付属資料 C ：Generation Expansion Plan

Appendix C.1 Existing Main Power Stations in Iraq

	No.	Plant Name	Generation Type	Status	Unit Type	Loading	Fuel Class	Annual Energy GWh	No of units	Installation Year	Operating Life	Rated Capacity MW	Available Capacity MW	No.of Maintenance Weeks/Year	Forced Outage Rate	Heat Rate btu/kWh	Capacity Factor %	Variable O&M Cost US$/MWh	Retirement Year	Reired Capacity MW
Steam Turbine Plants	1	Baji	TPS	E	Steam	B	FO	3942.00	5	1988	30	1320	450	6	0.124	10300	0.34	0.8	2018	1320
	2	Baghdad South	TPS	E	Steam	B	FO	1533.00	6	1965, 1983	30	355	175	6	0.124	10300	0.49	0.8	2013	355
	3	Dibis	TPS	E	Steam	B	GAS	280.32	4	1959	50	60	32	4	0.124	10300	0.53	0.8	2009	60
	4	Doura	TPS	E	Steam	B	FO	3626.64	4	1981	35	640	414	6	0.124	10300	0.65	0.8	2016	640
	5	Hartha	TPS	E	Steam	B	GAS	1379.70	1	1979	35	400	157.5	4	0.124	10300	0.39	0.8	2014	400
	6	Hartha	TPS	E	Steam	B	CO	1379.70	1	1979	35	400	157.5	7	0.124	10300	0.39	0.8	2014	400
	7	Musayab	TPS	E	Steam	B	FO	3390.12	2	1996	24	600	387	4	0.124	10300	0.65	0.8	2020	600
	8	Musayab	TPS	E	Steam	B	CO	3390.12	2	1996	24	600	387	7	0.124	10300	0.65	0.8	2020	600
	9	Najibiyah	TPS	E	Steam	B	GAS	630.72	1	1979	30	100	72	4	0.124	10300	0.72	0.8	2009	100
	10	Najibiyah	TPS	E	Steam	B	CO	630.72	1	1979	30	100	72	7	0.124	10300	0.72	0.8	2009	100
	11	Nasiriyah	TPS	E	Steam	B	CO	4730.40	4	1975	42	840	540	7	0.124	10300	0.64	0.8	2017	840
Gas Plants	12	Baji	GPS	E	Gas	B	GAS	919.80	1	1990	35	159	105	4	0.082	13127	0.66	2.5		
	13	Baji	GPS	E	Gas	B	CO	919.80	1	1990	35	159	105	7	0.082	13127	0.66	2.5		
	14	Dibis	GPS	E	Gas	B	GAS	516.84	3	1983	35	84	59	4	0.082	13127	0.70	2.5	2018	84
	15	Dibis (Mobile)	GPS	E	Gas	B	GAS	289.08	5	1982	35	50	33	4	0.082	13127	0.66	2.5	2017	50
	16	Doura	GPS	E	Gas	B	GAS	350.40	4	1983, 1989	35	100	40	4	0.082	13127	0.40	2.5		
	17	Hilla (or Hella)	GPS	E	Gas	B	GAS	560.64	4	1973	35	80	64	4	0.082	13127	0.80	2.5	2008	80
	18	Khor Alzubeir	GPS	E	Gas	B	GAS	1576.80	4	1990	30	252	180	4	0.082	13127	0.71	2.5		
	19	Mosul (Mansor)	GPS	E	Gas	B	GAS	1314.00	12	1976, 1982	30	240	150	4	0.082	13127	0.63	2.5	2012	240
	20	Mullah Abdullah (Old)	GPS	E	Gas	B	GAS	1314.00	12	1982	30	240	150	4	0.082	13127	0.63	2.5	2012	240
	21	Mullah Abdullah (New)	GPS	E	Gas	B	GAS	1314.00	6	1988	30	222	150	4	0.082	13127	0.68	2.5	2018	222
	22	Najaf	GPS	E	Gas	B	GAS	963.60	3	1976	35	189	110	4	0.082	13127	0.58	2.5	2011	189
	23	Al Quds	GPS	E	Gas	B	GAS	700.80	1	2003	30	123	80	4	0.082	13127	0.65	2.5		
	24	Al Quds	GPS	E	Gas	B	CO	700.80	1	2003	30	123	80	4	0.082	13127	0.65	2.5		
	25	Shua'yba	GPS	E	Gas	**P**	GAS	175.20	2	1973	35	40	20	4	0.082	13127	0.50	2.5	2008	40
	26	Taji	GPS	E	Gas	B	GAS	700.80	7	1980	30	140	80	4	0.082	13127	0.57	2.5	2010	140
	27	Taji Mobile	GPS	E	Gas	**P**	GAS	157.68	2	1980	30	60	17	4	0.082	13127	0.30	2.5	2010	60
Diesel Power Plants	28	Erbil	DPS	E	Diesel	B	MSD	177.83	4	2003	20	29	26	7	0.140	10800	0.70	2.8		
	29	Dahuk	DPS	E	Diesel	B	MSD	177.83	4	2003	20	29	26	7	0.140	10800	0.70	2.8		
	30	Mobile Generators Sets	DPS	E	Diesel	B	MSD	367.92	1	2004	20	60	0	7	0.140	10800	0.70	2.8		
	31	SDMO	DPS	E	Diesel	B	MSD	1655.64	27	1991	20	270	192	7	0.140	10800	0.70	2.8	2011	270
	32	Sulaymaniah	DPS	E	Diesel	B	MSD	177.83	4	2003	20	29	26	7	0.140	10800	0.70	2.8		
	33	Zaferina	DPS	E	Diesel	B	MSD	306.60	7	2004	20	39	35	7	0.140	10800	0.90	2.8		
Hydropower Plants	34	Derban Dikhan	HPS	E	Hydro	**P**		872.50	3	1992	50	249	165	1	0.008	0	0.40	0		
	35	Dokan	HPS	E	Hydro	**P**		1436.64	5	1983	50	410	168	1	0.008	0	0.40	0		
	36	Haditha Dam	HPS	E	Hydro	**P**		1734.48	5	1986	50	660	160	1	0.008	0	0.30	0		
	37	Himreen	HPS	E	Hydro	**P**		175.20	2	1981	50	50	21	1	0.008	0	0.40	0		
	38	Mosul-Main	HPS	E	Hydro	**P**		2628.00	4	1986	50	750	600	1	0.008	0	0.40	0		
	39	Mosul-Regulation	HPS	E	Hydro	**P**		210.24	4	1985	50	60	60	1	0.008	0	0.40	0		
	40	Mosul-Pumped Storage	HPS	E	Hydro	**P**		840.96	2	1989	50	240	120	1	0.008	0	0.40	0		
	41	Sad'at Al Hind'iya	HPS	E	Hydro	**P**		43.80	4	1989	50	15	5	1	0.008	0	0.33	0		
	42	Samara	HPS	E	Hydro	**P**		294.34	3	1972	50	84	55	1	0.008	0	0.40	0		
								48487.48				10650	5926							7030

** Status: E=Existing, C=Committed, G=Generic (Candidate)*

**Loading: P=Peaking, I=Intermediate, B=Base Load*

** MSD=Medium Speed Diesel, FO=Fuel Oil*

** GAS= Natural Gas*

Appendix C.2 Committed Power Stations in Iraq

	No.	Plant Name	Generation Type	Status	Unit Type	Loading	Fuel Class	Annual Energy GWh	No of units	Installation Year	Operating Life	Rated Capacity MW	Available Capacity MW	No.of Maintenance Weeks/Year	Forced Outage Rate	Heat Rate btu/kWh	Capacity Factor %	Variable O&M Cost US$/MWh	First Year available for Installation
Gas Turbine Plants	1	Buzurgan	GPS	C	Gas	B	GAS	280.32	1	2005	20	43	32	4	0.082	13127	0.74	2.5	2005
	2	Baghdad South	GPS	C	Gas	B	GAS	1515.48	2	2005	20	240	173	4	0.082	13127	0.72	2.5	2005
	3	Baji	GPS	C	Gas	B	FO	2207.52	4	2005	20	318	252	6	0.082	13127	0.79	2.5	2005
	4	Baji Mobile	GPS	C	Gas	B	GAS	1261.44	8	2005	20	184	144	4	0.082	13127	0.78	2.5	2005
	5	Hartha	GPS	C	Gas	B	GAS	1497.96	2	2005	20	246	171	4	0.082	13127	0.70	2.5	2005
	6	Kirkuk (New)	GPS	C	Gas	B	GAS	2076.12	2	2005	20	325	237	4	0.082	13127	0.73	2.5	2005
	7	Al Quds	GPS	C	Gas	B	GAS	2557.92	8	2005	20	422	292	4	0.082	13127	0.69	2.5	2005
	8	Musayab (New)	GPS	C	Gas	B	MSD	2759.40	10	2005	20	500	315	7	0.082	13127	0.63	2.5	2005
	9	Nasiriyah (New)	GPS	C	Gas	B	MSD	254.04	1	2005	20	40	29	7	0.082	13127	0.73	2.5	2005
Diesel	10	Baghdad W.G.	DPS	C	Diesel	B	MSD	508.08	39	2005	20	100	58	7	0.140	10800	0.58	2.8	2005
	11	Northern Industries	DPS	C	Diesel	B	MSD	499.32	39	2005	20	78	57	7	0.140	10800	0.73	2.8	2005
								15417.6	116			2496	1760						

** Status: E=Existing, C=Committed, G=Generic (Candidate)*

**Loading: P=Peaking, I=Intermediate, B=Base Load*

** MSD=Medium Speed Diesel, FO=Fuel Oil*

** GAS= Natural Gas*

Appendix C.3 Candidate Power Stations in Iraq

Option Case (1)

	No.	Plant Name	Generation Type	Status	Unit Type	Loading	Fuel Class	Annual Energy GWh	No of units	Operating Life	Rated Capacity MW	No.of Maintenance Weeks/Year	Forced Outage Rate	Heat Rate btu/kWh	Capacity Factor %	Installation Cost US$/kW	Levelized Carrying Charge %	Fixed O&M Cost US$/kW/Y	Variable O&M Cost US$/MWh	First Year available for Installation
Steam	1	Salah Al Din	TPS	G	Steam	B	FO	7726.32	6	20	1260	6	0.124	10300	0.70	1100	10.6	28.0	0.8	2006
	2	Al Wassit	TPS	G	Steam	B	FO	5665.97	6	20	924	6	0.124	10300	0.70	1100	10.6	28.0	0.8	2011
	3	Yousifiyah	TPS	G	Steam	B	FO	6438.60	5	20	1050	6	0.124	10300	0.70	1100	10.6	28.0	0.8	2014
Gas T. Plants	4	Hartha (New)	GPS	G	Gas	B	GAS	2452.80	2	20	400	4	0.082	13127	0.70	700	11.8	14.0	2.5	2007
	5	Al Anbar	GPS	G	Gas	B	GAS	3728.26	4	20	608	4	0.082	13127	0.70	700	11.8	14.0	2.5	2009
	6	Al Samawah	GPS	G	Gas	B	GAS	6438.60	5	20	1050	4	0.082	13127	0.70	700	11.8	14.0	2.5	2008
	7	Al Shamal	GPS	G	Gas	B	GAS	7456.51	8	20	1216	4	0.082	13127	0.70	700	11.8	14.0	2.5	2010
	8	Al Basrah	GPS	G	Gas	B	GAS	11184.77	12	20	1824	4	0.082	13127	0.70	700	11.8	14.0	2.5	2012
	9	Kirkuk	GPS	G	Gas	B	GAS	22369.54	24	20	3648	4	0.082	13127	0.70	700	11.8	14.0	2.5	2013 & 2018

Option Case (2)

	No.	Plant Name	Generation Type	Status	Unit Type	Loading	Fuel Class	Annual Energy GWh	No of units	Operating Life	Rated Capacity MW	No.of Maintenance Weeks/Year	Forced Outage Rate	Heat Rate btu/kWh	Capacity Factor %	Installation Cost US$/kW	Levelized Carrying Charge %	Fixed O&M Cost US$/kW/Y	Variable O&M Cost US$/MWh	First Year available for Installation
Steam	1	Salah Al Din	TPS	G	Steam	B	FO	7358.40	8	20	1200	6	0.124	10300	0.70	1100	10.6	22.0	0.8	2006
	3	Al Wassit	TPS	G	Steam	B	FO	1839.60	2	20	300	6	0.124	10300	0.70	1100	10.6	22.0	0.8	2011
	4	Yousifiyah	TPS	G	Steam	B	FO	3679.20	2	20	600	6	0.124	10300	0.70	1100	10.6	22.0	0.8	2019
Gas T. Plants	5	Al Anbar	GPS	G	Gas (S/C)	B	GAS	7358.40	4	20	1200	4	0.082	13127	0.70	700	11.8	14.0	2.5	2009
	2	Al Samawah	GPS	G	Gas (S/C)	B	GAS	5518.80	3	20	900	4	0.082	13127	0.70	700	11.8	14.0	2.5	2008
	6	Al Shamal	GPS	G	Gas (S/C)	B	GAS	7358.40	8	20	1200	4	0.082	13127	0.70	700	11.8	14.0	2.5	2010
	7	Al Basrah	GPS	G	Gas (S/C)	B	GAS	20235.60	11	20	3300	4	0.082	13127	0.70	700	11.8	14.0	2.5	2012
	8	Kirkuk	GPS	G	Gas (S/C)	B	GAS	18396.00	10	20	3000	4	0.082	13127	0.70	700	11.8	14.0	2.5	2013
Hydro	9	Bakhma	HPS	G	Hydro	**P**		1401.60	2	50	400	1	0.008	0	0.40	1500	10.1	15.0	0.0	2012
	10	Al Mokuhhol	HPS	G	Hydro	**P**		1047.70	4	50	260	1	0.008	0	0.46	1500	10.1	15.0	0.0	2017

Option Case (3)

	No.	Plant Name	Generation Type	Status	Unit Type	Loading	Fuel Class	Annual Energy GWh	No of units	Operating Life	Rated Capacity MW	No.of Maintenance Weeks/Year	Forced Outage Rate	Heat Rate btu/kWh	Capacity Factor %	Installation Cost US$/kW	Levelized Carrying Charge %	Fixed O&M Cost US$/kW/Y	Variable O&M Cost US$/MWh	First Year available for Installation
Steam	1	Salah Al Din	TPS	G	Steam	B	FO	7358.40	8	20	1200	6	0.124	10300	0.70	1100	10.6	22.0	0.8	2006
	3	Al Wassit	TPS	G	Steam	B	FO	1839.60	2	20	300	6	0.124	10300	0.70	1100	10.6	22.0	0.8	2011
	4	Yousifiyah	TPS	G	Steam	B	FO	3679.20	2	20	600	6	0.124	10300	0.70	1100	10.6	22.0	0.8	2019
C/C Gas Plants	5	Al Anbar	GPS	G	Gas (C/C)	B	GAS	7358.40	4	20	1200	4	0.082	9200	0.70	1100	11	22.0	2.0	2009
	2	Al Samawah	GPS	G	Gas (C/C)	B	GAS	5518.80	3	20	900	4	0.082	9200	0.70	1100	11	22.0	2.0	2008
	6	Al Shamal	GPS	G	Gas (C/C)	B	GAS	7358.40	8	20	1200	4	0.082	9200	0.70	1100	11	22.0	2.0	2010
	7	Al Basrah	GPS	G	Gas (C/C)	B	GAS	20235.60	11	20	3300	4	0.082	9200	0.70	1100	11	22.0	2.0	2012
	8	Kirkuk	GPS	G	Gas (C/C)	B	GAS	18396.00	10	20	3000	4	0.082	9200	0.70	1100	11	22.0	2.0	2013
Hydro	9	Bakhma	HPS	G	Hydro	**P**		1401.60	2	50	400	1	0.008	0	0.40	1500	10.1	15.0	0.0	2012
	10	Al Mokuhhol	HPS	G	Hydro	**P**		1047.70	4	50	260	1	0.008	0	0.46	1500	10.1	15.0	0.0	2017

** Status: E=Existing, C=Committed, G=Generic (Candidate)*

**Loading: P=Peaking, I=Intermediate, B=Base Load*

** MSD=Medium Speed Diesel, FO=Fuel Oil*

** GAS= Natural Gas*

Appendix C.4 Recommended Generation Expansion Plans

Plan (1): Conventional Thermal Candidates Only

Calendar Year	Peak Power Demand MW	Installed Capacity MW	Total Capacity MW	Retired Capacity MW	Net Capacity MW	Reserve Margin %	Added Plant	Added Units	Plant Type
2004	7363.0	5926	5926	0	5926				
2005	7472.0	1974	7900	0	7900	5.73			
2006	8019.0	630	8530	0	8530	6.37	Salah Al Din	3x210	Steam
2007	8264.0	630	9160	0	9160	10.84	Salah Al Din	3x210	Steam
2008	9057.0	1050	10210	120	10090	11.41	Al Samawah	5x210	Gas
2009	9782.0	912	11122	260	10862	11.04	Al Anbar Al Shamal	4x152 2x152	Gas Gas
2010	10422.0	912	12034	200	11834	13.55	Al Shamal	6x152	Gas
2011	11164.0	924	12958	459	12499	11.96	Al Wassit	6x154	Steam
2012	12124.0	400	13358	490	12868	6.14	Hartha	2x200	Gas
2013	12978.0	912	14270	355	13915	7.22	Al Basrah	6x152	Gas
2014	14100.0	912	15182	800	14382	2.00	Al Basrah	6x152	Gas
2015	15123.0	912	16094	0	16094	6.42	Kirkuk	6x152	Gas
2016	15582.0	912	17006	640	16366	5.03	Kirkuk	6x152	Gas
2017	16267.0	912	17918	890	17028	4.68	Kirkuk	6x152	Gas
2018	16795.0	912	18830	1655	17175	2.26	Kirkuk	6x152	Gas
2019	17540.0	630	19460	0	19460	10.95	Yousifiyah	3x210	Steam
2020	18095.0	420	19880	1200	18680	3.23	Yousifiyah	2x210	Steam
		19880		7069		7.43			

Appendix C.4 Recommended Generation Expansion Plans (Cont.)

Plan (2): Thermal and Hydropower Stations Candidates

Calendar Year	Peak Power Demand MW	Installed Capacity MW	Total Capacity MW	Retired Capacity MW	Net Capacity MW	Reserve%	Added Plant	Added Units	Plant Type
2004	7363.0	5926	5926	0	5926				
2005	7472.0	1974	7900	0	7900	5.73			
2006	8019.0	600	8500	0	8500	6.00	Salah Al Din	4x150	Steam
2007	8264.0	600	9100	0	9100	10.12	Salah Al Din	4x150	Steam
2008	9057.0	900	10000	120	9880	9.09	Al Samawah	3x300	Gas
2009	9782.0	900	10900	260	10640	8.77	Al Anbar	3x300	Gas
2010	10422.0	900	11800	200	11600	11.30	Al Anbar Al Shamal	1x300 4x150	Gas Gas
2011	11164.0	900	12700	459	12241	9.65	Al Shamal Al Wassit	4x150 2x150	Gas Steam
2012	12124.0	1060	13760	490	13270	9.45	Bakhma Al Basrah	1x160 3x300	Hydro Gas
2013	12978.0	900	14660	355	14305	10.22	Kirkuk Al Basrah	2x300 1x300	Gas Gas
2014	14100.0	1200	15860	800	15060	6.81	Kirkuk Al Basrah	2x300 2x300	Gas Gas
2015	15123.0	1200	17060	0	17060	12.81	Kirkuk Al Basrah	2x300 2x300	Gas Gas
2016	15582.0	900	17960	640	17320	11.15	Kirkuk Al Basrah	2x300 1x300	Gas Gas
2017	16267.0	720	18680	890	17790	9.36	Al Basrah Al Mokuhhol	2x300 1x120	Gas Hydro
2018	16795.0	600	19280	1655	17625	4.94	Kirkuk	2x300	Gas
2019	17540.0	0	19280	0	19280	9.92			
2020	18095.0	600	19880	1200	18680	3.23	Yousifiyah	2x300	Steam
		19880		7069		8.66			

Appendix C.4 Recommended Generation Expansion Plans (Cont.)

Plan (3): Thermal, High Efficient Combined Cycle and Hydropower Stations Candidates

Calendar Year	Peak Power Demand MW	Installed Capacity MW	Total Capacity MW	Retired Capacity MW	Net Capacity MW	Reserve%	Added Plant	Added Units	Plant Type
2004	7363.0	5926	5926	0	5926				
2005	7472.0	1974	7900	0	7900	5.73			
2006	8019.0	600	8500	0	8500	6.00	Salah Al Din	4x150	Steam
2007	8264.0	600	9100	0	9100	10.12	Salah Al Din	4x150	Steam
2008	9057.0	900	10000	120	9880	9.09	Al Samawah	3x300	C/C
2009	9782.0	900	10900	260	10640	8.77	Al Anbar	3x300	C/C
2010	10422.0	900	11800	200	11600	11.30	Al Anbar Al Shamal	1x300 2x300	C/C C/C
2011	11164.0	900	12700	459	12241	9.65	Al Shamal Al Wassit	2x300 2x150	C/C Steam
2012	12124.0	1060	13760	490	13270	9.45	Bakhma Al Basrah	1x160 3x300	Hydro C/C
2013	12978.0	900	14660	355	14305	10.22	Kirkuk Al Basrah	2x300 1x300	C/C C/C
2014	14100.0	1200	15860	800	15060	6.81	Kirkuk Al Basrah	2x300 2x300	C/C C/C
2015	15123.0	1200	17060	0	17060	12.81	Kirkuk Al Basrah	2x300 2x300	C/C C/C
2016	15582.0	900	17960	640	17320	11.15	Kirkuk Al Basrah	2x300 1x300	C/C C/C
2017	16267.0	720	18680	890	17790	9.36	Al Basrah Al Mokuhhol	2x300 1x120	C/C Hydro
2018	16795.0	600	19280	1655	17625	4.94	Kirkuk	2x300	C/C
2019	17540.0	0	19280	0	19280	9.92			
2020	18095.0	600	19880	1200	18680	3.23	Yousifiyah	2x300	Steam
		19880		7069		8.66			

Appendix C.5 Annual Fuel Usage & Cost

Option Case 1

Year	GAS						Diesel					
	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/MSCF)	Fuel Used (MSCF)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/ton)	Fuel Used (ton)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)
2006	12,098	13035	1.00	157,697,430	440	36.35	581	10800	42.86	146,402	26	45.14
2007	13,256	13043	1.00	172,898,008	486	36.63	764	10800	42.86	192,515	35	45.59
2008	15,043	13127	1.00	197,469,461	558	37.12	640	10800	42.86	161,269	29	46.04
2009	20,527	13127	1.00	269,457,929	767	37.38	497	10800	42.86	125,236	23	46.50
2010	24,083	13127	1.00	316,137,541	907	37.64	578	10800	42.86	145,646	27	46.97
2011	21,576	13127	1.00	283,228,152	818	37.91	441	10800	42.86	111,125	21	47.44
2012	24,482	13127	1.00	321,375,214	935	38.17	731	10800	42.86	184,200	35	47.91
2013	31,484	13127	1.00	413,290,468	1,210	38.44	440	10800	42.86	110,873	21	48.39
2014	38,349	13127	1.00	503,407,323	1,484	38.71	346	10800	42.86	87,186	17	48.88
2015	42,761	13127	1.00	561,323,647	1,667	38.98	365	10800	42.86	91,974	18	49.37
2016	49,490	13127	1.00	649,655,230	1,943	39.25	369	10800	42.86	92,982	18	49.86
2017	72,400	13127	1.00	950,394,800	2,862	39.53	446	10800	42.86	112,385	22	50.36
2018	80,453	13127	1.00	1,056,106,531	3,202	39.80	344	10800	42.86	86,682	17	50.86
2019	86,636	13127	1.00	1,137,270,772	3,472	40.08	337	10800	42.86	84,918	17	51.37
2020	89,893	13127	1.00	1,180,025,411	3,628	40.36	450	10800	42.86	113,392	23	51.88
	Total			8,169,737,917	24,378	***38.42***	Total			1,846,785	352	***48.44***

Year	Fuel Oil						Crude Oil					
	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/ton)	Fuel Used (ton)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/ton)	Fuel Used (ton)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)
2006	20,387	10300	40.87	5,137,903	738	36.22	9,453	10100	40.08	2,382,118	296	31.30
2007	20,428	10300	40.87	5,148,236	747	36.58	9,453	10100	40.08	2,382,118	299	31.61
2008	23,662	10522	40.87	6,091,793	893	37.74	9,453	10100	40.08	2,382,118	302	31.93
2009	23,836	10472	40.87	6,107,428	904	37.94	8,982	10100	40.08	2,263,428	290	32.25
2010	23,994	10488	40.87	6,157,305	921	38.38	8,982	10100	40.08	2,263,428	293	32.57
2011	28,009	10438	40.87	7,153,363	1,080	38.58	8,982	10100	40.08	2,263,428	295	32.90
2012	28,724	10502	40.87	7,380,951	1,126	39.20	8,982	10100	40.08	2,263,428	298	33.23
2013	26,677	10432	40.87	6,809,260	1,049	39.33	8,982	10100	40.08	2,263,428	301	33.56
2014	26,417	10403	40.87	6,724,151	1,046	39.61	7,957	10100	40.08	2,005,132	270	33.89
2015	26,423	10404	40.87	6,726,325	1,057	40.01	7,957	10100	40.08	2,005,132	272	34.23
2016	23,670	10417	40.87	6,033,041	958	40.46	7,957	10100	40.08	2,005,132	275	34.58
2017	9,341	10653	40.87	2,434,785	390	41.79	4,446	10100	40.08	1,120,374	155	34.92
2018	6,165	10719	40.87	1,616,898	262	42.47	4,446	10100	40.08	1,120,374	157	35.27
2019	5,998	10720	40.87	1,573,246	257	42.90	4,446	10100	40.08	1,120,374	158	35.62
2020	9,773	10638	40.87	2,543,802	420	43.00	1,879	10100	40.08	473,500	68	35.98
	Total			77,638,487	11,850	***39.61***	Total			28,313,515	3,729	***33.59***

Appendix C.5 Annual Fuel Usage & Cost (Cont.)

Option Case 2

Year	GAS						Diesel					
	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/MSCF)	Fuel Used (MSCF)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/ton)	Fuel Used (ton)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)
2006	12,425	13038	1.00	161,997,150	452	36.36	615	10800	42.86	154,970	28	45.14
2007	13,571	13045	1.00	177,033,695	497	36.63	805	10800	42.86	202,846	37	45.59
2008	15,300	13127	1.00	200,843,100	568	37.12	580	10800	42.86	146,150	27	46.04
2009	20,791	13127	1.00	272,923,457	777	37.38	456	10800	42.86	114,904	21	46.50
2010	24,324	13127	1.00	319,301,148	916	37.64	540	10800	42.86	136,071	25	46.97
2011	27,446	13127	1.00	360,283,642	1,040	37.91	490	10800	42.86	123,472	23	47.44
2012	28,082	13127	1.00	368,632,414	1,072	38.17	907	10800	42.86	228,549	43	47.91
2013	34,182	13127	1.00	448,707,114	1,314	38.44	773	10800	42.86	194,783	37	48.39
2014	40,191	13127	1.00	527,587,257	1,556	38.71	802	10800	42.86	202,091	39	48.88
2015	45,418	13127	1.00	596,202,086	1,770	38.98	691	10800	42.86	174,120	34	49.37
2016	50,789	13127	1.00	666,707,203	1,994	39.25	752	10800	42.86	189,491	37	49.86
2017	67,746	13127	1.00	889,301,742	2,678	39.53	775	10800	42.86	195,287	39	50.36
2018	76,339	13127	1.00	1,002,102,053	3,038	39.80	620	10800	42.86	156,230	32	50.86
2019	81,432	13127	1.00	1,068,957,864	3,264	40.08	692	10800	42.86	174,372	36	51.37
2020	89,000	13127	1.00	1,168,303,000	3,592	40.36	565	10800	42.86	142,371	29	51.88
	Total			8,228,882,925	24,528	***38.42***	Total			2,535,707	488	***48.44***

Year	Fuel Oil						Crude Oil					
	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/ton)	Fuel Used (ton)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/ton)	Fuel Used (ton)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)
2006	20,001	10300	40.87	5,040,624	724	36.22	9,453	10100	40.08	2,382,118	296	31.30
2007	20,039	10300	40.87	5,050,201	733	36.58	9,453	10100	40.08	2,382,118	299	31.61
2008	23,636	10557	40.87	6,105,340	895	37.87	9,453	10100	40.08	2,382,118	302	31.93
2009	23,661	10503	40.87	6,080,535	900	38.05	8,982	10100	40.08	2,263,428	290	32.25
2010	23,842	10521	40.87	6,137,550	918	38.50	8,982	10100	40.08	2,263,428	293	32.57
2011	23,606	10538	40.87	6,086,617	919	38.94	8,982	10100	40.08	2,263,428	295	32.90
2012	22,140	10665	40.87	5,777,419	881	39.81	8,982	10100	40.08	2,263,428	298	33.23
2013	21,375	10632	40.87	5,560,533	857	40.08	8,982	10100	40.08	2,263,428	301	33.56
2014	21,352	10629	40.87	5,552,983	864	40.47	7,957	10100	40.08	2,005,132	270	33.89
2015	20,970	10583	40.87	5,430,034	853	40.70	7,957	10100	40.08	2,005,132	272	34.23
2016	18,293	10650	40.87	4,766,833	757	41.37	7,957	10100	40.08	2,005,132	275	34.58
2017	12,112	10949	40.87	3,244,783	520	42.95	4,446	10100	40.08	1,120,374	155	34.92
2018	6,682	11099	40.87	1,814,620	294	43.98	4,446	10100	40.08	1,120,374	157	35.27
2019	7,228	11113	40.87	1,965,372	321	44.47	4,446	10100	40.08	1,120,374	158	35.62
2020	7,766	10928	40.87	2,076,507	343	44.17	1,879	10100	40.08	473,500	68	35.98
	Total			70,689,952	10,781	***40.28***	Total			28,313,515	3,729	***33.59***

Appendix C.5 Annual Fuel Usage & Cost (Cont.)

Option Case 3

Year	GAS						Diesel					
	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/MSCF)	Fuel Used (MSCF)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/ton)	Fuel Used (ton)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)
2006	12,425	13038	1.00	161,997,150	452	36.36	615	10800	42.86	154,970	28	45.14
2007	13,571	13045	1.00	177,033,695	497	36.63	805	10800	42.86	202,846	37	45.59
2008	9,439	13127	1.00	123,905,753	350	37.12	580	10800	42.86	146,150	27	46.04
2009	15,480	10874	1.00	168,329,520	479	30.96	456	10800	42.86	114,904	21	46.50
2010	19,595	10457	1.00	204,904,915	588	29.99	540	10800	42.86	136,071	25	46.97
2011	24,621	10173	1.00	250,469,433	723	29.38	490	10800	42.86	123,472	23	47.44
2012	26,043	10341	1.00	269,310,663	783	30.07	907	10800	42.86	228,549	43	47.91
2013	33,494	9906	1.00	331,791,564	972	29.01	773	10800	42.86	194,783	37	48.39
2014	40,444	9692	1.00	391,983,248	1,156	28.58	802	10800	42.86	202,091	39	48.88
2015	48,115	9548	1.00	459,402,020	1,364	28.35	691	10800	42.86	174,120	34	49.37
2016	53,013	9540	1.00	505,744,020	1,512	28.53	752	10800	42.86	189,491	37	49.86
2017	67,128	9749	1.00	654,430,872	1,971	29.35	775	10800	42.86	195,287	39	50.36
2018	77,319	9504	1.00	734,839,776	2,228	28.82	620	10800	42.86	156,230	32	50.86
2019	80,830	9502	1.00	768,046,660	2,345	29.01	692	10800	42.86	174,372	36	51.37
2020	86,615	9443	1.00	817,905,445	2,515	29.03	565	10800	42.86	142,371	29	51.88
	Total			6,020,094,734	17,935	***30.75***	Total			2,535,707	488	***48.44***

Year	Fuel Oil						Crude Oil					
	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/ton)	Fuel Used (ton)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)	Generated Energy (GWh)	Average Heat Rate (btu/kWh)	Heat Content (Mbtu/ton)	Fuel Used (ton)	Fuel Cost (Million US$)	Fuel Cost (US$/MWh)
2006	20,001	10300	40.87	5,040,624	724	36.22	9,453	10100	40.08	2,382,118	296	31.30
2007	20,039	10300	40.87	5,050,201	733	36.58	9,453	10100	40.08	2,382,118	299	31.61
2008	27,897	9964	40.87	6,801,216	997	35.74	9,453	10100	40.08	2,382,118	302	31.93
2009	26,972	9953	40.87	6,568,444	973	36.06	8,982	10100	40.08	2,263,428	290	32.25
2010	26,571	9949	40.87	6,468,189	967	36.40	8,982	10100	40.08	2,263,428	293	32.57
2011	24,331	9944	40.87	5,919,928	894	36.75	8,982	10100	40.08	2,263,428	295	32.90
2012	22,759	9949	40.87	5,540,232	845	37.14	8,982	10100	40.08	2,263,428	298	33.23
2013	20,810	9919	40.87	5,050,511	778	37.39	8,815	10100	40.08	2,221,345	296	33.56
2014	18,042	9905	40.87	4,372,547	680	37.71	7,587	10100	40.08	1,911,894	257	33.89
2015	17,062	9880	40.87	4,124,604	648	38.00	7,248	10100	40.08	1,826,467	248	34.23
2016	15,690	9841	40.87	3,777,962	600	38.22	7,172	10100	40.08	1,807,315	248	34.58
2017	11,012	9670	40.87	2,605,482	418	37.94	4,446	10100	40.08	1,120,374	155	34.92
2018	7,801	9577	40.87	1,827,996	296	37.95	4,446	10100	40.08	1,120,374	157	35.27
2019	6,207	9588	40.87	1,456,147	238	38.37	4,446	10100	40.08	1,120,374	158	35.62
2020	8,659	9639	40.87	2,042,185	337	38.96	1,879	10100	40.08	473,500	68	35.98
	Total			66,646,267	10,130	***37.29***	Total			27,801,712	3,660	***33.59***

Appendix C.6 Annual Gas Consumption in MSCF

Year	Case		
	Option Case 1	**Option Case 2**	**Option Case 3**
2006	157,697,430	161,997,150	161,997,150
2007	172,898,008	177,033,695	177,033,695
2008	197,469,461	200,843,100	123,905,753
2009	269,457,929	272,923,457	168,329,520
2010	316,137,541	319,301,148	204,904,915
2011	283,228,152	360,283,642	250,469,433
2012	321,375,214	368,632,414	269,310,663
2013	413,290,468	448,707,114	331,791,564
2014	503,407,323	527,587,257	391,983,248
2015	561,323,647	596,202,086	459,402,020
2016	649,655,230	666,707,203	505,744,020
2017	950,394,800	889,301,742	654,430,872
2018	1,056,106,531	1,002,102,053	734,839,776
2019	1,137,270,772	1,068,957,864	768,046,660
2020	1,180,025,411	1,168,303,000	817,905,445
Total	**8,169,737,917**	**8,228,882,925**	**6,020,094,734**

Appendix C.7 Annual Diesel Consumption in Tons

Year	Case		
	Option Case 1	Option Case 2	Option Case 3
2006	146,402	154,970	154,970
2007	192,515	202,846	202,846
2008	161,269	146,150	146,150
2009	125,236	114,904	114,904
2010	145,646	136,071	136,071
2011	111,125	123,472	123,472
2012	184,200	228,549	228,549
2013	110,873	194,783	194,783
2014	87,186	202,091	202,091
2015	91,974	174,120	174,120
2016	92,982	189,491	189,491
2017	112,385	195,287	195,287
2018	86,682	156,230	156,230
2019	84,918	174,372	174,372
2020	113,392	142,371	142,371
Total	**1,846,785**	**2,535,707**	**2,535,707**

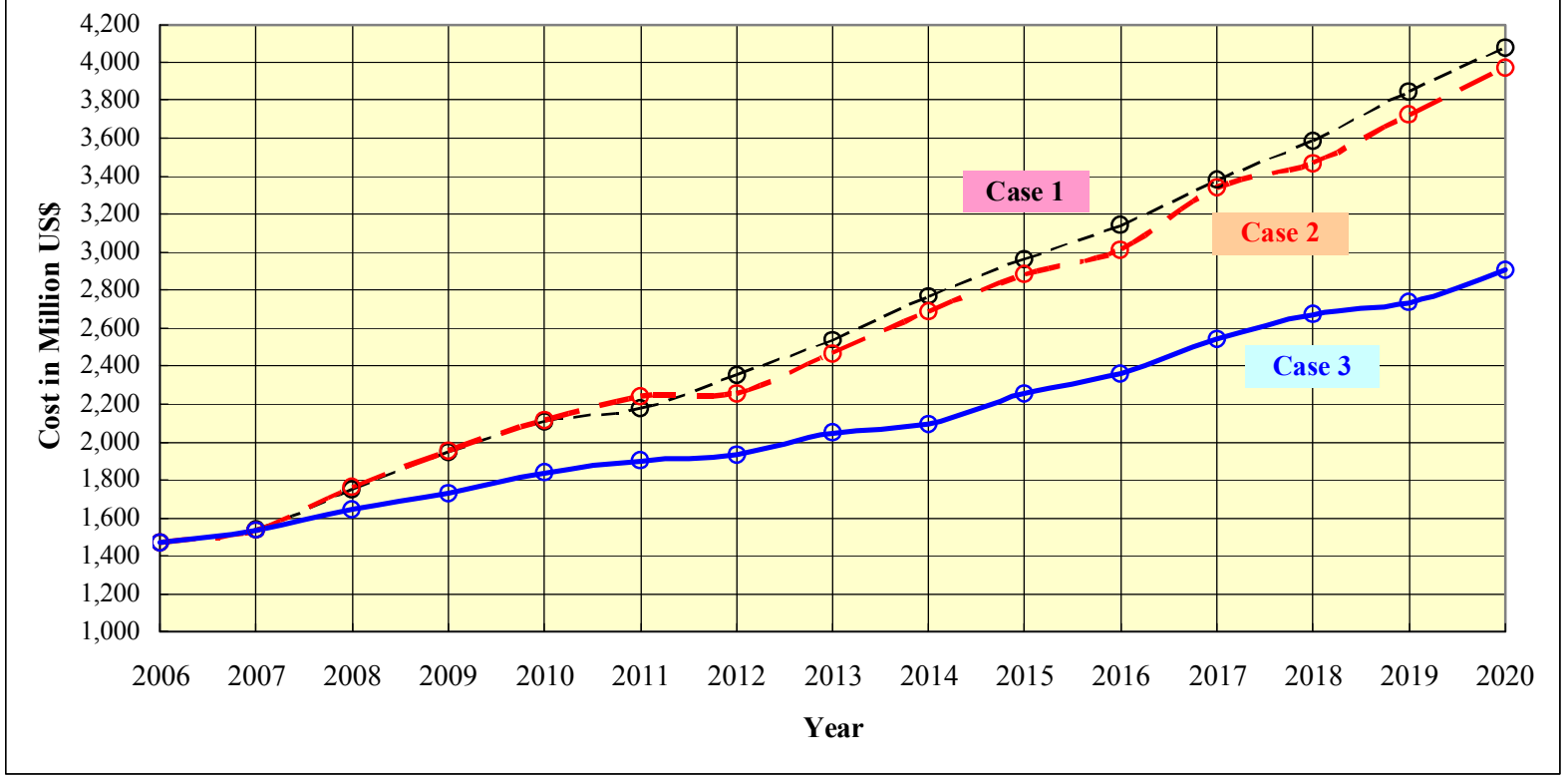
Appendix C.8 Annual Fuel Oil Consumption in Tons

Year	Case		
	Option Case 1	Option Case 2	Option Case 3
2006	5,137,903	5,040,624	5,040,624
2007	5,148,236	5,050,201	5,050,201
2008	6,091,793	6,105,340	6,801,216
2009	6,107,428	6,080,535	6,568,444
2010	6,157,305	6,137,550	6,468,189
2011	7,153,363	6,086,617	5,919,928
2012	7,380,951	5,777,419	5,540,232
2013	6,809,260	5,560,533	5,050,511
2014	6,724,151	5,552,983	4,372,547
2015	6,726,325	5,430,034	4,124,604
2016	6,033,041	4,766,833	3,777,962
2017	2,434,785	3,244,783	2,605,482
2018	1,616,898	1,814,620	1,827,996
2019	1,573,246	1,965,372	1,456,147
2020	2,543,802	2,076,507	2,042,185
Total	**77,638,487**	**70,689,952**	**66,646,267**

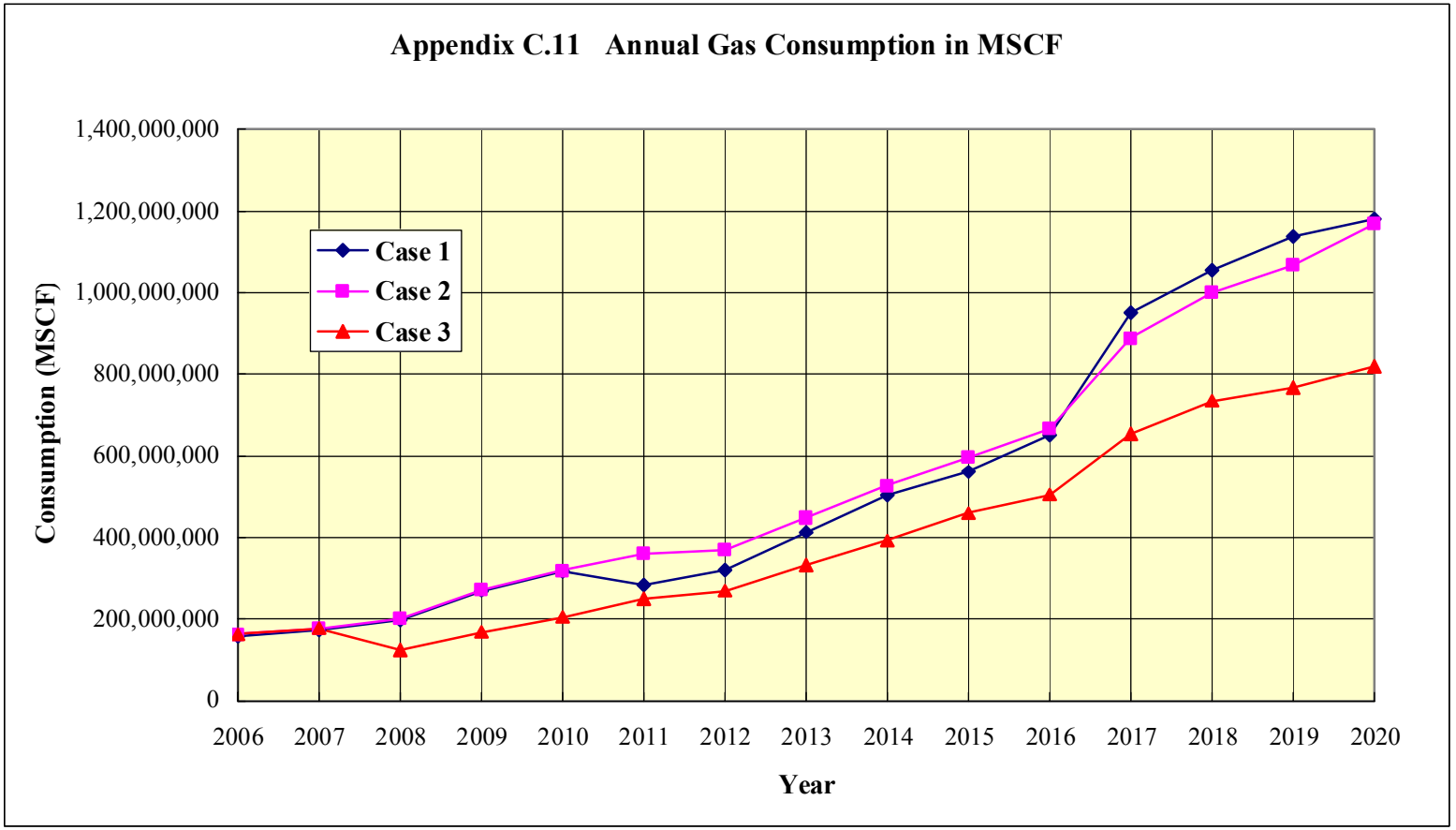
Appendix C.9 Annual Crude Oil Consumption in Tons

Year	Case		
	Option Case 1	Option Case 2	Option Case 3
2006	2,382,118	2,382,118	2,382,118
2007	2,382,118	2,382,118	2,382,118
2008	2,382,118	2,382,118	2,382,118
2009	2,263,428	2,263,428	2,263,428
2010	2,263,428	2,263,428	2,263,428
2011	2,263,428	2,263,428	2,263,428
2012	2,263,428	2,263,428	2,263,428
2013	2,263,428	2,263,428	2,221,345
2014	2,005,132	2,005,132	1,911,894
2015	2,005,132	2,005,132	1,826,467
2016	2,005,132	2,005,132	1,807,315
2017	1,120,374	1,120,374	1,120,374
2018	1,120,374	1,120,374	1,120,374
2019	1,120,374	1,120,374	1,120,374
2020	473,500	473,500	473,500
Total	**28,313,515**	**28,313,515**	**27,801,712**

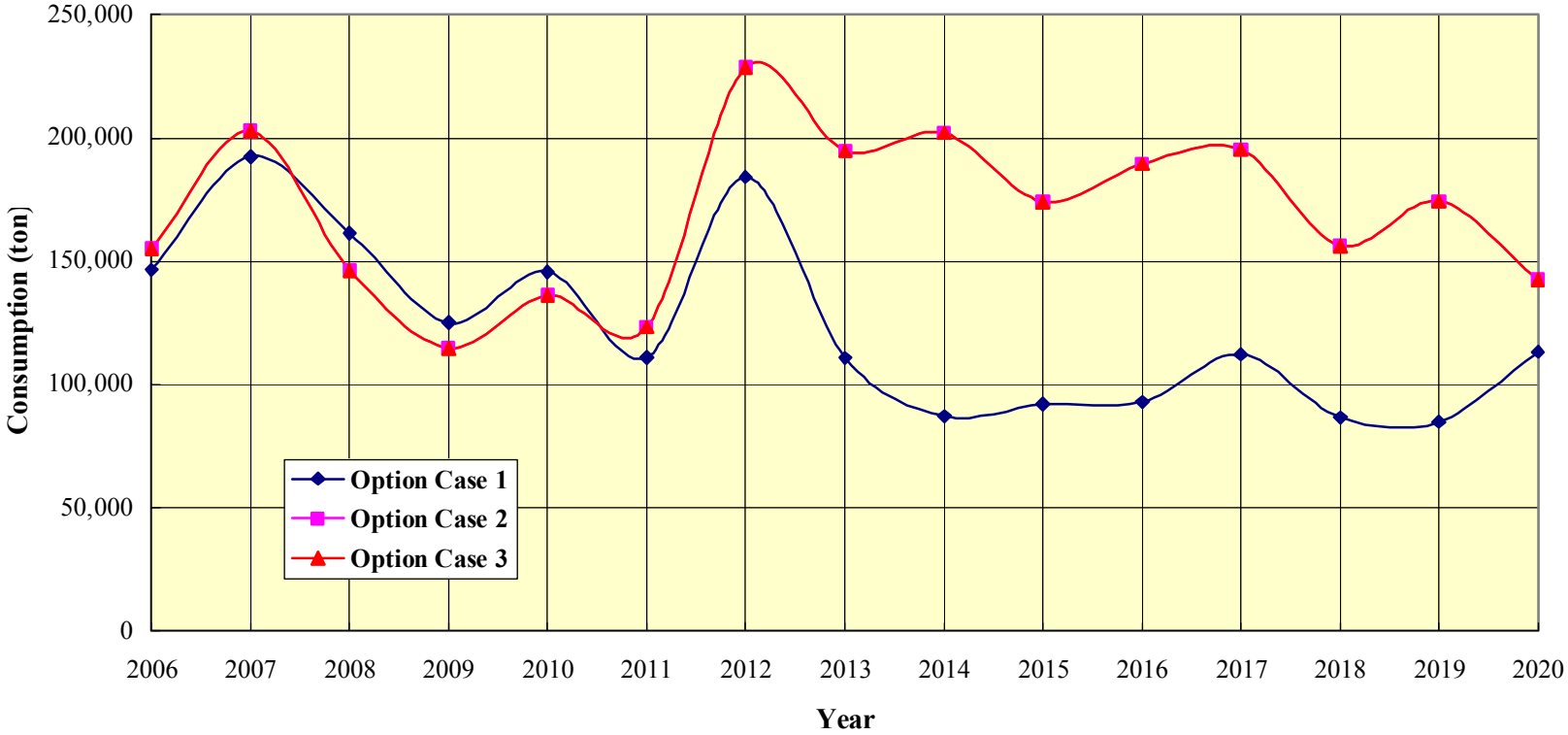
Appendix C.10 Annual Estimated Fuel Cost in Million US$



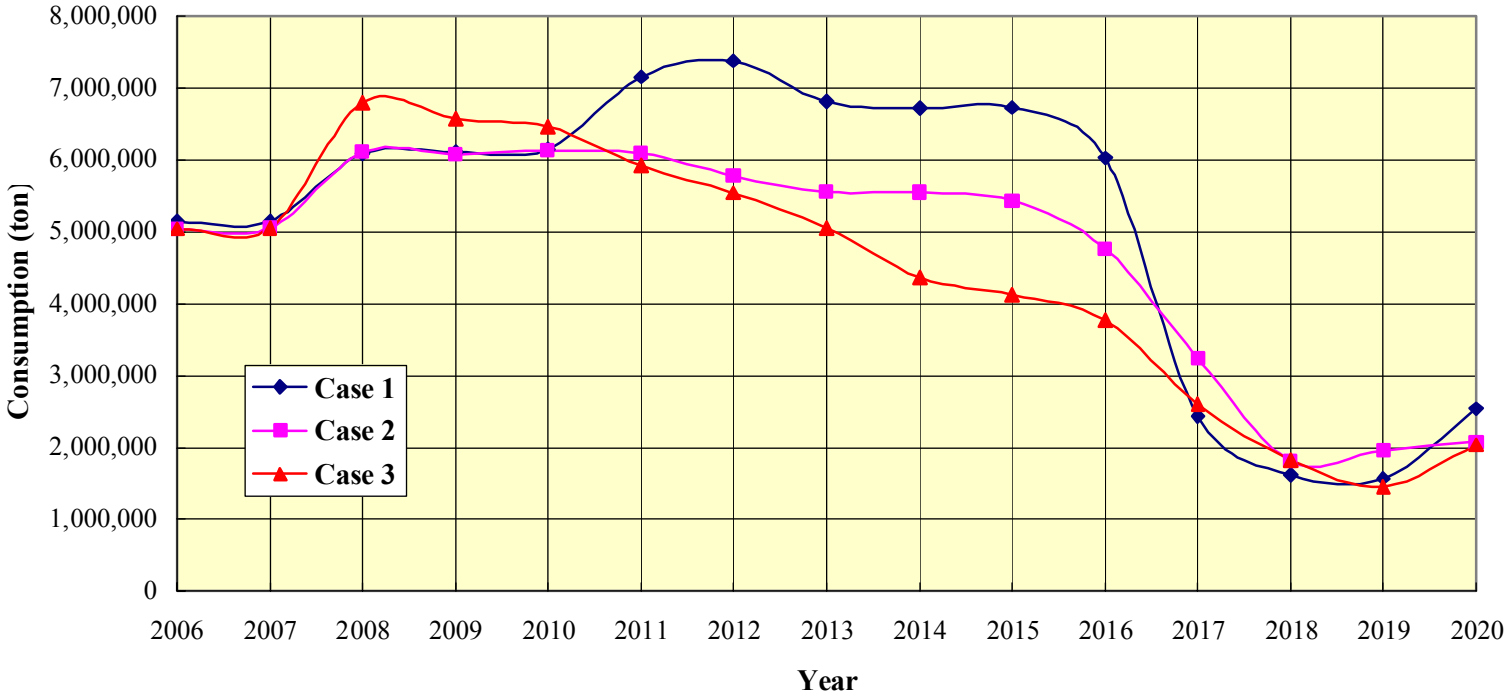
Appendix C.11 Annual Gas Consumption in MSCF



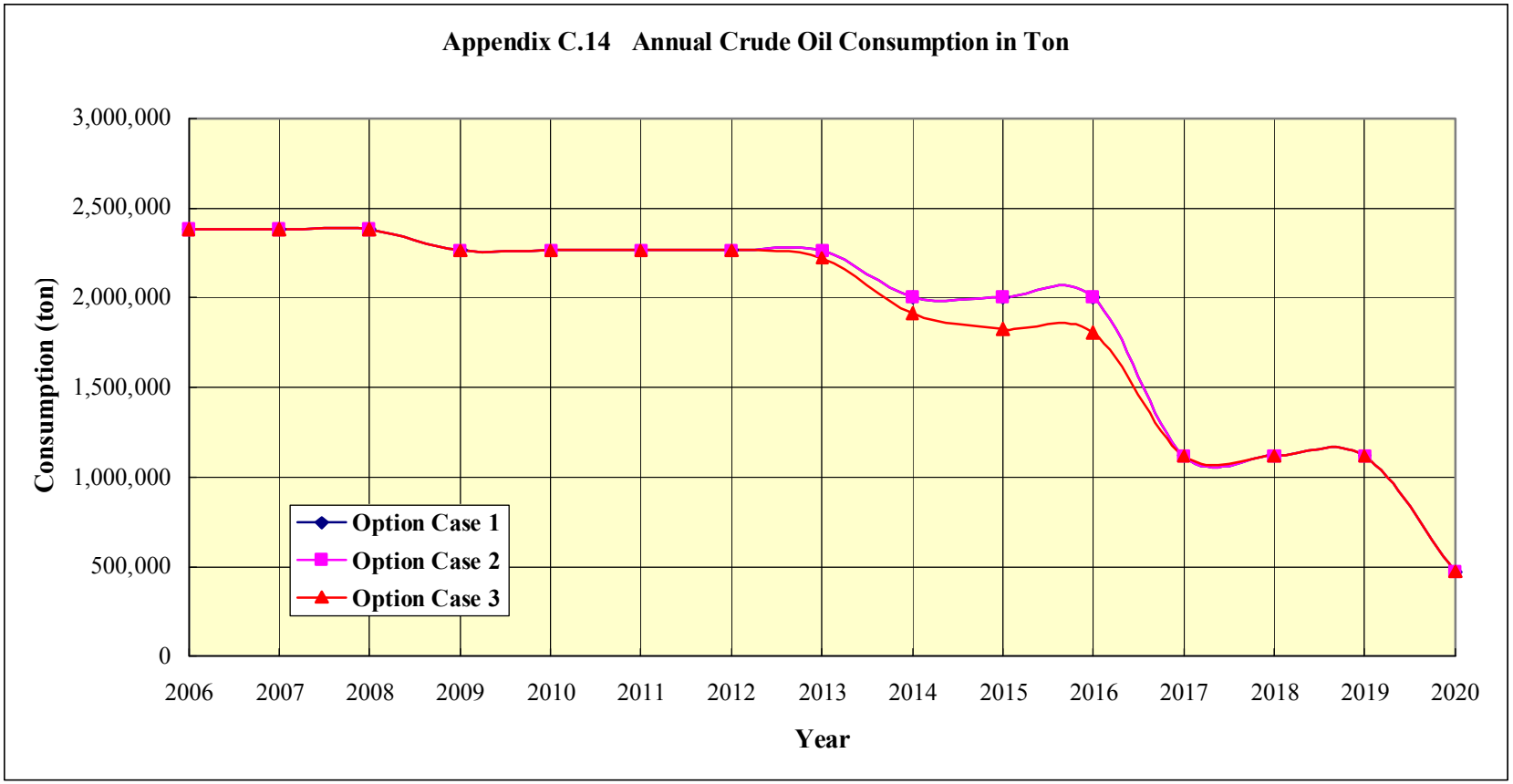
Appendix C.12 Annual Diesel Consumption in Ton



Appendix C.13 Annual Fuel Oil Consumption in Ton



Appendix C.14 Annual Crude Oil Consumption in Ton



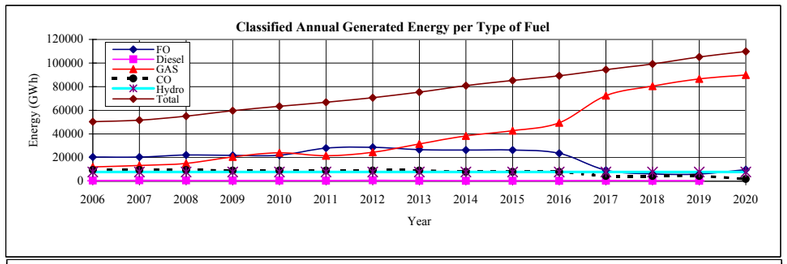
Appendix C.15 Annual Emission Reduction

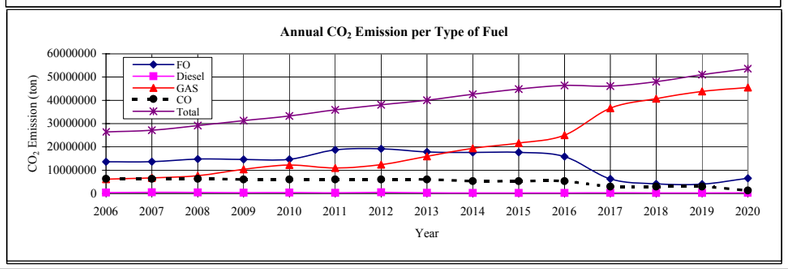
CO_2 Annual Emission of (Case 1)

Operating Year	Energy Generated (GWh)					CO_2 Emission (ton)				Total Energy	Total Emission	Annual CER ton
	Hydro	FO	Diesel	GAS	CO	FO	Diesel	GAS	CO			
2006	7779	20,387	581	12,098	9,453	13,618,516	388,108	6,121,588	6,314,604	50298	26,442,816	69,674
2007	7779	20,428	764	13,256	9,453	13,645,904	510,352	6,707,536	6,314,604	51680	27,178,396	73,074
2008	7779	23,662	640	15,043	9,453	15,806,216	427,520	7,611,758	6,314,604	56577	30,160,098	46,724
2009	7779	23,836	497	20,527	8,982	15,922,448	331,996	10,386,662	5,999,976	61621	32,641,082	486,322
2010	7779	23,994	578	24,083	8,982	16,027,992	386,104	12,185,998	5,999,976	65416	34,600,070	574,876
2011	7779	28,009	441	21,576	8,982	18,710,012	294,588	10,917,456	5,999,976	66787	35,922,032	883,402
2012	7779	28,724	731	24,482	8,982	19,187,632	488,308	12,387,892	5,999,976	70698	38,063,808	3,077,186
2013	7779	26,677	440	31,484	8,982	17,820,236	293,920	15,930,904	5,999,976	75362	40,045,036	2,791,208
2014	7779	26,417	346	38,349	7,957	17,646,556	231,128	19,404,594	5,315,276	80848	42,597,554	4,476,982
2015	7779	26,423	365	42,761	7,957	17,650,564	243,820	21,637,066	5,315,276	85285	44,846,726	3,799,868
2016	7779	23,670	369	49,490	7,957	15,811,560	246,492	25,041,940	5,315,276	89265	46,415,268	3,816,538
2017	7779	9,341	446	72,400	4,446	6,239,788	297,928	36,634,400	2,969,928	94412	46,142,044	1,331,632
2018	7779	6,165	344	80,453	4,446	4,118,220	229,792	40,709,218	2,969,928	99187	48,027,158	308,588
2019	7779	5,998	337	86,636	4,446	4,006,664	225,116	43,837,816	2,969,928	105196	51,039,524	2,561,084
2020	7779	9,773	450	89,893	1,879	6,528,364	300,600	45,485,858	1,255,172	109774	53,569,994	2,326,000
Total	**116685**	**303504**	**7329**	**622531**	**112357**	**202,740,672**	**4,895,772**	**315,000,686**	**75,054,476**	**1,162,406**	**597,691,606**	**26,623,158**

Fuel Type	FO	CO	GAS	Diesel	Hydro
CO_2 Emission Rate (ton/GWh)	668	668	506	668	0

Sources: IPIECA, IETA, UNIDO



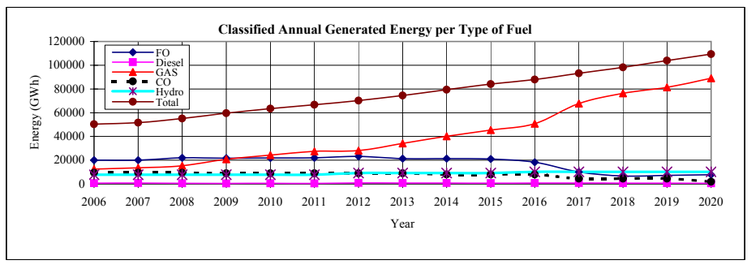


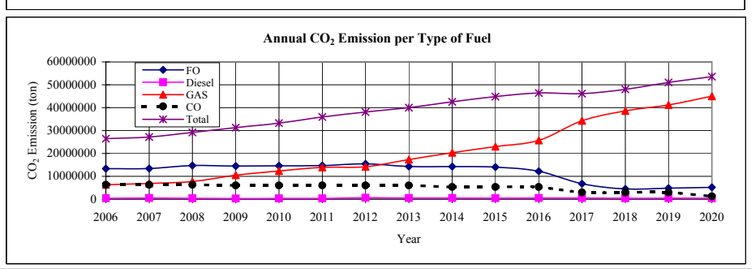
CO_2 Annual Emission (Case 2)

Operating Year	Energy Generated (GWh)					CO_2 Emission (ton)				Total Energy	Total Emission	Annual CER ton
	Hydro	FO	Diesel	GAS	CO	FO	Diesel	GAS	CO			
	7779	20,001	615	12,425	9,453	13,360,668	410,820	6,287,050	6,314,604	50273	26,373,142	0
	7779	20,039	805	13,571	9,453	13,386,052	537,740	6,866,926	6,314,604	51647	27,105,322	0
	7779	23,636	580	15,300	9,453	15,788,848	387,440	7,741,800	6,314,604	56748	30,232,692	119,318
	7779	23,661	456	20,791	8,982	15,805,548	304,608	10,520,246	5,999,976	61669	32,630,378	475,618
	7779	23,842	540	24,324	8,982	15,926,456	360,720	12,307,944	5,999,976	65467	34,595,096	569,902
	7779	22,606	490	27,446	8,982	15,100,808	327,320	13,887,676	5,999,976	67303	35,315,780	277,150
	9139	23,140	907	28,082	8,982	15,457,520	605,876	14,209,492	5,999,976	70250	36,272,864	1,286,242
	9139	21,375	773	34,182	8,982	14,278,500	516,364	17,296,092	5,999,976	74451	38,090,932	837,104
	9139	21,352	802	40,191	7,957	14,263,136	535,736	20,336,646	5,315,276	79441	40,450,794	2,330,222
	9139	20,970	691	45,418	7,957	14,007,960	461,588	22,981,508	5,315,276	84175	42,766,332	1,719,474
	10159	18,293	752	50,789	7,957	12,219,724	502,336	25,699,234	5,315,276	87950	43,736,570	1,137,840
	10159	12,112	775	67,746	4,446	8,090,816	517,700	34,279,476	2,969,928	95238	45,857,920	1,047,508
	10159	8,682	620	76,339	4,446	5,799,576	414,160	38,627,534	2,969,928	100246	47,811,198	92,628
	10159	7,228	692	81,432	4,446	4,828,304	462,256	41,204,592	2,969,928	103957	49,465,080	986,640
	10159	7,766	565	89,000	1,879	5,187,688	377,420	45,034,000	1,255,172	109369	51,854,280	610,286
	134025	**274703**	**10063**	**627036**	**112357**	**183,501,604**	**6,722,084**	**317,280,216**	**75,054,476**	**1,158,184**	**582,558,380**	**11,489,932**

Fuel Type	FO	CO	GAS	Diesel	Hydro
CO_2 Emission Rate (ton/GWh)	668	668	506	668	0

Sources: IPIECA, IETA, UNIDO



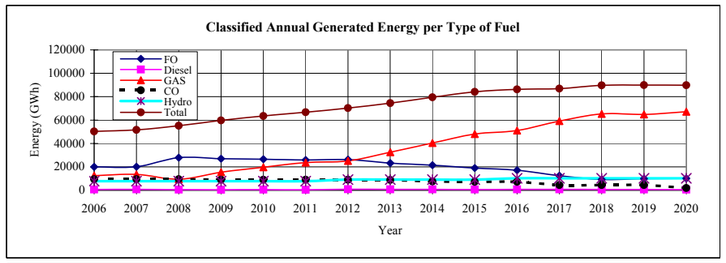


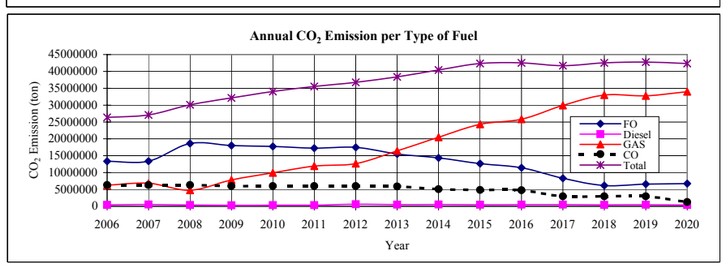
CO_2 Annual Emission (Case 3)

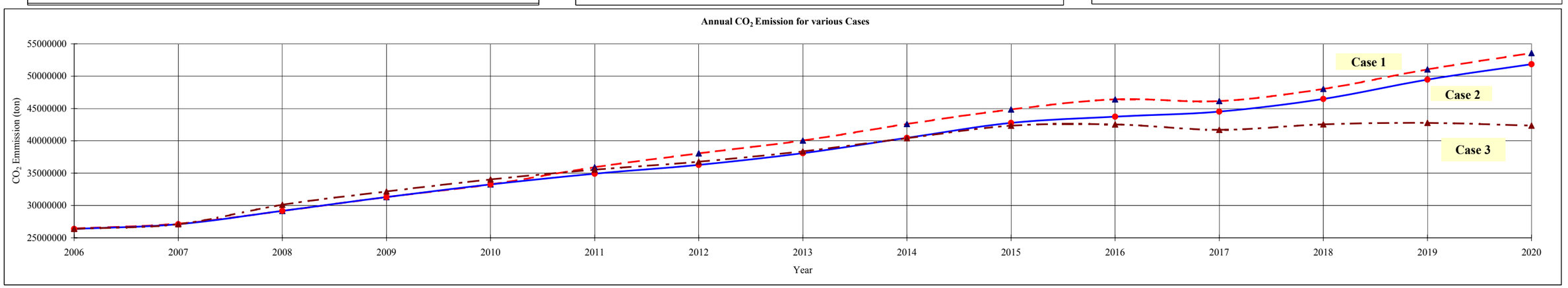
Operating Year	Energy Generated (GWh)					CO_2 Emission (ton)				Total Energy	Total Emission	Annual CER ton
	Hydro	FO	Diesel	GAS	CO	FO	Diesel	GAS	CO			
	7779	20,001	615	12,425	9,453	13,360,668	410,820	6,287,050	6,314,604	50273	26,373,142	
	7779	20,039	805	13,571	9,453	13,386,052	537,740	6,866,926	6,314,604	51647	27,105,322	
	7779	27,897	580	9,439	9,453	18,635,196	387,440	4,776,134	6,314,604	55148	30,113,374	
	7779	26,972	456	15,480	8,982	18,017,296	304,608	7,832,880	5,999,976	59669	32,154,760	
	7779	26,571	540	19,595	8,982	17,749,428	360,720	9,915,070	5,999,976	63467	34,025,194	
	7779	24,331	490	24,621	8,982	16,253,108	327,320	12,458,226	5,999,976	66203	35,038,630	
	9139	22,759	907	26,043	8,982	15,203,012	605,876	13,177,758	5,999,976	67830	34,986,622	
	9139	20,810	773	33,494	8,815	13,901,080	516,364	16,947,964	5,888,420	73031	37,253,828	
	9139	18,042	802	40,444	7,587	12,052,056	535,736	20,464,664	5,068,116	76014	38,120,572	
	9139	17,062	691	48,115	7,248	11,397,416	461,588	24,346,190	4,841,664	82255	41,046,858	
	10159	15,690	752	53,013	7,172	10,480,920	502,336	26,824,578	4,790,896	86786	42,598,730	
	10159	11,012	775	67,128	4,446	7,356,016	517,700	33,966,768	2,969,928	93520	44,810,412	
	10159	7,801	620	77,319	4,446	5,211,068	414,160	39,123,414	2,969,928	100345	47,718,570	
	10159	6,207	692	80,830	4,446	4,146,276	462,256	40,899,980	2,969,928	102334	48,478,440	
	10159	8,659	565	86,615	1,879	5,784,212	377,420	43,827,190	1,255,172	107877	51,243,994	
	134025	**273853**	**10063**	**608132**	**110326**	**182,933,804**	**6,722,084**	**307,714,792**	**73,697,768**	**1,136,399**	**571,068,448**	

Fuel Type	FO	CO	GAS	Diesel	Hydro
CO_2 Emission Rate (ton/GWh)	668	668	506	668	0

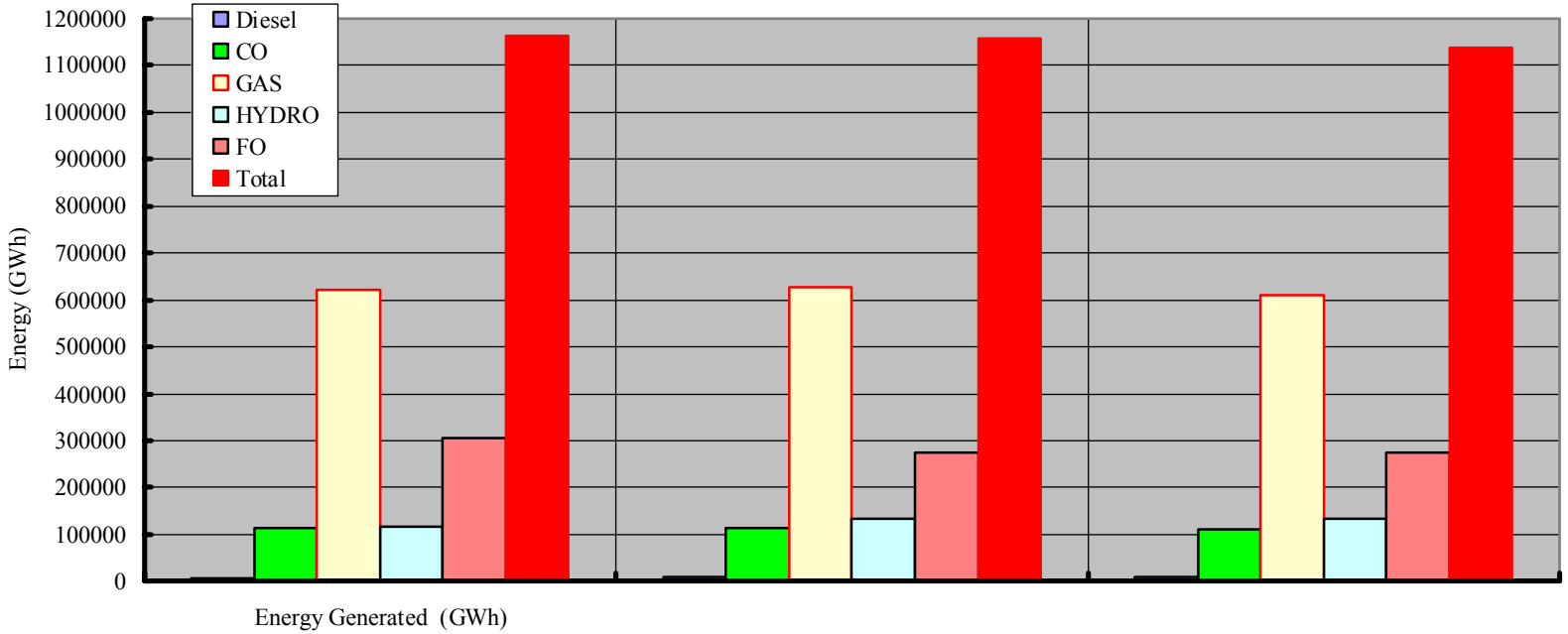
Sources: IPIECA, IETA, UNIDO







Appendix C.16 Total Generated Energy per Type of Fuel between 2006 & 2020



付属資料 D ：Standards related to the Electricity Sector

Appendix D.1 Environmental Quality Standards for Air Pollution (For main substance)

	Japan	US	UK
Substance	Environmental Regulation		
Sulfur dioxide	Daily average of hourly values shall not exceed 0.04ppm, and hourly values shall not exceed 0.1ppm	3-hr: Not to be at or above this level more than once per calendar year: 550ppb (Secondary) 24-hr: Not to be at or above this level more than once per calendar year:145ppb (Primary) Annual: Not to be at or above this level:35ppb(Primary)	
Carbon monoxide	Daily average of hourly values shall not exceed 10ppm, and average of hourly values in eight consecutive hours shall not exceed 20ppm	1-hr: Not to be at or above this level more than once per calendar year:35.5ppm 8-hr:Not to be at or above this level more than once per calendar year:9.5ppm	
Suspended particulate substance	Daily average of hourly values shall not exceed 0.10mg/m^3, and hourly values shall not exceed 0.2mg/m^3		
Nitrogen dioxide	Daily average of hourly values shall be within the range from 0.04ppm to 0.06ppm or below.		

Flue Gas Standards

1) Sulfur Oxide Emission Regulation

$q=Kx10^{-3}He^2$

q : Permissible emission volume of Sulfur oxides(m_N^3/h)

K : Each region value shown in Table

He (Effective stack height) =Ho+0.65(Hm+Ht)(m)

Ho :Actual height of the outlet(m)

Q : Amount of exausted gas at 15°C (m^3/s)

V : Exhausted gas velocity (m/s)

T: Exhausted gas temperature(K)

$$Hm = \frac{0.795\sqrt{Q/V}}{1 + \frac{2.58}{V}}$$

$$Ht = 2.01 \times 10^{-3} \cdot Q(T-288) \cdot \left(2.30 \log J + \frac{1}{J} - 1\right)$$

$$J = \frac{1}{\sqrt{Q \cdot V}}\left(1.460 - 296 \times \frac{V}{T-288}\right) + 1$$

Region Name	K Value
Tokyo(city), Yokohama, Kawasaki, Nagoya, Osaka, Kobe	3.0
Hitachi	4.5
Shizuoka	10.0

2) **Nitrogen Oxide Emission Regulation**

(refer to other sheet)

Appendix D.2 Environmental Quality Standards for Water Pollution

1) Standards related to the Protection of Human Health (yearly average)

Item	Standard Values	Item	Standard Values
Cadmium	0.01mg/l or less	1,1,1-trichloroethane	1mg/l or less
Total cyanogens	Not detectable	1,1,2- trichloroethane	0.006mg/l or less
Lead	0.01mg/l or less	Trichloroethylene	0.03mg/l or less
Sexivalent Chrome	0.05mg/l or less	Tetrachloroethylene	0.01mg/l or less
Arsenic	0.01mg/l or less	1,3-dichloropropene	0.002mg/l or less
Total Mercury	0.0005mg/l or less	Thiram	0.006mg/l or less
Alkyl Mercury	Not detectable	Simazine	0.003mg/l or less
PCB	Not detectable	Thiobecarb	0.02mg/l or less
Dichlomethane	0.02mg/l or less	Benzene	0.01mg/l or less
Carbon tetrachloride	0.002mg/l or less	Selenium	0.01mg/l or less
1,2- dichloroethane	0.004mg/l or less	Nitra-N and nitrite-N	10mg/l or less
1,1- dichloroethylene	0.02mg/l or less	Fluoride	0.81mg/l or less
Cis 1,2- dichloroethylene	0.04mg/l or less	Boron	11mg/l or less

2) Standard related to the Preservation of the Living Environment(Coastal Value)

Class	A	B	C
Water use	Bathing	Industrial water	Conservation of the environment
Hydrogen ion exponent(pH)	7.8 ～ 8.3	7.8 ～ 8.3	7.8 ～ 8.3
Chemical Oxygen Demand(COD)	2mg/l or less	3mg/l or less	8mg/l or less
Dissolved Oxygen(DO)	7.5mg/l or less	5mg/l or less	2mg/l or less
Total coliform	1,000MPN/100ml or less	--	--
N-hexane Extracts(oil content etc	Not detectable	Not detectable	Not detectable

Waste Water Standards

Type Toxic Substance	Permissible Limits
Cadmium and its compounds	Cadmium 0.01mg/l
Cyanide compounds	Cyanide 1mg/l
Organic Phosphorous compounds(parathion, methal parathion, methyl dimethone and EPN only)	1mg/l
Lead and its compounds	0.1mg/l or less
Sexivalent Chrome compounds	Sexivalent Chrome 0.5mg/l
Arsenic and its compounds	Arsenic 0.1mg/l
Mercury, Alkyl Mercury, and other mercury compounds	Mercury 0.005mg/l or less
Alkyl Mercury compounds	Not detectable
PCB	0.003mg/l
Trichloroethylene	0.3mg/l or less
Tetrachloroethylene	0.1mg/l or less
Dichlomethane	0.2mg/l or less
Carbon tetrachloride	0.02mg/l or less
1,2- dichloroethane	0.04mg/l or less
1,1- dichloroethylene	0.2mg/l or less
Cis 1,2- dichloroethylene	0.4mg/l or less
1,1,1-trichloroethane	3mg/l or less
1,1,2- trichloroethane	0.06mg/l or less
1,3-dichloropropene	0.02mg/l or less
Thiram	0.06mg/l or less
Simazine	0.03mg/l or less
Thiobecarb	0.2mg/l or less
Benzene	0.01mg/l or less
Selenium and its compounds	0.03mg/l or less

Appendix D.3 Design parameter for 400/132 kV Transmission Lines and Substation Equipment

400 kV Transmission Line

Tower Structure	:	Single circuit twin earth peaks
Conductor	:	DIN ACSR 490/65 in double bundle
Earth wire	:	OPGW with equivalent electric characteristic to ACSR 'Dorking' conductor
Insulator set	:	Glass insulator, 27 and 33 units for suspension and tension set respectively
Tower type	:	Tangent/minor deviation, medium angle and heavy angle/terminal
Design span	:	300 – 330m

132 kV Transmission Line

Tower Structure	:	Double circuits and single peak
Conductor	:	ACSR Teal in double bundle
Earth wire	:	OPGW with equivalent electric characteristic to ACSR 'Dorking' conductor
Insulator set	:	Glass insulator, 10 and 12 units for suspension and tension set respectively
Tower type	:	Tangent/minor deviation, medium angle and heavy angle/terminal
Design span	:	300 – 330m

Substation Equipment

Highest System Voltage	420kV	145kV
Nominal Voltage	**400kV**	**132kV**
Frequency	50Hz	50Hz
Neutral Point earthed	Solidly earthed	Solidly earthed
Three Phase Short Circuit Current	31.5kA; 40kA	25kA; 31.5kA
Duration of Short Circuit	1 sec; 3sec	1 sec; 3 sec
Lightning Impulse Withstand Voltage • Switchgear Equipment • Transformer Windings • Neutral Point	 1425kV 1300kV	 650kV 550kV 325 kV
Power Frequency Withstand Voltage/1 min • Switchgear Equipment • Transformer Windings • Neutral Point	 630kV 570kV	 275kV 230kV
Minimum Creepage Distance (mm/kV) for System Highest Voltage • Outdoor Exposed Insulators	 25mm	 25mm
Current Ratings • Busbar • Switchgear	 4,000A 2,000A	 1,600A 1,250A
Auto/Transformer Data		
• Transformer nominal rated voltage • Cooling method • Continuous maximum rating • On- load tap changer rate • Nos of Step • HV Side (On Load Tap Changer) • MV Side (Off Load Tap Changer) • LV Side • Vector groupe	400/138.6/11kV ONAN/ONAF/OFAF 250MVA 400+-10 % kV 21 - - - - Yy0d11	132/33/11kV - - - - 132+-8x1.25% kV 33+-2x2.5% kV 11.5 kV -
Current Transformer Rated ratio • OH Line bay • Transformer bay • Bus Coupler bay	 2000/1A 2000-1000/1A 2000-1000/1A	 1200-600/5A(1A) 300-150/5A (1A) 1600-800/5A (1A)

Voltage Transformer • Nominal system voltage • Rated secondary voltage	 400/√**3** kV 110/√**3** / 110/√**3**V	 132/√**3** kV 110/√**3** / 110/√**3** V
Lightning Arrester Rated Voltage • Phase to Earth connection • 132kV Neutral to Earth connection • Lightning Arrester Discharge Current	 390kV 360kV 10kA	 120kV 84kV 10kA

Substation design condition is shown on table

1. Indoor	
Maximum indoor ambient temperature	50 °C
(in absence or failure of air-conditioning)	
2. Outdoor	
Altitude	< 1000 m above sea level
Ambient temperature • Maximum outdoor-peak • Maximum outdoor daily average • Maximum outdoor yearly average • Minimum outdoor • Maximum round at depth 1m • Design ambient temperature	 + 50 °C + 40 °C + 30 °C - 10 °C + 35 °C + 50 °C
Relative Humidity • Maximum • Minimum • Yearly average	 92 % 12 % 44 %
Maximum wind velocity • Maximum • Minimum • Maximum in one day • Yearly average	 500 m/m 50 m/m 65 m/m 150 m/m
Atmosphere	subject to sand storms and wind blown dust
Average number of days per year of dust storm	21.5
Average number of days per year of thunder storm	15

付属資料 E ：Specific Features of Thermal Plant

Appendix E.1 Tentative Calculation for Application of Pre-cooler

1. Condition of Study
   1) Gas Turbine to be applied: GE/Hitachi MS6001B: Output 39.5MW
   2) Precooler: Munter made,
   3) Output Increase Coefficient: 0.65%/degree centigrade (from Gas Turbine Data)
   4) Operating hours: 10months, each 360hours(daily 12hrs),total 3,600hours
   5) Place: Baghdad and Basrah (Refer to Reference Table)
   6) Average Temperature Decrease of Gas Turbine Inlet Air By Precooler
      6 months : 10 degree centigrade 4 months: 5 degree centigrade
2. Result of Calculation:
   1) Output Increase by Precooler: 39.5MW x 10 x 0.65%=2.56MW
      39.5MW x 5 x 0.65%= 1.28MW
   2) Power Increase obtained : 2.56MW x 360Hrs x 6.months= 5,530MWH
      1.28MW x 360Hrs x 4 months=1,843MWH
      Total 7,373MWH
   3) Power Generation Cost: 28.5US$/MWH
   4) Total Gains of Power Generation Cost: 28.5US$ x 7,373MWH = 210,130US$
   5) Water Consumption: 504g/s to cool the 125kg/s of air(required for Frame6) by 10 months
      Therefore: 504g/s x 3,600 = 1,814kg/y = 2 m3/hr
   6) Water Cost: if 1US$/m3 , total cost per year=1 US$ x 2 x 3,600=7,200US$
   7) Installation Cost of Precooler: (TBD)

3. Reference Table: Temperature and Humidity in Baghdad and Basra

	Baghdad						Basrah					
	Humidity(%)			Temperature(□)			Humidity(%)			Temperature (□)		
	Low-est	High-est	Daily Ave.	Low-est	High-Est	Daily Ave.	Low-est	High-est	Daily Ave.	Low-est	High-est	Daily Ave.
January	36	100	72	3.7	15.5	8.9	30	100	71	7.3	18.0	12.2
February	26	100	61	5.2	18.3	11.7	17	96	62	9.1	20.8	14.7
March	21	100	52	9.2	22.9	15.5	14	90	54	13.3	25.3	19.0
April	14	98	42	14.9	29.8	22.4	9	75	44	19.3	32.3	25.6
May	11	76	31	19.7	36.3	28.3	6	47	34	24.7	38.7	31.2
June	6	66	24	22.8	41.2	32.3	5	38	29	27.2	42.5	35.0
July	8	58	24	25.1	43.8	33.4	5	60	29	28.7	44.3	36.5
August	8	62	26	23.9	43.4	33.7	3	86	30	27.7	44.2	35.9
September	9	66	30	20.1	40.1	30.1	3	85	33	24.4	41.9	32.9
October	13	80	40	15.4	33.1	23.9	10	91	43	19.6	35.6	27.0
November	18	87	57	9.2	23.8	16.0	11	84	57	13.6	26.7	19.5
December	23	100	72	5.2	17.0	10.7	31	100	69	8.8	20.0	13.8

10 degree C decrease 5 degree C cdecrease

4. Conclusion:
   1) The output of gas turbine can be increased by 6.5% through hotter time of the year.
      This will be beneficial for overcome the peak power demand.
   2) During a few months of hotter season, more than 6.5% power output may be expected, if more water consumption is allowed.
   3) Cost data of electricity and Precooler is not available, the period of payback is not clear.
      However, according to the information of user in Austria, Norske Skog GmbH, the payback period is only a couple of months on the whole Preco0ler installation.

Appendix E.2 Sample of Rated Repair Interval (by Toshiba)

1. Recommended Inspection period of high temperature parts of gas turbine
   (based on the rated load: long term continuous operating gas turbine: gas fuelled)

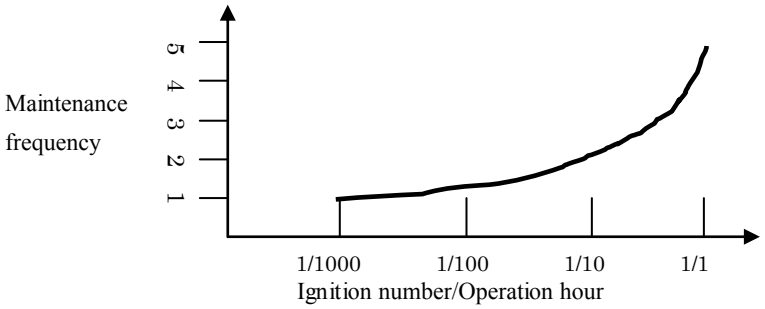
Parts Name	Rated Repair interval(hour)(RI)
Combustion chamber liner	8,000
Transition piece	8,000～12,000
Fuel nozzle	8,000
Flare transmission tube	8,000
Turbine: First stage nozzle	24,000
Turbine: Second stage nozzle	24,000
Turbine: Third stage nozzle	24,000
Turbine; First stage bucket	24,000
Turbine: Second stage bucket	24,000
Turbine: Third stage bucket	24,000

2. Factor of maintenance frequency

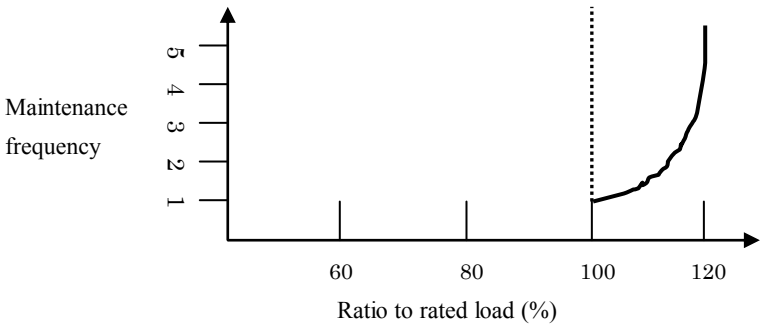
2-1 Factor of Fuel(Ff)

Kind of Fuel	Factor of Fuel(Ff)
Heavy oil residue	3
Heavy Oil (Fuel Oil)	2
Distilled Oil	1.5
Natural Gas	1

2-2Factor of Start Frequency (Fs)



2-3 Factor of Loading(F_L)



3. Guideline of Inspection/Repair Interval=

$$\frac{\text{Rated Repair Interval(RI)}}{(Ff) \times (Fs) \times (F_L)}$$

Appendix E.3 Derating Factor Method to decide inspection and repair interval

（Proposed by Toshiba）

1. Recommended Inspection interval of high temperature parts of gas turbine
   (based on the rated load: long term continuous operating gas turbine: gas fuelled)

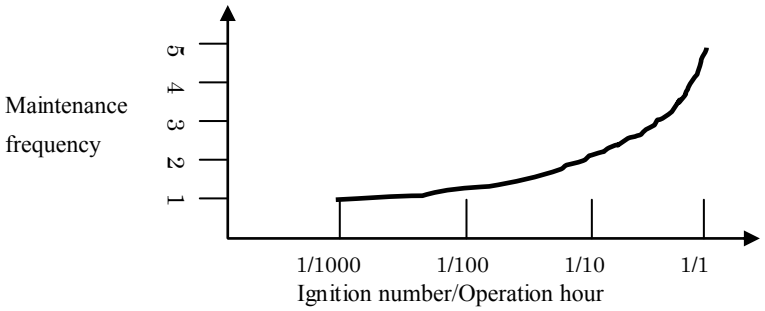
Parts Name	Rated Repair interval(hour)(RI)
Combustion chamber liner	8,000
Transition piece	8,000～12,000
Fuel nozzle	8,000
Flare transmission tube	8,000
Turbine: First stage nozzle	24,000
Turbine: Second stage nozzle	24,000
Turbine: Third stage nozzle	24,000
Turbine; First stage bucket	24,000
Turbine: Second stage bucket	24,000
Turbine: Third stage bucket	24,000

2. Factor of maintenance frequency

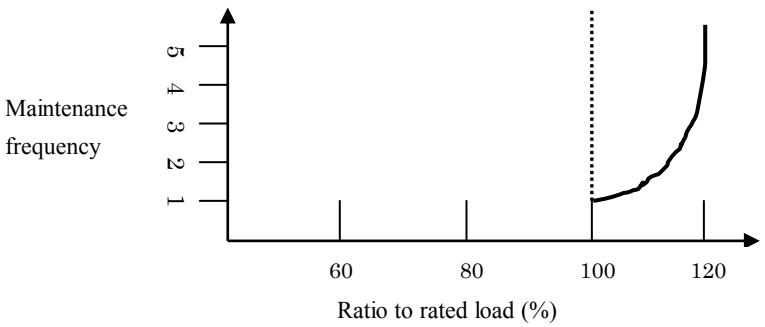
2-1 Factor of Fuel(Ff)

Kind of Fuel	Factor of Fuel(Ff)
Heavy oil residue	3
Heavy Oil (Fuel Oil)	2
Distilled Oil	1.5
Natural Gas	1

2-2Factor of Start Frequency (Fs)



2-3 Factor of Loading(F_L)



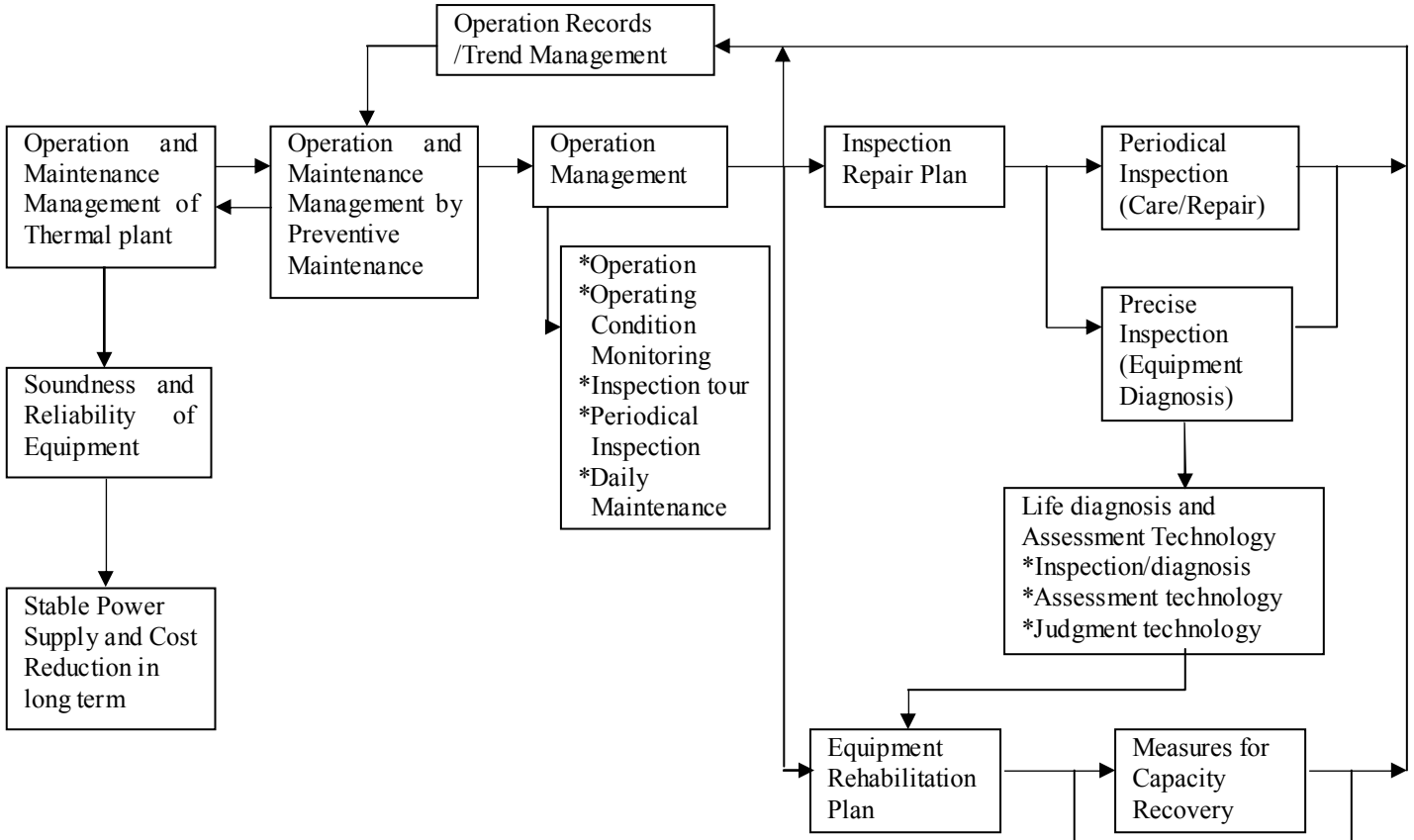
3. Guideline of Inspection/Repair Interval=

$$\frac{\text{Rated Repair Interval(RI)}}{(FF) \times (Fs) \times (F_L)}$$

Reference: "Preventive Maintenance and Residual Life Diagnosis of Power Generation Plant" Thermal and Nuclear Power Engineering Society of Japan,2002

付属資料 F ：Items to be Considered for Selection of New Generating Plant

Appendix F.1 Operation and Maintenance Management Cycle for Thermal Plant



Reference: "Preventive Maintenance and Residual Life Diagnosis of Power Generation Plant" Thermal and Nuclear Power Engineering Society of Japan,2002

Appendix F.2 Power Plant Deterioration Diagnosis and Residual Life Assessment

Equipment Name	Component	Place	Phenomena of Deterioration	Diagnosis and Test Technology	Residual Life Assessment Technology
Boiler	Furnace	Pipe support welding portion, furnace wall piping	Thermal fatigue cracking	PT,MT,	SAM, MACM, others
			Corrosion fatigue,	UT	
			Erosive thickness reduction	VT,UT	
			High temperature corrosion thickness reduction	VT,UT, Scale analysis	
	Superheater, Reheater	Pipe support welding portion, Pipe peripheral welding portion	High temperature corrosion thickness reduction	VT, UT, Sampling check.	SAM, MACM, others
			Thermal fatigue cracking	PT, MT, Sampling check	
			Creep fatigue cracking	PT, UT, RT	
	Superheater, Reheater Piping Support	Pipe support, Pipe support welding portion	Creep, Thermal fatigue cracking,	PT, MT	SAM, MACM, others OCM, CGDM, VARM
	Main & Reheat Steam Piping	Pipe support welding portion, Longitudinal /peripheral welding point	Thermal fatigue cracking,	PT, MT,	MACM, HMM, others OCM, CGDM, VARM
			Creep	PT, MT, UT, RT	
	Forced Draft Fan	Impeller, Bearing	Fatigue cracking	VT, PT, MT, UT	SAM
			Wearing	VT,UT	
Turbine	High/Intermediate pressure Rotor	Outer surface, Center hole	Creep, Fatigue, Fragility	VT, PT, MT, UT	HMM, OCM MACM EPM EM
	High/Intermediate pressure Casing	Steam inlet portion,, Turbine nozzle coupling portion	Creep, Fatigue, Fragilization	VT, PT, MT,	HMM, OCM MACM EPM EM
	High/Intermediate pressure buckets	Buckets embedded area, shroud	Creep	VT, PT, MT, UT	HMM, OCM
	Main valve	Valve box, Valve stem, Welding point with piping	Creep, Fatigue, Fragility	VT, PT, MT, UT	HMM, OCM MACM EPM EM
Generator	Rotor	Center hole, Shaft, Wedge, End ring, Coil	Low cycle fatigue cracking,	UT, MT, VT	MACM HMM,
			Fatigue cracking,	MT, UT, VT	MACM HMM,
			Creep, Fatigue cracking,	PT, UT, VT Disassembling, inspection	HMM, OCM
			Stress corrosion cracking	PT, UT, VT Disassembling inspection	
			Durum powder	VT, Disassembling, inspection	
			Deterioration of insulation	Insulation resistance measurement	ICT
	Stator	Coil	Deterioration of insulation	VT, Insulation resistance measurement	OC,ICT

RT (Radiographic Examination) UT (Ultrasonic examination)

MT (Magnetic Particle testing) PT (Penetrating testing)

ET (Eddy Current testing) AET (Acoustic Emission test)

ST Strain measuring test VT Visual testing

SAM (Stress Analysis Method) MACM (Micro-analyzed Crack Method)

OCM (Organization Contrast Method) CGDM (Crystal Grain Deform Method)

VARM (Void Area Ratio Method) HMM (Hardness Measurement Method)

EPM (Electrical Polarization Method) EM (Etching Method)

ICT (Insulation Characteristics Test) OC (Operation Carrier)

Reference: "Preventive Maintenance and Residual Life Diagnosis of Power Generation Plant" Thermal and Nuclear Power Engineering Society of Japan,2002

付属資料 G ：Power Network Diagram for the Power Flow Calculation

Appendix G Power Network Diagram for the Power Flow Calculation