5.6 Operation and Maintenance of New Combined Cycle Plant

5.6.1 Organizational Systems for Operation and Maintenance

New systems are required, separate from existing systems, for the operation and maintenance of new facilities. However, the people who will work with the new facilities must be selected from among those working with existing equipment and must begin to act as an organization from before the trial operation of the new facilities. The only new departments that need to be created are an operation department to focus on the operation of the new facility and a maintenance department devoted to the inspection and maintenance of the new facility. Other related work can be covered by existing departments. Before personnel are moved from existing facilities, it is desirable to supplement the staff of the areas they will be leaving.

The staff of the new operation department should include a balanced mix of experienced veterans and young employees. Simulation equipment should be used prior to the trial operation of the new facility to provide workers with a thorough understanding of the operation technology and ensure that there are no problems once operation of the actual facility begins.

In the maintenance department, members of staff who were involved in the construction of the new facility should remain. Three groups should be formed to inspect and maintain gas and steam turbines, the HRSG, and the electrical systems and controls. The work of maintenance personnel will cover all aspects of maintenance, from creating maintenance plans to managing budgets and monitoring maintenance work. The new facility will be the first combined cycle power plant in Uzbekistan, and in particular many workers will be working with a gas turbine for the first time. It is therefore necessary to make every effort to train workers in the technology by means such as manufacturer training courses.

5.6.2 Operation and Maintenance of Combined Cycle Power Plant

(1) Characteristics of Combined Cycle Power Plant

A distinguishing characteristics of the combined cycle power plant that will be introduced to the DC "TASHTPP" are that the gas turbines and steam turbines operate on separate shafts, and that it is composed of gas turbines, an HRSG, and steam turbines. Compared to a conventional thermal power plant, the new facility has the following advantages:

- High efficiency/resource conserving
- Startup and shutdown times are brief (low startup loss)

Other advantages of a combined cycle power plant are as follows.

a. Thermal Efficiency

A distinguishing characteristic of a combined cycle generating facility is that it operates at around 55% thermal efficiency under high loads (lower calorific power base), making it possible to operate at high thermal efficiency. However, if the gas turbine load is reduced to reduce the unit load, the efficiency of the facility is reduced as the load is reduced. This is because the facility efficiency is heavily dependent on the efficiency characteristics of the gas turbine unit. When operating at low loads, the thermal efficiency of a combined cycle facility may be less than that of a conventional thermal facility. Accordingly, it will be necessary to keep the output of the gas turbine in the new facility to be constructed at the DC "TASHTPP" at as high a load as possible to maintain high efficiency for the facility.

b. Plant Characteristics

In most gas turbines, the amount of exhaust gases is stable regardless of the load, and only the temperature of the exhaust gases varies with the load. In contrast, in a combined cycle facility, the inlet guide vane of the gas turbine compressor is designed to be controlled to reduce the amount of exhaust gases at low loads. This increases the temperature of the exhaust gases, making it easier for the HRSG to recover the heat and at the same time reduce the fluctuation of the main steam temperature.

In contrast, a characteristic of the HRSG is that the steam temperature is determined by the exhaust gas temperature. (In plants in the region above 1300°C, the exhaust gas temperature is high, so spray controls are employed to keep the main steam temperature and reheated steam temperature at the rated temperature. Where the load is roughly 50% or more, the temperatures of the main steam and reheated steam are stable.)

Due to the characteristics of the exhaust gases from a gas turbine at low loads, the temperature is much lower than a conventional thermal power plant, so it is necessary to reduce the rate of change in the load due to limit of the thermal stress of the steam turbine rotors when great fluctuation in the load is expected.

c. Combined Cycle Power Plant Control

(a) Gas Turbine Controls

There are two methods of controlling a gas turbine: fuel control and inlet guide vane angle control.

Fuel control involves controlling the flow of fuel to the gas turbine. It is made up of fuel program control at startup, speed/load control as a governor, and temperature control to maintain the high temperature part by limiting the combustion temperature.

Inlet guide vane angle control is a control that raises the exhaust temperature of the gas turbine during partial load in order to reduce the temperature fluctuation range of the generated steam from the HRSG after utility paralleling. During partial load, the inlet guide vane angle is halfway open. The inlet guide vane angle opens as the exhaust temperature rises due to increased output, increasing the flow of air.

In addition, there is a control for the low NO_x combustor that allows adjustment of the ratio of diffusing combustion to premix combustion, the timing for premix combustion, and the related air flow adjustment mechanism. The following are some of the issues that should be kept in mind.

- Ensuring stable combustion
- Reducing the amount of NO_x in the exhaust gas
- Limiting combustion vibration
- Reducing the amount of load variation when switching combustion methods

(b) Steam Cycle Controls

Some of the main controls of the HRSG and steam turbines are as follows:

- Control valve control
- Drum water level control
- Economizer recirculation control
- Turbine bypass control

The generated steam from the HRSG changes depending on the gas turbine output, and there is a time lag for settling. At startup, the control valve opening is adjusted in coordination with the turbine bypass control to keep the drum water level from changing greatly with the rise in gas turbine output. This valve control also limits the increase of startup losses and the enlargement of the difference in temperature of the coolant at the inlet and outlet of the condenser by leading generated steam to the condenser through the turbine bypass valve. During rated load operation, the valve is kept fully open.

The drum water level is basically controlled by the water level deviation, the feed water flow, and the amount of steam. One characteristic of a combined cycle plant is that the amount of heat input to the HRSG in a combined cycle plant is larger than the amount of heat input to the boiler at startup in a conventional thermal power plant. Therefore, the drum water level setting at startup is set lower than for normal operation, to prevent a sudden rise in the drum water level caused by the sudden absorption of heat. The feed to the drum is taken directly from the condenser by the condensate pump (low pressure feed pump) and the high/medium pressure feed pump, so the feed volume can vary greatly with changes in the drum water level. This makes it impossible to establish a suction head in the condensate pump, which makes the water level too high. Therefore, it is necessary to keep in mind the balance of the system as a whole when determining the response of the feed adjustment valve to changes in the drum water level.

The economizer recirculation system ensures that the temperature of the feed water to the economizer is above a prescribed value, and prevents low temperature corrosion (acid dew point corrosion) at the exhaust gas outlet. The exhaust heat recovery cycle does not include a feed water heater, and condensate from the condenser is supplied directly to the HRSG to improve heat recovery efficiency.

The turbine bypass system is intended for the recovery of surplus steam to the condenser at startup/shutdown and when load is shut down. For a load shutdown and other instances when the control valve is closed suddenly, the turbine bypass valve is closed suddenly, allowing the fluctuation of the drum water level due to the change in pressure to be limited.

(2) Startup/Shutdown Operations for a Combined Cycle Power Plant

The startup/shutdown of a plant involves the following five main processes.

a. Startup operation

(a) Coolant System Startup

After starting the circulating water pump, open the valves in the system to the filling circulating water level, and fill the pipes and condenser chamber with water. After the chamber has been filled, start the circulating water pump (low pressure feed pump) and then open the valves to the operation level.

(b) Vacuum Increase

Perform gland sealing using supplemental steam. The operations performed from that point to the point where the condenser vacuum is raised follow the same procedure as for a conventional thermal power plant.

(c) HRSG Startup (Drum Water Level Adjustment)

Start the feed pump and feed water until the drum water level reaches the prescribed level. After starting (lighting) the gas turbine, the water is heated by the gas turbine exhaust, creating bubbles in the steam generation piping. Also, as the water temperature rises, the volume increases, so the drum water level should be set lower than the normal water level. By the time the drum water level adjustment is complete, open the HRSG outlet damper and prepare to start the gas turbine.

(d) Starting Gas Turbine

A gas turbine requires supplementation by a separate power source in the interval between purging and lighting and after lighting while it is increasing speed. After lighting, the gas turbine goes into speed control, which is controlled by adjusting the flow of fuel.

The exhaust gas from the gas turbine causes the HRSG heat to move. When heat absorption is high upstream, the temperature is slow to rise downstream. Conversely, when the upstream heat absorption is low, the downstream temperature rises quickly. The amount of heat absorption is determined by the pressure in the high pressure drum, and is affected by the control of the main steam pressure by the turbine bypass valve. When the HRSG is hot and the exhaust temperature is low, the heat absorption at the high pressure side will be low, making it easier for the temperature to rise on the low pressure side. Conversely, when the HRSG is cold, heat is taken from the exhaust gas to raise the temperature of the high pressure side, so it is hard for the temperature to rise on the low pressure side.

The HRSG is divided into high, medium, and low pressure sections, but the exhaust and air ducts are once-through, so influences on the upstream side affect the downstream side. Further, the heat source is the exhaust from the gas turbine, so when the turbine speed is increasing, it is impossible to increase or decrease the amount of heat supplied based on the HRSG side demand. Accordingly, the initial temperature increase characteristics and steam generation characteristics are controlled by the initial status of high, medium, or low pressure and the turbine bypass pressure setting.

(e) Utility Paralleling/Load Increasing

Connect the generator to the utility by using the gas turbine governor to achieve synchronous operation. After utility paralleling, shift to increasing the load after the initial load is taken. Control the load by increasing the rate of increase in the fuel input. If starting the gas turbine alone at the normal load increase rate, it would not be a problem, but the exhaust gas temperature rises dramatically with the increase in gas turbine output, so it is necessary to consider the thermal stress of the downstream HRSG and the thermal stress of the steam turbine receiving the increased steam temperature. It is necessary to set an appropriate rate of fuel flow increase and holding load/holding duration.

For the steam turbine, until the condenser vacuum and steam conditions reach the prescribed value, keep the steam control valve closed. Aerate when the main steam temperature reaches the allowance value with regard to the representative metal temperature of the steam turbine. After aeration, it is necessary to set the opening of the control valve to match the steam generation. The main steam pressure is controlled using the control valve, and rises according to the open rate for the set pressure. The turbine bypass valve is closed by the control operation, to allow all the main steam to pass through the control valve to the steam turbine. If the open rate of the control valve is too fast, it will cause a loss of main steam pressure. If it is too slow, it will cause a rapid increase in main steam pressure, so it is necessary to coordinate it with the increase in gas turbine output. The turbine bypass valve is closed as soon as possible after aeration, increasing the amount of steam working in the steam turbine to minimize startup losses. It also prevents large amounts of hot steam from entering the condenser from the turbine bypass, which would cause the coolant temperature difference between the condenser inlet and outlet to exceed the limit. After increasing the turbine speed to the prescribed rpm, perform utility paralleling and increase the load. This operation is the same as the startup operation for a conventional steam turbine.

b. Shutdown Operation

(a) Load Reduction

When reducing the steam turbine load, reduce the steam flow by starting to close the control valve before the gas turbine output decreases, so as not to cause a reduction in the main steam temperature. However, if the control valve is closed too soon, a large amount of hot steam will flow to the condenser form the turbine bypass, increasing shutdown losses and increasing the coolant temperature difference between the condenser inlet and outlet. To prevent this, it is necessary to set the timing of the start of the close operation and the close rate appropriately. The subsequent parallel off and shutdown operations are the same as for conventional facilities. During those operations, reduce the load of the gas turbine accordingly.

(b) Parallel Off/Gas Turbine Shutdown

After the gas turbine is off grid, maintain combustion, reduce the fuel and the number of rotations, gradually decrease the temperature of the combustion gases, and minimize the flow of air at extinguishment to reduce the thermal stress to the gas turbine.

After extinguishment, fully close the HRSG outlet damper when the number of rotations has dropped from 100 rpm to few score rpm. This prevents the gas turbine rpm from failing to decrease due to the smokestack effect, where air flows into the smokestack from the gas turbine. It also places the HRSG in blanking status while placing the gas turbine turning status.

(c) HRSG Shutdown

Stop the HRSG pump after extinguishment and adjust the drum water level when it has stabilized if performing a midnight shutdown. For an inspection shutdown, perform a drum water blow.

(d) Vacuum Break

Follow the same procedure as for a conventional facility.

(e) Coolant System Shutdown

Follow the same procedure as for a conventional facility.

(3) Combined Cycle Power Plant Maintenance

The maintenance of all the equipment of a combined cycle power plant is the same as for a conventional thermal power plant, except for the gas turbine. The following section therefore explains the maintenance of the gas turbine, the most important part of a combined cycle facility.

a. Gas Turbine Maintenance Philosophy

To ensure that the gas turbine is maintained and operated in good condition for a long time, it is necessary to proactively implement painstaking short-term and long-term preventive maintenance appropriate to the facility's operating condition. Table 5.6-1 lists the necessary management and inspection points to include in the maintenance and management program of the gas turbine. These points are explained below.

Table 5.6-1 Gas Turbine Management and Inspection

Item	Management/Inspection
Operation management	Set a management standard for each operation item to monitor operating conditions all the time and perform appropriate management.
Daily inspection	Set a visual inspection procedure for inspections carried out at least once a day and confirm items using a check sheet.
Combustor inspection	Disassemble combustor parts including the tail pipe, which is subject to severe environmental conditions, and inspect them at least once a year.
Periodic inspection	For all equipment: ① Disassemble and inspect equipment. ② Check equipment operation and adjust as necessary. ③ Confirm records. Select the actions to be performed in appropriate combinations depending on the equipment and perform them at intervals not longer than two years.

(a) Operation Management

In order to gain an understanding of the operating condition of the gas turbine and keep it operating stably at all times, it is necessary to set operation management standards for the following items, take hourly records, and perform appropriate operation management.

- Generator output

- Gas turbine speed
- Discharge pressure of gas turbine air compressor
- Inlet air temperature of gas turbine air compressor
- Combustion gas temperature at gas turbine inlet
- Gas turbine bearing inlet lubricant pressure/temperature
- Condition of lubricant
- Gas turbine vibration
- Gas turbine control oil pressure
- Condition of fuel being used
- Gas turbine efficiency

(b) Daily Inspections

Continuous inspection of the condition of the equipment as it operates is an important daily job that predicts problems by allowing the discovery of abnormalities at an early stage and monitoring fluctuation in conditions such as vibration over time. It is especially important to monitor the parts after startup and shutdown. The items to be inspected for each piece of equipment are as shown in Table 5.6-2.

Table 5.6-2 Gas Turbine Daily Inspection Items

Equipment	Inspection item
Gas turbine	① Abnormal vibration, sound, heat or other abnormality ② Fuel gas or lubricant leak ③ Abnormality in frames or metal supports, or loosened nuts or bolts
Air compressor	① Abnormal vibration, sound, heat or other abnormality ② Fuel gas or lubricant leak ③ Abnormality in frames or metal supports, or loosened nuts or bolts
Fuel combustion equipment	① Fuel supply pressure ② Fuel gas leak ③ Abnormal vibration, sound or other abnormality
Other	① Abnormal vibration, sound, deformation, leaking or other abnormality ② Abnormality in frames or metal supports, or loosened nuts or bolts ③ Inappropriate operating condition of levers or links

(c) Combustor Inspection

Normally, inspection of the combustor is performed as part of periodic inspections. However, because the equipment is operated under severe conditions, in which sudden bursts of heat and heat loads are brought to bear, it is more vulnerable than other parts to wear, deformation, and damage. Therefore, it should be inspected once every six months until expertise is built up through operation of the equipment and a maintenance management method is established.

(d) Periodic Inspection

To operate the gas turbine stably at high efficiency, thorough inspections must be performed regularly, during which problem areas must be repaired and internal inspection and maintenance performed. The desirable interval for periodic inspection is once a year. However, this interval can be extended, with the agreement of the manufacturer, provided that measures are in place to prevent failures and problems, and the equipment has been found to be in sound condition in combustor inspections at intervals of shorter than once a year. The periodic inspection should be performed in accordance with the procedure shown in Table 5.6-3.

Table 5.6-3 Periodic Inspection Of Gas Turbine Equipment

Equipment	Regular periodic inspection	Initial inspection	Daily inspection	Remarks
Gas turbine				
Turbine casing	a. Remove upper half of turbine casing for inspection. b. Perform liquid penetrant test and interval measurements as necessary.	Same as left	• Monitor gas temperature at turbine inlet and outlet. • Check for gas leak • Check for abnormal sound	• Recommended to remove upper and lower nozzle assemblies to inspect turbine casing every 4-6 years.
Rotor, disk	a. Rotate rotor slowly without removing it to inspect the following: • Rotor • Disk • Blade mounting parts • Balance weight installation condition b. Perform the following as necessary: • Liquid penetrant test • Rotor runout measurement	a. Remove rotor to inspect the following: • Rotor • Disk • Blade mounting parts • Balance weight installation condition b. Perform the following as necessary: • Liquid penetrant test • Rotor runout measurement	• Monitor wheel space temperature • Monitor shaft vibration	• Recommended to remove rotor for inspection every 4-6 years. • Recommended to perform integrity inspection (hardness, structure, central hole, etc.) every 80,000 hours.

Equipment	Regular periodic inspection	Initial inspection	Daily inspection	Remarks
Nozzles (diaphragm, stationary blade, turbine nozzle)	a. Inspect nozzles after removing upper nozzles but not lower nozzles. b. Perform the following as necessary: • Liquid penetrant test • Interval measurement • Cooling hole inspection	a. Inspect nozzles after removing upper and lower nozzles. b. Perform the following as necessary: • Liquid penetrant test • Interval measurement • Cooling hole inspection	• Monitor gas temperature at turbine inlet and outlet. • Monitor wheel space temperature. • Perform visual inspection through inspection hole using a borescope when turbine is stopped.	• Recommended to remove upper and lower nozzles for inspection every 4-6 years. • Recommended to remove nozzle after 40,000 hours to perform special integrity inspection (hardness, structure, etc.). • Recommended to inspect 1st stage nozzle at the same time as the combustor is inspected.
Moving blades	a. Rotate moving blade rows slowly when they are contained in the lower half of the turbine casing to inspect following parts: • Blades • Blade mounting parts b. Perform the following tests as necessary: • Liquid penetrant test • Cooling hole inspection • Coating peeling inspection	a. Remove the rotor and inspect the following items: • Blades • Blade mounting parts b. Perform the following tests as necessary: • Liquid penetrant test • Cooling hole inspection • Coating peeling inspection	• Monitor shaft vibration. • Monitor turbine inlet and outlet temperature. • Monitor turbine inlet and outlet temperature pattern (changes and distribution). • Perform visual inspection through inspection hole using a borescope when turbine is stopped.	• Recommended to remove rotor for inspection every 4-6 years. • Recommended to remove blades to perform special integrity inspection (hardness, structure, etc.) every 40,000 hours.
Bearing	a. Inspect bearing visually.	a. Open bearing and inspect it. b. Perform liquid penetrant test as necessary.	• Monitor oil inlet and outlet temperatures. • Monitor shaft vibration. • Monitor oil outlet amount and color.	• Open bearing to inspect it when the rotor is removed for inspection.

Equipment	Regular periodic inspection	Initial inspection	Daily inspection	Remarks
Shaft coupling	a. Rotate shaft coupling slowly to inspect it when it is contained in the lower half of the turbine casing. b. Measure runout as necessary.	a. Disconnect shaft coupling to inspect it. b. Measure runout as necessary.	•Monitor shaft vibration.	•Recommended to remove rotor to inspect shaft coupling every 4-6 years.
Speed governor and emergency stop equipment	a. Visually inspect speed governor, emergency speed governor and trip equipment. b. Perform operation test for emergency stop equipment and auxiliary oil pump.	Same as left	•Greasing •Check for loose bolts, pins and jam nuts. •Check for oil leakage. •Perform operation test for emergency stop equipment and auxiliary oil pump.	•Perform following inspections every 4-8 years: (a) Check for wear and rust on lever and link mechanism. (b) Check servo valves and electromagnetic valves if foreign matter is trapped and if they are worn. (c) Check for wear on hydraulic equipment.
Air compressor	a. Inspect the following items after opening the upper half of the turbine casing but not removing the rotor: • Turbine casing • Rotor • Moving blades • Stationary blades b. Perform the following as necessary: • Liquid penetrant test • Cooling air outlet inspection c. Inspect feed air filter.	a. Inspect the following items after opening the upper half of the turbine casing and removing the rotor: • Turbine casing • Rotor • Moving blades • Stationary blades b. Perform the following as necessary: • Liquid penetrant test • Cooling air outlet inspection c. Inspect feed air filter.	•Monitor shaft vibration. •Monitor compressor outlet pressure and temperature. •Check for abnormal sound and vibration. •Monitor pressure difference at feed air filter.	•Recommended to remove the rotor to inspect air compressor every 4-6 years.

Equipment	Regular periodic inspection	Initial inspection	Daily inspection	Remarks
Combustor	a. Remove combustor liner and tailpipe to inspect them. b. Perform the following tests as necessary: • Liquid penetrant test • Check for peeling of thermal shield coating.	Same as left	• Monitor turbine inlet and outlet temperatures. • Check combustion condition. • Perform the following tests when the operation time reaches 8,000 hours or the number of startups reaches 400 times, whichever comes first: (a) Remove combustor liner and tailpipe to inspect the combustor. (b) Perform the following tests as necessary: • Liquid penetrant test • Check for peeling of thermal shield coating.	

b. Maintenance and Management of High Temperature Parts

Because the gas turbine uses combustion gases that exceed the melting point for metal as its working fluid, it is important to pay attention to deterioration in the combustor inner liner, tailpipe, moving and stationary blades that come in direct contact with the combustion gases. Service life management is also essential.

(a) Causes of Deterioration of High Temperature Parts

The deterioration of high temperature parts is naturally affected by factors such as the characteristics of the gas turbine itself, the number of startups, and the hours of operation. Because the gas turbine is an open cycle, its deterioration is greatly affected by the fuel used and the air quality. Therefore, as part of daily maintenance, it is necessary to manage the amount of metallic elements in the fuel and to periodically change the air intake chamber filter.

(b) Causes of Aging and Damage

The high temperature parts of the gas turbine show various forms of deterioration due to aging, due to the operating environment. Forms of deterioration include high temperature oxidation and corrosion, creep damage or material structural change caused by high temperature and high stress, thermal low cycle fatigue, and vibratory high cycle fatigue. The forms of deterioration of the high temperature parts of the gas turbine are highly varied, and it is necessary to obtain a detailed understanding of the status of the various kinds of deterioration and their progression during periodic inspections and inspections of the combustor. In other words, to prevent problems with the operation of the gas turbine, it is necessary to take appropriate preventive measures based on the inspection results, such as replacing parts, to maintain and improve the durability of the equipment.

(c) Inspection of High Temperature Parts

Because the high temperature parts are used under severe environmental conditions, it is possible that problems such as cracks, wear, and deformation will occur after many hours of operation. The following inspection methods are commonly used to detect these problems.

- Cracking: Check for cracking by means of dye penetrant inspection or fluorescent penetrant tests. However, for high temperature parts that have a coating, it is hard to obtain a valid result using penetrant tests, so visual inspection or inspection using a magnifying glass is common.
- Wear: Use equipment such as scales, calipers or depth gauges to asses the depth and range of wear.
- Deformation: Use equipment such as scales or calipers to measure deformation.
- Corrosion/erosion: Measure the depth and range of corrosion/erosion by means of visual inspection or by taking a cast using a compound.

The main inspection items and management items that change over time, which are necessary for repairing or replacing high temperature parts, are as follows.

i Combustor inner liner

- Cracks in inner liner: Repair cracks that exceed allowance
- Wear on fixed parts: Repair wear that exceed allowance
- Roundness, cylindricity: Repair deformation that exceeds allowance
- Internal coating peeling: Recoat if peeling exceeds allowance

ii Tailpipe

- Main body cracks: Repair cracks that exceed allowance

- Fixed seal wear: Repair wear that exceeds allowance
- Outlet fame creep deformation: Repair deformation that exceeds allowance
- Internal coating peeling: Recoat if peeling exceeds allowance

iii Turbine moving blades

- Surface coating peeling: Recoat if peeling exceeds allowance
- Corrosion/erosion: Replace if corrosion/erosion exceeds allowance
- Cracking: Repair cracks that exceed allowance
- Edge wear: Replace or repair if wear exceeds allowance

(d) Service Life Management of High Temperature Parts

The following are elements that determine the service life of gas turbine high temperature parts: creep damage, low cycle fatigue, material deterioration under high temperature usage environment, and high temperature corrosion and erosion.

• Main cause	Creep	Increases mainly with operation time
	Low cycle fatigue	Increases mainly with the number of startups/ shutdowns
• Accelerating factors	Material deterioration	Mainly due to operation time, air and fuel
	High temperature corrosion	Influenced by aging
	Erosion	

In addition to the many factors discussed above that affect the service life of high temperature parts, the deterioration of materials is also a factor. However, because the mechanism of the deterioration of the nickel-base and cobalt-base heat resistant allows used in the high temperature parts is not yet fully understood, the accuracy of service life predictions for these parts is currently low. Accordingly, it is now common to manage the service life of high temperature parts by limiting the hours of use. As for the maximum allowed usage time, it is managed based on operating experience alone, or a method whereby the operating time is counterweighted by the effects of elements such as the number of startups and shutdowns.

When starting load operation rapidly, which is characteristic of gas turbines, the thermal stress that is generated in the turbine moving and stationary blades reaches its peak immediately after the turbine is lit. This stress decreases as the temperature difference decreases. It increases gradually with the load increase. Also, the problems of creep and low cycle fatigue, which are damage characteristics of the material, tend to have more of an effect jointly than they do separately.

Accordingly, the counterweighted operation time method is best suited to predicting the service life with greater accuracy.

Because the service life of the high temperature parts varies widely depending on the operating and environmental conditions of each plant, for greater accuracy in service life management, it is necessary to establish a method of management suited to the plant's particular characteristics, based on actual operation records.

(e) High Temperature Parts Repair Technology

The high temperature parts of a gas turbine can be categorized as follows.

i Parts that are predicted to be at the end of their service life at the time of the periodic inspection and are to be replaced.

- Turbine moving blades
- Turbine shroud segments

ii Parts to be repaired when repair is found to be necessary based on the repair criteria employed at the periodic inspection or combustor inspection and replaced when the total operating time reaches the predicted end of the service life.

- Turbine stationary blades
- Combustor inner liner
- Tailpipe

The repairs outlined above in b) for high temperature parts must as a minimum be maintained in sound condition until the next periodic inspection. Generally these repairs involve combinations of welding/heat treatment and mechanical finishing. Because the materials are cobalt-based or nickel-based heat resistant alloys, special techniques are required for welding. It is therefore desirable that this work be performed at specialist workshops. The repaired parts do not recover their original condition; on the contrary, the structural deterioration of the material itself will progress with increased operating hours and startups/shutdowns. Further, because it is not the case that parts can be repaired any number of times as long as they have not exceeded their service lives. It is thus necessary to determine the most economically beneficial action to take, considering the cost of repair and the expected service life extension benefits.

(f) Operation of High Temperature Parts

As discussed above, service life management is required for high temperature parts. It is necessary to replace or repair parts in a planned way. For replacement, it is essential to thoroughly understand the relationship between the designed service life and the hours of operation, and to prepare in advance the required replacement parts.

Parts such as turbine stationary blades that are repaired while they continue to be used, are normally managed using substitute parts that are interchanged because it is difficult to complete the repair work within the periodic inspection process.

c. Steam Turbine Maintenance and Management

There is no particular difference in steam turbine maintenance and management from the method of open inspection and repair that have been performed up to now at the DC "TASHTPP". Therefore, this section will provide a simple explanation of the particular deterioration phenomena seen in steam turbines.

The material used in steam turbines is used in high-temperature, high-pressure steam, so over long periods of time various forms of deterioration and damage develop. These include material deterioration, cracking, splitting, deformation, and thickness reduction. The causes of these problems included softening, embrittlement, creep, fatigue, erosion, corrosion and wear. Table 5.6-4 shows the categories of deterioration due to aging. This deterioration cannot be avoided in continuous operation. Therefore, it is important to gather precise data during each periodic inspection and to introduce the kind of preventive maintenance and remaining service life diagnostic techniques described above from the initial stages of the equipment's operation, so as to prolong the service life.

Table 5.6-4 Categories of Deterioration Due to Aging

Deterioration and damage	Causes	Deteriorated parts
Material deterioration	Softening	Rotor
	Embrittlement	Rotor
Break and crack	Creeping	Casing
	Stress corrosion cracking	Moving blades
	Corrosion fatigue	Moving blades
Deformation	Creeping	Casing

d. HRSG Maintenance and Management

(a) Operation Management

In combined cycle power plant, the three main components are the gas turbine, the steam turbine and the HRSG. These do not operate independently of each other, but rather work in coordination with each other. The HRSG functions as the heat exchanger that is the intermediary between the gas turbine and the steam turbine.

The HRSG recovers the heat from the exhaust of the gas turbine and uses it to generate steam. It has no way of adjusting the incoming exhaust (such as the amount, temperature, and pressure). The nature of the steam it generates is also determined by the heat recovery rate, and it flows without alteration to the steam turbine. Compared to a conventional steam boiler, the HRSG is more of a heat exchanger.

Even if the conditions of the exhaust gas change, there is no problem with the exchange of heat between the exhaust gases and water or steam as long as there is water in the HRSG. However, if there is an extreme drop in the drum water level, it will boil dry. On the other hand, if the water level is too high it can cause damage in the steam turbine due to the incomplete separation of the steam and the water. Therefore, it is important to maintain the drum water level within the prescribed range.

The temperature of the high pressure steam/reheated steam is maintained at a temperature that corresponds to the load by controlling the spray volume of the desuperheater installed on either the superheater or the reheater, respectively. Another distinctive feature is that the HRSG prevents corrosion due to condensation on the surface of the heat transfer pipe by keeping the metal temperature higher than the exhaust gas due point (where there is sulfur in the fuel). This is achieved because the economizer inlet feed temperature rises as the economizer inlet feed water is circulated from the economizer outlet to the economizer inlet.

(b) Maintenance and Management

The HRSG differs from a conventional boiler in that it has no burner but rather functions as a heat exchanger. There is no water-wall tubes, so the structure is simple. There is no need for a complex array of heat transfer pipes at the opening to the casing, so there is no need to worry that the thermal stress will damage the piping. However, the following points do need to be kept in mind.

i Finned tubes

The gas temperature in the HRSG is lower than in a conventional steam boiler, and because natural gas is mostly used as the fuel for gas turbines, the exhaust is relatively clean. Therefore, finned tubes are used in the heat transfer pipes. A combined cycle generating facility has a short startup time, so stress is created in the nozzle stub and stub tube weld due to the temperature difference that occurs in the heat transfer pipes at startup. This stress leads to creep and heat fatigue damage. Therefore, during periodic inspections, the inspected parts of the nozzle stub and stub tube weld should be cleaned, visually inspected, and color checked for defects. Steps should then be taken to eliminate any defects that are found. The finned tubes themselves must be checked for the peeling of steam oxidization scales from the inside of the high pressure superheater and reheater. One way to do this is to remove a sample tube during a periodic inspection and assess the growth of scales on the inner layer. The scales can be eliminated by acid cleansing as necessary.

ii Drum

The drum is usually installed at the top of the HRSG. It does not come in contact with the exhaust gas from the gas turbine, nor is it used in an area of high temperature creep, so fatigue remains as a cause of damage. The drum has a larger diameter than other pressure-resistant parts, so it is made of thick shell plate. Accordingly, a temperature difference is created between the inside and outside of the drum whenever there is a sudden change in the boiler water temperature, such as at startup and shutdown or when forced cooling or load fluctuation occurs. Because of the short startup time for a combined cycle facility, the temperature of the exhaust gas also rises quickly, increasing this temperature difference. A large amount of thermal stress is created in the direction of the thickness of the drum's shell plate, due to the temperature gradient. When this thermal stress is repeated, it causes fatigue damage. The fatigue damage is particularly severe in parts where the thermal stress is concentrated. Therefore, it is necessary to check for defects during periodic inspections, by cleaning, visual inspection, and color checks. If defects are found, measures must be taken to eliminate them.

iii Header

Parts such as the body base material and side plate of the header and the longitudinal and outer edge welded couplings of the header, and nozzle stub and stub tube weld that are used in high temperature areas are susceptible to creep damage.

At startup, there is a concentration of stress due to the difference in temperature between the inside and outside of the body, as there is in the drum. This causes thermal fatigue and displacement due to the different temperatures of the heat transfer pipes. This in turn causes stress in the nozzle stub and stub tube weld. In addition, at startup there is also a temperature difference in the vertical direction of the header, which causes the header edges to dislocate substantially. This causes stress in edges of the nozzle stub and stub tube weld. Therefore, it is necessary to look for creep and heat fatigue in the nozzle stub and stub tube weld, and the measures described in the section on finned tubes also apply here.

iv Desuperheater

The HRSG desuperheater spray device is used under harsh conditions, due to the demands made on it by rapid load changes and rapid startups. It is therefore necessary to be careful of fatigue caused by coolant heat shock.

v Casing/ducts

The HRSG casing and ducts differ from a conventional steam boiler's furnace wall in that the casing and ducts are not cooled by boiler water, so there are places that are used at higher temperatures. For example, parts that are immersed in turbine exhaust steam of over 600°C are used in conditions that are more severe than the ducts of a conventional steam boiler. Because each part of the HRSG has a different heat structure, the temperature of the casing and duct plates can range from ambient temperature to high temperature of exhaust gas, so the causes of damage differ.

Generally, fatigue damage occurs where casing and ducts are used in high temperature and low temperature corrosion occurs at low temperatures. Thermal stress accompanies the rapid rise in the temperature of exhaust gases at times such as startup. The casing and duct plates also increase in temperature, but the rise in temperature of the outer reinforcing materials is delayed. This creates a temperature difference between the plates and the reinforcing material, so a large amount of thermal stress is created at places such as the flanges and corners of the casing and ducts. If the exhaust gas contains SOx and the temperature of the casing and ducts falls below the dew point, low temperature corrosion (acid dew-point corrosion) can occur, so care is required.

e. Air-Cooled Generator Maintenance and Management

(a) Characteristics of Air-Cooled Generators

Because the heat capacity of the air used as a cooling medium is less than that of hydrogen, compared to a hydrogen-cooled generator, the capacity of an air-cooled generator and the cooler are greater, so the weight is increased. The density of air is also greater than the density of hydrogen, so there is the demerit that windage losses during operation are large. However, because a dangerous explosive like hydrogen is not used, there is no need to worry about hydrogen leaks during operation. There is also no need for a seal oil device to separate the hydrogen out of the bearing lubricant or a hydrogen monitoring panel, so the auxiliary equipment is simplified. Further, at periodic inspections there is not only less auxiliary equipment to inspect, but there is also no need to replace hydrogen with carbon dioxide and carbon dioxide with air when opening the generator (nor to reverse this process when reassembling the equipment). Thus, periodic inspections require less time, which in turn has benefits such as reducing the number of people required to perform the inspections.

(b) Generator Deterioration and Inspection

Generally, the following problems can be caused by operating a generator over an extended period of time.

i Low cycle fatigue and wear on rotors due to increased startups and shutdowns

ii Coil and insulation fatigue and wear due to repeated heat changes caused by load fluctuation, including startups and shutdowns

iii Parts loosening and high cycle fatigue and wear on rotors due to electromagnetic vibration and rotor vibration

iv Diminished performance and aging of rotors due to environmental changes and extended operation

Generators and their auxiliary equipment are made up of many parts. Some of these parts have a great effect on equipment performance, some deteriorate with depending on the conditions of use and environmental conditions, and some have little effect on performance. In order to conduct efficient maintenance and management, and ensure the stable operation of the equipment over a long period of time, it is important to determine which parts are likely to cause deterioration and to decide maintenance and management items based on their level of importance. It is then necessary to clearly define methods of inspection, diagnosis, and management. A sample of such management procedures is provided in Table 5.6-5.

Table 5.6-5 Sample Maintenance and Management Procedure for Generator

Inspection item		Maintenance item	Inspection method
Rotor	Shaft central hole	Low cycle fatigue (defects, cracks and their development)	Non-destructive examination
	Shaft journal	Torsional fatigue (cracks)	Non-destructive examination
	Rotor wedge	Fatigue and creeping (cracks)	Non-destructive examination
	End ring	Stress corrosion cracking	Non-destructive examination
	Inter-electrode connecting copper band	Low cycle fatigue (cracks)	Visual inspection
	Rotor coil	Damaged insulation	Insulation resistance, visual inspection

Inspection item		Maintenance item	Inspection method
Stator	Stator winding	Insulation deterioration, insulation layer surface, loosened fixed parts	Insulation resistance, insulation diagnosis, loosened coil end binding, visual inspection
	Stator wedge	Looseness	Looseness
	Stator iron core	Iron core damage, hit mark	Visual inspection
Bearings	Side gap, clearance, rear gap, Babbitt contact level, sliding part smoothness	Wear, damage, peeling, burning	Distance measurements, dimension measurements
Cooling equipment	Internal water chamber	Cracks, pitting corrosion	Non-destructive examination, leakage inspection

CHAPTER 6 CDM PROGRESS IN UZBEKISTAN

THE DETAILED DESIGN STUDY FOR

MODERNIZATION OF TASHKENT THERMAL POWER PLANT

IN THE REPUBLIC OF UZBEKISTAN

FINAL REPORT

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CHAPTER 6 CDM PROGRESS IN UZBEKISTAN

From May 14 through June 3, 2003, the study group investigated the progress of the Uzbekistan government with respect to the Clean Development Mechanism (CDM) and its compliance with the requirements of the United Nations Framework Convention on Climate Change (UNFCCC). Information in this area was gathered mainly through interviews with government personnel. The results of the investigation are presented below.

People Interviewed for Information/Data

- Main Administration of Hydrometeorology at the Cabinet of Ministers, "Glavgidromet"
  Interviewees Dr. Tatyana A. Ososkova, Chief, Department of Environmental Pollution Monitoring and Ms. Gulunora Zubkova
- Ministry of Macro Economy
  Interviewee Mr. Vasikov Abdumadjit, Chief of Fuel Provision Complex
- Nature Protection Committee, "Goscompriroda"
  Interviewee Mrs. Nadezhda Dotsenko, Head of "Ozone Office" under UNDP/UNEP
- Oil / Gas Company ("UZBEKNEFTEGAZ" National Holding Company)
  Interviewees Mr. Yergen K. Tursinbayev, Head of Scientific and Technical Dept
  Mrs. Vilk Ludmilc, Chief of Environment Protection
- Carbon Company
  Interviewee Mr. Ibraghimov, Chief Engineer
- UzbekEnergo
  Interviewees Mr. Khamidov Shukrat, Chief of Investment Project's Dept.
  Mr. Unusov, Deputy chief of Investment Project's Dept.
  Mrs. Badaeva Nonna, Chief of Environment Protection Dept.
- Tashkent Thermal Power Plant
  Interviewees Mr. Yerzenkin, Chief of Joint Operational-Technical Dept.

6.1 UNFCCC Compliance

In 1993, Uzbekistan signaled its recognition of the importance of effective measures to mitigate the effects of global climate change by signing the UNFCCC, the international agreement to stabilize the concentration of greenhouse gases in the atmosphere. This was an expression of the Uzbek government's active involvement in the prevention of global warming. Uzbekistan further signed the Kyoto Protocol in 1998 and ratified it in 1999.

In 1993, the year Uzbekistan signed the UNFCCC, the National Commission of the Republic of Uzbekistan on Climate Change was established to implement requirements of the UNFCCC and to coordinate the related work of government bodies and state-run companies. This commission is chaired by the deputy prime minister and includes representatives from thirty-four related government agencies and departments (see attached list of members) as well as top class scientists and members of several NGOs. The commission performed the work required of signatory nations (such as organizing information on the emission and absorption of greenhouse gases in the country). The commission conducted the Uzbekistan Country Study on Climate Change, which was summarized in the "First National Communication of the Republic of Uzbekistan on Climate Change".

The organization assigned to comply with the requirements of the UNFCCC is the Main Administration of Hydro-Meteorology at the Cabinet of Ministers (Glavgidromet), which has been active in fulfilling its duties. With respect to the CDMs, however, decisions about organizational and systemic responses and policies have not yet been made. This is perhaps because deliberations over concrete procedures have been continuing for a long time and because Uzbekistan has no obligation to reduce its greenhouse gases.

6.1.1 History of Uzbekistan's Compliance with UNFCCC Requirements

- 1992: The Uzbekistan government designates the Main Administration of Hydro-Meteorology at the Cabinet of Ministers (Glavgidromet) as the organization responsible for providing information on hydro-meteorology, climate change, and environmental pollution to the government and related organizations, and for cooperating internationally on these issues.
- 1993: Uzbekistan expressed its understanding of the importance of global warning and its commitment to actively contribute to alleviate the problem by signing the United Nations Framework Convention on Climate Change.
- 1995: The National Commission of the Republic of Uzbekistan on Climate Change is established to deliberate and take measures to alleviate climate change, as part of the national response to the UNFCCC. The commission, which is made up of representatives from Glavgidromet and thirty-three other government bodies (including Energo), is chaired by the deputy prime minister. Although Glavgidromet remains the organization responsible for fulfilling Uzbekistan's commitments to the UNFCCC, the commission was changed to allow representatives of other bodies to participate only as required. The work of the commission effectively stopped in 2001. (See the list of committee members and the compliance organization chart.)
- 1995: V. E. Chub, the head of the hydro-meteorology monitoring organization is appointed as the Uzbekistan representative to the UNFCCC.
- 1998: Uzbekistan signs the Kyoto Protocol
- 1999: Uzbekistan ratifies the Kyoto Protocol (August, 1999)

- 1999: With the support of UNDP/GEF, Glavgidromet implemented the Uzbekistan Country Study on Climate Change, with the assistance of greenhouse gas specialists. The results of the study were summarized in the "First National Communication of the Republic of Uzbekistan on Climate Change", which described the state of climate change issues such as greenhouse gases for 1990 and 1994, forecasted conditions up to 2010, and proposed remedial measures. As Phase 2, the commission deliberated measures to reduce GHG emissions, alleviate the negative effects of climate change, and reinforce monitoring programs. These results are summarized in the "First National Communication of the Republic of Uzbekistan on Climate Change (Phase 2)".

6.1.2 National Commission of the Republic of Uzbekistan on Climate Change, List of Members

- Ministry of Macro-economics and Statistics
- Main Administration of Hydro-Meteorology (Glavgidromet)
- State Nature Protection Committee (GosComPriroda)
- Ministry of Energy and Electrification
- Ministry of Finance
- Ministry of Higher and Secondary Special Education (MinVUZ)
- Ministry of Agriculture and Water Management
- Ministry of Justice
- Ministry of Public Health
- Ministry of Foreign Affairs
- Ministry of Housing and Communal Services
- State Committee for Science and Technology (GKNT)
- Academy of Science
- State Forestry Committee
- State Committee for Architecture and Construction
- State Publication Committee
- Uzbek State Committee for Standards
- Uzbek State TV and Broadcast Company
- National Aviation Company "Uzbekiston Khavo Yullari"
- State Joint Stock Railway Company "Uzbekiston Temir Yullari"
- Association "Uzkhimprom"
- State Joint Stock Company for Automobile Transport "Uzaavtotrans"
- State Joint Stock Company "Uzavtodor"
- Republican association of enterprises and organizations of household services
- Agricultural Industrial Association "UzMetKombinat"
- State Committee for Control over safe working in industry and mine Supervision
- Joint Stock Company "UzVtorTsvetMet"

- Joint Stock Company "Ugol" (Coal)
- Almalyk Mining and Metallurgical Industrial Complex
- AK "UzStroyMaterialy" (Construction Materials)
- Navoii Mining and Metallurgical Industrial Complex
- National Oil and Gas Corporation "UzbekNefteGas"
- "SpetsSplav" State Facility (Special Alloys)
- GGP "UzbekGidroGeologiya" (State Hydrogeological Facility)

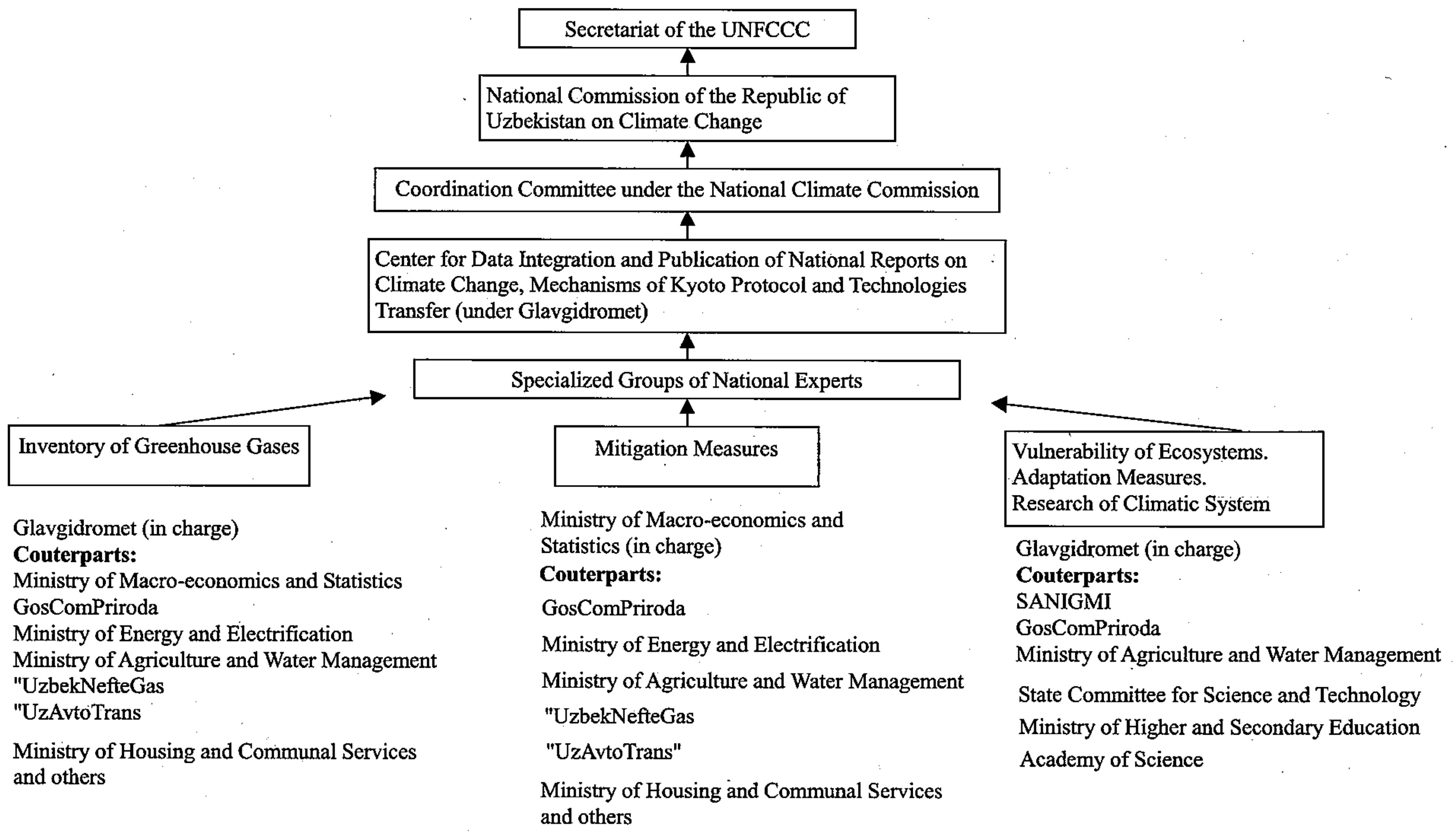

Figure 6.1-1 Organization chart of UNFCCC and activities related to the Kyoto Protocol
(Excerpted from "Initial National Communication of the Republic Uzbekistan under the UNFCCC/1999")

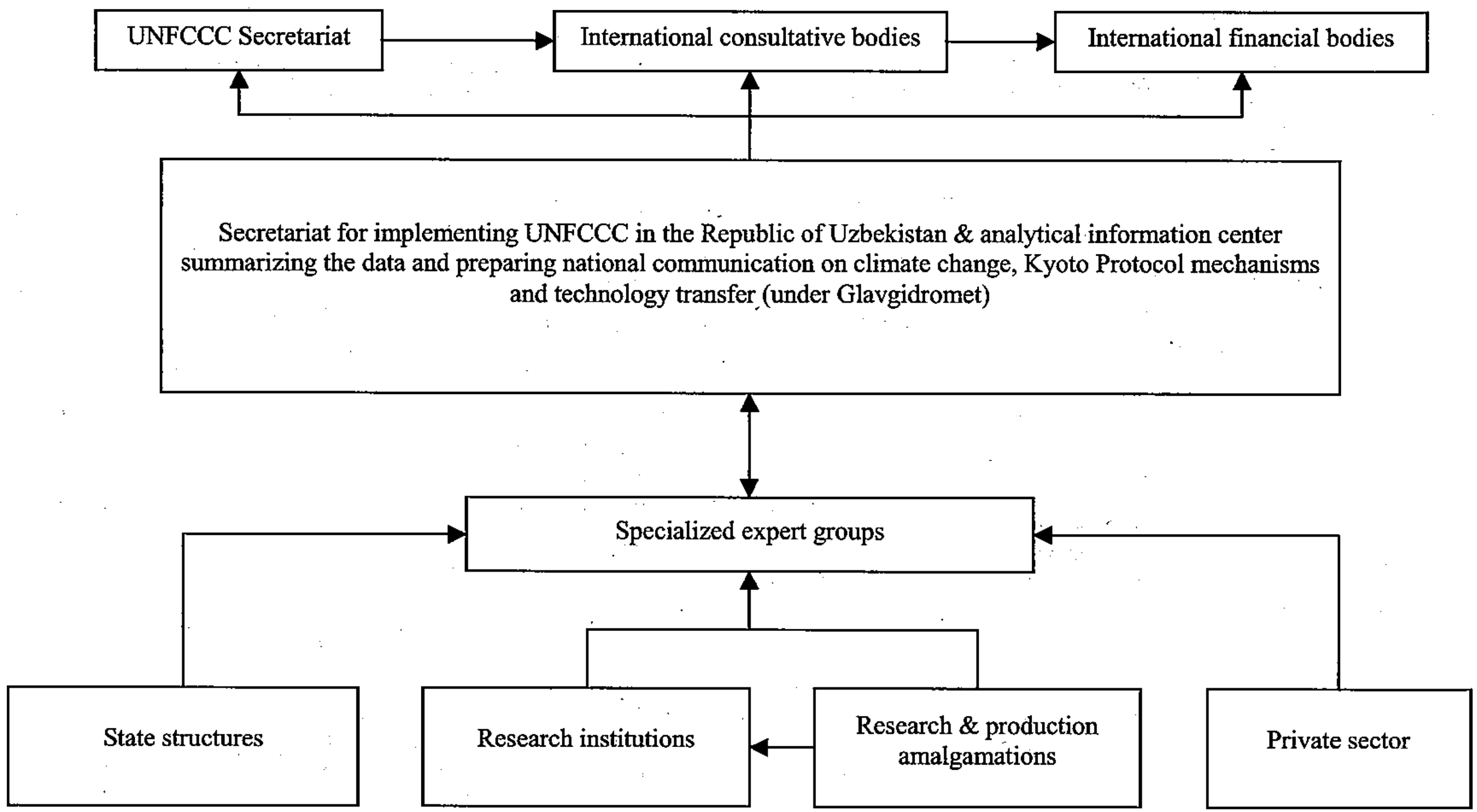

Figure 6.1-2 Chart of collaborative activity with national and international organizations
(Excerpted from "Initial National Communication of the Republic Uzbekistan under the UNFCCC/2001")

6.2 CDM Progress

Uzbekistan has been actively engaged in the prevention of global warming. The government is advancing legislation to protect the environment (see environmental protection and natural resource legislation), has implemented a climate change study (summarized in the "First National Communication of the Republic of Uzbekistan on Climate Change"), and is planning forty projects for the reduction of GHG (see attached list). With regard to the CDM, the government has held seminars on the reduction of GHG for people in related departments with responsibility for environmental issues, but there still is no national organization with designated CDM responsibilities, and there is no legal framework. Projects that can be expected to reduce GHG emissions are not designated as CDM projects.

However, there have recently been some encouraging changes with regard to the CDM. ① There have been attempts by developed countries to help implement CDM projects. ② The UNFCCC CDM executive board has clarified the procedures for implementing CDM projects. ③ There are regional authorities that are implementing heat supply projects, with the help of foreign aid organizations, as CDM projects. Perhaps these changes are the reason for the directive, issued from the cabinet to the hydro-meteorology monitoring organization on May 30, 2003, to draft a Resolution of Cabinet Ministers, based on input from related government bodies, to prepare for the establishment of a CDM National Authority and the implementation of CDM projects. This indicates that a national effort to implement CDM projects and to set up the appropriate systems for their management has begun in Uzbekistan. The draft of the Resolution of Cabinet of Ministers will be promulgated as an executive order, signed by the prime minister and passed by the cabinet for implementation. It is estimated that by the end of this year (2003), the process of formulating, approving, and implementing the proposed system will be complete.

Table 6.2-1 Proposed Projects for the Reduction of CO_2 Emissions in Uzbekistan (as of 2001) 1/2

	Project Category	Project Title	Budget, in mil US$	Potential reduction of CO_2
1	Renewable source of energy	Construction of a wind-driver power station	6.0	14.2 k.t/yr
2	Oil & gas supply	Utilization of accompanying gas of Kokdumalak oil and condensed gas deposit at the Mubared oil-and-gas processing plant	82	1.135 mil.t/yr
3	Oil & gas supply	Installation of pre-cleaning of departing gases by a method SCOT on Mubarek oil- and-gas processing plant	28.3	148 k.t/yr
4	Oil & gas supply	Installation of system of the automatic control of structure of departing gases and loading, parity hydrogen and oxygen on Mubarek oil-and-gas processing plant	0.8	60 k.t/yr
5	Oil & gas supply	Installation of pre-cleaning of departing gases by a method adsorption on a cold layer of the catalyst on Mubarek oil-and gas processing plant	2.3	79 k.t/yr
6	Oil & gas supply	Gas fractional installation on Fergana oil-and-gas processing plant	76.8	0.2 mil.t/yr
7	Oil & gas supply	Reconstruction of Flare system of the main unit of the Oil and Gas Enterprise "Shurtanneftegaz"	59.5	0.47 mi.t/yr
8	Oil & gas supply	The second step of installation of reception of sulfur by a method of direct oxidation on Mubarek oil-and gas processing plant	0.8	26 k.t/yr
9	Oil & gas supply	Reconstruction of torch system on Mubarek oil-and gas processing plant	60	0.5 mil.t/yr
10	Oil & gas supply	Reconstruction of compressor station S-0 in Mubarek city	63.8	111 k.t/yr
11	Oil & gas supply	Reconstruction of thermal boiler-house No1 and No.2 on Mubarek oil-and-gas processing plnat	2.5	52.6 k.t/yr
12	Oil & gas supply	Reconstruction of compressing stations of the main units at the Gazli deposit	100	154 k.t/yr
13	Oil & gas supply	Reduction of methane emission from outflow at transportation of natural gas	3.8	641 k.t/yr
14	Oil & gas supply	Reduction of outflow of gas on a main gas pipeline	64	147 k.t/yr
15	Electric power engineering (EPE)	Tashkent thermal power plant modernization	221	
16	EPE	Reconstruction of Navoi power plant	232	751 k.t/yr
17	EPE	Introduction of gas turbine with utilizing boiler at the Tashkent heat power plant	22	175 k.t/yr
18	EPE	Reconstruction of Mubarek heat power plant	98.9	362 k.t/yr
19	EPE	Reconstruction of Joint-stock venture "Bukaharaenergomarkaz" ---- Gas turbine introduction	40	162 k.t/yr

Table 6.2-1 Proposed Projects for the Reduction of CO_2 Emissions in Uzbekistan (as of 2001) 2/2

	Project Category	Project Title	Budget, in mil US$	Potential reduction of CO_2
20	EPE	Hydroelectric power station on the river Paskem	420	1 mil.t/yr
21	EPE	Introduction of energy-saving complex on Talimarjan hydroelectric power station	2.5	12.6 k.t/yr
22	District heating	Utilization of domestic waste as the low-calorie fuel (Incinerating plant in Smarkand city)	45	128.1 k.t/yr
23	District heating	Technology of electric and heat generation on the base of a bio-gas from the surplus active sludge at the water treatment plant of Tashkent city	8.0	
24	Chemical industry	Reconstruction of manufacture of carbamide on Chirchik plnat	56.7	127 k.t/yr
25	Chemical industry	Construction of the new unit of ammonia on Chirchik plant	263.6	205 k.t/yr
26	Chemical industry	Reconstruction of carbamide manufacture on Fergana plant	71	138 k.t/yr
27	Chemical industry	Reconstruction of large-weighty of the unit of ammonia on Fergana plant	25	357 k.t/yr
28	Chemical industry	Reconstruction of large-weighty of the unit of ammonia on Chirchik plant	25	357 k.t/yr
29	EPE	Construction of energy unit on Navoi plant	136	148 k.t/yr
30	Chemical industry	Construction of new manufacture of carbamide on Navoi plant	71	220 k.t/yr
31	Cement manufacture	Transfer of a technical line of manufacture from a wet method to dry method	84.4	193 k.t/yr
32	Cement manufacture	Transfer of a technical line of manufacture from a wet method to dry method	87.2	245 k.t/yr
33	Cement manufacture	Transfer of a technical line of manufacture from a wet method to dry method	87.2	179 k.t/yr
34	Building	Modernization of manufacture of glassware in join stock company	6	15 k.t/yr
35	District heating	Reconstruction of district heating system	0.14	404 t/yr
36	District heating	Demonstration project for district heating system	0.54	1.6 k.t/yr
37	District heating	Demonstration project for district heating system	0.44	11.3 k.t/yr
38	District heating	Demonstration project for the large solar station of heating supply	0.26	658 t/yr
39	District heating	Demonstration project of a factory of the equipment of solar heating supply	0.15	330 t/yr
40	Forest shelter belt	Development of forest shelter belt system at the irrigated lands to stabilize the agriculture landscapes in Besharuk district	0.12	3.6 k.t/yr

6.3 Organizations and Systems Related to Climate Change/Environmental Protection

6.3.1 Organizations

The following government bodies in Uzbekistan are involved in the issues of climate change and environmental protection. The Main Administration of Hydro-Meteorology at the Cabinet of Ministers (Glavgidromet) provides data and forecasts about water and climate issues and pollution levels to government bodies. The head of Glavgidromet is the Uzbek representative to the UNFCCC secretariat. The Nature Protection Committee (Goskompriroda) is the main organization that regulates the activities of government bodies, companies and other organizations with respect to their effects on the environment. It monitors compliance with environmental standards and criteria, implements environmental evaluations, issues/revokes discharge permits for pollutants and wastes, and formulates national environmental programs. The Ministry of Macro-economics and Statistics forecasts the medium- and long-term environmental effects and costs and benefits of protective measures. Governmental bodies such as the Department of the Interior the State Committee for Control over Safe Working in Industry and Mine Supervision, the Ministry of Agriculture and Water Management and the National Land Committee also contribute to environmental proposals in their areas of responsibility.

6.3.2 Legal Systems

There are roughly 100 laws and regulations concerned with environmental protection and natural resources in many areas, including the following: Rational Energy Use (1997), Protection of Nature (1992), Water and Water Use (1993), Specially Protected Natural Areas (1993), Air Protection (1996), Protection and Use of Animals (1997), and Use of Vegetation (1997).