- 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 Sum90.25×10^6, equivalent to US$90,250 and equivalent to 10.8 million yen (at JPY120 = US$1).

If the fuel savings is allocated to maintenance, and if more thorough equipment inspection and repairs (including equipment diagnosis) are carried out, along with the implementation of planned maintenance and upgrading based on highly accurate information, it will be possible to keep the equipment in good condition. This will improve the reliability of the equipment and maintain high availability.

The main causes of reduced unit efficiency for all generating equipment and the particular problems of the particular units were presented to us by the DC "TASHTPP" staff. These are summarized below.

(a) Main causes of reduced efficiency common to all units

- i Air inflow to boiler furnace and flue
- ii Air inflow to condenser
- iii Loss of steam and condensate due to leaks
- iv Overheated exhaust gas due to insufficient heat recovery on the air side of the air heater

(b) Problems with particular units

- i Overextended service life of main steam pipes in units 1-4, and poor condition of main steam pipe material in unit 10
- ii Overextended service life of crossover piping for low-pressure turbine steam in all units
- iii Overextended service of turbines in units 2 and 4.
- iv Overextended service life of main steam stop valves and control valves in units 3 - 12
- v Deterioration of auxiliaries due to aging
- vi Generator stator winding requiring replacement in units 1, 5, 6, 7, 11 and 12
- vii Poor condition of water feed pumps in all units except 1A, 2A, 3A, 4A and 8A
- viii Main girders, support girders, and boiler drums requiring diagnostic examination
- ix Bukhara gas pipeline requiring diagnosis and Cathodic Protection System requiring upgrading
- x Installation of new Bukhara gas pipeline from the gas distribution station to the DC

"TASHTPP" required

xi Deterioration of storage batteries due to aging

xii Deterioration of air-blast circuit breakers for the 110 kV and 220 kV switching stations due to aging

DC "TASHTPP" staff shares the understanding of the study team with regard to the problems common to all units, which are related to improving the thermal efficiency of the units. The problems with the individual units are due to the overextended use of the units and the associated deterioration.

Further, it must not be forgotten that eliminating human accidents by improving the working environment is also important in ensuring the soundness of the equipment.

Based on presentations from the power plant staff and our own on-site inspections, we have formulated possible improvements below for the equipment related to improving the condenser vacuum and saving auxiliary power. In addition, we also list improvements for equipment related to improving availability, safety and the working environment. We also offer qualitative evaluations of the effectiveness and cost of each improvement.

a. Boiler equipment

Equipment to be renovated/repaired	Improvement	Effectiveness	Cost
Replace boiler tubes	Save auxiliary power, improve efficiency and reliability	Medium	Large
Repair air and exhaust gas leaks	Save auxiliary power, improve efficiency and working environment, reduce pollution	Large	Medium
Repair expansion joints on all air and gas ducts	Save auxiliary power, improve efficiency and working environment, reduce pollution	Medium	Medium
Replace air heater element	Reduce auxiliary power, improve efficiency	Low	Large
Replace air heater seal	Reduce auxiliary power, improve efficiency	Large	Medium
Make electrical equipment around the boiler flameproof	Prevent accidents, ensure safety	Low	Large

b. Turbine equipment

Equipment to be renovated/repaired	Improvement	Effectiveness	Cost
Renovate vacuum ejector	Improve vacuum, reduce auxiliary power, improve efficiency	Large	Medium
Renovate valves and pipes in vacuum system	Improve vacuum and efficiency	Large	Large
Install condenser washing equipment	Improve vacuum and efficiency	Large	Low

c. Common items

Equipment to be renovated/repaired	Improvement	Effectiveness	Cost
Clearly identify dangerous areas and install grounding equipment	Prevent accidents and ensure safety	Medium	Low
Renovate adjustment valves and control equipment	Improve efficiency and prevent mistaken operation	Large	Medium
Repair leaks in water and steam systems	Reduce auxiliary power, improve efficiency	Large	Low
Repair insulating plates in hot water and steam systems	Improve efficiency and ensure safety	Medium	Low
Repair walkways and handrails	Ensure safety, improve working environment	Medium	Low
Add lighting	Ensure safety, improve working environment	Medium	Medium

5.2.2 Results of Repairs and Improvements

The following is a summary of the most effective of the improvements outlined above, and the main improvements that could be expected.

(1) Restoration of Condenser Vacuum

The designed vacuum of the DC "TASHTPP" condenser is 25.7 mmHg (the value read from an absolute vacuum 0 mmHg at atmospheric pressure of 1 atm = 760 mmHg). As Figure 5.1-6shows, there is now quite a large deviation between the condenser vacuum and the designed value of 25.7 mmHg, due to the reduced vacuum.

The following causes of the problem were identified in discussions between the study group and the DC "TASHTPP" staff.

a. Distortions in pipe joints leading to the condenser hot well and air inflow due to corrosion in the condenser and the low pressure heater

(a) Decreased ability to eject incoming air due to deteriorated performance of the steam vacuum ejector (vacuum device)

(b) Soil on the inside of the condenser tubes

We have concluded that the following measures would be most effective in addressing these problems:

(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. Reducing house consumption means that power generation can be increased for the same amount of fuel input. This is why reducing house consumption leads to increased thermal efficiency.

Figure 5.1-10shows that although the equipment is aging, house consumption is only rising slightly. The units are designed so that the auxiliary equipment has some spare power even in maximum load operation, so if the units are operating at the designed efficiency, there is no need for the auxiliary equipment to operate at full power.

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. However, when efficiency decreases still further, maximum output cannot be maintained even when the auxiliaries are working at 100% capacity. When this happens, even though the power used by the auxiliaries has not increased, it does represent a larger proportion of the generating power, causing an increase in the house consumption rate.

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. Auxiliaries consuming large amounts of power are fans such as FDFs, IDFs and GRFs, and water feed pumps for boilers, pumps such as condensate pumps and coolant pumps for turbines, and compressors used by both.

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. To remedy this problem, the staff of the DC "TASHTPP" sends a small amount of fuel gas to the air heater's exhaust gas side to cause a series of explosions in order to sweep away the soot with the resulting explosion pressure. This method not only carries the risk of damaging the air heater, it also can possible damage the flue, so it cannot be recommended. We propose instead that a soot blower be installed to sweep off the soot using air pressure.

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. In Japan, control measures are taken to reduce these openings, but at the DC "TASHTPP", the seal is of a fixed construction. Therefore, it is necessary to set the seal when the opening is small, and this allows greater leaks when the opening is enlarged. The best solution would be to employ the same method as used in Japan, but this cannot be recommended due to the high cost of installing new equipment. Instead, it is necessary that 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. In particular, there are many cases where boiler tubes have become clogged due to the precipitation of hardness minerals such as silica that are dissolved solids from the boiler water. Blockage also occurs in the condenser tubes due to accumulated debris and thickly growing plant organisms. When there are leaks of steam or water from the piping joints, the pumps must work harder to maintain the required flow rate and pressure, and this increases the pump power consumption.

For the boiler tubes, the most effective remedy is to monitor the discharge pressure of the feed pump and perform acid cleaning when it exceeds a prescribed value. During periodic maintenance at the DC "TASHTPP", the staff removes the boiler tubes, visually inspects the interior for scales and decides whether or not to perform acid cleaning based on the adhesion conditions. However, because the acid solution is circulated in the boiler for a prescribed length of time for acid cleaning, this method of cleaning is not as accurate as using a test piece to check the level of cleaning, and it is harder to manage appropriately. Thus, excessive cleaning can occur that removes not only the silica; the boiler tube itself is exposed, causing the base material to elute. When the thickness of a tube falls below the necessary thickness to maintain the strength, there is an increased risk of accidents caused by rupture, particularly at times when there is variation in the pressure in the tubes, as at start-up. Thus, the problem can affect unit shutdown times. To prevent precipitation of hardness minerals, the water quality of the boiler water should be managed appropriately and a boiler water blow must be implemented periodically to keep the hardness of the boiler water below a standard level. This will not only reduce the power consumption of the feed pump, it will also help prevent the precipitation of mineral deposits and thereby reduce the frequency of boiler tube ruptures and help to improve equipment availability, as will be discussed later.

The method discussed in the previous section is appropriate for the condenser tubing.

Implementing the measures discussed above for stopping leaks will help to keep the insides of the piping clean and help reduce house consumption.

(3) Equipment Availability Improvement

Availability is greatly affected by unit shutdown time. There are times when it shutting down and starting a unit is unavoidable due to load-dispatch instructions, but at other times, equipment failures necessitate emergency shutdowns. At the DC "TASHTPP", the staff has not received technical instructions from the equipment manufacturers since Uzbekistan became independent from the Soviet Union. Even though they are constrained by a limited budget, the employees of the DC "TASHTPP" have maintained a high skill level, which has allowed them to repair many kinds of failures. Their efforts have succeeded in keeping equipment that is quite old operating at near the output of the equipment when it was new. Figure 5.1-8shows availability of over 70%, calculated based on operating hours.

As explained in Chapter 1, over 70% over 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, which also accounted for 50% of the total. 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. Reducing the number of boiler tube rupture failures should bring dramatic improvements in equipment availability. To achieve this reduction, the water management measures described above are necessary, and the following inspections and repairs should also be performed.

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 periodic 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 periodic inspection. The accumulated data can be used to understand the deterioration of the equipment, so that equipment nearing the end of its service life at the time of the next periodic 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) Other Equipment Maintenance

a. Repair of Insulating Sheets

There are various pipes criss-crossing any power plant site, some of which carry hot fluids. These pipes are wrapped with thermal insulating material to prevent the heat from being lost to the atmosphere, and the outer covering is sheet metal, which is to protect the insulation from the effects of the wind and rain.

At the DC "TASHTPP", however, there are many pipes from which the sheet metal has been removed, leaving only the insulation. There are even some pipes from which the insulation has fallen away, exposing the bare pipes. Some pipes would cause burns if they were touched. The boilers themselves are in similar condition, and heat that should be absorbed by the feed water and steam is being released to the atmosphere.

It is difficult to make a quantitative prediction of how much of a reduction could be made in the amount of heat lost if the insulating sheets were kept in good condition. However, improvements in unit thermal efficiency can be expected by reducing the heat loss.

b. Repair of Handrails and Walkways

As discussed in 5.1-6(4), the walkways and stairways around the boilers are not of sufficiently thick grating, so they are warped and generally in poor condition. The handrails are made of even thinner metal and are of very unsafe construction. These hazards must surely make it difficult for people to relax and do their jobs. Repairing such accessory equipment may not directly improve unit efficiency, but it is essential to inspection and repair work. By improving the accessory equipment, workers will be able to concentrate on their work, which will allow them to detect slight abnormal conditions at an early stage, and to perform their work with greater precision, which is sure to result in increased equipment availability.

(5) Results of Repairs and Improvements

a. Reduced Fuel Consumption

It can be estimated that if the measures described above are taken to restore the condenser vacuum and reduce house consumption, the generated efficiency of unit 6 will improve by one point from 33.4% to 34.4%. The yearly consumption of natural gas would decrease from 230.2×10^6 m^3 to 220.7×10^6 m^3, a reduction of 9.5×10^6 m^3 or 17.38%.

If this reduction in the fuel used by unit 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

Compared to natural gas, the combustion of heavy oil produces more emissions of atmospheric pollutants, so 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% 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. In particular, the reduction in emissions of carbon dioxide, a greenhouse gas, could be considered material for greenhouse gas emissions rights trading.

c. Reduction of Toxic Substances

In addition to the atmospheric pollutants discussed above, it is also possible to reduce the production of substances that are harmful to human health. The most serious of these is the carbon monoxide (CO) produced when fuel is not fully combusted. By maintaining the proper ratio of fuel and air in the boiler, all the carbon in the fuel should theoretically be combusted allowing the emissions of CO to be controlled. Therefore, it is recommended to calculate the theoretical amount of air for the fuel composition and control in real time the amount of air sent to the boiler. It will also reduce the power used by auxiliaries. However, as it is in fact impossible to continuously analyze the composition of the fuel. A practicable method would be to analyze the composition of fuel when it is received and feed about 10% more air than the theoretical amount of air. This would ensure perfect combustion and reduce CO emissions to zero.

5.2.3 Maintenance and Repair Plan

(1) Current State of Maintenance and Repairs

Maintenance and repair work at the DC “TASHTPP” follows guidelines called "Regulations on Conducting Maintenance and Repair Works of Power Plant Equipment." 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	165	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	

Remark: 1.Unit No.9 - Rewind of Stators of Generator
2.Unit No.11- Opening of Turbine casing

Chief Engineer	Mr. Eolyan L.A.
Chief Engineer of "Uzbekenergotamir" 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 number of days allotted for the three types of maintenance and repair work is seventy, thirty and twenty-one days, respectively. This duration can increase depending on the work to be done. 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 (see the organizational chart in Figure 5.4-1). The finally approved work plan for 2003 is shown in Figure 5.2-4.

As described above, the primary purpose of the maintenance and repair work performed at the DC "TASHTPP" is literally maintenance and repair. It seems that there is a slight difference in thinking between this approach and the periodic inspections carried out in Japan's thermal power plants. At the DC "TASHTPP", there is an inspection manual, and problem areas 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

As discussed in 5.2.3, (1), periodic maintenance work is performed at the DC "TASHTPP" roughly every two years. It is possible and would not create any problems, in terms of the timing or duration of maintenance and repair work, for data for preventive maintenance to be collected according to the DC "TASHTPP" existing maintenance and repair schedule.

For the equipment requiring preventive maintenance, an inspection appropriate to the degree of deterioration should be started during the Capital Repair period, which is longer than the others, or the Extended Current Repair period, which can be extended as needed. Efforts should be made to assess the locations of deterioration.

In addition to the above, 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 a maintenance and repair schedule that follows the periodic maintenance and repair schedule for unit 6, and includes measures to upgrade, repair and inspect the equipment discussed above.

- During the 2005 Capital Repairs
  - (a) Renovate the vacuum ejector.
  - (b) Introduce condenser tube washing equipment (used by all units).
  - (c) Repair air leaks around the condenser (vacuum, steam pipes and valves).
  - (d) Perform detailed inspection of primary equipment such as the boiler and turbine, as well as the auxiliary equipment and main valves.
- During the 2007 Extended Current Repairs
  - (a) Repair the air and gas leaks around the boiler.
  - (b) Repair the seal of the air heater.
  - (c) Renovate adjustment valves and control equipment.
  - (d) 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 (especially, give priority to reinforcing weak parts of boiler tubes)
- During the 2009 Midterm Repairs
  - (a) Renovate the air heater element.
  - (b) Flameproof the electrical parts around the boiler.
  - (c) Repair leaks in the water and steam systems.
  - (d) Repair the insulating sheets for the hot water and steam systems.
  - (e) Repair walkways and handrails.
  - (f) Add lighting.

(3) Repair Work Cost Calculations

Rough outlines of the cost calculations for the renovation, maintenance and inspection work to be carried out according to the maintenance and repair plan described in (2)) are provided below, for each of the years in which maintenance is to be performed.

Table 5.2-3 2005 Periodic Maintenance Costs

Item	Cost (in millions of yen)
a) Renovate vacuum ejector	25
b) Introduce condenser tube washing equipment	12
c) Repair air leaks around condenser	10
d) Perform detailed inspection of primary equipment, auxiliary equipment and main valves	8
Subtotal (foreign currency, domestic currency)	55 (42, 13)
Contingency	2.8(2.1, 0.7)
Consultant	2.3(2.3, 0)
Total	60.1(46.4, 13.7)

Table 5.2-4 2007 Periodic Maintenance Costs

Item	Cost (in millions of yen)
a) Repair air and gas leaks around boiler	10
b) Repair air heater seal	3
c) Renovate adjustment valves and control equipment	50
d) Repair and renovate equipment identified in previous inspection	50
Subtotal (foreign currency, domestic currency)	113(90, 23)
Contingency	5.7(4.5, 1.2)
Consultant	4.7(4.7, 0)
Total	123.4(99.2, 24.2)

Table 5.2-5 2009 Periodic Maintenance Costs

Item	Cost (in millions of yen)
a) Renovate air heater element	50
b) Flameproof electrical parts around boiler	8
c) Repair leaks in water and steam systems	5
d) Repair insulating sheets for hot water and steam systems	6
e) Repair walkways and handrails	4
f) Add lighting	3
Subtotal (foreign currency, domestic currency)	76(50, 26)
Contingency	3.8(2.5, 1.3)
Consultant	3.2(3.2, 0)
Total	83.0(55.7, 27.3)

5.2.4 Financial Analysis of Maintenance Plan

(1) Maintenance in Financial Value

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 (3) 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.

The maintenance cost saving may cause a risk to cause an effect to make lower availability and reliability of the facility. Even if the facility capacity is maintained, it does not mean a good maintenance that the facility availability and reliability is low. If some parts of the plant become broken, it sometimes results in outage. Outage of the facility is a loss of revenue and a financial damage. Availability and reliability of older units are lower than those of younger units. Should a unit has not been well maintained, it causes many troubles to result in lower availability and reliability. Reasonable maintenance cost should be allowed so that all parts of the facility would work to fulfill their function. If generation cost of facility including maintenance cost becomes higher than that of a new power plant, it is judged that a new power plant should be built to replace the existing power plant.

Further issue is a value of facility. 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. If 2 units out of the existing 12 units are to be replaced by the new 370MW combined cycle power plant, then all 12 units have to be maintained to work for further 3 – 4 years till completion of the new power plant. For this purpose, maintenance cost is considered to be out of question or can be considered reasonable to spend an amount equivalent to a cost to provide the same generation cost by the new 370MW combined cycle power plant. Sum 4,000 million per unit (Sum 48billion for 12 units) is calculated at 5.5.5 (2).

As mentioned in 5.3.1 (1) 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.

(2) Improvement of Thermal Efficiency

Table 5.2-5 shows annual fuel cost saving against thermal efficiency improvement per unit.

Table 5.2-5 Annual Fuel Cost Saving against Thermal Efficiency Improvement per Unit

Unit: thousand Sum

Efficiency Improvement	Equivalent Heat Rate Improvement (Kcal/kWh)	Fuel Price excluding VAT(Sum/1000kCal)					
		1.6	1.8	2.0	2.2	2.4	2.6
0.1%	7.8	10,657	11,989	13,321	14,653	15,985	17,317
0.2%	15.5	21,048	23,679	26,310	28,940	31,571	34,202
0.3%	23.1	31,377	35,299	39,221	43,143	47,065	50,987
0.4%	30.6	41,645	46,851	52,056	57,262	62,467	67,673
0.5%	38.1	51,853	58,334	64,816	71,297	77,779	84,260
0.6%	45.6	62,000	69,750	77,500	85,250	93,000	100,750
0.7%	53.0	72,088	81,099	90,110	99,121	108,132	117,143
0.8%	60.4	82,117	92,382	102,646	112,911	123,175	133,440
0.9%	67.7	92,087	103,598	115,109	126,620	138,131	149,642
1.0%	75.0	102,000	114,750	127,500	140,250	153,000	165,750
1.1%	82.2	111,855	125,837	139,819	153,801	167,783	181,764
1.2%	89.5	121,653	136,860	152,066	167,273	182,480	197,686

(Note) Annual Generation is assumed as 850MWh/year.

Sum 1.7/1000kCal fuel price is equivalent to current price on assumption that gas and heavy fuel oil ratio is 70% and 30% and that gas price including VAT is Sum 15.5/m3 and oil price including VAT is Sum 25,000/ton.

1% thermal efficiency improvement produces fuel cost saving 100 million Sum per year. If thermal efficiency improvement continues for 5 years, the saving becomes 500 million Sums. When fuel cost is supposed to rise in future, the saving becomes larger. Table 5.2.4-1 shows the saving at several unit costs for fuel.

(3) Financial Analysis on the Maintenance Plan at 5.2.3, (2)

At 5.2.3, (2) example cases of maintenance plans are indicated. In this sub-paragraph these plan are studied in financial views.

a. Capital Repair in 2005

The maintenance and repair plan in 2005 (the "Capital Repair 2005") aims to improve a vacuum level in condenser, which shows higher value than that of design value. An improvement of thermal efficiency is expected. Financial benefit of thermal efficiency improvement is shown at the Table 5.2.4-1. If one percent improvement is achieved, benefit is expected to be produced in Sum 100 million per year.

A rough estimation of cost of the Capital Repair 2005 is Sum 500 million. In this assumption, it takes 5 years to recover the cost. However, if fuel cost was assumed to rise in future, the period to recover the cost would become shorter. Further, the Capital Repair 2005 is considered to contribute in availability and reliability improvement of the parts under the Capital Repair 2005. If 50% of the cost is assumed for availability and reliability improvement, the cost for thermal efficiency improvement can be considered to be recovered within 2 or 2.5 years.

It also can be considered that the thermal efficiency may continue to decrease, if the Capital Repair 2005 is not performed. In this assumption, the Capital Repair 2005 is necessary in relation to ageing of the unit. Maintenance for ageing recovery is necessary, though ageing itself cannot be prevented.

As mentioned at 5.2-5, Sum 12,838 million may be allowed as the maximum maintenance fee per year in addition to present maintenance fee. The amount per unit is Sum 1 billion, which is bigger than the rough cost estimate. A result will be evaluated after completion of the Capital

Repair 2005. If it is considered good result, the same maintenance to remaining 11 units can be performed. The cost being rough estimate can be reduced by detailed study by DC "TASHTPP".

It is suggested to make a further study on the Capital Repair 2005.

b. Extended Current Repair 2007

The maintenance and repair plan 2007 (the "Extended Current Repair 2007") aims to improve auxiliaries power consumption so that the net plant efficiency would be improved. However, effect of the Extended Current Repair 2007 would be larger in ageing mitigation including availability and reliability improvement than it for thermal efficiency improvement.

In the Extended Current Repair 2007, repair of the air heater has a close relationship with burning heavy fuel oil, for which more maintenance is required than that for gas burning. Existing 12 units at DC "TASHTPP" is contributing in supply and demand situation of oil and gas during winter in Uzbekistan. It is important to secure high availability and reliability for use of heavy fuel oil in winter. Though thermal efficient improvement by the Extended Current Repair 2007 may be 0.2 – 0.3%, the benefit for oil burning security is considered to be large.

Cost for the Extended Current Repair 2007 is roughly estimated as Sum 1,000 million. The financial benefit of thermal efficiency improvement would be Sum 20-30 million per year at current price. The maintenance relating to use of heavy fuel oil is necessary cost which cannot be avoid. Maintenance of auxiliaries is also important. Other factor of the Extended Current Repair 2007 is considered for ageing mitigation and for securing availability and reliability. This type of maintenance under the Extended Current Repair is not required to be performed every year. Sum 1,000 million can be recovered in several years of the maintenance cycle. An annual cost of the Extended Current Repair can be divided by the maintenance cycle period.

Maintenance of auxiliaries is important. A maintenance plan to secure availability and reliability is suggested to be established. The cost estimate may be lower or bigger than Sum 1,000 million depending on a scope of auxiliaries for maintenance performed. In recognizing that DC "TASHTPP" is contributing important role, development of maintenance plant is necessary.

c. Midterm Repair 2009

The maintenance and repair plan 2009 (the "Midterm Repair 2007") includes more general maintenance and repair than those under the Capital Repair 2005 and the Extended Current Repair 2007. In other words the Midterm Repair is considered to be necessary to secure availability and reliability. As mentioned at 5.2.4, (1), availability and reliability of the facility is important. Quality of maintenance has a close relationship with the expenses spent for the maintenance. Saving of maintenance expenses may cause a risk to loose revenue due to low availability and reliability. If some parts are found to be unreliable, those have to be replaced in the following maintenance outage.

It may require a big investment, if a big repair, replacement or refurbishment is performed for extending life of the existing units. The study on the refurbishment is necessary to be studied. On the other hand, there are many maintenance and repair to be performed for maintaining the availability and reliability, and those maintenance and repair are expected also to contributing in securing the life. For the existing 12 units of 30-40 years old, the maintenance and repair to maintain availability and reliability is very important.

Cost for the Midterm Repair 2009 is estimated roughly as Sum 700 million. The financial contribution per unit is assumed as Sum 1,000 million as mentioned at 5.2.4.1. In comparison of Sum 1,000 million with the Sum 700 million, which is considered to be spent every year, the cost for the Midterm Repair 2009 would be lower. The Midterm Repair 2009 does 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 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."