FY 2020

Feasibility Study for Implementing Integrated Coal Gasification Combined Cycle Power Plant ("IGCC") in the Republic of Uzbekistan

February, 2021

Ministry of Economy, Trade and Industry, Agency for Natural Resources and Energy

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Mitsubishi Power, Ltd

Table of Contents

1. Outline of Feasibility Study and Conclusion

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1.1 Executive Summary

Republic of Uzbekistan is experiencing a stable economic and population growth, but which leads to push the per capita power consumption. At present, Uzbekistan's energy shortage at peak demand is covered by the power imported from the neighboring countries. Furthermore, it has become an urgent task to replace the old power generation facilities that were delivered during the Soviet era.

In addition, the Republic of Uzbekistan, where thermal power generation accounts for more than 80% of the total power generation relies heavily on natural gas as the main fuel for power generation, which poses a potential risk to the reliability of its power supply system from the perspective of the energy mix.

Under such circumstances, the Government of Uzbekistan is considering the utilization of renewable energy such as hydropower, solar power, and wind power, and there is continuing demand for technology that utilizes domestic coal resources to minimize environmental load. Therefore, the Government of Uzbekistan is planning to install Japan's state-of-the-art Integrated Coal Gasification Combined Cycle (IGCC) .

Mitsubishi Corporation (MC) and Mitsubishi Power, Ltd. (Mitsubishi Power) have been entrusted by the Ministry of Economy, Trade and Industry (METI) to "Business Implementation Survey Project for Overseas Expansion of High Quality Energy Infrastructure in FY2020", and conducted this "Study for Implementing Integrated Coal Gasification Combined Cycle Power Plant (IGCC) in the Republic of Uzbekistan" .

The objective of this Study is to introduce an air blown IGCC technology into the Republic of Uzbekistan to form a project based on a Memorandum of Understanding (MOU) signed by MC and Mitsubishi Power jointly with the Ministry of Energy of the Republic of Uzbekistan (MOE) and an official request from JSC Thermal Power Plants (TPP) in order to increase the power supply and diversify the power supply system of the country.

The following were done in the Study and the results are indicated in the Report:

1. Investigation of fuel properties, supply conditions of water and clarifications of specifications and quantities of new facilities, and details of jurisdiction of facilities supply and various services.
2. The technical, environmental (Reduction of CO2 emissions) and economic benefits were clarified, and the appropriateness, effectiveness and/or necessity of application of IGCC manufactured by Mitsubishi Power as a solution to solve the energy shortage in the Republic of Uzbekistan were confirmed.
3. Based on the above, a large foothold to realize the project by development of low-grade coal-fired IGCC to the Republic of Uzbekistan was confirmed.

1.2 Purpose of Feasibility Study

In the latter half of 2019, MOE indicated a strong interest in Japan's latest IGCC technology, and requested an implementation of feasibility study to introduce IGCC into the Republic of Uzbekistan. As the background of this request, there is a strong expectation for the reform in each sector promoted by the President Mirziyoyev, and in the electric power sector, the continuous and effective utilization of coal resources is expected from the viewpoint of energy mix, stable electric power supply and effective utilization of domestic resources, while aiming at introduction of renewable energy. According to the "Concept Note for ensuring electricity supply in Uzbekistan in 2020-2030", total 12.9 GW of power generation capacity as of 2019 will be expanded to total 29.3 GW by 2030, and the power source composition will be diversified from the viewpoint of energy mix. At the same time, coal resources will be continuously used, and 1.7 GW will be coal-fired thermal power. Under such circumstances, in December 2019, when President Mirziyoyev's first visit to Japan, a memorandum of understanding was concluded between MC, Mitsubishi Power and MOE for mutual cooperation in the investigation for the introduction of IGCC technology in Uzbekistan. In addition, in February 2020, MOE and TPP issued formal requests, which expressed the government's strong intention to use domestic coal effectively and interest in IGCC technology.

Since 1980, Mitsubishi Power's air blown IGCC technology has been developed. 250 MW class IGCC demonstration plant as a joint research project of Japanese domestic electric companies was constructed with the support of METI, and its main facilities such as gasifier, gas turbine, steam turbine, generator and auxiliaries were designed and supplied by Mitsubishi Power. This demonstration plant verified its high availability by achieving 2,000 hours continuous operation earlier than IGCC plant based on other company's technology, and successfully completing 5,000 hours reliability run test.
After completion of demonstration, commercial operation was started as No. 10 unit of Nakoso Power Station of Joban Joint Power Co., Ltd., and knowledge on long term reliability based on 3,917 hours continuous operation, which is world record, was accumulated, and IGCC technology such as the introduction of advanced O&M technology was innovated.

Also, in Japan, Nakoso IGCC Power GK and Hirono IGCC Power GK were established in 2016, and started to construct 540 MW class air blown IGCC Plant at each site, and will start commercial operation soon.

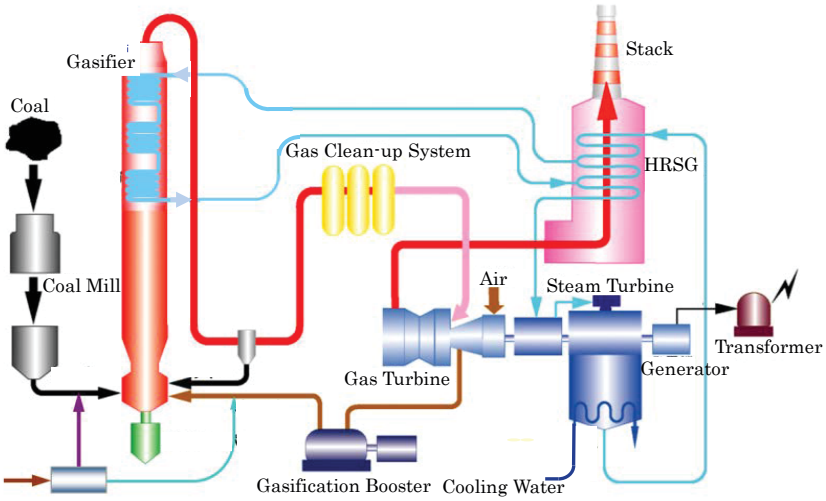

Fig. 1.2-1 Configuration of Air Blown IGCC Plant (Example)

The purpose of this study is to confirm the validity and effectiveness to introduce IGCC technology in the Republic of Uzbekistan, which applies Japan's state-of-the-art technology to meet the demand such as increase in power supply from low-environmental-impact thermal power plants using domestic resources and diversification of power source composition. It is also expected to contribute to the improvement of the reliability of Japan's advanced thermal power generation technology in partner countries, which will lead to the improvement of orders received.

1.3 Study Result

1.3.1 Technical Study

The followings are results of this feasibility study.

(1) Basic Concept of the Project

Design conditions (ambient temperature, barometric pressure, relative humidity, etc.,) and general outline of the plant were selected. Also, scope of work of the plant equipment was decided.

Project schedule was studied considering transportation time and restrictions due to the characteristic of Uzbekistan as dual-landlocked country.

(2) Coal

It was confirmed that properties of coal from Angren mine informed by TPP were suitable for IGCC.

(3) Construction Site

It seems that IGCC plant can be located at the candidate site which is located at the north of existing power plant informed by TPP.

It was confirmed that cooling tower water was used for condenser cooling, and river water from Akhangaran River was used as cooling tower make-up water. It is same way as existing power plant.

Natural gas transported by the pipeline will be used as unit start-up fuel.

Considering transportation restriction due to dual-landlocked country, overland transportation is preferred. For equipment which need oversea transportation, they seem to be able to be transported overland after unloading at major port in Romania and/or Turkey. However, further study is necessary to confirm the equipment weight limit for overland transportation.

It seems that the environmental impact on residential area to be small, because there are the existing units between IGCC power plant and residential area, even though there is residential area near IGCC power plant.

(4) Gasifier, Gas Clean-up System and Auxiliaries

The appropriate system configurations of gasifier and gas clean-up system were

determined based on coal properties evaluated in above item (2).

(5) Power Plant Facilities

Basic design of IGCC power plant was carried out based on study result on gasifier and gas clean-up system indicated in above item (4), and gross plant efficiency and net plant efficiency were estimated.

It was confirmed that IGCC power plant could be arranged in the candidate site informed by TPP as a result of arrangement study of IGCC power plant.

(6) Emissions

It was confirmed that expected flue gas emissions would meet TPP requirements.

(7) Carbon Dioxide Reduction Effect

The use of high efficiency IGCC power plant is expected to reduce carbon dioxide emissions by 317,000 ton per year.

1.3.2 Economic Evaluation

This Study compares Cost of Electricity (COE) and Regional Average Tariff when new IGCC Power Generation Facility is newly constructed and operated for 30 years at a candidate site on the north side of the existing Angren Power Plant. As a result, it was confirmed that Cost of Electricity (COE) is lower than the Regional Average Tariff, and met the requirement level in Uzbekistan (Angren).

1.3.3 Pending

Not disclosed.

2. Study Result (Detail)

2. Study Result (Detail)

2.1 Basic Concept of the Project

2.1.1 General

The feasibility of the implementation of the state-of-the-art IGCC technology was studied based on the needs of Uzbekistan to use domestic coal and to increase electrical power supply. Necessary information for power plant design such as TPP requirements regarding plant output, candidate site, etc., and site conditions were researched, and the basic configurations of the IGCC power plant were determined. TPP requirements and power plant outline are shown in Table 2.1.1-1.

Table 2.1.1-1 TPP Requirements and Power Plant Outline

Item	TPP Requirement	Power Plant Outline (Study Result)	Remarks
Plant Type	Integrated Coal Gasification Combined Cycle Power Plant (IGCC)	Same as left column	
Gross Output	500MW class x 1unit	Same as left column	
Number of Unit	1 unit	Same as left column	
Location	Mine Mouth Near the Angren Mine	Same as left column	
Main Fuel	Coal	Same as left column	Angren Coal
Auxiliary Fuel	Natural Gas	Same as left column	for start-up fuel
Ambient Temp.	Max. : 40.0 °C Min. : -17 °C Design : —	Max. : Same as left column Min. : Same as left column Design : 15 °C	Average of max and min is used as design.
Ambient Press.	Max. : 955 hPa Min. : 920 hPa Design : —	Max. : Same as left column Min. : Same as left column Design : 937.5 hPa	Average of max and min is used as design.
Relative Humidity	60.0 %	Same as left column	
Condenser Cooling Method	River Water One Through and/or Wet Cooling Tower Water (Natural Draft) (Closed Cycle)	Wet Cooling Tower Water (Natural Draft) (Closed Cycle)	Wet cooling tower water was applied, because IGCC needed large cooing water consumption.
Cooling Water Temperature	River Water : 14 °C Cooling Tower Water : —	Cooling Tower Water : 17.7 °C (for performance)	
Turbine Shaft Configuration	—	1 on 1	

2.1.2 Equipment/Systems to be Installed

This study is to install IGCC power plant in greenfield in the vicinity of Angren power plant which is located near Tashkent, the capital city of Uzbekistan.

Equipment/Systems to be installed are shown in Figure 2.1.2-1.

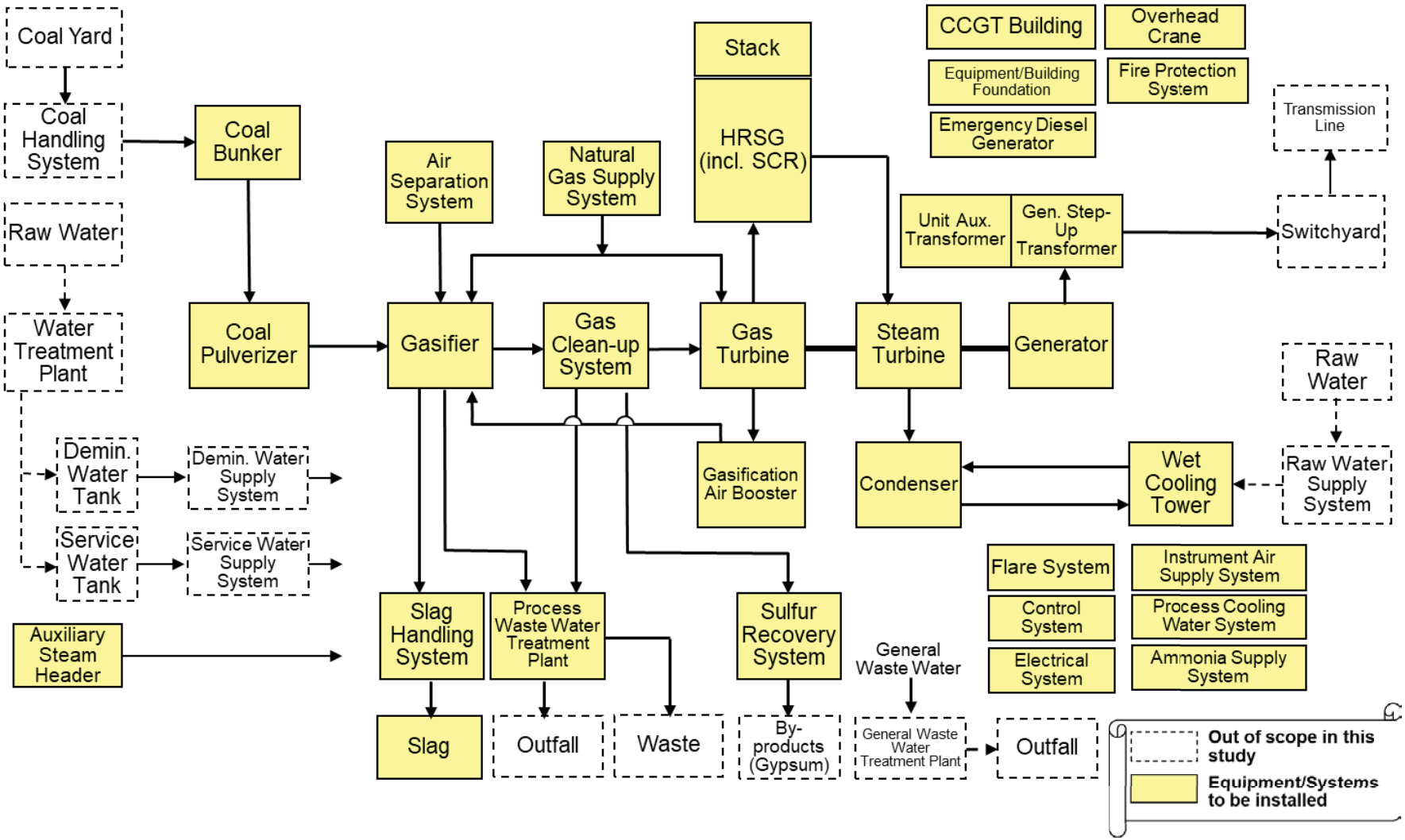

Fig. 2.1.2-1 Equipment/Systems to be Installed

2.1.3 Scope of Work

(1) Scope of Work for Equipment/Systems

Not disclosed.

(2) Scope of Work for Service between TPP, MC and Mitsubishi Power

Scope of work for service in this study is shown in Table 2.1.3-1. In general, service regarding equipment to be provided is under the scope of the party who will supply the equipment. In addition, the work, which shall be performed by the power plant developer, such as permits and/or approvals (e.g. environmental impact study, etc.,) is within the scope of TPP. The work for permits and/or approvals related to the civil work and equipment construction work is within the scope of MC and Mitsubishi Power (only for equipment/systems to be supplied by them).

	Uzbekistan IGCC		
Description	**TPP**	**MC, Mitsubishi Power**	**Remarks**
<Permits and/or Approvals>			
Environmental Impact Study	○	△	MC and Mitsubishi Power to provide data, if necessary.
Permits for Construction of Power Plant	○	△	MC and Mitsubishi Power to provide data, if necessary.
Construction Permits	○	△	MC and Mitsubishi Power to provide data, if necessary.
Factory Operation Permits	○	△	MC and Mitsubishi Power to provide data, if necessary.
Permit for Power Plant Operation	○	△	MC and Mitsubishi Power to provide data, if necessary.
Permit for Fuel Handling System	○	△	MC and Mitsubishi Power to provide data, if necessary.
Permit for Excavation Work / Back Fill Work	○	△	MC and Mitsubishi Power to provide data, if necessary.
Permit for Waste Water Discharge	○	△	MC and Mitsubishi Power to provide data, if necessary.
Certificate of Power Transmission	○	△	MC and Mitsubishi Power to provide data, if necessary.
Certificate of Pressure Vessels	-	○	for equipment to be supplied by MC and Mitsubishi Power
Certificate of Lifting Devices	-	○	for equipment to be supplied by MC and Mitsubishi Power
Permit for Temporary Structures for the Construction	-	○	for equipment to be supplied by MC and Mitsubishi Power
Permit to Import	○	○	each scope of work
Permit for Transportation	○	○	each scope of work
Permit for Temporary Utilities	○	-	telephone, temporary electricity, water, etc.,
Permit for Permanent Utilities	○	-	telephone, electricity, water, etc.,
<Engineering>			
Equipment Design and Procurement	○	○	each scope of work
Design Drawings	○	○	each scope of work
Operation and Maintenance Manual	○	○	each scope of work
Transportation	○	○	each scope of work
Transportaion Route Survey	○	○	each scope of work
Noise Simulation	△	○	TPP to provide noise data for equipment supplied by TPP
Training	△	○	TPP to prepare training room and facilities
Study and Evaluation of Utilizing and/or Expanding Existing Facilities	○	–	
<Construction and Commissioning>			
Site organization	○	○	each scope of work
Construction Manager	○	○	each scope of work
Site Safety Manager	–	○	
Construction Schedule Control	○	○	each scope of work
Commissioning Supervisor	–	○	
Commissioning Worker	○	–	

○:Person in Charge、△:Support (providing information, etc.,)

Table 2.1.3-1-(1)　Scope of Work for Service

	Uzbekistan IGCC		
Description	**TPP**	**MC, Mitsubishi Power**	**Remarks**
Operation / Maintenance Work	○	–	
Coalyard Operation	○	–	
Soil Investigation	○	–	
Site Boundary Survey	○	–	
Soil Improvement Work	○	–	
Ground Compaction	○	–	
Buried Objects Removal Work	○	–	
Access Road Construction (outside of Site Boundary)	○	–	
Access Road Construction (inside of Site Boundary)	–	○	
Site Security for Construction Area	○	–	
Temporary Gate and Fence for Construction Area	○	–	including removal work after completion of construction
Touch Up Paint	○	○	each scope of work
Periodic and Final Cleaning Work	–	○	for construction area only
Reinforcement/Removal/Restoration Work for Transporation Route	○	○	each scope of work
Waste Disposal during Civil and Construction Work	–	○	not including waste generated from construction work executed by TPP
Temporary Site Office	○	○	prepare by each party
Facilities for Temporary Site Office (furnitures, HVAC, toilet, etc.,)	○	○	each scope of work
Temporary Warehouse for Construction Work	○	○	prepare by each party, if necessary
Facilities for Temporary Warehouse for Construction Work	○	○	prepare by each party, if necessary
Modification Work of Existing Facilities	○	–	including investigating work of deteriolation, etc., of existing facilities
Performance Test	–	○	
<Utilities>			
Land Acquisition	○	–	
Land Acquisition	○	–	for storage yard and ground assembly
Land for Temporary Site Office	○	–	including parking area
Fuel for Commissioning	○	–	Coal, Natural Gas, Light Oil, etc.,
Utilities for Commissioning	○	–	Electricity, Water, etc.,
Consumables for Commissioning	○	–	Limestone, Ammonia, Grease/Lub. Oil, CO2 Gas, H2 Gas, Chemicals, etc.,
Consumables for Commissioning (initial filling)	–	○	Grease/Lub. Oil, CO2 Gas, H2 Gas Not including consumables for equpment supplied by TPP
Waste Transportation/Disposal during Commissioning	○	–	Slag, Gypsum, etc.,
Waste Transportation/Disposal during Commissioning	○	–	Waste from waste water treatment plant, oily waste, etc.,
Utilities for Civil and Construction Work (incl. Temporary Facilities for Supply)	○	–	Electricity, Water, etc.,

○: Person in Charge、△: Support (providing information, etc.,)

Table 2.1.3-1-(2) Scope of Work for Service

2.1.4 Project Overall Schedule

Not disclosed.

2.2 Coal

Table 2.2-1 shows the coal properties using for existing Angren Power Plant provided by TPP for IGCC implementation study. Coal gasification was studied based on indicated coal properties.

Table 2.2-1 Coal Properties (received from TPP)

Item	Unit	Angren Coal	Remarks
Calorific Value			
Higher Heating Value (HHV)	kJ/kg	16,413	as received
Lower Heating Value (LHV)	kJ/kg	15,062	as received
Industrial Analysis			
Total Moisture	wt%	35	as received
Fixed Carbon (FC)	wt%	35.5	as received
Volatile Matter (VM)	wt%	17.5	as received
Fuel Ratio (FC/VM)	wt%	2.03	as received
Ash Content	wt%	12.0	as received
Total Sulfur	wt%	1.60	as received
HGI		65	(Note1)
Ash Melting Point (Reduction)	°C	1,260	
Ash Flow Point (Reduction)	°C	1,300	

(Note1) Assumption based on Mitsubishi Power's experience.

2.3 Construction Site

2.3.1 Construction Areas and Conditions

Not disclosed.

2.3.2 Availability of Utilities

Available utilities are shown in Table 2.3.2-1 as a result of TPP confirmation. It seems that these utilities will be supplied mainly from existing units.

More detail survey and study are necessary for terminal point between existing units and IGCC power plant and conditions.

Table 2.3.2-1 Available Utilities

Item	Use	Remarks
Cooling Water (cooling tower make-up water)	Condenser Cooling	use Akhangaran River water Properties are shown in Table 2.3.2-2.
Demin. Water	Cycle Make-up	Properties are shown in Table 2.3.2-2.
Ammonia	Feedwater Treatment, SCR	(Note1)
Limestone	Flue Gas Desulfurization	
Natural Gas	Start-up fuel	to be supplied via pipeline Refer to Table 2.3.2-3 for natural gas properties

(Note1) In this study, 24 wet% aqueous ammonia was assumed to be used.

Table 2.3.2-2 Water Properties (provided by TPP)

Item	Unit	River Water (Akhangaran River)	Demineralized Water
SS	mg/m^3	12.6	-
Mineral Content	mg/m^3	153	-
Chlorides	mg/m^3	5.0	-
Sulfates	mg/m^3	33.2	-
Fe	mg/m^3	0.15	-
Cu	mg/m^3	0.010	2.0
Nitrates	mg/m^3	1.7	-
Nitrogen Nitrate	mg/m^3	0.38	-
Oil Products	mg/m^3	0.16	-
BOD	mg/m^3	5.9	-
Hardness	mg $CaCO_3/m^3$	2.0	0.2
Alkalinity	mg $CaCO_3/m^3$	1.5	-
Silicic Acid	mg/m^3	5000	20
Na (Sodium)	mg/m^3	8.0	15
pH	-	8.0	5.5 ~ 6.
Temperature	°C	18.1	-
Calcium Hardness	mg $CaCO_3/m^3$	1.4	-
Magnesium Hardness	mg $CaCO_3/m^3$	0.6	-
Electric Conductivity	µS/cm	-	0.5

Table 2.3.2-3 Natural Gas Properties (provided by TPP)

Item	Unit	Value
Methane	mol%	95.61
Oxygen	mol%	0.67
Nitrogen	mol%	0.88
Carbon Dioxide	mol%	0.68
Ethane	mol%	1.85
Propane	mol%	0.26
i-Buthane	mol%	0.0261
n-Buthane	mol%	0.0237
i-Pentane	mol%	0.0030
n-Pentane	mol%	0.0016
Hydrogen Sulfide*1	g/Nm^3	0.0065
Density	kg/m^3	0.78
Calorific Value	kJ/kg	44313.43

*1：Tentative value based on Mitsubishi Power's experience

2.3.3 Transportation Condition

Considering that Uzbekistan is a dual-landlocked country, overland transportation will be applied after unloading at major port of Romania and/or Turkey. As a result of preliminary route survey, transportation can be carried out by selecting adequate equipment size and applying equipment split transportation, even though there are equipment size restriction (width and height).

For weight limitation of bridges and culverts located on the route to the site, it is necessary to study in detail.

Figure 2.3.3-1 Survey of Transportation Conditions

2.3.4 Residential Area

There is a residential area near the candidate IGCC power plant site. On the other hand, existing units are located between IGCC power plant and residential area. Therefore, the existing units become a soundproof wall for IGCC power plant and environmental impact such as noise is expected to be small. Also, environmental impact such as vibration due to IGCC power plant is smaller than existing units, because it is located away from residential area from existing units.

2.4 Gasifier, Gas Clean-up System and Auxiliaries

The properties of Angren coal used for this study are high moisture (35 wt%, as received), high ash content (12.0 wt%, as received) and high sulfur (1.6 wt%, as received).

Due to these coal characteristics, fuel calorific value is lower than bituminous coal commonly used at power plant in Japan. Even though basic plant system configuration does not change, the capacity of coal pulverizing/feeding system and slag handling system become larger, since coal input for required plant output is larger than that of IGCC plant using bituminous coal.

Also, capacity and/or number of H_2S absorber and sulfur recovering system become larger, because H_2S and COS contents in syngas generated from gasifier is larger than that of gasifier using bituminous coal.

2.4.1 Gasifier

Figure 2.4.1-1 shows basic system configuration of Mitsubishi Power's gasifier. The coal gasification system consists of gasifier, pulverized coal feed system and char recovery and feed system. Brief description of the coal gasification system is as follows.

- Pulverized coal feed system

  Raw coal stored in coal bunker is pulverized at coal mill and dried in order to obtain adequate size and moisture for gasification. Then, pulverized coal is pressurized and led to combustor and reductor of gasifier by nitrogen from air separation system (ASU).

- Gasifier

  Syngas such as carbon monoxide (CO) and hydrogen (H_2) are generated from coal gasification under the high temperature/pressure environment using oxygen enriched air as gasification accelerator. The heat of syngas is absorbed and utilized to generate high temperature and pressure steam, at syngas cooler (SGC). Syngas is led to char recovery system after SGC.

  Ash content in coal is melted by high temperature combustion in the gasifier and discharged as molten slag.

- Char Recovery and Feed System

  Syngas from which char is removed at char recovery and feed system will be led to gas clean-up system downstream of char recovery and feed system.

Removed char is fed to combustor of the gasifier for reuse.

Based on coal properties specified in Clause 2.2, the gasifier and auxiliaries are designed. From reliability and economy points of view, same system configuration as commercial unit in Japan was applied in this design.

Table 2.4.1-1 shows the gasifier configuration.

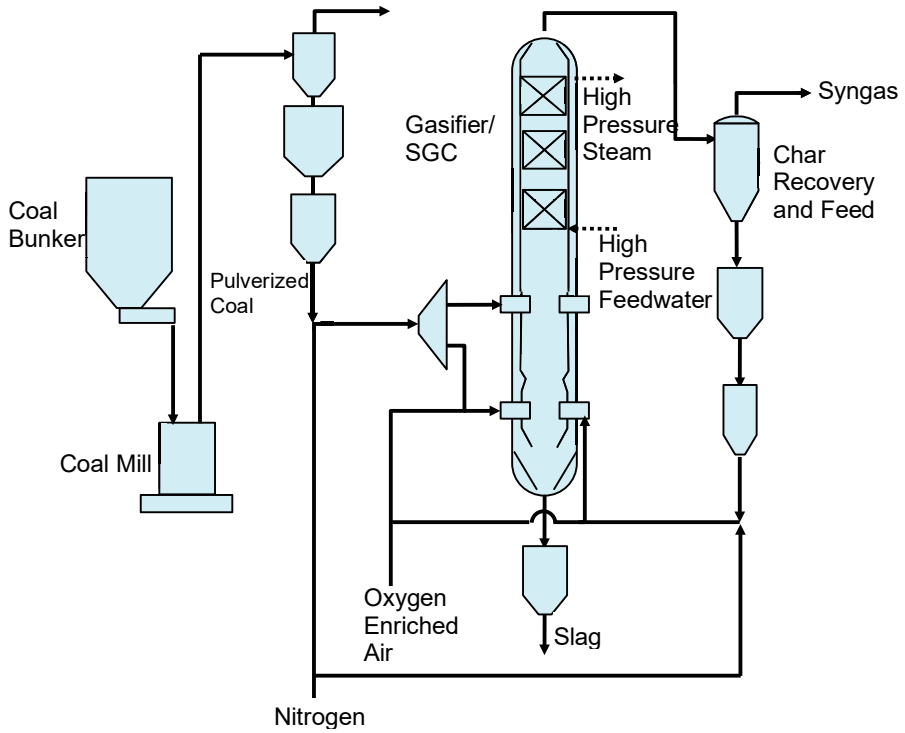

Figure 2.4.1-1 Gasifier System Configuration

Table 2.4.1-1 Gasifier Outline

Item	Description	Remarks
No. of Installed	1 set	
Type	Dry Coal Feed, Air-blown, Two-Chamber Two-Stage entrained Bed Type	
Main Fuel	Coal	Angren Coal
Start-up Fuel	Natural Gas	
Gasifying Agent	Oxygen-enriched Air	extracted from GT compressor
Coal Feeding System	Nitrogen High Concentration Feed System	
Char Feeding System	Nitrogen High Concentration Feed System	
Char Recovery System	Cyclone and Porous Filter	
Byproduct	Slag	

2.4.2 Gas Clean-up System

Table 2.4.2-1 shows gas clean-up system outline.

Table 2.4.2-1 Gas Clean-up System Outline

Item	Description	Remarks
No. of Installed	1 set	
Type	Wet Gas Clean-up System*1	
H_2S Absorber	MDEA Chemical Absorption*1	
Sulfur Recovery System	Limestone Type FGD	
Byproduct	Gypsum	

*1: Subject to change according to design progress, selected vendor, etc.,

2.5 Power Plant Facilities

2.5.1 Combined Power Plant System

Combined cycle power plant system of IGCC consists of gas turbine, HRSG, steam turbine same as GTCC plant. The characteristics of Mitsubishi Power's IGCC plant are that feedwater is fed to SGC, steam generated in SGC is added to steam system of combined cycle and compressed air is extracted from gas turbine compressor and fed to gasifier as gasification agent.

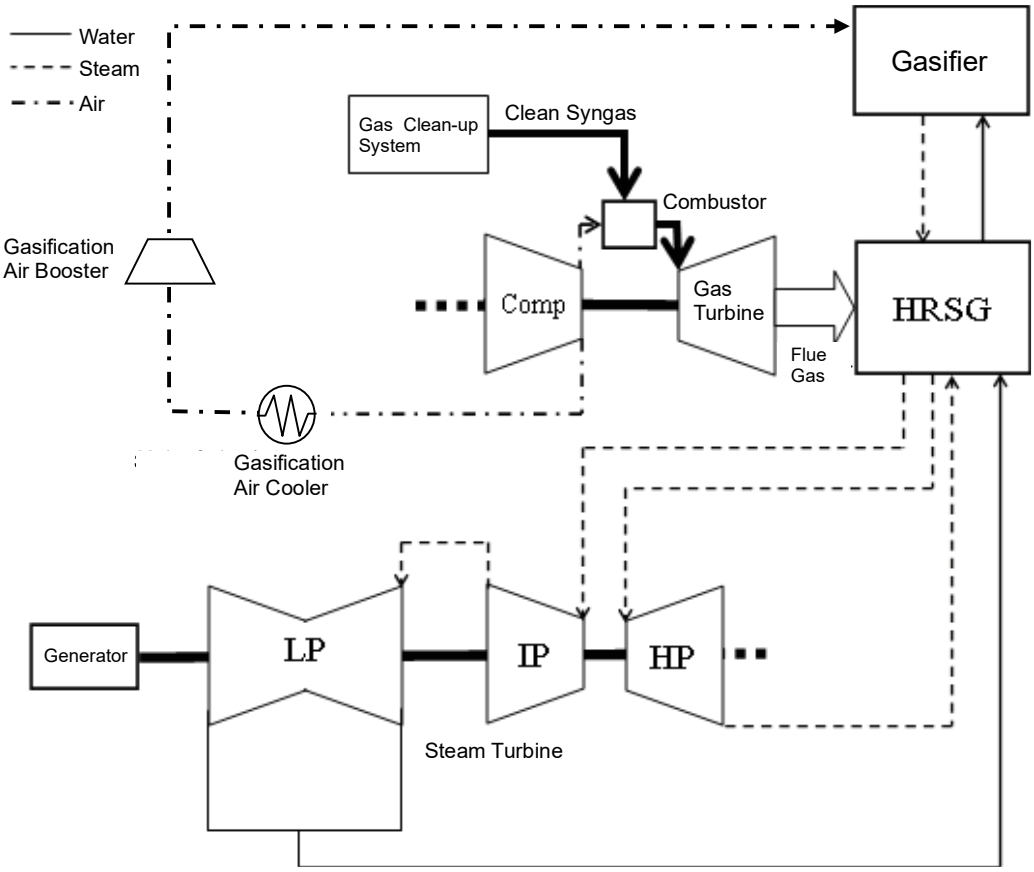

Figure 2.5.1-1 System Configuration of Combined Power Plant

2.5.2 Air Separation Unit (ASU)

Not disclosed.

2.5.3 Plant Output / Efficiency

Not disclosed.

2.5.4 Plot Plan

Not disclosed.

2.5.5 Construction Schedule

Not disclosed.

2.6 Emissions

Table 2.6-1 shows that gaseous emission limits at ground level in accordance with Uzbekistan regulation, required by TPP. According to Mitsubishi Power's experience in Uzbekistan, flue gas emissions seem to be met the limits indicated in Table 2.6-1, even though it should be confirmed by the flue gas dispersion simulation. Refer to clause 2.1.3 of this report for the scope of flue gas simulation.

It should be noted that changes in gas emission limits affect plant efficiency and cost.

Table 2.6-1 Flue Gas Emission Limits (provided by TPP)

Item	Unit	Value
SO_2	mg/m^3N (dry, 6%O_2)	0.1
NO_2	mg/m^3N (dry, 6%O_2)	0.05
NO	mg/m^3N (dry, 6%O_2)	0.12
Particles	mg/m^3N (dry, 6%O_2)	0.03

(Note1) Values indicated in above table are for ground level concentrations.

2.7 Carbon Dioxide Reduction Effect

Carbon dioxide reduction effect by applying high efficiency IGCC power plant is shown in Table 2.7-1. As indicated in Table 2.7-1, annual reduction amount of carbon dioxide is expected to be 317,000 ton which is equivalent to about 30% of carbon dioxide emissions of existing units (1,016,000ton[1]).

The Republic of Uzbekistan following Kyoto Protocol and Paris Agreement has decided to reduce greenhouse gas emissions approximately 10% from the 2010 level and modernize infrastructure by applying environmentally safe technology at presidential meeting regarding to environmental issue held on 4th and 30th October 2019. The implementation of IGCC power plant is expected to contribute to such Uzbekistan's goal.

Table 2.7-1 Carbon Dioxide Reduction

	Coal Fired Power Plant	IGCC Power Plant	Remarks
Unit Gross Output	500MW class	495MW	
CO_2 Reduction	Base	317,000ton/year	

[1] The Feasibility Study on Angren Thermal Power Plant Modernization Project in Uzbekistan (2006, JETRO)

2.8 Economic Evaluation

2.8.1 Project Economic Evaluation

In this section, we carried out a Project Economic Evaluation on the basis of the information obtained in this study for the case where an IGCC Power Generation Facility is newly constructed and operated for 30 years at a candidate site on the north side of the existing Angren Power Plant. Economic Efficiency is evaluated from the comparison with the regional average tariff and Cost of Electricity (COE) calculated based on the following Evaluation Formula. Table 2.8-3 shows the Result of Economic Evaluation

Evaluation Formula of Cost of Electricity (COE) (30 year NPV)

$$\text{Cost of Electricity (COE)} = \frac{\text{EPC Cost + Total Fuel Cost + Total Maintenance Cost}}{\text{Total Power Generation}}$$

Table 2.8-1 Basis of Calculation for Cost of Electricity (COE)

Item	This Study
EPC Cost	Equipment: Calculations are based on the candidate site & weather condition provided by TPP, Gross Power Output, Coal Properties, Gasifier, Gas Clean-up System , and Power Generation Facilities. Transportation & construction costs: Calculations are based on the estimated quantity of Equipment.
Total Fuel Cost	Calculations are based on domestic coal price obtained from customer (Converted to $/ t at current rate) and coal consumption (t/y) confirmed through this study.
Total Maintenance Cost	On the assumption that Long Term Maintenance Agreement (LTSA) will be concluded between Mitsubishi Power and TPP, calculated from the Power Generation Facility condition and its estimation experience for past projects.
Total Power Generation	Total Power Generation based on Table 2.8-2 Other Prerequisites.

Table 2.8-2 Other Prerequisites

Item	Unit	This Study
Operation Year	Year	30
Availability	%	90
Plant Output Gross Output Net Output	 kWe kWe	 495,000 428,210
Plant Gross Efficiency	%	47.39
Discount Rate	%	7.00

Table 2.8 -3 Result of Economic Evaluation

EPC Cost	$2,828/kW
Cost of Electricity (COE)	$3.90 cent/kWh *Applying ODA loan
Regional Average Tariff	$4.04 cent/kWh

From the above, it can be said that the Cost of Electricity (COE) when applying the ODA loan is below the Regional Average Tariff, hence the required tariff level in Uzbekistan (Angren) will be cleared.

2.8.2 Sub-income by Slag

In conventional coal-fired thermal power generation, the ash content in coal is discharged as ash after combustion, and disposal costs are high. On the other hand, in case of IGCC, ash in coal is vitrified and discharged as slag. Since this slag can be used for paving roads, etc., it is possible to obtain profit from the sale of slag. However, the income from the sale of slag is not taken into account in this Economic Evaluation.

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Unapproved List for Second Use

Title of Report：
FY 2020
Feasibility Study for Implementing Integrated Coal Gasification Combined Cycle Power Plant (“IGCC”) in the Republic of Uzbekistan

Commissoned Project Name：Feasibility Study for Implementing Integrated Coal Gasification Combined Cycle Power Plant (“IGCC”) in the Republic of Uzbekistan

Contractors: Mitsubishi Corporation,Mitsubishi Power, Ltd

Page	No.	Title
2.1-1	Table 2.1.1-1	TPP Requirements and Power Plant Outline
2.2-1	Table 2.2-1	Coal Properties (received from TPP)
2.3-2	Table 2.3.2-2	Water Properties (provided by TPP)
2.3-2	Table 2.3.2-3	Natural Gas Properties (provided by TPP)
2.6-1	Table 2.6-1	Flue Gas Emission Limits (provided by TPP)
2.8-2	Table 2.8-2	Other Prerequisites