(a) Replace/repair vacuum ejectors

(b) Repair air leaks to the condenser

(c) Install condenser tube cleaning equipment

In particular, by installing the cleaning equipment called for in measure 3), it will be possible to clean the inside of the tubes efficiently in the course of periodic repair work, using pressurized water and brushes, rather than just water. Keeping the inside of the tubes clean, can be expected to bring improvements in the rate of heat exchange between the cooling water and the steam. These measures will make it possible to approach the proper condenser vacuum, which will result in increased work being performed by the steam in the turbines and increased turbine efficiency.

(2) Reduction of House Consumption

A reduction in house consumption is directly effected by reducing the power used by the auxiliary equipment in each unit.

When the efficiency of the units as a whole decreases with age, at first the full capabilities of the auxiliary equipment are used to maintain maximum output.

It can be assumed that because most auxiliary equipment is currently operating at the upper limits of its capacity, maintaining the output of the units, there has only been a slight increase in the house consumption rate.

The following are causes of the increased power requirements of fans:

(a) Leaks of air and exhaust gases from the boilers and flues

(b) Clogged air heater elements

The following are causes of the increased power requirements of pumps:

(a) Narrowing down water and steam pipes due to foreign matter

(b) Deterioration of the pump impellers due to age

(c) Water and steam leaks

Most of the power used in the plant is used by auxiliaries

Especially in the winter, when heavy oil is burned, soot is produced that adheres to the air heater elements, making the air heater more susceptible to clogging and increasing the power consumed by the IDF.

In most air heaters, if air leaks from the positive pressure air side to the negative pressure exhaust side through cracks in the rotator, the power consumption of the FDF and IDF increases, so it is necessary that the structure permit minimal leaks. Therefore, it is necessary to set the seal when the opening is small, and this allows greater leaks when the opening is enlarged and the staff of the DC "TASHTPP" use their high level of technical skill to take accurate measurements when reassembling the equipment after disassembly inspection so as to set the seal so that the size of the opening does not change.

Pumps are used for pumping out fluids, mostly water in this case, but when solids become adhered to the insides of the pipes, the diameter is reduced and the flow of the fluid is obstructed. To ensure that a pump achieves its designed flow rate, the pressure must be increased at the pump outlet, which increases the power consumption of the pump.

(3) Equipment Availability Improvement

Availability is greatly affected by unit shutdown time. Their efforts have succeeded in keeping equipment that is quite old operating at near the output of the equipment when it was new.

Over 70% of the emergency shutdowns that occurred between 2000 and 2002 were due to boiler equipment failures. Of these, the majority were caused by boiler tube ruptures. The problem of ruptured boiler tubes occurs in all units, and all parts of boilers, so the cause of the problem is hard to identify. However, it is possible to identify trends such as parts and materials that are deteriorating due to the equipment's age, the resulting loss of strength, and the overheating expansion discussed above, caused by tubes that are clogged by hardness minerals.

In order to maintain the service life of the equipment for more than a few more years with high availability, and to eliminate shutdowns primarily caused by the need for repair work, it is recommended that inspections of important points known to be liable to failure are carried out during periodical maintenance.

With this method, problems that the inspections reveal to require urgent attention can be repaired during the inspection work period, and other inspection results can be kept as data accumulated at each periodical inspection. The accumulated data can be used to understand the deterioration of the equipment, so that equipment nearing the end of its life time at the time of the next periodical inspection can be identified and listed. It is necessary to account for the funds required for the repair and to make a maintenance plan corresponding to the repair. This method will improve availability and prolong the service life of the equipment.

(4) Results of Repairs and Improvements

a. Reduced Fuel Consumption

An analysis of the effects of such improvements, based on 2002 operating data for unit No.6 obtained from the DC "TASHTPP" yields the following:

- Annual power generation: 879.3×10^6 kWh
- Gross thermal efficiency: 33.4%; Net thermal efficiency: 31.6%
- Fuel gas consumption: 230.2×10^6 m^3; Heavy oil: 94.6×10^6 kg

Assuming the above values are correct and that the yearly generated power and supplied heat are the same, with the generated efficiency for the unit rising one point to 34.4%(Gross Thermal efficiency at the time of 1980 is 35.4%), the yearly consumption of natural gas would be 220.7×10^6 m^3, a reduction of 9.5×10^6 m^3. From the 2002 unit cost of natural gas of Sum9.5/m^3, the yearly savings on fuel would be Sum90.25 $\times$ 10^6, equivalent to US$90,250.

If this reduction in the fuel used by unit No.6 is applied to the power plant as a whole, the use of natural gas for 2002 would have been reduced from 2833.9×10^6 m^3 to 2716.9×10^6 m^3, a reduction of 117.0×10^6 m^3. This is equivalent to 1,112 million Sum, so the unit generation cost for 2002 of 3.90 Sum/kWh would have been 3.79 Sum/kWh, so a reduction in the generating costs of 2.8% is to be expected.

b. Reduction of Atmospheric Pollutants

This section will evaluate the effect of reducing the amount of heavy oil used on the emission of atmospheric pollutants. In 2002, the power plant as a whole used 684.3×10^3 tons of heavy oil, but if thermal efficiency improves by 1 point under the conditions described above, a yearly reduction of 117.0×10^3 tons can be expected.

With this reduction in heavy oil consumption, the yearly emissions from the power plant of roughly 305,000 tons of CO_2, 839.6 tons of NO_2 and 8,424 tons of SO_2 would be reduced by 19.8%, 16.0%, and 17.1%, respectively.

5.2.3 Maintenance and Repair Plan

(1) Current State of Maintenance and Repairs

Every year, a ten-year maintenance and repair schedule for each unit is proposed and updated based on the maintenance and repair plan shown in

Figure 5.2-3. There are three types of maintenance and repair work: Capital Repairs (K), Midterm Repairs (C), and Extended Current Repairs (PTP). Capital Repairs, Extended Current Repairs, and Midterm Repairs are repeated about every two years.

Long-term plan of capital, mid-life and extended current repairs of the main equipment of TashTPP for the period of 2000-2010

Unit No.	Installed capacity	Scheduled types of repairs (years)											Notes
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
1	150		M		C		ECR		M		C		Capital repair of Unit No.11 in 2000 was done without opening of Turbine casing, which planning to be held in the middle of 2004
2	150			ECR		C		ECR		M		C	
3	150			M		C		ECR		M		C	
4	150	M		C		ECR		M		C		ECR	
5	150		C		M		M		C		ECR		
6	155				M		C		ECR		M		
7	165	M			C		ECR		M		C		
8	165	ECR			M		C		ECR		M		
9	150	C		M		M		C		ECR		M	
10	165		C		ECR		M		C		ECR		
11	155	C	ECR			M		C		ECR		M	
12	155			C		ECR		M		C		ECR	
Distribution of repair works in years		2/2/1	2/1/1	2/2/1	2/3/1	2/2/2	2/2/2	2/2/2	2/2/2	2/2/2	2/2/2	2/2/2	

Stack No.	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1						inspection		repair			
2	repair						inspection		repair		
3		inspection		repair							

Symbolic Notation: 1/2/3

1 – number of capital repairs(C)
2 – number of midterm repairs(M)
3 – number of extended current repairs(ECR)

Chief engineer L.A. Eolyan

Figure 5.2-3 Medium Term Maintenance and Repair Schedule (2000 - 2010)

Schedule of Repair of the Plants on Tashkent Thermal Power Plant for 2002

Plant	Load (MW)	Year of last Repair	1st quarter			2nd quarter			3rd quarter			4th quarter			Period of Repair	Total Number of Repair Person	Remarks
			1	2	3	4	5	6	7	8	9	10	11	12			
Capital Repairs																	
Unit No.4	150	29/05/96					1	—	—	19					70	412	
Unit No.12	155	11/11/95							5	—	—	15			70	412	
Midterm Repairs																	
Unit No.2	150	11/07/97				7 —	—	25							30	298	
Unit No.3	150	13/12/98									2	—	31		30	298	
Extended Current Repairs																	
Unit No.9	150	10/06/00						1	—	—	8				70	493	
Unit No.11	155	30/11/00								5	—	15			40	493	
Capital Repairs of Transformers																	
AT-4 180000/220		07/84					1	—	—	27					34	8	
T-4 200000/110		10/89					1	—	—	27					34	8	

Remarks 1.Unit No.9 – Rewind of Stators of Generator
2.Unit No.11– Opening of Turbine casing

Chief Engineer	Mr. Eolyan LA.
Chief Engineer of "Uzbokenergotamir" Company	Kamalov S.U.
Chief Engineer of "Electrozolit" JV	Takunov S.G.
Chief Engineer of Jointstock Company "Energotamir"	Salikov R.M.

Figure 5.2-4 2003 Maintenance and Repair Schedule

The details of the work to be done are decided by the previous year, along with the budget. The Maintenance Department creates a plan, which is approved by the Chief Engineer and finally adopted. The finally approved work plan for 2003 is shown in

Figure 5.2-4 2003 Maintenance and Repair Schedule

As described above, the primary purpose of the maintenance and repair work performed at the DC "TASHTPP" is literally maintenance and repair. At the DC "TASHTPP", there is an inspection manual, and problem equipments are inspected during the maintenance and repair periods. Based on these inspections, the materials and length of time required for the next maintenance and repair work are decided. However, preventive maintenance inspections, which record the changes in the equipment over time to manage the changes and provide service life diagnoses, are not being performed. As it is not desirable to replace all the aging equipment at once, a program of preventive maintenance should be introduced at the earliest opportunity to replace the current program of reactive maintenance. By identifying deteriorating parts at an early stage and taking remedial measures, failures can be prevented and unit availability improved.

(2) Maintenance and Repair Plans

Maintenance and repair work should be commenced for equipment for which improvements would directly improve thermal efficiency. As a priority, work should be commenced to restore the condenser vacuum and to repair other leaks that have already been identified.

After that, work to repair the other equipment problems that have been identified should be scheduled during the periodic maintenance, to gradually extend the service life and efficiency of the equipment.

An example is provided below of maintenance and repair schedule that follows the periodical maintenance and repair schedule for unit No.6, and includes measures to upgrade, repair and inspect the equipment discussed above.

Year	2005	2007	2009
Kind of Repair	Capital Repair	Extended Current Repair	Midterm Repair
Contents of Repair and Renovation	• Renovate the vacuum ejector. • Introduce condenser tube washing equipment. • Repair air leaks around the condenser. • Perform detailed inspection of primary equipment such as the boiler and turbine, as well as the auxiliary equipment and main valves.	• Repair the air and gas leaks around the boiler. • Repair the seal of the air heater. • Renovate adjustment valves and control equipment. • Repair and renovate the equipment used in the high temperature/high pressure areas that the results of the previous detailed inspection showed would not last until the next periodic maintenance.	• Renovate the air heater element. • Flameproof the electrical parts around the boiler. • Repair leaks in the water and steam systems. • Repair the insulating sheets for the hot water and steam systems. • Repair walkways and handrails. • Add lighting.
approximate cost	US$ 500,000	US$ 1,100,000	US$ 700,000

5.2.4 Financial Analysis of Maintenance Plan

Maintenance is made for purpose to maintain a facility to keep its production ability and performance, to improve its ability and performance and/or to extend a life of the facility.

Financial benefit to keep the ability and performance is revenue corresponding to the maintenance cost. Maintenance cost of old unit is higher than a new unit in comparison of the same type of facility. The units at DC "TASHTPP" are 30-40 years old. Maintenance cost is considered to be higher at comparison with it during initial years after commencing operation. Financial evaluation of maintenance cost to keep ability and performance should not be made on the cost at initial years but on revenue contributed by the units.

At paragraph 5.3.2 (2) it is assumed that DC "TASHTPP" is making financing contribution at Sum 1.31/kWh, which corresponds to Sum 12,838 million at 9,800GWh generation of plant net electricity output per year. In application of this amount, DC "TASHTPP" has an allowance to spend further Sum 12,838 million per year for maintenance to keep its ability and performance. If any saving of the maintenance cost is achieved, the saved amount becomes a financial benefit.

In case of power generation, a lead time to build a power plant is necessary. It takes several years to build power plant for commencing operation. There is a possibility that any of units in system becomes unable to be operated due to accident which may be caused even under proper maintenance such as due to natural disease. A reasonable safe margin of generation and supply capability is necessary. Generating unit being stand-by has also a value. Generating facilities should be maintained to be operated until a new facility would be put into operation, even if they are planned to be replaced by the new facility.

DC "TASHTPP" is one of the important generating plants in Uzbekistan. A proper maintenance should be made, and a reasonable cost for maintenance should be allowed.

At 5.2.4, (3) a financial review on the maintenance and repair plans mentioned at 5.2.4, (3) is made. All of the maintenance plans are considered to contribute in availability and reliability improvement of the parts under the maintenance plan. Maintenance and improvement of availability and reliability is based on maintenance and repair of equipment and parts composing the facility. For the existing 12 units of 30-40 years old, the maintenance and repair to maintain availability and reliability is very important. It is suggested to make further study and development of the maintenance and repair plans suggested under 5.2.3, (2).

Maintenance and repair do not provide a guarantee that the facility will not become an outage, but decreases a risk for an outage or shutdown. There would be no perfect. Important is to decrease a risk.

DC "TASHTPP" should do its best for maintaining availability and reliability of the facility. It is important to establish a maintenance and repair plan for several years together with their annual budget. The maintenance and repair plan should include those for maintaining availability and reliability. The plan is also necessary to be discussed between DC "TASHTPP" and the head office of SJSC "Uzbekenergo", because the amount Sum 1,000 million per unit (one twelfth of Sum 12,838 million) was assumed in an analysis based on financial contribution of DC "TASHTPP" and needs to be finally decided in an analysis to take into consideration of all factors in SJSC "Uzbekenergo".

5.3 Production and Financial Contribution of DC "TASHTPP"

5.3.1 Production (Generation) Contribution of DC "TASHTPP"

The total installed generating capacity of the 12 existing units at Tashkent Thermal Power Plant (DC "TASHTPP") is 1,750MW at present capacity, which corresponds to 18% of total installed capacity 9,669MW of all the thermal, heating and hydro power plants in Uzbekistan, and to 23% of the total thermal power plants capacity 7,730MW in Uzbekistan.

DC "TASHTPP" generated 10,315GWh at generation terminal in 2002, which corresponds to about 20 % of total generation by thermal power plants, heating stations and hydro power plants in Uzbekistan. The fact that DC "TASHTPP" produces 20% of electric power in Uzbekistan is considered that the share is big and generation by it is contributing to people and industry of Uzbekistan as one of the important power plants.

Generation at DC "TASHTPP" in winter is larger than in summer as described in Table 5.3-1 showing generation in each month at DC "TASHTPP" in 2002. One of the reasons of higher generation in winter is to meet higher demand.

Table 5.3-1 Monthly Generation at DC "TASHTPP" in 2002

Unit: kWh

Month	Gross Generation	Net Generation	Station Use
Jan-02	1,050,343	989,594	5.78%
Feb-02	912,425	858,262	5.94%
Mar-02	908,052	855,083	5.83%
Apr-02	916,498	863,791	5.75%
May-02	782,334	737,082	5.78%
Jun-02	668,007	629,415	5.78%
Jul-02	657,056	619,046	5.78%
Aug-02	806,759	760,578	5.72%
Sep-02	829,186	782,398	5.64%
Oct-02	900,180	850,738	5.49%
Nov-02	897,741	845,812	5.78%
Dec-02	986,685	927,468	6.00%
Total	10,315,266	9,719,267	5.78%

Other reason is that availability of hydro generation is high during dry summer months. Fuel burning for thermal generation can be saved. Water is discharged for irrigation from reservoirs, and it drives hydro turbine generators.

The reservoirs exist not only in Uzbekistan but also in Kyrgyzstan and Tajikistan. In upper stream of Syrdarya, there are several large reservoirs and hydro power plants in Kyrgyzstan such as 1,200 MW Toktogul power plant, 800 MW Kurpsal power plant and 450MW Tashkumyr power plant. Water discharged from these reservoirs in Kyrgyzstan irrigates the land in Uzbekistan, and also electricity generated at these power plants is exported to Uzbekistan. Similar features are also found in Tajikistan. Table 5.3-2 shows electricity export and import during each month in 2002 with neighbor Asian countries. In winter Uzbekistan needs to export electricity and natural gas to Kyrgyzstan and Tajikistan so as to reserve water for irrigation at the reservoirs in Kyrgyzstan and Tajikistan.

Table 5.3-2 Electricity Trade of Uzbekistan with Neighboring Asian Countries in 2002

Unit in MWh

Country	to and from Kyrgyzstan		to and from Tajikistan		to and from Turkmenistan		Total	
Month	Export	Import	Export	Import	Export	Import	Export	Import
Jan-02	63,800		32,400				96,200	0
Feb-02	22,900		28,200				51,100	0
Mar-02		65,500	32,400				32,400	65,500
Apr-02		2,900	46,200			4,900	46,200	7,800
May-02	50,000		1,700		6,200		57,900	0
Jun-02		20,500		18,500	100		100	39,000
Jul-02		207,900		49,000	300		300	256,900
Aug-02		203,600		4,400		2,200	0	210,200
Sep-02	59,500		37,800			800	97,300	800
Oct-02	70,500		82,500			600	153,000	600
Nov-02		22,800	30,600			3,300	30,600	26,100
Dec-02			66,200			1,000	66,200	1,000
Total	266,700	523,200	358,000	71,900	6,600	12,800	631,300	607,900

Table 5.3-3 shows fuel consumption in each month at DC "TASHTPP" in 2002. It is found that the boiler operation depended on heavy fuel oil in winter, during which in the months from December to February 60% - 70% of energy source was heavy fuel oil, and in the months from June to October the boilers were operated only in use of gas. In winter domestic natural gas demand increases for heating use etc. and gas export to Kyrgyzstan and Tajikistan also increases. DC "TASHTPP" is contributing also in gas supply situation.

Table 5.3-3 Fuel Consumption of the Generating Units at DC "TASHTPP" in 2002

Month	Gas Consumption (thousand M3)		H.F. Oil Consumption (000 kg)	Equivalent Energy Consumption (G.cal)		Ratio of Gas and Oil		Heat Rate (kcal/kWh)	
	Shurtan	Bukhara		Gas	Oil	Gas	Oil	Gross	Net
Jan-02	66,900	32,700	199,000	814,828	1,928,310	29.7%	70.3%	2,612	2,772
Feb-02	88,800	19,000	155,500	881,912	1,506,795	36.9%	63.1%	2,618	2,783
Mar-02	54,900	154,900	65,200	1,716,374	631,788	73.1%	26.9%	2,586	2,746
Apr-02	24,800	243,700	12,900	2,196,599	125,001	94.6%	5.4%	2,533	2,688
May-02	56,600	185,700	1,200	1,982,256	11,628	99.4%	0.6%	2,549	2,705
Jun-02	101,000	107,400	0	1,704,920	0	100.0%	0.0%	2,552	2,709
Jul-02	63,700	140,400	0	1,669,742	0	100.0%	0.0%	2,541	2,697
Aug-02	38,600	212,400	0	2,053,431	0	100.0%	0.0%	2,545	2,700
Sep-02	23,900	232,200	0	2,095,154	0	100.0%	0.0%	2,527	2,678
Oct-02	49,500	226,300	0	2,256,320	0	100.0%	0.0%	2,507	2,652
Nov-02	77,100	139,300	55,000	1,770,368	532,950	76.9%	23.1%	2,566	2,723
Dec-02	70,400	20,600	195,500	744,471	1,894,395	28.2%	71.8%	2,674	2,845
Total	716,200	1,714,600	684,300	19,886,375	6,630,867	75.0%	25.0%	2,571	2,728

DC "TASHTPP" is considered to being making much contribution.

5.3.2 Financial Analysis of Production (Generation) at DC "TASHTPP"

Generation cost in 2002 at DC "TASHTPP" as mentioned at Table 5.3-4 and 5.3-5 showing generation cost in each month, is Sum 4.14/kWh in average year (at higher tension side of main transformer). In Sum 4.14/kWh, fuel cost is Sum 3.63/kWh and other costs (consumables, maintenance, salary, administration, depreciation etc.) are Sum 0.51/kWh (excluding VAT).

Fuel cost in burning heavy fuel oil is higher than in burning gas. Fuel cost per kWh at price as of December 2022 is:

Natural Gas:	Sum 4.60/kWh including VAT	Sum 3.83/kWh excluding VAT
Heavy Fuel Oil:	Sum 7.01/kWh including VAT	Sum 5.84/kWh excluding VAT

Table 5.3-4 Generation Cost at DC "TASHTPP" in 2002

Unit: 000 Sum

Year	Fuel Cost	Consum-Ables	Mainte-nance	Staff Salary	Insurance Premium	Other Costs	Depreci-Ation	Total
Jan-02	4,222,702	65,682	76,247	95,087	36,952	34,142	30,843	4,561,654
Feb-02	3,215,928	47,579	66,384	100,568	38,060	53,051	27,462	3,549,032
Mar-02	2,565,067	49,166	82,762	96,020	38,915	99,813	31,501	2,963,244
Apr-02	2,550,209	48,943	56,343	115,932	45,214	22,268	31,147	2,870,055
May-02	2,121,068	71,489	70,070	113,958	44,597	87,536	27,886	2,536,604
Jun-02	1,927,682	58,833	62,835	103,586	41,887	76,433	27,111	2,298,367
Jul-02	1,887,833	57,833	78,624	115,504	44,430	41,454	32,140	2,257,817
Aug-02	2,509,610	161,157	73,147	125,654	47,316	48,491	32,194	2,997,569
Sep-02	2,560,450	97,382	84,653	126,024	48,268	55,408	32,157	3,004,340
Oct-02	2,965,252	87,266	85,321	122,243	47,775	47,090	32,002	3,386,949
Nov-02	3,827,357	51,275	118,056	123,862	48,634	179,516	28,406	4,377,106
Dec-02	4,937,971	129,999	78,001	137,576	54,457	109,951	32,854	5,480,810
Total	35,291,127	926,603	932,441	1,376,013	536,506	855,153	365,703	40,283,546

Table 5.3-5 Generation Cost at DC "TASHTPP" in 2002

Unit: Sum/kWh

Year	Fuel Cost	Consum-Ables	Mainte-nance	Staff Salary	Insurance Premium	Other Costs	Depreci-ation	Total
Jan-02	4.27	0.07	0.08	0.10	0.04	0.03	0.03	4.61
Feb-02	3.75	0.06	0.08	0.12	0.04	0.06	0.03	4.14
Mar-02	3.00	0.06	0.10	0.11	0.05	0.12	0.04	3.47
Apr-02	2.95	0.06	0.07	0.13	0.05	0.03	0.04	3.32
May-02	2.88	0.10	0.10	0.15	0.06	0.12	0.04	3.44
Jun-02	3.06	0.09	0.10	0.16	0.07	0.12	0.04	3.65
Jul-02	3.05	0.09	0.13	0.19	0.07	0.07	0.05	3.65
Aug-02	3.30	0.21	0.10	0.17	0.06	0.06	0.04	3.94
Sep-02	3.27	0.12	0.11	0.16	0.06	0.07	0.04	3.84
Oct-02	3.49	0.10	0.10	0.14	0.06	0.06	0.04	3.98
Nov-02	4.53	0.06	0.14	0.15	0.06	0.21	0.03	5.18
Dec-02	5.32	0.14	0.08	0.15	0.06	0.12	0.04	5.91
Total	3.63	0.10	0.10	0.14	0.06	0.09	0.04	4.14

Weighted average electricity tariff in 2002 (from January to December) was Sum 11.56/kWh (including VAT). Assuming transmission and distribution loss as 12.9% and generation cost being 65% in cost structure including transmission, distribution and head office administration, price corresponding at high tension side of main transformers at DC "TASHTPP" is obtained as Sum 5.45/kWh excluding VAT.

In the above assumption, DC "TASHTPP" is considered to have contributed the difference between Sum 5.45/kWh and Sum 4.14/kWh. Annual contribution amount for 9,800GWh is calculated as Sum 12,838 million.

5.3.3 Issues and Suggestions under Financial Analysis

5.3.2 tells that DC "TASHTPP" is contributing Sum 12,838 million per year.

The first unit at DC "TASHTPP" commenced in 1963, and the last unit No. 12 commenced in 1971. The ages of 12 units are between 32 and 40 years. They are not young, and there may be risks that some of the units would not be operated well. Therefore, if life of the units can be extended by investment within annual expenditure of Sum 12-13 billion or an additional maintenance to spend Sum 12-13 billion can make the units operated reliably, it is considered that DC "TASHTPP" should spend additional Sum 12-13 million for maintenance. If any unit in DC "TASHTPP" loose capability, it means that the unit can not make any contribution.

The Table 5.3-9 mentions that DC "TASHTPP" spent Sum 932 million in 2002 for maintenance. 13-14 times of expenses can be spent for maintenance, if it provides a good availability and reliability of the 12 units at DC "TASHTPP". It is considered that more maintenance costs would be allowed for good maintenance for increasing availability and reliability of the units.

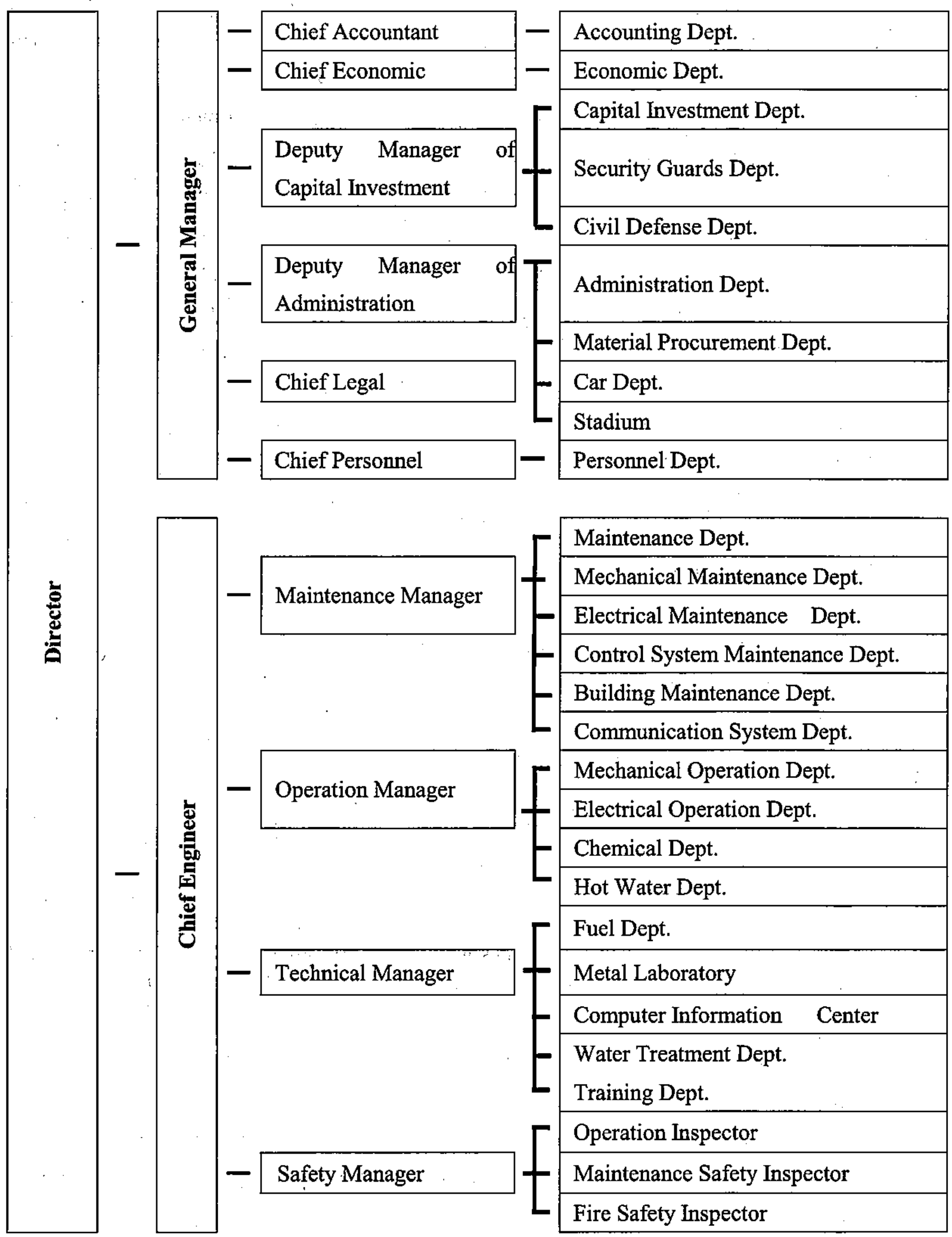
5.4 Operation Management Plan for Existing Power Plant

5.4.1 Proposal for Organizational Review

As of the end of 2002, the power plant had a staff of nearly 1,300 people. The organization is arranged as shown in Figure 5.4-1. Under the Director, there are coordinators of the various departments that are directly under the director and about 200 indirect department staff. The Chief Engineer is in charge of both the Operation and Maintenance Departments, and oversees the work of over 1,000 employees.

Further, although at present the proportion of generating costs represented by personnel costs is low, and less than 10%, labor costs are expected to rise. While they are still low, commissioning or subcontracting work to outside firms should be considered as means of reducing the overall cost of labor.

Organization Chart of Tashkent Thermal Power Plant



Note: See the detailed organization charts provided below for the shaded areas.

Figure 5.4-1 Tashkent Thermal Power Plant Organization Chart

(1) Reorganizing the Technical Departments

The organization of the technical departments under the Chief Engineer is complex, and as shown by the shaded parts of Figure 5.4-1, the difference between the operation departments and the maintenance departments is not clear.

At present, the Operation Department and the Maintenance Department exist as separate departments under the Chief Engineer. Both departments have a Deputy Chief Engineer, and at first glance it appears as if there is a clear division of labor. However, compared to the relatively simple organization of the mechanical maintenance department, the electrical maintenance department is the Electrical Workshop in the Operation Department. In addition to the Operation Department shift workers that operate the units, there is an electrical operation division in the Electrical Workshop, which monitors and operates the electrical equipment.

In this complex organization, it is difficult to coordinate the activities of the different departments responsible for maintenance and repairs. At times such as the periodical maintenance, where the safety of workers must be ensured in the turning over of equipment from the operation department to the maintenance department, the chain of command is not clear, so the possibility of accidents exists. In the event that an accident did occur, the location of responsibility is not clear.

Upon reviewing the organization as a whole in consideration of such issues, the study team proposes that the operation department and the maintenance department be clearly separated, and that departments within the organization be given equal status. The following are detailed proposals for each organization.

a. All work relating to generating equipment operation and monitoring, and the related operation management, such as efficiency management, should be centralized in the Operation Department. The aim of this department should be to ensure the efficient operation of the equipment.

b. The aim of the Maintenance Department should be to rationalize maintenance and repair work. Daily minor maintenance jobs should be performed by the Maintenance Department itself, while big jobs such as periodic maintenance should be performed from the standpoint of the contractor. The Maintenance Department should prepare a schedule and a budget for the maintenance work, and should manage the contracting and supervision of the work. The Maintenance Department should also include a mechanical maintenance group and an electrical maintenance group, and the equipment with which each group is concerned should be clearly defined. The practice of having one worker manage only one item of equipment each should be abandoned in favor of a system in which each member of a group is thoroughly familiar with all of the equipment for which the group is responsible. The system should be arranged to allow flexible allocation of personnel.

c. A new technical department should be established to manage the operation of water processing equipment and other shared equipment, as well as fuel.

d. The indirect departments should be centralized under a general administration department directly under the Director.

e. A safety management department should be newly established.

Proposed organization chart which arranged the technical section and added the Engineering Department and the Safe Department to the organization, it is shown in Figure 5.4-2.

(2) Establishment of Safety Management Department

Currently, the responsibility for safety matters rests with the Senior Safety Inspector and the Fire Safety Inspector, both of whom are under the Chief Engineer. And it seems that a commitment to safety is weak in the organization as a whole.

There were five on-the-job accidents at the DC "TASHTPP" in 2002. There were no deaths, and five accidents is not a large number. Maximum effort should be made to prevent accidents. To achieve this, the level of safety awareness in the workplace must be raised, and all unsafe practices must be thoroughly eliminated. The elimination of on-the-job accidents should be understood to be one of the main objectives of the DC "TASHTPP", along with achieving high unit efficiency and availability. We propose that a safety department be established directly under the Director to strongly promote the creation of a safe and hygienic workplace.

(3) Mutual Personnel Exchanges between the Operation and Maintenance Departments

It seems that personnel in the technical departments do not move easily to other departments once they are assigned. As a result, staff members develop highly specialized expertise with regard to their particular area. These people become indispensable specialists in their fields, but a side-effect is that the work is overly specialized, and people do not seem to have much interest in other areas of the operation. It seems that this arrangement denies employees the chance to obtain wide-ranging expertise.

We propose that personnel from the technical departments are circulated to the operation and maintenance departments, so as to develop wide-ranging expertise and learn to view the strengths and shortcomings of different departments objectively. This practice will develop a staff that is able to analyze problems and make improvements.

(4) Spin-off of Maintenance Department

It would seem that employees in the maintenance department, especially those who directly repair and maintain the equipment, could be of use in a wide range of areas. We propose that such skilled repairmen be gathered together into a subsidiary company for general maintenance and repair work.

Proposed Organization Chart of DC "TASHTPP""TASHTPP"

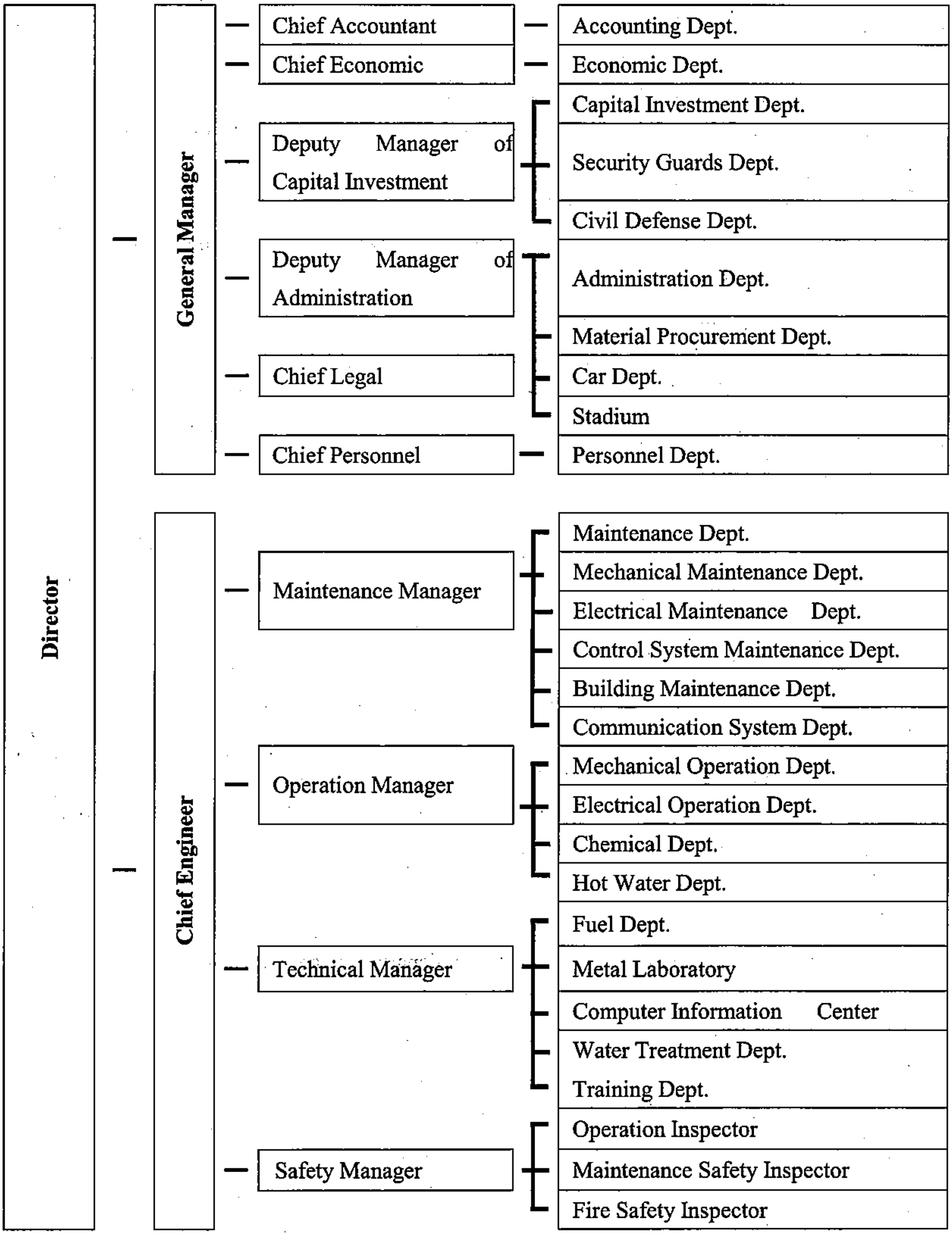


Figure 5.4-2 Proposed Organization Chart of DC "TASHTPP"

5.4.2 Equipment Operation Management

The job of thermal power plant is to take the heat energy from fuel and convert it to good quality electrical energy as efficiently as possible, using boilers, turbines, and generators. It is therefore important that the reliability of power plant equipment be maintained, and that the equipment always be operated at high availability and high efficiency.

The work of managing the operation of generating equipment includes the following areas. First, the equipment must be monitored and patrolled to gain an understanding of the operating condition of each piece of equipment. Operation target values must be maintained, efficiency managed, and the performance of the equipment checked and managed. Finally, the equipment must be maintained to keep it in sound condition, as this ensures reliability and maintained thermal efficiency.

(1) Operation Management

a. Monitoring Equipment Proposals

It is necessary for the equipment to be able to operate stably and at high efficiency for any level of demand within its operating range. Therefore, it is necessary that the operators working in the operation rooms constantly monitor the status of the equipment. They must pay careful attention to the monitoring instruments at all times, so as not to miss even minor changes.

It must also be remembered that it is impossible to completely eliminate the possibility of human error due to inattentiveness. It is important that all measures be taken to prevent accidents due to mistaken understanding or operation. This is why the operators stationed in the operating room monitor the operating condition of each unit via the output of the monitoring instruments such as indicators, recorders and warning devices. The indicators for pressure meters and thermometers and other instruments need to have some marking to indicate the desired level, so that even operators with differing levels of monitoring expertise can determine whether the condition is good or bad.

b. Monitoring Capability Improvements

- The people working in relation to the operation of the equipment need to have knowledge and experience sufficient to allow them to determine if the results of an equipment inspection are normal or not.

Such means should be employed to provide operators with as many opportunities as possible to see the actual equipment and expand their knowledge and improve their level of technical expertise through hands-on experience.

(2) Performance Management

The purpose of managing the performance of the generating units in thermal power plant is to accurately understand the operating status of the units at all times, so as to improve thermal efficiency.

a. Standard values should be set for representative numeric data related to the units, and the units managed based on the deviation between the actual data and the set values.

b. From the daily operation records, it is possible to gain an understanding of the operating status. In addition, representative values affecting performance (such as condenser vacuum level deviation, exhaust gas temperature and exhaust gas CO_2) should be examined to manage daily, weekly and monthly variation trends.

To evaluate the effectiveness of measures taken during periodic maintenance to improve performance and thermal efficiency, performance test items (such as high pressure turbine internal efficiency, air heater efficiency and feed water heater) should be understood. Further, records should be kept for each unit as a whole, to facilitate precise management.

(3) (3) Maintenance

It is no exaggeration to say that the most important issues in generating equipment that must be used for extended periods of time are ensuring reliability and maintaining thermal efficiency. Therefore, it is necessary to perform appropriate maintenance, taking steps to prevent failures, learning about preventive maintenance and inspection techniques, and fully understanding the deterioration/improvement status of the aging generating equipment. It is important to implement preventive maintenance measures for the generating equipment and keep the equipment in sound working order.

a. Introduction of Preventive Maintenance Technology

The existing generating facilities of the DC "TASHTPP" are generally well maintained and managed. To ensure that future power needs can be met, the introduction of preventive maintenance technology is crucial. This technology allows the detection of problems before they occur for equipment that is closely related to the operation of the main equipment, making it possible to prevent problems by replacing vulnerable parts in advance.

Implementing preventive maintenance in a thermal power plant and thoroughly inspecting and repairing the equipment ensures the safety of the equipment and prevents unplanned shutdowns. This makes stable supply and cost reduction possible.

b. Equipment Required for Preventive Maintenance

- In the performance of preventive maintenance and remaining service life diagnosis, a thorough understanding of the condition of the equipment is vital. To ensure an accurate understanding of the equipment condition, it is necessary to perform detailed inspections of all the important generating equipment.

5.4.3 Safety and Hygiene

Safety and hygiene programs give top priority to human safety on site, and aim to prevent accidents before they occur so as to avoid situations where people would be in danger. They also aim to improve the work environment to ensure that the health of power station employees is maintained.

Safety and hygiene is therefore related to maintaining the equipment in sound condition, and as such is one of the most important elements in operating the generating equipment at high availability and efficiency. This connection needs to be understood by all power station staff members, who should be encouraged to always be aware of the importance of safety and hygiene.

(1) Working Condition

Maintaining a proper work condition on site is an important measure to ensure that workers can concentrate on their monitoring work when they are operating or patrolling the equipment, without being distracted by anything else. Concentration allows them to detect problem areas in the equipment at an early stage and also to detect minute changes during periodic maintenance and inspection.

(2) Labor Safety

On any site, safety should be the first priority. The safety management department should take the lead in periodically patrolling the site to prevent hazards due to equipment failures and human error before they occur. It is important not only to prevent hazards and thoroughly implement activities to detect dangers, but also to involve all staff members in safety programs to prevent accidents and injuries.

To achieve this, first the manager as well as every employee must recognize that the continuation of such efforts will have the optimum consequences for the management of the power plant. They must also endeavor to keep the work site safe and build up such an environment as to take the initiative in behaving for safety. In addition to this, individual sections and their subsidiary groups must set security of the work site as their goal by organization, and the company must institute a prize according to its achievement level for establishment of the safety action.

5.5 Financial and Economical Analysis of the New Power Plant

5.5.1 Assumption for Analysis

Financial analysis was made to make projection of financial statements for business conducted by the New Power Plant under assumptions below.

(1) Performance and Cost of the New Power Plant

Main performances of the new power plant to be built at DC "TASHTPP" are expected to be:

Net Plant Electrical Output Capacity	:	370 MW
Fuel Consumption	:	1,536 kcal/kWh

The construction cost and period of the plant is estimated roughly at US$226,500,000 excluding VAT and as 34 months.

(2) Operation Mode of the New Power Plant

Fuel consumption of the new power plant is good, even if average fuel consumption in actual operation may be 1,567 kcal/kWh – 1,582 kcal/kWh being 2%-3% higher of 1,536 kca/kWh of the new clean conditions at the rated capacity operation. The good fuel consumption would make that the plant will be operated more frequently than other units in the whole generation system so as to seek the lowest fuel cost. A long term operation mode of the new power plant was assumed to be:

Plant Factor	:	85% (annual net generation 2,755,020MWh)
Average Fuel Consumption	:	1,597 kcal/kWh

(3) Revenue of the New Power Plant

Weighted average electricity tariff as from April 2003 is Sum 15.83/kWh including VAT. Annual revenue of the new power plant for generation 2,755,020MWh is calculated as Sum 21,261 million excluding VAT as at price April 2003 at the plant outgoing substation based on 58.5% of the retail tariff after taking consideration of transmission and distribution energy loss 10% and 65% revenue allocation to generation.

(4) Fuel Cost

Under the fuel consumption rate at 1,597kcal/kWh on net energy base in application of natural gas energy assumption of 8,181 kcal/m^3, annual fuel consumption is calculated as 537,803,000 m^3 for annual generation of 2,755,020MWh. At gas price Sum 15.52/m^3 including VAT, annual fuel cost is calculated as Sum 6,954 million excluding VAT.

(5) Other Operation and Maintenance Cost

It is not easy to forecast purchase cost of spare parts for maintenance replacement. Though it is to rough, annual average parts purchase cost might be 5% of the gas turbine price being equivalent to US$ 2,750,000 and annual average purchase cost of other parts of the plant might be 1% of the construction cost, being equivalent to US$ 1,420,000. The total parts purchase cost estimation in this method provides US$ 4,170,000. A rough estimation of annual maintenance costs is around in a range between US$ 4 million and US$ 4.5 million. In addition to parts purchase, it will be necessary to have presence of manufacturer's engineer(s) in gas turbine overhaul and important inspections so that the maintenance of high tech gas turbine can be made adequately. A cost to receive such engineer(s) will be involved. The annual spare parts purchase and engineer support service cost would be US$4 million – US$4.7 million in total. Analysis is made in assumption that annual total maintenance fee would be US$4,350,000.

In addition to maintenance fee, Salary Sum 336 million, Insurance Premium Sum 680 million, Consumables Sum 250 million and Other Costs Sum200 million are to be assumed as cost in 2003 price in this analysis.

(6) Operation Period

A life of gas turbine combined cycle power plant is considered to be shorter than it of conventional boiler steam turbine plant, because combustion temperature of gas turbine is higher. A life depends on maintenance. In this study the plant life 25 years which are commonly used for financial calculation of combined cycle power plant and little bit shorter than conventional plant were used.

(7) Other Assumption

a. Funding cost

For financial projection it assumes that 1.9% p.a. of loan interest and handling charge would be charged as financing cost, 85% of the construction payment would be financed by the loan, and repayment would be made at equal installments from year 2012 until year 2031.

b. Plant Depreciation

The Notice No. 7 dated February 27, 1997 from Ministry of Finance stipulates that annual depreciate rate for building is 5% and for turbines and equipments is 8%. 14% of construction cost is depreciated at 5% and 86% is depreciated at 8% in proportion to the cost breakdown estimate for civil and architectural works and for other potions in the Table 5.5-2.

c. Corporate Income Tax

It is assumed that the project will pay corporate income tax at 35% of profit, if net income is positive in the year. 5 years loss carrying over is also assumed to be allowed.

d. Price Escalation

Price escalation as below is assumed in US Dollar during whole life of the project.

Gas	: 4 % per year
Salary	: 5% per year
Electricity:	3.8% per year
Others	: 3% per year

5.5.2 Projection

Projection of financial statements in US Dollar is shown in

Table 5.5-1	projection of generation cost,
Table 5.5-2	projection of income statement
Table 5.5-3	projection of cashflow statement
Table 5.5-4	projection of balance sheet

Return on Equity at Discount Cashflow Method (ROE) in this projection was 2.05 % per year. Equity IRR corresponding to 5% and 10% per year was obtained by changing tariff increase rate. The calculation result is as follows;

Tariff increase in US$ per 3.80% per year ROE	2.05 % per year
Tariff increase in US$ per 4.25% per year ROE	5.03 % per year
Tariff increase in US$ per 5.46% per year ROE	10.00 % per year

In case of 4.25% increase per year of electricity, ROE 5.03% is expected, and 5.46% per year increase would produce 10% ROE. ROE is desired not less than interest rate. In case of 4.25%

increase per year of electricity ROE 5.03% is expected, and 5.46% per year increase would produce 10% ROE. Decree UP-2812 mentions about future sound sustainable development of energy sector and to attract foreign and private investments to energy sector of Uzbekistan. For promoting the policy under Decree UP-2813, it is important to make a tariff adjustment to a reasonable level.

Table 5.5-1 Projection of Generation Cost of the New Power Plant

(Unit: thousand US$)

	1 2007	2 2008	3 2009	4 2010	5 2011	6 2012	7 2013	8 2014	9 2015	10 2016	11 2017	12 2018	13 2019
Gas Purchase	8,137	8,463	8,801	9,153	9,519	9,900	10,296	10,708	11,136	11,582	12,045	12,527	13,028
Annual Replacement Parts Cost	4,896	5,043	5,194	5,350	5,510	5,676	5,846	6,021	6,202	6,388	6,580	6,777	6,980
Salary Cost	408	429	450	473	496	521	547	575	603	634	665	699	733
Insurance Permium	680	680	680	680	680	680	680	680	680	680	680	680	680
Cost of Consumables	281	290	299	307	317	326	336	346	356	367	378	389	401
Other Costs	225	232	239	246	253	261	269	277	285	294	303	312	321
Depreciation Cost Civil/Build	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Depreciation Cost Plant/Equip	15,918	15,918	15,918	15,918	15,918	15,918	15,918	15,918	15,918	15,918	15,918	15,918	7,959
Generation Cost (Excluding Financing Cost)	32,165	32,673	33,200	33,747	34,314	34,902	35,512	36,144	36,801	37,482	38,188	38,921	31,722
Ave. Generation Cost cent/kWh (Excluding Interest)	1.17	1.19	1.21	1.22	1.25	1.27	1.29	1.31	1.34	1.36	1.39	1.41	1.15
Interest	3,658	3,658	3,658	3,658	3,658	3,567	3,384	3,201	3,018	2,835	2,652	2,469	2,286
Total Generation Cost	35,823	36,331	36,858	37,405	37,972	38,468	38,895	39,345	39,818	40,317	40,840	41,390	34,008
Average Generation Cost	1.30	1.32	1.34	1.36	1.38	1.40	1.41	1.43	1.45	1.46	1.48	1.50	1.23

	14 2020	15 2021	16 2022	17 2023	18 2024	19 2025	20 2026	21 2027	22 2028	23 2029	24 2030	25 2031	Total
Gas Purchase	13,549	14,091	14,654	15,241	15,850	16,484	17,144	17,829	18,542	19,284	20,056	20,858	338,875
Annual Replacement Parts Cost	7,190	7,406	7,628	7,857	8,092	8,335	8,585	8,843	9,108	9,381	9,663	9,952	178,503
Salary Cost	770	809	849	892	936	983	1,032	1,084	1,138	1,195	1,254	1,317	19,492
Insurance Permium	680	680	680	680	680	680	680	680	680	680	680	680	17,000
Cost of Consumables	413	426	438	452	465	479	493	508	523	539	555	572	10,259
Other Costs	331	340	351	361	372	383	395	407	419	431	444	458	8,207
Depreciation Cost Civil/Build	1,620	1,620	1,620	1,620	1,620	1,620	1,620	0	0	0	0	0	32,391
Depreciation Cost Plant/Equip	0	0	0	0	0	0	0	0	0	0	0	0	198,974
Generation Cost (Excluding Financing Cost)	24,552	25,371	26,220	27,101	28,015	28,964	29,948	29,350	30,410	31,510	32,652	33,837	803,701
Ave. Generation Cost cent/kWh (Excluding Interest)	0.89	0.92	0.95	0.98	1.02	1.05	1.09	1.07	1.10	1.14	1.19	1.23	1.17
Interest	2,103	1,920	1,738	1,555	1,372	1,189	1,006	823	640	457	274	91	54,870
Total Generation Cost	26,655	27,291	27,957	28,656	29,387	30,153	30,954	30,173	31,051	31,968	32,926	33,928	858,571
Average Generation Cost	0.97	0.99	1.01	1.04	1.07	1.09	1.12	1.10	1.13	1.16	1.20	1.23	1.25

Table 5.5-2 Projection of Income Statement of the New Power Plant (Unit: thousand US$)

Year	1 2007	2 2008	3 2009	4 2010	5 2011	6 2012	7 2013	8 2014	9 2015	10 2016	11 2017	12 2018	13 2019
Revenue	24,681	25,619	26,593	27,603	28,652	29,741	30,871	32,044	33,262	34,526	35,838	37,200	38,613
Generation Cost without Interest	32,165	32,673	33,200	33,747	34,314	34,902	35,512	36,144	36,801	37,482	38,188	38,921	31,722
Interest	3,658	3,658	3,658	3,658	3,658	3,567	3,384	3,201	3,018	2,835	2,652	2,469	2,286
Profit before Tax	-11,142	-10,712	-10,265	-9,801	-9,319	-8,727	-8,024	-7,301	-6,556	-5,791	-5,002	-4,190	4,605
Corporate Income Tax	0	0	0	0	0	0	0	0	0	0	0	0	0
Profit after Tax	-11,142	-10,712	-10,265	-9,801	-9,319	-8,727	-8,024	-7,301	-6,556	-5,791	-5,002	-4,190	4,605
Retained Profit in Beginning	0	-11,142	-21,854	-32,119	-41,921	-51,240	-59,967	-67,991	-75,292	-81,848	-87,639	-92,641	-96,831
Undistributed Profit	-11,142	-21,854	-32,119	-41,921	-51,240	-59,967	-67,991	-75,292	-81,848	-87,639	-92,641	-96,831	-92,226
Dividend	0	0	0	0	0	0	0	0	0	0	0	0	0
Retained Profit at Ending	-11,142	-21,854	-32,119	-41,921	-51,240	-59,967	-67,991	-75,292	-81,848	-87,639	-92,641	-96,831	-92,226

Year	14 2020	15 2021	16 2022	17 2023	18 2024	19 2025	20 2026	21 2027	22 2028	23 2029	24 2030	25 2031	Total
Revenue	40,081	41,604	43,185	44,826	46,529	48,297	50,133	52,038	54,015	56,068	58,198	60,410	1,000,626
Generation Cost without Interest	24,552	25,371	26,220	27,101	28,015	28,964	29,948	29,350	30,410	31,510	32,652	33,837	803,701
Interest	2,103	1,920	1,738	1,555	1,372	1,189	1,006	823	640	457	274	91	54,870
Profit before Tax	13,425	14,313	15,227	16,170	17,142	18,144	19,178	21,864	22,964	24,100	25,272	26,481	142,055
Corporate Income Tax	0	6,076	5,330	5,660	6,000	6,351	6,712	7,652	8,038	8,435	8,845	9,268	78,366
Profit after Tax	13,425	8,237	9,898	10,511	11,142	11,794	12,466	14,212	14,927	15,665	16,427	17,213	63,689
Retained Profit in Beginning	-92,226	-78,801	-70,564	-60,666	-50,156	-39,013	-27,220	-14,754	-542	0	0	0	
Undistributed Profit	-78,801	-70,564	-60,666	-50,156	-39,013	-27,220	-14,754	-542	14,385	15,665	16,427	17,213	
Dividend	0	0	0	0	0	0	0	0	14,385	15,665	16,427	17,213	63,689
Retained Profit at Ending	-78,801	-70,564	-60,666	-50,156	-39,013	-27,220	-14,754	-542	0	0	0	0	

Table 5.5-15 Projection of Cashflow Statement of the New Power Plant (Unit: thousand US$)

ROE/DCF = 2.05% per year

Year	-3 2004	-2 2005	-1 2006	1 2007	2 2008	3 2009	4 2010	5 2011	6 2012	7 2013	8 2014	9 2015	10 2016	11 2017	12 2018
Generation Revenue				24,681	25,619	26,593	27,603	28,652	29,741	30,871	32,044	33,262	34,526	35,838	37,200
Cash Inflow				24,681	25,619	26,593	27,603	28,652	29,741	30,871	32,044	33,262	34,526	35,838	37,200
Operating Cost				-32,165	-32,673	-33,200	-33,747	-34,314	-34,902	-35,512	-36,144	-36,801	-37,482	-38,188	-38,921
Less Depreciation				17,537	17,537	17,537	17,537	17,537	17,537	17,537	17,537	17,537	17,537	17,537	17,537
Payment of Tax				0	0	0	0	0	0	0	0	0	0	0	0
Cash Outflow from Operation				-14,628	-15,136	-15,663	-16,209	-16,776	-17,364	-17,974	-18,607	-19,263	-19,944	-20,651	-21,383
Cashflow from Operation				10,053	10,483	10,930	11,394	11,876	12,377	12,897	13,438	13,999	14,582	15,187	15,816
Construction	-50,000	-88,000	-88,500												
Cashflow from Investment	-50,000	-88,000	-88,500												
Principal Repayment (Borrowing)	42,500	74,800	75,225	0	0	0	0	0	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626
Loan Interest	-404	-1,518	-2,943	-3,658	-3,658	-3,658	-3,658	-3,658	-3,567	-3,384	-3,201	-3,018	-2,835	-2,652	-2,469
Capital Injection (Dividend)	7,904	14,718	16,218	0	0	0	0	0	0	0	0	0	0	0	0
Cashflow from Financing	50,000	88,000	88,500	-3,658	-3,658	-3,658	-3,658	-3,658	-13,193	-13,010	-12,827	-12,644	-12,461	-12,278	-12,095
Net Cash Increase	0	0	0	6,396	6,825	7,272	7,736	8,218	-816	-113	611	1,355	2,121	2,909	3,721
Cash at Beginning	0	0	0	0	6,396	13,221	20,493	28,229	36,447	35,631	35,519	36,129	37,484	39,605	42,514
Cash at Ending	0	0	0	6,396	13,221	20,493	28,229	36,447	35,631	35,519	36,129	37,484	39,605	42,514	46,235

Year	13 2019	14 2020	15 2021	16 2022	17 2023	18 2024	19 2025	20 2026	21 2027	22 2028	23 2029	24 2030	25 2031	Total
Generation Revenue	38,613	40,081	41,604	43,185	44,826	46,529	48,297	50,133	52,038	54,015	56,068	58,198	60,410	1,000,626
Cash Inflow	38,613	40,081	41,604	43,185	44,826	46,529	48,297	50,133	52,038	54,015	56,068	58,198	60,410	1,000,626
Operating Cost	-31,722	-24,552	-25,371	-26,220	-27,101	-28,015	-28,964	-29,948	-29,350	-30,410	-31,510	-32,652	-33,837	-803,701
Less Depreciation	9,579	1,620	1,620	1,620	1,620	1,620	1,620	1,620	0	0	0	0	0	231,365
Payment of Tax	0	0	-6,076	-5,330	-5,660	-6,000	-6,351	-6,712	-7,652	-8,038	-8,435	-8,845	-9,268	-78,366
Cash Outflow from Operation	-22,144	-22,933	-29,827	-29,930	-31,141	-32,395	-33,695	-35,041	-37,003	-38,448	-39,945	-41,497	-43,105	-650,702
Cashflow from Operation	16,470	17,148	11,777	13,255	13,685	14,134	14,602	15,091	15,035	15,567	16,122	16,701	17,304	349,924
Construction														
Cashflow from Investment														
Principal Repayment (Borrowing)	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626	-9,626	0
Loan Interest	-2,286	-2,103	-1,920	-1,738	-1,555	-1,372	-1,189	-1,006	-823	-640	-457	-274	-91	-59,735
Capital Injection (Dividend)	0	0	0	0	0	0	0	0	0	-14,385	-15,665	-16,427	-17,213	-24,849
Cashflow from Financing	-11,912	-11,730	-11,547	-11,364	-11,181	-10,998	-10,815	-10,632	-10,449	-24,651	-25,748	-26,327	-26,930	-84,584
Net Cash Increase	4,557	5,419	230	1,891	2,504	3,136	3,787	4,459	4,585	-9,084	-9,626	-9,626	-9,626	38,840
Cash at Beginning	46,235	50,792	56,211	56,441	58,332	60,836	63,971	67,759	72,218	76,803	67,719	58,093	48,466	
Cash at Ending	50,792	56,211	56,441	58,332	60,836	63,971	67,759	72,218	76,803	67,719	58,093	48,466	38,840	

Table 5.5-16 Projection of Balance Sheet of the New Power Plant (Unit: thousand US$)

Year	-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cash	0	0	0	6,396	13,221	20,493	28,229	36,447	35,631	35,519	36,129	37,484	39,605	42,514
Civil & Building	7,057	19,589	32,391	30,772	29,152	27,532	25,913	24,293	22,674	21,054	19,435	17,815	16,196	14,576
Plant & Machinery	43,347	120,333	198,974	183,056	167,138	151,220	135,302	119,384	103,467	87,549	71,631	55,713	39,795	23,877
Asset Total	50,404	139,922	231,365	220,223	209,511	199,246	189,444	180,125	161,772	144,122	127,195	111,012	95,595	80,967
Loan	42,500	117,300	192,525	192,525	192,525	192,525	192,525	192,525	182,899	173,273	163,646	154,020	144,394	134,768
Retained Proft (Loss)	0	0	0	-11,142	-21,854	-32,119	-41,921	-51,240	-59,967	-67,991	-75,292	-81,848	-87,639	-92,641
Capital	7,904	22,622	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840
Debt & Equity Total	50,404	139,922	231,365	220,223	209,511	199,246	189,444	180,125	161,772	144,122	127,195	111,012	95,595	80,967

Year	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Cash	46,235	50,792	56,211	56,441	58,332	60,836	63,971	67,759	72,218	76,803	67,719	58,093	48,466	38,840
Civil & Building	12,956	11,337	9,717	8,098	6,478	4,859	3,239	1,620	0	0	0	0	0	0
Plant & Machinery	7,959	0	0	0	0	0	0	0	0	0	0	0	0	0
Asset Total	67,150	62,129	65,928	64,538	64,810	65,694	67,210	69,378	72,218	76,803	67,719	58,093	48,466	38,840
Loan	125,141	115,515	105,889	96,263	86,636	77,010	67,384	57,758	48,131	38,505	28,879	19,253	9,626	0
Retained Proft (Loss)	-96,831	-92,226	-78,801	-70,564	-60,666	-50,156	-39,013	-27,220	-14,754	-542	0	0	0	0
Capital	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840	38,840
Debt & Equity Total	67,150	62,129	65,928	64,538	64,810	65,694	67,210	69,378	72,218	76,803	67,719	58,093	48,466	38,840

5.5.3 Issues and Suggestions from Financial and Economical Analysis

(1) Tariff Increase

Projection of financial statements shows that current electricity tariff would not provide enough revenue for the project. Electricity is one of the most important infrastructures for people and industry. The tariff increase will cause big impact to people and industry, and is better to be made at reasonable span.

On the other hand, the existing units may produce financial gain. However, all plants have life, and will become not operative in some day. For this reason, investments to new project are necessary, and financial aspects of the new project would be basically the same.

The financial projection in Sum at 4.25% per year tariff increase show that net income of the project in early years will be still loss but cashflow is positive during the full period of the operation period. This case may be one of the minimum levels to produce the sound financial position, though continuous reviews and studies are necessary on the case involving many assumptions so as to reflect further developments and movements. The financial projection is only made for the New Power Plant, and a study on tariff increase should be made for the financial projection of the whole SJSC "Uzbekenergo".

(2) Maintenance of the Existing Units

The existing units are considered providing financial contribution. As far as they are making contribution, maintenance of them should be made so that they would be able to work. For the purpose that the existing will function well, it is considered that more maintenance fee can be allowed.

In this relation, there might be a plan that two units out of the existing 12 units would be demolished. This plan is considered to be re-studied, because;

a. it is difficult to determine which unit will become broken,
b. it is better to continue to operate the existing units until they becomes non operative or generation cost including maintenance fee becomes larger than a marginal point on which generation cost is higher than value of generation, and
c. units being not operated can be stand-by and can work, when necessary on some occasion that accident happen in any other units in DC "TASHTPP" or in other units in Uzbekistan.

(3) Fuel Arrangement

In winter gas use ratio in fuel becomes low. This ratio was 28.2% in December 2002, in which 91,000,000 m^3 was received. The new power plant will consume about 50,000,000 m^3 in month under a full operation. If the new plant is operated, gas available to the existing units might be decreased in winter, and half of gas might be burnt at the new power plant.

It is necessary to study what is the minimum requirement of gas for safe and stable operation of the existing units, and also what amount of gas will be available to DC "TASHTPP".

(4) Future Expansion

Gas combined cycle power plant is superior in fuel consumption. However, operation in use of heavy fuel oil is not suitable. Therefore, it is necessary to make study on fuel production and supply plan in Uzbekistan what will be the best combination of gas and oil. There is a relation with hydro reservoir operation in Uzbekistan and neighbor countries.

(5) Maintenance of Gas Turbine Combined Cycle

Maintenance of gas turbine combined cycle requires to spend much money for purchasing replacement parts, and the purchase is import. The situation is very different from that for the existing units on which maintenance work can be taken in DC "TASHTPP" or in SJSC "Uzbekenergo" without purchasing many spare parts from outside.

The superiority of good fuel consumption provides merits when the plant is working. For purpose to make the plant available, procurement of spare parts is necessary. A good system to procure spare parts and to manage inventory of them is better to be developed.

5.6 Operation and Maintenance of New Power Plant

5.6.1 Organizational Systems for Operation and Maintenance

New Power Plant is required new organization, separate from existing one, for the operation and maintenance of new plant. However, the people who will work with the new plant 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 plant. The only new departments that need to be created are an operation department to focus on the operation of the new plant and a maintenance department devoted to the inspection and maintenance of the new plant.

The staff of the new operation department should include a balanced mix of experienced veterans and young employees.

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 new plant 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 New Facility

(1) Characteristics of Combined Cycle Power Plant

a. Thermal Efficiency

A distinguishing characteristic of a combined cycle generating facility is that it operates at around 55% thermal efficiency under high loads, 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 plant 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. 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 plant, the inlet guide vane of the gas turbine compressor is designed to control 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.

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.

(b) Steam Cycle Controls

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. 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. 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.

(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) Cooling Water 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.

(b) Vacuum Increase

Perform gland sealing using supplemental steam.

(c) HRSG Startup (Drum Water Level Adjustment)

Start the feed pump and feed water until the drum water level reaches the prescribed 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 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.

(e) Synchronization/Load Up

Connect the generator to the utility by using the gas turbine governor to achieve synchronous operation. After synchronization, 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 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. 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.

b. Shutdown Operation

(a) Load Down

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.

(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.

(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 plant.

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 plant'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, take hourly records, and perform appropriate operation management.

(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.

(c) Combustor Inspection

Normally, inspection of the combustor is performed as part of periodical 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) Periodical 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 periodical inspection is once a year.

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) Transition piece

- 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.

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""TASHTPP". Therefore, this section will provide a simple explanation of the particular deterioration phenomena seen in steam turbines.

d. HRSG 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 also no water-wall tubes, so the structure is simple. 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 plant 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.

(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.

(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.

(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.

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

CHAPTER 6 CDM PROGRESS IN UZBEKISTAN

THE DETAILED DESIGN STUDY FOR

MODERNIZATION OF TASHKENT THERMAL POWER PLANT

IN THE REPUBLIC OF UZBEKISTAN

FINAL REPORT (SUMMARY)

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CHAPTER 6 ARRANGEMENT FOR CDM IN UZBEKISTAN

6.1 Arrangements for UNFCCC

In 1993 Uzbekistan signed the United Nations Framework Convention on Climate Change (UNFCCC) aiming at reducing and stabilizing the density of atmospheric greenhouse gas. And also Uzbekistan signed Kyoto Protocol in November 1998 and ratified it in August 1999. In 1993, "the National Commission of the Republic of Uzbekistan on Climate Change" was established with 34 members from organizations concerned. And as a part of obligatory activities, the study on the condition of climate change was conducted and its result was compiled in the report of "Initial Communication of the Republic of Uzbekistan under the UNFCCC". The government of Uzbekistan assigned "Glavgidromet," as a liaison for UNFCCC.

6.2 Arrangement for CDM

For the terrestrial climate change mitigation, Uzbekistan has positively accomplished arrangements, such as preparing laws and regulations of the environment protection, studying climate change in Uzbekistan, and planning 40 projects which would contribute to GHG reduction. On the other hand, Uzbekistan has not prepared regulatory framework of CDM and has not named an organization in charge of matters regarding CDM and has not carried out CDM projects. On May 30 this year, Cabinet of Ministers has requested Glavgidromet to develop procedures of the creation of the CDM National Authority and to prepare the draft of resolution on CDM practice together with Ministries concerned. This request would mean that the preparation of organizational system and regulatory framework to cope with CDM at the national level has started in Uzbekistan.

6.3 Organizations concerning with Climate Change and Environmental Protection, etc.

6.3.1 Organizations concerned

The following governmental organizations are accomplishing tasks related to the climate change and the environmental protection:

- "Glavgidromet": providing the governmental units and other agencies with information on actual and expected hydro-meteorological conditions and climate change, the level of environmental pollution and other relevant information.
- "Goskompriroda": regulating environmental activities of organizations, monitoring compliance to environmental quality norms and standards, conducting state environmental appraisals, issuing or annulling permits for emissions and discharges of pollutants and wastes, and preparing the state environmental program.
- The Ministry of Macroeconomics: developing of short and long-term forecast on costs

and benefits of environmental protection measures.

- The Ministry of Interior, the State Committee of Workers and Industrial Safety, the Ministry of Agriculture and Water, the State Land Committee, and other governmental organizations: executing selected environmental laws and regulations.

6.3.2 Laws and regulations

About 100 laws and regulations related to environmental protection and natural resources, such as Rational Energy Use, Protection of Nature, Water and Water Use, Specially Protected Natural Areas, Air Protection, Protection and Use of Animals, Use of Vegetation, are in force now.