacity.

(7) Funding for newly constructed equipment

Not determined.

(8) Environmental impact of newly constructed equipment

There is the potential for improvement.

Due to the construction of GTCC-3, specific fuel consumption will be improved by 10 % (based on calorific value), so compared to a conventional gas thermal power plant of similar capacity, CO_2 emissions will be reduced.

(9) Potential for resettlement and alienation of agricultural land

No resettlement.

Construction is planned on the TPP territory.

(10) Problems relating to transportation of equipment

No particular problem.

There are past records of transportation of GTCC-1 and GTCC-2 equipment, which will be used as benchmarks to draw up a transportation plan.

(11) Preparation progress regarding the new construction

Construction of GTCC-3 is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015. However, there is no current progress in discussing technical and other issues.

(12) Challenges to power plant construction

Construction of a 500 kV transmission system (under construction) and a gas pipeline is required.

(13) Need for and urgency to construct new equipment

The third and fourth GTCC must be constructed to address issues such as ensuring the implementation of the state policy of the Republic of Uzbekistan on reducing gas consumption and meeting the electricity demand of Uzbekistan. In addition, if constructing new equipment will help reduce dependence on existing equipment, it will provide an opportunity to comply with emission standards, which is becoming increasingly difficult task given the obsolescence of existing equipment.

(14) Evaluation of the construction site

Designed and constructed in the Soviet period, existing equipment lacks efficiency. Moreover, taking into account the fact that the equipment does not meet emission standards (NOx) and is operated with payments of penalties, construction of new equipment is appropriate based on the regional environmental measures. Constructing new GTCC will also boost plant-wide efficiency and reduce CO2 emissions.

5.2.3 Syrdarya TPP

This paragraph shows the results of a study on the potential to provide further yen loans to construct GTCC1 and GTCC2, which are scheduled for completion by 2019.

(1) Outline of the power plant

Figure 5.2.3-1 Location of Syrdarya TPP

Syrdarya TPP is a plant constructed to play a central role in the power supply of Uzbekistan. 10 power-generating units of 300 MW each were built at Syrdarya TPP in 1972-1981, with total capacity of 3,000 MW. However, the generating plant capacity has currently stopped at 2,020 MW due to obsolescence of equipment. In 2014-2015 the repowering of existing unit No. 1 and 2 was performed and total capacity was boosted by 50 MW.

On January 27, 2015 the Government of Uzbekistan and the Japanese International Cooperation Agency signed an agreement to grant a yen loan of 3 billion yen to the energy sector efficiency increase project. One of the three projects included in the energy sector efficiency increase project is the Syrdarya Engineering Service, which aims to facilitate a feasibility study, detailed design and preparation of other documents while taking into account environmental and social aspects in order to introduce combined-cycle plants (450 MW x 2) at Syrdarya TPP

The construction of GTCC1 and GTCC2 (priority potential projects) at Syrdarya TPP is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

Pic. 5.2.3-1 Panoramic view of Syrdarya TPP

(2) Power plant operation

Existing equipment: operated under the load-dispatch instructions of NDC[4]. The demand for the current day is indicated on the evening previous to the day, with the decision regarding the operation mode of plant units made independently. However, Syrdarya TPP as a frequency regulation thermal power plant responds flexibly to the load-dispatch instructions of NDC.

New GTCC: there are plans to operate at the rated capacity (base load).

(3) The construction site

The construction site is determined.

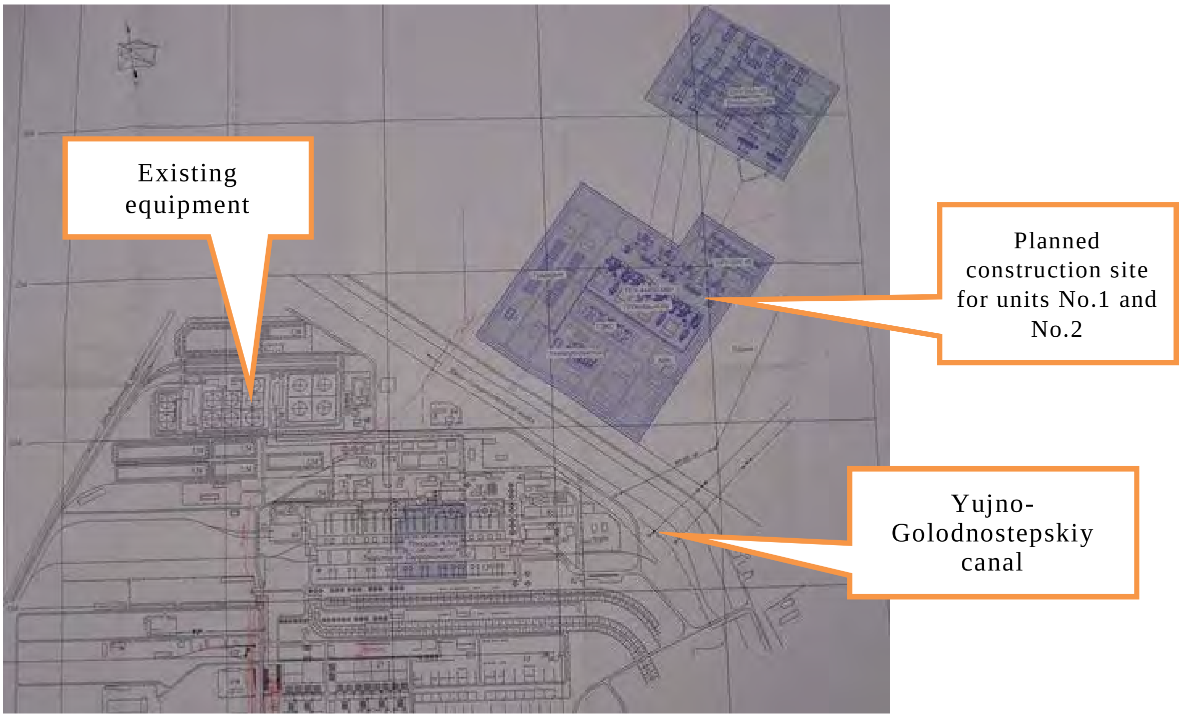
For construction within the plant area, many objects have to be removed, so there are plans to construct outside the plant area (adjacent area located across the Yujno-Golodnostepskiy canal).

There are fields and country houses located on the planned construction site. However, oral agreement has been reached with farmers to relocate fields as the construction starts. Uzbekenergo JSC plans to draw up an equipment layout plan which will not involve removing country houses.

Pic. 5.2.3-2 Planned construction site for unit No. 1 and 2

Pic. 5.2.3-3 Yujno-Golodnostepskiy canal

[4] National Dispatch Center



Source: Uzbekenergo JSC

Figure 5.2.3-2 Layout drawing of unit No. 1 and 2

(4) Fuel supply stability

Construction of a new gas pipeline is required.

Pipeline: 720mm diameter, 2 lines, each with capacity of 500,000m^3/h (the gas pipeline connected to the gas distribution station (GDS) located near the plant is divided into two lines), incoming pressure of 12kg/cm^2 (both new and existing equipment. However, the existing equipment is operated under pressure reduced to 1.8-2.0 kg/cm^2). There are plans to construct 700mm×2 lines×500,000 m^3/h when commissioning the new GTCC.

Gas consumption: existing 3,000 MW equipment: 700,000 m^3/h±5 %, newly constructed GTCC: 75,000 m^3/h, 2 units.

(5) Provision of utilities

There is no problem with the volume and quality of water.

Feed water for the boiler and cooling tower is supplied from the Yujno-Golodnostepskiy canal and feed water for the boiler is treated before use. Henceforth, there are plans to conduct F/S and consider the expansion of facilities before commissioning unit No. 1 and 2.

(6) Problems relating to the grid connection

No particular problem.

Existing equipment: connection to the 220 kV grid.

New equipment: there are plans to step-up to 500 kV and transmit electricity within Uzbekistan. Regarding the transmission capacity, henceforth there are plans to conduct F/S and consider expanding facilities before commissioning unit No. 1 and 2.

(7) Funding for newly constructed equipment

Not determined.

(8) Environmental impact of newly constructed equipment

There is the potential for improvement.

Due to the construction of GTCC1, specific fuel consumption will be improved by 6.4 % (based on calorific value), so CO_2 emissions will be reduced compared to a conventional gas thermal power plant of similar capacity.

(9) Possibility of resettlement and alienation of agricultural land

This is a possibility.

There are fields and country houses located on the planned construction site. Oral agreement has been reached with farmers to relocate fields as construction starts. There are plans to draw up an equipment layout plan which will not involve the removal of country houses.

(10) Problems relating to transportation of the equipment

Since the motor roads near the plant are uneven, they must be repaired or reconstructed.

(11) Preparation progress regarding the new construction

The Pre F/S is now completed and is being reviewed by appropriate ministries and agencies. The construction of GTCC1 and GTCC2 is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

(12) Challenges to power plant construction

Since the motor roads near the plant are very uneven, they must be repaired or reconstructed. There is also the potential to alienate agricultural land for construction.

(13) Need and urgency to construct new equipment

Syrdarya TPP is located 300m from the Tajikistan border and plays an important role to regulate the power grid frequency and control the power flow. The role of Syrdarya TPP will remain unchanged after the new power-generating facilities are constructed, so the construction of the new GTCC is reasonable, given the need to ensure sufficient capacity to regulate the power grid frequency and reliably meet the electricity demand of Uzbekistan. In addition, obsolescence of existing equipment is hindering efforts to comply with emission standards, which underlines the urgent need to construct new equipment.

(14) Evaluation of the construction site

Syrdarya TPP is located only 180 km from Tashkent, which is a large-scale electricity consumer, located in the center of Uzbekistan and with a number of advantages from the perspective of power grid operation, making Syrdarya TPP an appropriate plant for use as a base power supply facility. Taking into account the further increase in electricity demand, the development of power-generating facilities should be prioritized. The construction of the new GTCC will boost plant-wide efficiency and thus reduce CO_2 emissions, while in the short term, a contribution to the economic development of Shirin city with the inflow of construction workers is also expected.

5.2.4 Turakurgan TPP (construction place)

This paragraph shows the results of the study on the potential to allocate further yen loans to construct GTCC 3 and GTCC 4, which are scheduled for completion by 2022.

(1) Outline of the power plant

Figure 5.2.4-1 Location of Turakurgan TPP

The Fergana region is located in eastern Uzbekistan, housing a high population density, comprising one third of the total. Electricity is supplied to the region by HPP, located in the region and power transmitted from the central part of the country, but when the electricity demand peaks at 1,650 MW, the power shortage in winter is 540 MW and even in summer, when there is a lot of water, the shortage is 322 MW, which are covered by electricity imports from Kyrgyzstan.

On November 10, 2014 the Government of Uzbekistan and the Japanese International Cooperation Agency signed an agreement to grant a yen loan of 71 billion 839 million yen to the Turakurgan TPP construction project. A further annual increase in electricity demand of the region is forecast at around 8 %. Since the electricity shortage is expected to continue, construction of highly efficient power-generating facilities has become an urgent task. The aim of the project is to increase power and heat supply security through construction of a GTCC plant (900 MW) in the Namangan region,and modernizationof power transmission lines and transformer substations.

(2) Power plant operation

There are plans to operate under the load-dispatching instructions of NDC. To cover the electricity demand of Fergana Valley there are plans to operate at the rated capacity.

(3) Allocation of construction site

The construction site is determined.

The construction site is currently a vacant lot, with sufficient space to accommodate two GTCC units.

(4) Fuel supply stability

For the new GTCC 3-4, a gas pipeline has to be expanded.

There is a gas pipeline near the planned construction site, access to which would not cause any difficulties. In 2014, NHC "Uzbekneftegaz" issued a guarantee letter for a gas supply contract for two units. This gas supply contract is to be concluded between JSC "Uztransgaz" and renewed annually.

Pipeline: diameter 720 and 530 mm, two lines, minimum capacity 180,000 m^3/h, gas pressure at the connection point of 9 kg/cm^2.

Gas consumption: Unit No. 1 and 2 is 75,000 m^3/h, for unit No. 3 and 4, also 75,000 m^3/h.

(5) Provision of utilities

Feed water intake for boiler and cooling water is carried out from the Grand Canal. For the newly constructed unit No. 3 and 4, there is a need to design and construct feed water treatment facilities.

(6) Problems relating to the grid connection

No particular problem.

Connection to the grid of 220 kV is planned by four lines. While constructing unit No. 3 and 4, construction of new switchgear is necessary. Also reconstruction of nearby substation is required.

(7) Funding for newly constructed equipment

Not determined.

(8) Environmental impact of newly constructed equipment

Demand for electricity in the Fergana Valley is 1,650 MW, so if all four planned GTCC are constructed (unit No. 1, 2, 3, 4 with total capacity of 1,800 MW) and the existing equipment of Fergana CHP with 305 MW (available capacity is 250 MW) may be decommissioned or have the load limited due to increased power generation efficiency, a reduced environmental burden can be expected (CO_2 emissions).

(9) Possibility of resettlement and alienation of agricultural land

Since the construction site is a vacant lot, there is no resettlement or alienation of agricultural land involved.

(10) Problems relating to transportation of the equipment

There are previous records for transportation of GTCC-1 and GTCC-2 equipment, which will be used as a reference to draw up a transportation plan for GTCC-3 and GTCC-4.

Access roads are currently under construction.

(11) Preparation progress regarding the new construction

The construction of the third and fourth units is planned taking future demand trends into account, but no decision on construction has currently been accepted and there has not been any progress in discussing technical issues, such as the drawing up of Pre F/S.

Since the planning of units 1 and 2 excludes the construction of units 3 and 4, in Uzbekenergo JSC, there are plans for reconsideration, provision of water and fuel and expansion of switchgear.

(12) Challenges to power plant construction

Since the planning of units 1 and 2 excludes the construction of units 3 and 4, there is a need to design and construct power transmission facilities, a fuel supply facility and utility networks.

(13) Need and urgency to construct new equipment

The electricity demand in Fergana Valley is 1,650 MW, even if 900 MW from the two GTCC of Turakurgan TPP is added to the capacity of the existing Fergana CHP equipment, which is 305 MW (available capacity of 250 MW) plus a new GTCC of 57.7 MW (planned), it will not cover all the electricity demand, nor solve the issue regarding the transfer of power at a considerable distance from western Uzbekistan. In this regard, it becomes necessary to build a third GTCC unit (450 MW). Taking into account the supply and demand balance at the time of construction, there is a need to construct the fourth GTCC unit.

(14) Others

To construct GTCC-1 and GTCC-2, there are plans to attract yen loans of 71 billion 800 million yen.

As for unit No. 1 and 2, SV consultants of the project are currently making the tender documents, scheduled for completion in mid-year.

(15) Evaluation of the construction site

The electricity demand in Fergana Valley is 1,650 MW, even if 900 MW from two GTCC of Turakurgan TPP is added to the capacity of existing equipment of Fergana CHP, which is 305 MW (available capacity is 250 MW) plus a new GTCC of 57.7 MW (planned), it will not meet all electricity demand nor solve the issue involving the transfer of power at distance from western Uzbekistan. In this regard, a third GTCC unit will have to be constructed (450 MW). Furthermore, regarding the construction of the fourth unit, it is advisable to determine the time of construction, taking into account the demand-and-supply balance of electric power in Uzbekistan.

5.2.5 Tashkent TPP

This paragraph shows the results of the study on the potential for further yen loans to construct GTCC2,450 MW which is scheduled for completion by 2024.

(1) Outline of the power plant

Figure 5.2.5-1 Location of Tashkent TPP

Tashkent TPP is an obsolete thermal power plant built in 1963-1971 to supply to Tashkent city with a view to interconnecting Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan. At that time Tashkent TPP was the largest power plant in Central Asia.

There are 12 power-generating units, but only ten are currently operational and the total capacity is 1,860 MW. Due to the obsolescence limiting the available capacity to 1,665 MW, the plant efficiency is 30.3 %. Currently the 370 MW GTCC (GE main equipment) is under construction, with commissioning planned for 2016.

Pic. 5.2.5-1 Panoramic view of Tashkent TPP

Pic. 5.2.5-2 370 MW GTCC with commissioning planned for 2016

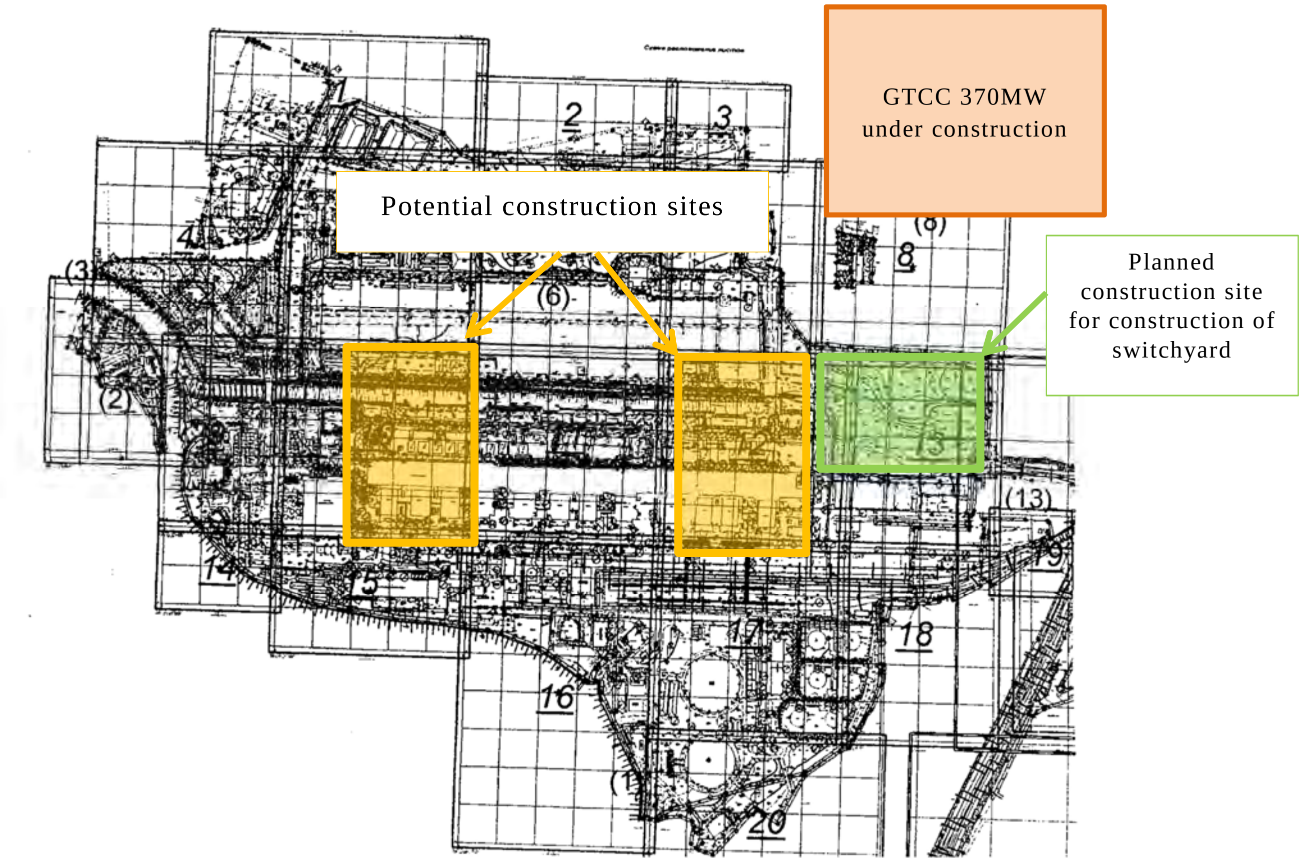
(2) Power plant operation

Existing equipment: operated under the load-dispatch instructions of NDC. The demand for the current day is indicated every morning at 4 am, with the decision regarding the operation mode of plant units made independently. No units are operated under automatic frequency control (AFC).

New equipment: there are plans to operate at the rated capacity (base load).

(3) Allocation of construction site

There are plans to allocate the site for construction after decommissioning the three existing (most probably unit No. 1, 2 and 3, but possibly also unit No. 10, 11 and 12).



Source: Uzbekenergo JSC

Figure 5.2.5-2 Potential project sites to construct GTCC2 of Tashkent TPP

(4) Fuel supply stability

No problem.

After commissioning GTCC1 (370 MW), which is under construction, there are plans to decommission the two existing units. This will reduce gas consumption by 100,000 m^3/h, allowing sufficient supply capacity to be ensured without having to construct a new gas pipeline.

Pipeline: 720mm diameter, two lines, with capacity of 500,000m^3/h each.

Gas consumption: existing 1,860 MW equipment: 600,000 m^3/h±5 %, GTCC1 (370 MW): 80,000-89,000 m^3/h, GTCC2: 75,000 m^3/h.

(5) Provision of utilities

There is no problem with the volume and quality of water.

Feed water for boiler: water is supplied from Charvak water reservoir and treated before use.

Cooling water: intake of water is carried out from Bozsu canal, heat exchange is carried out in the condenser and water is discharged $\Delta T = 9$℃.

Henceforth, there are plans to conduct F/S and consider expanding facilities before starting to construct GTCC2.

(6) Problems relating to the grid connection

No particular problem.

Connection to the existing 220 kV grid. Along with the GTCC1 (370 MW) commissioning, two existing units will be decommissioned, followed by a further three units (about 450 MW), so there will be no problem with transmission capacity.

(7) Funding for newly constructed equipment

Not determined.

(8) Environmental impact of newly constructed equipment

There is the potential for improvement.

Due to the construction of GTCC2, specific fuel consumption will be improved by 8.9 % (based on calorific value), so CO_2 emissions will be reduced compared to a conventional gas thermal power plant of similar capacity.

(9) Possibility of resettlement and alienation of agricultural land

Possibility of resettlement and alienation of agricultural There is no such possibility.

There are plans to allocate the site for construction after decommissioning existing units

(10) Problems relating to transportation of the equipment

No particular problem.

There are plans to draw up a transportation plan using past transportation records of 370 MW GTCC (GE main equipment) as reference.

(11) Preparation progress regarding the new construction

Currently there is no progress in the discussion of technical and other issues.

(12) Challenges to power plant construction

There are no particular challenges.

(13) Need and urgency to construct new equipment

New equipment needs to be constructed to increase the reliability of the power supply and reducing gas consumption by replacing obsolete equipment using the scrap-and-build method, to meet the electricity demand of Uzbekistan and reduce transmission loss during the local production of electricity for local consumption.

(14) Evaluation of the construction site

Tashkent TPP is located in Tashkent city, which is a large-scale electricity consumer and supplies electricity to the Tashkent region and Fergana Valley, ranking third in Uzbekistan in terms of total capacity. However, the progressive obsolescence of every unit built in 1960-1970 means Tashkent TPP ranks second in Uzbekistan among the least efficient power plants. The increased reliability and efficiency of the power supply due to replacing obsolete equipment using the scrap-and-build method will allow gas consumption to be reduced, so the construction of the new GTCC complies with the state policy of the Republic of Uzbekistan. Besides, taking into account the fact that existing equipment does not meet emission standards and is incurring penalties, from the perspective of regional environmental measures, it is appropriate to construct new equipment.

5.2.6 Angren TPP

This paragraph shows the results of the study on the potential to allocation of further yen loan to construct 150 MW coal-fired thermal power plant, which is scheduled for completion by 2021.

(1) Outline of the power plant

Figure 5.2.6-1 Location of Angren TPP

Construction of Angren TPP as source of power for the coal industry of Angren city, was launched in 1953 and with the newest equipment manufactured in 1963 and total capacity of 480 MW (available capacity - 197 MW), the plant equipment has become obsolete. The construction of a 150 MW coal-fired thermal power plant is currently underway, commissioning of which is scheduled in 2016. After the commissioning of a new coal-fired power unit, there are plans to decommission units with a capacity of 220 MW. The number of units to be decommissioned after commissioning a coal-fired power unit planned for construction in 2021 and with capacity of 150 MW (potential priority project) has yet to be determined.

The main fuel for all units is Angren coal (lignite), natural gas and gas of underground gasification, while the reserve fuel is fuel-oil. Generated ash is sold to cement plants in Uzbekistan, Russia and China.

Construction of a 150 MW coal-fired power unit (priority potential project) is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

Pic. 5.2.6-1 Panoramic view of Angren TPP

Pic. 5.2.6-2 Turbine department

(2) Power plant operation

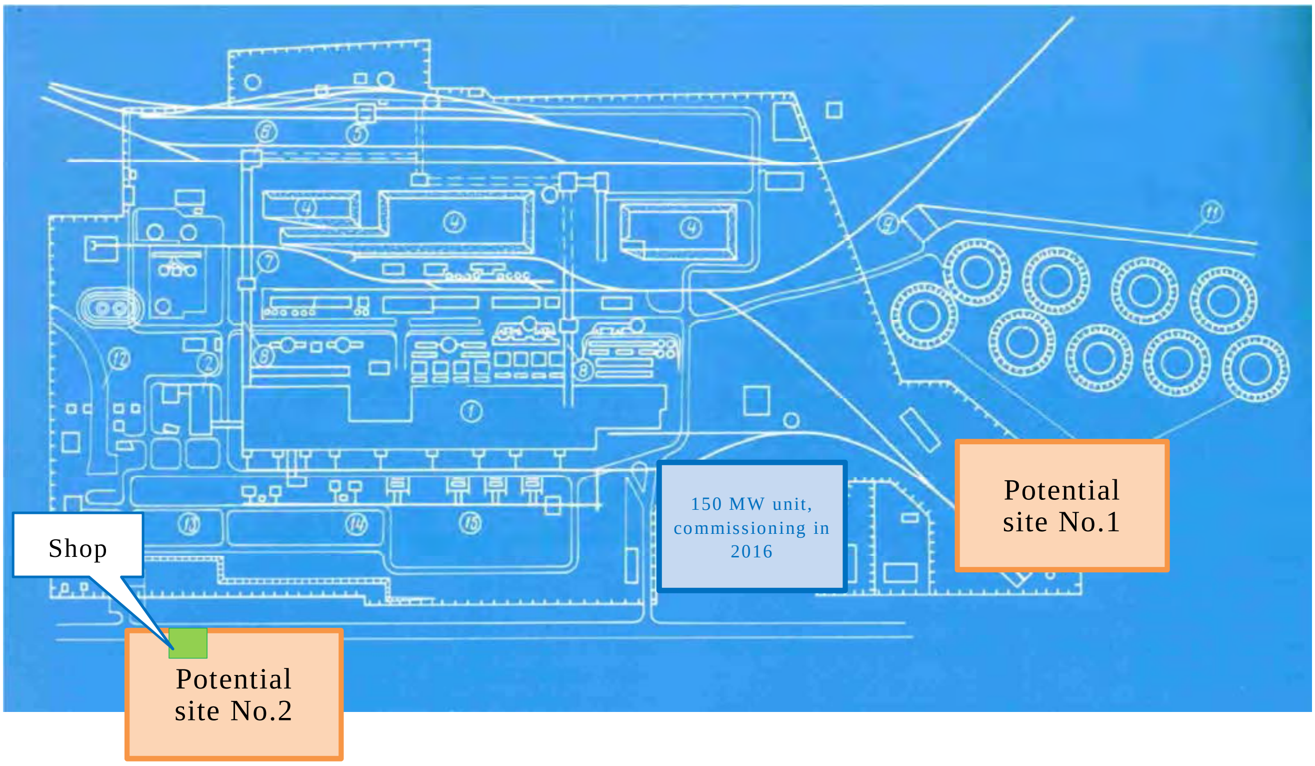
Existing equipment: operated under the monthly load-dispatch instruction of NDC. Demand curve shows nearly rated capacity. Taking into account the efficiency of obsolete equipment and the gas consumption reduction policy, there is no other alternative but to operate the equipment at rated capacity.

New equipment: there are plans to operate at rated capacity.

(3) Allocation of construction site

The construction site is determined.

Construction is planned near (potential site No. 1) the new 150 MW equipment (commissioning in 2016) or on the territory of the existing thermal power plant on the other side of the road (potential site No. 2). If constructing on potential site No. 2, there is a need to displace shops and if constructing on potential site No. 1, there is a need to dismantle the existing equipment, which would increase the construction cost.



Source: Uzbekenergo JSC

Figure 5.2.6-2 Planned construction sites of the 150 MW unit at Angren TPP

(4) Fuel supply stability

No problem.

There are plans for the new equipment to be constructed as a coal-fired unit.

Coal will be supplied by OJSC "Uzbekugol" (about 10 km from Angren TPP) and OJSC "Shargunkumir" (Surkhandarya region, 700 km) to ensure a stable supply. There are plans to transport the coal by railroad.

Source: Uzbekenergo JSC

Pic. 5.2.6-3 Coal mine of Uzbekugol

(5) Provision of utilities

There is no problem with the volume and quality of water.

Feed water for boiler: water is obtained from Akhangaran canal. Feed water for the boiler is treated before use.

Cooling water:

Existing equipment: in summer, water is obtained from Akhangaran Canal ($8\text{-}10m^3/h$) and discharged $\Delta T = 10$℃.

In winter, due to lack of water (freezing) one of the four cooling towers is used.

New equipment: same as the existing equipment. In summer, water is obtained from the canal. In winter, there are plans to use cooling towers. During the commissioning, the cooling capacity will be determined and a final decision made on the annual use of cooling towers (depending on the temperature fluctuation of water in the canal and the changes in water shortage). Henceforth, there are plans to conduct F/S and consider expanding facilities.

(6) Problems relating to the grid connection

No particular problem.

Connection to the grid of 220 kV is planned by four lines. Due to the decommissioning of the existing equipment, no transmission system expansion is planned. No problem with transmission capacity.

(7) Funding for newly constructed equipment

Not determined.

(8) Environmental impact of newly constructed equipment

There is the potential for improvement.

Due to the construction of a new 150 MW unit, specific fuel consumption will be improved by 7.5 % (based on calorific value), so CO_2 emissions will be reduced compared to a conventional gas thermal power plant of similar capacity. In addition, since the installation of the latest environmental equipment is expected, there is the potential to reduce NOx, SOx and ash dust.

Besides, the existing equipment does not meet emission standards and operation incurs financial penalties.

(9) land

This is a possibility.

If constructing on potential site No. 2, there is a need to displace the shop.

(10) Problems relating to transportation of the equipment

No particular problem.

There are plans to transport by rail based on past transportation records of the new 150 MW unit (commissioning in 2016).

Pic. 5.2.6-4 Shop that might be moved.

(11) Preparation progress regarding the new construction

Currently, technical documentation is being developed, No pre F/S is carried out.

Construction of a 130-150 MW coal-fired power unit is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

(12) Challenges to power plant construction

If constructing on potential site No. 2, there is a need to displace the shop.

(13) Need and urgency to construct new equipment

Existing equipment is significantly obsolete. New equipment needs to be constructed to improve power supply reliability and boost electricity using coal, as well as reducing gas consumption, which is part of the state policy of the Republic of Uzbekistan. This is also to ensure a stable power supply to Almalyk industrial zone.

(14) Evaluation of the construction site

The increased reliability and efficiency of the power supply by replacing obsolete equipment constructed in the 1950s-1960s, using the scrap-and-build method will allow coal consumption to be reduced. Construction of the new equipment will increase the consumption of local coal and reduce gas consumption, which complies with the state policy of the Republic of Uzbekistan. Besides, taking into account the fact that the equipment does not meet emission standards and operation incurs financial penalties, from the perspective of regional environmental measures, the construction of new equipment is appropriate. Regarding the new equipment, it is recommended to construct a highly efficient coal-fired power unit with the latest environmental technology of Japan, to ease the burden on the environment.

5.2.7 Novo-Angren TPP

This paragraph shows the results of the study on the potential for further yen loans to construct a 300 MW coal-fired power-generating unit which is scheduled for completion by 2024.

(1) Outline of the power plant

Figure 5.2.7-1 Location of Novo-Angren TPP

Novo-Angren TPP is a relatively new plant built in 1985-1995 to supply electricity to Angren city, Akhangaran region, Almalyk industrial zone. The plant is adjacent to Tashkent region and Fergana Valley and thus plays an important role as a central power-generating facility in Uzbekistan. There are seven units, each with 300 MW. The total capacity is 2,100 MW, which means it ranks second among the power plants of Uzbekistan. However, the current available capacity is 1,320 MW, which is extremely low.

The main fuel for unit No. 1-5 is Angren coal (brown coal) and natural gas from Bukhara deposit, for units 6 and 7, the main fuel is natural gas of the Bukhara deposit. The reserve fuel for all units is fuel-oil. Also, in future, there are plans to transfer unit No. 6 and 7 to the burning of coal.

The generated coal ash is sold to cement plants in Uzbekistan, Russia and China.

Pic. 5.2.7-1 Panoramic view of Novo-Angren TPP

There are plans to carry out further modernization gradually, in three stages.

Stage 1: transfer unit No. 1-5 to the burning only (planned to complete by 2015).

Stage 2: transfer unit No. 6 and 7 from gas burning to coal burning alone (included in Decree No. UP-4707). There are plans to carry this out in 2018-2020.

Stage 3: construction of a new 300 MW coal-fired power-generating unit (priority potential project). The commissioning is planned for 2021.

(2) Power plant operation

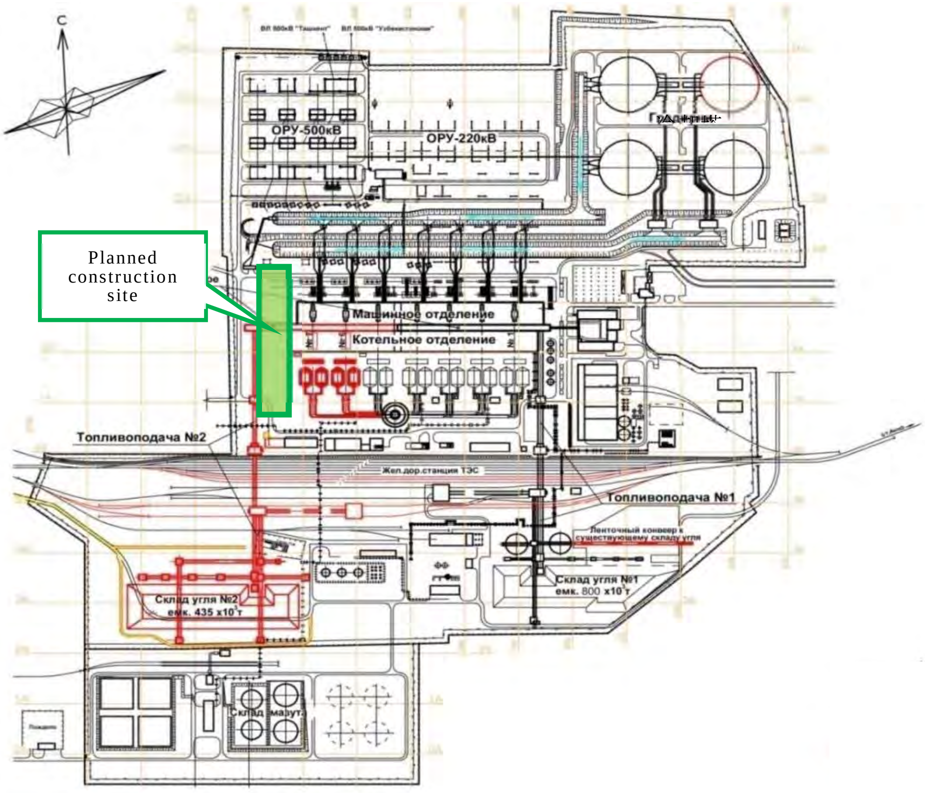
Existing equipment: operated under the everyday load-dispatch instructions of NDC. Unlike Angren TPP, where the demand curve shows nearly rated capacity, Novo-Angren TPP is often operated at medium load to respond to considerable load changes throughout the day.

New equipment: efficiency will increase compared to existing equipment, so the new equipment is expected to be operated at rated capacity. However, as Novo-Angren TPP is at the halfway point of the Uzbekistan transmission grid and taking the plant capacity into account, there is a possibility that Novo-Angren TPP will become a medium-load power plant.

(3) Allocation of construction site

The construction site is determined.

Construction sites for all eight new units to be constructed are determined at Novo-Angren TPP.



Source: Uzbekenergo JSC

Figure 5.2.7-2 Planned construction site for unit No.8 of Novo-Angren TPP

(4) Fuel supply stability

No problem.

There are plans for new equipment to be constructed as coal-fired equipment.

Coal will be supplied by OJSC "Uzbekugol" (about 10 km from Angren TPP) and OJSC "Shargunkumir" (Surkhandarya region, 700 km) to ensure a stable supply. There are plans to transport the coal by railroad.

(5) Provision of utilities

There is no problem with the volume and quality of water.

Feed water for boiler: water is obtained from the Akhangaran canal and treated before use. There is no lack of flow of water.

Cooling water:	Existing equipment	Water is taken from the Akhangaran canal and supplied to three cooling towers. It is only necessary to resupply the evaporated water volume on a constant basis.
	New equipment	Same as the existing equipment. Cooling is planned via cooling towers. However, it is necessary to construct a fourth cooling tower in addition to the three existing cooling towers. The second cooling tower is under construction, so it is not used.
	Henceforth, there are plans to conduct F/S and consider expanding facilities.	

Source: Uzbekenergo JSC

Pic. 5.2.7-2 Cooling towers

(6) Problems relating to the grid connection

No particular problem.

There are plans to carry out power transmission via four 220 kV lines. The transmission grid was originally constructed taking into account the transmission volume of all eight units, so there is no problem with transmission capacity. However, as the construction period has not been determined, the grid has not been worked out up to switchgears, so more connection cells, circuit breakers and other equipment must be installed.

(7) Funding for newly constructed equipment

Not determined.

(8) Environmental impact of newly constructed equipment

There is the potential for improvement.

Due to the construction of a new 300 MW unit, specific fuel consumption will be improved by 4.1 % (based on calorific value), so compared to a conventional coal-fired thermal power plant of similar capacity, CO_2 emissions will be reduced. Besides, up-to-date environmental devices are expected to be installed, so there is scope to reduce NOx, SOx, soot and dust emissions.

(9) Possibility of resettlement and alienation of agricultural land

There is no such possibility.

There are plans to carry out construction within the plant area.

(10) Problems relating to transportation of the equipment

No particular problem.

There are plans to transport equipment by railroad referencing past transportation records of 150 MW coal-fired power unit to Angren TPP, the commissioning of which is planned for 2016.

(11) Preparation progress regarding the new construction

Currently there is no progress in the discussion of technical and other issues.

(12) Challenges to power plant construction

Reconstruction of cooling tower No. 2 and construction of new switchgear is required.

(13) Need and urgency to construct new equipment

New equipment needs to be constructed to boost electricity production using coal, as well as reducing the gas consumption, decreasing the environmental burden and ensuring a stable power supply to Almalyk industrial zone.

(14) Evaluation of the construction site

Although existing equipment with total capacity of 2,100 ranking second in Uzbekistan was built in the 1980s, the current plant efficiency is 29.5 %, which is the lowest value among the thermal power plants held by Uzbekenergo JSC. The existing equipment does not meet emission standards and is incurring penalties, however, taking the service life of the equipment into account, the option of scrap-and-build method should not be prioritized.

It is recommended to increase the efficiency and extend the life of existing equipment by properly maintaining environmental devices of existing equipment, as well as taking measures to increase the efficiency of main BTG equipment (boilers, turbines, generators).

5.2.8 Tashkent CHP

This paragraph shows the results of the study on the potential for further yen loans to construct GTCS 2, 3, which is scheduled for completion by 2020.

(1) Outline of the power plant

Figure 5.2.8-1 Location of Tashkent CHP

In 2013, under the NEDO project at Tashkent CHP, the MHPS Gas Turbine Unit of the H-25 type was introduced, the remaining equipment was built in the 1930s-1950s and is extremely outdated. The rated capacity is 57 MW, but the current available capacity is 49.5 MW. The construction of two GTCS (priority potential project) is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

Pic. 5.2.8-1 Panoramic view of Tashkent CHP (left side is conventional equipment, right side is NEDO demonstration project equipment)

(2) Power plant operation

Existing equipment: operated under the load-dispatch instructions of NDC. The demand for the current day is indicated once a month, however, the plant is mostly operated at the rated capacity.

New equipment: there are plans to operate at the rated capacity as NEDO project equipment.

(3) Allocation of construction site

The construction site is determined.

There are plans to carry out construction aside of the NEDO project equipment.

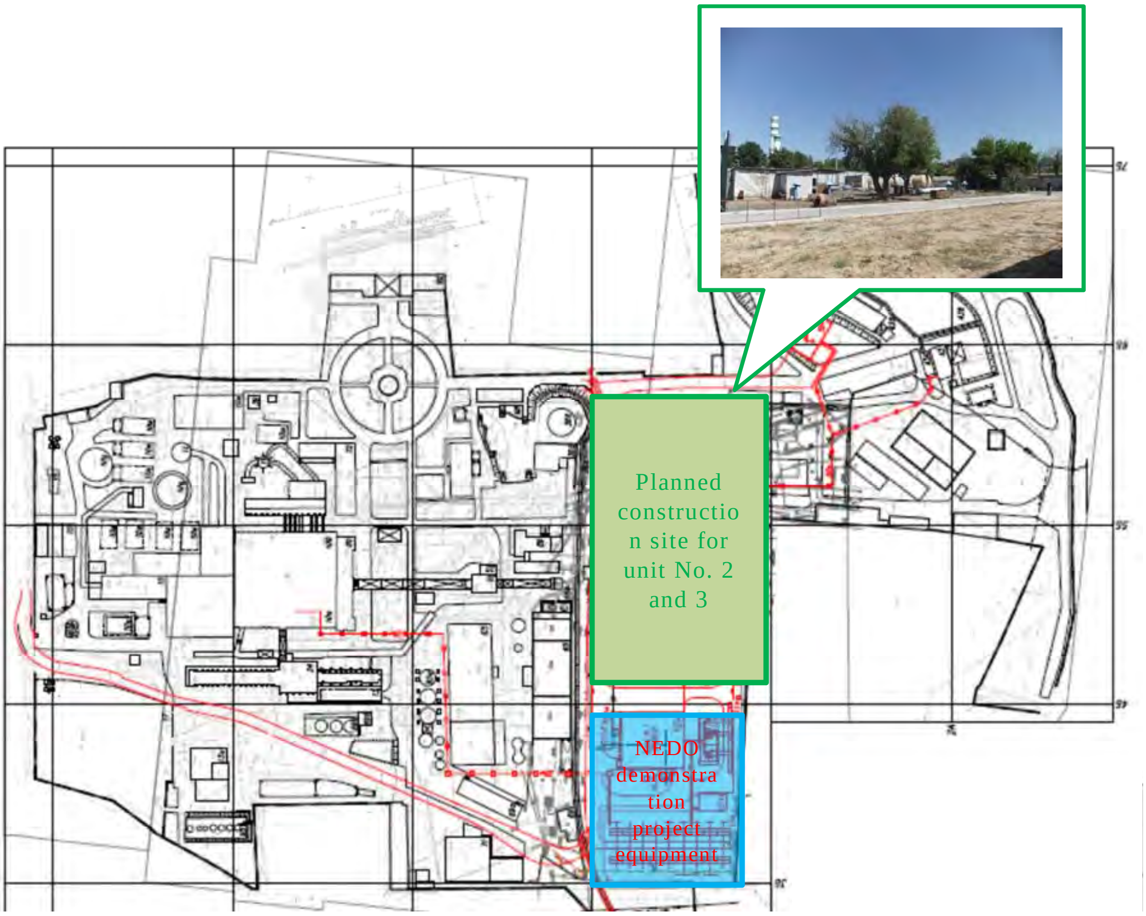


Figure 5.2.8-2 Planned construction site for GTCS No. 2 and 3

(4) Fuel supply stability

No problem.

The gas pipeline capacity was originally designed taking into account the construction of 27 MW GTCS×2 in addition to NEDO project equipment (27 MW GTCS×1), so there is enough supply capacity. Problems with incoming pressure and quality of gas which occurred during the NEDO project have been solved due to construction of a new pipeline.

Pipeline: 530mm diameter with capacity of 300,000m^3/h, incoming pressure of 4.5kg/cm^2.

Gas consumption: existing equipment: 40,000 m^3/h, NEDO project equipment: 10,000 m^3/h.

New GTCS No. 2 and 3: expected to be about 10,000 m^3/h.

(5) Provision of utilities

There is no problem with the volume and quality of water.

Feed water for boiler: tap water is used and treated before use.

Cooling water: tap water.

The construction site, electric transmission facilities, fuel pipeline and others have been completed during NEDO equipment planning, however, the supply contract must be amended.

As for the water treatment facilities, henceforth there are plans to conduct F/S and consider expanding facilities.

(6) Problems relating to the grid connection

No particular problem.

There are plans to connect to the existing 110 kV grid.

The switchgear, transmission grid necessary for GTCS No. 2 and 3 were already constructed during the construction of NEDO project equipment.

(7) Funding for newly constructed equipment

Not determined.

(8) Environmental impact of newly constructed equipment

There is the potential for improvement.

Due to the construction of GTCS No. 2 and 3, specific fuel consumption will be improved by 0.8 % (based on calorific value), so CO_2 emissions will be reduced compared to a conventional gas thermal power plant of similar capacity. In addition, if the use of existing low-efficient equipment is reduced, it will help reduce the CO_2 emission intensity of the energy system.

(9) Possibility of resettlement and alienation of agricultural land

There is no such possibility.

There are plans to carry out construction within the plant area.

(10) Problems relating to transportation of the equipment

No particular problem.

There are plans to transport equipment mainly by railroad, using past records of the NEDO project.

(11) Preparation progress regarding the new construction

The Pre F/S is completed.

The construction of GTCS No. 2 and 3 is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

(12) Challenges to power plant construction

There are no particular challenges.

(13) Need and urgency to construct new equipment

New equipment needs to be constructed to reduce the gas consumption and the transmission loss during the local production of electricity for local consumption due to increased supply reliability and efficiency.

(14) Evaluation of the construction site

Although the conditions necessary for construction such as the construction site, fuel pipeline, utilities and others are satisfied, taking into account the capacity of the power facilities to be constructed in the vicinity of Tashkent, the need to construct power-generating facilities is low.

Since the prospect of heat demand increase (production plan) at an adjacent sewing factory is uncertain, it is currently recommended to extend the life of existing equipment by carrying out proper maintenance and introducing the GTCS gradually as the prospect of heat demand becomes certain.

5.2.9 Mubarek CHP

This paragraph shows the results of the study on the potential for further yen loans to construct 150 MW GTCS which is scheduled for completion by 2019.

(1) Outline of the power plant

Figure 5.2.9-1 Location of Mubarek CHP

Mubarek CHP is a relatively new plant in Uzbekistan, which supplies steam to the Mubarek gas processing plant. The total power of the plant is 120 MW. The entire volume of produced heat and almost the entire volume of electricity is supplied to the gas processing plant, while the remaining electricity is supplied to the power grid.

After the construction of the 140 MW GTCS (priority potential project) is completed the existing equipment is planned to be used as backup equipment.


Pic. 5.2.9-1 Panoramic view of Mubarek CHP

(2) Power plant operation

Existing equipment: electricity generation and heat supply is carried out in accordance with the production plan of the gas processing plant, with no load-dispatch instructions from NDC. After commissioning the new GTCS, the existing equipment is planned to be used as backup equipment.

New equipment: prioritizing the power and heat supply to the gas processing plant, operation as a medium-load plant to regulate the power grid frequency is also considered.

(3) Allocation of construction site

The construction site is allocated within the Mubarek CHP area.

Source: Uzbekenergo JSC

Figure 5.2.9-2 Planned construction site to construct GTCS at Mubarek CHP

Pic. 5.2.9-2 Current state of the planned construction site

(4) Fuel supply stability

No problem.

The gas supply for new GTCS is ensured by a supply contract with the gas processing plant, which has already been concluded with Mubarek gas processing plant. Since the gas supply line is currently a single line, a new gas pipeline must be constructed by the time construction of the new GTCS is complete.

Pipeline: 426mm diameter, single line, incoming pressure of 9-10 kg/cm^2, capacity of 108,000 m^3/h.

Gas consumption: existing equipment: 35,000 m^3/h.

New GTCS: 43,000 m^3/h.

(5) Provision of utilities

Feed water for boiler: treated water is purchased from the Mubarek gas processing plant.

Cooling water: feed water for cooling tower is supplied from the Mubarek water treatment plant.

Henceforth, there are plans to conduct F/S and consider expanding facilities.

(6) Problems relating to the grid connection

No particular problem.

There are plans to carry out power transmission via two 220 kV lines. Mubarek CHP is mainly intended to supply power to the adjacent Mubarek gas processing plant, so no significant increase in demand is expected. After the construction of the new GTCS, there are plans to use existing CHP equipment as backup equipment and there is no problem with transmission capacity.

(7) Funding for newly constructed equipment

Not currently determined.

The Ministry for Foreign Economic Relations, Investments and Trade (MFERIT) is currently reviewing finance sources. The Uzbekistan Fund for Reconstruction and Development (UFRD) is considered the source of financing with the most potential.

(8) Environmental impact of newly constructed equipment

There is the potential for improvement.

Due to the construction of GTCS1, specific fuel consumption will be improved by 4.8 % (based on calorific value), so CO_2 emissions will be reduced compared to a conventional thermal power plant of similar capacity.

(9)Possibility of resettlement and alienation of agricultural land

There is no such possibility.

There are plans to carry out construction within the plant area.

(10) Problems relating to transportation of the equipment

No particular problem.

Railroad transportation is possible via rail tracks adjacent to the CHP. It was used during the construction of the existing equipment, and is currently used for transporting chemicals. Use of the railroad is possible during the new construction.

Pic. 5.2.9-3 Railroad near the Mubarek CHP

(11) Preparation progress regarding the new construction

The design organization under the Ministry of Economy is currently developing the Pre F/S.

(12) Challenges to power plant construction

It is necessary to construct a new gas pipeline for new equipment.

There is a possibility that chemicals control at the Mubarek gas processing plant will have an impact on the construction and maintenance of new equipment, so monitoring of this issue is recommended.

(13)Need and urgency to construct new equipment

New equipment needs to be constructed to increase supply reliability and reduce gas consumption due to increased plant efficiency.

(14) Evaluation of the construction site

The conditions necessary for construction such as a construction site, fuel pipeline, utilities and others are satisfied. As the existing equipment was built in the mid-1980s, it is considered feasible to extend the life of equipment by carrying out proper maintenance.

Taking into account the fact that Mubarek CHP was built mainly to supply heat to an adjacent gas processing plant and the locational conditions of the plant, which is located between Navoi TPP and Talimarjan TPP, the need to construct a power supply facility is low. It is recommended to decide whether to construct GTCS in accordance with the state policy as a measure to replace obsolete heat supply equipment, or additionally install special heat supply boilers considering the economic efficiency.

5.2.10 Fergana CHP

This paragraph shows the results of the study on the potential to allocate further yen loans to construct a 57.7 MW GTCC, which is scheduled for completion by 2018.

(1) Outline of the power plant

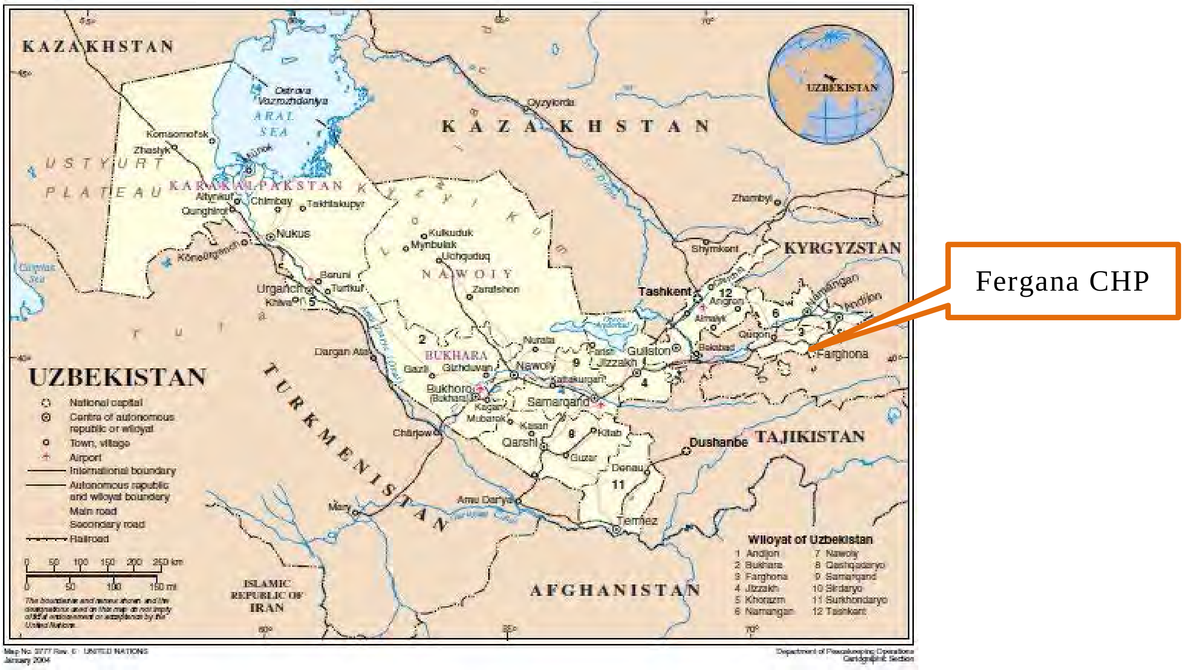


Figure 5.2.10-1 Location of Fergana CHP

The Fergana CHP was designed to supply heat and power to nearby plants. Steam is supplied to the fertilizer plant (SC "Ferganaazot") and Fergana refinery (NHC "Uzbekneftegaz") in the Fergana-Margilan industrial zone. Most of the production capacity of CHP aims to produce heat. The plant equipment was built from the early 1950s to the beginning of the 1980s and is extremely outdated. The rated capacity is 305 MW, but the currently available capacity is 250 MW.

Although coal was originally used as fuel, the main fuel is currently natural gas and the reserve fuel is fuel-oil.

In 2014, in Fergana CHP, a study to disseminate technology within the NEDO project in Tashkent CHP was conducted and it was recommended to construct two 30 MW class GTCS and expand GTCC in the view of demand.

Construction of 57.7 MW GTCC (priority potential project) is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

Pic. 5.2.10-1 Panoramic view of Fergana CHP

Pic. 5.2.10-2 Turbine department

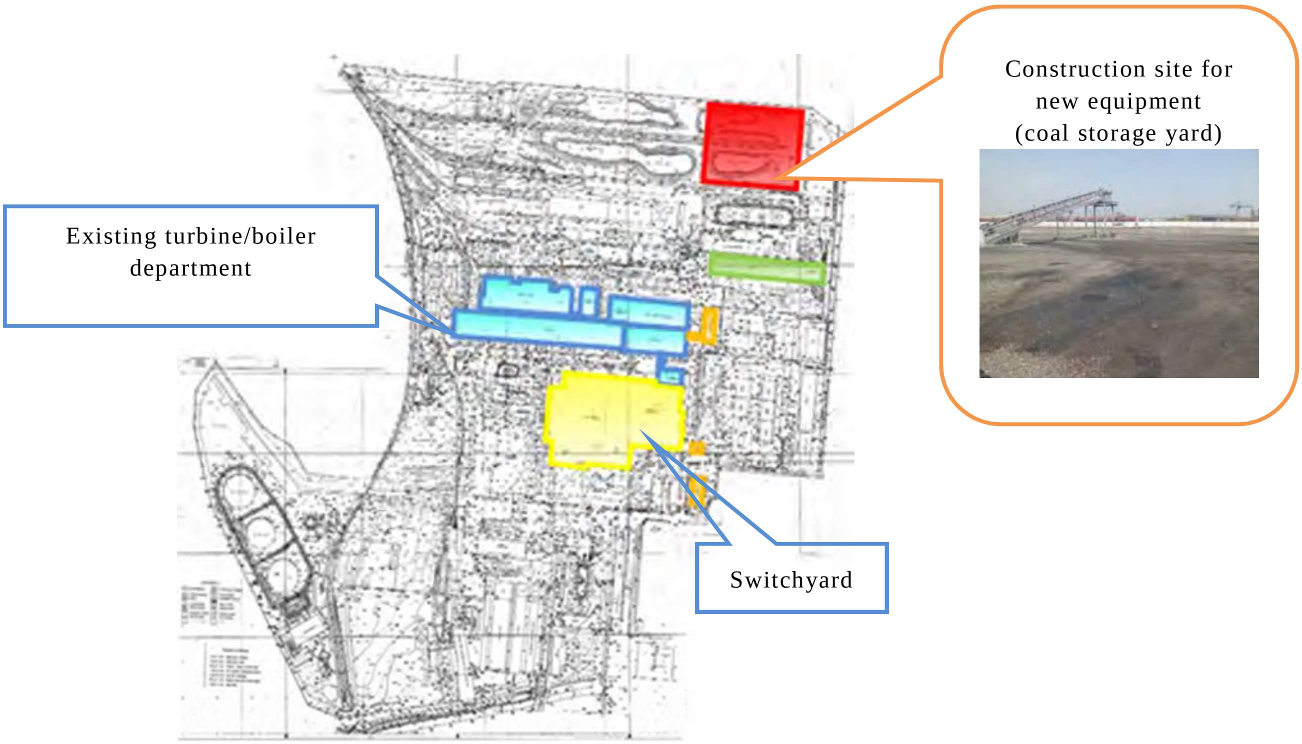
(2) Power plant operation

Existing equipment: since the CHP was mainly built and operated to supply heat and electricity to the Fergana refinery (NHC "Uzbekneftegaz") and SC "Ferganaazot" (fertilizer plant), the demand depends on the production plan of consumers.

New equipment: there are plans to operate at rated capacity to cover electricity demand of Fergana Valley.

(3) Allocation of construction site

The construction site is determined on the territory of Fergana CHP (coal storage yard).



Source: Prepared by JICA Study Team based on Fergana CHP Pre F/S of Uzbek side.

Figure 5.2.10-2 Fergana CHP, placement plan of new equipment

(4) Fuel supply stability

No problem.

Gas pipeline expansion is planned when constructing new equipment.

Gas supply: gas pipe, diameter 530 mm, two lines with total capacity of 100,000 m^3/h.

Gas consumption: for existing equipment 60,000 m^3/h and for newly constructed equipment, 25,000 m^3/h.

(5) Provision of utilities

Feed water for boiler: treated water is purchased from the nearby SC "Ferganaazot". Part of the treated water is produced in the Fergana CHP.

Cooling water: feed water for cooling towers is purchased.

Henceforth, there are plans to conduct F/S and consider expanding facilities.

(6) Problems relating to the grid connection

No particular problem

There are plans to connect to the existing 110 kV grid.

Most of the generated electric power will be directly delivered to the nearby refinery and fertilizer plant, the rest will be supplied to the grid, which is currently possible through existing equipment.

(7) Funding for newly constructed equipment

Not determined.

(8) Environmental impact of newly constructed equipment

No such impact.

Due to the construction of the new GTCC unit, CO_2 emissions of the Fergana CHP will not be reduced, but if the use of existing low-efficient equipment will be reduced, it will help reduce the CO_2 emission intensity of the energy system.

(9) Possibility of resettlement and alienation of agricultural land

No such possibility.

Construction is planned on the territory of CHP.

(10) Problems relating to transportation of the equipment

For the overland route, since it traverses Tajikistan territory, verification of the transportation route is essential, i.e. the feasibility for safe passage of trucks with bulky equipment, flatness and width of roads, load-carrying capacity of bridges. Transportation of GTCC-1 and GTCC-2 cannot serve as a reference as their construction was later than GTCC of Fergana CHP.

For rail, opening of the tunnel on the Angren-Pap railroad is imperative.

(11) Preparation progress regarding the new construction.

By August 2015, NEDO had completed a feasibility study to construct three 17 MW class gas turbines. Construction of 57.7 MW GTCC (priority potential project) is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

(12) Challenges to power plant construction

In recent years, there was no experience of transporting bulky power-generating units in Fergana Valley, hence a safe and secure transportation route must be considered.

(13) Need and urgency to construct new equipment

Construction of the new equipment will help increase the reliability of heat (steam, hot water) and power supply of Fergana refinery and SC “Ferganaazot” and slightly increase the energy supply capacity of Fergana Valley.

However, the electricity demand in Fergana Valley is 1,650 MW, so even if 900 MW from two GTCC of Turakurgan TPP is added to the capacity of existing equipment of Fergana CHP, which is 305 MW (available capacity is 250 MW) plus a new GTCC of 57.7 MW (planned), it will not meet all electricity demand nor solve the issue involving the transfer of power at distance from western Uzbekistan.

(14) Others

In 2015, NEDO conducted a primary study of the Model project to construct three 17 MW class gas turbines in Fergana CHP, which was completed before August. No MOU with the Uzbek side has yet been signed, nor has any decision on project implementation been made.

Construction of a 57.7 MW GTCC is included in Appendix No. 3 to Decree No. UP-4707 of the President of the Republic of Uzbekistan dated March 4, 2015.

(15) Evaluation of the construction site

Although, all the necessary conditions for construction, such as the construction site, fuel supply, utilities, a study on the NEDO Model Project to construct three 17 MW class gas turbines (total capacity of 51 MW) moving forward, the construction period of the NEDO project matches the construction period of 57 MW GTCC, as mentioned in Decree No. UP-4707 of the President of the Republic of Uzbekistan. From the perspective of the original objectives of Fergana CHP, namely to replace obsolete equipment and heat supply to the nearby refinery, the construction of gas turbines is reasonable.

Accordingly, if it is supposed that the power shortage of Fergana Valley will remain after implementing the NEDO project and constructing two GTCC units on Turakurgan TPP, the construction of 57.7 GTCC can be considered.

5.3 Evaluation of priority potential project sites

Based on the circumstances of the potential project sites described in paragraph 4.2 the evaluation was conducted as shown in Table 5.3-1.

The priority projects selected taking into account the fuel supply plan, environmental and social considerations, an optimal electric power development scenario in Uzbekistan and other issues are listed in the next section.

Table 5.3-1 Evaluation of priority potential project sites

			Navoi TPP	Talimardjan TPP	Syrdarya TPP	Turakurgan TPP	Tashkent TPP	Angren TPP	Novo-Angren TPP	Tashkent CHP	Mubarek CHP	Fergana CHP
Scheduled commissioning of priority potential projects			450MW GTCC in 2021	450MW GTCC in 2021 450MW GTCC in 2022	450MW GTCC in 2018 450MW GTCC in 2019	450MW GTCC in 2021 450MW GTCC in 2022	450MW GTCC in 2024	150MW coal-fired TPP in 2021	300MW coal-fired TPP in 2024	27MWx2 GTCS in 2020	140MW GTCS in 2019	57.7MW GTCC in 2018
Preparation progress regarding the new construction.	Technical study		There is no progress in the discussion of the technical and other issues.	There is no progress in the discussion of the technical and other issues.	Pre F/S is completed. Pre F/S is under verification in state agencies.	There is no progress in the discussion of the technical and other issues.	There is no progress in the discussion of the technical and other issues.	Technical documentation is being developed. Pre F/F is not done. Consultant is not selected.	There is no progress in the discussion of the technical and other issues.	Pre F/S is completed.	Pre F/S stage (being developed by research institute under the Ministry of Economics)	NEDO has completed feasibility study of the Project on construction of three 17MW GTCS.
	Authorization by Presidential Decree		The Project is included in Appendix No.3 to the Presidential Decree No. UP-4707	The Project is included in Appendix No.3 to the Presidential Decree No. UP-4707	The Project is included in Appendix No.3 to the Presidential Decree No. UP-4707	N/A	N/A	The Project is included in Appendix No.3 to the Presidential Decree No. UP-4707	N/A	The Project is included in Appendix No.3 to the Presidential Decree No. UP-4707	N/A	The Project is included in Appendix No.3 to the Presidential Decree No. UP-4707
Possibility of resettlement and alienation of agricultural land			There is a possibility	No such possibility	There is a possibility	No such possibility	No such possibility	There is a possibility	No such possibility	No such possibility	No such possibility	No such possibility
Challenges	Allocation of construction site		Determined	Determined	Determined	Determined	Will be determined after the decommissioning of the existing equipment	Determined	Determined	Determined	Determined	Determined
	Fuel supply stability		No problem	Gas pipeline should be constructed	Gas pipeline should be constructed	Gas pipeline should be constructed	No problem	No problem	No problem	No problem	No problem	No problem
	Provision of utilities		No problem	No problem	No problem	Designing and construction is necessary	No problem	No problem	No problem	No problem	No problem	No problem
	Problems relating to the grid connection		No particular problem	No particular problem	No particular problem	No particular problem	No particular problem	No particular problem	No particular problem	No particular problem	No particular problem	No particular problem
	Transportation		No problem	No problem	Access roads are rough and needs to be repaired.	No problem	No problem	No problem	No problem	No problem	No problem	Reconnaissance required
	Challenges in power plant construction	To be solved within the plant	Construction of new 110kV Switchyard (is being planned by Uzbekenergo JSC)	N/A	N/A	Transmission line, gas pipeline and utilities for Phase-2 (Unit 3 and 4) need to be constructed because Phase-1 (Unit 1 and 2) does not consider future expansion.	N/A	N/A	N/A	N/A	N/A	N/A
		To be solved outside the plant	Necessary to discuss with the residents regarding the construction site.	Construction of 500kV transmission system (is being planned by Uzbekenergo JSC)	Necessary to discuss with the residents regarding the construction site.			Necessary to discuss with the residents regarding the construction site.				
		To be solved by the third party	N/A	Construction of gas pipeline for new GTCC (Uzbekneftegaz)	Construction of gas pipeline for new GTCC (Uzbekneftegaz)			N/A			Construction of gas pipeline for new GTCS (Uzbekneftegaz)	
Necessity and urgency of the construction of new equipment	Improvement of power demand and supply balance		Meeting the needs of Uzbekistan in electric power.	Meeting the needs of Uzbekistan in electric power.	Meeting the needs of Uzbekistan in electric power.	Ensure increase of power supply capacity of Fergana Valley and decrease power transmission loss by local generation and consumption.	Meeting the needs of Uzbekistan in electric power.	Stable power supply to Almalyk industrial zone	Stable power supply to Almalyk industrial zone			Ensure increase of power supply capacity of Fergana Valley and decrease power transmission loss by local generation and consumption.
	Regional division of power grid		South-West (Samarkand)	South-West (Samarkand)	Central region (Tashkent)	East (Fergana)	Central region (Tashkent)	Central region (Tashkent)	Central region (Tashkent)	Central region (Tashkent)	South-West (Samarkand)	East (Fergana)
	Environmental benefit		At obsolescence of existing equipment, it is difficult to comply with emission standards (gas emission)	At obsolescence of existing equipment, it is difficult to comply with emission standards (gas emission)	At obsolescence of existing equipment, it is difficult to comply with emission standards (gas emission)		At obsolescence of existing equipment, it is difficult to comply with emission standards (gas emission)	At obsolescence of existing equipment, it is difficult to comply with emission standards (gas emission)	At obsolescence of existing equipment, it is difficult to comply with emission standards (gas emission)			

		Navoi TPP	Talimardjan TPP	Syrdarya TPP	Turakurgan TPP	Tashkent TPP	Angren TPP	Novo-Angren TPP	Tashkent CHP	Mubarek CHP	Fergana CHP
	Others	Reduction of gas consumption	Reduction of gas consumption	①Ensuring allowance for frequency control in the power system ②Reduction of gas consumption		Decrease of reliability of power supply due to the obsolescence of the equipment and reduction of gas consumption	Decrease of reliability of power supply due to the obsolescence of the equipment and reduction of gas consumption due to the use of coal	Decrease of reliability of power supply due to the obsolescence of the equipment and reduction of gas consumption due to the use of coal	Decrease of reliability of power supply due to the obsolescence of the equipment	Reduction of gas consumption	Decrease of reliability of power supply due to the obsolescence of the equipment and reduction of gas consumption
Evaluation		The increase of reliability and efficiency of power supply by the replacement of obsolete equipment using scrap-and-build method will allow reducing the gas consumption, which complies with the state policy of the Republic of Uzbekistan. Besides, taking into account the fact that existing equipment does not meet emission standards and is being operated with payment of penalties, from the point of view of environmental measures of the region the construction of new equipment is appropriate.	Designed and constructed in the Soviet period, existing equipment has a low efficiency, furthermore, taking into account the fact that the equipment does not meet the emission standards (NOx) and being operated with payments of penalties, from the point of view of environmental measures of the region construction of new equipment is appropriate. Also, construction of new GTCC will increase the entire efficiency of the plant and reduce gas consumption. In the short term the contribution to economic development of Karshi city due to inflow of construction workers is also expected.	Syrdarya TPP is located only 180 km from Tashkent which is a large-scale consumer of electricity, and located in the center of Uzbekistan, and has a number of advantages from the point of view of power grid operation, so Syrdarya TPP is an appropriate plant to be used as a base power supply facility. Taking into account the further increase of electricity demand, the priority should be given to the development of power generating facilities. The construction of new GTCC will lead to increase of the entire plant efficiency, thus leading to the reduction of gas consumption. In the short term the contribution to economic development of Shirin city due to inflow of construction workers is also expected.	The demand for electricity in Fergana Valley is 1,650 MW, even if 900 MW from two GTCC of Turakurgan TPP will be added to the capacity of existing equipment of Fergana CHP, which is 305 MW (available capacity is 250 MW) plus a new GTCC of 57.7 MW (planned), it will not cover the entire demand for electricity and will not solve the issue with the transfer of power at a great distance from the western part of Uzbekistan. In this regard, it becomes necessary to build a 3rd unit of GTCC (450 MW). Furthermore, regarding the construction of the 4th unit, it is advisable to determine the time of construction, taking into account the demand-and-supply balance of electric power in Uzbekistan.	Tashkent TPP is located in Tashkent city which is a large-scale consumer of electricity, and supplies electricity to Tashkent region and Fergana Valley ranking 3rd in Uzbekistan by total capacity. However, due to the progress of obsolescence of every unit built in 1960-1970 Tashkent TPP ranks 2nd in Uzbekistan among the power plants with the lowest efficiency. The increase of reliability and efficiency of power supply due to replacement of obsolete equipment using scrap-and-build method will allow reducing gas consumption, so the construction of new GTCC complies with the state policy of the Republic of Uzbekistan. Besides, taking into account the fact that existing equipment does not meet emission standards and is being operated with payment of penalties, from the point of view of environmental measures of the region the construction of new equipment is appropriate.	The increase of reliability and efficiency of power supply due to replacement of obsolete equipment, which was constructed in 1950-1960s, using scrap-and-build method will allow reducing coal consumption. Construction of the new equipment will increase the consumption of local coal and reduce gas consumption, which comply with the state policy of the Republic of Uzbekistan. Besides, taking into account the fact that the equipment does not meet the emission standards and being operated with payments of penalties, from the point of view of environmental measures of the region construction of new equipment is appropriate.	Although existing equipment with total capacity of 2,100 ranking 2nd in Uzbekistan has been built in 1980s, the current plant efficiency is 29.5% which is the lowest value among the thermal power plants held by SC «Uzbekenergo JSC». The existing equipment does not meet emission standards and is being operated with payment of penalties, however, taking into account the service life of equipment, the option of scrap-and-build method should not be given priority. It is recommended to increase the efficiency and extend the life of existing equipment by carrying out properly the maintenance of environmental devices of existing equipment, as well as taking measures to increase the efficiency of main equipment BTG (boilers, turbines, generators).	Although the conditions necessary for construction such as construction site, fuel pipeline, utilities and others are satisfied, taking into account the capacity of power facilities to be constructed in the vicinity of Tashkent the necessity of construction of power generating facilities is low. The prospect of heat demand increase (production plan) at adjacent sewing factory is not certain, so currently it is recommended to extend the life of existing equipment by carrying out properly its maintenance, and introduce the GTCS gradually as the prospect of heat demand becomes certain.	The conditions necessary for construction such as construction site, fuel pipeline, utilities and others are satisfied. As the existing equipment has been built in the middle 1980s, it is considered possible to extend the life of equipment by carrying out properly its maintenance. Taking into account the fact that Mubarek CHP has been built mainly for heat supply to adjacent gas processing plant, and locational conditions of the plant which is located between Navoi TPP and Talimarjan TPP, the necessity of construction of power supply facility is low. It is recommended to decide whether to construct GTCS in accordance with the state policy as a measure for replacement of obsolete heat supply equipment, or additionally install the special heat supply boilers considering the economic efficiency.	Although, there are all necessary conditions for construction, such as construction site, fuel supply, utilities, study on the NEDO Model Project on construction of three 17 MW class gas turbines (total capacity of 51 MW) moving forward, the construction period of the NEDO Project duplicates with the construction period of 57 MW GTCC, which is mentioned in the Decree No. UP-4707 of the President of the Republic of Uzbekistan. From the viewpoint of the original objectives of Fergana CHP, that is the replacement of obsolete equipment and heat supply to nearby refinery, the construction of gas turbines is reasonable. Thus, if it is supposed that the power shortage of Fergana Valley will remain after the implementation of NEDO Project and the construction of two GTCC units on Turakurgan TPP, the construction can be considered.

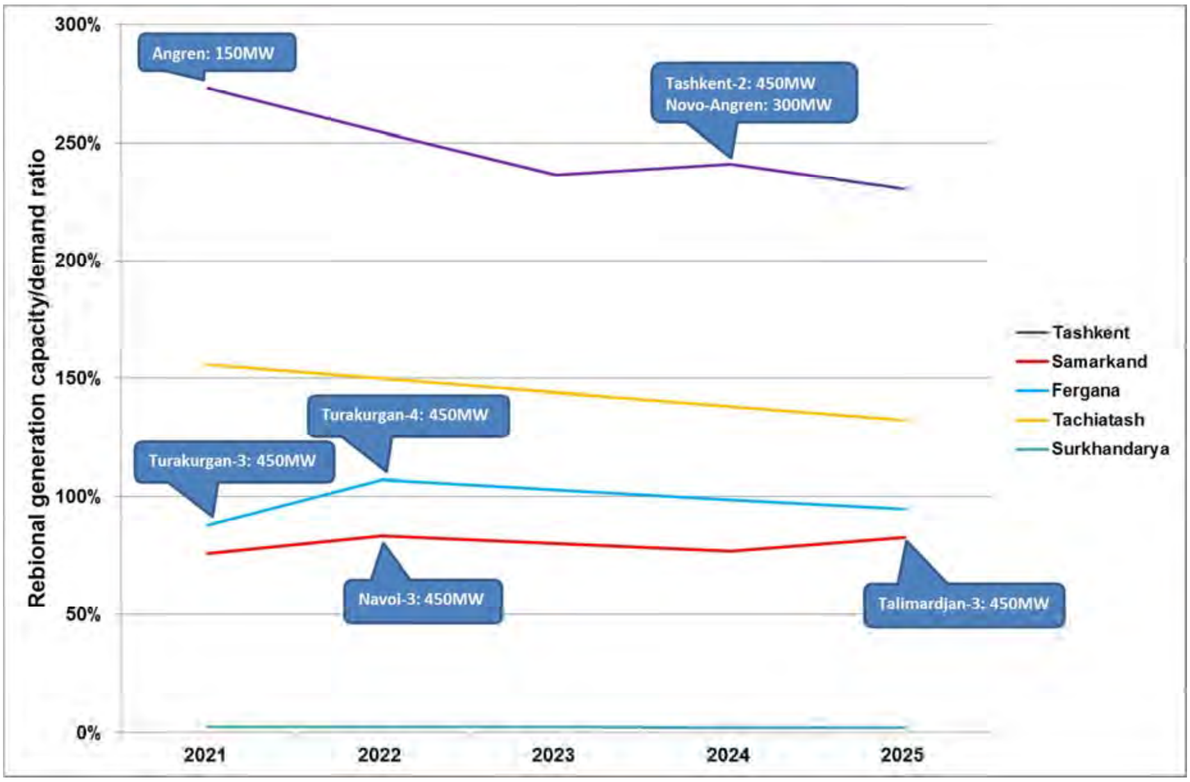
5.4 Selection of priority projects

To select priority projects listed in Table 5.3-1, an evaluation was conducted in terms of issues such as expectations of increased efficiency increase by replacing obsolete equipment using the scrap-and-build method, the absence of problems involving environmental and social considerations, helping improve the supply-demand imbalance by regions and eliminating technical construction problems. Furthermore, the projects, which have progressed to some extent, such as Pre F/S completed or F/S currently implemented, have not been considered priority projects.

There are three reasons to construct new thermal power plants in Uzbekistan, namely ① To meet nationwide electricity demand, ② Improve the supply-demand imbalance in regions, ③ Increase thermal efficiency by replacing obsolete TPP by new ones. It is desirable that both ① and ③ as well as ② could be satisfied concurrently. In other words, it is desirable that nationwide electricity demand be met by improving the supply-demand imbalance in regions, as well as replacing obsolete TPP by new ones. Based on the results of a local study of potential priority project sites, no particular restrictions in terms of locational conditions of potential sites for the new construction and enhancement of power plants have been observed. Therefore, the supply-demand balance of a region was considered the main prerequisite for selecting priority projects.

Speaking of the supply-demand balance in regions, as shown in Figure 3.5-1, the power supply capacity in Tashkent region is more than twice the demand. So, even taking into account the stable power supply to the capital city, the concentration of power supply facilities around the capital city is remarkable. Therefore, future construction of thermal power plants should be prioritized in regions such as Samarkand (Navoi, Bukhara, Samarkand, Kashkadarya) and Fergana (Fergana, Namangan, Andijan), which lack power supply capacity.

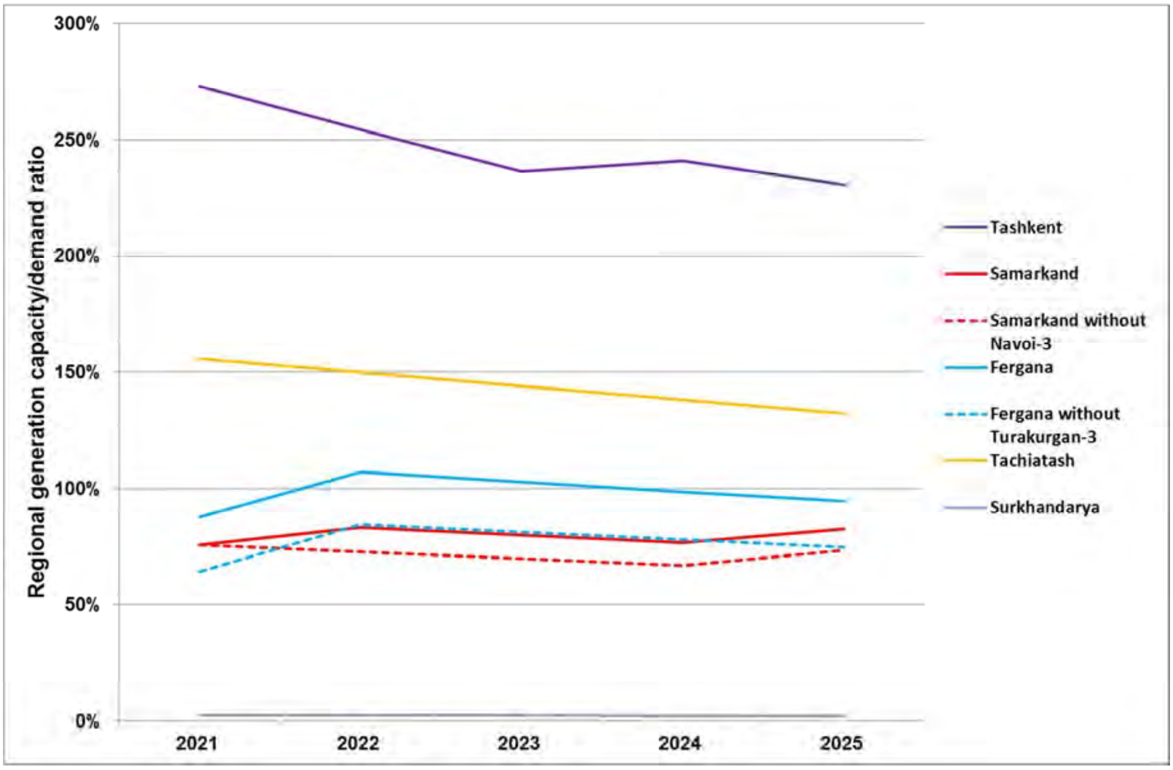
The following construction of the new thermal power plants is planned in the aforementioned priority regions: Navoi TPP (unit No. 3), Talimardjan TPP (unit No. 3, 4) and Turakurgan TPP (unit No. 3, 4). The Figure 5.4-1, prepared by the Japan International Cooperation Agency (JICA) in the review plan of the power development concept, shows the forecasted ratio of generation capacity to electricity demand by these regions in 2021-2025 years.



Source: JICA Study Team

Figure 5.4-1 The ratio of generation capacity to electricity demand by regions and power development concept

Figure 5.4-2 shows the ratio of generation capacity to electricity demand by the aforementioned regions, excluding the generation of unit No. 3 in Navoi TPP and unit No. 3 in Turakurgan TPP; the commencement of these units is scheduled for the near future. In case unit No. 3 in Navoi TPP is excluded, the ratio of generation capacity to demand in Samarkand region will gradually decrease to 76 % in 2021, and to 67 % in 2024. If these of unit No.3 Talimardjan TPP commences in 2025, the ratio will return to 73 %. In case unit No. 3 of Talimardjan TPP is excluded, the ratio of generation capacity to demand in Fergana region will decrease to 64 % in 2021, and after use of unit No.4 commences at Turakurgan TPP in 2022, the ratio will increase to t 85 %. However, in 2025 the ratio will decrease to 75 %.



Source: JICA Study Team

Figure 5.4-2 The ratio of generation capacity to electricity demand by regions in case of absence of the unit No. 3 of Navoi TPP and the unit No. 3 of Turakurgan TPP

In view of the foregoing, it can be concluded that unit No. 3 of Navoi TPP and unit No. 3 of Turakurgan TPP are essential in maintaining a balance between generation capacity and demand in Samarkand and Fergana regions, respectively, and that these projects are prioritized.

Chapter 6 Investment Plan

Chapter 6 Investment Plan

6.1 An investment program based on the power development plan

Based on the power development plan, a 15-year investment plan, from 2015 to 2030, was developed to meet long-term power demand in Uzbekistan. The following are the preliminary assessment conditions:

(1) Investments in power generation equipment: by years

Based on the method of consideration for the optimal power development plan, as presented in Chapter 3, a breakdown of the investment amount was performed and presented on an annual basis (Figure 5.2-1). The investment amount was calculated using the WASP model. The WASP model is designed for calculating operational expenses (maintenance, fuel) by stochastic simulation of demand and supply according to the structure of power sources by year, which covers the maximum power demand and takes into consideration technical maintenance of power generation equipment annually. These operation expenses and other expenses related to changes in the power source structure (which were converted to the current price of generation equipment) were taken as annual expenses in the planning scenario. These expenses will be taken into account during the dynamic planning phase, where minimal expenses will be used from the start of operation until the decommission year.

(2) Power generation by each power plant

The electricity supply volume was calculated based on the power demand forecast (Base case) and the total volume of electricity supply, as generated by each power generation facility, was calculated by modeling the optimal primary energy source development (Table 5.2-2).

(3) Operating period

Taking into account a 30-year operating period for thermal power plant equipment, the volume of electricity generation was calculated for a 30-year period starting from 2030, which is the last year of investment, up to 2060.

The normal operating period for hydropower plant equipment is 50 years, so there will be no new hydropower plant expired before 2060. Volume of electricity to be produced until 2060 was has been calculated in the same way as for thermal power plants (Table 5.2-2).

(4) Electricity tariffs

The price at which power companies sell electricity to Uzbekenergo JSC is decided by the Ministry of Finance based on the decree of the Cabinet of Ministers [1]The price at which electricity is sold is different for each power plant taking into consideration the power generation costs and certain

[1] Decree #239 of the Cabinet of Ministers, of 28 October 2010

profit margin. Wholesale prices, at which power plants in this investment plan are to sell electricity to Uzbekenergo JSC, will also be decided by the Ministry of Finance considering their profitability. In the meantime, however, these prices have yet to be decided. For this reason, wherever electricity tariffs need to be calculated in this plan, we will use the price at which TashTETS, an affiliate company of Uzbekenergo JSC, sells electricity to Uzbekenergo JSC.

In 2014 the average wholesale electricity price, at which TashTETs, as an affiliate of Uzbekenergo JSC, delivered to Uzbekenergo JSC, was 78.10 UZS (per kWh). However, according to financial statements of TashTETs for 2014, its operating costs exceed sales revenues and operating profit was not calculated, based on this price level. The margin on sales of Uzbekenergo JSC was about 10 %, but to reach such operating profit it was estimated that the wholesale electricity price should exceed the price for 2014, namely 78.10 UZS per kWh, by 12 % and should be 87.78 UZS (per kWh). In addition, taking into account the fact that in recent years, the increase in the electricity price to the end consumer was about 20 % per year, it was proposed in this investment plan to establish a wholesale electricity price for 2015 of 110 UZS (per kWh), which is equivalent to $0.0427 USD (kWh), or 42,685 USD (GWh).

(5) Electricity sale revenues

According to Uzbekenergo JSC, transmission losses comprise 16 % of the total generation. The electricity volume after deducting a 16 % transmission loss from the total generation was taken for the delivery volume. Based on the above tariff, annual electricity sales revenues were calculated.

(6) Operations and maintenance costs and fuel costs

The Operation and Maintenance (O&M) costs required to generate power were calculated based on the investment plan and fuel prices (Table 5.2-2). The O&M costs are not published in Uzbekistan and similar examples of other countries and “Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants” published by the Ministry of Energy of the USA were referenced to set the fixed and variable O&M costs and which were then used in WASP to calculate O&M costs for each type of power plants.

(7) Price growth ratio

It is hard to forecast the inflation rate for the long term, but if we assume that future costs and benefits will grow in equal proportions, inflation would be compensated for in relation to costs and benefits. Accordingly, 2015, which is the first year of the investment plan implementation, will be taken as a base year and the price growth ratio for each specific category shall not be considered.

6.2 Financing plan

(1) Consideration of proposed investors

Below are the organizations that provide investment required for construction under the power source development plan.

- International Aid Organizations: provide investment to the government of Uzbekistan, and in the form of credit through UFRD[2].
- UFRD: provides credits from its own funds.

(2) Funds attraction plan

As the investment plan assumes credits in US dollars, the amount of investment must also be calculated in USD in order to avoid risks caused by changes in exchange rate. Although investment from international aid organizations may be received not only in USD, but also in Japanese yen and other currencies, the funds attraction plan was developed with both principal and interest converted to USD.

All investments will be covered by credits and as these support development, they will be provided for the long term under mild conditions. Credit conditions will be similar for both international aid organizations and UFRD. For this reason, the proportion of credits from international organizations and UFRD will not be considered.

[2] UFRD is a government fund established in 2006 by the Government of Uzbekistan to finance key sectors for national economic growth, such as the power sector, heavy and chemical industry, metal mining, transportation, infrastructure and others.

(3) Preliminary loan terms and conditions

The total loan is the funding received as a sum of annual credit balances; the annual credit is the funding capable of covering financing deficit, which is based on the balance of expenditure incurred for annual investment, operating costs, fuel costs and loan repayment amount, and income in the form of proceeds from electricity sales. The interest on the loan during the construction period will be paid by the organization performing the project.

- **Interest**: Fixed in USD 3.00 %
  Due to investors nor the interest on investments being defined in this plan, the interest isbased on the level of credits from international organizations[3] that have worked on similar projects, and the level of credits in USD[4] in recent years.

- **Repayment period**: 30 years, including 15-year period of concessions on repayment, with equal repayment of principal.

- **Loan amount**: the total loan is USD 5,348,000,000 (5 billion and 348 million) (the total amount as of 2030, see Figure 5.2-1, Figure and Table 5.2-2).

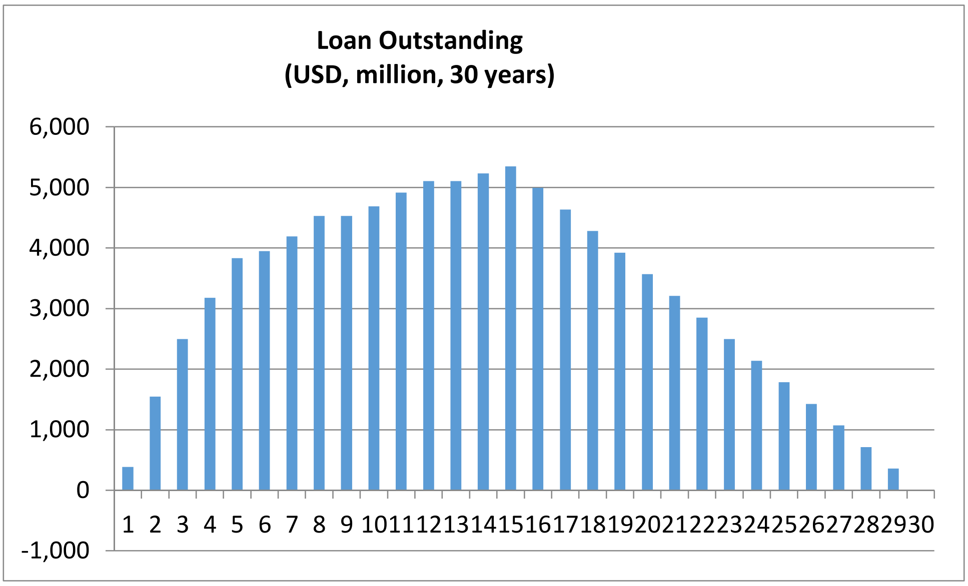


Figure 5.2-1 Changes in total loan amount

[3] According to a report of ADB, the cumulative interest expenses on the loan received from ADB to implement the Samarkand Solar Power Project in Uzbekistan, which commenced in 2015, amounts to 2.50 % in USD.
[4] At the moment of development of this report, the US Treasury interest rates on 10 year bonds was 1.81 %, on 30 year bonds – 2.67 %.

(4) Consideration of potential for loan repayment

Based on the cash flow in this particular power development plan and the above-mentioned preliminary terms and conditions for obtaining the loan, the cash outflows and inflows were calculated (Table 5.2-2). Consequently, it was estimated that to invest in the equipment to implement the power development plan, a loan would be required for a 15-year period starting from the equipment commissioning, i.e. up to 2030 and the total credit balance amount would be 5,348,000,000 USD. As far as the funding to repay the loan is concerned, calculations showed it would be feasible to repay the loan in full by 2030, if allocating the positive cash flows received from the power development to repay the principal amount. In addition, it is estimated that the cash flows in the power generation project will remain positive up to 2060, even after the loan repayment.

Uzbekenergo JSC will use its own funds to make interest payments during the construction period. As of 2015, the first year of implementing the power development plan, this amount was 12 million USD. According to the cash flow report for 2013, the operating cash flow was 145 million USD. After deducting the cash flow from investing activities, the free cash flow was 37 million USD, meaning an interest rate of 3.0 % to make interest payments as part of the preliminary loan condition was considered feasible. It was calculated that after the commissioning, the interest payments during construction should grow and peak by 2030 at 160 million USD (Figure 5.2-2). To avoid additional borrowing to repay the principal loan and to use personal funds to make interest payments, it would be preferred to attract UFRD as an investor offering low interest rates or obtain funds from international financial institutions, to implement the power development plan.

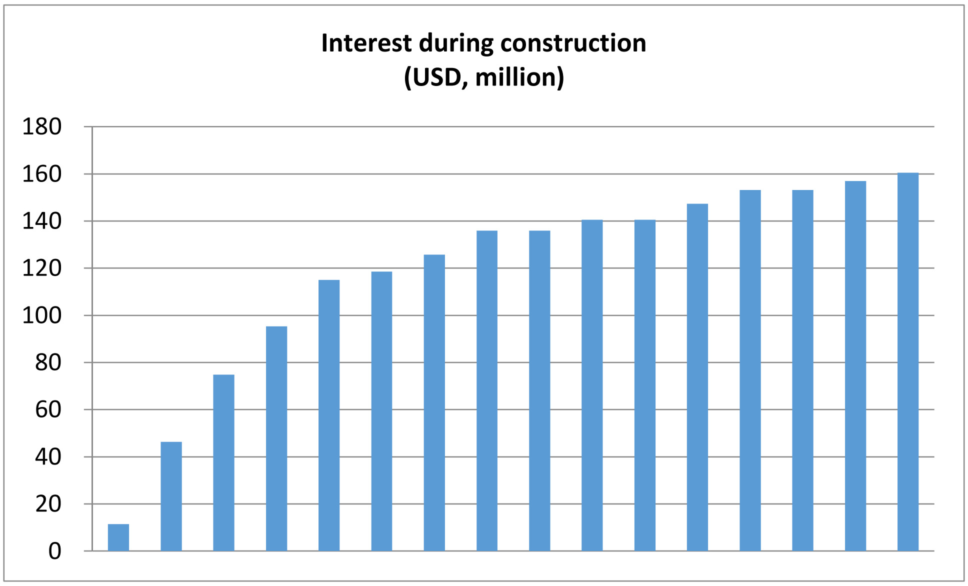


Figure 5.2-2 Amount of interest payments during construction

Table 5.2-1 Investment plan based on the power development plan

As of September 11, 2015 Plant Name	Unit	Year of commissioning	Installed capacity (MW)/	Construction cost (million USD)	Construction period	Annual expenditure on power plant construction (million USD)															
						2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Thermal Power Plants																					
Talimarjan TPP	2	2016	450	405	2	126	279														
	3	2017	450	405	2		126	279													
	4	2025	450	405	2										126	279					
	5	2026	450	405	2											126	279				
	6	2029	450	405	2														126	279	
	7	2030	450	405	2															126	279
New-Syrdarya TPP	GTCC-1	2018	450	405	2			126	279												
	GTCC-2	2019	450	405	2				126	279											
Novo-Angren TPP	8	2024	300	570	3								57	331	182						
Tashkent TPP	GTCC-1	2016	370	333	2	103	230														
	GTCC-2	2024	450	405	2									126	279						
	GTCC-3	2026	450	405	2											126	279				
	GTCC-4	2028	450	405	2													126	279		
	GTCC-5	2029	450	405	2														126	279	
	GTCC-6	2030	450	405	2															126	279
	GT-1	2029	140	140	1														43	97	

Navoi TPP	GTCC-2	2017	450	405	2		126	279													
	GTCC-3	2022	450	405	2							126	279								
Takhiatash TPP	GTCC-1	2019	250	225	2				70	155											
	GTCC-2	2020	250	225	2					70	155										
Angren TPP	Coal-1	2016	150	285	3	165	91														
	Coal-2	2021	150	285	3					29	165	91									
Ferghana CHPP	GTCS	2018	57.7	80	2			25	55												
Mubarek CHPP	3	2019	140	140	2				43	97											
Tashkent CHPP	3	2020	27	50	2					16	35										
	4	2020	27	50	2					16	35										
Tashkent CHPP-2	1~4	2020	120	320	4			16	83	157	64										
Turakurgan TPP	1	2017	450	405	2		126	279													
	2	2018	450	405	2			126	279												
	3	2021	450	405	2						126	279									
	4	2022	450	405	2							126	279								
Hydropower Plants																					
Kamolot HPP		2017	8	12	3	1.2	7.0	3.9													
Irgailiksai HPP		2022	13.6	25	3						2.5	14.5	8.0								
Nijne-Koksu HPP		2023	20	180	3							18.0	104.4	57.6							
Nijne-Chatkal HPP		2024	100	106	3								10.6	61.2	33.8						
Mullalak HPP		2027	240	474	5									18.9	71.1	161.1	170.5	52.1			
Akbulak HPP		2028	60	63	3												6.3	36.4	20.1		
Pskem HPP		2029	404	837	5											33.5	125.6	284.6	301.4	92.1	

Renewable energy																					
Solar-1		2016	100	276	1		276														
Solar-2		2019	100	210	1					210											
Solar-3		2022	100	210	1								210								
Solar-4		2025	100	210	1											210.0					
Solar-5		2028	100	210	1														210.0		
Wind-1		2021	50	122	1							121.9									
Wind-2		2024	50	122	1										121.9						
Wind-3		2026	50	122	1												121.9				
Wind-4		2029	50	122	1															121.9	
Total Investment Costs (million USD)						**395**	**1,260**	**1,134**	**936**	**1,027**	**582**	**776**	**949**	**594**	**814**	**935**	**983**	**499**	**1,105**	**1,121**	**559**

Table 5.2-2 Volume of power supply, the revenues based on the power development plan and loan repayment plan

Year		Outflow (USD, million)							Electricity Production/Distribution				Inflow (USD, million)				Cash Balance
		New Investment	Fuel cost for Thermal Power Plants	O&M costs for Thermal Power Plants	O&M costs for Hydro Power Plants	UFRD Loan: Debt repayment	UFRD Loan: Interest	Total Outflow	Thermal Power Plants capacity (GWh)	Hydro Power Plants capacity (GWh)	Total Power generation (GWh)	Total Electricity Distribution after Loss (GWh)	Revenue from investment in one new power plant	UFRD Loan	Interest during construction	Total inflow	
1	2015	395	0	0	0			395	0	0	0	0	0	384	12	396	0
2	2016	1,260	67	31	0			1,358	4,181	0	4,181	3,512	150	1,162	46	1,358	0
3	2017	1,134	111	54	0			1,299	7,620	31	7,651	6,427	274	950	75	1,299	(0)
4	2018	936	165	80	0			1,181	11,223	31	11,254	9,454	404	682	95	1,181	0
5	2019	1,027	268	131	0			1,426	18,255	31	18,286	15,361	656	655	115	1,426	(0)
6	2020	582	383	187	0			1,152	25,519	31	25,550	21,462	916	117	119	1,152	(0)
7	2021	776	470	233	0			1,479	30,966	31	30,998	26,038	1,111	242	126	1,479	(0)
8	2022	949	533	270	1			1,753	35,608	84	35,692	29,982	1,280	337	136	1,753	(0)
9	2023	594	553	276	1			1,424	37,307	162	37,469	31,474	1,343	0	136	1,479	55
10	2024	814	634	316	5			1,769	40,466	551	41,018	34,455	1,471	157	141	1,768	(0)
11	2025	935	677	338	5	0		1,955	43,738	551	44,289	37,203	1,588	226	141	1,955	(0)
12	2026	983	746	377	5	0		2,111	48,854	551	49,405	41,500	1,771	192	147	2,111	(0)
13	2027	499	768	384	12	0		1,663	50,857	1,486	52,343	43,968	1,877	0	153	2,030	367
14	2028	1,105	819	408	14	0		2,347	54,710	1,720	56,430	47,401	2,023	171	153	2,347	0
15	2029	1,121	891	448	27	0		2,487	59,251	3,294	62,545	52,538	2,243	86	158	2,487	(0)
16	2030	559	961	486	27	357		2,391	64,621	3,294	67,915	57,048	2,435		161	2,596	205
17	2031		961	486	27	357	150	1,982	64,621	3,294	67,915	57,048	2,435			2,435	453
18	2032		961	486	27	357	139	1,972	64,621	3,294	67,915	57,048	2,435			2,435	464
19	2033		961	486	27	357	129	1,961	64,621	3,294	67,915	57,048	2,435			2,435	474
20	2034		961	486	27	357	118	1,950	64,621	3,294	67,915	57,048	2,435			2,435	485

21	2035		961	486	27	357	107	1,939	64,621	3,294	67,915	57,048	2,435			2,435	496
22	2036		961	486	27	357	96	1,929	64,621	3,294	67,915	57,048	2,435			2,435	506
23	2037		961	486	27	357	86	1,918	64,621	3,294	67,915	57,048	2,435			2,435	517
24	2038		961	486	27	357	75	1,907	64,621	3,294	67,915	57,048	2,435			2,435	528
25	2039		961	486	27	357	64	1,896	64,621	3,294	67,915	57,048	2,435			2,435	539
26	2040		961	486	27	357	54	1,886	64,621	3,294	67,915	57,048	2,435			2,435	549
27	2041		961	486	27	357	43	1,875	64,621	3,294	67,915	57,048	2,435			2,435	560
28	2042		961	486	27	357	32	1,864	64,621	3,294	67,915	57,048	2,435			2,435	571
29	2043		961	486	27	357	21	1,854	64,621	3,294	67,915	57,048	2,435			2,435	582
30	2044		961	486	27	357	11	1,843	64,621	3,294	67,915	57,048	2,435			2,435	592
31	2045		961	486	27	0	0	1,475	64,621	3,294	67,915	57,048	2,435			2,435	960
32	2046		961	486	27	0	0	1,475	64,621	3,294	67,915	57,048	2,435			2,435	960
33	2047		871	441	27	0	0	1,339	58,760	3,294	62,054	52,126	2,225			2,225	886
34	2048		758	382	27	0	0	1,167	50,211	3,294	53,505	44,944	1,918			1,918	752
35	2049		674	339	27	0		1,040	44,258	3,294	47,552	39,944	1,705			1,705	665
36	2050		596	300	27	0		923	39,212	3,294	42,506	35,705	1,524			1,524	602
37	2051		539	275	27	0		841	36,551	3,294	39,845	33,470	1,429			1,429	587
38	2052		480	247	27	0		753	33,034	3,294	36,328	30,516	1,303			1,303	549
39	2053		404	207	27	0		638	27,335	3,294	30,629	25,728	1,098			1,098	460
40	2054		404	207	27	0		638	27,335	3,294	30,629	25,728	1,098			1,098	460
41	2055		312	164	27	0		503	23,126	3,294	26,420	22,193	947			947	445
42	2056		274	144	27	0		445	20,277	3,294	23,571	19,799	845			845	400
43	2057		199	104	27	0		330	14,577	3,294	17,871	15,012	641			641	311
44	2058		199	104	27			330	14,577	3,294	17,871	15,012	641			641	311
45	2059		161	84	27			272	11,727	3,294	15,021	12,618	539			539	266
46	2060		75	40	27			142	5,700	3,294	8,994	7,555	322			322	180

Chapter 7 Environmental and Social Considerations

Chapter 7 Environmental and Social Considerations

7.1 Strategic Environmental Assessment (SEA)

7.1.1 Laws, regulations and organizations related to Environmental and Social Considerations

(1) Legal framework

The legislation of the Republic of Uzbekistan in the field of protection and use of natural resources and environmental protection consists of laws, Presidential Decrees, decisions of the Government, departmental normative legal acts, and also local acts of local authorities.

The Constitution of the Republic of Uzbekistan establishes principles of environmental legislation. It is reflected in Article 55, defining that the earth, its subsoil, waters, flora and fauna and other natural resources are national wealth, and shall be rationally used and protected by the state; in Article 47&48, defining responsibilities of citizens to observe the Constitution and law; in Article 50, establishes the obligation of citizens to use surrounding environment sparingly; in Article 51, obliging citizens to pay statutory taxes and other constitutional provisions defining powers of state authorities, including in the field of regulation of the environmental relations.

The legislation system in the field of regulation of relations on nature management and environmental protection consists of the following areas of environmental legislation: land, water, mining, legislation on flora and fauna, as well as environmental protection.

The main act regulating environmental relations is the Law from December 9, 1992 "On Environmental Protection." Followings are the basic but important laws in the field of environmental protection:

- The Law of the Republic of Uzbekistan «On environmental protection» (December 9 1992, No. 754-XII)
- The Law of the Republic of Uzbekistan «On water and water use» (May 6, 1993, No. 837-XII)
- The Law of the Republic of Uzbekistan «On protection of atmospheric air» (December 27, 1996, No. 353-I)
- The Law of the Republic of Uzbekistan «On protection and use of flora» (December 26, 1997, No.543-I)
- The Law of the Republic of Uzbekistan «On protection and use of fauna» (December 26, 1997, No.545-I)
- Land Code of the Republic of Uzbekistan (April 30 1998, No.599-I)
- The Law of the Republic of Uzbekistan «On forest» (April 15, 1999, No.770-I)
- The Law of the Republic of Uzbekistan «On protection of the population and territories against emergency situations of natural and technogenic nature» (August 20, 1999,

No.824-I)

- The Law of the Republic of Uzbekistan «On ecological expertise» (May 25, 2000, No.73-II)
- The Law of the Republic of Uzbekistan «On radiation safety» (August 31, 2000, No.120-II)
- The Law of the Republic of Uzbekistan «On protection of agricultural plants against pests, diseases and weeds» (August 31, 2000, No.116-II)
- The Law of the Republic of Uzbekistan «On waste» (April 5, 2002, No.362-II)
- The Law of the Republic of Uzbekistan «On subsoil» (New edition), (December 13, 2002, No.444-II)
- The Law of the Republic of Uzbekistan «On protected natural territories» (December 3, 2004, No.710-II)
- The Law of the Republic of Uzbekistan «About ratification of Amendments to the Montreal protocol on the substances that deplete the ozone layer» (September 7, 2006, No.ZRU-44, 45)

Any laws in relation to the SEA have not been enacted as of April 2015.

(2) Environmental Impact Assessment (EIA)

1) Outline of the EIA in Uzbekistan

On May 25, 2000 Oliy Majlis (Parliament) of the Republic of Uzbekistan enacted law of the Republic of Uzbekistan "On Ecological Expertise," which, along with the Law "On Environmental Protection" provides the basis of materials of the environmental impact assessment. Specially authorized state body in the State Ecological Expertise is the State Committee for Nature Protection of the Republic of Uzbekistan (Article 12).

According to Annex 2 of the Resolution No.491 dated December 31, 2001 "Regulations on the State Ecological Expertise in the Republic of Uzbekistan," all economic activities in Uzbekistan are divided into four categories (categories I-IV), depending on the degree of the potential impact. Category I and II should be under the control of Goskompriroda (State Committee of the Republic of Uzbekistan for Nature Protection), and Category III and IV should be under the Regional Goskompriroda for approval process.

The EIA category of a power plant varies by plant capacity: over 300 MW to be category I, between 100 and 300 MW to be category II, and less than 100 MW to be category III. The related projects of power transmission lines and gas pipeline developments are under the category II, and required for EIA preparation. Besides, any projects considered in the protected/vulnerable lands or inter-regional development shall be considered as category I, but there is no size or scale based definition between categories.

Plan of EIA procedure difference by category is shown in Table 7.1.1-1.

Table 7.1.1-1 EIA procedure difference by category

Point	Category I	Category Ⅱ	Category Ⅲ	Category Ⅳ
Preparation of pre-project and project documentation before commissioning of the object	Stage I. EIA Draft Stage II EIA* Stage III Statement of environmental effects (SEE)	Stage I. EIA Draft Stage II EIA* Stage III SEE	Stage I. EIA Draft Stage II SEE	EIA Draft
Considering authorities	Goskompriroda	Goskompriroda	Regional Goskompriroda	Regional Goskompriroda
Fee for petition to conduct expertise of the application	Minimum salary of 25 people	Minimum salary of 15 people	Minimum salary of 7.5 people	Minimum salary of 1 person
Period of the ecological expertise	30 days (By the decision of Goskompriroda on complicated objects period may be extended, but not more than 2 months)	30 days (By the decision of Goskompriroda on complicated objects period may be extended, but not more than 2 months)	20 days	10 days

*Developed only on demand of Goskompriroda by results of consideration the EIA Draft, in case of insufficiency of data to establish the impact on the environment.
Source: Goskompriroda

2) Procedure of the EIA

As defined in the Regulations No.491, the development of EIA materials is composed of 3 stages, which are carried out in the following sequence: Draft EIA during the planning stage; EIA, on demand of Goskompriroda in case of the need for further research; and the development of the Statement of environmental effects (SEE) of an object on the environment before commissioning.

【Planning stage】

I. Preparation of the EIA Draft

EIA Draft should be prepared at the planning stage of the project and submitted to the State Committee for Nature Protection. The validity of conclusions of Goskompriroda is three (3) years. In case of the expiration of the validity of Conclusion or changes during the design process, the EIA Draft must undergo state geological expertise again.

II. EIA

When considering the EIA Draft, in case that lack of data and/or the results of the survey is identified, Goskompriroda makes decision on the redevelopment of EIA.

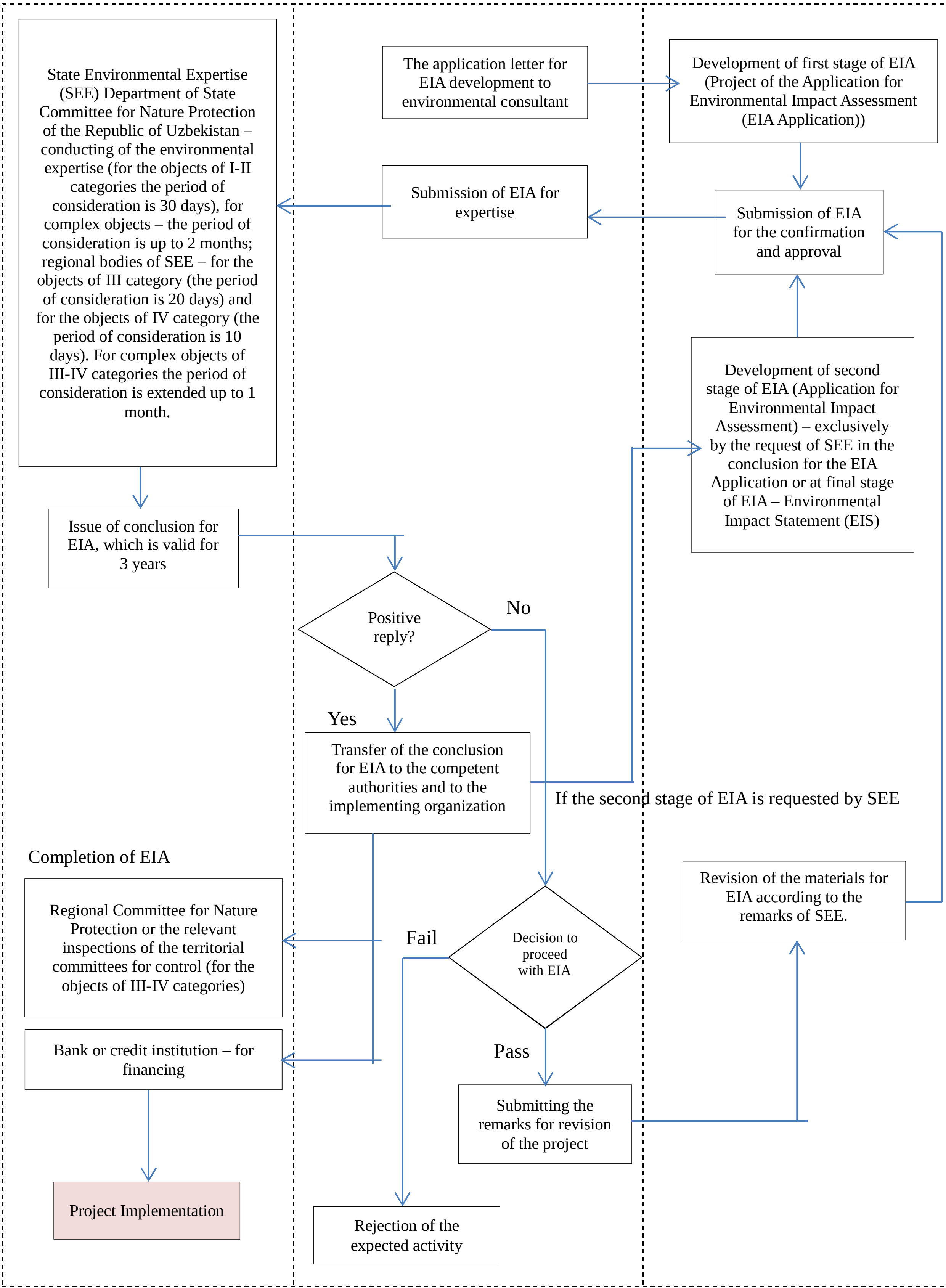
【Preparation stage for commissioning of the object】

Statement of environmental effects (environmental regulations for the enterprise) is the final stage of the EIA procedure, and must be prepared and submitted to Goskompriroda before commercial exploitation of projected object.

Commissioning of the facility is not permitted without a positive conclusion of Goskompriroda of Uzbekistan, in which environmental standards for emissions, discharges and wastes, for which the company makes payments, as well as action plans to reduce the impact on air, water and waste management are approved.

This procedure is similar to the approval procedure of the application for pre-commissioning stage in Japan.

The following Figure 7.1.1-1 illustrates typical procedure of the EIA activities.



Source: JICA Study Team

Figure 7.1.1-1 Procedure of EIA in Uzbekistan

3) Public Consultations

In Uzbekistan, public meeting as part of the EIS or the SEA is not particularly regulated in the Resolution of the Cabinet of Ministers No.491. Article 11 of the aforementioned Resolution states that the results of the public consultation should be described, if necessary, in the development of Stage II of the EIA – Environmental Impact Statement. As a practice of EIA material development shows, Goskompriroda of Uzbekistan necessarily requires public hearings in problem areas of the projected objects (without breaks with residential buildings, or non-compliance with the size of the sanitary protection zone or in the prediction of level increase of noise and air emissions) in order to decrease in a degree of concern at people, opportunity to explain the presence of actions to reduce the impact to standard level. For power generation projects in Uzbekistan, public meeting is usually held by the company as instructed that produces electric power within the environmental impact assessment, in case if project location is in close proximity to residential areas.

4) Comparison between JICA's ESC Guidelines and Uzbekistan EIA Laws

The result of comparison between JICA's ESC Guidelines and Uzbekistan EIA Laws is shown in Table 7.1.1-2. In the EIA laws of Uzbekistan, items such as information disclosure of the EIA and public consultations are not the obligation of project proponents. In addition, necessity of social considerations is not sufficiently mentioned in the EIA laws of Uzbekistan in comparison with JICA's ESC Guidelines.

Table 7.1.1-2 Comparison between JICA Guidelines and Uzbekistan EIA Laws

No.	Item	JICA Guidelines	EIA Laws of Uzbekistan	Gaps
1	Information disclosure	In principle, project proponents etc. disclose information about the environmental and social considerations of their projects.	Project proponents etc. are able to disclose information about the EIA of their projects.	As project proponents are not obliged to disclose the information about the EIA in Uzbekistan legal norms, there is no equivalence.
2	Categorization	-Category A for a project in which significant adverse impacts on the environment and society are expected -Category B for a project whose potential adverse impacts are less than those of Category A projects -Category C for a project which has minimal or little adverse impact -Category FI	-Category I for a project which has high risks of environmental deterioration -Category II for a project which has middle risks of environmental deterioration -Category III for a project in which minimal negative impact is expected -Category IV for a project in which little negative impact is expected and which is the subject to draft EIA only	There is no equivalence since the consideration of adverse impacts on the society as classification criteria of the categories is not clearly and broadly mentioned in Uzbekistan legal norms.

No.	Item	JICA Guidelines	EIA Laws of Uzbekistan	Gaps
3	Impacts to be assessed	As shown in scoping items in Table 7.2.2-1 below	Items of social consideration such as poor people, ethnic minorities, social capital and social organizations, gender, rights of the child, and infectious diseases, etc. are not mentioned in Uzbekistan legal norms.	As some items are not included in Uzbekistan legal norms, there is no equivalence.
4	Public consultations	In principle, project proponents etc. consult with local stakeholders through means that induce broad public participation to a reasonable extent, in order to take into consideration the environmental and social factors in a way that is most suitable to local situations, and in order to reach an appropriate consensus.	The results of the public consultation should be described, if necessary, in the development of the EIA.	As project proponents are not obliged to implement public consultations, there is no equivalence.

Source: JICA Study Team

(3) Land acquisition and resettlement

1) Codes and resolutions on land acquisition and resettlement

There are no laws or legislation, especially on matters concerning specifically the acquisition of land and resettlement. Land acquisition and resettlement are regulated by the following laws:

- Civil Code: This code, adopted by the Oliy Majlis of the Republic of Uzbekistan, No. 257-I dated 29 August 1996, was amended in accordance with the laws of the Republic of Uzbekistan of 1996-2012.
- Land Code: This Code was approved by Law of the Republic of Uzbekistan No. 598-I dated 30 April 1998, and amended under Section XIX of the Legislation Act of the Republic of Uzbekistan dated 30 August 2003, Para 41 of Legislative Act of the Republic of Uzbekistan dated 3 December 2004. Amendments govern matters relating to the release and the withdrawal of land for non-agricultural purposes and compensation for losses of agricultural production.
- State Land Cadastre: This law was approved by the Parliament of the Republic of Uzbekistan by Act No. 666-I dated 28 August 1998, and it was amended in accordance with the laws of the Republic of Uzbekistan of 2002-2004.
- State Cadastre: This law was approved by the Parliament of the Republic of Uzbekistan by Act No. 171-II dated 15 December 2000, and it was amended in accordance with the laws of the Republic of Uzbekistan of 2002-2011.

The key legal instruments are the Land Code and the following Resolutions of the Cabinet of Ministers of the Republic of Uzbekistan as listed:

- The Resolution of the Cabinet of Ministers No. 146 dated 25 May 2011 "On Measures to Improve the Provision of Land for Urban Construction and other Non-Agricultural Needs"
- Resolution of the Cabinet of Ministers No. 54 dated 25 February 2013 "On Measures to Radically Simplify the System of Lands Provision for Urban Construction and other Non-Agricultural Needs, as well as the Issuance of Permits for Construction of Facilities"

According to the Land Code, all the land in the country are government property and land use permits are provided and controlled by the government through the district, region and city administrations. National legislation defines two types of land transfer: (a) For use, lease or ownership by legal entities engaged in various kinds of trade and services for the inherited usage throughout the life (with housing provision), and (b) for the use or rent by individuals. Since all land belongs to the government, ultimately land plots cannot be sold without buildings on that land. In case of certain lands, lands can be purchased only with buildings located on the subject land. A similar provision applies to land used by legal entities (owners of trade or services facilities).

All the land occupied by permanent structures necessary for the project, in particular, the transmission lines, wells, sewer and river outlets, water-measuring devices, manifolds and relative safety perimeters ("sanitary zone") are provided by the Government of the Republic of Uzbekistan through local authorities and remain the property of the Government of the Republic of Uzbekistan upon termination of the projects.

2) Rights for Land Use

According to the law of the Republic of Uzbekistan No. 598-I dated 30 April 1998, and amended under Section XIX of the Legislation Act of the Republic of Uzbekistan dated 30 August 2003, all land (both above and under-ground) is owned by the state government and registered to the central government. General public and people can use the national land with land use permit issued by the government.

3) Compensation and recovery policy

The legislation provides the payment of compensation for the damage caused by land users in full, including loss of income, as in the following examples: (i) Seizure, purchase or temporary occupation of lands; (ii) Restriction of the rights of users; and (iii) Land degradation as a result of construction and maintenance and other activities that lead to a decrease in the quantity or quality of agricultural products. In case of the acquisition of agricultural land, in addition to compensation for damages, the legislation provides for compensation for the loss of agricultural production. The Land Code defines the following user categories of arable lands, which are entitled to compensation for loss or damage in connection with the acquisition of land:

- Land owners: citizens who were allocated plots of land for private housing or agriculture, based on the life of the property with right to inheritance.
- Leaseholders: farmers who were allocated plots of land for agricultural production on the basis of long-term leasing.
- Land users: users of land plots occupied by merchants and services which are used as private property.
- Other land users: all other enterprises and institutions which are entitled to use non-agricultural land. It is the largest category, which includes businesses and institutions of all types (private and public). Examples include hospitals, schools, businesses and factories.

Analysis of the legal framework governing land acquisition for public use reveals that in Uzbekistan the following guidelines are observed:

- Compensation to affected families rebuilds their pre-project income and standard of living after the resettlement.
- Affected families are entitled to compensation for the full replacement cost for lost assets, including temporary loss or impacts.
- Compensation is fully provided up to the acquisition of land for construction or demolition.
- Affected families are consulted during the preparation and implementation of resettlement.
- Affected families fully informed of their options for compensation.
- Mechanisms for complaints about compensation are established.
- All the affected families receive compensation regardless of the legal status of land use and land resources.
- Provision of equivalent lands is the preferred type of compensation for lost land, if the aggrieved family does not select a monetary compensation.
- Compensation is available, giving equal emphasis to women and men.

In the law of the Republic of Uzbekistan, the cut-off date resettlement is defined as the date, when the district division office of the State Committee for Land Resources, Geodesy, Cartography and State Cadaster signs the Certificate of agreement for purchase of lands.

The cut-off date, however, in LARAP shall be set to the date in which the first public consultation is held, and the project outline and its environmental and social impact should be explained to the local residents.

Recovery policy in respect of the acquisition of land is as follows:

- Compensation for loss of property is carried out on the basis of full recovery of the replacement cost, regardless of the legal status of land and land use rights.
- The level of income and life should be protected until the implementation of the project.
- Loss of rights to land and agricultural production means are reimbursed on the basis of the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 54 dated 25 February 2013.
- Loss of the right to use of land is compensated with the provision of alternative lands, or money, if the affected families wish to be refunded by money. The District Administration is not responsible for the arrangement of alternative lands. Affected households have the opportunity to choose alternative lands among the lands offered by the district administration.

4) Grievance System

Complaints may be received from the public concerning the assessments, payments, other forms of reimbursement or assistance, as well as other aspects of the project implementation, for example, the effects of the construction. In this regard, the following mechanisms should be involved to ensure that all complaints are processed and administrative authorities are taking steps to address the matter.

Initially, the aggrieved person may lodge a complaint with the District Administration Office, which will register the complaint and take action to address it. A committee - comprising representatives of the cadaster, agronomists, and the tax authority, Chairmen of local committees and officials of the project proponent - is organized. If the applicant receives a satisfactory evaluation, he/she can hire an independent evaluator and submit evaluations of the land for decision of the Committee. By enabling farmers to the Committee, the risk of complaints is minimal, and the possibility for compromise among stakeholders will be maximized. However, should complaints not be resolved in two weeks, a claim is transferred to the regional administration.

At the level of regional administration a complaint is considered by the Commission, similar to the district administration, which includes the Chairmen of the respective regional authorities and representatives of the project proponent. The responsible authority in the regional administration receives and registers complaints and takes action to resolve the situation. The applicant may also take legal action, should the district or regional authority not be capable to resolve the issue.

Reports and claims processing procedures are controlled by employees of the Project Management Unit responsible for internal monitoring and evaluation. Any person, who is not satisfied with their complaints, should contact the Project Management Unit directly at any time to request assistance in the search for a settlement of the complaint. During public consultations detailed information shall be provided to the local population.

5) Implementation System and Organizational Structure

Procedures, functions and powers of the bodies responsible for implementation and compliance procedures for the purchase of land for purposes other than agriculture and forestry shall be established by Resolution of the Cabinet of Ministers No. 54 dated 25 February 2013.

The extent of the losses of owners, users, leaseholders and owners of land plots due to withdrawal (redemption) of their lands and the sizes of the losses in the agricultural and forestry production are determined in the manner prescribed by Resolutions of the Cabinet of Ministers No. 97 dated 29 May 2006 "On Approval of the Regulation on the Procedure for Compensation of Damages to Citizens and Legal Entities in Connection with the Withdrawal of Lands for Public Purposes," and No. 146 dated 25 May 2011 "On Measures to Improve the Provision of Land for the Implementation of Urban Construction and other Non-Agricultural Need." (In the presence of damages and losses).

1. Specify the location of the structures and facilities provided by the project;
2. Select land plots for construction;
3. Prepare and approves certificates of land acquisition agreement; and
4. Approve certificates for the right to land use specifying area of acquired lands for agricultural crops, agreed terms and total loss costs from agricultural production. The Commission, together with the permanent members, also includes representatives of companies or organizations that are allocated with lands for construction and agricultural organizations from which land plots are being purchased.

Losses of agricultural production are assessed by the Evaluation Commission, which is established by order of the Governor of the district administration, together with the definition of losses incurred by the landowners and land users, due to the acquisition of land for public use, based on information submitted to the Design Institute, which has developed a plan for the acquisition of land. Conclusions of the Evaluation Commission are executed as certificates for the right to land use specifying area of acquired lands for agricultural crops, agreed terms and total loss costs from agricultural production.

Upon request of the Division (Department) for architecture and construction of the district (City) for the inclusion of material of land allocation, within five days the competent authorities shall submit the following conclusions:

- Conclusion of relevant Goskompriroda authority on State Ecological Expertise for facilities stipulated by Resolution No. 491 dated 31 December 2001 "On Approval of the Regulations on State Ecological Expertise in the Republic of Uzbekistan";

- Conclusion of the Department for Land Resources and the State Cadastre of District (City);
- Conclusion of District (City) Sanitary-Epidemiological Service; and
- Conclusion of territorial body of the State Fire Inspectorate.

6) Comparison between JICA's ESC Guideline/WB Safeguard Policy and Uzbekistan EIA Laws in Terms of Land Acquisition and Resettlement

The result of comparison between JICA's ESC Guideline/WB Safeguard Policy and Uzbekistan EIA Laws in terms of land acquisition and Resettlement is shown in Table 7.1.1-3. In the EIA laws of Uzbekistan, there is no provision of such items as exploring all viable alternatives in the case of involuntary resettlement (No.1), preparation of the RAP (No.6), and the manner of public consultations which should be understandable to the affected people (No.8), etc.

Table 7.1.1-3 Comparison between JICA Guideline/WB Safeguard Policy and Uzbekistan EIA Laws

No.	JICA Guidelines/ WB Safeguard Policy	EIA Laws of Uzbekistan	Gaps
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	As there is no policy in Uzbekistan legal norms, there is no equivalence.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	Department of State Committee on land resources, geodesy, cartography and cadaster of Republic of Uzbekistan conducts estimation of production means loss and loss of the lands, makes consideration of means to restore farmland and alternative land.	Corresponds
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)	Uzbekistan law has a social policy for all citizens. No specific policies for settlers.	As there is no specific policy in Uzbekistan legal norms, there is no equivalence.
4	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	The State Commission shall assess the value of agricultural land, loss of income from crops/trees and the market value for the land allotted. Affected families have a right to receive compensation at full replacement cost (excluding depreciation) for their lost assets, including temporary losses or impacts.	As compensation is provided at full replacement cost excluding depreciation under Uzbekistan legal norms, there is no equivalence.
5	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	Compensation must be provided before construction works.	Corresponds
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	As there is no policy in Uzbekistan legal norms, there is no equivalence.
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	As there is no policy in Uzbekistan legal norms, there is no equivalence.
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	As there is no policy in Uzbekistan legal norms, there is no equivalence.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	No specific policy in Uzbekistan legal norms	As there is no specific policy, there is no equivalence.

No.	JICA Guidelines/ WB Safeguard Policy	EIA Laws of Uzbekistan	Gaps
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	Resettlement has standard grievance mechanism.	Corresponds
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 State Committee on land resources, geodesy, cartography and cadaster of Republic of Uzbekistan conducts estimation of production means loss and loss of the lands including the implementation of population census whose commencement date is set at cut-off date.	Corresponds
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/buildings/shops that are registered under the Land Code, estimated at appropriate levels of region / district. People apply for registration for the use of a particular land. Use of unregistered land is not compensable.	There is no correspondence as unnamed land is not compensable.
13	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	Uzbekistan Policy refers only to compensation means in which farmland shall be compensated by the equivalent farmland.	There is no correspondence as Uzbekistan Policy refers only to compensation means.
14	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	No specific policy; the life of all citizens is regulated by social policy of the Republic of Uzbekistan.	As there is no specific policy in Uzbekistan legal norms, there is no equivalence.
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)	Uzbekistan Policy refers only to compensation. Improvement of living standards applied to all citizens.	There is no correspondence as Uzbekistan Policy refers only to compensation.
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	As there is no specific policy in Uzbekistan legal norms, there is no equivalence.

Source: JICA Study Team

(4) Regulations and Standards related to energy sector

1) Atmosphere

The maximum permissible concentration (MPC) for the protection of human health is set to ambient air of populated areas and work area in Uzbekistan. Table 7.1.1-4 illustrates MPC and hazard categories of main pollutants produced by emissions of thermal power plants. The 30 min MPC value for NO2 in Uzbekistan is very strict comparing to the one hour average value of common fundamental principles of IFC / WB EHS and environmental standards of EU.

Table 7.1.1-4 Regulation of Hazard Contents of the Main Pollutants Generated by Thermal Power Plant (MPC)

Pollutant	Maximum Permissible Concentration MPC)** (mg/m^3)			Hazard category*	IFC / WB EHS Guideline Fundamental principles (mg/m^3 (2007))	EU Environmental standard (mg/m^3)
	30 min	Daily average	Work zone			
Nitrogen dioxide (NO_2)	0,085	0,06	2,0	2	0,2 (on the average 1 hour) 0.04 (annual average)	0,2 (on the average 1 hour) 0.04 (annual average)
Nitrogen oxide (NO)	0,6	0,25	-	3	—	—
Sulphur dioxide (SO_2)	0,5	0,2	10,0	3	0.5(10 min) 0,125 (Daily average)	0,35 (on the average 1 hour) 0,125 (daily average) 0.02 (annual average)
Carbon oxide (CO)	5,0	4,0	20,0	4	—	—
Suspended particles (Dust)	0,15	0,1	-	3	0,15 (daily average) 0,07 (annual average)	0,05 (daily average) 0.04 (annual average)

Note:* Hazard category it is classified as follows according to the Russian standard:
1. Polluting substance of extreme danger
2. Polluting substance of high danger
3. Polluting substance of medium danger
4. Polluting substance of low danger

Source:** The sanitary norms, rules and hygienic standards of the Republic of Uzbekistan (San PiN №0179-04, Hygienic standards), the list of maximum permissible concentration (MPC) of pollutants in the ambient air of populated areas on the territory of the Republic of Uzbekistan")

※ Because Uzbekistan previously was a part of Soviet Union, the government utilizes any Russian regulations where there is no referring codes and regulations as the Uzbekistan government permits.

2) Emission

In the Republic of Uzbekistan the pollutants in the exhaust gas emitted by power plants are regulated by the concentration of air pollutants in the surface layer of the atmosphere created by the release from each exhaust pipe or chimney instead of the exhaust air quality at the emission point, such as stack.

The standard values of maximum pollutant concentration calculated and they should not exceed the value of MPC shown on Table 7.1.1-5. The surface layer MPC calculation should be made based on the guideline[1], and the result will be compared with the 30 minute MPC in order to set the permissible exhaust air amount. The implementation agency, after the EIA approval is obtained, must prepare Normative Document illustrates actual design and calculated air distribution for approval by Goskompriroda, since the EIA reported figure is only assumption. According to the

[1] Ministry of Justice, Reg. No. 1553 from 03.01.2006 "Guidelines for the inventory of pollution sources and regulation of pollutants emission into the atmosphere for the enterprises of the Republic of Uzbekistan" , Tashkent, 2006

Approval on the Normative Document by Goskompriroda, final MPC figure of air emission and quality that the implementation agency must comply with will be set.

Table 7.1.1-5 Quotas on Polluting Substances emitted in atmosphere by enterprises

Location	Quota shares of MPC based on the class of risk of emitted substances			
	1	2	3	4
Region: Tashkent, Fergana, Andijan, Namangan City: Navoi, Samarkand, Bukhara	0.17	0.20	0.25	0.33
Area: Bukhara, Djizak, Kashkadarya, Navoi, Samarkand, Surkhandarya, Syrdarya	0.20	0.25	0.33	0.50
The Republic of Karakalpakstan, the Khorezm province	0.25	0.33	0.50	1.00

Source: Instruction on the inventory of sources of pollution and regulation of emissions into the atmosphere for the enterprises of the Republic of Uzbekistan, the Ministry of Justice of the EGR. No. 1553, Tashkent, 2006. Category 1, 2, 3 and 4 refers to the hazard category applied in Table 7.1.1-4.

The concentration of NOx should refer to Russian Standard (GOST 29328-92), shown in Table 7.1.1-6 in this project, as there is no particular rules on concentrations of pollutants in exhaust gases in Uzbekistan.

Table 7.1.1-6 Standard on Concentration of Pollutants in Emissions

The Polluter	GOST 29328-92*	Basic principle OOSMFK/WB for thermal power plant (2008)
Nitrogen oxides (NOx)	50 mg/Nm^3 (25 mg/m^3)	50 mg/Nm^3 (25 mg/m^3)

* GOST 29328-92: the plant turbine to drive the turbo generator
Note: the dry gas, O2 = 15%
Source: Ministry of Justice of the EGR

3) Water Quality

The discharged water also should comply with the regulation of surface water protection (San PiN RUz No. 0172-04) as shown in Table 7.1.1-7, and the allowable water temperature increase is maximum three (3) degree Celsius.

Table 7.1.1-7 Environmental Standard for Surface Water Protection

Indicators	Water use category	
	I (drinking water supply)	II (recreational use)
1. Suspended solids*	During effluent discharge, producing of works on water bodies and coastal zone content of suspended solids in the water control point should not increase in comparison with natural conditions by more than:	
	0.25 mg/L	0.75 mg/L
	For water bodies containing in low water more than 30 mg/L of natural suspended solids is allowed to increase their content in water within 5%	
	Suspended metters with a settling rate more than 0.4 mm/s for flowing water reservoir and more than 0.2 mm/s for water reservoirs are prohibited to discharge	
2. Floating impurities	On s water surface films of oil products, oil, grease and accumulation of other impurities should not be found	
3. Colouring	Should not be detected in the column:	
	20 cm	10 cm
4. Odour	Water should not acquire odors intensity more than 2 points, which are detected:	
	Directly or upon subsequent chlorination	Directly
5. Temperature	Summer water temperatures as a result of wastewater discharges should not rise by more than 3 °C in comparison with monthly average water temperature of the hottest month of year for the last 10 years.	
6. pH value	Should not go beyond 6.5 - 8.5	
7. Water salinity	No more than 1000 mg/L, including chlorides: 350; sulphates: 500 mg/L	
8. Dissolved oxygen	Should not be less than 4 mg /L at any time during the year, in sample collected before 12 pm	
9. Biochemical oxygen demand (BOD)	At a temperature of 20 °C should not exceed:	
	2 mg O_2/L	4 mg O_2/L
10. Chemical oxygen demand (bichromateoxidability) (COD)	Should not exceed:	
	15 mg O_2/L	30 mg O_2/L
11. Chemical matters	Should not contain in water bodies in concentrations exceeding the maximum permissible concentration or approximate permissible level	
12. Causative agents of enteric infections	Water should not contain causative agents of enteric infections	
13. Viable helminth eggs (ascarids, whipworm, toxocara, fasciola and others), armed tapeworm and viable cysts of pathogenic intestinal protozoa	Should not contain in 25 liters of water	
14. Thermotolerant coliform bacteria **	No more than:	
	100 CFU /100 ml**	100 CFU /100 ml
15. Total coliform bacteria **	No more than:	
	1000 CFU /100 ml**	500 CFU /100ml
16. Coliphage **	No more than:	
	10 PFU/100 ml**	10 PFU/100 ml
17. Total volumetric activity of radionuclides at compresence***	$\sum(\frac{A_i}{VB_i}) \leq 1$	

Notes:

* -content of suspended solids in the water neprirodnogo origin (flakes of metal hydroxides, resulting from the treatment of wastewater, particles of asbestos, glass fibers, basalt, kapron, lavsan, etc.) is not allowed;
** -for centralized water supply; When necentralizovannom water supply water to decontaminate;
* * * -in case of exceeding the levels of radioactive contamination of the water is controlled by the additional control of radionuclide contamination in accordance with the regulations and radiation safety. 1 -specific activity i-equipment of the radionuclide in the water. VB1 -appropriate level of intervention for the i-equipment of the radionuclide.
Source: San Pin No. 0172-04. "Hygienic requirements for the protection of surface waters in the territory of the Republic of Uzbekistan").

The maximum permissible concentration (MPC) of pollutants in surface water is illustrated in Table 7.1.1-8. MPC is divided into 4 categories, and most concerned category is under the Fishery.

Table 7.1.1-8 Maximum Permissible Concentration (MPC) of Pollutants in Surface Water

Parameters	Fishery	Culture-household	Household-drinking	Irrigation*
COD	15	40	30	40
BOD20, mgO/L	3	3-6	3-7	10
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Suspended matters	15	30	30	50
Salinity	1000	1000	1000-1500	1000
Including: sulfates	100	500	400-500	
chlorides	300	350	250-350	
Ca	190			
Mg	40			
Ammonium nitrogen (ammonium salt) (NH_4^+)	0.5	2	0.5	1.5
Nitrite nitrogen (NO_2^-)	0.02	0.5	3	0.5
Nitrate nitrogen (NO_3^-)	9.1	25	45	25
Nitrites	0.08	3.3	3	
Nitrates	40	45	45	
Phosphates (PO_4^{3-})	0.3	1	3.5	1
Ether-solubles	0.05	0.8	0.8	0.8
Oil products	0.05	0.3	0.1	0.3
Synthetic Surface Active Agents`	0.1	0.5	0.5	0.5
Phenol	0.001	0.001	0.001-0.1	0.001
Fluorine (F)	0.05	1.5	0.7	1
Arsenic (As)	0.05	0.05	0.05	0.1
Iron (Fe)	0.05	0.5	0.3-3	5
Chrome (Cr^{6-})	0.001	0.1	0.05	0.1
Copper (Cu)	0.001	1	1	1
Zinc (Zn)	0.01	1	3	5
Cyanides	0.05	0.1		
Lead (Pb)	0.03	0.1	0.03	0.2
Nickel (Ni)	0.01	0.1	0.1	
Cadmium (Cd)	0.005	0.01		
Cobalt (Co)	0.1	1		
Molybdenum (Mo)	0.0012	0.5	0.25	
Strontium (Sr_2^+)		2	7	
Selenium (Se)	0.001		0.01	
Thiocyanates	0.1			
Mercury (Hg)		0.005	0.0005	

Source: San Pin No. 0172-04. "Hygienic requirements for the protection of surface waters in the territory of the Republic of Uzbekistan").

4) Noise and vibration

Standards for noise and sound pressure level, the environmental standard for areas directly adjacent to the homes are shown in Table 7.1.1-9 and Table 7.1.1-10.

The noise level should not exceed 45 decibels at night and 55 decibels in the daytime in accordance with KMC 2.01.08-96 “protection against noise” (The State Committee of the Republic of Uzbekistan for architecture and construction, Tashkent, 1996). Noise is equal to the value of the standard Guide to CCA OST IFC/World Bank.

Permissible vibration levels (up to 50 DB) in houses are standardized under the hygienic standards of the Sanitary Standard of the Republic of Uzbekistan No.04-0146 "Sanitary Rules and Norms in Design of Houses in the Climatic Conditions of Uzbekistan."

Table 7.1.1-9 Environmental standard for noise (residential area)

Category	Standard, Uzbekistan		Guide to CCA WB/IFC OST (2007)	
	Day time	Night time	Day time	Night time
Residential area	55dB (A)	45dB (A)	55dB (A)	45dB (A)
Working area	80 dB (A)			

Source: KMK 2.01.08-96 "protection against noise. (The State Committee of the Republic of Uzbekistan for architecture and construction, Tashkent, 1996); Sanitary code no. 0175-04" health standards for noise levels in the workplace.
There is also a rule on noise caused by equipment companies regulated under the sanitary code no. 0175-04 «sanitary norms of noise at work, under which the company's noise level must not exceed 80 DB.
Determination of Day Time and Night Time: Day Time 7:00 AM to 23:00 PM, Night Time 23:00 PM to 7:00 AM.

Table 7.1.1-10 DB sound pressure levels in octave bands with frequency in Hz

Premises and territory	Sound level, DB(a)	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Living rooms apartments, dormitories in pre-school institutions	30	72	55	44	35	29	25	22	20	18
Territory, directly adjacent to the houses (in 2 meters from walls, platforms vacations neighborhoods and inside residential houses, a nursery, school sites	45	84	67	57	49	44	40	37	35	33

Source: KMK 2.01.08-96 "protection against noise." (The State Committee of the Republic of Uzbekistan for architecture and construction, Tashkent, 1996).

5) Waste

Regulations of waste production is carried out in accordance with the technological features of the main and auxiliary production (education and public nature of waste disposal is not standardized). Waste regulations are defined in units of mass (volume) in relation to the quantity of used raw materials, or to the number of products. Limit values mass, area and duration of the temporary placement of waste generated in the processes of primary and secondary production in the territory of the enterprise, determines the limit of waste disposal.

Waste disposal limits do not apply to:

- objects of long-term storage of waste (over one year);
- objects of permanent placement of wastes (tailings, landfills, dumps, etc.);
- waste disposal in the subsoil; and
- radioactive waste.

To improve the reception of waste, reducing their exposure to humans and the environment, as well as addressing the issues of their further processing and utilization, environmental protection measures are developed. Procedure for development projects of environmental regulations for waste disposal is governed by the resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 14, 21.01.2014. Class of danger of wastes to the environment in the development of environmental standards is in accordance with the catalogue of waste. All the waste generated should be separated and disposed in accordance with the applicable law s and regulations. Waste recycle, reuse and reproduction of solid waste are made by only the companies with permission. All waste is divided into 5 classes as shown in Table 7.1.1-11.

Table 7.1.1-11 Class of danger of wastes

Class	Degree
(I)	Highly dangerous
(II)	Dangerous
(III)	Moderately hazardous
(IV)	A little dangerous
(V)	Almost no dangerous

Source: Regulations on the development and coordination of projects environmental regulations (Decree of the Cabinet of Ministers of the Republic of Uzbekistan No.14, Jan. 21, 2014.

6) Establishing Sanitary (Sanitary-Protective Zone: SPZ)

SPZ is set according to the sanitary norms, rules and regulations of the Republic of Uzbekistan hygienic sanitary code of the Republic of Uzbekistan No.0246-08 “Sanitary norms and rules on the protection of atmospheric air of localities of the Republic of Uzbekistan.” SPZ has been established based on the Russian regulation, and this defines specific area around any industrial development concerned of pollution such as emission of pollutant gas or contents, where residential areas or zones are located around. This is a kind of buffer zone to protect the residential areas and the livelihood. Any developments of schools, hospitals, recreational park, and related others are restricted in SP, and SPZ is categorized in 5 levels according to the scale of facilities.

7.1.2 Relevant organizations

The following public officials and institutions play a major role regarding environmental management in the Republic of Uzbekistan.

(1) Goskompriroda (State Committee of the Republic of Uzbekistan for Nature Protection)

In Uzbekistan in 1989 State System of Nature Protection was created, which is controlled by the State Committee for Nature Protection (Goskompriroda), which is specifically authorized, superior departmental and coordinating body responsible for control and inter-sectoral management of nature protection as well as use and reproduction of natural resources in nation level or inter-regional or inter-state, and it functions as the main authority of EIA for permission. Local Nature Protection Committees (Regional Goskompriroda) are in charge of state level and large city including the Republic of Karakalpakstan and in large cities, and these should monitor the condition of air and water discharge and quality as well as soil condition of the facilities within their jurisdiction.

(2) Uzhydromet (Center of Hydrometeorological Service at Cabinet of Ministers of the Republic of Uzbekistan)

It is under the Cabinet of Ministers, and conducting monitoring on water, air and soil environment in wider regional environment.

(3) Goskomzemgeodezkadastr (State Committee of the Republic of Uzbekistan on Land Resource, Geodesy, Cartography and State Cadaster)

This is to control and manage land in Uzbekistan.

(4) Ministry of Health

It is to monitor the environment on the basis of health and sanitary point of views, such as soil and noise.

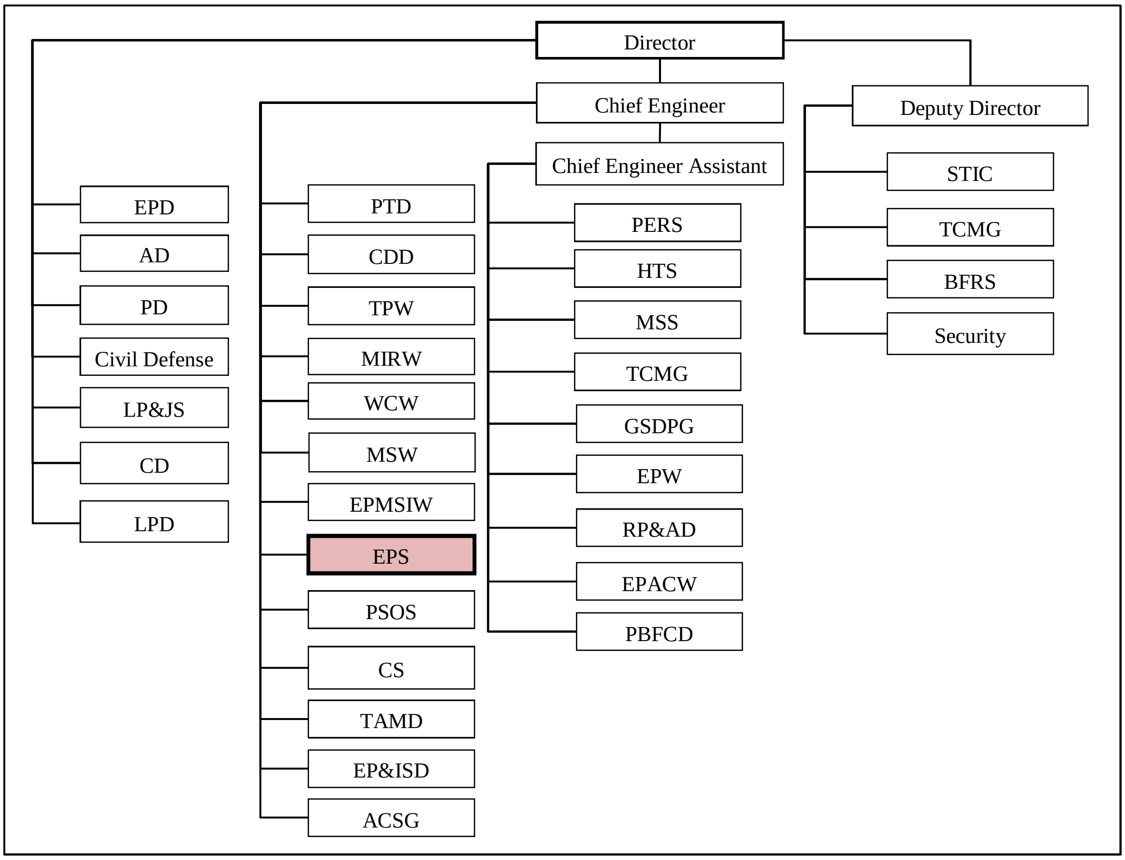
(5) Ministry of Agriculture and Water Resource

It is to monitor the quality of water of irrigation, canal and river in the country.

(6) Ministry of Internal Affairs

This organization is to monitor environmentally related activities in the country. If illegal activities or violation are identified, this will investigate, further monitor, instruct the concerned parties, and check the procedure of activities in order to make it improved.

Organizational Structure of Uzbekenergo JSC including EPS for environmental sector is illustrated in Figure 7.1.2-1, and its administration list is shown in Table 7.1.2-1.



Source: Uzbekenergo JSC

Figure 7.1.2-1 Organizational Structure of Uzbekenergo JSC

Table 7.1.2-1 Administration List (corresponding to the above organization structure)

CD	Correspondence department	TPW	Thermal power workshop
AD	Accounting department	TAMD	Thermal automatics and measurements department
PD	Personnel department	MSW	Metal and steampipe workshop
Civil Defense	Civil defense department	WCW	Water chemistry workshop
PTD	Production and technical department	MIRW	Metrology and instrument repair workshop
EPD	Economic planning department	EPMSIW	Electric power metering systems and instruments workshop
LPD	Logistics and procurement department	EPACW	Electrical process automatic control workshop
LP&JS	Labor protection and job safety department	RP&AD	Relay protection and automation department
ACSG	Automatic control system group	GSDPG	General system documentation preparation group
PBFCD	Production buildings and facilities control department	PSOS	Power station operation service
EP&ISD	Environmental protection and industrial sanitation department	PERS	Power equipment repair service
BFRS	Buildings and facilities repair section	HTS	Hydrotechnical service
STIC	Scientific and technical information center “Uzinformenergo”	MSS	Metrology and standardization service
CDD	Chief Designer Department	EPS*	Environmental protection service
CS	Cadastral service	TCMG	Technical conditions modernization group
EPW	Electric power workshop		

Source: Uzbekenergo JSC

7.1.3 Current Status of Environment and Society

(1) Natural Environment

1) Geography

Uzbekistan is located in Central Asia with an area of 447,000 km2 surrounded by Kyrgyzstan (east), Kazakhstan (north), Turkmenistan (south west), Afghanistan (south), and Tajikistan (south east). It stretches 1,425 km from east to west and 930 km from north to south. Uzbekistan in view of geography consists of various types of area represented by hilly area of the Tian Shan Mountains on southeastern area, Fergana valley on eastern area surrounded by mountain ranges to the north, south and east, and Qizilqum (Kyzyl Kum in Russian spelling) Desert which spreads the northern lowland portion of Uzbekistan.

Source: ezilon Maps (http://www.ezilon.com/maps/asia/uzbekistan-physical-maps.html)

Figure 7.1.3-1 Geographical configuration of Uzbekistan

2) Meteorology

Monthly average temperature in Uzbekistan by Province/Republic is shown in Table 7.1.3-1. Most of the provinces are characterized by extremely hot summer and cold winter except Samarkand which is the only province whose monthly average temperature does not exceed 30°C throughout the year and tends to be cooler than other provinces during summer season.

Table 7.1.3-1 Monthly average temperature in Uzbekistan by Province/Republic

Unit: °C

Province/ Republic	City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Andijan	Andijan	+2.7	+4.8	+14.0	+23.3	+28.9	+33.6	+36.1	+35.8	+31.5	+21.7	+12.4	+5.0
Bukhara	Bukhara	+5.0	+5.7	+14.6	+24.1	+31.5	+36.1	+37.0	+36.1	+31.1	+21.4	+12.0	+5.2
Djizzak	Djizzak	+3.6	+4.5	+12.9	+22.3	+28.8	+33.8	+34.6	+34.5	+29.5	+19.9	+10.1	+4.4
Kashkadarya	Karshi	+7.1	+7.8	+15.7	+25.0	+31.9	+36.6	+37.8	+37.1	+32.8	+22.9	+13.6	+7.2
Navoi	Navoi	+4.2	+5.2	+13.6	+23.1	+30.2	+34.8	+35.5	+34.8	+29.9	+20.4	+11.0	+4.6
Namangan	Namangan	+4.8	+6.5	+15.1	+24.7	+30.8	+35.2	+37.7	+37.3	+32.6	+22.9	+13.4	+6.3
Samarkand	Samarkand	+0.3	+2.3	+9.1	+17.9	+22.9	+27.7	+29.2	+29.0	+24.7	+15.6	+7.5	+1.7
Surkhandarya	Termez	+8.7	+9.0	+17.1	+26.1	+31.9	+37.0	+38.3	+37.2	+33.1	+24.4	+15.6	+9.5
Syrdarya	Gulistan	+4.6	+5.4	+14.2	+23.8	+30.9	+35.9	+36.8	+37.0	+31.7	+21.0	+10.6	+4.6
Tashkent	Tashkent	+4.0	+5.4	+13.7	+23.4	+30.0	+35.3	+36.4	+36.5	+31.1	+21.0	+11.4	+5.0
Fergana	Fergana	+3.0	+4.6	+13.3	+22.8	+29.1	+33.9	+36.1	+35.7	+30.9	+20.8	+11.4	+4.5
Khorezm	Urgench	+1.2	+2.3	+11.9	+22.6	+30.9	+35.4	+36.2	+35.5	+29.5	+19.4	+9.6	+2.5
Karakalpakstan	Nukus	-0.2	+0.9	+10.8	+22.0	+30.8	+35.2	+36.0	+35.5	+28.7	+18.3	+8.6	+1.2

Source: World weather: Uzbekistan as of 2014 (http://uzbekistan.pogoda360.ru/)

Monthly average precipitation in Uzbekistan by Province/Republic is shown in Table 7.1.3-2 Seasonal tendency of rainfall is almost similar among all Provinces/Republic, that is, it tends to be dry from June to September, and has certain amount of rainfall from October to May. As for regional difference, such provinces as Syrdarya (212.7mm) and Samarkand (209.5mm) have larger amount of annual total precipitation, and such areas as Karakalpakstan Republic (44.2mm) and Khorezm Province (45.2mm) have smaller amount of it.

Table 7.1.3-2 Monthly average precipitation in Uzbekistan by Province/Republic

Unit: mm

Province/ Republic	City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Andijan	Andijan	16.4	26.0	27.1	19.8	6.7	5.3	1.0	1.0	2.5	6.0	15.4	19.3	146.5
Bukhara	Bukhara	12.6	17.5	21.0	6.9	2.0	0.2	0.0	0.1	1.1	4.5	9.4	9.5	84.8
Djizzak	Djizzak	14.2	26.5	39.8	20.3	2.1	1.6	0.3	0.8	0.4	6.4	16.9	12.8	142.1
Kashkadarya	Karshi	24.3	30.1	37.1	12.4	7.6	0.7	0.0	0.0	1.2	6.0	12.9	13.6	145.9
Navoi	Navoi	15.4	21.4	26.8	9.9	1.8	0.6	0.0	0.7	1.1	5.5	13.2	10.9	107.3
Namangan	Namangan	13.9	18.6	20.1	9.0	5.7	4.9	1.4	0.8	1.5	4.1	9.6	14.7	104.3
Samarkand	Samarkand	26.2	36.0	48.2	30.3	18.8	8.2	1.6	1.0	0.2	9.0	16.8	13.2	209.5
Surkhandarya	Termez	12.3	26.0	15.3	8.0	1.4	0.1	0.0	0.0	0.0	1.8	12.8	9.9	87.6
Syrdarya	Gulistan	29.7	30.6	49.9	25.8	5.8	3.4	1.3	0.7	0.4	11.6	29.2	24.3	212.7
Tashkent	Tashkent	37.3	34.3	41.3	18.1	3.1	2.1	1.1	2.1	0.5	11.4	21.1	24.0	196.4
Fergana	Fergana	12.4	19.8	20.4	18.9	14.9	9.6	3.4	3.3	3.5	5.3	10.8	13.1	135.4
Khorezm	Urgench	5.8	11.6	11.1	6.6	1.5	0.2	0.1	0.1	0.2	1.1	3.7	3.2	45.2
Karakalpakstan	Nukus	6.1	5.5	11.8	9.1	0.4	0.6	0.4	0.1	0.5	2.7	2.5	4.5	44.2

Source: World weather: Uzbekistan as of 2014 (http://uzbekistan.pogoda360.ru/)

3) Hydrology

Hydrological configuration in Uzbekistan consists of two major rivers: the Amu Darya River and the Syr Darya River. The Amu Darya River flows from Tajikistan to the west of Uzbekistan via Afghanistan and Turkmenistan. The Syr Darya River flows from Kyrgyz Republic to Kazakhstan via the east of Uzbekistan. These two international rivers supply water for irrigation, industrial use and domestic use to the basin countries, and finally flow into the Aral Sea.

Source: CA Water Info (http://www.cawater-info.net/index_e.htm)

Figure 7.1.3-2 Hydrological map of Uzbekistan and neighboring countries

4) Flora and fauna

Uzbekistan's flora and fauna are composed of more than 3,700 species of plants[2] of which 20% are endemic to Uzbekistan and more than 23,000 species of animals[3] including many representatives of Asian fauna such as bears, dears, and billy-goats as mammals and jays, shrikes, and bearded vultures as birds.

As for endangered species in Uzbekistan, in the 2015 IUCN (International Union for Conservation of Nature and Natural Resources) Red List, 681 species are categorized as Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threaded (NT), Data Deficient (DD), and Least Concerned (LC) in Uzbekistan. Out of 681 species, 12 species are categorized as CR and 16 are categorized as EN (Table 7.1.3-3).

[2] International Conference: the most important reserves of implementing the food program in Uzbekistan (http://www.ifc.uz/en/about_uzb/flora.php)
[3] Animals in Uzbekistan (http://www.listofcountriesoftheworld.com/uz-animals.html)

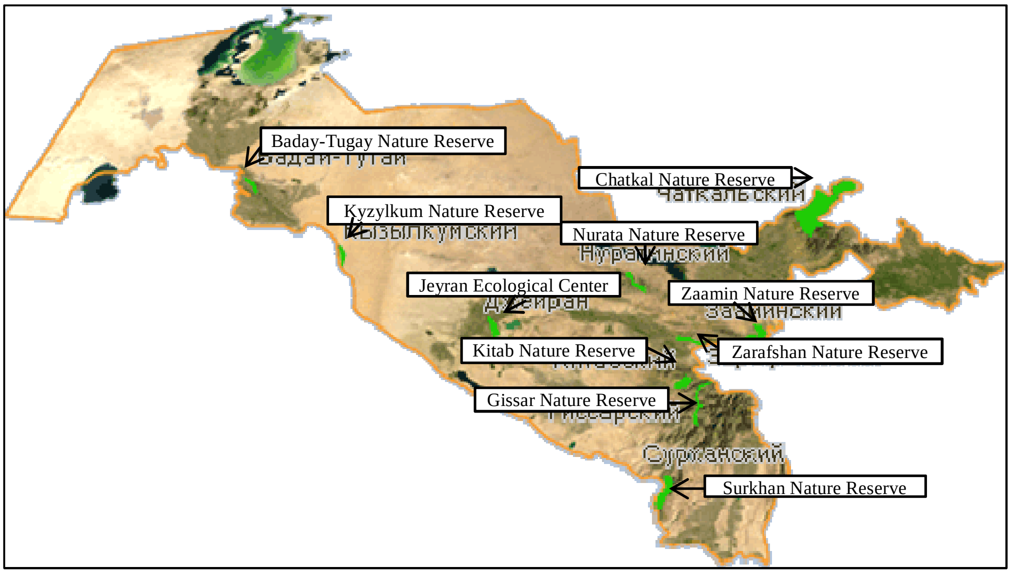
Table 7.1.3-3 List of Critically Endangered (CR) and Endangered (EN) species in Uzbekistan

Red List status	Kingdom	Genus	Species	Common names
Critically Endangered (CR)	Animalia	Dreissena	caspia	
		Leucogeranus	leucogeranus	Siberian Crane, Siberian White Crane, Snow Crane
		Numenius	tenuirostris	Slender-billed Curlew
		Pseudoscaphirhynchus	fedtschenkoi	Syr-darya Shovelnose Sturgeon, Syr Darya Sturgeon
		Pseudoscaphirhynchus	hermanni	Dwarf Sturgeon, Little Shovelnose Sturgeon, Little Amu-Darya Shovelnose, Small Amu-dar Shovelnose Sturgeon
		Pseudoscaphirhynchus	kaufmanni	False Shovelnose Sturgeon, Amu Darya Shovelnose Sturgeon, Big Amu Darya Shovelnose, Amu Darya Sturgeon, Large Amu-dar Shovelnose Sturgeon, Shovelfish
		Saiga	tatarica	Mongolian Saiga, Saiga Antelope, Saiga
		Vanellus	gregarius	Sociable Lapwing, Sociable Plover
	Plantae	Calligonum	calcareum	
		Pyrus	korshinskyi	
		Ribes	malvifolium	
		Zygophyllum	bucharicum	
Endangered (EN)	Animalia	Equus	hemionus	Asiatic Wild Ass, Asian Wild Ass
		Falco	cherrug	Saker Falcon, Saker
		Melanitta	fusca	Velvet Scoter
		Neophron	percnopterus	Egyptian Vulture, Egyptian Eagle
		Oxyura	leucocephala	White-headed Duck
		Panthera	tigris	Tiger
		Panthera	uncia	Snow Leopard, Ounce
	Plantae	Aldrovanda	vesiculosa	Waterwheel, Common Aldrovanda
		Armeniaca	vulgaris	Wild Apricot
		Astragalus	bobrovii	
		Betula	tianschanica	
		Calligonum	elegans	
		Calligonum	matteianum	
		Calligonum	molle	
		Lonicera	paradoxa	
		Malus	niedzwetzkyana	

Source: IUCN Red List (http://www.iucnredlist.org/)

5) Protected areas

There are 9 nature reserves and 1 ecological center in Uzbekistan as shown in Figure 7.1.3-3. As for the location of priority projects proposed in Chapter 5, none of them are planned on or close to the protected areas.



Source: IUCN Central Asia (http://iucnca.net/map/08_uzb_rus.gif)

Figure 7.1.3-3 Location of nature reserve and ecological center in Uzbekistan

(2) Social and economic conditions

Current status of population and social conditions of Uzbekistan is shown in Table 7.1.3-4.

1) Population

The total population of Uzbekistan is approximately 30,492,800 as of 2014, in which the large provinces in terms of population are Samarkand (3,445,600 ppl), Fergana (3,386,500 ppl), and Kashkadarya (2,895,300 ppl). As for population density, Tashkent City (7044.6 ppl/km2) is the densest area, followed by Andijan Province (652.4 ppl/km2), Fergana Province (501.0 ppl/km2), and Namangan Province (336.6 ppl/km2). On the other hand, Navoiy Province (8.1 ppl/km2) and the Republic of Karakalpakstan (10.4 ppl/km2) are the sparser. The composition of age group is similar among most of the provinces, but the percentage of elderly people in Tashkent City (13.9%) is notably higher than the national average (8.4%), then that of younger people (below working age) in Tashkent City (24.8%) is lower than the average (29.9%).

2) Economy and industry

As for industrial output, Tashkent City (14,312.3 billion som) and some other provinces such as Tashkent (9,627.8 billion som), Andijan (8,648.6 billion som), Navoiy (6,656.9 billion som) and Kashkadarya (6,263.7 billion som) are the major areas contributing to the total industrial output of Uzbekistan (63,871.7 billion som). On the other hand, there are notable gaps between the aforementioned major areas and provinces of low industrial output such as Jizzakh (808.6 billion som), Khorezm (1,085.4 billion som) and Karakalpakstan Republic (1,143.0 billion som).

3) Public infrastructure and service

As for infrastructure for public service, sanitation and electricity are fully provided in the whole Uzbekistan. The coverage of centralized water supply is 81.0% and that of natural gas is 90.0% at national average, while most people in Tashkent City are able to access water (99.7%) and natural gas (98.0%).

As for health service, hospitals and medical sites are widely distributed in the whole Uzbekistan. In view of population per 1 physician, Tashkent City (210) has the best access to medical service. In contrast, such provinces as Jizzakh (618) and Surkhandarya (618) have worse access compared to the national average.

Educational facilities are also widely distributed in the whole Uzbekistan, though out of 66 higher education institutions in Uzbekistan, more than a half of them are located in Tashkent City (34).

Table 7.1.3-4 Current status of population and social conditions of Uzbekistan by City, Province, and Republic

Indicator (As of January 1st, 2014)	Whole Uzbekistan	Tashkent City	Province: Andijan	Bukhara	Fergana	Jizzakh	Namangan	Navoiy	Kashka-darya	Samar-kand	Syrdarya	Surkhan-darya	Tashkent	Khorezm	Karakal-pakstan Republic
Population (1,000 ppl)	30,492.8	2,352.9	2,805.5	1,756.4	3,386.5	1,226.8	2,504.1	901.1	2,895.3	3,445.6	763.8	2,308.3	2,725.9	1,684.1	1,736.5
Ethnic group (%)[1)] - Ethnic Uzbeks	80.0	73.0	-												
Ethnic group (%)[1)] - Russians	5.5	18.0	-												
Ethnic group (%)[1)] - Other nationalities	14.5	9.0	-												
Population density (ppl/km^2)	67.8	7,044.6	652.4	43.6	501.0	57.8	336.6	8.1	101.3	205.5	178.5	114.8	178.7	278.4	10.4
Average age (year old)		32.4	28.1	28.8	28.5	26.9	27.7	28.4	26.4	27.0	26.6	26.3	29.3	27.2	27.0
Age group (% of total) - Below working age (0-16 years)	29.9	24.8	29.6	28.3	28.9	31.7	29.7	28.5	32.3	31.4	31.0	32.3	28.2	31.2	31.3
Age group (% of total) - Working age (male 16-59, female 16-54)	61.7	61.3	62.2	63.0	62.4	60.5	62.6	63.2	60.7	60.8	62.3	61.0	61.9	61.5	61.4
Age group (% of total) - Elderly age (male older than 59, female older than 54)	8.4	13.9	8.2	8.7	8.7	7.8	7.7	8.3	7.0	7.8	6.7	6.7	9.9	7.3	7.3
Major religion[2)]	Muslims	-													
Fertility rate (per 1,000 ppl)	22.3	17.7	23.1	21.1	21.9	22.6	22.9	21.6	25.1	24.1	22.1	24.7	20.3	22.7	22.7
Mortality rate (per 1,000 ppl)	4.8	6.9	5.1	4.4	5.0	4.0	4.6	4.6	3.9	4.5	4.8	4.2	5.8	4.4	4.7
Number of labor force (1,000 ppl/year)	17,814.1	1,537.0	1,641.7	1,035.1	1,947.5	708.8	1,480.0	546.8	1,654.2	1,973.8	448.7	1,320.2	1,589.5	934.2	996.6
Average monthly pension (1,000 soums)	-	415.3	294.5	330.3	299.7	293.5	291.0	435.6	300.6	320.7	347.2	318.4	354.9	317.7	338.5
Industrial output (at current prices) (billion som)	63,871.7	14,312.3	8,648.6	2,716.6	4,674.7	808.6	1,667.3	6,656.9	6,263.7	3,376.7	1,743.3	1,146.8	9,627.8	1,085.4	1,143.0
Industrial production growth rate (%/year)	-	15.8	15.9	10.3	7.4	11.8	10.1	4.3	2.9	12.5	2.1	7.2	12.5	15.2	9.6
Housing provision (m^2/ppl)	-	19.5	10.4	12.4	13.4	10.8	13.9	22.2	16.1	13.4	15.9	15.2	16.0	24.1	16.2
Centralized water supply provision (%)[3)]	81.0	99.7	-												
Sanitation provision (%)	100.0	-													
Electricity provision (%)[4)]	100.0	-													
Natural gas provision (%)[5)]	90.0	98.0	-												
Number of hospitals	1,067	76	122	73	148	69	105	29	86	97	37	64	81	34	46
Number of outpatient medical sites	6,324	789	549	575	595	276	405	291	456	606	216	418	523	311	314
Population per 1 physician	423	210	429	342	486	618	500	361	539	427	482	618	497	376	440
Number of educational institutions	9,758	320	745	535	919	546	690	356	1,122	1,235	302	860	879	529	720
Number of colleges and academic lyceums	1,556	121	129	88	157	79	118	51	144	175	52	121	127	91	103
Number of higher education institutions	66	34	4	3	3	2	3	2	2	6	1	1	2	1	2

Source: 1) Ethnic group (except Tashkent city): worldpopulationreview.com (http://worldpopulationreview.com/countries/uzbekistan-population/)
2) Major religion: uzbekembassy.org (http://www.uzbekembassy.org/e/culture_religion/)
3) Centralized water supply provision (except Tashkent city): United Nations Statistics Division
4) Electricity provision: World Bank
5) Natural gas provision (except Tashkent city): Center for Economic Research, Uzbekistan
Other indicators: Statistical Yearbook of the Republic of Uzbekistan (by provinces), Tashkent, 2014.

7.1.4 Examination of alternatives of the power development plan

(1) Outline of the power development plan

Based on Power Development Plan up to 2030 made by Uzbekenergo JSC, optimal type and capacity of power development to be necessary up to 2030 is clarified through comparison of power development scenarios using the software for power development planning with minimum cost (WASP). Such conditions as power demand, load duration curve, power supply reliability, ongoing power development projects, abolition plan of the existing power plant, development candidate of power plant, and fuel price are taken into account to examine optimal power development plan.

Details are described in Chapter 3 “Power Development Plan”.

(2) Examination of alternatives to achieve the objective of the power development plan

1) Setting the development scenarios

As described in Chapter 3, three scenarios shown in Table 7.1.4-1 were set, and power development plan of each scenario with minimum cost was formulated using WASP.

- Scenario 1: Optimizing Power Development Plan up to 2030 made by Uzbekenergo JSC using WASP
- Scenario 2: Adding 1,500MW of coal-fired power generation to Scenario-1
- Scenario 3: Adding 200MW of pumped storage hydro power generation to Scenario-1

In the examination of alternatives, the percentages of energy balance and capacity share of renewable energy of the three scenarios are set at the same figure (0.8% and 3.4%, respectively), and there is no scenario which has more percentage of renewable energy than others. The reason is that if the generation capacity of renewable energy whose output is not necessarily stable exceeds 10% of system capacity, additional investment is needed for system stabilization measures, while the first priority of investment is capital investment to satisfy power demand in Uzbekistan. Given the above situation, existing power development plan in which generation capacity of renewable energy to be developed accounts for approximately 6% of system capacity is regarded as sufficiently environment-friendly plan.

Table 7.1.4-1 Comparison of power development scenarios (same as Table 3.4.1-1)

	Scenario-1	Scenario-2	Scenario-3
Outline of scenario	Gas, coal and hydro are balanced	More coal than Scenario-1	With pumped storage hydro
Total generation cost (up to 2030)	$37,811million	$39,471million	$37,968million
Energy balance (Energy share in 2030)	Gas: 76.8% Coal: 12.6% Hydro: 9.8% Renewable: 0.8%	Gas: 68.1% Coal: 21.4% Hydro: 9.8% Renewable: 0.8%	Gas: 76.7% Coal: 12.6% Hydro: 9.9% Renewable:0.8%
Capacity share (MW and %)	Gas: 14,760 (71%) Coal: 2,700 (13%) Hydro: 2,653 (13%) Renewable: 700 (3.4%)	Gas: 13,270 (64%) Coal: 4,200 (20%) Hydro: 2,653 (13%) Renewable: 700 (3.4%)	Gas: 14,760 (70%) Coal: 2,700 (13%) Hydro: 2,853 (14%) Renewable: 700 (3.4%)

Source: JICA Study Team

2) Scoping on the power development plan

Above-mentioned power development scenarios consist of several types of power generation such as gas, coal, hydro and renewable energy. Thus, scoping was conducted on the component of each scenario (gas, coal, hydro, and renewable energy) focusing on major scoping items from environmental and social point of view as shown in Table 7.1.4-2 and then the three scenarios were evaluated based on the scoping result as shown in Table 7.1.4-3.

Based on the result of the assessment, scoping items which have more than one “B-” or “A-” were set as extremely important scoping items for decision making on power development plan: air pollution, water pollution, CO2 emission, natural resource consumption, water resource, and biodiversity as environmental items, and land acquisition and involuntary resettlement, human health hazard, and risk of accident as social items.

Table 7.1.4-2 Scoping on the Power Development Plan

Scoping items		Type of power generation				Reason
		Thermal power (gas)	Thermal power (coal)	Hydro power	Renewable Energy (solar, wind)	
Environmental	**Air pollution**	**B-**	**A-**	D	D	Exhausted gas and wastewater could cause negative impacts on existing air, soil, and water if these are not properly treated.
	Soil pollution	C-	C-	D	D	
	Water pollution	**B-**	**B-**	**B-**	D	
	CO_2 emission	**B-**	**A-**	**D(dam type hydro)/ B-(pumped storage hydro)**	D	Fossil fuel such as natural gas and coal which causes CO2 emission is used for power generation. Electricity consumption with CO2 emission for pumping up water can be expected in case of pumped storage hydro power plant.
	Natural resource consumption	**B-**	**B-**	C-	D	Natural resources such as gas and coal are consumed for power generation.

	Water resource	C-	C-	**B-**	D	Water for hydro power generation affects on the allocation of water for other purposes (agriculture, industry, etc.).
	Preserved area	C-	C-	C-	C-	Negative impact can be expected if the location is not properly planned.
	Biodiversity	**B-**	**B-**	**B-**	C-	Exhausted gas and wastewater can cause negative impact on biodiversity if these are not properly treated.
Social	**Land acquisition and involuntary resettlement**	**B-**	**B-**	**A-(dam type hydro)/ B-(pumped storage hydro)**	**B-**	Land acquisition is expected regardless of types of power development, and it can be huge in case of dam type hydro power plant. Involuntary resettlement is also expected and number of affected people tends to be large if the location is not properly planned.
	Human health hazard	**B-**	**A-**	C-	C-	High risk depending on the extent of air pollution is expected.
	Risk of accident	**B-**	**B-**	**B-**	C-	Risk of accident can be high in both construction and operation periods if proper safety control is not applied to construction/operation activities.

A-: Significant negative impact is expected. B-: Negative impact is expected.
C-: Extent of negative impact is unknown. D: No impact is expected.
Source: JICA Study Team

3) Evaluation of development scenarios

As shown in Table 7.1.4-3, three development scenarios along with Scenario-0 (zero option) were evaluated based on the result of assessment of the scoping items. From an environmental point of view, Scenario-3 is highly evaluated because of the low negative impacts of pumped storage hydro power generation. From a social point of view, the evaluation of Scenario-1 and Scenario-3 is considered to be almost equivalent. Finally, considering not only environmental and social aspects but also economic and technical aspects discussed in Chapter 3, Scenario-1 is recommended as the optimal power development plan up to 2030.

Table 7.1.4-3 Evaluation of development scenarios

Option		Scenario-0 Zero option	Scenario-1 Gas, coal and hydro are balanced	Scenario-2 More coal than Scenario-1	Scenario-3 With pumped storage hydro
Evaluation	Environmental	- Higher negative impact than Scenario-1 to 3 in terms of air pollution and CO2 emission derived from obsolete existing plants	- Negative impact of air pollution, water pollution, CO_2 emission, natural resource consumption, water resource, and biodiversity	- Higher negative impact of air pollution and CO_2 emission than Scenario-1	- Lower negative impact than Scenario-1 and 2 in terms of air pollution, CO_2 emission, natural resource consumption, - Negative impact of water resource
			++	+	+++
	Social	- Higher negative impact than Scenario-1 to 3 in terms of human health hazard derived from obsolete existing plants - No negative impact of land acquisition	- Negative impact of land acquisition and involuntary resettlement, human health hazard, and risk of accident	- Higher negative impact than Scenario-1 in terms of human health hazard	- Lower negative impact than Scenario-1 and 2 in terms of human health hazard - Higher negative impact than Scenario-1 and 2 in terms of land acquisition
			++	+	++
	Economic (Scenario-1 to 3 are discussed in Chapter 3)	- 10.2 trillion sum as additional cost is expected up to 2030 under the operation of existing inefficient power plants.	Most economical (As shown in Table 3.4.1-2)	-	-
	Technical (Scenario-1 to 3 are discussed in Chapter 3)	-Obsolete existing plants and facilities cause malfunction and supply hindrance.	Recommended (As described in Chapter 3.5)	-	-
Result			Recommended		

+++: Lower negative impact compared to other scenarios, ++: Medium negative impact, +: Higher negative impact

Source: JICA Study Team

7.1.5 Mitigation measures on assumed environmental and social impacts

Table 7.1.4-3 shows expected avoidance/mitigation measures to be taken at planning stage and at implementation stage of the power development.

At planning stage, the main purpose of avoidance/mitigation measures is to avoid/mitigate irreversible and cumulative negative impacts on which measures must be taken prior to the implementation of a project. As it is done in this Study, the examination of best mix of power generation system considering technical, economic, environmental and social aspects can be a main mitigation measure for air pollution, water pollution, CO2 emission, natural resource consumption and human health hazard derived from air pollution, etc. In addition, careful consideration of the location/site of a new power plant can be a main avoidance/mitigation measure for biodiversity, involuntary resettlement, and land acquisition. To mitigate risk of accident, a guideline on safety control, preparation and training for accident (e.g. evacuation, firefighting, etc.) should be formulated prior to the implementation of a project.

At implementation stage, the installation of a new power plant with high energy efficiency and treatment system can be a main mitigation measure for air pollution, water pollution, CO2 emission, natural resource consumption, biodiversity and human health hazard. In addition, proper compensation on the loss of stakeholders should be implemented to mitigate negative impacts by land acquisition and involuntary resettlement. To mitigate risk of accident, safety control measures, preparation and training for accident should be implemented.

Table 7.1.5-1 Expected measures for avoidance/mitigation at planning stage

Items	Measures for avoidance/mitigation	
	Planning stage	Implementation stage
Air pollution	Examination of the best mix of power generation system considering energy efficiency and environmental burden	Installation of exhaust gas system which meets the international standards for the emissions of NOx, SOx and dust for the generators and an engine with low NOx emissions
Water pollution		Installation of wastewater treatment system with proper discharge system to avoid negative impacts by thermal discharge
CO2 emission		Installation of generator which has high energy efficiency and keep the emissions of CO2 low
Natural resource consumption	Examination of the best mix of power generation system considering limited natural resource and energy efficiency	Installation of power generation system with high energy efficiency
Water resource	Examination of proper water allocation considering water for other purposes such as agriculture, industry, and residential use	Proper water use within allocated volume
Biodiversity	Careful consideration of the location/site of a new power plant and related facilities	Decrease of environmental burden through mitigation measures of air/water pollutions above
Involuntary resettlement		Implementation of proper compensation on the loss of stakeholders
Land acquisition		
Human health hazard	Examination of the best mix of power generation system considering energy efficiency and environmental burden	Decrease of environmental burden through mitigation measures of air/water pollutions above
Risk of accident	Formulation of a guideline on safety control, preparation and training for accident (e.g. evacuation, firefighting, etc.)	Implementation of safety control measures, preparation and training for accident (e.g. evacuation, firefighting, etc.)

Source: JICA Study Team

7.1.6 Examination of monitoring structure at planning stage

It is recommended that monitoring at planning stage in view of environmental and social aspects on long-term development plans such as power sector master plan, long-term power development plan, and network development plan should be conducted under the initiative of the EPS of Uzbekenergo JSC. That is, on the way to create the development plan by a technical team of Uzbekenergo JSC and relevant organizations, the draft development plan should be regularly assessed by the EPS and Goskompriroda as a supervisor.

In addition, as indicated in Chapter 7-1-5, proper location planning is one of the most important issues to avoid and/or mitigate negative social impacts derived from the implementation of the power development plan. From this viewpoint, not only organizations at national level but also those of regional level such as relevant local government, local Goskompriroda and

Goskomzemgeodezkadastr should also be involved in the assessment on the draft development plan if necessary.

Monitoring structure at implementation stage which project proponent (construction stage) and operator (operation stage) are involved is discussed in Chapter 7-2-3 below.

7.2 Scoping on Priority Projects

7.2.1 Outline of priority projects

Candidates of priority projects proposed in the power development plan consist of ten power plants including five gas power plants, two coal power plants, and three heat and power supply stations as shown in Table 7.2.1-1. In Table 7.2.1-1, “Availability of building lot”, “Possibility of the improvement of environmental impact”, and “Possibility of land acquisition/ involuntary resettlement” are based on the result of existing site survey.

Further details are described in Chapter 5 “Priority Projects”.

Table 7.2.1-1 Outline of priority projects (extracted from Chapter 5)

No.	Name of power plant	Type of power plant/ Generation capacity	Expected operation year	Availability of building lot	Possibility of the improvement of environmental impact	Possibility of land acquisition/ involuntary resettlement
1	Navoiy thermal power plant	GTCC/450MW	2021	Reserved	Improvement expected	Partly expected
2	Talimarjan thermal power plant	GTCC/450MW GTCC/450MW	2021 2022	Reserved	Improvement expected	Not expected
3	Syrdarya thermal power plant	GTCC/450MW GTCC/450MW	2018 2019	Reserved	Improvement expected	Partly expected
4	Turakurgan thermal power plant	GTCC/450MW	2024	Reserved	None	Not expected
5	Tashkent thermal power plant	GTCC/450MW	2024	To be replaced with existing plant	Improvement expected	Not expected
6	Angren coal-fired power plant	Coal-fired/150MW	2021	Reserved	Improvement expected	Partly expected
7	Novoangren coal-fired power plant	Coal-fired/300MW	2024	Reserved	Improvement expected	Not expected
8	Tashkent heat and power supply station	GTCS/27MW (2 units)	2020	Reserved	Improvement expected	Not expected
9	Mubarek heat and power supply station	GTCS/140MW	2019	Reserved	Improvement expected	Not expected
10	Fergana heat and power supply station	GTCC/57.7MW	2018	Reserved	None	Not expected

Source: JICA Study Team

7.2.2 Result of scoping on priority projects

Priority projects can be categorized by types of power generation: gas and coal. And, there are a lot of common positive/negative impacts derived from power generation by gas and by coal respectively.

Thus, scoping on priority projects examined in Chapter 5 was firstly done on power generation by gas (No. 1, 2, 3, 4, 5, 8, 9, and 10 in Table 7.2.1-1). Secondly, additional assessment was done on specific items of which coal power generation has more positive/negative impacts than gas such as air quality and local resource use (No. 6 and 7 in Table 7.2.1-1). The result of scoping is shown in Table 7.2.2-1.

Table 7.2.2-1 Scoping table

Cate-gory	No.	Item	Assessment		Reason of assessment
			Construction phase	Operation phase	
Environmental consideration	1	Air quality	B-	A+(gas)/ B+(coal)	Construction phase: Dust formation during excavation and other construction works is expected. Formation of air pollutants (SOx, NOx, etc.) is assumed from the operation of heavy machinery and trucks, but the effects are local and will be limited only in the vicinity. Operation phase: NOx might be generated during the operation of power plants, but environmental burden will decrease in many priority projects by the operation of energy-efficient power plants with latest treatment devices.
	2	Water quality	B-	B-	Construction phase: Turbid water formed by dredging and land preparation. Oil contained waste water will be generated during the construction phase, but the effects may be limited only in the vicinity. Operation phase: Wastewater generated during the operation of power plants, including heating water, blowdown water and boiler water, is discharged into the canal or the river near the site.
	3	Waste	B-	B-	Construction phase: Consumer waste, hazardous waste will be generated as a result of construction works. Operation phase: Consumer waste, waste of production and consumption, including hazardous wastes will be generated. Proper waste management in compliance with the regulations is necessary.
	4	Soil pollution	B-	B-	Construction phase: The possibility of soil contamination caused by leakage of fuel and lubricants from construction machinery and vehicles is expected. Operation phase: The possibility of soil contamination caused by leakage of fuel and lubricants is expected during the operation of power plants.
	5	Noise and vibration	B-	B-	Construction phase: The impact of noise and vibration caused by the operation of heavy machinery and trucks will occur, but limited only in the vicinity. The effect of high noise, such as pile-driving, can be significant, but only for a short time. Operation phase: Noise and vibration by the operation of the power plants will be expected.
	6	Land subsidence	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the ground condition of the site.
	7	Offensive odor	B-	B-	Construction phase: Waste rotting process in personal service rooms for workers and their disposal to landfill forms an objectionable odor of rotting waste. Operation phase: Removal and transport of waste containers to landfill will cause objectionable odor.
	8	Bottom sediment	B-	B-	Construction/Operation: Discharge of untreated wastewater can cause contamination of sediments of the canal or the river near the site.
	9	Protected area	D	D	Construction phase/Operation phase: Positive/Negative impact is not expected since there is no protected area around the sites of priority projects.

Cate-gory	No.	Item	Assessment		Reason of assessment
			Construction phase	Operation phase	
	10	Ecosystem	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the natural environmental condition of the site.
	11	Hydrology	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the condition of water use for construction and operation of the power plant.
	12	Topography, geological feature	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the ground condition of the site.
Social consideration	13	Involuntary resettlement and land acquisition	B-	D	Construction phase: Involuntary resettlement and land acquisition near the project site are partly expected in Navoiy, Syrdaria, and Angren power plants.
	14	Poor people	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the condition of the project affected people.
	15	Ethnic minorities and indigenous peoples	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the condition of the project affected people.
	16	Local economy	B+/ C-(in case of land acquisition)	B+	Both job creations at construction phase and that at operation phase contribute to the activation of local economy. In case of land acquisition, negative impact on local economy can be expected depending on the condition of land owner.
	17	Land use and local resource use	C-	B+(gas)/ A+(coal)	Construction phase: In addition to the land of existing power plants, additional land for extension and/or adjoining facilities might be needed. Operation phase: Gas and/or coal as local resources will be consumed, but fuel efficiency will become much higher than that of existing power plants.
	18	Water use	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the condition of water use for construction and operation of the power plant.
	19	Existing social infrastructure and social service	D	A+	Operation phase: Power supply as a part of social infrastructure will be stable and reliable.
	20	Social capital and social organizations	D	D	Construction/Operation: Negative impact is not expected since construction/operation of the priority projects do not affect on existing/future social capital and specific social organization.
	21	Equality of benefits and losses	D	D	Construction/Operation: Negative impact in terms of equality of benefits and losses is not expected since the beneficiaries of the priority projects are not limited to people of specific economic/social stratum.
	22	Local conflict	C-	C-	Construction phase/Operation phase: Negative impact such as conflict between workers and residents can be expected depending on the condition of the site.
	23	Cultural heritage	D	D	Construction/Operation: Negative impact is not expected since there is no cultural heritage around the sites of priority projects.
	24	Landscape	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the condition of the site and types of plant to be constructed.
	25	Gender	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the condition of the project affected people.
	26	Rights of the child	C-	C-	Construction phase/Operation phase: Negative impact can be expected depending on the condition of the project affected people and the situation of child labor in construction sector of Uzbekistan.

Cate-gory	No.	Item	Assessment		Reason of assessment
			Construction phase	Operation phase	
	27	Infectious diseases	B-	D	Construction phase: Temporary influx of migrants during the construction period may increase the risk of infectious diseases. Therefore, periodic medical examinations are required. Operation phase: only limited personnel will access to the facility and property. Therefore, there is no high risk of infections envisaged.
	28	Work Environment	B-	B-	Construction/Operation: Occupational injuries of workers are projected during the construction and operation works.
Others	29	Accident	B-	B-	Construction phase: Possibility of accidents during the construction works and operation of construction machines. Operation phase: Probability of accidents during operation of the facility and operation of vehicles.
Others	30	Cross-boundary impact and climate change	C-	A+	Construction phase: Negative impact can be expected depending on the condition of the site. Operation phase: CO2 generated during operation of priority projects is lower than that from existing power plants. So, the impact on climate change will be positive.

Evaluation A+/-: Significant positive / negative impact is expected.
Evaluation B+/-: Positive / negative impact is expected to some extent.
Evaluation C+/-: Positive / Negative impact is not clear.
(Further examination is necessary, and level of impact becomes clear by the progress of the examination.)
Evaluation D: No impact is expected
Source: JICA Study Team

7.2.3 Recommendation of monitoring structure and monitoring method

Table 7.2.3-1 shows expected monitoring methods and responsible organizations for the monitoring on priority projects at implementation stage which is composed of construction phase and operation phase.

In construction phase, it is recommended that monitoring on environmental and social aspects is conducted by main contractor under the supervision of Project Management Unit to be formulated in Uzbekenergo JSC in cooperation with private consultant which has expertise in specific field such as environment and health. In addition, regularly measured indicators shown in Table 7.2.3-1 should be properly reported to the local Goskompriroda via the PMU of Uzbekenergo JSC. The budget for monitoring should be included in contract cost by main contractor prior to the conclusion of contract.

In operation phase, monitoring should be conducted by the operator of a priority project under the supervision of local Goskompriroda. In addition, necessary expense for regular monitoring should be included in operation cost in advance.

Table 7.2.3-1 Expected monitoring methods and responsible organizations

No.	Item	Indicator	Method	Frequency	Responsibility	Budget
Construction phase						
1	Air quality	NO2, NO, SO2, dust	Ambient air quality analyzers	Quarterly	Main contractor, Environmental consultant, PMU of a priority project in Uzbekenergo JSC	Expenses shall be included in contract cost by main contractor.
2	Water quality/ bottom sediment	pH, SS, oil and grease	Sample analysis	Quarterly	Main contractor, Environmental consultant, PMU of a priority project in Uzbekenergo JSC	Expenses shall be included in contract cost by main contractor.
3	Waste	-Storage method (oil and chemical materials) -Separation of waste by type and hazard level, and amount -Appropriateness of storage and legal disposal -The type and amount of waste	Contract and record	Continuously	Main contractor, Environmental consultant, PMU of a priority project in Uzbekenergo JSC	Expenses shall be included in contract cost by main contractor.
4	Soil pollution	Soil conditions (transformation of soil, leakage of hazardous materials)	Visual inspection	During construction	Main contractor, Environmental consultant, PMU of a priority project in Uzbekenergo JSC	Expenses shall be included in contract cost by main contractor.
5	Noise and Vibration	Noise level Vibration level	1) Sound-level meter 2) Monitoring of grievance	1) Quarterly 2) Continuously	Main contractor, Environmental consultant, PMU of a priority project in Uzbekenergo JSC	Expenses shall be included in contract cost by main contractor.
6	Offensive odor	Odor level	1) Odor measurement 2) Monitoring of grievance	1) Quarterly 2) Continuously	Main contractor, Environmental consultant, PMU of a priority project in Uzbekenergo JSC	Expenses shall be included in contract cost by main contractor.
7	Involuntary resettlement and land acquisition	Status of compensation to stakeholders	Monitoring of grievance	Continuously	Main contractor, Environmental consultant, PMU of a priority project in Uzbekenergo JSC	Expenses shall be included in contract cost by main contractor.
8	Infectious diseases	Worker's health and public health around the site	Monitoring of grievance	Continuously	Main contractor, health and safety consultant, PMU of a priority project in Uzbekenergo JSC	Expenses shall be included in contract cost by main contractor.
9	Work environment	Conformity of local laws and regulations	Inspection	Continuously	Main contractor, PMU of a priority project in Uzbekenergo JSC, health and safety consultant	Expenses shall be included in contract cost by main contractor.

No.	Item	Indicator	Method	Frequency	Responsibility	Budget
10	Accident	Conformity of laws and regulations, occurrence of accidents	Inspection (Accident log)	Continuously	Main contractor, PMU of a priority project in Uzbekenergo JSC, health and safety Consultant	Expenses shall be included in contract cost by main contractor.
Operation phase						
1	Air quality: ambient air quality	NO_2, NO	Ambient air quality analyzers	Quarterly	Operator of a power plant	Expenses shall be included in operation cost
2	Air quality: exhaust gas	NOx, SOx, dust	Continuous Emission Monitoring System (CEMS)	Continuously	Operator of a power plant	Expenses shall be included in operation cost
3	Water quality/ bottom sediment	Temperature, pH, SS, BOD, Oil and grease, Nitrite, Nitrate, Ammonia-nitrogen, Sulfate, Chloride, Phosphate, Fe, Cu, Zn	Sample analysis	Quarterly	Operator of a power plant	Expenses shall be included in operation cost
4	Waste	The type and amount of waste (waste oil, sludge, other hazardous and domestic wastes)	Contract and record	Annually	Operator of a power plant	Expenses shall be included in operation cost
5	Soil pollution	Soil conditions (transformation of soil, leakage of hazardous materials)	Visual inspection	Continuously	Operator of a power plant	Expenses shall be included in operation cost
6	Noise and vibration	Noise level Vibration level	1) Sound-level meter 2) Monitoring of grievance	1) Twice a year 2) Continuously	Operator of a power plant	Expenses shall be included in operation cost
7	Work environment	Conformity of laws and regulations and laws	Inspection	Continuously	Operator of a power plant	Expenses shall be included in operation cost
8	Accident	Conformity of laws and regulations, , occurrence of accidents	Inspection (Accident log)	Continuously	Operator of a power plant	Expenses shall be included in operation cost

Source: JICA Study Team

7.3 Stakeholder's Meeting

7.3.1 Objective of the Stakeholder's Meeting

The objective of the Stakeholder's Meeting is to collect stakeholders' opinions and concerns in view of environmental, biophysical, economic, and social aspects at the early stage of the examination of the development plan and to reflect the opinions to the development plan.

7.3.2 Result of the Stakeholder's Meeting

As a part of the SEA activity for making power development plan, two Stakeholder's Meetings were held during the examination of the power development plan in the following manner.

(1) The first Stakeholder's Meeting held on 8th April, 2015

1) Agenda

- Objectives of the implementation of JICA projects
- A summary of the Master Plan Study for Power Sector Development in Uzbekistan
- Outline and objective of the SEA

The first Stakeholder's Meeting held on 8th April, 2015

2) Participants

Representatives from environmental protection service of Uzbekenergo JSC, Goskompriroda, Ministry of Agriculture and water resources, design institutes, JICA Study team and 20 engineers of Uzbekenergo JSC

3) Main points discussed

- Economic activity in Uzbekistan should shift to more environmentally friendly way, and the power sector master plan should correspond to this trend.
- Power development and network development should be properly combined in the master plan.
- Development of renewable energy should be further promoted in the master plan.
- The result of existing power sector study done by German consultant[4] should be taken into account for making the master plan.
- Though legislative structure for SEA has not been established in Uzbekistan, experience

[4] Asian Development Bank Technical Assistance Consultant's Report "Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan" (Cofinanced by the Regional Cooperation and Integration Fund under the Regional Cooperation and Integration Financing Partnership Facility) Prepared by Siegfried Grunwald Fichtner GmbH & Co. KG Stuttgart, Germany, October 2012

of SEA activities must be good not only for environment and society of Uzbekistan, but also getting further financial support by international donors who will assign the implementation of the SEA as a condition for new project loan.

(2) The second Stakeholder's Meeting held on 26th August, 2015

1) Agenda

- Review of the 1st Public Consultation
- Introduction of the draft Power Development Plan
- Result of the SEA

The second Stakeholder's Meeting held on 26th August, 2015

2) Participants

Representatives from relevant organizations same as the 1st Stakeholder's Meeting, and 15 engineers of Uzbekenergo JSC

3) Main points discussed

- Percentage of hydro power generation in the draft power development plan should be increased in terms of saving natural gas consumption, but construction of dam-type hydro power plant should be carefully considered because of its huge environmental negative impacts.
- Along with the future diffusion of electronics with battery represented by electric vehicle, consumption of electricity at night is expected to increase. Because of this, the importance of pumped-storage hydro power generation using electricity at night might decrease in the future.
- The percentage of renewable energy should also be increased.
- The possibility of nuclear power generation should also be considered, but it is the matter of the highest reaches of the government of Uzbekistan.

As a result of the second Stakeholder's Meeting, proposed opinions such as the increase of percentage of hydro power generation and renewable energy in the power generation plan have been taken into account to finalize the power development plan.

ATTACHMENT　Contact List

ATTACHMENT

Contact List

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