No.

独立行政法人
国際協力機構

ウズベクエネルゴ電力公社
(State Joint Stock Company "Uzbekenergo")

ウズベキスタン国 タシケント火力発電所 近代化事業詳細設計調査

ファイナルレポート
(別冊)

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ウズベキスタン国タシケント火力発電所近代化事業詳細設計調査

ファイナルレポート(別冊)

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Japan International Cooperation Agency (JICA)
State Joint Stock Company "Uzbekenergo"

The Comparison Study on Type of Shaft Arrangement of 370MW combined Cycle Power Plant

Document No. TMP-0008

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Tokyo Electric Power Services Co., Ltd.

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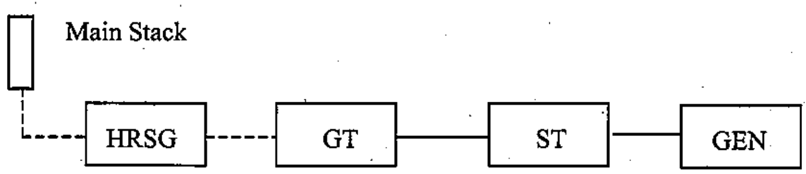
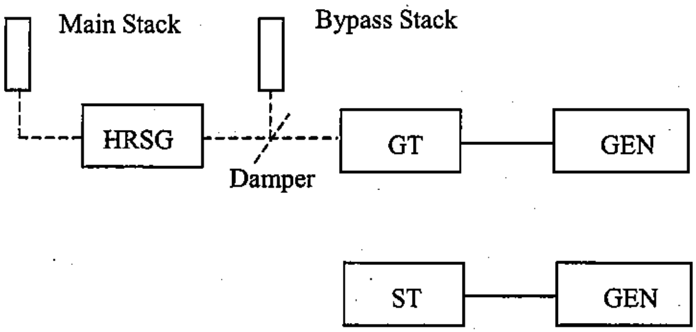
Comparison Study on the Shaft Arrangement

Here made is the comparison study on the type of the shaft arrangement of the combined cycle power plant comprised of the one (1) same model of gas turbine. Basically, there are two (2) types of shaft arrangements. One is called single-shaft arrangement where the gas turbine, a steam turbine and a generator are connected on the same shaft. The other is called multi-shaft arrangement where the gas turbine/generator shaft and the steam turbine/generator are separate. The following figures show the both types of shaft arrangements:

Single-shaft combined cycle power plant



Multi-shaft combined cycle power plant



As shown above, in case of the multi-shaft arrangement a generator and a bypass stack with a damper are additionally necessary.

The comparison study is performed from the viewpoints of operability, thermal efficiency, operating availability, maintainability, installation area requirement and construction cost.

1. Operability

In case of the shingle-shaft arrangement, the power plant could not be operated unless the components of the gas turbine, the heat recovery steam generator and the generator are all healthy.

On the other hand, in case of the multi-shaft arrangement, even if any components of the heat recovery steam generator, the steam turbine, and the steam turbine generator are out of service due to any reasons, the gas turbine/generator could be operated as a simple cycle provided that the exhaust gas from the gas turbine is discharged into atmosphere through the bypass stack.

Thus, the operability of multi-shaft combined cycle power plant is more flexible than the single-shaft combined cycle power plant. The combined cycle power plant could be operated only by adjustment of the fuel flow into the gas turbine, so that there is no difference with the operation between both types of power plants. Such things as stated above are reasons why the multi-shaft combined cycle power plants are commonly employed in the developing countries for continuous base load operation

Moreover, in case of the multi-shaft combined cycle power plant, two-stage construction could be also expected. That is to say, there is an advantage that the gas turbine/generator will be put into service at the former stage because the completion period is shorter, and the bottoming cycle equipment will be constructed at the latter stage to meet the increment of the power demand.

In case of the single-shaft combined cycle power plant, the auxiliary steam for cooling, sealing and hogging is required because the steam turbine has to be accelerated with start-up of the gas turbine. For the purpose, an auxiliary boiler will be needed unless the steam is available from external sources. While, such steam is not needed for start-up of the multi-shaft combined cycle power plant because the steam turbine will be started up after the necessary steam is available from the heat recovery steam generator. However, the start-up time to the full load of the multi-shaft combined cycle power plant will be longer because of sequential start-up of the gas turbine and the steam turbine.

2. Experience with Both Types of Shaft Arrangements

As shown in the attached Tables 1 and 2, there are much application experiences with both shaft types of combined cycle power plants. It is understood that both types of shaft arrangements are technically feasible without any difficulties.

3. Thermal Efficiency

The single-shaft combined cycle power plant is equipped with one (1) large size generator, while two (2) small size of generators are employed in the multi-shaft combined cycle power plant. Therefore, the thermal efficiency of the single-shaft combined cycle power plant is theoretically higher by the difference of the generator efficiencies between both plants. However, the difference is negligibly small.

4. Operating Availability (Probability)

The operating availabilities of both power plants are calculated on the assumption that the reliabilities of components are as shown below:

Gas turbine:	$A_1 = 97.5\%$
Heat recovery steam generator	$A_2 = 99.0\%$
Steam turbine	$A_3 = 98.5\%$
Gas turbine generator and transformer	$A_4 = 99.7\%$
Steam turbine generator and transformer	$A_5 = 99.7\%$

The impact on the operating availability due to the maintenance is not considered for this comparison because it is not envisaged that there exists the significant difference between the operating availabilities of both power plants.

The followings are the theoretically calculated operating availabilities on an hour basis of the single-shaft combined cycle power plant as OAH_S and the multi-shaft combined cycle power plant as OAH_M.

$$OAH_S = A_1 \times A_2 \times A_3 \times A_4 = 0.975 \times 0.990 \times 0.985 \times 0.997 = 0.948 = 94.8\ \%$$

$$OAH_M = A_1 \times A_2 \times A_3 \times A_4 \times A_5 + A_1 \times A_4 (1 - A_2 \times A_3 \times A_5)$$

$$= 0.975 \times 0.990 \times 0.985 \times 0.997 \times 0.997 + 0.975 \times 0.997(1 - 0.990 \times 0.985 \times 0.997)$$

$$= 0.945 + 0.027 = 0.972 = 97.2\ \%$$

The figure of 94.5% out of the operating availability (97.2%) of the multi-shaft combined cycle power plant shows the operating availability where the power plant will be wholly operated. While, the figure of 2.7% is the operating availability (probability) where only the gas turbine/generator will be operated.

As far as the operating availability on an hour basis is concerned, the multi-shaft combined cycle power plant is higher by 2.4%(=97.2 - 94.8) than the single-shaft combined cycle power plant.

Similarly, the operating availabilities on an energy basis of both types of plants are can be theoretically calculated as follows:

Single-shaft combined cycle power plant:	94.8%
Multi-shaft combined cycle power plant:	96.3%

Where, the ratio of the gas turbine power output is assumed to be two third (2/3) of the power plant.

As the results, the operating availability on an energy basis of the multi-shaft combined cycle power plant is higher by 1.5% (=96.3 - 94.8) than the single-shaft combined cycle power plant.

5. Maintainability

Compared with the single-shaft combined cycle power plant, the multi-shaft combined cycle power plant is equipped with additional components such as a bypass stack, a bypass stack silencer, an exhaust gas damper, a generator, a step-up transformer, a lubricating oil system and a control oil system. Therefore, it is easily envisaged that the maintenance of the multi-shaft combined cycle power plant needs more man-hour requirement and is costly.

6. Installation Area Requirement

The requirement area for installation of one (1) unit of single-shaft combined cycle power plant is 69,000m^2 (60m by 115m) as shown in the attached Figure 1 "Typical Layout of Single-shaft Type". While 86,250m^2 (75m by 115m) is required for one (1) unit of multi-shaft combined cycle power plant with 25% of requirement area increase as shown in the attached Figure 2 "Typical Layout of Multi-shaft Type". However, one (1) unit of multi-shaft combined cycle power plant can be installed on the given site area without any difficulties.

7. Construction Cost

The multi-shaft combined cycle power plant is constituted of more components as mentioned in above clauses. Therefore, the construction cost will increase compared with the single-shaft combined cycle power plant. The attached Table 3 shows the tentative cost comparison between the multi-shaft type and single-shaft type. As shown in the table, the cost of the former is higher by some 4 % than the latter. The detailed cost comparison will be made through the Study.

8. Generation Cost

The generation cost of the single-shaft combined cycle power plant is estimated at 2.13 US cents in Table 13-2 of Feasibility Stage Report. While that of the multi-shaft combined cycle power plant can be calculated as follows:

(1) Fuel cost

Fuel cost is increased by 2.4 % due to the improvement of the operating availability on an hour basis. Therefore, the fuel cost is calculated at 41.28 MMUS$ (= 40.313 × 1.024).

(2) Operating and maintenance cost

If the fixed maintenance cost is proportional to the construction cost and the variable maintenance cost is proportional to the operating availability, the operating and maintenance cost can be calculated as follows referring to 3) of Clause 13.1.3 of the Report.

$1.8 \times 1.041 + 1.8 \times 1.024 + 0.091 + 1 = 4.81$MMUS$

(3) Capital cost

Since the capital cost is proportional to the construction cost, it is calculated at 41.28MMUS$ (40.313 × 1.04).

(4) Energy sales

Since the energy sales is proportional to the operating availability on an energy basis, it is calculated at 2,558MMkWh (2,520 × 1.015).

Therefore, the generation cost of the multi-shaft arrangement power plant is estimated at 2.16 US cents/kWh (= (41.28+4.81+41.28) × 100/2,558)

9. Conclusion

Above study results are summarized as described below:

(1) Operability

The operability of multi-shaft combined cycle power plant is more flexible than the single-shaft combined cycle power plant because the gas turbine/generator could be operated as a simple cycle even if any components of the heat recovery steam generator, the steam turbine, and the steam turbine generator are out of service due to any reasons.

Moreover, in case of the multi-shaft combined cycle power plant, two-stage construction could be also expected.

(2) Experience

As shown in attached Tables 1 and 2, there is much experience with both types of combined cycle power plants. Therefore, both types can be deemed technically proven.

(3) Thermal Efficiency

The difference of the thermal efficiencies between both types of combined cycle power plants is negligibly small.

(4) Operating Availability

The hour and energy basis operating availabilities of both power plants are as calculated as below:

	Single-shaft	Multi-shaft
Hour basis operating availability	Base (1.0)	1.024
Energy basis operating availability	Base (1.0)	1.015

(5) Maintainability

The maintenance of the multi-shaft combined cycle power plant needs more man-hour requirement and is costly.

(6) Installation Area Requirement

The multi-shaft combined cycle power plant needs more installation area, but can be installed on the given area without any difficulties.

(7) Construction Cost

It is estimated that the construction cost of the multi-shaft combined cycle power plant is higher by approximately 4% than that of the single-shaft one. The detailed cost estimation of both types of combined cycle power plants will be made through the Study, but it is foreseen that either of their costs will be settled in the specified budget cost.

(8) Generation Cost

The generation cost of the multi-shaft combined cycle power plant is estimated at 2.16 US cents/kWh compared with 2.13 US cents/kWh of the single-shaft combined cycle power plant described in the clause 13.2.4 of Feasibility Study Report. The generation cost difference is approximately 1.4%.

As described above, there is no significant difference between the single-shaft and multi-shat combined cycle power plants.

We understand that the type of the shaft arrangement of the combined cycle power plant to be introduced in Tashkent Thermal Power Plant will be determined depending on the intent of Uzbekistan side.

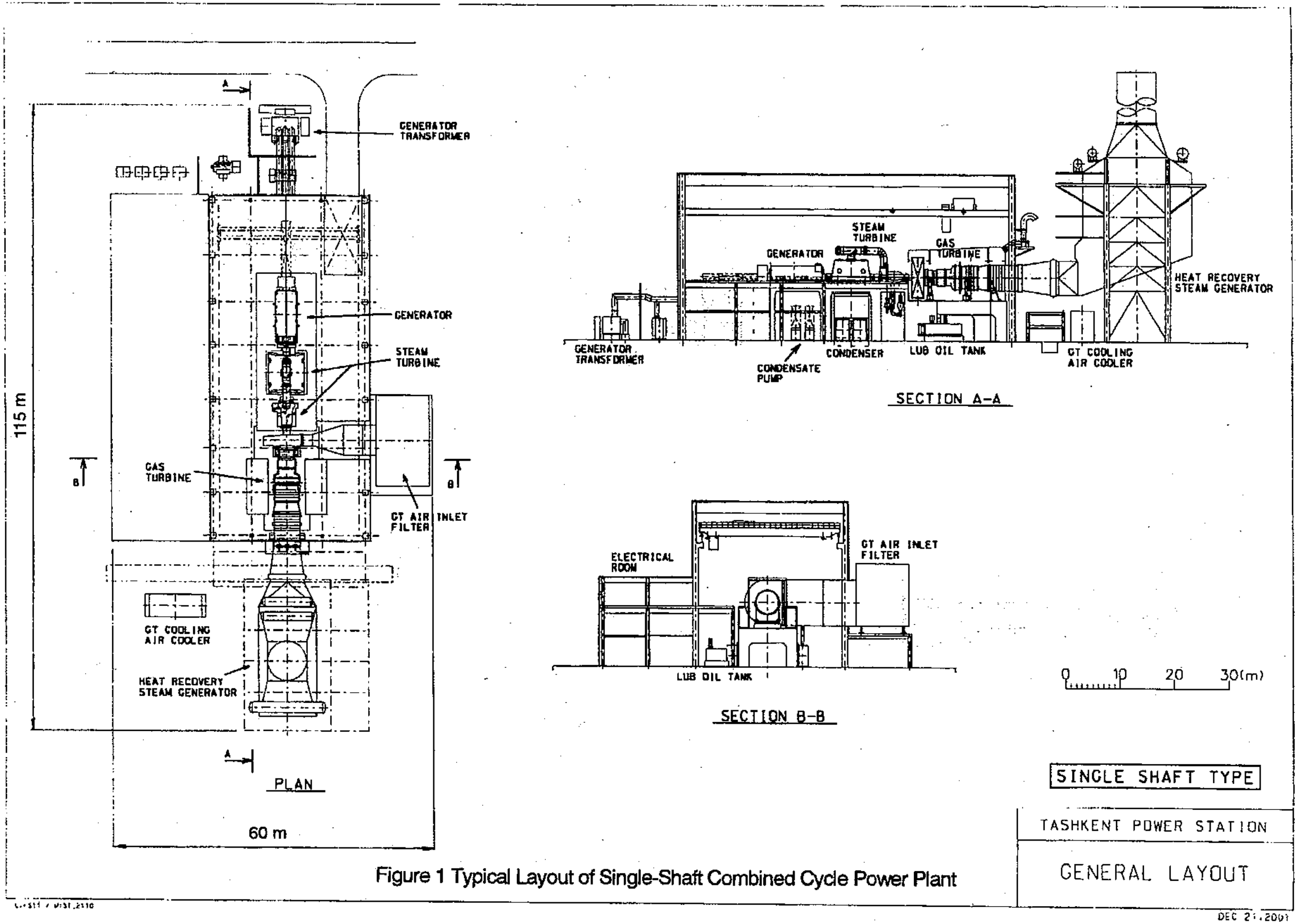


Figure 1 Typical Layout of Single-Shaft Combined Cycle Power Plant

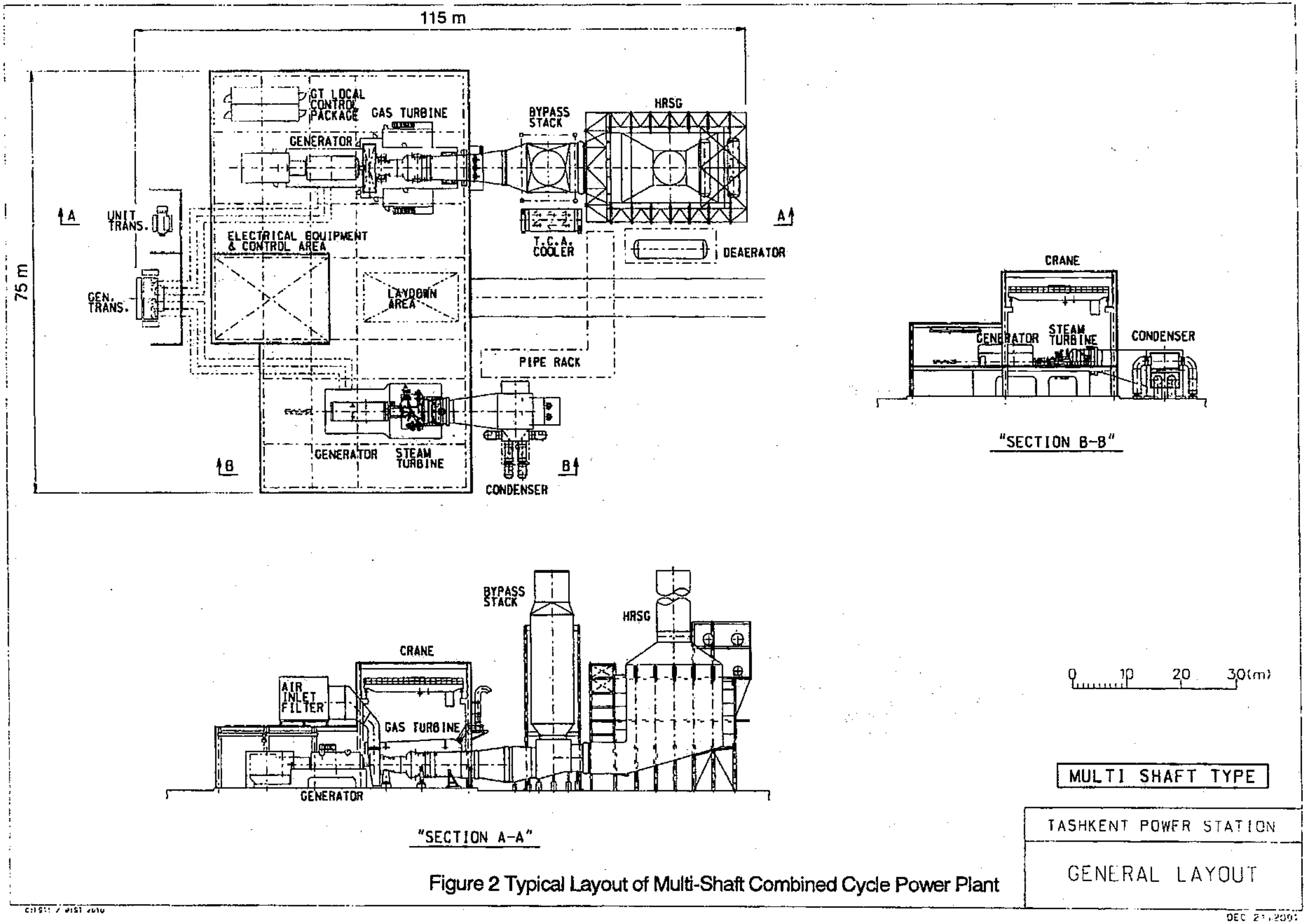


Figure 2 Typical Layout of Multi-Shaft Combined Cycle Power Plant

Table 1 Single-shaft Combined Cycle Power Plant (above 100MW) Experience

Model	Plant Name	Country	Operation Year	Unit Capacity	No. of Unit
ABB					
KA26	Staythorpe	UK	2003	400	4
KA24	Monterrey	Mexico	2003	250	4
KA26	San Roque	Spain	2002	400	2
KA26	B sos	Spain	2002	400	2
KA26	Bowin	Thailand	2002	350	2
KA26	Chiba	Japan	2002	400	1
KA26	Swanbank	Austraria	2002	380	1
KA26	Bang Bo	Thailand	2002	350	1
KA26	Castejan	Spain	2002	380	1
KA24	Termobahia	Brazil	2002	185	1
KA24	Termorio	Brazil	2002	185	1
KA24	Hermosillo	Mexico	2001	253	1
KA24	Milford	USA	2001	265	2
KA24	Bellingham	USA	2001	265	2
KA26	Enfield	UK	1999	396	1
KA24	Agawan	USA	1999	271	1
KA11N2	Dighton	USA	1999	168	1
KA26	Taranaki	NZ	1998	360	1
KA26	RDK-4S	Germany	1998	360	1
KA13E2	AP11GCC	Italy	1998	275	1
KA11N2	Bao Shan	China	1997	150	1
KA13E2	Meishi II	China	1996	237	1
KA13E2	Diemen 33	NZ	1995	160	1
KA11N	West Winsor	Canada	1995	120	1
KA13E2	Lage Weide 6	NZ	1994	248	1
KA13D	Deep	Dubai	1993	135	1
KA11N	Orland	USA	1993	120	1
KA13E	Roosecote	UK	1991	224	1
KA11	Hazleton	USA	1989	135	1
KA13E	MK 12	NZ	1989	225	1
KA13E	Hemweg	NZ	1988	200	1
KA13D	Korneuburg	Austria	1980	128	1
TOTAL					***43***
GE					
STAG 109 FA	Shinagawa	Japan	2001-2003	380	3
STAG 109 FA	Chiba	Japan	1998	360	4
STAG 109 FA	Akzo	NZ	1998	360	1

Model	Plant Name	Country	Operation Year	Unit Capacity	No. of Unit
GE					
STAG 106FA	Baffolora	Italy	1998	110	1
STAG 107FA	Kawagoe	Japan	1998	235	7
STAG 109 FA	Yokohama	Japan	1997	350	8
STAG 107FA	Hermiston	USA	1996	213	2
STAG 107FA	Cogentrix	USA	1996	248	1
STAG 109FA	Gent	Belgium	1996	350	2
STAG 109FA	Black Point	China	1995	340	8
STAG 109FA	EPON	Netherland	1995	350	5
STAG 107F	Connah's Quey	UK	1995	350	4
STAG 107EA	Shin-Oita	Japan	1992	138	5
STAG 107F	Yanai	Japan	1990	125	6
STAG 107E	Yokkaichi	Japan	1988	112	5
STAG 109E	Futtsu	Japan	1986	165	14
TOTAL					***76***
MHI					
MPCP1(M701F)	Serervaya	Azerbaijan	2002	438	1
MPCP1(M701F)	Harripur	Bangladesh	2001	365	1
MPCP1(M701F)	Tuas II	Singapore	2001	360	2
MPCP1(M701F)	PPN	India	2001	348	1
MPCP1(M701F)	Saltend	UK	2000	400	3
MPCP1(M701F)	San Ishidro	Chile	1998	370	1
MPCP1(M701F)	Chiba	Japan	1999	360	4
MPCP1(M701D)	JR Kawasaki	Japan	1999	190	1
MPCP1(M501F)	Nanpu	Taiwan	2003	251	1
MPCP1(M501F)	Trans Alta	Mexico	2002	282	1
MPCP1(M501D)	Hunamachi	Japan	1999	149	1
MPCP1(M501F)	Shin-Ohita	Japan	1997	218	2
MPCP1(M501F)	Kawagoe	Japan	1997	243	7
MPCP1(M701D)	STEAG	Netherland	1997	145	1
MPCP1(M501F)	Shin-Ohita	Japan	1996	218	2
MPCP1(M501D)	Fukuyama	Japan	1996	145	1
MPCP1(M501D)	Mizushima	Japan	1995	145	2
MPCP1(M701D)	Kawasaki Steel	Japan	1988	145	1
TOTAL					***33***
Siemens					
GUD 1S. V94.3A	Campo de Gibraltar	Spain	2003	385	2
GUD 1S. V94.3A	Pulau Seray	Singapore	2002	370	2
GUD 1S. V84.3A	San Lorenzo	Philippines	2002	250	2

Model	Plant Name	Country	Operation Year	Unit Capacity	No. of Unit
Siemens					
GUD 1S. V94.3A	Donaustadt	Austria	2001	385	1
GUD 1S. V64.3A	San Pedro	Domonican	2001	100	3
GUD 1S. V64.3A	Rzeszow	Poland	2001	100	1
GUD 1S. V94.3A	Seabank 2	U.K	2000	385	1
GUD 1S. V64.3A	Terni	Italy	2000	100	1
GUD 1S. V94.3A	Cottam	UK	1999	380	1
GUD 1S. V84.3A	Santa Rita	Philippine	1999	260	4
GUD 1S. V94.3A	Otahuhu	NZ	1998	260	1
GUD 1S. V84.3A	St. Fransis	USA	1998	260	2
GUD 1S. V94.3A	Quteiro	Portugal	1996	260	3
GUD 1S. V94.3	King's Lynn	U.K	1996	340	1
GUD 1S. V94.2	Buggenum	Netherlands	1993	280	1
TOTAL					***26***

Table 2 3,000rpm Multi-Shaft Combined Cycle Power Plant Experience (1/3)

Model	Plant Name	Country	Operation Year	Configuration	Unit Capacity(MW)	No. of Unit	Type of Fuel
ABB							
KA26-1	RDK Karlsruhe	DE	1997	1 on 1	360	1	NG/DO
KA26-2	Rocksavage	UK	1997	2 on 1	720	1	NG
KA26-2	Dock Sud	AR	2000	2 on 1	775	1	NG/DO
KA26-2	Coryton	UK	2001	2 on 1	775	1	NG/DO
KA26-1	Senoko	SG	2001	1 on 1	400	1	NG/DO
Total						*5*	
GE							
S209FA	Keadby	UK	1995	2 on 1	780	2	NG
S209FA	Little Barford	UK	1996	2 on 1	780	2	NG
S209FA	AES Medway	UK	1996	2 on 1	780	2	NG
S209FA	South Bangkok II	TH	1997	2 on 1	780	2	NG/DO
S109FA	Gent-Ringvaart	BE	1998	1 on 1	390	1	NG
S109FA	Nueva Renca	CL	1998	1 on 1	390	1	NG/DO
S109FA	Saint-Ghislain	BE	1999	1 on 1	390	1	NG
S209FA	Dabhol Power	IN	1999	2 on 1	780	2	NG/DO
S209FA	Rachaburi	TH	2000	2 on 1	780	1	NG/DO
S209FA	Tri Energy	TH	2000	2 on 1	780	2	NG/DO
S209FA	Sutton Bridge	UK	2000	2 on 1	780	2	NG
S209FA	Rachaburi	TH	2000	2 on 1	780	4	NG/DO
S109FA	Pulau Sakra	SG	2000	1 on 1	390	1	NG/DO
S109FA	Esch-Sur-Alzette	LX	2001	1 on 1	390	1	NG/DO
S209FA	Dabhol Power	IN	2001	2 on 1	780	4	NG/DO
S209FA	Castellon	SP	2001	2 on 1	780	2	NG/DO
Total						*30*	

Table 2 3,000rpm Multi-Shaft Combined Cycle Power Plant Experience (2/3)

Model	Plant Name	Country	Operation Year	Configuration	Unit Capacity(MW)	No. of Unit	Type of Fuel
MHI							
MPCP2(M701F)	EGAT Wang Noi I	TH	1997	2 on 1	650	2	NG/DO
MPCP2(M701F)	EGAT Wang Noi II	TH	1998	2 on 1	720	1	NG/DO
MPCP1(M701F)	San Isidro	CL	1998	1 on 1	370	1	NG/DO
MPCP2(M701F)	TEAS Bursa	TK	1999	2 on 1	700	2	NG
MPCP2(M701F)	Costanera	AR	1999	2 on 1	830	1	NG/DO
MPCP3(M701F)	Phu My I	VN	2001	3 on 1	1,090	1	NG/DO
MPCP2(M701F)	AES Parana	AR	2001	2 on 1	740	1	NG/DO
MPCP1(M701F)	AES Haripur	BAN	2001	1 on 1	360	1	NG
MPCP1(M701F)	PPN	IN	2001	1 on 1	360	1	NG/Naphtha
MPCP2(M701F)	Damhead	UK	2001	2 on 1	790	1	NG
MPCP2(M701F)	Port Dickson	ML	2004	2 on 1	730	1	NG/DO
MPCP2(M701F)	Cairo North	EGY	2004	2 on 1	750	1	NG/DO
Total						***14***	
Siemens							
GDU 1. 94.3A	Lujan De Cuyo	AR	1998	1 on 1	380	1	NG/DO
GDU 1. 94.3A	Nehuenco	CH	1998	1 on 1	380	1	NG/DO
GDU 2. 94.3A	Didcot	UK	1998	2 on 1	760	1	NG
GUD 2. 94.3A	Genelba	AR	1999	2 on 1	760	1	NG/DO
GUD 3. 94.3A	Al Taweelah	UAE	2000	3 on 1	1,155	2	NG/DO
GUD 3. 94.3A	Peterhead	UK	2000	3 on 1	1,155	1	NG
GUD 2. 94.3A	Seabank	UK	2000	2 on 1	770	1	NG
GUD 2. 94.3A	Salta	AR	2000	2 on 1	770	1	NG/DO
GUD 3. 94.3A	Al Taweelah	UAE	2001	3 on 1	1,155	2	NG/DO
GDU 1. 94.3A	Porto Marghera	IT	2001	1 on 1	385	1	NG
GDU 1. 94.3A	Verbrande Brug	BE	2001	1 on 1	385	1	NG
GDU 1. 94.3A	–	GR	2001	1 on 1	385	1	NG
GUD 3. 94.3A	Jebel Alik	UAE	2002	3 on 1	1155	2	NG/DO

Table 2 3,000rpm Multi-Shaft Combined Cycle Power Plant Experience (3/3)

Model	Plant Name	Country	Operation Year	Configuration	Unit Capacity(MW)	No. of Unit	Type of Fuel
GUD 1. 94.3A	La Casella	IT	2002	1 on 1	385	5	NG
GUD 1. 94.3A	Hunstown PWR Stat	IR	2002	1 on 1	385	1	NG
GUD 2. 94.3A	Teluk Gong	ML	2002	2 on 1	770	1	NG/DO
GUD 2. 94.3A	Phu My 3	VN	2003	2 on 1	770	1	NG/DO
GUD 2. 94.3A	Knapsack	GR	2004	2 on 1	770	1	NG
GUD 2. 94.3A	Rijnmond	NL	2004	2 on 1	770	1	NG
Total						*26*	

Table 3 Consuruction Cost Comparison

Name of Components	Single-Shaft Combined Cycle Power Plant			Multi-Shaft Combined Cycle Power Plant		
	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion	Total
Gas Turbine & Accessaries	41,625	3,963	45,588	51,725	4,925	56,650
Generator & Accessories-Gas Turbine	28,776	2,986	31,762			
Steam Turbine & Accessaries				21,805	2,263	24,068
Generator & Accessories-Steam Turbine						
Electrical Systems-Gas Turbine/Generator	1,250	234	1,484	4,322	716	5,038
Electrical Systems-Steam Turbine Generator	5,945	1,189	7,134	3,389	678	4,067
High Voltage Switchyard	2,273	682	2,955	2,386	716	3,102
HRSG & Accessories	18,805	4,870	23,675	18,805	4,870	23,675
Condenser & Accessories	3,421	416	3,837	3,421	416	3,837
Circulating Water System	2,060	1,488	3,548	2,060	1,488	3,548
Water Treatment System	836	621	1,457	836	621	1,457
Waste Water Treatment System	191	94	285	191	94	285
Closed Cooling Water System	527	210	737	527	210	737
Buildings	13,222	8,101	21,323	13,222	8,101	21,323
Fire Protection Ststem	778	500	1,278	778	500	1,278
Fuel Gas Pre-treatment & Compressor Stn.	7,080	2,994	10,074	7,080	2,994	10,074
Bypass Stack & Diverter Damper	0	0	0	2,069	650	2,719
Station & Instrument Air System	510	119	629	510	119	629
Plant Contor and Monitoring System	2,186	296	2,482	2,186	296	2,482
Continuous Emission Monitoring System	503	319	822	503	319	822
Sub-Total	129,988	29,082	159,070	135,815	29,976	165,791
Training of Client's Staff at Factory	153	0	153	153	0	153
Supervisory by Engineers for One (1) Year	878	0	878	878	0	878
Transportation to Site	10,399	0	10,399	10,865	0	10,865
Spare Parts	12,999	0	12,999	13,582	0	13,582
Sub-Total	154,417	29,082	183,499	161,293	29,976	191,269
Price Escalation(3.5%)	5,513	1,038	6,551	5,758	1,070	6,828
Sub-Total	159,930	30,120	190,050	167,051	31,046	198,097
Physical Contingency(8%)	12,794	2,410	15,204	13,364	2,484	15,848
Consulting Service including P/S(3%) & P/C(5%)	4,700	700	5,400	4,700	700	5,400
Grand Total	177,424	33,230	210,654	185,115	34,230	219,345

Unit: 1,000 US$ (132.66JPY/US$)

State Joint Stock Company "Uzbekenergo"

Tashkent Thermal Power Plant Modernization Project

Basic Technical Specifications and Data for Preparation of Tender Documents of 370MW Combined Cycle Power Plant

Documents No. TMP-0006 R1

November 27, 2002

Japan International Cooperation Agency
Tokyo Electric Power Services Co., Ltd.

Foreword

This is to inquire basic technical specifications and data necessary for preparation of Tender Documents for international competitive bidding for Engineering, Procurement and Construction of nominal capacity 370MW Combined Cycle Power Plant. The Plant will be installed in the premise of Tashkent Thermal Power Plant.

Some basic technical specifications and data are already given by the Study Team based on the information which was given at the Feasibility Study Stage, the relevant JICA /JBIC reports and TEPSCO's experience. They will be discussed and finalized with Uzbekenergo during the First On-site Study. The remaining specifications and data will be provided with Uzbekenergo by the beginning stage of the Second On-site Study where the preparation works of the Tender Documents will start.

We would like to solicit for your cooperative support for decision of such basic technical specifications as described in the attached sheets and for our acquisition of the data enquired in the sheets.

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Basic Technical Specifications and Data to be provided and/or clarified by Uzbekenergo

Discription	Specifications and Data
1. Tender Requirements	
(1) Conditions for requirements	
a. Ambient temperature	16 °C
b. Barometric pressure	96 kPa
c. Alutitude	500 m
d. Relative humidity	52%
e. Cooling water temperature	12 °C
f. Type of fuel	Bukhara gas (March to Oct.) Shurtan gas (Nov. to Feb.)
g. Supply pressure of natural gas at terminal point	Normal 7.84 bar (g) Mimimum 6.0 bar(g)
h. Supply temperature of natural gas at terminal	14 °C
I. Type of gas turbine	Single-shaft simple open cycle heavy duty industrial type gas turbine with a firing temperature of 1,350°Cclass
j. Type of shaft configuration of combined cycle plant	Multi-shaft configuration with one(1) gas turbine
(2) Requirements	
a. Net plant power output	350 MW ~ 380 MW
b. Net plant heat rate at full load on a basis of LHV of natural gas	Max. ______ kJ/kWh
2. Design Conditions and/or Basic Technical Specifications	
(1) Ambient conditions	
a. Temperature range	-15.6 to +41.1°C
b. Design temperature	16 °C
c. Relative humidity	9 to 73 %
d. Cooling water temperature range	3 to 16 °C
e. Design cooling water temperature	12 °C

Discription	Specifications and Data
(2) Service life on ISO 3977 Part 3	25 years
(3) Anticipated operation load range	50 to 100 % load
(4) Anticipated averaged load factor	91.2 % per annum
(5) Minimum controllable load	30%
(6) Anticipated annual operating hours.	
Total	8000 hours
a. At full load	7980 hours
b. At 50 % load	0 hours
c. At 30 % load	20 hours
(7) Anticipated No. of start-up times per annum	
a. Cold start after stop for more than 36 hours	2 times
b. Warm start after stop for less than 36 hours	____times
c. Hot start after stop more than 8 hours	1 times
d. Very hot start after stop for less than 1hour	____times
(8) Time required for start-up to full load after pushing start-up button	
a. Cold start	At longest 4 hours
b. Warm start	At longest 3 hours
c. Hot start	At longest 2 hours
d. Very hot start	At longest 1 hours
(9) Plant layout	Consideration of future extension of same size combined cycle power plant
(10) Equipment layout	
a. Gas and steam turbine generators	Installed inside the building with a ventilation system, a lifting crane and laydown space
b. Arrangement of gas and steam turbine generators	Parallel arrangement
c. Control and electrical equipment	Installed in the rooms integrated into the building
d. Natural gas pre-treatment/compressor station	Installed nearby the building

Discription	Specifications and Data
e. New switchyard	Installed adjacent to existing one
f. Cooling water intake	Installed at the end of artificial intake pond
(11) Plant operation	
a. Type of operation	CRT(touch-screen type) operation in the
b. Function of existing control room	Displaying operating conditions with minimum operating parameters
c. Type of shift	3 shifts by 4 regular and 1 training
(12) Operation on oil fuel	**No**
(13) Speed and load control	
a. Automatic frequency control	yes
b. Constant load control	yes
c. Droop (governor free) operation	yes
d. Load limit control	yes
d. Overspeed trip device	Equipped with both mechanical and electrical type devices
(14) Gas turbine control	
a. Surge limit control	yes
b. Temperature control	yes
c. Acceleration speed control	yes
d. Inlet guide vane control	yes
(15) Frequency variation under which load operation is allowed	50 +/- 1.5 Hz
(16) Full load shedding capability without trip	yes
(17) Operating pressure control	Sliding pressure above 60% load Constant pressure below 60% load
(18) Airborne emissions on dry condition (75 - 100% load of gas turbine over all ambient conditions)	
a. NOx	< 25ppmv(dry)

Discription	Specifications and Data
b. SOx	Depends on sulphur contents in natural gas yes
b. CO	yes < 15ppmv(dry)
c. Particulate	yes < 5mg/Nm^3(dry)
(19) Noise emissions on steady state conditions	to be discussed with TEP
a. On power station boundary limit(without background noise)	_dB(A)
b. At a distance of 1m from equipment or enclosure	_dB(A)
(20) Cooling water temperature increase across the condenser	not more than 5℃
(21) Waste efluent water	World bank guide line or Uzbekistan regulation. , whichever is severer.
(22) Black-out start capability	no
(23) Type of starting device of gas turbine	The following both types are available: a. A synchronous generator/motor with a thyristor frequency converter b. A squirrel cage motor with a torque converter
(24) Type of steam turbine exhaust direction	Depends on choice of manufacturers
(25) Gas turbine compressor cleaning device	yes
(26) Type of heat recovery steam generator	Both types of exhaust gas vertical flow type and lateral flow type are available.
(27) Connection of auxiliary steam line with existing medium pressure steam line(header)	yes
Steam condition:	1.0 MPa (gauge) x 270 ℃
(28) Type of cooling method of generator	To be discussed.
(29) Type of bottoming cycle	To be discussed.
(30) Type of 220kV switchyard	Open air type
Opearting voltage	220 kV
Maximum design voltage	______kV
BIL withstand voltage	______kV
Low frequency withstand voltage	______kV
Required minimum clearances:	
Metal- Metal: Phase- Phase	______mm
Phase-Ground	______mm
Bus design clearances	
Phase spacing (centerline to centerline)	

Discription	Specifications and Data
Main bus	______mm
Branch bus	______mm
Phase height above ground:	
Main bus	______mm
Branch bus	______mm
(31) Bypass exhaust stack for simple cycle operation	yes
(32) Exhaust stack height above the ground level	__m (to be determined based on EIA results)
(33) Shaft strength of gas and steam turbines	Shall be designed to withstand the transient torque due to short circuit or out-of-phase synchronization, whichever is greater.
(34) Spare parts	For five (5) years operation
(35) Trainning period of 10 staff at EPC contractor's works	Four (4) weeks
(36) Three(3) resident engineers (mechanical, electrical and control) of EPC contractor during defect liability period	yes
(37) Inspection intervals of gas turbine on an EOH basis	
a. Combustion inspection	Min. 8,000 hours
b. Turbine inspection	Min. 16,000 hours
c. Major inspection	Min. 32,000 hours
(38) Ambient air and cooring water temperatures to define the maximum capability of combined cycle power plant	Ambient air temperature 3 °C Cooling water temperature 3 °C
(39) Make-up water treatment equipment	New ~~or common use of existing one~~
(40) Waste water treatment equipment	New ~~or common use of existing one~~
(41) Continouos airborne emission monitoring system	yes
(42) Cooling water discharge channel	~~New or~~ partial reuse of existing concrete culvert for a cooling tower
3. Guarantee Requirements	
(1) Guarantee Conditions	
a. Ambient temperature	16 °C
b. Barometric pressure	96 kPa
c. Altitude	500 m

Discription	Specifications and Data
d. Relative humidity	52%
e. Cooling water temperature	12 °C
f. Type of fuel	Bukhara gas and Shurtan gas
g. Supply pressure of natural gas	7.84 bar
h. Supply temperature of natural gas	14 °C
i. Blowdown and make-up	0%
j. Power factor, voltage and frequency at generator terminals	Equal to specified values
k.Gas turbine inlet temperature at full load	Equal to specified value
(2) Guaranteed Items	
a. Power output	
a) Gas turbine gross power output	yes
b) Plant net power output	yes
b. Heat rate	
a) Plant net heat rate at full load	yes
b) Plant net heat rate at 75 % load	yes
c) Plant net heat rate at 50 % load	yes
c. Airborne emissions(75 - 100 % load) on dry conditions	
a) NOx	yes
b) SOx	yes
c) CO	yes
e) Particulate	yes
d. Noise emissions	
a) Noise level on the station boundary limit on full load steady state conditions	yes
b) Noise level at a distance of 1m from equipment on full load steady state conditions	yes

Discription	Specifications and Data
e. Two (2) weeks reliability run	yes
4. Technical information and/or data to be provided by Uzbekenergo	
(1) Meteorological data at site area or in the premise of Tashkent Thermal Power Plant	Item 1 in the attached sheets to be filled
(2) Water conditions for raw water for make-up and cooling water	Item 2 in the attached sheets to be filled
(3) Fuel specification	Item 3 in the attached sheets to be filled
(4) Voltage rating for the new power plant	Item 4 in the attached sheets to be filled
(5) Environment protection regulations	Item 5 in the attached sheets to be filled
(6) Data for financial and economical analysis	Item 6 in the attached sheets to be filled
(7) Drawings to show the shapes of site area with dimensions and the site boundaries	To be provided by Uzbekenergo
(8) Drawings to show the terminal points of natural gas	To be provided by Uzbekenergo
(9) Single line diagram of existing 220kV switchyard	To be provided by Uzbekenergo
(10) Drawings to show the steel structure frameworks of 220kV switchyard	To be provided by Uzbekenergo
(11) Drawings to show the cross section of artificial cooling water intake pond around the condidate cooling water intake point for new	To be provided by Uzbekenergo
(12) List of services to be provided free of charge by Uzbekenergo including electric load, fuel, make-up water, potable water during commissioning.	To be provided by Uzbekenergo
(13) List of items to be monitored at the inlet to the exhaust gas stack	To be provided by Uzbekenergo

Discription	Data and/or Information to be provided by Uzbekenergo

1. Meteorological Data

i. Monthly ambient temperature (℃)

	Min.	Mean	Max.
January	−15.6	−0.3	16.6
February	−8.4	−5.3	19.8
March	−2.8	11.9	28.6
April	3.3	17.2	31.5
May	12.2	24.9	38.3
June	11.4	28.2	41.1
July	14.9	27.2	38.8
August	14.4	25.8	38.1
September	2.8	19.7	36.4
October	−1.3	12.8	31.5
November	0.2	10.6	26.4
December	−8.5	4.7	20.5

ii. Monthly Relative Humidity (%)

	Min.	Mean	Max.
January	16	73	—
February	22	66	—
March	11	55	—
April	11	53	—
May	12	40	—
June	10	30	—
July	9	34	—
August	10	39	—
September	12	39	—
October	12	62	—
November	17	68	—
December	18	69	—

iii. Rainfall

Annual averaged 423 mm/year

Hourly maximum — mm/y

Rainy season From Oct to May

Averaged total rainfall in the rainy season 18.3 mm

iv. Snowfall

Maximum 130 mm

Discription	Data and/or Information to be provided by Uzbekenergo
	Snowfall days 15
	v. Wind data Maximum speed 4−5 m/s with the recurrence of 2.7%. The usual wind speed is 1m/s with the recurrence of 73.8% Averaged speed 1.4 m/s Prevailing direction. The following winds are prevailed: ENE, E, ESE – 35.7%; West winds: W, WNW, NW – 25.1 % From____to____in_____season From____to____in_____season From____to____in_____season
	vi. Isokeraunic level IKL _______
2. Water Conditions (1) Raw water for make-up water	i. Source of water ☐ River water ☐ Sea water ☐ Industrial water ☐ Tap water ☒ Canal freshwater
	ii. Supply conditions Available flow rate Max. 230 m³/h Temperature Min. 11 ℃ Mean 19.5 ℃ Max. 28 ℃ Pressure 0 Bar(g) Location of terminal At the end of intake canal
	iii. Analysis data (Fill in Table 1 "Analysis Data of Raw Water")
(2) Cooling Water	i. Type of cooling water ☒ Once-through type ☐ Re-circulation use type ☐ No use type ii. Source of water ☐ River water ☐ Sea water

Discription	Data and/or Information to be provided by Uzbekenergo

☐ Industrial water ☐ Well water

☒ Canal freshwater

iii. Supply conditions

Available flow rate: Max. 44,000 m^3/h

Temperature: Min. 3 °C

Mean 9.5 °C

Max. 16 °C

Pressure: 0 Bar(g)

Location of terminal

Intake: At the end of intake canal

Discharge: At the end of existing concrete culvert

iv. Restriction on usage of the water source

Restriction: **Yes**

Maximum temperature rise: 5 °C

Maximum discharge temperature. Should not raise more than 5°C.

_____ °C

v. Level of river water at the relevant canal

Elevation of datum level 501.00 m

Normal water level 497.10 m

High water level 498.00 m

Low water level 496.75 m

vi. Analysis data of cooling water
(Fill in Table 2 "Analysis Data of Cooling Water")

3. Fuel

(1) Shurtan Gas

i. Type of gas

☒ Sour natural gas ☐ Sweetened natural gas

☐ Liquified natural gas ☐ Blast furnace gas

☐ Coke oven gas ☐ others

ii. Supply source

Name of supply authority: Uztransgaz

iii. Supply conditions at the terminal point

Distance from the new power plant to the terminal point

Discription	Data and/or Information to be provided by Uzbekenergo

______m

Maximum available supply flow rate for the new power plant except for winter season 75,000 N m^3/d

Temperature

Max. 26 ℃

Min. 2 ℃

Pressure

Max. 0.98 MPa

Nor. 0.78 Mpa

Min. 0.60 Mpa

Max. step change 0.2 MPa

Max. ramp change 0.7 kPa/sec.

Solids

Total ______mg/N m^3

Size range ≧10 μ ______%

≧5 μ ______%

≧1 μ ______%

<1 μ ______%

Dew point ______℃

iv. Compositions (mole %, dry)

	Average	Min.	Max.
CO_2	2.35	2.11	2.66
N_2	0.73	0.61	0.92
O_2	-	-	-
CH_4	91.79	91.23	92.03
C_2H_6	3.89	3.53	4.15
C3H8	0.92	0.76	1.05
i-C_4H_{10}	0.12	0.08	0.19
n-C_4H_{10}	0.13	0.06	0.18
C_5H_{10} + Heavier	-	-	-
H_2S	0.07	0.06	0.09
Total	100.00		
Mercaptan S (gram/m^3)	0.024	0.020	0.029

Density (kg/Nm^3) 0.790

Discription	Data and/or Information to be provided by Uzbekenergo
	Lower cal. value (MJ/ Nm^3) 36.53 Higher cal. value (MJ/ Nm^3) 40.53 Design maximum of H_2S (vol. %) 0.12
(2) Bukhara gas	i. Type of gas ☐ Sour natural gas ☒ Sweetened natural gas ☐ Liquified natural gas ☐ Blast furnace gas ☐ Coke oven gas ☐ others ii. Supply source Name of supply authority Uztransgaz iii. Supply conditions at the terminal point Distance from the new power plant to the terminal point ______m Maximum available supply flow rate for the new power plant 75,000 N m^3/d Temperature Max. Ambient °C Min. Ambient °C Pressure Max. 0.98 MPa Nor. 0.78 Mpa Min. 0.60 Mpa Max. step change 0.2 MPa Max. ramp change 0.7 kPa/sec. Solids Total ______mg/N m³ Size range ≧10 μ ______% ≧5 μ ______% ≧1 μ ______% <1 μ ______% Dew point ______°C iv. Compositions (mole %, dry)

Discription	Data and/or Information to be provided by Uzbekenergo

	Average	Min.	Max.
CO_2	1.44	1.18	1.75
N_2	0.45	0.30	0.66
O_2	-	-	-
CH_4	93.12	92.37	93.56
C_2H_6	3.76	3.53	4.02
C3H8	0.99	0.84	1.07
i-C_4H_{10}	0.10	0.07	0.13
n-C_4H_{10}	0.15	0.10	0.27
C_5H_{10} + Heavier	-	-	-
Total	100.00		
H_2S (gram/ m^3)	0.009	0.003	0.014
Mercaptan S (gram/m^3)	0.010	0.005	0.020

Density (kg/Nm^3) 0.777
Lower cal. value (MJ/ Nm^3) 36.97
Higher cal. value (MJ/ Nm^3) 40.92
Design maximum of H_2S (gram/ m^3) 0.02

4. Voltage Rating

i. Voltage rating of power, lighting, instrument and control

Generator	AC 18 kV
Auxiliary power	
150 kW≦P	AC 6,300 V
1 kW≦P≦ 150 kW	AC 400 V
P≦ 1 kW	AC 230 V
Lighting	AC 230 V
Instrument	AC 230 V
Control power	AC 230 V
Control signal	DC 230 V

5. Environment Preservation

i. If the restrictions on the following items are applied for construction of the new power plant by any laws and/or regulations of your country, provide their registered numbers and their complete copies.

			Registered Number
Sulfur oxides	☒ Yes	☐ No	________
Nitrogen oxides	☒ Yes	☐ No	________
Particulates	☒ Yes	☐ No	________

Discription	Data and/or Information to be provided by Uzbekenergo

Smoke(Color)	☐ Yes	☒ No	______
Noise	☒ Yes	☐ No	______
Ground vibration	☐ Yes	☐ No	______
Waste water	☐ Yes	☒ No	______
Thermal effluent	☒ Yes	☐ No	______
Disposal waste	☒ Yes	☐ No	______

1. The list of limited contaminant loads permissible in the atmosphere of populated places of the Republic of Uzbekistan. СанПИН № 0015-94 (Sanitarian rates, rules and hygienic regulations of the Republic of Uzbekistan, 1994).

2. КМК 2.01.08-96 "Noise protection" (State Architecture and Building Committee of the Republic of Uzbekistan, Tashkent, 1999).

   (House Building Regulations).

3. ГОСТ 12.1.003-86. The system of labor safety standards. Noise. General safety requirements (regulations, noise at the work places).

4. КМК 2.07.01-94 (Item-12.39). Grading and building of urban and countryside settlements. Allowed vibration levels.

5. Sanitarian rules and surface water protection regulations. СанПИН № 0056-96, Tashkent, 1996

6. РД 118.0027714.31-94. The order of carrying out the state ecology control at the toxic and industrial waste placements of the enterprises of the Republic of Uzbekistan, Tashkent, 1994.

7. РД 118.0027714.62-97. Waste products handling and demand. Methodical instructions on determining the limits of disposal waste products, Tashkent, 1997.

8. РД 118.0027714.31-94. Waste products handling and demand. Instruction. Engineering and the order of carrying out of waste products inventorying and using on the enterprises.

6. Data for Financial and Economical Analysis

   i. Project life ____25____ years

Discription	Data and/or Information to be provided by Uzbekenergo

ii. Project cost estimation time As of March, 2002

iii. Currency exchange rate

US$ 1.00 = 132.66 Japanese Yen

_____ = ________ Japanese Yen

iv. Custom duties and taxes 0 % of CIF cost

v. Insurance premium rate _____% of project cost

vi Annual interest rate during construction

1.8 % for off-shore portion

1.8 % for on-shore portion

vii. Annual escalation rate

1.1 % for off-shore portion

1.1 % for on-shore portion

viii. Terms and conditions of long term loan

Fund source JBIC

Payback period

Construction works 30 years

Consulting services 40 years

Grace period

Construction works 10 years

Consulting services 10 years

Annual interest rate

Construction works 1.8 %

Consulting services 1.8 %

ix. Contingency

Construction works 8 %

Consulting services 5 %

x. Terms and conditions of short term loan (if any)

Fund source ________

Payback period ________years

Grace period ________years

Annual interest rate ________%

xi. Type and period of depreciation of investment cost

Type Straight line

Period 25 years

Discription	Data and/or Information to be provided by Uzbekenergo
	xii. Scrap value of plant after depreciation Value _______US$ or __0__% of total investment cost xiii. Power energy sales price at the terminals of power generation ______US cents/kWh or ______Soum/kWh xiv. Natural gas cost _______US cents/MJ or Nm^3

Discription	Data and/or Information to be provided by Uzbekenergo

Table 1 Analysis Data of Raw Water

Source of Water : Boz-Su Canal Freshwater

Limit		Min	Max
Temperature	℃	11℃	28℃
pH	℃	7.95	8.2
Conductivity	Micro S/cm	155	245
Turbidity	degree	0	40
Suspended Solid	mg/l	5	348
Total Hardness	mg/l as $CaCO_3$	36.47	52.71
Ca Hardness	mg/l as $CaCO_3$	28.06	43.69
Mg Hardness	mg/l as $CaCO_3$	8.02	14.03
Sulphate	mg/l as SO_4^{2-}	14	22
Nitrate	mg/l as NO_3^-	0.14	2
Iron Ion	mg/l as Fe	0.012	0.47
Chlorine Ion	mg/l as Cl^-	0.5	1.2
Silica	mg/l as SiO_2	5.5	7.5
COD (KMnO4)	mg/l as O	0.4	1.62
Bicarbonate	mg/l as HCO_3		
Total Dissolved Solid	mg/l as HCO_3	118	170
Potassium	mg/l as K^+		
Sodium	mg/l as Na^+	0.36	4.14

Discription	Data and/or Information to be provided by Uzbekenergo

Table 2 Analysis Data of Cooling Water

Source of Water : Boz-Su Canal Freshwater

Limit		Min	Max
Temperature	°C	3°C	16°C
pH	°C	7.95	8.,2
Dissolved Oxygen	Ppm		
Chlorine Ion	mg/l as Cl^-	0.5	1.2
Ratio of SO4/Cl			
Oxygen Demand		0.4	1.14
BOD	Ppm		
COD	Ppm		
Conductivity	Micro S/cm	155	245
Turbidity	Degree		
Suspended Solid	mg/l	5	348

Japan International Cooperation Agency (JICA)

State Joint Stock Company "Uzbekenergo"

The Study Result of Generator Cooling Method

of

370 MW Combined Cycle Power Plant

Document No. TMP-0021E

November,2002

Tokyo Electric Power Services Co.,Ltd.

Selection of Generators Cooling System

In the previous feasibility studies, Uzbekenergo required to apply a water cooled system to both the stator and the rotor of generator. They explained that former Soviet Union era, they experienced serious explosion of hydrogen cooled generator and the guideline to apply water cooled generator has been stipulated.
According to the preceeding investigations by the JICA study team, the following facts about the water cooled technology of the generators have been recognized.

a) Electrosila in St. Petersburg is the only one manufacturer in the world who has a manufacturing experience of generator with both the water cooled stator and rotor.

b) Although some European manufacturers declare to have the capabilities to manufacture water cooled generators in their brochures, they have no supply record.

c) Most of generator manufacturers can supply water cooled generators of larger capacity , however, the water cooled technology is applied to only stator with larger capacity , not to any capacity rotor or to the similar capacity stator.

As an alternative to the full water cooled generator without risk of hydrogen explosion, the air cooled type generator is also considered. The multi-shaft arrangement for this combined cycle power plant being selected, the capacities of the generator are approximately 250 MW (300 MVA) for the gas turbine unit and 125 MW(150 MVA) for the steam turbine unit respectively. And in this case, Alstom Power in Switzerland is the only one eligible manufacturer in the world for the pre-qualification for the Tender, having manufacturing experience of at least three (3) units of 250 MW range air cooled generators..(Refer to "Operating Experience of Air Cooled Generators" attached)

Since the manufacturers capable of supplying full water cooled or air cooled generators of the specified rating are very limited, it is difficult to specify the water cooled or air cooled generators for the Plant by reason that the Tender will be made through International Competitive Bidding using the finance of ODA.

It should be noted that the hydrogen cooled generators have been used since late 1930's and a sufficient experience to justify their use has been accumulated.

From the above observations, it is recommended that the hydrogen cooled type generators could be specified for the International Competitive Bidding for the Plant.

Operating Experience of Air Cooled Generator

Mar 12. 2002
Rev.Jun 26. 2003

TOKYO ELECTRIC POWER SERVICE CO. ,LTD
Overseas Business Center

MELCO: MITSUBISI ELECTRIC
TSB: TOSHIBA
HTC: HITACHI
FUJI: FUJI ELECTRIC
ALS: ALSTOM
SIE: SIEMENS

Operating Experience of Air Cooled Generator

Name of Country	Name of Project	Rated Capacity (MVA)	Rated·Power Output (MW)	Rotating Speed (rpm)	Start-up Year	Operating Hours
MELCO (>150MVA)						
JAPAN	Tokyo Electric Power Co,Yokosuka	160	144		1992	
JAPAN	T plant	286	272		1996	
JAPAN	Koa Oil,Osaka	166	150		1997	
JAPAN	Endesa Sanisidro,Chile	162	138		1997	
Australia	AES.Mt.Stuart	172	155		1998	
JAPAN	Nakayama Electric Power Co.,Funamachi	166	150		1998	
JAPAN	Akemi,Power Co.	163	147		1999	
JAPAN	Nakayama Electric Power Co.,Nagoya	166	150		1999	
MEXICO	CEF, Mexico STG	178	160		1999	
MEXICO	CEF, Mexico STG	160	144		1999	
	CONOCO	171	146		2000	
JAPAN	Nippon Steel Co.,Muroran	161	145		2000	
DOMINICA	AES,DOMINICA GTG	219	197		2000	
ALABAMA	ALABAMA	212	191		2000	
MEXICO	TUXPAN GTG	189	170		2000	
MEXICO	TUXPAN STG	210	189		2000	
JAPAN	Osaka Gas Co.,LTD,Torishima	167	150		2001	
	Altamira STG	210	189		2001	
	Altamira GTG	190	171		2001	
	Rio Gen Power Plant GTG	204	173		2001	
USA	AES/Kentucky GREYSTONE GTG	219	197		2001	
	Mirant Co.Wyandotte C/C GTG	232	197		2001	

Operating Experience of Air Cooled Generator

Name of Country	Name of Project	Rated Capacity (MVA)	Rated Power Output (MW)	Rotating Speed (rpm)	Start-up Year	Operating Hours
	TENASKA C/C GTG	213	192		2002	
	PG&E C/C STG	173	147		2002	
TAIWAN	Chang-Bin/Fong-Der C/C GTG	188	160		2002	
JAPAN	Cosmo Oil Co.,LTD,Yokkaichi	248	223		2003	
	Koa Oil,Maribu	166	149		2004	

Operating Experience of Air Cooled Generator

Name of Country	Name of Project	Rated Capacity (MVA)	Rated Power Output (MW)	Rotating Speed (rpm)	Start-up Year	Operating Hours
TSB (>100MVA)						
PAKISTAN	COSTAL,SABA	170	136		1998	
JAPAN	Nippon Steel Co.,KAMAISI#1	166	149		1999	
CANADA	NOVA CHEMICAL,JOFFRE	157	133		1999	
SAUDI ARABIA	SWCC,AL KHOBAR3 #6	150	120		1995	
SAUDI ARABIA	SWCC,AL KHOBAR3 #7	150	120		1995	
SAUDI ARABIA	SWCC,AL KHOBAR3 #8	150	120		1996	
SAUDI ARABIA	SWCC,AL KHOBAR3 #9	150	120		1996	
JAPAN	Tokyo Electric Power Co,OI#1	142	128		1993	
MALAYSIA	NEB,PAKA#1	124	105		1986	
MALAYSIA	NEB,PAKA#2	124	105		1987	
MALAYSIA	NEB,PAKA#3	124	105		1987	
USA	FLUOR DANIEL,SALT CITY	107	91		1992	

Operating Experience of Air Cooled Generator

Name of Country	Name of Project	Rated Capacity (MVA)	Rated Power Output (MW)	Rotating Speed (rpm)	Start-up Year	Operating Hours
HTC (>200MVA)						
Japan	TOA-STG	217		3000	2002	
Korea	Hanwha-4	202		3600	2001	
Korea	Hanwha-3	202		3600	1999	

Operating Experience of Air Cooled Generator

Name of Country	Name of Project	Rated Capacity (MVA)	Rated Power Output (MW)	Rotating Speed (rpm)	Start-up Year	Operating Hours
FUJI (>100MVA)						
Indonesia	Amoseas Indonesia Inc.Darajat Ⅱ	101		3000	1997	
Indonesia	Mandara Nusantara Ltd.Wayang Windu#1	138		3000	1997	
Taiwan	Formosa Chemical and Fiber Corp. SK-14	174		3600	1998	
Japan	Taiheiyou Cement Itoigawa	166		3000	1998	
Japan	UBE Power Center	240		3600	1998	
India	Venkatesh Coke & Power Ltd.	138		3000	1999	
Bangladesh	AES Haripur Private Ltd.	165		3000	1999	
Taiwan	Formosa Chemical and Fiber Corp. LT72	203		3600	1999	
Taiwan	Chinese Petroleum Corp. #23	125		3600	1999	
Taiwan	Chinese Petroleum Corp. #24	125		3600	1999	
Bangladesh	AES Meghnaghat Ltd.	238		3000	2000	
Taiwan	Formosa Chemical and Fiber Corp. G-8	130		3600	2000	
Malaysia	TNB Gelugor Power Station	130		3000	2000	
Mexico	ENRON Vitro Alcali CCPP	127		3600	2000	
Canada	CALPINE Calgary Energy Center Project	158		3600	2001	
Brazil	Termonorte energia Ltda.	138		3600	2001	

Operating Experience of Air Cooled Generator

Name of Country	Name of Project	Rated Capacity (MVA)	Rated Power Output (MW)	Rotating Speed (rpm)	Start-up Year	Operating Hours
ALS (>100MVA)						
	Il Var Taranto	129	103		1994	
	Zahrani	185	148		1995	
	Poryong	200	180		1995/96	
	Vasilikos	173	138		1997	
	Hai Fu	208	177		1997	
	Ruwais	210	168		1998	
	Burgin Kentucky	208	177		1998	
	Kerman	200	160		1999	
	Jebel Ali	153	122		1999	
	Hassi Berkine	145	117		1999	
	Pelican Point	210	168		1999	
	Hay Road 8	206	185		2000	
	Birr test center	300	240		1994	
	Karlsruhe	300	240		1995	
	Rocksavage	300	255		1995	
	Beijing	235	200		1997	
	Agawam	280	238		1997	
	La Spezia	290	261		1997	
	Monterrey	280	252		1998	
	Ford/Rouge	280	238		1998	
	Island Cogen	280	238		1998	
	Midlothian	280	238		1998	

Operating Experience of Air Cooled Generator

Name of Country	Name of Project	Rated Capacity (MVA)	Rated Power Output (MW)	Rotating Speed (rpm)	Start-up Year	Operating Hours
	Coryton	300	255		1998	
	Puerto Rico	300	255		1999	
	Stock generators	280	238		1998/99	

Operating Experience of Air Cooled Generator

Name of Country	Name of Project	Rated Capacity (MVA)	Rated Power Output (MW)	Rotating Speed (rpm)	Start-up Year	Operating Hours
SIE (>250MVA)						
United Kingdom	Didcot B 51	291.5	233	3000	1996	
United Kingdom	Didcot B 52	291.5	233	3000	1996	
United Kingdom	Didcot B 61	291.5	233	3000	–	
United Kingdom	Didcot B 62	291.5	233	3000	–	
Argentinia	Costanera	257	219	3000	1995	
Argentinia	Generba STG	261	222	3000	–	
Chile	Nehuenco GT	273	232	3000	–	
Austria	KW Theiss 2000	260	221	3000	1999	
Argentinia	CTCC Salta STG 2	270	230	3000	–	
Malaysia	Panglima GTG 11	303	233	3000	–	
Malaysia	Panglima GTG 12	303	233	3000	–	
Ireland	Huntstown GTG	288	230	3000	2002	
Viet Nam	Phu My3-STG 10	292	263	3000	–	
Italy	Priolo Gargallo-Lot 8	288	259	3000	–	
Italy	Priolo Gargallo-Lot 10	288	259	3000	–	
Italy	Termini Lmerese-Lot 9	288	259	3000	–	
Italy	Termini Lmerese-Lot 11	288	259	3000	–	
Italy	ENEL Repowering	288	259	3000	–	
United Arab.Emirates	Shuweihat STG 10	299	254	3000	–	
United Arab.Emirates	Shuweihat STG 20	299	254	3000	–	
United Arab.Emirates	Shuweihat GTG 11	262	223	3000	–	
United Arab.Emirates	Shuweihat GTG 12	262	223	3000	–	

Operating Experience of Air Cooled Generator

Name of Country	Name of Project	Rated Capacity (MVA)	Rated Power Output (MW)	Rotating Speed (rpm)	Start-up Year	Operating Hours
United Arab.Emirates	Shuweihat GTG 21	262	223	3000	–	
United Arab.Emirates	Shuweihat GTG 22	262	223	3000	–	
United Arab.Emirates	Shuweihat GTG 23	262	223	3000	–	
Netherlands	Rijnmond GTG 11	316	265	3000	–	
Netherlands	Rijnmond GTG 12	316	265	3000	–	
Italy	Moncalieri GTG 11	280	252	3000	–	
Germany	Koln Niel II GTG	327	262	3000	–	

State Joint Stock Company "Uzbekenergo"

Tashkent Thermal Power Plant Modernization Project

List of Tie-in Points for Utilities and Communications of 370MW Combined Cycle Power Plant

Document No. TMP-0030E

November 28, 2002

Japan International Cooperation Agency
Tokyo Electric Power Services Co., Ltd.

List of Tie-in Points of Utilities/Communications

No.	Item	No.	Description of Tie-in Point	Location	Temp. (℃)	Press. MPa(g)	Flow	Size	Shape	Material	Remarks
1	Natural gas (Shurtan)	1	offset pipe before existing pressure reducing station								
2	Natural gas (Bukhara)	1	offset pipe before existing pressure reducing station								
3	Circulating water-intake	1	end part of existing canal								
4	Circulating water discharge	1	end of existing concrete culvert for cooling water discharge of No. 12								
5	Auxiliary steam	1	from existing auxiliary steam header pipe								
6	Hot water in	1									
7	Hot water out	1									
8	Buck-up steam for hot water from existing unit	1									
9	Drain return to existing unit	1									
10	Make-up water (raw water)	1	end part of existing canal								
11	Plant service water	1	from existing header pipe								
12	Drinking water	1	from existing header pipe								
13	Fire-fighting water	2	from existing ring pipe								
15	220 kV outgoing	1	to existing switchyard								
16	6.3 kV interconnection	1	from existing 6.3 kV circuit								
17	Telephone lines (refer to attached)	5	at junction box								
18	Paging lines (refer to attached)	16	at junction box								
19											
20											