No.

Ministry of Industry and Trade
Socialist Republic of Viet Nam

The Study on National Energy Master Plan in Viet Nam

Final Report
(Appendix)

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JAPAN INTERNATIONAL COOPERATION AGENCY

THE INSTITUTE OF ENERGY ECONOMICS, JAPAN
TOKYO ELECTRIC POWER COMPANY

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Appendix 1

Supplemental Data and Information of Vietnam

1． Economy and Development Plan

Figure 1.1 Economic Development by Sector

(unit: Value in 1994, billion VND)

Fiscal year	Total (Growth Rate)		Agriculture & Forestry	Manufacturing & Mining	Commercial & Trade	Transport & Communications	Service & Others
1990	131,968		51,120	29,923	17,174	4,558	29,193
1991	139,634	5.81	56,537	33,225	17,734	5,206	26,932
1992	151,782	8.70	51,513	41,381	20,984	6,402	31,502
1993	164,043	8.08	49,000	47,409	23,643	6,657	37,334
1994	178,534	8.83	48,968	51,540	30,185	7,154	40,687
1995	195,567	9.54	53,160	56,237	32,033	7,790	46,347
1996	213,833	9.34	59,358	63,572	33,898	8,167	48,838
1997	231,264	8.15	59,601	74,178	36,069	9,157	52,260
1998	244,596	5.76	63,058	79,473	37,794	9,537	54,734
1999	256,272	4.77	65,181	88,400	38,052	9,961	54,677
2000	273,666	6.79	67,143	100,520	38,936	10,745	56,322
2001	292,534	6.89	67,988	111,541	41,202	11,810	59,993
2002	313,247	7.08	72,139	120,558	44,211	12,334	64,004
2003	336,243	7.34	75,797	132,715	45,657	13,552	68,521
2004	362,435	7.79	73,917	142,621	59,659	13,975	72,263
2005	392,989	8.43	76,905	157,808	64,634	15,318	78,324
Average Growth Rate		7.55	2.76	11.72	9.24	8.42	6.80

Table 1.2 Strategic Target of "Socio-Economic Development Strategy: 2001-2010"

Strategic Goals（2001-2010）

GDP will have at least doubled the 2000 level.

Growth Rtae in Agriculture: 4-5%、 Share : 16-17%

Growth Rtae in Industry : 10-15%、 Share : 40-41%

Growth Rtae in Service : 7-8%、 Share : 42-43%

To ensure rapid, efficient and sustainable development, economic growth is to go along with social progress and equity, and environmental protection.

To continue intensively, extensively and harmoniously with the Socio-economic Development Plan, State apparatus must be renewal, geared towards the establishment and improvement of the institutions of a socialist-oriented market economy,

To closely link building of an independent and autonomous economy with proactive international economic integration.

To closely combine socio-economic development with defense and security.

Source: Ministry of planning and investment (MPI), "Socio-Economic Development strategy: 2001-2010 years".

Table 1.3 Development Goal of "Socio-Economic Development Plan: 2001-2005"

Five-year Socio-Economic Development Plan（2001-2005）

General objectives（Rapid and sustainable economic growth.）
Significant transformation of the economic and labor structure towards industrialization and modernization.
Significant improvement of the quality, competitiveness and efficiency of the economy.
Improvement in the efficiency and expansion of the country's international economic relations.
Providing more jobs to the people, eliminating hunger and reducing the number of poor households, fighting against and eliminating social evils, stabilizing and improving people's lives.
Continuing enhancement of social and economic infrastructure in order to build socialistorientated market-based economic institutions.
Maintenance of political and social stability and protection of the nation's independence, territorial integrity, national sovereignty and security.
Economic targets:
- Annual Growth Rate of GDP: 7.5%
- Agriculture: 4.8%, Industry: 13%, Service: 7.5%
- Share: Agriculture: 20-21%、Industry: 38-39%、Service: 41-42%
- FDI: 9-10billion Dollar in Next 5 years
- ODA:10-11billion Dollar
- Export Growth Rate: 16%Annually, Import Grwth Rate: 15%Annually

Source: Ministry of Planning and Investment (MPI), "Socio-Economic Development Plan: 2001-2005".

Table 1.4 Development Goal of "Socio-Economic Development Plan: 2006-2010 "

Five-year Socio-Economic Development Plan（2006-2010）

General Goals
- Boost the Economic Growth Rate
- Quickly bringing our country out of the low development State
- Significantly improve people's material, cultural and spiritual life
- Create foundations to boost the industrialization and modernization process and gradually develop the knowlwdge-based economy
- Stabilize politics, orders, and social security
- Firmly protect our independence, sovereignity, territory, and national security
- Improve Vietnam's status in the region and the world

Main Tasks
- GDP: 2.1times higher (2010/2000), 1,050-1,100 Dollar/capita
- Economic Growth Rate : 7.5-8.0% (2006-2010)
- Agriculture: 3.0-3.2%, Industry: 9.5-10.2%, Service: 7.7-8.2%
- Share : Agriculture: 16-16%、Industry: 43-44%, Service: 40-41.2%
- FDI : 23.8billion Dollar

Source: Ministry of Planning and investment (MPI, "Socio-Economic Development Plan: 2006-2010".

Table 1.5 Transition of Investment by Capital Form

	2000	2001	2002	2003	Prel. 2004	Est. 2005
Total Investment	115,089	129,455	148,067	167,228	186,556	212,000
State Company	68,070	77,426	83,467	90,343	100,062	110,800
Non-state Company	26,335	29,241	38,754	49,593	57,595	68,000
FDI	20,685	22,787	25,846	27,292	28,899	33,200
(Energy sector)	20,228	19,030	21,386	25,322	28,085	31,900
Share(%)	100.0	100.0	100.0	100.0	100.0	100.0
State Company	59.1	59.8	56.4	54.0	53.6	52.3
Non-state Company	22.9	22.6	26.2	29.7	30.9	32.1
FDI	18.0	17.6	17.5	16.3	15.5	15.7
(Energy sector)	17.6	14.7	14.4	15.1	15.1	15.0

Source: GSO: Statistical Yearbooks 1990-2005.

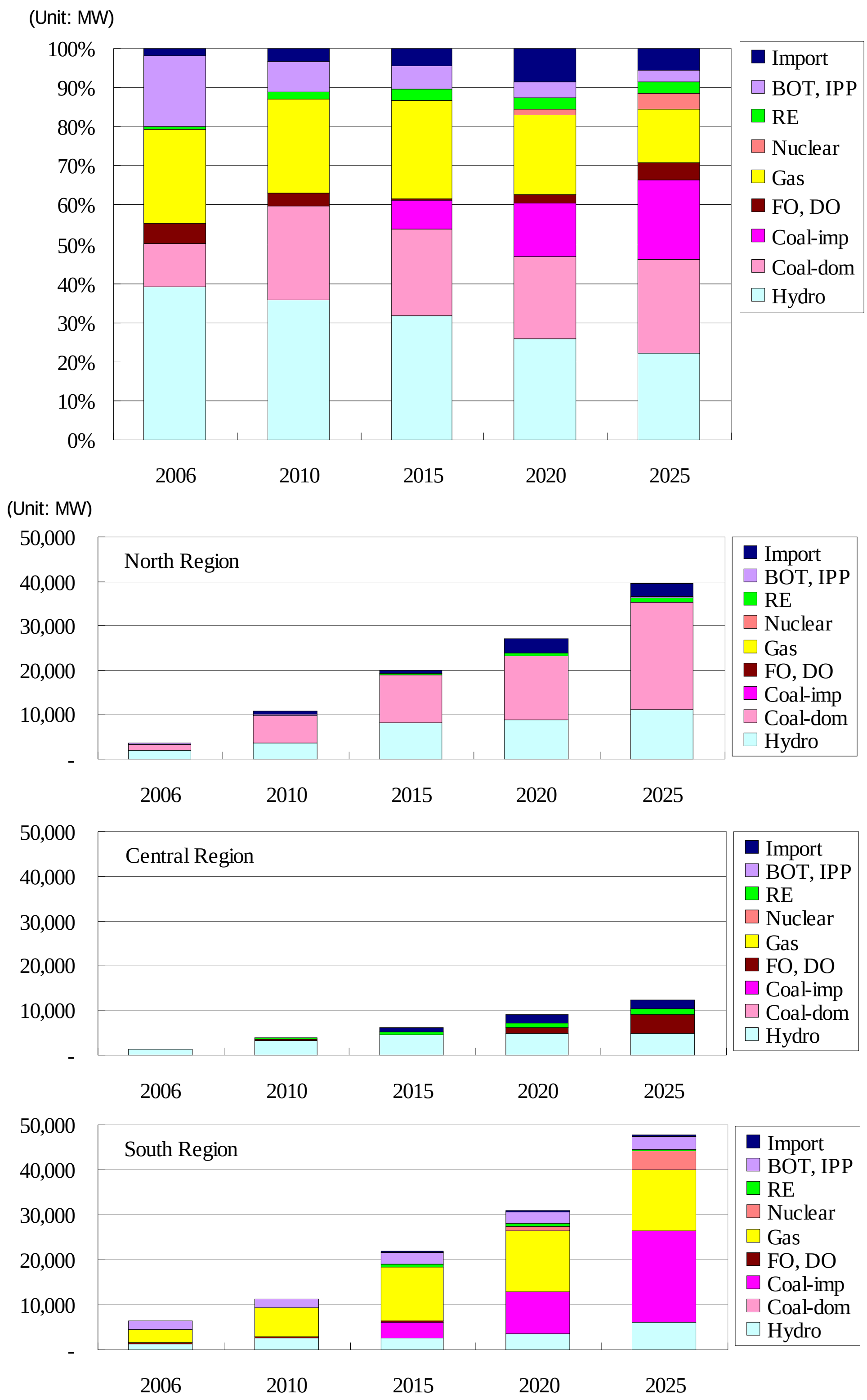
Table 1.6 Accumulation of Direct Foreign Investment (FDI) and Energy-related Investment

	Number of projects	Registered capital *(Mill. USD)*			
		Total	Of which: Legal capital		
			Total	Of which	
				Foreign side	Vietnam side
Total	7,279	66,244	30,271	25,285	4,985
Investment on energy	118	5,264	3,140	2,929	211
Mining and quarrying	95	3,336	2,538	2,343	195
Electricity, gas & water supply	23	1,928	602	586	16
Share(%)	1.6	7.9	10.4	11.6	4.2

Source: GSO Statistical yearbooks 1990-2005.

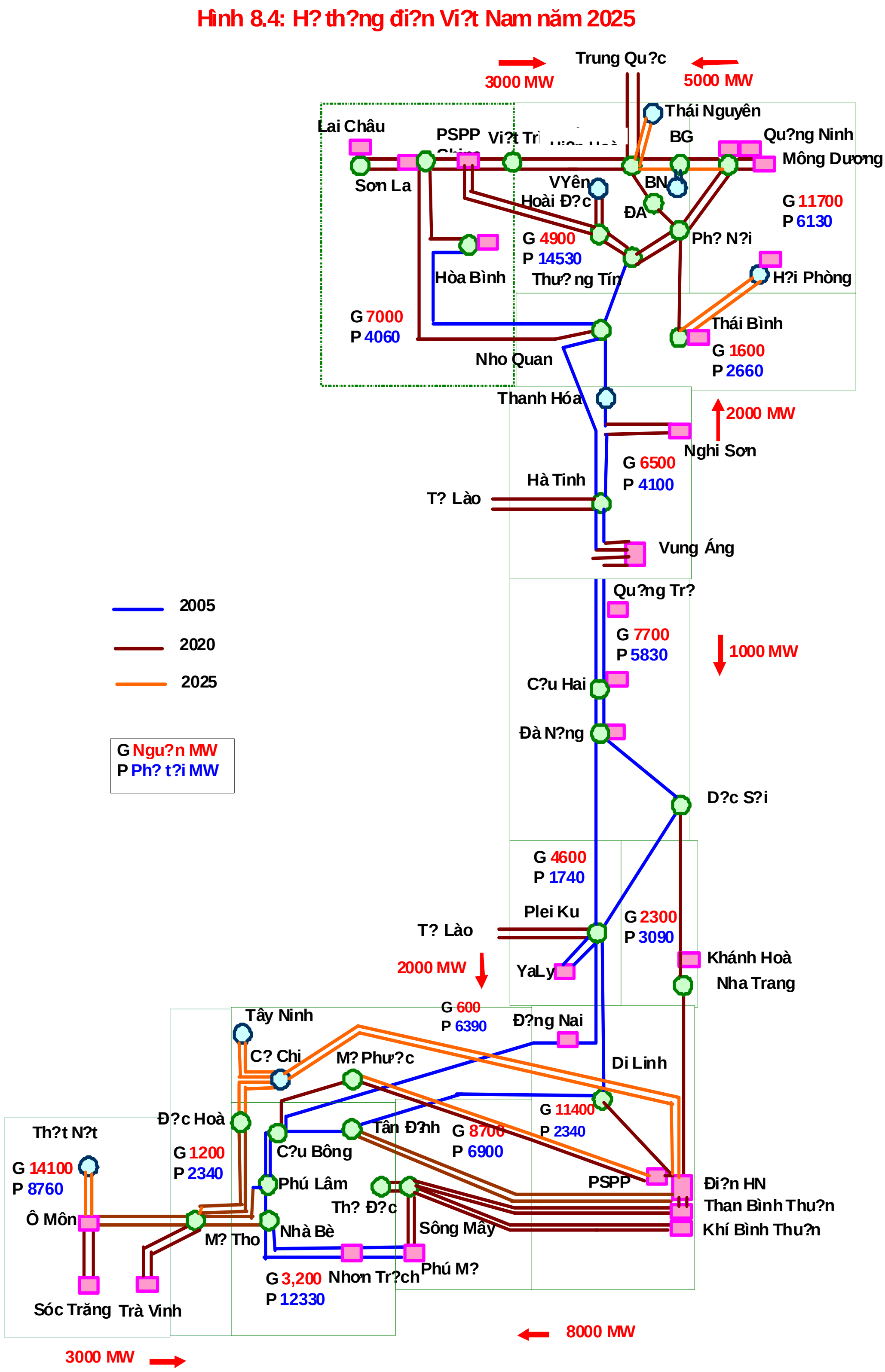
2. Electric Power Sector

Figure 2.1 Power Composition Ratio by Energy Source (plan till 2025)



Source: Institute of Energy

Figure 2.2 National Power Grid as of 2025 (Plan)



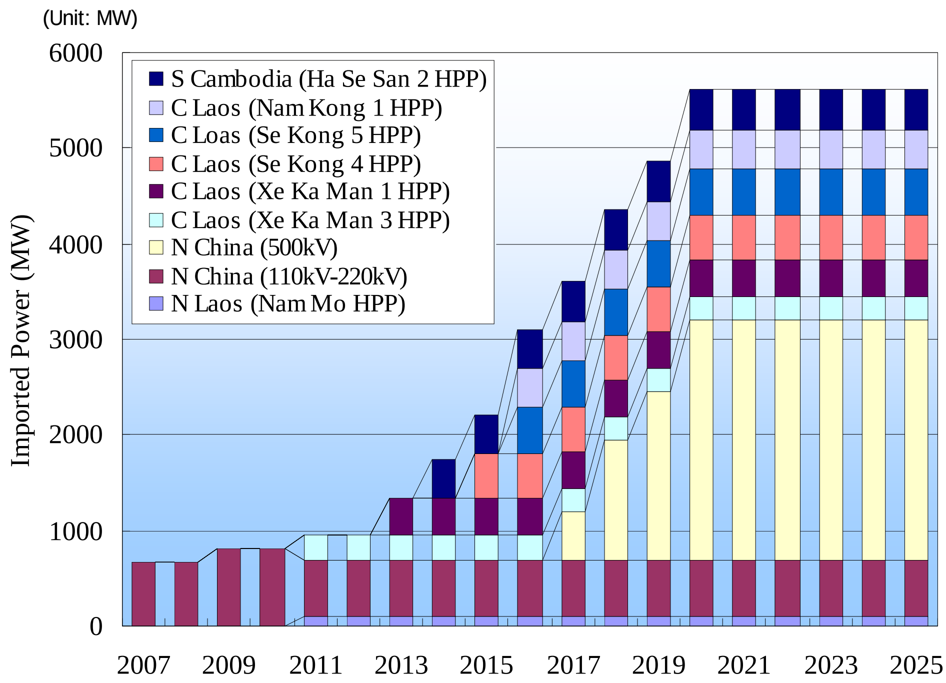
Source: Draft 6th PDP

Table 2.3 Exploitable Hydropower Potential in Vietnam

River Catchment		Capacity (MW)	Electricity (TWh)	Share of power
1	Lo, Gam, Chay	820	3.159	3.9%
2	Da	7345	31.196	38.0%
3	Ma	542	2.026	2.5%
4	Ca	398	1.555	1.9%
5	Huong	282	1.170	1.4%
6	Vu Gia - Thu Bon	1119	4.299	5.2%
7	Tra Khuc	135	0.625	0.8%
8	Ba	709	3.095	3.8%
9	Se San	1736	8.265	10.1%
10	Srepok	702	3.325	4.1%
11	Dong Nai	2790	11.518	14.0%
	Total of 11 Rivers	16578	70.233	85.7%
	Country Total	17700	82.000	100.0%

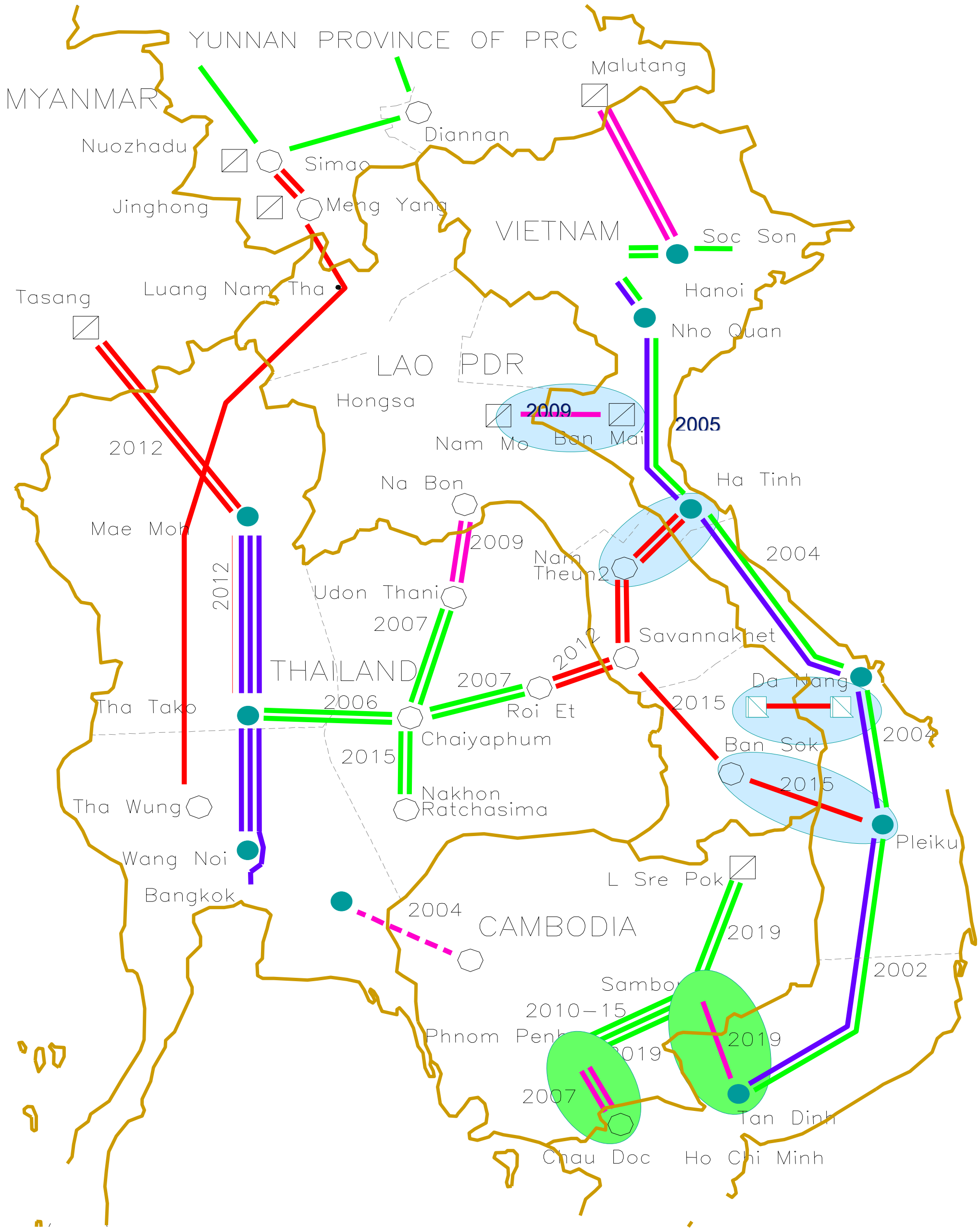
Source: Institute of Energy

Figure 2.4 Planed Power Import to Vietnam from the Neighboring Countries



Source: Draft 6th PDP

Figure 2.5 Power Interconnection Plan among the Indochina Countries



Source: NOCONSULT、Power System Interconnection Master Plan for Great Mekong Subregion（GMS)、2003

3. Coal Sector

Table 3.1 Reserves of Coal (excluding peat, end of 2006)

(Unit : 1000 t)

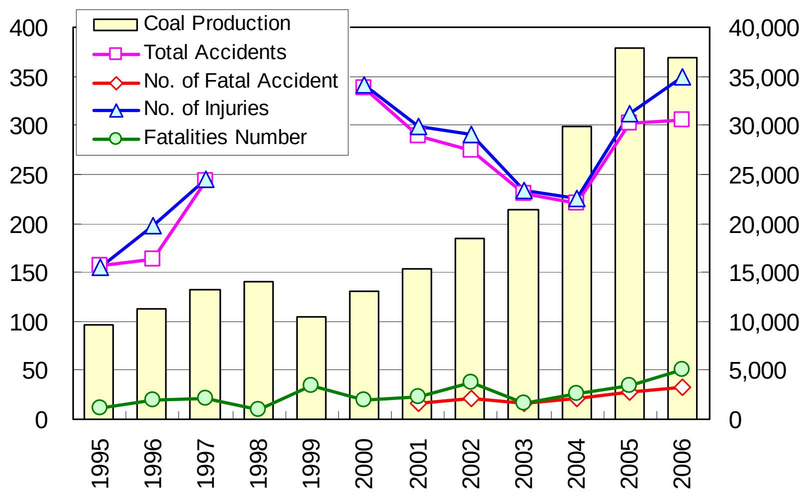
Category	Geological coal reserves						Industrial coal reserves
	Total	A+B+C	A+B	C1	C2	P	
Total of all types	**5,833,058**	**4,756,784**	**370,609**	**2,028,409**	**2,357,766**	**1,076,274**	**3,390,528**
	100.0%	**81.5%**	**6.4%**	**34.8%**	**40.4%**	**18.5%**	**58.1%**
Anthracite	4,155,783	3,571,984	327,765	1,450,063	1,794,156	583,799	2,829,839
Loany bituminous coal	1,580,956	1,088,481	0	524,871	563,610	492,475	524,871
Fat Coal	96,319	96,319	42,844	53,475	0	0	35,818
Total Quang Ninh basin	**4,049,559**	**3,484,716**	**315,155**	**1,401,399**	**1,768,161**	**564,843**	**2,757,139**
(Anthracite)	**100.0%**	**86.1%**	**7.8%**	**34.6%**	**43.7%**	**13.9%**	**68.1%**
Hon Gai	740,417	713,791	37,520	229,689	446,582	26,626	422,570
Uong Bi	1,346,279	1,252,578	17,309	444,107	791,163	93,701	1,042,712
Cam Pha	1,962,863	1,518,347	260,326	727,604	530,417	444,516	1,291,857
Others	**1,783,499**	**1,272,068**	**55,453**	**627,009**	**589,604**	**511,430**	**633,389**
	100.0%	**71.3%**	**3.1%**	**35.2%**	**33.1%**	**28.7%**	**35.5%**
Interior areas	165,110	165,110	55,454	91,901	17,755	0	90,040
Local mines	37,434	18,478	0	10,238	8,240	18,956	18,478
Khoai Chau (80km^2)	1,580,956	1,088,481	0	524,871	563,610	492,475	524,871

Note : Geological coal reserves is an amount to indicate potential of coal resources as a sum of Measured, Indicated and Inferred reserves plus potential reserves. Industrial coal reserve is an amount of A, B and part of C of the geological coal reserves. Fat coal is a kind of coking coal.

Source : VINACOMIN

Figure 3.2 Injury Rate in Coal Mines

(Unit: Number of Case & People per a million ton) (Unit: 1,000tons)



Note : Data in 1998 and 1999 was not gathered completely.

Source : Material presented by VINACOMIN

4. Oil and Gas Sector

Table4.1 Oil and Gas Reserves

Unit: *MCMOE

Basin	Potential	Explored	Exploited	Remain reserver	Remark
Song Hong	560-700	250-700	0.5	250-270	Mainly gas, CO2: 60-90%
Phu Khanh	300-700				Mainly gas, high CO2
Cuu Long	800-900	500	203	297	Mainly petroleum
Nam Con Son	600-800	180	5.5	174.5	Petroleum & gas
Malay- Tho chu	300-400	170-180	5	165-175	Mainly gas
Tu Chinh- Vung May	750-900				Mainly gas
Total	**3310-4400**		**214**	**3100-2180**	

Note: MCMOE: Million Cubic Meter in oil equivalent

Source : Institute for Petroleum and Gas - Petrovietnam（Updated till the end of 2005）

Table 4.2 Actual Production and Export of Crude Oil

Unit: Mill. tons

Fields	Bach Ho	Rong	Dai Hung	PM3 Block	Rang Dong	Ruby	Su Tu Den	Total of production	Export
Commissioning time	Jun-86	Dec-94	Oct-94	Jul-97	Aug-98	Oct-98	Oct-2003		
1990	2.70							2.70	2.5
1991	3.96							3.96	3.6
1992	5.50							5.50	5.2
1993	6.31							6.31	6.05
1994	6.90	0.01	0.15					7.06	6.80
1995	6.60	0.11	0.96					7.67	7.50
1996	7.97	0.25	0.58					8.80	8.62
1997	9.41	0.02	0.37	0.15				9.95	9.78
1998	10.91	0.09	0.53	0.29	0.42	0.09		12.33	11.89
1999	11.60	0.53	0.36	0.33	1.35	1.05		15.21	14.88
2000	11.99	0.60	0.25	0.35	1.55	1.12		15.86	15.50
2001	12.77	0.55	0.14	0.37	2.14	1.03		17.00	16.86
2002	12.24	0.53	0.12	0.39	2.07	1.00		16.35	16.80
2003	12.54	0.58	0.07	0.55	2.54	0.85	0.45	17.58	17.18
2004	11.56	0.66	0.01	1.40	2.18	0.63	3.84	20.28	19.50
2005	10.00	0.57	0.10	1.35	2.34	0.72	3.45	18.53	18.5
2006	9.15	0.66	0.05	1.15	2.45	0.76	2.68	16.90	17.8

Source: Petrovietnam Annual Reports

Table 4.3 Import and Export of Petroleum Products

Unit: 1000 tons

Year	Gasoline			Jet Fuel		Kerosene		DO		FO		LPG			Other petroleum products			Total	
	Import	Export	Production	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Production	Import	Production	Export	Import	Production
1990	615			194		205		1205		534		0.1			26			2246	
1991	545			215		211		1144		633		0.3			24			2140	
1992	642			351		162		1187		673		0.4			268			2610	
1993	910			207		209		2002		804		834			54			4215	
1994	1052			267		286		2193		808		24.6			39			3862	
1995	906			399		289		2063		862		46.0			232			3935	
1996	926			430		379		2466		997		47.7			224			4472	
1997	961			417		198		2904		972		54.3			135			4669	
1998	1136		8	395		243		3063		1503		60.7		96	117			5016	104
1999	1274		76	440		231		3052		1792		74.2	17	129	246			5317	204
2000	1397		107	421		363		3513		1995		50.6		246	124			5869	353
2001	1548		127	471		510		3599		2203		99.3		272	224			6450	399
2002	2043		238	548		400		4037		2436		159.9		316	164			7353	554
2003	2328		267	528		350		4493		2470		238.1		334	412			8348	600
2004	2607		267	539		339		4910		2292		352.9		337	366			9115	604
2005	2641		286	544		333		5308		2214		489.9		315	321			9636	601
2006	2837		286	564		325		5795		2314		563		276	327			10411	561

Source: Ministry of Trade and Industry, Petrovietnam Gas Company, Custom General

Table 4.4 Petroleum Products Consumption by Sector

(Unit: 1000 tons)

Year	Industry				Power generation		Agriculture			Transport				Commerce & service				Residential				Total consumption					
	Kerosene	DO	FO	LPG	DO	FO	Gasoline	DO	FO	Gasoline	Jet fuel	DO	FO	DO	FO	Kerosene	LPG	DO	FO	Kerosene	LPG	Gasoline	Jet fuel	DO	FO	Kerosene	LPG
1990	4	230	213		134	248	44	96	3	582	190	649	34	86	31	142		11	4	59		626	190	1205	534	205	
1991	4	220	245		126	306	39	92	3	516	211	616	39	81	36	146		10	3	61		554	211	1144	633	211	
1992	3	220	275		167	304	46	92	5	608	345	617	44	82	40	111		10	4	47		653	345	1187	673	162	
1993	4	260	362	1	173	321	65	165	5	860	204	1240	58	146	53	144		18	5	61	4	925	204	2002	804	209	5
1994	7	270	387	2	266	293	76	173	5	995	263	1311	62	154	57	196	5	19	5	83	9	1071	263	2193	808	286	16
1995	6	280	450	6	114	255	65	175	5	857	392	1318	87	156	60	199	17	20	5	84	27	922	392	2063	862	289	50
1996	8	350	554	10	175	260	66	210	7	876	423	1521	88	187	81	250	49	23	7	121	32	942	423	2466	997	379	91
1997	4	410	510	8	335	292	87	222	7	891	410	1740	82	173	75	131	50	25	7	63	72	978	410	2904	972	198	130
1998	5	420	665	31	437	612	116	212	10	1040	389	1758	109	209	96	141	100	28	11	97	63	1156	389	3063	1503	243	195
1999	5	470	810	30	268	700	117	215	13	1179	432	1842	135	231	118	142	82	27	15	83	110	1297	432	3052	1792	231	222
2000	9	582	830	85	493	817	77	240	17	1345	413	1931	180	235	130	221	86	32	20	134	134	1422	413	3513	1995	363	305
2001	13	593	870	52	441	968	65	250	15	1510	463	2020	200	270	133	313	111	25	17	184	192	1575	463	3599	2203	510	356
2002	15	685	1179	66	383	876	79	285	15	1999	539	2343	220	320	135	239	140	22	11	146	242	2078	539	4037	2436	400	448
2003	16	847	1360	226	148	686	81	304	17	2287	519	2837	273	299	101	197	143	57	32	137	237	2368	519	4493	2470	350	607
2004	10	982	1250	331	151	642	113	341	17	2539	529	3040	248	355	115	203	178	42	21	127	299	2652	529	4910	2292	339	808
2005	9	1062	1207	424	160	598	115	368	16	2572	534	3290	262	368	111	199	202	61	20	124	337	2687	534	5308	2214	333	964
2006	10	1139	1275	465	163	604	122	394	17	2765	554	3640	279	395	117	190	229	65	22	126	392	2887	554	5795	2314	325	1086

Source: 90-03' data was estimated by IEA
04-06' data was estimated by VPI

Table 4.5 Petroleum product sale statistics of Petrolimex

Unit: Kl except tons for Diesel Oil

Year	Wholesale to Industrial customers				Wholesale to agencies				Retail		
	Gasoline	DO	FO	Kerosene	Gasoline	DO	FO	Kerosene	Gasoline	DO	Kerosene
1996	20,700	733,500	532,100	39,400	394,000	624,800	150,000	206,800	487,200	357,300	48,000
1997	25,300	787,100	596,500	22,000	480,800	670,500	168,200	107,800	533,200	376,400	37,100
1998	28,500	794,100	633,700	20,100	541,700	649,700	178,700	105,800	556,000	386,200	36,800
1999	25,200	703,000	771,200	19,500	479,800	623,400	217,500	95,300	563,800	390,900	38,900
2000	28,000	1,002,100	1,035,100	26,600	531,100	853,600	291,900	130,200	639,100	557,100	61,500
2001	33,000	802,300	1,029,500	34,600	626,900	683,400	290,300	168,900	710,400	494,000	56,700
2002	43,800	1,027,100	1,144,800	27,800	833,400	875,000	322,900	126,900	813,600	558,100	53,300
2003	45,900	1,134,700	1,085,400	23,500	872,400	966,600	306,100	107,000	914,200	753,600	53,100
2004	20,600	496,600	984,900	22,100	926,800	1,817,800	188,500	113,600	1,020,900	789,200	49,400
2005	14,600	569,400	1,051,500	10,400	946,500	1,821,900	183,200	133,500	1,102,600	817,400	53,700
2006	12,900	481,600	974,800	9,300	980,700	980,700	154,700	92,700	1,211,300	907,800	44,200

Source : Petrolimex

Table 4.6 Prices of Imported Petroleum Product and Gas

Year	Gasoline (VND/liter)		DO (VND/liter)		Kerosene	FO	LPG	NG ($/Mil.BTU)	
	RON 92	RON 90	0.5%S	1%S	VND/liter	VND/liter	VND/kg	Non-Associated	Associated
1990							14,000		
1991							13,500		
1992									
1993									
1994							6,300		
1995									1.15
1996	3,800	3,700		2,900	3,000	1,560	10,832		1.76
1997	4,300	4,200		3,500	3,600	1,650	9,730		1.87
1998	4,300	4,200		3,500	3,600	1,650	6,527		2.1
1999	4,300	4,275		3,575	3,675	1,763	9,100	2.880	2.1
2000	4,958	4,733		3,825	3,783	2,175	7,659	2.935	2.1
2001	5,300	4,900	4,100	4,000	3,800	2,500	8,051	2.990	2.1
2002	5,300	4,900	4,033	4,067	4,000	2,683	6,788	3.047	2.1
2003	5,575	5,267	4,367	4,375	4,283	3,183	8,990	3.105	2.1
2004	6,850	6,650	4,630	4,763	4,692	3,575	12,500	3.164	2.1
2005	8,933	8,733		6,500	6,300	4,633	13,800	3.202	2.1
2006	10,479	10,279		8,029	8,029	5,400	14,842	3.246	2.1

Note : Gasoline, DO, FO, Kerosene and LPG: End retail price
NG: End User price（including wellhead price, tariff and distribution fee）
Source：Information from market, Gas sale agreements of Petrovietnam

5. Natural Gas Sector

Table 5.1 Gas Production, Processing, Export and Consumption

Unit: BCM

Field	Commissioning time	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Bach Ho	1995						0.15	0.25	0.51	0.89	1.20	1.53	1.68	1.72	1.66	1.66	1.38	1.10
Rang Dong	2001												0.03	0.43	0.51	0.47	0.50	0.70
Tien Hai	1981	0.01	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Lan Tay	2003														0.81	2.58	3.55	4.00
PM3 Block	2002													0.03	0.06	1.59	1.44	1.70
Total production		**0.01**	**0.03**	**0.02**	**0.02**	**0.03**	**0.18**	**0.27**	**0.53**	**0.91**	**1.22**	**1.55**	**1.73**	**2.20**	**3.05**	**6.32**	**6.89**	**7.52**
of which: + Non-Associated	1981	0.01	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.89	4.19	5.01	5.72
+ Associated	1995	0.00	0.00	0.00	0.00	0.00	0.15	0.25	0.51	0.89	1.20	1.53	1.71	2.15	2.17	2.13	1.88	1.80
Pipelines		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Bach Ho System	1995						0.15	0.25	0.51	0.89	1.20	1.53	1.71	2.15	2.17	2.13	1.88	1.80
Nam Con Son	2003														0.81	2.58	3.55	4.00
Low Pressure Pipeline	2004															0.23	0.31	0.33
Total production		0.01	0.03	0.02	0.02	0.03	0.18	0.27	0.53	0.91	1.22	1.55	1.73	2.20	3.05	6.32	6.89	7.52
Export to Malaysia	2003													0.03	0.06	1.59	1.44	1.45
Total consumption (wet gas)		**0.01**	**0.03**	**0.02**	**0.02**	**0.03**	**0.18**	**0.27**	**0.53**	**0.91**	**1.22**	**1.55**	**1.73**	**2.17**	**2.99**	**4.73**	**5.45**	**6.07**
Total consumption (dry gas)		**0.01**	**0.03**	**0.02**	**0.02**	**0.03**	**0.18**	**0.27**	**0.53**	**0.81**	**1.03**	**1.22**	**1.25**	**1.57**	**2.40**	**4.24**	**5.24**	**5.76**
In which: Power generation	1995						0.15	0.25	0.51	0.79	1.01	1.20	1.23	1.55	2.38	3.74	4.43	4.97
Fertilizer	2004															0.25	0.47	0.43
Industry (include fertilizer)	1981	0.01	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.50	0.81	0.79
Gas processing (From Associated Gas)																		
+ Input	1998	0	0	0	0	0	0	0	0	0.89	1.20	1.53	1.71	2.15	2.17	2.13	1.88	1.80
+ Output																		
- Dry gas	BCM									0.79	1.01	1.20	1.23	1.55	1.58	1.65	1.64	1.50
- LPG	ton									104	140	268	296	344	363	367	343	302.00
- Condensate	ton									0.07	0.09	0.10	0.13	0.15	0.15	0.13	0.11	90.00

Source : Petrovietnam Annual Reports

Table 5.2. Gas Consumption by Industrial Sub-sector

Unit: BCM

Year	Non-metallic mineral (*)	Iron & Steel	Chemical	Food processing	Other	Total
1990	0.006					0.006
1991	0.028					0.028
1992	0.019					0.019
1993	0.023					0.023
1994	0.025					0.025
1995	0.024					0.024
1996	0.023					0.023
1997	0.022					0.022
1998	0.021					0.021
1999	0.021					0.021
2000	0.022					0.022
2001	0.020					0.020
2002	0.020					0.020
2003	0.020			0.021	0.00085	0.042
2004	0.050		0.255	0.223	0.01185	0.540
2005	0.077	0.0017	0.480	0.250	0.01710	0.826
2006	0.099	0.0066	0.439	0.237	0.01962	0.801

Source : Petrovietnam Annual Reports、Petrovietnam Gas Company（PVGAS）

6. Renewable Energies

Table 6.1 Daily Average Amount of Solar Radiation in Vietnam

(unit : kWh/m2/day)

Province and Cities		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Average
North	Ha Giang	1.24	2.66	2.85	3.91	4.61	4.22	4.46	4.54	4.49	3.34	2.83	2.25	3.45
	Lao Cai	2.37	2.77	3.42	4.29	5.01	4.61	4.6	4.57	4.39	3.45	2.82	2.32	3.72
	Yen Bai	2.16	2.58	3.13	4.59	4.44	4.68	4.68	4.59	3.84	3.05	2.19	2.49	3.54
	T. Quang	2.37	2.39	2.7	3.4	5	4.25	4.97	4.8	4.7	3.91	3.11	2.52	3.69
	Cao Bang	2.25	2.45	3.04	4.07	5.42	5.35	5.92	5.85	5.19	4.16	3.22	2.77	4.15
	Phu Tho	2.42	2.45	2.67	3.6	5.24	4.85	5.21	4.79	4.82	4.2	3.35	2.77	3.87
	Lai Chau	3.29	3.83	3.58	5.43	5.32	4.48	4.54	4.73	4.81	4.12	3.46	3.12	4.12
	Hoa Binh	2.62	2.66	2.94	3.81	5	4.53	4.86	4.56	4.36	4.04	3.21	2.73	3.78
	Ha Noi	2.44	2.4	2.53	3.46	5.23	5.31	5.59	5.1	4.79	4.18	3.45	2.97	4.08
Central	Da Nang	3.07	3.27	4.55	5.09	5.27	5.81	5.77	5.42	4.91	3.52	2.89	3.07	4.43
	B. Dinh	3.16	4.06	4.99	5.93	5.93	5.76	5.55	5.8	5.35	4.07	3.02	2.8	4.7
	Gia Lai	4.28	5.15	5.51	5.66	5.51	4.96	4.71	4.51	4.48	4.45	3.84	3.8	4.79
	Kon Tum	4.1	4.98	5.53	5.74	5.32	4.59	4.26	4.45	4.1	4.55	3.85	3.67	4.61
	Dac Lac	4.07	4.82	5.06	5.23	4.73	4.45	4.24	4.21	3.97	3.91	3.61	3.54	4.32
	Q. Ngai	2.86	3.78	4.68	5.68	5.87	5.83	5.74	5.75	5.33	3.99	2.88	2.71	4.6
	Nha Trang	4.66	5.29	5.69	5.91	5.9	5.66	5.66	5.51	4.92	4.42	4.04	4.15	5.15
South	TP HCM	4.65	5.19	5.43	5.45	4.79	4.67	4.34	4.78	4.42	4.4	4.31	4.28	4.72
	S. Trang	4.81	5.35	5.54	5.55	4.49	4.28	4.53	4.5	4.35	4.22	4.44	4.44	4.71

Source: IE: Master Plan on Renewable Resources in Vietnam, 2000

Table 6.2 Monthly Average Sunshine Hours in Vietnam

(unit : hour)

Province and Cities		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Average
North	Lai Chau	132	141	183	201	187	122	130	151	178	154	136	129	1873
	Tuyen Quang	69	48	55	89	182	167	194	182	181	160	130	103	1559
	Ha Noi	67	45	47	80	166	156	183	163	160	165	125	109	1465
Central	Da Nang	135	142	104	205	256	237	256	207	174	145	123	112	2096
	Binh Dinh	173	207	269	262	278	232	270	233	202	183	131	130	2559
	Gia Lai	256	260	275	233	209	143	138	118	135	179	198	233	2377
	Dac Lac	246	246	270	253	227	180	179	162	162	174	174	204	2480
	Kon Tum	249	233	272	224	196	147	124	113	114	178	210	238	2298
	Nha Trang	184	202	264	259	251	228	245	239	205	182	142	151	2554
South	TP HCM	245	246	272	239	195	171	180	172	162	182	200	223	2489
	An Giang	282	256	293	238	232	161	208	183	193	211	225	250	2732

Source: IE: Master Plan on Renewable Resources in Vietnam, 2000

Table 6.3 Classification of Solar Power Potential in Vietnam

Category	Area
Level I: Suitable for solar power Over 150kcal/cm^2/year (1744.5kWh/m^2/year, or 4.8kWh/m^2/day)	Central Provinces Khanh Hoa, Ninh Thuan, Binh Thuan, Ba Ria - Vung Tau, Kon Tum, Gia Lai, Dac Lac, Lam Dong, Dong Nai.
Level II: Suitable for solar power 120-150 kcal/cm^2/year (1395.6-1744.5kWh/m^2/year, or 3.8-4.8kWh/m^2/day)	Most of provinces not inclued in Level I
Level III: Not suitable for solar power 100-120 kcal/cm^2/year (1163-1395.6 kWh/m^2/year, or 3.2-3.8 kWh/m^2/day)	Provinces located in middle of northen area Ha Giang, Lao Cai, Tuyen Quang, Yen Bai, Phu Tho and Hoa Binh.
Level IV: Not suitable for solar power Less than 100 kcal/cm^2/year (1163 kWh/m^2/year, or 3.2 kWh/m^2/day)	Part of mountainous area Ha Giang, Lao Cai and Yen Bai

Note: IE: Master Plan on Renewable Resources in Vietnam, 2000

Table 6.4 Annual Average Wind Speed in Vietnam

Area	Annual Average Wind Speed
Islands	- Near to coastal line: 5-6m/s - Offshore: 6-8m/s - South/South-west area near to equator: 3-4m/s
Plain	- Central coastal area （Cai Hai-Kim Son, Cua Hoi-Cua Thuan）: Over 4m/s - Notrhern Plain: 3-4m/s（Section from Hai Van pass to Quang Ngai is more smaller） - Southern coastal area: Over 3m/s - Cuu Long River Delta: 2-3m/s
Mountainous Area	- Northern and Central mountainous area: 2-3m/s - Northern low midland: 2m/s - Highlands: 3-3.5m/s - Low mountainous area (north east of Da river, Kon Tum, Central south coastal area near Truong Son range, North of Vam Co Dong river）: Under 2m/s - Hoang Lien Son & Truong Son mountains （at 1,400-1,500m elevation）: Over 4m/s - Northern boarder area （at 1,400m elevation）: 6-7m/s

Note: IE: 6th Power Development Master Plan (Draft), 2007

Table 6.5 Wind Power Potential (Wind Speed: greater or equal to 3m/s)

No.	Area	Wind Speed	Potential	Progress
1	Hai Phong area: 1. Bach Long Vi island 2. Do Son area	 9.7 m/s (at 50 m height) 4.5 m/s (at 10 m)	 5 MW 10 MW	 In operatin （0.8 MW） In preparation for operation
2	Ninh Thuan province: 1. Ca Na, Ninh Phuoc 2. Ninh Hai, Ninh Phuoc	 6.7 m/s (at 50 m) 7.1 m/s (at 60 m)	 15 MW 100 MW	 Measuring wind speed Measuring wind speed
3	Binh Dinh province: Phuong Mai peninsula	 6.8 m/s (at 50 m)	 150 MW	F/S completed, under tariff negotiaion
4	Tay Trang, Lai Chau	6.5 m/s (at 10 m)	3 MW	In preparation for operation
5	Van Phong peninsula, Tu Bong pass, Khanh Hoa	6.8 m/s (at 50 m)	100 MW	Measuring wind speed
6	Phu Yen	-	45 MW	Measuring wind speed
7	Binh Thuan: 1. Phu Qui island 2. Mui Ne 3. Tuy Phong district	 8.8 m/s (at 60 m) 5.6 m/s (at 10 m) 7.2 m/s (at 60 m)	 3 MW 50 MW 45 MW	 Measuring wind speed Measuring wind speed
8	Quang Ngai, Ly Son	6.7 m/s (at 30 m)	3 MW	F/S
9	Quang Tri	6.7 m/s (at 50 m)	10 MW	Measuring wind speed
10	Quang Binh	-	5 MW	-
11	Hai Hau - Nam Dinh	7.8 m/s (at 50 m)	40 MW	Measuring wind speed
12	Quang Ninh: 1. Co To island 2. Mong Cai area	 1.5 m/s (at 10 m) 7.1 m/s (at 50 m)	 5 MW 10 MW	 Measuring wind speed Measuring wind speed

Note : IE: 6th Power Development Master Plan (Draft), 2007

Table 6.6 Area and Wind Power Potential by Wind Speed

Average Wind Speed	Low < 6 m/s	Average 6 - 7 m/s	Relatively high 7 - 8 m/s	High 8 - 9 m/s	Very high > 9 m/s
Area (km^2)	197,242	100,367	25,679	2,178	111
(%)	60.60%	30.80%	7.90%	0.70%	» 0 %
Potential （MW）		401.444	102.716	8.748	452

Source: World Bank: Wind Energy Resource Atlas of Southeast Asia, 2001

Table 6.7 Status of Wind Speed and Wind Power Potential at 65m from the Ground

Area	Status of Wind Speed
South	- Cuu Long river delta：3-4m/s - Coastal districts (Tra Vinh province), Phu Thanh district (Ben Tre province) ：7 - 7.5 m/s. - Con Son island：8 - 9 m/s
Highlands	- Lam Dong, Buon Me Thuat, Pleiku, Kon Tum：7 - 7.5 m/s, - Top of moutains (at 1,500-2,000m elevation)：8m/s
Central-South Coastal Area	- Ninh Phuoc (Ninh Thuan province) ：8 - 8.5 m/s - Tuy Phong, Bac Binh, coastal line of Nam Phan Thiet and Phu Quy island (Binh Thuan province) and on high mountains between Ninh Thuan and Binh Thuan, Lam Dong provinces：8 - 8.5 m/s
Central-North Coastal Area	- Top of Truong Son mountain range (at 1,800m elevation) (Near Lao border)：8.5 - 9 m/s（Construction of wind power plants is not economic because access to site is difficult） - Coastal area（Quang Tri to Quang Ngai） ：Wind speed is low
Northen Coastal Area	- Near Hai Phong：6 - 6.5 m/s - Offshore islands：Over 7 m/s - Mountainous area (at 700-1,000m elevation) north-east of Hai Phong：7 - 7.5 m/s. - Mau Son mountainous area (Lang Son province) (at 1,300m elevation) ：Over 9 m/s
Potential	- 600MW; 12 provinces of north and central regions (not including highlands), Based on the data measured by hydro-meteorological stations - 1,600MW; Lam Dong province and 4 southern coastal provinces (Tra Vinh, Ben Tre, Soc Trang), PECC3

Note：PECC3: Wind energy potential for electric power generation in the south coastal areas

Table 6.8 Small Hydro Power Potential by Province (Capacity 100kW-10MW)

Province		Number of Sites	Potential (MW)
North	Cao Bang	19	53.97
	Bac can	8	7.4
	Thai Nguyen	7	27
	Bac Giang	3	8
	Lang Son	27	58.65
	Ha Giang	23	33.9
	Tuyen Quang	10	37.13
	Yen Bai	18	28.66
	Lao Cai	56	99.95
	Quang Ninh	15	18.27
	Lai Chau	34	63.94
	Son La	42	86.53
	Hoa Binh	3	0.8
	Thanh Hoa	18	77.56
Central	Nghe An - Ha Tinh	9	4.4
	Quang Binh - Quang Tri - Thua Thien	20	61
	Quang Nam	14	30.3
	Quang Ngai - Binh Dinh	28	71.38
	Phu Yen	16	53.35
	Binh Duong - Binh Phuoc	20	26.63
	Ninh Thuan - Binh Thuan	14	48.65
	Lam dong	26	61.07
	Gia Lai	80	79.1
	Kon Tum	49	71.58
	Dac Lac	43	196.03
South	Tay Ninh	8	4.5
	Total	**610**	**1310**

Note：UNDP/World Bank: ESMAP, Renewable Energy Action Plan, 2002

Table 6.9 Renewable Energy Development Plan

	Capacity (MW)	2006-2010		2011-2015		2016-2020		2021-2025	
		Year	Capacity	Year	Capacity	Year	Capacity	Year	Capacity
Total	**2267**		**467**		**900**		**350**		**550**
（Small Hydro）	**1767**		**467**		**700**		**300**		**300**
（Wind and New energy）	**500**		**0**		**200**		**50**		**250**
North	810		210		200		200		200
Small Hydro（Plant）	210		210		0		0		0
NAM MU	11	Existing	11						
Na_loi	9	Existing	9						
Nam Dong (22MW)	22	2007	22						
SUOI SAP(16MW)	16	2006	16						
Minh Luong	22	2007	22						
BAN COC-HUONG SON2	30	2007	30						
Ho Bon (18MW)	18	2008	18						
SEO CHUNG HO	22	2008	22						
BAN COC-HUONG SON2	30	2009	30						
CHU LINH	30	2010	30						
Small Hydro（Bundle）	500		0		200		200		100
TD nho moi MB	500			2015	200	2017	100	2022	100
						2020	100		
Wind and New energy	100		0		0		0		100
Wind and New energy	100							2021	100
Central	1007		257		300		100		350
Small Hydro（Plant）	118		118		0		0		0
SUOI VANG	10	Existing	10						
Ryninh	9	Existing	9						
DRAY HLING	28	Existing	28						
HCHAN_HMUN	27	2007	27						
EAK RONG ROU	28	2007	28						
DA DANG DACHAMO	16	2008	16						
Small Hydro（Bundle）	639		139		200		100		200
TDnho_MienTrung1	55	2008	55						
TDN M.Trung2 (84MW)	84	2009	84						
New Small HPP-Center-South	500			2013	100	2016	100	2022	200
				2014	100				
Wind and New energy	250		0		100		0		150
Wind and New energy	250			2012	50			2022	100
				2015	50			2023	50
South	450		0		400		50		0
Small Hydro（Plant）	0		0		0		0		0
no plant	0								
Small Hydro（Bundle）	300		0		300		0		0
New Small HPP-Center-South	300			2012	100				
				2014	100				
				2015	100				
Wind and New energy	150		0		100		50		0
Wind and New energy	150			2012	50	2017	50		
				2015	50				

Note: IE: 6th Power Development Master Plan (Draft), 2007

Table 6.10 Hot Water Resources in Vietnam

Temparature Range	Areas						Total
	North West	North East	Red River Delta	Northern Coastal Central	Southern Coastal Central	South	
Warm (30-40^{o}C)	35	6	9	11	27	52	140 (52.0%)
Medium Hot (41-60^{o}C)	38	3	3	19	20	1	84 (31.2%)
Very Hot (61-100^{o}C)	6	2	2	11	20	0	41 (15.2%)
Extremely Hot (>100^{o}C)	0	0	3	1	0	0	4 (1.5%)
Total	79 (29.4%)	11 (4.1%)	17 (6.3%)	42 (15.6%)	67 (24.9%)	53 (19.7%)	269

Note: IE: 6th Power Development Master Plan (Draft), 2007

Table6.11 Potential Geothermal Sites

No	Site	District	Province	Temparature (^{o}C)		Flow (l/s)	Capacity(MW)
				Surface	Underground		
1	Pac Ma	Muong Te	Lai Chau	62.5	174	1.5	
2	Pe Luong	Dien Bien	Dien Bien	53.8	146	1.7	
3	Pom Lot	Dien Bien	Dien Bien	74	150	5	
4	Na Hai	Dien Bien	Dien Bien	78	150	5	9.6
5	Ban Sang	Tuan Giao	Lai Chau	50.5	237	0.5	
6	Nam Pam	Muong La	Son La	55.5	190	1	
7	Na Ban	Than Uyen	Lai Chau	36.7	198	1.2	
8	Bo Dot	Bac Quang	Ha Giang	71.5	207.8	1	
9	My Lam	Yen Son	Tuyen Quang	64	146	13.2	13.7
10	Kim Da	Tuong	Nghe An	73.5	164	2.5	
11	Son Kim	Hong Son	Ha Tinh	78	177.6	5	8
12	Bang	Le Thuy	Quang Binh	100	193	40	23.3
13	Huyen Co	Da Krong	Quang Tri	70.2	217.4	3	
14	Thanh Tan	Phong Dien	TT - Hue	67.3	210.2	1.5	
15	Duong Hoa	Huong Thuy	TT - Hue	68	185.1	3	
16	Que Loc	Que Son	Q Nam	58	209.7	12	
17	Phong Que	Que Son	Q Nam	64	208	1.2	
18	Phu Ninh	Tam Ky	Q Nam	71	146	1.4	
19	Thach Bich	Tra Bong	Q Ngai	68	164.8	5	
20	Nghia Thang	T Nghia	Q Ngai	78	151.9	2.4	18
21	Mo Duc	Mo Duc	Q Ngai	80	183.5	6	21.4
22	Hoi Van	Phu Cat	Binh Dinh	83	142.3	8.6	18
23	Phu Sen	Phu Hoa	Phu Yen	71	145.4	8.5	10.3
24	Tu Bong	Van Ninh	K Hoa	73	149.1	7.3	18
25	Hoc Chim	Van Ninh	K Hoa	71	177.8	6.67	
26	Danh Thanh	Dien Khanh	K Hoa	72	135.1	7.9	14
27	Ta Cu	Ham Thuan Nam	Binh Thuan	78	153.2	1	11
28	Suoi Luong	Kon Long	Kon Tum	63	136.4	5	
29	Binh Chau	Binh Chau	BR - VT	82	159.8	15	15.3

Note: Red Colored Sites: Evaluated as possible sites

Note: IE: 6th Power Development Master Plan (Draft), 2007

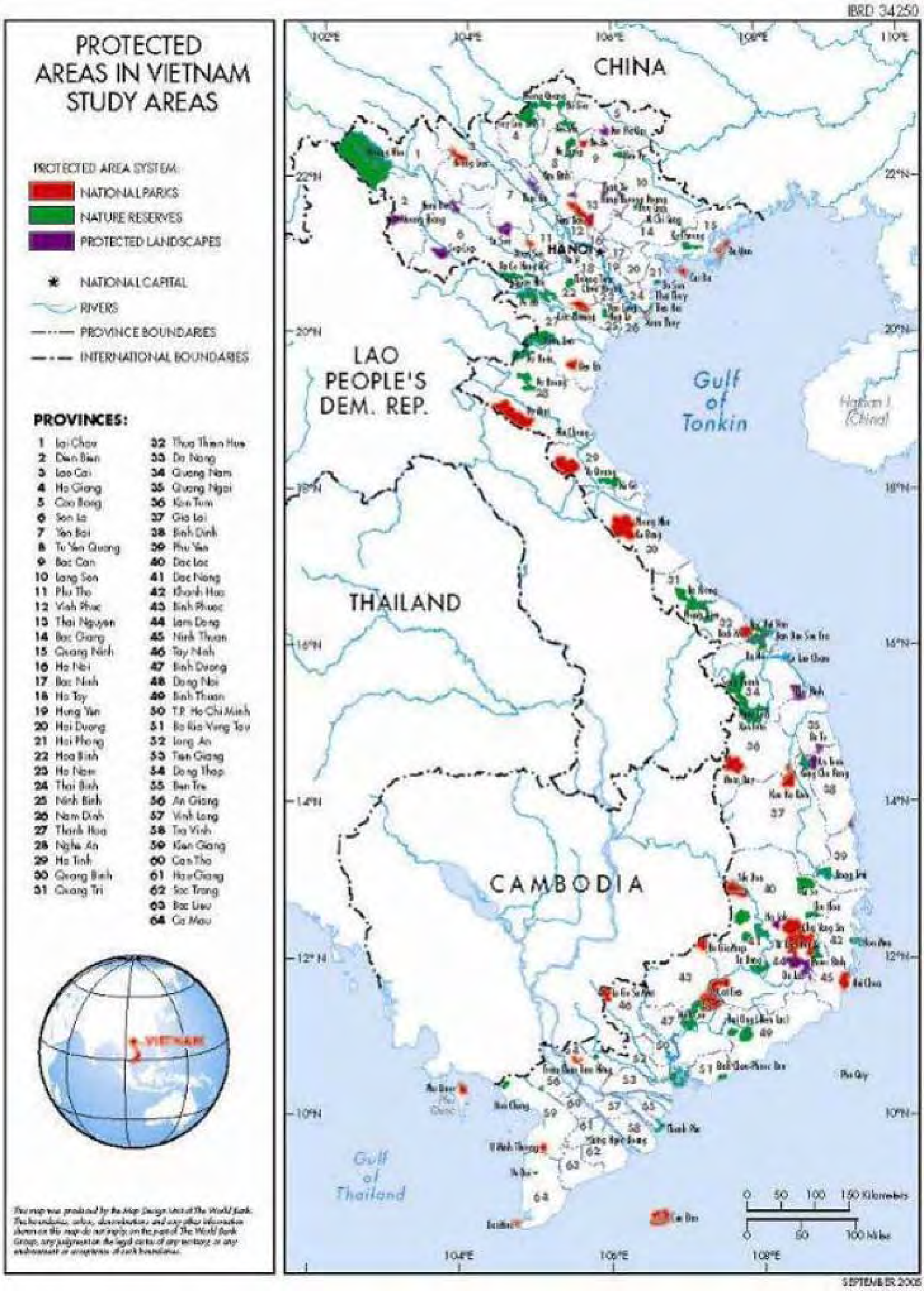
Table 6.12 Renewable Energy Development Plan (Detail)

	Capacity (MW)	2006-2010		2011-2015		2016-2020		2021-2025	
		Year	Capacity	Year	Capacity	Year	Capacity	Year	Capacity
Total	**2267**		**467**		**900**		**350**		**550**
（Small Hydro）	**1767**		**467**		**700**		**300**		**300**
（Wind and New energy）	**500**		**0**		**200**		**50**		**250**
North	810		210		200		200		200
Small Hydro（Plant）	210		210		0		0		0
NAM MU	11	Existing	11						
Na_loi	9	Existing	9						
Nam Dong (22MW)	22	2007	22						
SUOI SAP(16MW)	16	2006	16						
Minh Luong	22	2007	22						
BAN COC-HUONG SON2	30	2007	30						
Ho Bon (18MW)	18	2008	18						
SEO CHUNG HO	22	2008	22						
BAN COC-HUONG SON2	30	2009	30						
CHU LINH	30	2010	30						
Small Hydro（Bundle）	500		0		200		200		100
TD nho moi MB	500			2015	200	2017	100	2022	100
						2020	100		
Wind and New energy	100		0		0		0		100
Wind and New energy	100							2021	100
Central	1007		257		300		100		350
Small Hydro（Plant）	118		118		0		0		0
SUOI VANG	10	Existing	10						
Ryninh	9	Existing	9						
DRAY HLING	28	Existing	28						
HCHAN_HMUN	27	2007	27						
EAK RONG ROU	28	2007	28						
DA DANG DACHAMO	16	2008	16						
Small Hydro（Bundle）	639		139		200		100		200
TDnho_MienTrung1	55	2008	55						
TDN M.Trung2 (84MW)	84	2009	84						
New Small HPP-Center-South	500			2013	100	2016	100	2022	200
				2014	100				
Wind and New energy	250		0		100		0		150
Wind and New energy	250			2012	50			2022	100
				2015	50			2023	50
South	450		0		400		50		0
Small Hydro（Plant）	0		0		0		0		0
no plant	0								
Small Hydro（Bundle）	300		0		300		0		0
New Small HPP-Center-South	300			2012	100				
				2014	100				
				2015	100				
Wind and New energy	150		0		100		50		0
Wind and New energy	150			2012	50	2017	50		
				2015	50				

Note: IE: 6th Power Development Master Plan (Draft), 2007

7. Environment and Social Consideration

Figure 7.1 Protected Areas in Vietnam



Source: MONRE (Vietnam)/ WB/ SIDA, 2005, Vietnam Environmental Monitor (VEM) 2005, pp38.

7.2 Record of the First Workshop held on 19 December 2006

In the first workshop for the Project, the study team and the key Vietnamese counterpart persons explained the Inception Report and had discussion and Q/A session on the concept, approach and method of the Master Plan Study including the SEA concerned. The method of SEA for the Project had been discussed with the Department of Reviewing, Appraisal and EIA in the Ministry of Natural Resources and Environment (MONRE) prior to the workshop, using the workshop material and the study schedule. It was endorsed in principle by MONRE at the discussion. The profile of the First Workshop is shown below.

Table 7.1 Profile of the First Workshop

08:30	Registration		
08:40	Introduction	Dr. Tran Thanh Lien, IE	V
08:45	Welcome Address	Dr. Do Huu Hao, Vice Minister, MOI Mr. Y. Tojo, JICA	V J
9:00 -16:30	**Meeting Session** Co-Chairs: Dr. Pham Khanh Toan, Director of IE Mr. K. Kanekiyo, Team Leader		V J
09:00	Outline of the Study Plan	Mr. K. Kanekiyo, Team Leader	J
09:30	Outline of National Energy Strategy in Vietnam	Mr. Le Tuan Phong, MOI	V
10:00	Tea Break		
10:15	Discussion		
10:45	Concept of Strategic Environmental Assessment	Mr. T. Sasaka	J
11:15	Introduction to IEEJ's Database	Mr. S. Omoteyama	J
11:45	Lunch		
13:00	Methodology of Energy Demand Survey and Forecasting	Mr. T. Inoue	J
13:30	Methodology of Demand & Supply Optimization Model	Mr. T. Asakura	J
14:00	Discussion		
14:20	Tea Break		
14:40	Outline of the 6th Master Plan of Power Sector	Mr. Nguyen Anh Tuan, IE	V
15:10	Outline of Oil & Gas Sector Strategy	Mr. Nguyen Huy Tien, Petrovietnam	V
15:40	Overview on Current Situation and Development Directions of Vietnam Coal Industry	Dr. Nguyen Canh Nam, Vinacomin	V
16:10	Discussion		
16:30	Closing Remark	Dr. Pham Khanh Toan, Director of IE	V

Source: The Study Team, The First Workshop Material, 19 December 2006.

Note: V stands for Vietnamese counterpart persons and experts in the concerned working groups.
J stands for a JICA expert and the Japanese Study Team members.

1) Participants of the First Workshop

Participants in the 1st workshop are listed below. 67 people were invited from the concerned organization to the 1st workshop by the implementing agency of the Project, IE (See the left column on the table below). Total Vietnamese participants who actually participated were 41 persons, including 16 Japanese side persons.

MONRE in charge of SEA and EIA in Vietnam was also invited, but not participated in the workshop.

Table 7.2.2 List of Participants to the First Workshop

Invited Organization	**Total Vietnamese Participants who actually participated**	**41**	**Japanese Participants**	**16**
Ministry of Industry (MOI)	Ministry of Industry (MOI)	4	JICA	3
MOI; Energy and Petroleum Dept, Planning Dept., Science and Technology Dept., International Cooperation Dept. Electricity Regulation Authority Dept.	MOI, Energy and Petroleum Dept.	4	Study Team	13
	MOI, Planning Dept.	2		
Ministry of Planning & Investment Industrial Dept., Institute of Strategy	Ministry of Planning & Investment, Institute of Strategy	2		
VINACOMIN	VINACOMIN	1		
Institute of Petroleum	Institute of Petroleum	2		
Gas-Power Dept. (PetroVN)	Gas-Power Dept. (PetroVN)	3		
Institute of Energy	Institute of Energy	20		
Governmental Secretariat	Governmental Secretariat	1		
Institute of Industrial Technology and Safety	Institute of Industrial Technology and Safety	1		
Institute of Strategy and Industrial Policy Research	AXIS Research Company	1		
Institute of Mine, Science and Technology				
Petrolimex				
Petroleum Information Center				
EVN (Power Utility Corp.) ICD, Planning Dept., Statistic General Dept., Customs General Dept., Electricity Source Dept., Rural Electricity Dept., Science and Technology Dept.				
MONRE, Reviewing, Appraisal and EIA Dept.				
International Economics Dept.				
Ministry of Transportation				
Ministry of Finance				
Chemical Corporation				

Source: The Study Team, Record of the First Workshop, 19 December 2006.

2) Discussed points in the First Workshop

<u>Expressions, Questions and Answers on the Study in general</u>

(V) We are expecting this study to formulate the national energy master plan that should integrate the energy sub-sectors of Vietnam for the first time.

(J) We expect it to enable a sustainable development.

(V) We have interests in a methodology fitting to the conditions of Vietnam where the focal points of the Study are supposed to be the utilization of the primary energy, such as coal, oil and natural gas, and the establishment of Ministry of Energy.

(J) The plan will be examined from the aspects of short-term (1-2 years), mid-term (around 5 years) and long-term (10 to 20 years). In the mid-term plan, capital investment plan can be rearranged and adjusted to some extent. In the long-term plan, we will examine alternative possible scenarios to create a road map for the master plan. At first, we will establish a national energy database to construct a simulation model for the energy sector and run simulation on the model regarding different scenarios to formulate the national energy master plan.

(V) How will you treat with 'Non-Commercial Energy' in the subject of energy consumption?

(J) We will keep it in mind that 'Non-Commercial Energy' will be gradually replaced by 'Commercial Energy'. We should understand, in formulation of the policy, that renewable energy development has the two objectives as alternative energy for fossil fuels and electrification of un-electrified villages.

(V) We also put an importance on the energy strategy including the approach to the energy security.

(J) It is the Vietnam side that should finally decide on the institutional and policy model in respects of environment, energy security and sustainable development, etc. We will examine important factors on energy security regarding alternative scenarios to evaluate the sufficiency level on the energy security. Energy diversification, energy conservation and new technology can be considered as measures for the issue.

(V) How do you treat with the regional climate conditions in the optimization model?

(J) Vietnam is supposed to be treated as three different regions in the model concerned. If you find any wrong assumption on the model, let us know it and we will listen to you who know Vietnam better than us.

(J) How the nuclear energy should be treated in this Study?

(V) The nuclear power development is the national policy following the decision of the prime minister on 'the Strategy for Utilization of the Nuclear Power'. Currently, we assume to be utilizing 2,000 MW of nuclear power in 2020 according to 'the Sixth Power Sector Master Plan'. However, we are prepared to consider the other options if JICA experts propose the alternatives though the introduction of the nuclear power should be the base case for planning.

(V) We will start preparing the renewable energy master plan in 2007. In its preparation process, we will have discussions with the concerned people related to the relevant plans including the power sector master plan.

(V) In formulating the Vietnam Energy Master Plan, we like to have a reference to the Japanese experience of overseas investment activity.

(J) Investment activity on overseas oil development should follow the global standard in the business world.

(V) The Red River Delta has 1.6 billion of coal reserve which is made up of good bituminous coal with

6,000kcal/kg calorie. We have the plan to start developing it in 2010. So, we are seeking proposals on proper method of mining. Vietnam is supposed to start the import of coal in 2015, which will reach 40 to 60 million of import in 2020.

(J) We will judge from the economical aspect whether the future Vietnam should depend on imported coal or increased production of coal.

<u>Questions and Answers related to SEA</u>

Q 1 : The climate is quite different between the southern part and the northern part of Vietnam. Are the climate conditions considered in the examination of the SEA method?

A1: We propose three measures, namely indicators, weighting of indicators, and level of difficulty for mitigation measures, for the method of evaluating alternative plans. Since the impact area in space and the time duration of impact, the matters analyzed in ‘weighting of indicators’, are supposed to relate to the climate, those analysis will include the climate factor.

Q2: Power plants and factories have different emission factors of pollutants. Is it considered in deciding coefficients for the optimization model?

A2 : That will be considered, if possible and necessary for the master plan, in comparison of alternative plans with the indicators for air pollution load (and greenhouse gas emission) among six indicators proposed.

7.3 Discussion with Government Offices on the aspect of ESC

7.3.1 Ministry of Industry (MOI)

Twice on 18 December 2006 and 22 May 2007, the study team member and IE counterpart in charge of ESC visited the environmental office of MOI[1], to have communication and confirmation on the SEA procedure for the concerned study. The results of discussion are the following.

1) Legal obligation to enforce SEA and its appraisal organization

SEA is required for the national energy master plan (Article 14, 2 of the Law on Environmental Protection is applied). Since it is a national master plan that relates to multi-sectors, it is required of the approval of either the Government or the prime minister. Therefore, MONRE should be the appraisal organization for its SEA (Article 17, 7 a) of the same law is applied).

2) Procedure to start the SEA on the Vietnamese side

When the SEA report is prepared, MOI is to apply for the appraisal of SEA to MONRE. However, the Environment Office of MOI does not have intention to initiate the SEA process for itself. The office considers that the SEA study should be implemented either by the Institute of Energy (IE), the consultant for the concerned study, or the Energy and Petroleum Department (EPD) of MOI, taking charge of the study for the Vietnamese government.

The JICA study team conveyed an advice from JICA ESC Review Office that the Vietnamese Government should initiate the SEA process at the early stage of scoping, and recommended that MOI should facilitate communication between the EPD and the environmental office in MOI and keep contact with MONRE at an early stage of the concerned study.

3) Scoping documents

The study team handed in the documents for the draft scoping in the format of JICA ESC Review Office, asking the comment and review. It was accepted. (In December 2006 at the first joint study, the study team explained to the environmental office of MOI the start of the JICA study, the SEA method and its draft TOR. The office agreed to the explanation.)

7.3.2 Ministry of Natural Resources and Environment (MONRE)

Twice on 18 December 2006 and 22 May 2007, the study team member and IE counterpart in charge of ESC visited the environmental office of MONRE[2], to have communication and confirmation on the SEA procedure for the concerned study. The results of discussion are the following.

1) Legal obligation to enforce SEA and its appraisal organization

The MONRE office gave us the same conclusion for the concerned issue as the environmental office of

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1 Precisely, 'The Industrial Environment Office, Science and Technology Department of MOI'

2 Precisely, 'Department of Reviewing, Appraisal and Environmental Impact Assessment, MONRE'

MOI did.

2) Procedure to start the SEA on the Vietnamese side

MONRE also gave us the same answer as MOI regarding the time to initiate the procedure for SEA appraisal, meaning that the implementing organization of the SEA should apply its appraisal to MONRE when its report is drafted. Therefore, the TOR and scoping for SEA are legally not necessary to be approved (or supervised) by MONRE, according to MONRE official in charge of EIA and SEA.

MONRE also have the perception that the SEA study is to be done by the concerned consultant and have not mentioned about the obligation of MOI to implement the SEA. Under the present circumstance, the responsibility for the implementation of SEA is not strongly recognized and committed on the government side.

The JICA study team conveyed an advice from JICA ESC Review Office that the Vietnamese Government, MOI and MONRE, should initiate the SEA process at the early stage of scoping. MONRE expressed a welcome to the introduction of the study documents like a scoping document to MONRE during the study, with the reason that they like to refer the method of implementing a SEA.

3) Scoping documents

The study team handed in the documents for the draft scoping in the format of JICA ESC Review Office, asking the comment and review. It was accepted. （In December 2006 at the first joint study, the study team explained to the environmental office of MOI the start of the JICA study, the SEA method and its draft TOR. The office agreed to the explanation.）

7.4 Work Schedule and Other Relevant Information

7.4.1 Work procedure of the Study

The figure below is the flow chart of the Study work.

		Study Work stage	Study Work Item	Work shop	Technology Transfer Seminar	Report
FY2006	November					
	December		The first mission ● Formulate Steering Committee and Working Group ● 1st Workshop on Inception Report ● Collect and Review existing data and development plans ● Subcontract data updating	▽ W/S1		▼ Inception Report
	January		The second mission ● Collect and Review existing data and development plans ● Aanalyses and investigation on contents of models ● Technology transfer seminar ● Complete data updating subcontruat			
	February					
	March					
FY2007	April					
	May		The third mission ● Collect data and information including site surveys ● Analyse information and construct prototype models ● Technology transfer seminar ● Subcontract Energy Demand Survey and Database Programming ● Discuss on principle conditions for Progress Report		TTS1	
	June					
	July					
	August		The forth mission ● Collect data and information including site surveys ● Intensive analyses, simulation and drafting Progress Report ● 2nd Workshop on Progress Report ● Follow-up discussion on Interim Report for compilation of draft National Energy Master Plan and Roadmap for Energy Sector Commercialization ● Technology transfer seminar ● Complete energy demand survey subcontract	▽ W/S2	TTS2	▼ Progress Report
	September					
	October		The fifth mission ● Review scenarios and draft National Energy Master Plan ● 3rd Workshop on Interim Report ● Dicuss on principle conditions for Draft Final Report ● Complete Database programming subcontract ● OJT technology transfer	▽ W/S3		▼ Interim Report
	November					
	December					
	January		The sixth mission ● 4th Workshop on draft Final Report ● Discussion on any followup work ● OJT technology transfer	▽ W/S4		▼ Draft Final Report
	Februaly					
	March					
FY2008	April					
	May		(Reporting to JICA)			▼ Final Report
	June					

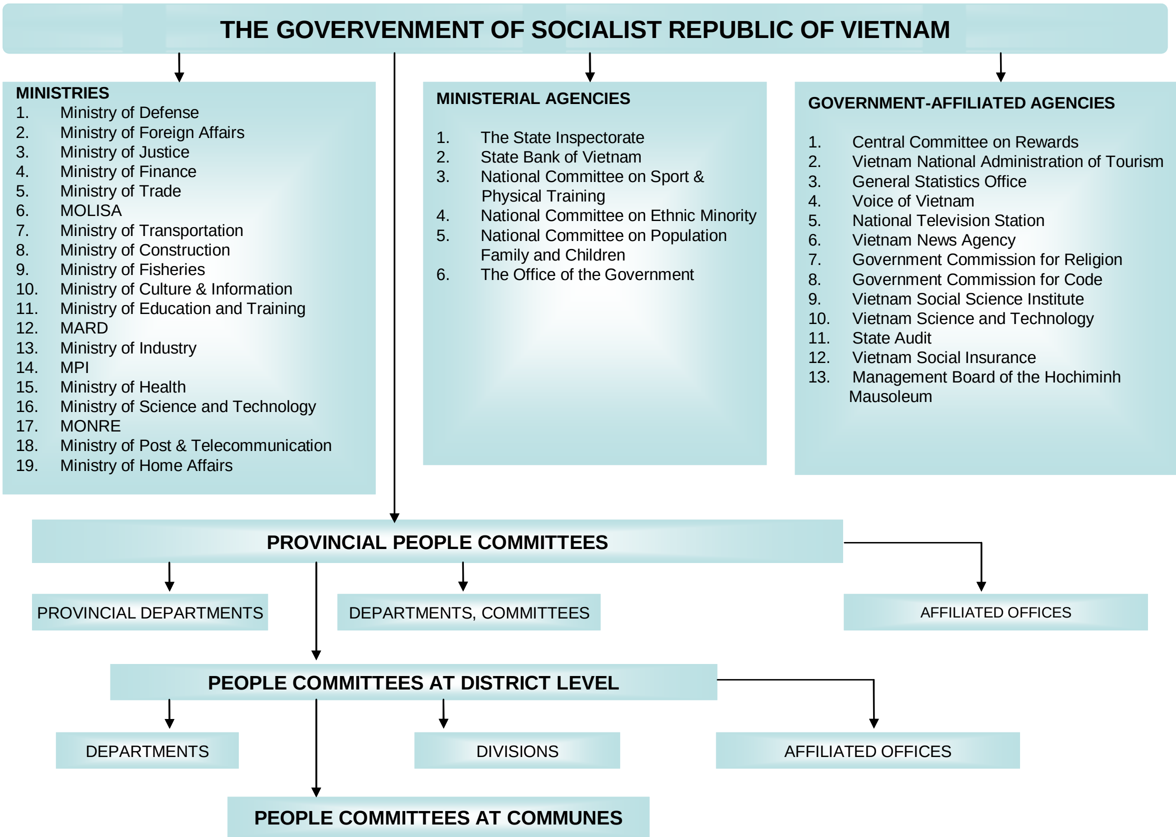
Figure 7.4.1 Flow Chart of the Study Work

Source: The Study Team, The Progress Summary, June 2007

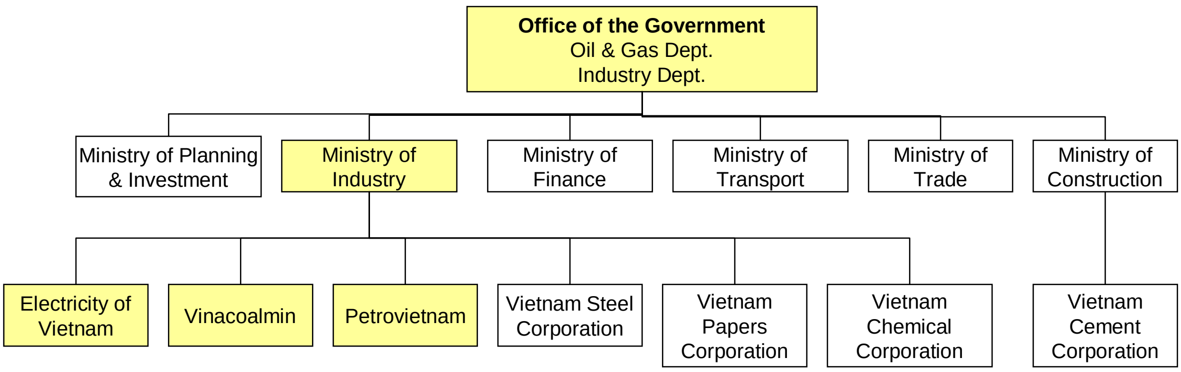
7.4.2 Other relevant information

Organizations of GOV, the Energy Sector, MOI and MONRE are as follows respectively.

1) Organization chart of the Government of Vietnam



2) Organization chart of the Energy Sector of Vietnam



3) Organization chart of MONRE

Appendix 2

Summary Tables of Case Studies

Appendix 2.1 BAU Case

	Unit	2005	2010	2015	2020	2025	Growth Rate 05-15	15-25	05-25
Economic Indicators							%	%	%
Population	Million	83.10	87.76	92.69	97.90	101.88	1.1%	0.9%	1.0%
Real GDP in 2005 price	$ Billion	52.50	78.94	118.71	178.49	262.26	8.5%	8.2%	8.4%
RGDP per capita	$	632	900	1,281	1,823	2,574	7.3%	7.2%	7.3%
Material Industry Ratio	%	9.0	9.0	9.1	9.0	8.7			
Energy Prices									
Crude Oil ;FOB	$/Bbl	50	65	65	65	65			
Coal; Steaming, FOB	$/ton	20	38	57	57	57			
Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5			
Energy Indicators									
TPE per capita	Toe	0.34	0.47	0.70	1.05	1.58	7.6%	8.4%	8.0%
TPE per GDP	Toe/$1000	0.54	0.52	0.55	0.57	0.62	0.2%	1.1%	0.7%
Electricity per capita	kWh	549	995	1,599	2,569	3,926	11.3%	9.4%	10.3%
Motorbike	million unit	19	26	29	30	30	4.2%	0.5%	2.3%
Passenger Car	1000 unit	195	449	950	1,835	3,084	17.2%	12.5%	14.8%
CO2 Emission	Million CO2-t	87	120	195	303	508	8.4%	10.1%	9.2%
Total Primary Energy Demand	kToe	*28,172*	*40,880*	*65,277*	*102,419*	*161,383*	*8.8%*	*9.5%*	9.1%
Coal	kToe	8,935	12,420	23,030	35,196	69,155	9.9%	11.6%	10.8%
Oil (excl. Stockpiling)	kToe	12,045	16,696	25,395	38,363	55,786	7.7%	8.2%	8.0%
Gas	kToe	5,727	8,175	11,208	19,690	25,790	6.9%	8.7%	7.8%
Hydro	kToe	1,396	2,976	4,502	5,477	5,477	12.4%	2.0%	7.1%
Nuclear	kToe	0	0	0	883	2,113	---	---	---
Renewables	kToe	64	185	402	571	704	20.2%	5.8%	12.8%
Power Import	kToe	6	418	688	2,134	2,135	61.6%	12.0%	34.5%
Non-commercial Energy	*kToe*	*14,694*	*14,262*	*13,585*	*12,562*	*10,779*	*-0.8%*	*-2.3%*	*-1.5%*
Coal	*%*	*31.7*	*30.4*	*35.3*	*34.4*	*42.9*			
Oil	*%*	*42.8*	*40.8*	*38.9*	*37.5*	*34.6*			
Gas	*%*	*20.3*	*20.0*	*17.2*	*19.2*	*16.0*			
Fossil Fuel	*%*	*94.8*	*91.2*	*91.4*	*91.0*	*93.4*			
Others	*%*	*5.2*	*8.8*	*8.6*	*8.9*	*6.5*			
Non-commercial Energy	*%*	*52.2*	*34.9*	*20.8*	*12.3*	*6.7*			
Final Demand (excl. Non-Com	kToe	*22,590*	*33,725*	*51,384*	*79,975*	*118,195*	8.6%	8.7%	8.6%
Agriculture	kToe	570	716	830	946	1,159	3.8%	3.4%	3.6%
Industry	kToe	10,549	15,852	25,834	43,949	67,532	9.4%	10.1%	9.7%
Light	kToe	5,626	9,151	16,743	31,859	52,029	11.5%	12.0%	11.8%
Heavy	kToe	4,922	6,701	9,091	12,090	15,503	6.3%	5.5%	5.9%
Transportation	kToe	6,687	9,660	13,285	18,029	23,645	7.1%	5.9%	6.5%
Others	kToe	4,784	7,498	11,434	17,051	25,859	9.1%	8.5%	8.8%
Electriciry (ex-PS)	GWh	51,730	99,376	166,346	279,085	442,786	12.4%	10.3%	11.3%
Gasoline	kToe	2,687	3,713	4,650	5,847	7,386	5.6%	4.7%	5.2%
Diesel Gas Oil	kToe	5,314	7,550	11,099	16,215	22,525	7.6%	7.3%	7.5%
Energy Import	*kToe*	*-16,564*	*-14,666*	*2,823*	*27,962*	*80,333*			
Coal	kToe	-9,142	-11,785	-5,295	1,721	30,530			
Oil	kToe	-7,428	-3,299	7,430	19,723	37,966			
Gas	kToe	0	0	0	4,384	9,703			
Electricity	kToe	6	418	688	2,134	2,135			
Energy Import Ratio	*%*	*-58.8*	*-35.9*	*4.3*	*27.3*	*49.8*			
Coal	%	-32.5	-28.8	-8.1	1.7	18.9			
Oil	%	-26.4	-8.1	11.4	19.3	23.5			
Gas	%	0.0	0.0	0.0	4.3	6.0			
Electricity	%	0.0	1.0	1.1	2.1	1.3			

Appendix 2.2 **Reference Case**

	Unit	2005	2010	2015	2020	2025	Growth Rate 05-15	15-25	05-25
Economic Indicators							%	%	%
Population	Million	83.10	87.76	92.69	97.90	101.88	1.1%	0.9%	1.0%
Real GDP in 2005 price	$ Billion	52.50	78.94	118.71	178.49	262.26	8.5%	8.2%	8.4%
RGDP per capita	$	632	900	1,281	1,823	2,574	7.3%	7.2%	7.3%
Material Industry Ratio	%	9.0	9.0	9.1	9.0	8.7			
Energy Prices									
Crude Oil ;FOB	$/Bbl	50	65	65	65	65			
Coal; Steaming, FOB	$/ton	20	38	57	57	57			
Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5			
Energy Indicators									
TPE per capita	Toe	0.34	0.46	0.63	0.85	1.15	6.4%	6.2%	6.3%
TPE per GDP	Toe/$1000	0.54	0.51	0.49	0.47	0.45	-0.9%	-0.9%	-0.9%
Electricity per capita	kWh	549	995	1,599	2,569	3,926	11.3%	9.4%	10.3%
Motorbike	million unit	19	26	29	30	30	4.2%	0.5%	2.3%
Passenger Car	1000 unit	195	449	950	1,835	3,084	17.2%	12.5%	14.8%
CO2 Emission	Million CO2-t	87	118	169	238	345	6.9%	7.4%	7.1%
Total Primary Energy Demand	kToe	*28,172*	*40,145*	*58,212*	*83,052*	*117,060*	*7.5%*	*7.2%*	7.4%
Coal	kToe	8,935	12,148	18,818	26,007	39,561	7.7%	7.7%	7.7%
Oil (excl. Stockpiling)	kToe	12,045	16,489	23,539	33,106	44,572	6.9%	6.6%	6.8%
Gas	kToe	5,727	7,919	10,215	14,780	22,307	6.0%	8.1%	7.0%
Hydro	kToe	1,396	2,976	4,502	5,477	5,477	12.4%	2.0%	7.1%
Nuclear	kToe	0	0	0	883	2,113	---	---	---
Renewables	kToe	64	185	402	571	704	20.2%	5.8%	12.8%
Power Import	kToe	6	418	688	2,134	2,135	61.6%	12.0%	34.5%
Non-commercial Energy	*kToe*	*14,694*	*14,262*	*13,585*	*12,562*	*10,779*	*-0.8%*	*-2.3%*	*-1.5%*
Coal	*%*	*31.7*	*30.3*	*32.3*	*31.3*	*33.8*			
Oil	*%*	*42.8*	*41.1*	*40.4*	*39.9*	*38.1*			
Gas	*%*	*20.3*	*19.7*	*17.5*	*17.8*	*19.1*			
Fossil Fuel	*%*	*94.8*	*91.1*	*90.3*	*89.0*	*90.9*			
Others	*%*	*5.2*	*8.9*	*9.6*	*10.9*	*8.9*			
Non-commercial Energy	*%*	*52.2*	*35.5*	*23.3*	*15.1*	*9.2*			
Final Demand (excl. Non-Com	kToe	*22,590*	*33,725*	*51,384*	*79,975*	*118,195*	8.6%	8.7%	8.6%
Agriculture	kToe	570	716	830	946	1,159	3.8%	3.4%	3.6%
Industry	kToe	10,549	15,852	25,834	43,949	67,532	9.4%	10.1%	9.7%
Light	kToe	5,626	9,151	16,743	31,859	52,029	11.5%	12.0%	11.8%
Heavy	kToe	4,922	6,701	9,091	12,090	15,503	6.3%	5.5%	5.9%
Transportation	kToe	6,687	9,660	13,285	18,029	23,645	7.1%	5.9%	6.5%
Others	kToe	4,784	7,498	11,434	17,051	25,859	9.1%	8.5%	8.8%
Electriciry (ex-PS)	GWh	51,730	97,524	148,346	225,807	325,217	11.1%	8.2%	9.6%
Gasoline	kToe	2,687	3,697	4,516	5,491	6,657	5.3%	4.0%	4.6%
Diesel Gas Oil	kToe	5,314	7,456	10,294	14,089	18,301	6.8%	5.9%	6.4%
Energy Import	*kToe*	*-16,564*	*-15,102*	*-3,082*	*9,219*	*36,042*			
Coal	kToe	-9,142	-12,057	-9,507	-7,468	936			
Oil	kToe	-7,428	-3,463	5,738	14,553	26,751			
Gas	kToe	0	0	0	0	6,220			
Electricity	kToe	6	418	688	2,134	2,135			
Energy Import Ratio	*%*	*-58.8*	*-37.6*	*-5.3*	*11.1*	*30.8*			
Coal	%	-32.5	-30.0	-16.3	-9.0	0.8			
Oil	%	-26.4	-8.6	9.9	17.5	22.9			
Gas	%	0.0	0.0	0.0	0.0	5.3			
Electricity	%	0.0	1.0	1.2	2.6	1.8			

Appendix 2.3 **High Growth Case**

	Unit	2005	2010	2015	2020	2025	Growth Rate 05-15	15-25	05-25
Economic Indicators							%	%	%
Population	Million	83.10	87.76	92.69	97.90	101.88	1.1%	0.9%	1.0%
Real GDP in 2005 price	$ Billion	52.50	81.15	127.75	201.10	316.58	9.3%	9.5%	9.4%
RGDP per capita	$	632	925	1,378	2,054	3,107	8.1%	8.5%	8.3%
Material Industry Ratio	%	9.0	9.0	9.1	9.0	8.5			
Energy Prices									
Crude Oil ;FOB	$/Bbl	50	65	65	65	65			
Coal; Steaming, FOB	$/ton	20	38	57	57	57			
Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5			
Energy Indicators									
TPE per capita	Toe	0.34	0.47	0.70	1.01	1.60	7.5%	8.7%	8.1%
TPE per GDP	Toe/$1000	0.54	0.51	0.50	0.49	0.51	-0.6%	0.2%	-0.2%
Electricity per capita	kWh	549	1,009	1,560	2,416	3,815	11.0%	9.4%	10.2%
Motorbike	million unit	19	26	28	28	26	4.0%	-0.7%	1.6%
Passenger Car	1000 unit	195	515	1,287	2,847	5,592	20.8%	15.8%	18.3%
CO2 Emission	Million CO2-t	87	122	192	292	507	8.2%	10.2%	9.2%
Total Primary Energy Demand	kToe	*28,172*	*41,567*	*64,482*	*98,723*	*162,515*	*8.6%*	*9.7%*	9.2%
Coal	kToe	8,935	12,665	22,512	34,020	66,082	9.7%	11.4%	10.5%
Oil (excl. Stockpiling)	kToe	12,045	16,955	25,498	38,155	58,522	7.8%	8.7%	8.2%
Gas	kToe	5,727	8,358	10,828	17,375	27,234	6.6%	9.7%	8.1%
Hydro	kToe	1,396	2,976	4,502	5,477	5,477	12.4%	2.0%	7.1%
Nuclear	kToe	0	0	0	883	2,113	---	---	---
Renewables	kToe	64	185	402	571	704	20.2%	5.8%	12.8%
Power Import	kToe	6	418	688	2,134	2,135	61.6%	12.0%	34.5%
Non-commercial Energy	*kToe*	*14,694*	*14,239*	*13,703*	*12,904*	*11,379*	*-0.7%*	*-1.8%*	*-1.3%*
Coal	*%*	*31.7*	*30.5*	*34.9*	*34.5*	*40.7*			
Oil	*%*	*42.8*	*40.8*	*39.5*	*38.6*	*36.0*			
Gas	*%*	*20.3*	*20.1*	*16.8*	*17.6*	*16.8*			
Fossil Fuel	*%*	*94.8*	*91.4*	*91.2*	*90.7*	*93.4*			
Others	*%*	*5.2*	*8.6*	*8.7*	*9.2*	*6.4*			
Non-commercial Energy	*%*	*52.2*	*34.3*	*21.3*	*13.1*	*7.0*			
Final Demand (excl. Non-Com	kToe	*22,590*	*34,262*	*51,088*	*77,917*	*121,298*	8.5%	9.0%	8.8%
Agriculture	kToe	570	724	844	963	1,140	4.0%	3.1%	3.5%
Industry	kToe	10,549	16,137	25,637	42,664	71,763	9.3%	10.8%	10.1%
Light	kToe	5,626	9,311	16,386	30,449	55,963	11.3%	13.1%	12.2%
Heavy	kToe	4,922	6,826	9,250	12,214	15,800	6.5%	5.5%	6.0%
Transportation	kToe	6,687	9,807	13,621	18,792	25,808	7.4%	6.6%	7.0%
Others	kToe	4,784	7,595	10,986	15,498	22,586	8.7%	7.5%	8.1%
Electriciry (ex-PS)	GWh	51,730	100,721	162,246	262,434	430,280	12.1%	10.2%	11.2%
Gasoline	kToe	2,687	3,761	4,834	6,399	8,784	6.0%	6.2%	6.1%
Diesel Gas Oil	kToe	5,314	7,667	11,116	16,009	23,099	7.7%	7.6%	7.6%
Energy Import	*kToe*	*-16,564*	*-12,951*	*2,585*	*26,908*	*85,524*			
Coal	kToe	-9,142	-11,540	-5,813	545	27,457			
Oil	kToe	-7,428	-1,829	7,711	22,160	44,784			
Gas	kToe	0	0	0	2,068	11,147			
Electricity	kToe	6	418	688	2,134	2,135			
Energy Import Ratio	*%*	*-58.8*	*-31.2*	*4.0*	*27.3*	*52.6*			
Coal	%	-32.5	-27.8	-9.0	0.6	16.9			
Oil	%	-26.4	-4.4	12.0	22.4	27.6			
Gas	%	0.0	0.0	0.0	2.1	6.9			
Electricity	%	0.0	1.0	1.1	2.2	1.3			

Appendix 2.4 Low Growth Case

	Unit	2005	2010	2015	2020	2025	Growth Rate 05-15	15-25	05-25
Economic Indicators							%	%	%
Population	Million	83.10	87.76	92.69	97.90	101.88	1.1%	0.9%	1.0%
Real GDP in 2005 price	$ Billion	52.50	78.94	114.92	161.19	220.84	8.1%	6.7%	7.4%
RGDP per capita	$	632	900	1,240	1,646	2,168	7.0%	5.7%	6.4%
Material Industry Ratio	%	9.0	9.0	9.1	9.0	8.7			
Energy Prices									
Crude Oil ;FOB	$/Bbl	50	65	65	65	65			
Coal; Steaming, FOB	$/ton	20	38	57	57	57			
Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5			
Energy Indicators									
TPE per capita	Toe	0.34	0.46	0.59	0.71	0.88	5.7%	4.0%	4.9%
TPE per GDP	Toe/$1000	0.54	0.51	0.48	0.43	0.40	-1.2%	-1.6%	-1.4%
Electricity per capita	kWh	549	977	1,360	1,798	2,291	9.5%	5.4%	7.4%
Motorbike	million unit	19	26	29	31	32	4.3%	0.9%	2.6%
Passenger Car	1000 unit	195	449	868	1,411	2,032	16.1%	8.9%	12.4%
CO2 Emission	Million CO2-t	87	117	155	194	252	6.0%	5.0%	5.5%
Total Primary Energy Demand	kToe	*28,172*	*40,040*	*54,608*	*69,735*	*89,167*	*6.8%*	*5.0%*	5.9%
Coal	kToe	8,935	12,146	16,029	20,268	26,976	6.0%	5.3%	5.7%
Oil (excl. Stockpiling)	kToe	12,045	16,390	22,319	28,505	35,088	6.4%	4.6%	5.5%
Gas	kToe	5,727	7,917	10,621	11,815	16,519	6.4%	4.5%	5.4%
Hydro	kToe	1,396	2,976	4,502	5,477	5,477	12.4%	2.0%	7.1%
Nuclear	kToe	0	0	0	883	2,113	---	---	---
Renewables	kToe	64	185	402	571	704	20.2%	5.8%	12.8%
Power Import	kToe	6	418	688	2,134	2,135	61.6%	12.0%	34.5%
Non-commercial Energy	*kToe*	*14,694*	*14,305*	*13,990*	*13,578*	*12,684*	*-0.5%*	*-1.0%*	*-0.7%*
Coal	*%*	*31.7*	*30.3*	*29.4*	*29.1*	*30.3*			
Oil	*%*	*42.8*	*40.9*	*40.9*	*40.9*	*39.4*			
Gas	*%*	*20.3*	*19.8*	*19.4*	*16.9*	*18.5*			
Fossil Fuel	*%*	*94.8*	*91.0*	*89.7*	*86.9*	*88.1*			
Others	*%*	*5.2*	*8.9*	*10.2*	*13.0*	*11.7*			
Non-commercial Energy	*%*	*52.2*	*35.7*	*25.6*	*19.5*	*14.2*			
Final Demand (excl. Non-Com	kToe	*22,590*	*33,097*	*44,275*	*57,232*	*70,952*	7.0%	4.8%	5.9%
Agriculture	kToe	570	713	839	962	1,164	3.9%	3.3%	3.6%
Industry	kToe	10,549	15,540	21,635	29,651	37,667	7.4%	5.7%	6.6%
Light	kToe	5,626	8,903	13,352	19,820	26,359	9.0%	7.0%	8.0%
Heavy	kToe	4,922	6,638	8,283	9,830	11,308	5.3%	3.2%	4.2%
Transportation	kToe	6,687	9,499	12,031	14,362	16,488	6.0%	3.2%	4.6%
Others	kToe	4,784	7,344	9,770	12,257	15,634	7.4%	4.8%	6.1%
Electriciry (ex-PS)	GWh	51,730	97,501	141,515	195,414	259,232	10.6%	6.2%	8.4%
Gasoline	kToe	2,687	3,697	4,442	5,117	5,762	5.2%	2.6%	3.9%
Diesel Gas Oil	kToe	5,314	7,359	9,569	11,759	13,853	6.1%	3.8%	4.9%
Energy Import	*kToe*	*-16,564*	*-14,005*	*-7,086*	*1,295*	*10,506*			
Coal	kToe	-9,142	-12,059	-12,296	-13,207	-11,649			
Oil	kToe	-7,428	-2,363	4,522	12,368	19,588			
Gas	kToe	0	0	0	0	432			
Electricity	kToe	6	418	688	2,134	2,135			
Energy Import Ratio	*%*	*-58.8*	*-35.0*	*-13.0*	*1.9*	*11.8*			
Coal	%	-32.5	-30.1	-22.5	-18.9	-13.1			
Oil	%	-26.4	-5.9	8.3	17.7	22.0			
Gas	%	0.0	0.0	0.0	0.0	0.5			
Electricity	%	0.0	1.0	1.3	3.1	2.4			

Appendix 2.5 High Price Case

	Unit	2005	2010	2015	2020	2025	Growth Rate 05-15	15-25	05-25
Economic Indicators							%	%	%
Population	Million	83.10	87.76	92.69	97.90	101.88	1.1%	0.9%	1.0%
Real GDP in 2005 price	$ Billion	52.50	77.50	113.87	167.31	240.20	8.0%	7.7%	7.9%
RGDP per capita	$	632	883	1,229	1,709	2,358	6.9%	6.7%	6.8%
Material Industry Ratio	%	9.0	9.0	9.1	9.0	8.7			
Energy Prices									
Crude Oil ;FOB	$/Bbl	50	75	75	75	75			
Coal; Steaming, FOB	$/ton	20	41	62	62	62			
Asian LNG CIF	$/MMBTU	6.4	8.7	8.7	8.7	8.7			
Energy Indicators									
TPE per capita	Toe	0.34	0.47	0.68	0.96	1.40	7.3%	7.4%	7.4%
TPE per GDP	Toe/$1000	0.54	0.53	0.56	0.56	0.59	0.4%	0.7%	0.5%
Electricity per capita	kWh	549	947	1,343	1,898	2,558	9.4%	6.7%	8.0%
Motorbike	million unit	19	26	29	30	31	4.3%	0.7%	2.5%
Passenger Car	1000 unit	195	424	841	1,533	2,447	15.8%	11.3%	13.5%
CO2 Emission	Million CO2-t	87	121	187	276	429	8.0%	8.7%	8.3%
Total Primary Energy Demand	kToe	*28,172*	*40,871*	*63,392*	*93,546*	*142,860*	*8.4%*	*8.5%*	8.5%
Coal	kToe	8,935	12,634	21,113	31,577	47,690	9.0%	8.5%	8.7%
Oil (excl. Stockpiling)	kToe	12,045	16,955	25,498	38,155	58,522	7.8%	8.7%	8.2%
Gas	kToe	5,727	7,693	11,137	14,641	25,972	6.9%	8.8%	7.9%
Hydro	kToe	1,396	2,976	4,502	5,477	5,477	12.4%	2.0%	7.1%
Nuclear	kToe	0	0	0	883	2,113	---	---	---
Renewables	kToe	64	185	402	571	704	20.2%	5.8%	12.8%
Power Import	kToe	6	418	688	2,134	2,135	61.6%	12.0%	34.5%
Non-commercial Energy	*kToe*	*14,694*	*14,377*	*14,044*	*13,508*	*12,459*	*-0.5%*	*-1.2%*	*-0.8%*
Coal	*%*	*31.7*	*30.9*	*33.3*	*33.8*	*33.4*			
Oil	*%*	*42.8*	*41.5*	*40.2*	*40.8*	*41.0*			
Gas	*%*	*20.3*	*18.8*	*17.6*	*15.7*	*18.2*			
Fossil Fuel	*%*	*94.8*	*91.2*	*91.1*	*90.2*	*92.5*			
Others	*%*	*5.2*	*8.8*	*8.8*	*9.7*	*7.3*			
Non-commercial Energy	*%*	*52.2*	*35.2*	*22.2*	*14.4*	*8.7*			
Final Demand (excl. Non-Com	kToe	*22,590*	*32,026*	*43,794*	*60,753*	*79,993*	6.8%	6.2%	6.5%
Agriculture	kToe	570	709	821	934	1,141	3.7%	3.4%	3.5%
Industry	kToe	10,549	14,838	21,259	31,800	43,156	7.3%	7.3%	7.3%
Light	kToe	5,626	8,437	13,172	21,761	31,129	8.9%	9.0%	8.9%
Heavy	kToe	4,922	6,401	8,087	10,039	12,027	5.1%	4.0%	4.6%
Transportation	kToe	6,687	9,370	12,133	15,377	18,749	6.1%	4.4%	5.3%
Others	kToe	4,784	7,109	9,581	12,641	16,947	7.2%	5.9%	6.5%
Electriciry (ex-PS)	GWh	51,730	100,721	162,246	262,434	430,280	12.1%	10.2%	11.2%
Gasoline	kToe	2,687	3,761	4,834	6,399	8,784	6.0%	6.2%	6.1%
Diesel Gas Oil	kToe	5,314	7,667	11,116	16,009	23,099	7.7%	7.6%	7.6%
Energy Import	*kToe*	*-16,564*	*-12,873*	*1,135*	*22,506*	*65,869*			
Coal	kToe	-9,142	-11,571	-7,212	-1,898	9,065			
Oil	kToe	-7,428	-1,720	7,660	22,270	44,784			
Gas	kToe	0	0	0	0	9,885			
Electricity	kToe	6	418	688	2,134	2,135			
Energy Import Ratio	*%*	*-58.8*	*-31.5*	*1.8*	*24.1*	*46.1*			
Coal	%	-32.5	-28.3	-11.4	-2.0	6.3			
Oil	%	-26.4	-4.2	12.1	23.8	31.3			
Gas	%	0.0	0.0	0.0	0.0	6.9			
Electricity	%	0.0	1.0	1.1	2.3	1.5			

Appendix 2.6 Low Price Case

	Unit	2005	2010	2015	2020	2025	Growth Rate 05-15	15-25	05-25
Economic Indicators							%	%	%
Population	Million	83.10	87.76	92.69	97.90	101.88	1.1%	0.9%	1.0%
Real GDP in 2005 price	$ Billion	52.50	78.94	118.71	178.49	262.26	8.5%	8.2%	8.4%
RGDP per capita	$	632	900	1,281	1,823	2,574	7.3%	7.2%	7.3%
Material Industry Ratio	%	9.0	9.0	9.1	9.0	8.7			
Energy Prices									
Crude Oil ;FOB	$/Bbl	50	50	50	50	50			
Coal; Steaming, FOB	$/ton	20	38	57	57	57			
Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5			
Energy Indicators									
TPE per capita	Toe	0.34	0.47	0.67	0.95	1.37	7.1%	7.4%	7.2%
TPE per GDP	Toe/$1000	0.54	0.52	0.53	0.52	0.53	-0.2%	0.1%	0.0%
Electricity per capita	kWh	549	986	1,514	2,323	3,386	10.7%	8.4%	9.5%
Motorbike	million unit	19	26	29	30	30	4.2%	0.5%	2.3%
Passenger Car	1000 unit	195	449	950	1,835	3,084	17.2%	12.5%	14.8%
CO2 Emission	Million CO2-t	87	121	185	275	429	7.9%	8.8%	8.3%
Total Primary Energy Demand	kToe	*28,172*	*41,258*	*62,329*	*93,420*	*139,491*	*8.3%*	*8.4%*	8.3%
Coal	kToe	8,935	12,579	21,357	31,375	54,994	9.1%	9.9%	9.5%
Oil (excl. Stockpiling)	kToe	12,045	16,946	24,398	35,443	49,455	7.3%	7.3%	7.3%
Gas	kToe	5,727	8,145	10,933	17,438	24,412	6.7%	8.4%	7.5%
Hydro	kToe	1,396	2,976	4,502	5,477	5,477	12.4%	2.0%	7.1%
Nuclear	kToe	0	0	0	883	2,113	---	---	---
Renewables	kToe	64	185	402	571	704	20.2%	5.8%	12.8%
Power Import	kToe	6	418	688	2,134	2,135	61.6%	12.0%	34.5%
Non-commercial Energy	*kToe*	*14,694*	*14,236*	*13,691*	*12,871*	*11,411*	*-0.7%*	*-1.8%*	*-1.3%*
Coal	*%*	*31.7*	*30.5*	*34.3*	*33.6*	*39.4*			
Oil	*%*	*42.8*	*41.1*	*39.1*	*37.9*	*35.5*			
Gas	*%*	*20.3*	*19.7*	*17.5*	*18.7*	*17.5*			
Fossil Fuel	*%*	*94.8*	*91.3*	*90.9*	*90.2*	*92.4*			
Others	*%*	*5.2*	*8.7*	*9.0*	*9.7*	*7.5*			
Non-commercial Energy	*%*	*52.2*	*34.5*	*22.0*	*13.8*	*8.2*			
Final Demand (excl. Non-Com	kToe	*22,590*	*34,204*	*50,026*	*74,591*	*105,438*	8.3%	7.7%	8.0%
Agriculture	kToe	570	717	832	947	1,161	3.8%	3.4%	3.6%
Industry	kToe	10,549	16,231	25,392	41,383	60,885	9.2%	9.1%	9.2%
Light	kToe	5,626	9,328	16,031	28,936	44,928	11.0%	10.9%	10.9%
Heavy	kToe	4,922	6,903	9,362	12,447	15,958	6.6%	5.5%	6.1%
Transportation	kToe	6,687	9,736	12,907	16,821	21,134	6.8%	5.1%	5.9%
Others	kToe	4,784	7,520	10,895	15,439	22,257	8.6%	7.4%	8.0%
Electriciry (ex-PS)	GWh	51,730	98,488	157,559	252,327	382,102	11.8%	9.3%	10.5%
Gasoline	kToe	2,687	3,731	4,563	5,558	6,749	5.4%	4.0%	4.7%
Diesel Gas Oil	kToe	5,314	7,670	10,772	15,028	19,933	7.3%	6.3%	6.8%
Energy Import	*kToe*	*-16,564*	*-5,434*	*13,488*	*32,260*	*70,806*			
Coal	kToe	-9,142	-11,626	-6,968	-2,100	16,369			
Oil	kToe	-7,428	5,775	19,768	30,093	43,977			
Gas	kToe	0	0	0	2,132	8,325			
Electricity	kToe	6	418	688	2,134	2,135			
Energy Import Ratio	*%*	*-58.8*	*-13.2*	*21.6*	*34.5*	*50.8*			
Coal	%	-32.5	-28.2	-11.2	-2.2	11.7			
Oil	%	-26.4	14.0	31.7	32.2	31.5			
Gas	%	0.0	0.0	0.0	2.3	6.0			
Electricity	%	0.0	1.0	1.1	2.3	1.5			

Appendix 3

Sample of Summary Report Sheets

Sample sheets shown in Appendix-3 are summarized to illustrate items included in the summary sheets as an output of the Supply/Demand Optimization Model, while estimation is made for all the years from 2005 through 2025. Annual figures are available in the form of Excel spread sheets on computer screen.

3.1 Overall Energy Outlook: Reference Case

reference	Summary sheet								Growth Rate			
TERM 1	TERM 2	TERM 3	Unit	2005	2010	2015	2020	2025	10/05	15/10	20/15	25/20
Economic Indicat	Exchange rate		VND/US$	15,959	16,856	17,947	19,610	21,168	1.1	1.3	1.8	1.5
	Population		Million	83	88	93	98	102	1.1	1.1	1.1	0.8
	GDP at current price on US $ base		Million US$	52,502	100,022	189,032	348,122	634,122	13.8	13.6	13.0	12.7
	GDP at 2005 price on US $ base		Million US$	52,502	78,944	118,705	178,492	262,263	8.5	8.5	8.5	8.0
	GDP at 2005 price on VND base		Trillion VND	838	1,260	1,894	2,848	4,185	8.5	8.5	8.5	8.0
	GDP per capita on 2005 US$ base		US$/person	632	900	1,281	1,823	2,574	7.3	7.3	7.3	7.1
	Material Industry at 2005 price		Trillion VND	76	114	173	256	362	8.5	8.8	8.1	7.2
	Material Industry Ratio		%	9.0	9.0	9.1	9.0	8.7	0.0	0.2	-0.3	-0.7
Energy Indicators	World Energy Price	IEA Crude Oil FOB	$/Bbl	49.9	65.0	65.0	65.0	65.0	5.4	0.0	0.0	0.0
	World Energy Price	Coal FOB	$/ton	19.7	38.1	56.5	56.5	56.5	14.1	8.2	0.0	0.0
	World Energy Price	Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5	3.2	0.0	0.0	0.0
	TPE per capita		TOE / person	0.3	0.5	0.6	0.8	1.1	6.2	6.5	6.7	6.8
	TPE per GDP		TOE/$1000	0.5	0.5	0.5	0.5	0.4	-1.1	-0.7	-0.6	-0.5
	Electricity per capita		kWh / person	549	995	1,599	2,569	3,926	12.6	9.9	10.0	8.9
	Vehicle number	Motorbike	1000Unit	19,073	25,985	28,801	29,941	30,141	6.4	2.1	0.8	0.1
		Car	1000Unit	195	449	950	1,835	3,084	18.2	16.2	14.1	10.9
		Motorbike per person	unit/1000psn	229.5	296.1	310.7	305.8	295.8	5.2	1.0	-0.3	-0.7
		Car per person	unit/1000psn	2.3	5.1	10.2	18.7	30.3	16.9	14.9	12.8	10.1
	Energy Efficiency Factor	Industry (Light)	%	100	94	88	83	79	-1.2	-1.3	-1.2	-1.1
		Industry (Heavy)	%	100	93	83	74	67	-1.4	-2.3	-2.2	-2.1
		Commercial	%	100	97	90	84	78	-0.7	-1.4	-1.4	-1.4
		Residential	%	100	98	92	87	82	-0.4	-1.2	-1.2	-1.2
	CO2 Emission		CO2-Mton	87	118	169	238	345	6.3	7.5	7.0	7.7
			SO2-Kton	239	337	607	841	1114	7.1	12.5	6.8	5.8
	Total Primary Energy	Commercial Total	kTOE	*28,172*	*40,145*	*58,212*	*83,052*	*117,060*	*7*	*7.7*	*7.4*	*7.1*
	Domestic Requirement	Coal	kTOE	8,935	12,148	18,818	26,007	39,561	6.3	9.1	6.7	8.8
	excluding Stockpiling	Oil(incl.LPG)	kTOE	12,045	16,489	23,539	33,106	44,572	6.5	7.4	7.1	6.1
		Gas	kTOE	5,727	7,919	10,215	14,780	22,307	6.7	5.2	7.7	8.6
		Fossil total	kTOE	26,707	36,556	52,572	73,893	106,439	6.5	7.5	7.0	7.6
		Fossil rate	%	94.8	91.1	90.3	89.0	90.9	-0.8	-0.2	-0.3	0.4
		Hydro	kTOE	1,396	2,976	4,502	5,477	5,477	16.3	8.6	4.0	0.0
		Nuclear	kTOE	0	0	0	883	2,113	0.0	0.0	0.0	19.1
		Renewable EP	kTOE	64	185	402	571	704	23.8	16.7	7.3	4.3
		Import	kTOE	6	418	688	2,134	2,135	136.2	10.5	25.4	0.0
		EP Total	kTOE	1,465	3,579	5,592	9,065	10,429	19.6	9.3	10.1	2.8
		Bio Fuel	kTOE	0	9	48	94	191	0.0	39.2	14.2	15.3
		Non-Commercials	kTOE	14,694	14,262	13,585	12,562	10,779	-0.6	-1.0	-1.6	-3.0
		Total	kTOE	*42,866*	*54,407*	*71,797*	*95,614*	*127,839*	*-0.6*	*-0.6*	*-0.9*	*-1.9*
	Final Energy Demand	Total	kTOE	22,590	33,725	51,384	79,975	118,195	8.3	8.8	9.3	8.1
		Agriculture	kTOE	570	716	830	946	1,159	4.6	3.0	2.6	4.2
		Industry (Light)	kTOE	5,626	9,151	16,743	31,859	52,029	10.2	12.8	13.7	10.3
		Industry (Heavy)	kTOE	4,922	6,701	9,091	12,090	15,503	6.4	6.3	5.9	5.1
		Transportation	kTOE	6,687	9,660	13,285	18,029	23,645	7.6	6.6	6.3	5.6
		Commercial	kTOE	1,322	1,913	2,724	3,723	5,362	7.7	7.3	6.4	7.6
		Residential	kTOE	3,341	5,434	8,508	13,058	20,142	10.2	9.4	8.9	9.1
		Others	kTOE	120	152	203	270	355	4.8	5.9	5.9	5.6
	Energy Net Import	Total	kTOE	*-16,564*	*-15,102*	*-3,082*	*9,219*	*36,042*	*0.0*	*0.0*	*0.0*	*31.3*
		Coal	kTOE	-9,142	-12,057	-9,507	-7,468	936	0.0	0.0	0.0	0.0
		Oil	kTOE	-7,428	-3,463	5,738	14,553	26,751	0.0	0.0	20.5	12.9
		Gas	kTOE	0	0	0	0	6,220	0.0	0.0	0.0	0.0
		Electricity	kTOE	6	418	688	2,134	2,135	136.2	10.5	25.4	0.0
		(Electricity)	GWh	66	4,858	7,997	24,815	24,830	136.3	10.5	25.4	0.0
	Import Ratio	Total	%	*-58.8*	*-37.6*	*-5.3*	*11.1*	*30.8*	*0.0*	*0.0*	*0.0*	*22.6*
	(excl. oil stockpiling)	Coal	%	-32.5	-30.0	-16.3	-9.0	0.8	0.0	0.0	0.0	0.0
		Oil	%	-26.4	-8.6	9.9	17.5	22.9	0.0	0.0	12.2	5.5
		Gas	%	0.0	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0
		Electricity	%	0.0	1.0	1.2	2.6	1.8	120.1	2.6	16.8	-6.6

3.2 Oil and Gas Sector Outlook: Reference Case

reference	Oil and Gas Sector								G R O W T H R A			
TERM 1	TERM 2	TERM 3	Unit	2005	2010	2015	2020	2025	10/05	15/10	20/15	25/20
Economic Indicat	Population		Million	83	88	93	98	102	1.1	1.1	1.1	0.8
	GDP at current price on US $ base		Million US$	52,502	100,022	189,032	348,122	634,122	13.8	13.6	13.0	12.7
	GDP at 2005 price on US $ base		Million US$	52,502	78,944	118,705	178,492	262,263	8.5	8.5	8.5	8.0
	GDP at 2005 price on VND base		Trillion VND	838	1,260	1,894	2,848	4,185	8.5	8.5	8.5	8.0
	GDP per capita on 2005 US$ base		US$/person	632	900	1,281	1,823	2,574	7.3	7.3	7.3	7.1
	Real Private consumption per capita		US$/person	76	114	173	256	362	8.5	8.8	8.1	7.2
	Material Industry Ratio		%	9.0	9.0	9.1	9.0	8.7	0.0	0.2	-0.3	-0.7
Energy Indicators	World Energy Price	IEA Crude Oil FOB	$/Bbl	49.9	65.0	65.0	65.0	65.0	5.4	0.0	0.0	0.0
	World Energy Price	Coal FOB	$/ton	19.7	38.1	56.5	56.5	56.5	14.1	8.2	0.0	0.0
	World Energy Price	Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5	3.2	0.0	0.0	0.0
	TPE per capita		TOE / person	0.3	0.5	0.6	0.8	1.1	6.2	6.5	6.2	6.3
	TPE per GDP		TOE/$1000	0.5	0.5	0.5	0.5	0.4	-1.1	-0.7	-1.0	-0.8
	Vehicle fuel per capita	Do : Car & Bus per C	Liter/Unit/Yea	3197	3150	3135	3126	3121	-0.3	-0.1	-0.1	0.0
		Gaso : Car per capita	Liter/Unit/Yea	1866	1805	1788	1777	1771	-0.7	-0.2	-0.1	-0.1
		Do : Truck per capita	Liter/Unit/Yea	8745	8447	8369	8318	8291	-0.7	-0.2	-0.1	-0.1
		Gaso : Bike per capit	Liter/Unit/Yea	174	173	172	172	171	-0.2	-0.1	0.0	0.0
	Vehicle number	Motorbike	1000Unit	19,073	25,985	28,801	29,941	30,141	6.4	2.1	0.8	0.1
		Passenger Car	1000Unit	195	449	950	1,835	3,084	18.2	16.2	14.1	10.9
	Tax on Oil products	Gasoline										
		DO										
		FO										
		LPG										
Oil sector	Final oil demand	Total	kTOE	*12,045*	*16,298*	*22,662*	*32,223*	*43,786*	*6.2*	*6.8*	*7.3*	*6.3*
		LPG	kTOE	963	1,971	3,641	4,342	4,418	15.4	13.1	3.6	0.3
		LPG substitute	kTOE	0	0	0	2,133	5,937	0.0	0.0	0.0	22.7
	including Bio-Fuel	Gasoline	kTOE	2,687	3,697	4,516	5,491	6,657	6.6	4.1	4.0	3.9
		Kerosene	kTOE	332	342	373	423	511	0.6	1.8	2.6	3.8
		Jet fuel	kTOE	534	736	1,031	1,415	1,872	6.6	7.0	6.5	5.8
	including Bio-Fuel	Diesel	kTOE	5,314	7,456	10,294	14,089	18,301	7.0	6.7	6.5	5.4
		General	kTOE	5,149	7,456	10,294	14,089	18,301	7.7	6.7	6.5	5.4
		EP	kTOE	165	0	0	0	0	-100.0	0.0	0.0	0.0
		Fuel oil	kTOE	2,215	2,096	2,807	4,329	6,090	-1.1	6.0	9.1	7.1
		General	kTOE	1,616	2,020	2,742	3,939	5,295	4.6	6.3	7.5	6.1
		EP	kTOE	599	76	65	390	795	-33.8	-3.1	43.1	15.3
	Crude oil	Production	kTOE	18,530	18,649	16,120	16,120	15,172	0.1	-2.9	0.0	-1.2
		(included condensate	kTOE	613	848	1,094	1,582	1,722	6.7	5.2	7.7	1.7
		Import	kTOE	0	1,208	3,813	7,043	7,805	0.0	25.8	13.1	2.1
		Processing	kTOE	0	6,950	14,396	14,396	14,396	0.0	15.7	0.0	0.0
		StockPiling	kTOE	0	1,208	90	2,277	3,039	0.0	-40.5	90.9	5.9
		Export	KTOE	18,530	11,699	5,447	6,490	5,542	-8.8	-14.2	3.6	-3.1
		Net Balance	KTOE	18,530	10,492	1,635	-553	-2,263	-10.8	-31.1	-180.5	0.0
	Oil product net import	Total	KTOE	*11,102*	*8,236*	*7,462*	*16,277*	*27,528*	*-5.8*	*-2.0*	*16.9*	*11.1*
		LPG	KTOE	633	1,103	1,849	2,258	2,258	11.7	10.9	4.1	0.0
		LPG substitute	KTOE	0	0	0	2,133	5,937	0.0	0.0	0.0	22.7
		Light Naptha	KTOE	0	-90	-1,578	-1,853	-886	0.0	0.0	0.0	
		Gasoline	KTOE	2,074	0	-889	0	0	-100.0	0.0	0.0	0.0
		Kerosene	KTOE	332	342	373	423	511	0.6	1.8	2.6	3.8
		Jet fuel	KTOE	534	294	245	630	1,087	-11.3	-3.5	20.8	11.5
		Diesel	KTOE	5,314	4,738	5,298	8,979	13,152	-2.3	2.3	11.1	7.9
		Fuel oil	KTOE	2,215	1,849	2,164	3,707	5,468	-3.6	3.2	11.4	8.1
Gas sector	Demand	Total	KTOE	*5,727*	*7,919*	*10,215*	*14,780*	*22,307*	*6.7*	*5.2*	*7.7*	*8.6*
		Power consumption	KTOE	4,473	6,003	7,011	9,246	13,961	6.1	3.2	5.7	8.6
		Others	KTOE	1,254	1,916	3,204	5,534	8,346	8.8	10.8	11.6	8.6
	Supply	Total	KTOE	*5,727*	*7,919*	*10,215*	*14,780*	*22,307*	*6.7*	*5.2*	*7.7*	*8.6*
		Production	KTOE	5,727	7,919	10,215	14,780	16,087	6.7	5.2	7.7	1.7
		Import	KTOE	0	0	0	0	6,220	0.0	0.0	0.0	0.0
LPG Sector	Potential Demand		KTOE	963	1,971	3,641	6,475	10,355	15.4	12.2	10.4	9.8
	Supply	**Supply Total**	kTOE	*963*	*1,971*	*3,641*	*4,342*	*4,418*	15.4	5.6	0.7	0.3
		Production	KTOE	330	868	1,792	2,084	2,159	21.4	15.6	3.1	0.7
		Gas Field	KTOE	330	456	588	851	926	6.7	5.2	7.7	1.7

3.3 Electric Power Sector Outlook: Reference Case

reference	Electric Power Sector								G R O W T H			R A
TERM 1	TERM 2	TERM 3	Unit	2005	2010	2015	2020	2025	10/05	15/10	20/15	25/20
Economic Indicat	Population		Million	83	88	93	98	102	1.1	1.1	1.1	0.8
	GDP at current price on US $ base		Million US$	52,502	100,022	189,032	348,122	634,122	13.8	13.6	13.0	12.7
	GDP at 2005 price on US $ base		Million US$	52,502	78,944	118,705	178,492	262,263	8.5	8.5	8.5	8.0
	GDP at 2005 price on VND base		Trillion VND	838	1,260	1,894	2,848	4,185	8.5	8.5	8.5	8.0
	GDP per capita on 2005 US$ base		US$/person	632	900	1,281	1,823	2,574	7.3	7.3	7.3	7.1
	Material Industry Ratio		%	9.0	9.0	9.0	9.0	9.0	0.0	0.0	0.0	0.0
Energy Indicators	Power Generation		GWh	51,770	99,376	166,346	278,858	440,734	13.9	10.9	10.9	9.6
	Peak Demand	(estimated)	MW	8,443	16,206	27,128	45,476	71,874	13.9	10.9	10.9	9.6
	Electricity Tariff	Agriculture use	VND/kWh	660	1,012	1,118	1,236	1,365	8.9	2.0	2.0	2.0
		Residential use	VND/kWh	695	1,065	1,177	1,301	1,437	8.9	2.0	2.0	2.0
		Industry use	VND/kWh	829	1,271	1,405	1,553	1,716	8.9	2.0	2.0	2.0
		Commercial use	VND/kWh	1,359	2,083	2,302	2,544	2,811	8.9	2.0	2.0	2.0
	Electricity per capita		kWh/person	549	995	1,599	2,569	3,926	12.6	9.9	10.0	8.9
	Sectoral Demand	Total	GWh	45,603	87,350	148,207	251,541	400,003	13.9	11.2	11.2	9.7
		Agriculture	GWh	574	1,034	1,441	1,916	2,683	12.5	6.9	5.9	7.0
		Industry (Light)	GWh	17,248	34,465	58,057	105,871	168,840	14.8	11.0	12.8	9.8
		Industry (Heavy)	GWh	4,054	6,172	9,357	13,654	18,920	8.8	8.7	7.9	6.7
		Transportation	GWh	337	745	1,216	1,971	3,010	17.2	10.3	10.2	8.8
		Commercial	GWh	2,162	4,659	8,683	14,599	24,859	16.6	13.3	11.0	11.2
		Residential	GWh	19,831	38,512	67,099	110,387	177,562	14.2	11.7	10.5	10.0
		Others	GWh	1,397	1,764	2,355	3,144	4,129	4.8	5.9	5.9	5.6
	Power Supply	Total	GWh	*51,730*	*97,524*	*148,346*	*225,807*	*325,217*	*13.5*	*8.8*	*8.8*	*7.6*
		Domestic Coal	GWh	8,472	18,198	36,618	49,818	73,138	16.5	15.0	6.4	8.0
		Imported Coal	GWh	567	857	4,347	12,423	41,461	8.6	38.4	23.4	27.3
		Oil	GWh	2,174	269	230	2,149	4,162	-34.2	-3.0	56.3	14.1
		Natural Gas	GWh	23,480	36,582	42,128	56,007	85,186	9.3	2.9	5.9	8.7
		Hydro	GWh	16,230	34,604	52,351	63,689	63,691	16.3	8.6	4.0	0.0
		Nuclear	GWh	0	0	0	10,268	24,566	0.0	0.0	0.0	19.1
		Renewables	GWh	741	2,157	4,675	6,637	8,181	23.8	16.7	7.3	4.3
		Power Import	GWh	66	4,858	7,997	24,815	24,830	136.3	10.5	25.4	0.0
	Power Capacity	Total	MW	*11,001*	*21,380*	*30,674*	*41,025*	*57,420*	*14.2*	*13.0*	*9.8*	*11.2*
		Domestic Coal	MW	1,345	3,865	7,075	8,675	12,470	23.5	22.7	14.8	23.5
		Imported Coal	MW	150	150	750	1,950	6,750	0.0	0.0	0.0	0.0
		Oil	MW	871	946	524	1,184	1,184	1.7	-8.7	0.3	0.3
		Diesel	MW	341	131	0	0	0	-17.4	-8.2	-7.2	-6.2
		Natural Gas	MW	4,089	6,484	7,534	9,034	14,284	9.7	6.8	1.2	5.1
		Hydro	MW	4154	9,337	13,524	16,465	16,465	17.6	19.7	16.4	13.2
		Nuclear	MW	0	0	0	2,000	4,000	0.0	0.0	0.0	0.0
		Renewables	MW	50	467	1,267	1,717	2,267	56.3	21.8	19.9	15.1

3.4 Coal and Renewable Energy Outlook: Reference Case

reference	Coal & Renewable Energy Sector								G R O W T H			R A
TERM 1	TERM 2	TERM 3	Unit	2005	2010	2015	2020	2025	10/05	15/10	20/15	25/20
Economic Indicat	Population		Million	83	88	93	98	102	1.1	1.1	1.1	0.8
	GDP at current price on US $ base		Million US$	52,502	100,022	189,032	348,122	634,122	13.8	13.6	13.0	12.7
	GDP at 2005 price on US $ base		Million US$	52,502	78,944	118,705	178,492	262,263	8.5	8.5	8.5	8.0
	GDP at 2005 price on VND base		Trillion VND	838	1,260	1,894	2,848	4,185	8.5	8.5	8.5	8.0
	GDP per capita on 2005 US$ base		US$/person	632	900	1,281	1,823	2,574	7.3	7.3	7.3	7.1
	Material Industry Ratio		%	9.0	9.0	9.1	9.0	8.7	0.0	0.2	-0.3	-0.7
Energy Indicators	World Energy Price	IEA Crude Oil FOB	$/Bbl	49.9	65.0	65.0	65.0	65.0	5.4	0.0	0.0	0.0
	World Energy Price	Coal FOB	$/ton	19.7	38.1	56.5	56.5	56.5	14.1	8.2	0.0	0.0
	World Energy Price	Asian LNG CIF	$/MMBTU	6.4	7.5	7.5	7.5	7.5	3.2	0.0	0.0	0.0
	TPE per capita		TOE / person	0.3	0.5	0.6	0.8	1.1	6.2	6.5	6.2	6.3
	TPE per GDP		TOE/$1000	0.5	0.5	0.5	0.5	0.4	-1.1	-0.7	-1.0	-0.8
Coal sector	Demand	Total	1000ton	*31,882*	*42,739*	*51,125*	*62,880*	*81,726*	*6.0*	*8.1*	*4.5*	*4.0*
		Domestic use	1000ton	13,895	18,932	30,319	42,235	65,541	6.4	8.7	12.2	9.6
		Power	1000ton	5,042	8,027	16,555	24,645	43,716	9.7	15.2	15.5	16.6
		Domestic	1000ton	4,751	7,588	14,930	20,265	29,490	9.8	16.2	16.3	18.0
		Import	1000ton	291	439	1,625	4,380	14,226	8.6	3.2	4.3	-3.0
		other sectors	1000ton	8,853	10,905	13,764	17,591	21,825	4.3	4.8	10.4	6.0
		Export	1000ton	17,987	23,807	20,806	20,645	16,185	5.8	7.6	-1.6	-2.2
	Supply	Total	1000ton	*31,882*	*42,739*	*51,125*	*62,880*	*81,726*	*6.0*	*3.6*	*4.2*	*5.4*
		Production	1000ton	31,591	42,300	49,500	58,500	67,500	6.0	3.2	3.4	2.9
		High quality coal	1000ton	8,775	11,750	13,750	16,250	18,750	6.0	3.2	3.4	2.9
		Middle quality co	1000ton	15,795	21,150	24,750	29,250	33,750	6.0	3.2	3.4	2.9
		Low quality coal	1000ton	7,020	9,400	11,000	13,000	15,000	6.0	3.2	3.4	2.9
		Import	1000ton	291	439	1,625	4,380	14,226	8.6	29.9	21.9	26.6
		Production	KTOE	18,077	24,205	28,325	33,475	38,625	6.0	3.2	3.4	2.9
Renewable	Power supply	Total	GWh	*741*	*2,157*	*4,675*	*6,637*	*8,181*	*23.8*	*16.7*	7.3	4.3
		Solar	GWh									
		Wind	GWh									
		Small Hydro	GWh									
		Biomass	GWh									
	Fuel Supply	Total	1000kl	0.0	33.6	89.1	176.3	448.8		21.5	14.6	20.5
		Bio-fuel(Etharnol)	1000kl	0.0	11.9	29.0	52.9	128.3		19.6	12.8	19.4
		Bio-fuel(Diesel)	1000kl	0.0	21.8	60.1	123.3	320.4		22.5	15.5	21.0
		ratio(Ethanol)	%	0.0	5.0	10.0	15.0	30.0		14.9	8.4	14.9
		ratio(Diesel)	%	0.0	0.0	5.0	7.5	10.0		0.0	8.4	
		Bio-fuel(Etharnol)	kTOE	0.0	9.2	22.6	41.2	99.9		19.6	12.8	19.4
		Bio-fuel(Diesel)	kTOE	0.0	0.0	25.7	52.8	91.5		0.0	15.5	11.6

Appendix-4

Manual for Energy Demand Forecasting Model

CONTENTS

Chapter 1. Energy Demand Forecasting Model

1.1 Structure of the Energy Demand Forecasting Model

The energy demand forecasting model is composed of the two blocks as shown in Figure1-1: the macro economic block and the energy demand block.

Figure 1-1 Outline of the Energy Demand Forecasting Model

Economic indicators are in principle given to the model referring to those announced by the government and/or projected by relevant offices as exogenous variables. Thus, the model reflects various economic and industrial policies stipulated under the Socio-economic Development Plan and other plans. However, it is not possible in this manner to obtain all the input data required at the demand forecasting block. Therefore, we calculate in the macro-economic block those future values of other indicators as internal variables, which are not available from government plans and projections. They are, for example, sectoral GDPs and energy consumption coefficients.

Then, in the Energy Demand Block, the final energy demand is divided into the transportation fuel such as gasoline and diesel gas oil and other general energy. The latter will be estimated by sector; agriculture, industry, commercial, residential and others. Then, they will be divided into two categories of power demand and fossil energy demand applying sectoral power ratios. The fossil fuel demand will be further divided into energy resources such as coal, oil, natural gas and renewable energies. In the electric power sector, fuel consumption at thermal power stations will be calculated applying the power flow system in generation and transmission processes. The calculated results will be entered into the Supply/Demand optimization model. Energy balance tables are compiled in the optimization model.

In building the model, as much data as generally available are used to make model maintenance and operation easier. In this project, however, we conducted energy demand survey to supplement not available data to a minimal extent. Since the data obtained through the survey is essential to grasp the fundamental energy tendency of Vietnam, it is required to establish a data collecting system and amplify the energy database. In line with the continued economic development, the energy demand of Vietnam will be affected greatly by impacts of changes in industrial energy consumption pattern, changes in life style, energy conservation policies and so on. Therefore, it is strongly recommended to establish a data collection system to continuously watch indicators of these trends.

1.2 Supplemental Calculation in Macro economic block

In the process of compiling the National Energy Master Plan, major economic indicators are set forth first referring to the Socio-economic Development Plan and other major programs. Then, other economic variables that are not available but necessary for the demand forecasting block will be estimated in the macro economic block. For example, in Economic Development Forecast up to 2050(EDF2050), GDP by production component are estimated referring to international movement, investment trend, etc, however, the Gross Domestic Expenditure (GDE) is not shown by demand sector. As GDE items are used as explanatory variables in this model, it is necessary to estimate them in line with the economic development scenario.

Generally in forecasting economic outlook, main economic indicators such as investment, labor productivity and foreign trade balance are decided in the early step, and then estimate other GDP items as above. That is, in the forecast of national accounts, the calculation progresses in the order of "Survey on Economic activities", "Forecast of GDE" and "Forecast GDP" as shown in Figure 1-2.

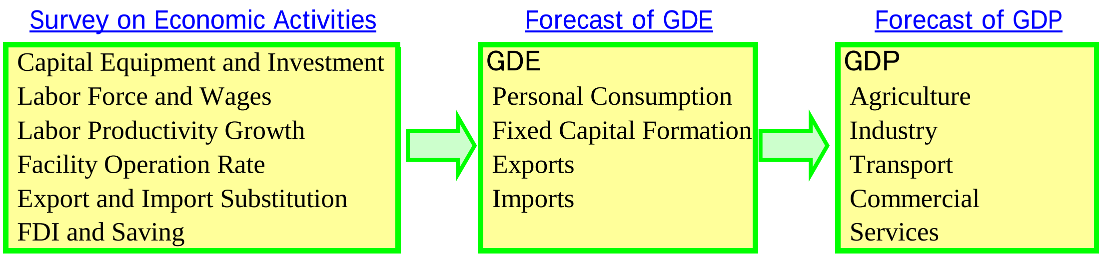


Figure 1-2 The Procedures on forecasting National Account

Here, the following equation system is considered for example to apply to the estimation of the GDE items.

< Forecast for GDE components>

Final Consumption

Final $Consumption_{(t-1)}$x(1+ α x Growth Rate of Labor Productivity)

Gross Fixed Capital Formation

Savings + FDI + Foreign trade balance

Exports of Goods and Services

Oil & Coal Export + Other Export

Import of Goods and Services

Import of Petroleum Products and Coal + Other Import

Statistical Discrepancy

β x Statistical Discrepancy ($\beta < 1$)

Gross National Expenditure

Aggregate of the above (Import is deducted)

<Equations for estimation of Foreign Trade>

Export of Oil

Crude Oil Price x (Production + Import - Domestic Use)

Export of Coal

Coal Price × (Production - Domestic Use)

Other Export

GDP - (GDP without Other Export)

Import of Petroleum Products

Petroleum Product Price x (Demand - Domestic Production)

Import of Coal

Coal Price x Coal Import

Other Import

α x Other Import (t-1) + β x (Incremental GDP)

Chapter 2　Function and Theory of Energy Demand Forecasting Model

2.1　Functions of Energy Demand Forecasting Model

In this model, the forecasting period is set for 2006 through 2025and the following functions are considered.

(1) Model linked to the changes of socio-economic activities

Energy demand should be forecasted on the scenarios such as Reference Case, High Growth Case, etc, considering socio-economic changes in trends of population, economic structure, economic growth rate and so on.

(2) Demand forecast considering energy conservation policies.

Vietnam Government is promoting policies of enhancing energy conservation institutions and systems aiming to reduce the total energy consumption by 3-5% (equivalent to 5 million toe) during 2006-2010 and 5-8%(equivalent to 13 million toe) during 2011-2015.　The model should incorporate these activities with quantified inputs of their effectiveness.

(3) Demand forecast incorporating energy price effects

Increase of crude oil price usually induces increase in prices of natural gas and petroleum products. Generally speaking, when prices of fuel such as petroleum products and natural gas rise, energy saving activity comes up (price effect on demand).　The model should reflect such energy saving effect caused by price hike in the energy demand forecast.

(4) Demand forecast incorporating the new and renewable energy development policy

In Vietnam, development of new and renewable energies such as biomass, wind power and nuclear is promoted. The model should reflect these development plans.

(5) Energy consumption in the power sector

Fuel consumption of the power sector should consider import of electricity.

2.2 Test and Evaluation of the Model Equations

The demand forecasting model is an econometric model and is formulated with regression equations and arithmetic equations. For selection and evaluation of regression equations, there are several kinds of testing methods. In this model, the following tests are conducted for selection of the regression equations.

(1) Evaluation of energy demand forecasting equations

・Determination coefficient (more than 0.85)

・T-value test of parameters (more than 2.0)

・Durbin Watson ratio test（1＜DW<3）

・Sign test of the regression coefficient (logical according to economic theory)

(2) Evaluation of macro economic forecast

・Real GDP growth rate

・GDP per capita（US$ base with international comparison）

・Labor productivity growth rate

(3) Evaluation of energy demand forecast

・Energy demand growth rate

・Energy consumption per GDP（GDP elasticity with international comparison）

・Energy consumption per capita

At this stage, we should also be careful about the following points.

a) Representativeness and Hetero-schedasity of the used data

As statistical coefficients obtained by regression analysis are those calculated on the given data, we should also take note of various errors that are inherent in these data. In particular, we should pay attention if the data keeps consistency over the period and have sufficient representativeness of the population examining whether the number of the sample is small and/or the data is biased or not. In such a case, we can supplement the analysis by cross-section analysis and/or international comparison.

b) Divergence of the model

Although multi co-linearity test is conducted on the coefficients of the forecasting equations with Durbin-Watson Ratio, we often encounter parameters to cause divergence of the forecasting values. For avoiding the phenomenon, the forecasting equations have to be checked in the manner such as to evaluate stableness of parameters applying different regression period, to evaluate prediction ability of the equation extrapolating it for the past record, and to evaluate movement of the solution operating the model as the total test. The magnitude of parameters can be known to some extent from empirical knowledge[1] and by technical analysis.

c) Adjustment of error

We often encounter discrepancy of an estimated value and the latest actual data, even though the forecasting equation has double-nine determination coefficient (0.99+). In such a case, if the equation[2] is applied without adjustment, it would produce funny and discontinuous forecast values. Therefore, such equation needs to be adjustment considering the tendency of the error. It is possible to install a measure to equation adjustment in advance, however, since the reasons of errors are different but not simple such as abnormal weather, accidents and so on, it is recommended that adjustment should be made one by one at the time of defining the equations.

We should note that, as the regression equations are calculated on past statistical figures, that is, on the past trend, *our future should not be a simple copy of the past*. In Vietnam, experiencing a rapid developing stage now, economic structure and people's life style will change quickly. We could not foresee the future simply extrapolating the past trend. We need to carry out versatile analysis with regard to shift of the economic development stage, change in the economic structure, life cycle of popular commodities, etc.

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[1] *The magnitude and signs of parameters can be estimated from investigations into income elasticity, price elasticity, unit consumption and energy efficiencies of energy demand.*

[2] *According to the definition, determination coefficient is the ratio of the deviation of the regression equation and the deviation of the actual data. For a high economic growth period , the determination coefficient of a regression equation tends to become high because the total deviation of the dependent variable is large. And we should be careful that, when a lagged subjective variable is used as an explanatory variable, we can generally obtain higher determination coefficient, however, it sometimes happens that predictive capability would be seriously damaged to cause divergence of the forecasted values. In the extreme, regression analysis tries to explain the changes in the subjective variable with a combination of several explanatory variables. However, there is no guarantee that the parameters from regression analysis represent the true values, namely, true relationships of them. When selecting the regression equation, therefore, we should always give priority to consider what the true relationship of the subjective and explanatory variables is. Analysts are sometimes required not to apply equations obtained by regression analysis but, with brave, to apply logically constructed equations.*

2.3 Theory of Forecasting Equations

In the model, energy demand is forecasted by sector, namely, agriculture, manufacturing, transportation, commercial & services, and residential and others. The forecasting procedure of each sector, excluding transportation fuel, is same and as shown below;

Total energy demand of a sector(TD) ＝*f*（Sectoral GDP and Investment）

Power demand before E-saving（BE） ＝TD x Power Ratio

Power demand after E-saving（AE） ＝BE x Power Saving Indicator

Fossil fuel demand before E-saving（BP） ＝TD - BE

Fossil fuel demand after E-saving（AP） ＝BP x Fossil saving indicator

Here, power ratios are set referring to ones of Malaysia, Thailand, Indonesia, Philippines, and Japan. Energy saving indicators are estimated considering energy price trend and energy conservation targets. In the model, the total energy demand (electricity + fossil fuels) excluding the transportation fuel of a sector is firstly estimated using the sectoral GDP and Investment. GDP refers to the energy consumption in accompany with production activity, and the investment refers to construction and upgrading of facilities in the sector. In general, rapid increase of energy demand is observed in the sector where investment is growing fast. It is known that, even in the developed countries, the relationship between increases of energy consumption and investment is in proportion. According to the above observations, it is considered in this model that sectoral GDP and investment are important explanation variables for energy demand forecasting.

2.4 Equations for Energy Demand Forecasting

In the energy demand forecasting model, the sectoral total energy demand excluding transportation fuel ($TD = f$ （Sectoral GDP and Investment）) is defined by the following expressions, where TD_t is the sectoral total energy demand in year *t*, P_t is the sectoral GDP in year *t*、 and I_t is the sectoral investment in year *t*.

Hypothesis 1: The sectoral total energy demand is expressed by sectoral GDP and sectoral investment as follows; “a” and “b” are energy intensities to GDP and Investment.

$$TD_t = aP_t + bI_t + c$$

Hypothesis 2: The growth rate of the sectoral investment (It) is proportional to that of the national investment (V_t); that is, $I_t = I_{t-1} \times V_t/V_{t-1}$. Then,

$$TD_t = aP_t + bI_{t-1} \times V_t/V_{t-1} + c$$

Hypothesis 3: Increase of the sectoral production(ΔP_t) is proportional to investment in the previous year (I_{t-1}), that is, $\Delta P_t = r\, I_{t-1}$ and $\Delta V_t = V_t/V_{t-1}$. Then,

$$TD_t = aP_t + b\Delta Pt / r\,\Delta V_t + c = Pt\,\Delta V_t\,(a / \Delta V_t + b/r\Delta P_t/P_t) + c$$

Hypothesis 4: The growth rate of the sectoral production(g)$= \Delta Pt/Pt$ is proportional to growth rate of the sectoral investment I_t/I_{t-1}) and the growth rate of sectoral investment is in turn proportional to the growth rate of national investment (V_t/V_{t-1}). Then,

$$TD_t = P_t \times \Delta V_t \times (a/\Delta V_t + b/r \Delta V_t) = P_t * (a + b/r \Delta V_t^2)$$

Hypothesis 5: When b/r is small, $a + b/r \times \Delta V_t^2$ can be estimated by $f(\Delta V_t)$.

$$TD_t = P_t \times f(\Delta V_t) = f(P_t \times \Delta V_t)$$

As explained above, the model forecasts the sectoral energy demand using GDP and investment by sector. As it is possible that the energy intensities are subject to change in the long run in accordance with energy conservation policies and technical innovation, it is difficult to express movement of these elements in the linear models like this. Therefore, model users are required to watch these movements and tendencies, and from time to time try to improve and update it.

2.5 Theory of Consumption Function and Demand Forecasting Equations

As the demand forecasting equations explained above are applied in this mode, we would like to touch upon some important points for improving it and/or building short term models. Energies are consumed in all aspects of the economic activities. As styles and efficiencies of energy consumption are diverse among sectors, there are big differences in behaviors of high energy consumption industries where they are strongly conscious of energy cost and sectors with a low energy ratio over the total cost and households. Nevertheless, the common truth is that, for consuming energies, energy equipment and/or appliances such as factories, automobiles, kitchen, bath, air conditioner, etc, are required. That is, energy consumption shall be built-in to a considerable extent at the time of purchasing equipments and appliances at factories or households.

In the theory of consumption function, it is discussed that consumption level at households are determined by permanent income, liquid asset and prices. In energy demand forecasting, it is important to recognize that there are such ***demand built-in*** **and** ***ratchet effec*****t**. Then, in the energy intensive industry where energy prices are strongly considered, the price factor will work strongly in determination of the demand and selection of energy source. On the other hand, in low energy intensive sectors, there are many other priority factors than energy, and the energy consumption pattern may be determined subject to decisions on producing new products, opening additional shops and so on. At households, people give priorities to improving their living standard, and hence the energy consumption is generally characterized as 1) income effect is rather high, 2) ratchet effect is strong and 3) price effect is relatively low. The energy efficiency may be examined to some extent but would not be given the first priority in selecting air-conditioners and automobiles. Thus, energy consumption is built-in at the time of purchasing equipment and appliances. Unfortunately, energy efficiencies would not be considered with the first priority. This is an important fact in considering energy conservation.

As a general consumption function to express consideration on the above factors and penetration speed of income effect and price effect, the flowing style equation with a lagged subjective variable is often used.

$$C_t = a\,C_{t-1} + b\,Y_t - C\,P_t + d$$

where C_t is Consumption, Y_t is Income and P_t is prices.

As Y_t is the variable to explain the effect of income, there are discussions to consider the permanent income to incorporate the inertia of income for a certain period and/or the liquid assets like saving deposit that should represent the total available fund to purchase durable goods. Anyway, a consumption function is a stable function and we do not need to stick to these discussions excessively in building a demand forecasting model. Rather, more difficult issues would arise in case when a logistic curve would become important for considering durable goods such as household appliances and automobiles, and in case a peculiar relationship exists in selection of energy sources such as superior and inferior goods like progressing from woods/charcoal, via kerosene and finally to gas/electricity. Then, we may need to create some devices like expressing the parameter *b* in a non-linear mode.

Then, in the above equation, *1/(1-a)* is defined as the demand adjustment speed, *b/(1-a)* is the log term income effect and *-c/(1-a)* is the long term price effect. For example, when *a*=0.7, demand adjustment speed is 1/(1 - 0.7)=3.3, which means the adjustment against changes in income and price takes 3 years to complete in case of annual data. [3] However, since use of the lagged subjective variable would incur divergence of the model, such functions are used to a minimal extent in the model.

[3] *By using the methodologies, IEA calculates the elasticity as follows. Oil demand elasticity on income is 0.09, and on prices is –0.15 for short term and –0.44 for long term. Power demand elasticity on income is 0.4 to 12 and on price is -0.04 to -0.14. However they are greatly different according to the economic development stages. (IEA World Energy Outlook 2006 Chapter 11)*

Chapter 3 Model Building and Simulation Procedures

Building the demand forecasting model, Simple-E, software developed by IEEJ and delivered to developing countries on grant base, is used as model development engine. The model is developed in accordance with the following procedure and has functions for simulation, analysis and output data transfer to the demand/supply optimization model.

(1) Procedures for making model Structures

a) Data entry

b) Description of the structures

c) Keep the simulation area

(2) Procedures for test and simulation

a) Data consistency check

b) Regression analysis and tests

c) Calculation of forecast values

(3)Procedures for analyzing simulation results

a) Comprehensive evaluation of forecasting equations

b) Evaluation of macro economic forecast values

c) Evaluation of energy demand forecast values

(4)Procedures for output data transfer

a) Making summary tables

b) Making reporting tables

c) Data connection to the Demand/Supply Optimization Model

3.1 Functions and Roles of the Sheets in Simple-E

The model is created by Simple-E and one book consists of six work sheets, namely, power sheet, data sheet, model sheet, simulation sheet, growth rate sheet, and summary sheet. The data sheet, the model sheet and the simulation sheet are created by Simple-E, however, the power sheet is a pre-procedure sheet for the model and the growth rate sheet and the summary sheet are the post-procedure sheets. Their functions and roles are summarized in the followings.

(1) Power sheet

Power Sheet is for preparing power development plan. Future power development plan, shares of power generators, power generation capacity and operation loads are described. Hydro, Nuclear and imported Power are consumed preferentially in the model. In the table, shares of power generators are calculated and used in the Model sheet.

(2) Data sheet

Data sheet is created by SimpleE. The actual values for all kinds of variables and future values in exogenous variables are set in the sheet.

In the model, the actual data are basically inputted from 1990 to 2005 and the future values are forecasted from 2006 to 2025. The variables in the model have actual data that the values are inputted or calculated. And the future values for some variables are given as political or economical assumptions. The variables are called “Exogenous variables”. Other hands, the future values of the variables not to be inputted are calculated in the model, the variables are called “Endogenous variables”.

If the forecasting cells are blank in the model, the variables are endogenous. And the variables that the future data are given are exogenous variables.

For making endogenous variable changes to exogenous variable, Simple E can set the future values in the forecasting term of the variable. The future values given are used preferentially in the model, even though expressions are defined for the variable in Model sheet.

The variables are arranged in line with the model structure orders. Then calculation of the model is basically performed from the upper variables to below variables. But it is possible that the upper variables are calculated by using the results of the below variables. And if the model contains the simultaneous equations, the SimpleE can solve the simultaneous equations.

(3) Model sheet

Model sheet is created by SimpleE. The model structures consist of definition equations and regression equations that are set in the Model sheet. Option types and meaning used in Model sheet are as follows;

“=” in Option type means Definition equation. Variable names in “Internal Y” are defined by the expressions in X1 area.

“$CA” in Option type means a regression equation. $CA is a command to keep the continuation of the forecasting values and the latest actual values. Examples;

Variable name YY in Internal Y”

Variable name AA in X1 area, BB in X2 area

“YY= a*AA + b*BB +c” is defined as regression equation by “$CA”.

(“$CA” means “$CA $LS”, $LS is a command to make a regression analysis, it can be omitted, then $CA” and “$CA $LS” are same meaning.)

(4) Simulation Sheet

In Simulation sheet, the actual values and the future forecasted values are shown. The all kinds of the results from the model are arranged and displayed in Simulation sheet. The contents are as follows;

· The actual data are input from 1990 to 2005, those do not have any calculation expression in Simulation sheet.

· In the model, the variable names described in Data sheet appeared in the same line number position in Simulation sheet as ones in Data sheet.

· The comment area in Data sheet, Model sheet, Simulation sheet and Growth rate sheet are filled out with the same comments and same variable names.

· In Simulation sheet, the values with black color are the actual and exogenous values that are described in Data sheet. The values with red color are ones forecasted by SimpleE.

· In Simulation sheet, the forecasting years are from 2006 to 2025. The forecasted values are red.

· The forecasted values have the expressions that calculated the values. The expressions are described in Model sheet.

· The actual values and forecasted values are referred by the Growth rate sheet and Summary sheet.

(5) Growth Rate Sheet

In Growth rate sheet, the growth rates of the forecasted values and elasticity to real GDP are calculated. Annual growth rates and average growth rates are calculated and elasticity between main variables and real GDP are calculated.

< Annual growth rate>

The annual growth rates from 2005 to 2025 are calculated for all variables The expression are follow;

The annual growth rate = (X / X(1) – 1)*100 X(1): previous value of X

< Average growth rate >

The following types of average growth rates are calculated in Growth rate sheet.

Average growth rate from 2000 to 2005	Shown by 2005 / 2000
Average growth rate from 2005 to 2010	Shown by 2010 / 2005
Average growth rate from 2010 to 2015	Shown by 2015 / 2010
Average growth rate from 2015 to 2020	Shown by 2020 / 2015
Average growth rate from 2020 to 2025	Shown by 2025 / 2020
Average growth rate from 2005 to 2020	Shown by 2020 / 2005
Average growth rate from 2005 to 2025	Shown by 2025 / 2005

< Elasticity to real GDP>

Power demand elasticity by sector

. Energy demand elasticity by sector

Energy demand elasticity by energy

(6) Summary sheet

Power demand, Final energy demand and Primary energy demand are summarized in the sheet. However Primary energy demand are calculated under power development plan shown in Power sheet.

< Power demand by sector>

The power demands by sector are brought from Simulation sheet. The trends of the actual and forecasting values by Agriculture, Light industry, Heavy Industry Transportation, Commercials & Service, Residential and other sector are shown..

< Final energy demand by sector without Non-commercial energy>

The Final energy demands by sector are brought from Simulation sheet. The trends of the actual and forecasting values by Agriculture, Light industry, Heavy Industry, Transportation, Commercials & Service, Residential and Other sector are shown in the table, Non-commercial energies are not included..

< Final energy demand by sector with Non-commercial energy>

The table format is the same as the above, Non-commercial energies are included..

<Final energy demand by energy>

The final energy demands by energy are brought from Simulation sheet. The trends of the actual and forecasting values by Agriculture, Light industry, Heavy Industry, Transportation, Commercials & Service, Residential and Other sector are shown in the table, Non-commercial energies are included..

<Intensity by sector>

Manufacturing(Agriculture +Light industry +Heavy Industry) sector

--> Final energy consumption to GDP in the sector,

Passenger transportation --> Gasoline consumption to Million Passenger km

Freight transportation --> Diesel consumption in transportation sector to Million ton km

Commercial & Service --> Final energy consumption to GDP in the sector

Residential sector --> Final consumption to 1000person

Total energy consumption --> Final energy consumption in the country to total GDP

Table 3-1 Functions of the Sheets

Sheet names	Format	Contents
Power Sheet	Special format	Input the future power development plan Calculate shares of power generation by thermal power plants Show power generation capacity by unit Calculate operation load by unit
Data Sheet	Model format	Input actual values on economy, energy, prices and efficiencies Input policy variables and exogenous variables Aggregate economic and energy values Describe variable names and comments
Model Sheet	Model format	Calculate the data used in the model Build the structure equations (Definition and Regression) Evaluate regression equations
Simulation Sheet	Model format	Show the actual data used in the model Show the forecast values and expressions
Growth Rate Sheet	Model format	Calculate growth rates Calculate elasticity
Summary Sheet	Special format	Summarize power demand Summarize final energy demand Summarize primary energy demand

3.2 Sectors and Energies forecasted in the Model

Sectors and Energies prepared in the Model are as follows;

(1) Classification of Sector

Following sectors are set in the model for power and energy demand forecasting.

a) Agriculture sector

Forecast energy demand in the agriculture and forestry sectors.

b) Light industry sector

Forecast energy demand in the manufacturing and construction sectors

c) Heavy industry sector

Forecast energy demand in heavy industries such as Iron & Steel, Chemical, Cement and Paper.

d) Transportation sector

Forecast energy demand of the transportation sector by automobile (truck, bus, passenger car and motorbike), railway, marine and aviation.

e) Commercials & Services sector

Forecast energy demand of the communication, services and government sectors.

f) Residential

Forecast energy demand for residential use

g) Other sector

Forecast energy demand of the non-classified sector

h) Power sector

Forecast energy demand by the power generation applying generation, transmission and delivery systems of the power sector.

(2) Energy Demand Forecasted in the Model

The energy demand by type to be forecasted by the model, which are the final energies in the above sectors plus fuel consumption in power sector, are as follows;

Table3-2 Energies forecasted in the Model

Energy	Final Demand	Power Generation
Coal	Yes	Yes
LPG	Yes	
Gasoline	Yes	
Jet Fuel	Yes	
Kerosene	Yes	
Diesel Gas Oil	Yes	Yes
Fuel Oil	Yes	Yes
Natural Gas	Yes	Yes
Non-commercial Energy	Yes	

Chapter 4. Model structure

4.1 Power Development plan description

For calculating primary energies, energy consumption in Power sector is required, therefore power development plan is prepared in Power Sheet. As detail items, shares of power generators, power generation capacity and operation loads are described. In the following table, blue color values are exogenous variables and block color values are actual or internal calculated values. Line numbers in the left hand side is sheet line number in Power sheet of the model.

(1) Data input for Hydro power and Nuclear power

Table 4-1 Data input for Hydro power and Nuclear power

Power generation (Base Load)

				2000	2001	2002	2023	2024	2025
3				2000	2001	2002	2023	2024	2025
4	Building	Hydro power	MW	3,516	472	0	0	0	0
5		Nuclear power	MW				0	1,000	1,000
6									
7	Capacity	Hydro power	MW	3,300	3,772	3,772	16,465	16,465	16,465
8		Nuclear power	MW				2,000	3,000	4,000
9		Foreign trade	MW				5,106	5,106	5,106
10		Renewable	MW				2,267	2,267	2,267
11	Generation	Hydro power	GWh	13,009	14,869	14,869	63,689	63,692	63,691
12		Nuclear power	GWh				12,276	18,425	24,566
13		Foreign trade	GWh				24,857	24,872	24,830
14		Renewable	GWh				8,177	8,179	8,181
15									

a. Building

In the area, the planned capacities of hydro and nuclear power stations are inputted in the years (2006 to 2025).

b. Capacity

In the area, the accumulative capacities of Hydro and Nuclear are calculated. When power is imported, the imported capacities are described in the foreign trade area.

c. Generation

The power generation of Hydro, Nuclear and import are calculated by using the capacity data. The power generation from renewable energies is set in the Renewable area.

The power generation shares by generation type in the future are sent to “Data sheet” as the future values of the exogenous variables for calculating energy consumption in power sector..

(2) Data input for Thermal power plants

Table 4-2 Data input for Thermal power plants

	Power generation (Thermal)							
			2000	2001	2002	2023	2024	2025
Building	Thermal(Coal)	MW	597	0	600	5,000	1,200	1,800
	Thermal(FO)	MW	550	0	0	0	0	0
	Gasturbine(FO)	MW	300	0	0	0	0	0
	Gasturbine(GAS)	MW	1,740	1,265	0	0	0	0
	Gas steam(GAS)	MW	0	0	0	0	0	0
	Diesel generator	MW	0	0	0	0	0	0
	Power from Fossil	MW						
						9,814.0	10,564.0	11,314.0
Capacity	Thermal(Coal)	MW	450	450	1,050	16,980	18,180	19,980
	Thermal(FO)	MW	550	550	550	1,184	1,184	1,184
	Gasturbine(FO)	MW	300	300	300			
	Gasturbine(GAS)	MW	720	1,985	1,985	12,004	12,754	13,504
	Gas steam(GAS)	MW				2,190	2,190	2,190
	Diesel generator	MW	30	30	30			
	Power from Fossil	MW	2,050	3,315	3,915	32,358	34,308	36,858
Load	Power from Thermal(Coal)	%	76.0	84.6	42.5	65.0	65.0	65.0
	Power from Thermal(FO)	%	27.0	27.4	23.6	27.0	27.0	27.0
	Power from Gasturbine(FO)	%				45.0	45.0	45.0
	Power from Gasturbine(GAS)	%	64.3	23.1	32.9	62.4	62.4	62.5
	Power from Gas steam	%				50.0	50.0	50.0
	Power from Diesel	%	654.4	585.4	508.4	0.0	0.0	0.0
	Power from Fossil	%	66.2	41.4	46.3	61.6	61.7	62.0
Geneartion	Power from Thermal(Coal)	GWh	2,995	3,337	3,907	96,684	103,517	113,766
	Power from Thermal(FO)	GWh	1,303	1,319	1,137	2,800	2,800	2,800
	Power from Gasturbine(FO)	GWh	1,509	1,418	1,187	0	0	0
	Power from Gasturbine(GAS)	GWh	4,056	4,017	5,715	65,581	69,667	73,890
	Power from Gas steam	GWh	300	405	2,598	9,592	9,592	9,592
	Power from Diesel	GWh	1,720	1,538	1,336	0	0	0
	Power from Fossil	GWh	11,883	12,034	15,880	174,658	185,577	200,048
Shares	Power from Thermal(Coal)	S%	25.2	27.7	24.6	55.4	55.8	56.9
	Power from Thermal(FO)	S%	11.0	11.0	7.2	1.6	1.5	1.4
	Power from Gasturbine(FO)	S%	12.7	11.8	7.5	0.0	0.0	0.0
	Power from Gasturbine(GAS)	S%	34.1	33.4	36.0	37.5	37.5	36.9
	Power from Gas steam	S%	2.5	3.4	16.4	5.5	5.2	4.8
	Power from Diesel	S%	14.5	12.8	8.4	0.0	0.0	0.0
	Power from Fossil	S%	100.0	100.0	100.0	100.0	100.0	100.0

a. Building

In the area, the capacities of coal fired thermal, fuel oil fired thermal, fuel oil fired turbine, gas fired turbine, gas steam and diesel generator are set in the years when installed.

b. Capacity

In the area, the accumulative capacities of the thermal power stations are calculated.

c. Load

In the area, the loads of the thermal power stations except diesel engines are inputted in the area. Regarding diesel engines, the generations of the engines are inputted in Generation area directly.

d. Generation

In the Generation line, the power generations of the thermal generators except diesel engines are calculated by using the above capacities. The generations of diesel engines are inputted in the area directly.

e. Shares

In the Share area, the generation shares of the thermal generators are calculated. The generation shares are sent to Data sheet as future values of exogenous variables.

(3) Forecast results for Power generation estimated

Table 4-3 Forecast results for Power generation estimated

58		Power supply forecasted							
59				2000	2001	2002	2023	2024	2025
60	Geneartion	Power from Hydro	GWh	15,050.7	18,709.6	18,697.7	63,688.8	63,692.1	63,691.3
61		Power from Fossil	GWh	11,510.4	11,898.4	17,098.3	172,066.9	186,988.9	201,896.0
62		Power foreign trade balance	GWh	0.0	0.0	0.0	24,857.4	24,871.5	24,829.9
63		Power from Renewable energy	GWh	0.0	0.0	0.0	8,177.0	8,179.4	8,180.9
64		Power from Nuclear	GWh	0.0	0.0	0.0	12,275.7	18,425.4	24,566.4
65		Total of power generation	GWh	26,561.0	30,608.0	35,796.0	281,065.7	302,157.4	323,164.6
66									
67	Shares	Power from Hydro	%	56.7	61.1	52.2	22.7	21.1	19.7
68		Power from Fossil	%	43.3	38.9	47.8	61.2	61.9	62.5
69		Power foreign trade balance	%	0.0	0.0	0.0	8.8	8.2	7.7
70		Power from New energy	%	0.0	0.0	0.0	2.9	2.7	2.5
71		Power from Nuclear	%	0.0	0.0	0.0	4.4	6.1	7.6
72		Total of power generation	%	100.0	100.0	100.0	100.0	100.0	100.0
73									
74	Load	Power from Hydro	%	52.1	56.6	56.6	44.2	44.2	44.2
75		Power from Nuclear	%	0.0	0.0	0.0	4.4	6.1	7.6
76									

a. Generation

The forecasted power generation of Hydro, Fossi, Foreign trade, Renewable energy and Nuclear power stations are arranged in the generation area.

b. Shares

The generation shares by power generator are calculated in the Share area.

c. Load

The operation load of Hydro and Nuclear stations are calculated in the Load area.

(4) Forecast results for Thermal power generation estimated

Table 4-4 Forecast results for Thermal power generation estimated

77		Thermal power supply forecasted							
78				2000	2001	2002	2023	2024	2025
79	Generation	Power from Thermal(Coal)	GWh	2,995.3	3,336.6	3,907.0	95,249.8	104,304.5	114,816.9
80		Power from Thermal(FO)	GWh	1,302.7	1,318.8	1,137.3	2,758.9	2,821.7	2,826.3
81		Power from Gasturbine(FO)	GWh	1,509.0	1,418.0	1,187.0	0.0	0.0	0.0
82		Power from Gasturbine(GAS)	GWh	4,056.0	4,017.2	5,714.9	64,608.3	70,197.5	74,572.1
83		Power from Gas steam	GWh	300.0	405.0	2,598.0	9,449.9	9,665.2	9,680.8
84		Power from Diesel	GWh	1,719.8	1,538.4	1,336.0	0.0	0.0	0.0
85		Power from Fossil	GWh	11,882.8	12,034.0	15,880.3	172,066.9	186,988.9	201,896.0
86									
87	Shares	Power from Thermal(Coal)	S%	25.2	27.7	24.6	55.4	55.8	56.9
88		Power from Thermal(FO)	S%	11.0	11.0	7.2	1.6	1.5	1.4
89		Power from Gasturbine(FO)	S%	12.7	11.8	7.5	0.0	0.0	0.0
90		Power from Gasturbine(GAS)	S%	34.1	33.4	36.0	37.5	37.5	36.9
91		Power from Gas steam	S%	2.5	3.4	16.4	5.5	5.2	4.8
92		Power from Diesel	S%	14.5	12.8	8.4	0.0	0.0	0.0
93		Power from Fossil	S%	100.0	100.0	100.0	100.0	100.0	100.0
94									
95	Load	Power from Thermal(Coal)	%	76.0	84.6	42.5	64.0	65.5	65.6
96		Power from Thermal(FO)	%	27.0	27.4	23.6	26.6	27.2	27.2
97		Power from Gasturbine(FO)	%	57.4	54.0	45.2	0.0	0.0	0.0
98		Power from Gasturbine(GAS)	%	64.3	23.1	32.9	61.4	62.8	63.0
99		Power from Gas steam	%	0.0	0.0	0.0	49.3	50.4	50.5
100		Power from Diesel	%	654.4	585.4	508.4			
101		Power from Fossil	%	66.2	41.4	46.3	60.7	62.2	62.5
102									

a. Generation

The forecasted power generation of coal fired thermal、fuel oil fired thermal、fuel oil gas-turbine、gas fired gas-turbine, gas steam and diesel engine are arranged in the generation area. The data are sent from Simulation sheet.

b. Shares

The generation shares by power generator are calculated in the Share area.

c. Load

The operation load of the thermal power stations are calculated in the Load area.

4.2 Model structure in model format

The main structure of the Energy Demand Forecasting Model consists of Data sheet, Model sheet, Simulation sheet and Growth rate sheet.

The sheets have the same model format, and the meaning of sign, color and poison in the sheet are follows;.

"Black character" means Endogenous variable

"Blue character" means Exogenous variable

"Number in left hand side" meet to line number in the model

"Unit of the variable" are shown in Data sheet and Simulation sheet

"=" in Option type located to Fourth column means Definition equation (Arithmetic equation)

"CA" in Option type means Regression equation

"X1" in Variables located fifth column means First explanation variable area

"X2 : in Variables located Sixth column means Second explanation variable area

The structures of the Energy Demand Forecasting Model are typically shown in Model sheet, the following explanations of the model structure expressions are explained by using Model sheet.

(1) Exchange rate, Population and Labor

Table 4-5 Structure of Exchange rate, Population and Labor

F	H	I	Y	Type	X1	X2
5	Economic data	Exchange rate	ECEXC	=	ECEXC	
6						
7	Population	Country number	POPNUM	=	Lag1.POPNUM*(1+POPNGR/100)	
8		Growth rate	POPNGR	=	POPNGR	
9		Urban number	POPUBN	=	POPNUM*POPUGR/100	
10		Urban population share	POPUGR	=	POPUGR	
11						
12	Household	County Number	HHNUM	=	Lag1.HHNUM*(1+HHNGR/100)	
13		Growth rate	HHNGR	=	POPNGR	
14		Urban number	HHUBN	=	HHNUM*HHUGR/100	
15		Urban HH rate	HHUGR	=	POPUGR	
16						
17	Labor force	Agriculture	LABAGR	=	POPNUM*LABSHP/100*LASAGR/100	
18	number	Mining (State sector)	LABMIN	=	POPNUM*LABSHP/100*LASMIN/100	
19		Manufacturing	LABMAN	=	POPNUM*LABSHP/100*LASMAN/100	
20		Services & Others	LABOTH	=	POPNUM*LABSHP/100*LASOTH/100	
21		Unemployed	LABUNE	=	POPNUM*LABSHP/100*LASUNE/100	
22		Total	LABTOT	=	LABAGR+LABMAN+LABOTH+LABUNE	
23						
24		Labor force share to Pop	LABSHP	=	19.0 +0.43*POPNUM	
25						
26	Labor shares	Agriculture & Forestry	LASAGR	=	100-LASMAN-LASOTH-LASUNE	
27		MIning	LASMIN	=	Lag1.LASMIN*(RGPMIN/RGDP)/(Lag1.RGPMIN/Lag1.RGDP)	
28		Manufacturing & Mining	LASMAN	=	Lag1.LASMAN*(RGPMAN/RGDP)/(Lag1.RGPMAN/Lag1.RGDP)	
29		Services & Others	LASOTH	=	Lag1.LASOTH*((RGPTRA+RGPTRN+RGPSER)/RGDP)/((Lag1.RGPTRA+Lag1.RGPTRN+Lag1.RGPSER)/Lag1.RGDP)	
30		Unemployed	LASUNE	=	LASUNE	
31		Total	LASTOT	=	100	
32						

a. Exchange rate

The exchange rates are set in the area. The variable is exogenous and the values are set in the future area.

b. Population

The data on the number of the population in whole country are set.

And also the data on the number of the urban population are set.

The annual growth rates of the total population are exogenous.

The shares of the urban population to the total population are exogenous.

c. Household

The data on the number of the households in the whole country are set.

The number of the household in urban area is calculated with the shares of the urban population to the total.

The annual growth rates on the household in urban area are exogenous.

d. Labor number

The numbers of labor by sector are inputted.

Sectoral labor force = Population in whole country* Share of labor force * Sectoral share

Unemployed = Population in whole country* Share of Labor force * Share of Unemployed

e. Labor shares

The shares of Sectoral labor are calculated by the following expression..

Sectoral labor share = Sctoral labor share(1)* (Sectroal GDP(1) / Sectoral Real GDP (1))

/ (Sectroal GDP / Sectoral Real GDP)

(2) GDP and GDE

Table 4-6 Structure of GDP and GDE

F	H	I	Y	Type	X1	X2
33	GDP	nGDP at current price	GDNOM	=	RGDP*GDFLT/100	
34		Growth rate	GDNGR	=	(GDNOM/Lag1.GDNOM-1)*100	
35						
36		uGDP on US $ base	GDDOL	=	GDNOM/ECEXC*1000	
37		Growth rate	GDDGR	=	(GDDOL/Lag1.GDDOL-1)*100	
38						
39		Foreign Direct Investment	FDIDOL	=	Lag1.FDIDOL*(1+FDIGR/100)	
40		Growth rate of FDI	FDIGR	=	FDIGR	
41						
42		uGDP per capita on US$ base	GDPDOL	=	GDDOL/POPNUM	
43		Growth rate	GDPDGR	=	(GDPDOL/Lag1.GDPDOL-1)*100	
44						
45		rGDP at 2005 price	RGDP	=	Lag1.RGDP*(1+RGDPGR/100)	
46		Growth rate	RGDPGR	=	RGDPGR	
47						
48		GDP deflator 1994 price	GDFLT	=	Lag1.GDFLT*(1+GDFGR/100)	
49		Growth rate	GDFGR	=	GDFGR	
50						
51		rGross Domestic Savings	GDSAV	=	GDSHA*RGDP/100	
52		Share to GDP	GDSHA	=	GDSHA	
53		Elasticity to Private Con	GDEVPC	=	((GDSAV/Lag5.GDSAV)^(1/5)-1)/((RGEFC/Lag5.RGEFC)^(1/5)-1)	
54						
55		rLabor productivity at 1994 price	LAPMAN	=	(RGDP)/(LABAGR+LABMAN+LABOTH)	
56		Growth rate	LAPMGR	=	(LAPMAN/Lag1.LAPMAN-1)*100	
57						
58						
59	nGDE at current price	Final consumption	NGEFC	=	RGEFC*GDFLT/100	
60		Gross fixed capital formation	NGEGF	=	RGEGF*GDFLT/100	
61		Exports of goods and services	NGEEX	=	RGEEX*GDFLT/100	
62		Import of goods and services	NGEIM	=	RGEIM*GDFLT/100	
63		Statistical discrepancy	NGESD	=	RGESD*GDFLT/100	
64		Total	NGETOT	=	NGEFC+NGEGF+NGEEX-NGEIM+NGESD	
65						
66		Export of oil	NGEEOL	=	FTCRDDN	
67		Export of others	NGEEOT	=	NGEEX-NGEEOL	
68		Import of Petroleum products	NGEIPE	=	FTPEPDN	
69		Import of others	NGEIOT	=	NGEIM-NGEIPE	
70						
71	rGDE at 2005 price	Final consumption	RGEFC	=	LAG1.RGEFC*(1+LAPMGR/100)	
72		Gross fixed capital formation	RGEGF	=	LAG1.RGEGF*(GDSAV+FDIDOL*ECEXC/1000)/(LAG1.GDSAV+LAG1.FDIDOL*ECEXC/1000)	
73		Exports of goods and services	RGEEX	=	LAG1.RGEEX*((RGEEOL+RGEEOT)/(LAG1.RGEEOL+Lag1.RGEEOT))	
74		Import of goods and services	RGEIM	=	LAG1.RGEIM*((RGEIPE+RGEIOT)/(LAG1.RGEIPE+LAG1.RGEIOT))	
75		Statistical discrepancy	RGESD	=	0.9*Lag1.RGESD	
76		Total	RGETOT	=	RGEFC+RGEGF+RGEEX-RGEIM+RGESD	
77						
78		Export of oil	RGEEOL	=	FTCRDRE	
79		Export of others	RGEEOT	=	RGDP*(LAG1.RGEEOT*(300+(Time-2005))/300)/LAG1.RGDP	
80		Import of Petroleum products	RGEIPE	=	FTPEPRM	
81		Import of others	RGEIOT	=	Lag1.RGEIOT*(1+0.9*((RGEEOL+RGEEOT)/(LAG1.RGEEOL+LAG1.RGEEOT)-1))	
82						
83	Shares of rGDE	Final consumption	RREFC	=	RGEFC/RGETOT*100	
84		Gross fixed capital formation	RREGF	=	RGEGF/RGETOT*100	
85		Exports of goods and services	RREEX	=	RGEEX/RGETOT*100	
86		Import of goods and services	RREIM	=	RGEIM/RGETOT*100	
87		Statistical discrepancy	RRESD	=	RGESD/RGETOT*100	
88		Total	RRETOT	=	RGETOT/RGETOT*100	
89						
90		Export of oil	RREEOL	=	RGEEOL/RGETOT*100	
91		Export of others	RREEOT	=	RGEEOT/RGETOT*100	
92		Import of Petroleum products	RREIPE	=	RGEIPE/RGETOT*100	
93		Import of others	RREIOT	=	RGEIOT/RGETOT*100	
94						
95	nGDP at current price	Agriculture & Forestry	NGPAGR	=	RGPAGR*GDFLT/100	
96		Mining	NGMIN	=	RGPMIN*GDFLT/100	
97		Manufacturing Light	NGPMAN	=	RGPMAN*GDFLT/100	
98		Manufacturing Heavy	NGPMAH	=	RGPMAH*GDFLT/100	
99		Commercial & Trade	NGPTRA	=	RGPTRA*GDFLT/100	
100		Transport and communications	NGPTRN	=	RGPTRN*GDFLT/100	
101		Service & Others	NGPSER	=	RGPSER*GDFLT/100	
102		Total	NGPTOT	=	RGPTOT*GDFLT/100	
103						
104	rGDP at 2005 price	Agriculture & Forestry	RGPAGR	=	WRKAGR/WRKTOT*RGDP	
105		Mining	RGPMIN	=	WRKMIN/WRKTOT*RGDP	
106		Manufacturing Light	RGPMAN	=	WRKMAN/WRKTOT*RGDP	
107		Manufacturing Heavy	RGPMAH	=	WRKMAH/WRKTOT*RGDP	
108		Commercial & Trade	RGPTRA	=	WRKTRA/WRKTOT*RGDP	
109		Transport and communications	RGPTRN	=	WRKTRN/WRKTOT*RGDP	
110		Service & Others	RGPSER	=	WRKSER/WRKTOT*RGDP	
111		Total	RGPTOT	=	WRKTOT/WRKTOT*RGDP	
112						
113	Sector growth rate	Agriculture & Forestry	RRPAGR	=	RRPAGR	
114		Mining	RRPMIN	=	RRPMIN	
115		Manufacturing Light	RRPMAN	=	RRPMAN	
116		Manufacturing Heavy	RRPMAH	=	RRPMAH	
117		Commercial & Trade	RRPTRA	=	RRPTRA	
118		Transport and communications	RRPTRN	=	RRPTRN	
119		Service & Others	RRPSER	=	RRPSER	
120		Total	RRPTOT	=	RRPTOT	
121						

a. nGDP at current price

The Nominal GDP is calculated by the following expression.

Nominal GDP = Real GDP * GDP deflator

b. uGDP on US $ base

GDP based on US$ are calculated by using nominal GDP and exchange rate.

c. uGDP per capita on US$ base

GDP per capita based on US$ are calculated by using GDP based on US$ and total population.

d. rGDP at 2005 price

Real GDP is calculated by using Nominal GDP and GDP deflator.

The annual growth rates of Real GDP are exogenous.

The future growth rates of Real GDP are given from growth rates of Real GDP.

e. GDP deflator 2005 price

GDP deflators are set.

The growth rate of GDP deflator is exogenous.

The future growth rates of GDP deflator are given from growth rates of GDP deflator.

f. rGross Domestic Savings

Real Gross Domestic Savings are calculated by using the Real GDP and the ratios to Gross Domestic Savings.

The ratios to Gross Domestic Savings are inputted.

The future growth rates of Gross Domestic Savings are exogenous.

g. rLabor productivity in Manufacturing at 2005 price

Real labor productivity in manufacturing is calculated by using Real GDP and Number of labor.

h. nGDE at current price

The components of Nominal GDE are calculated by the following expression.

Nominal final consumption = Real final consumption * GDP deflator

Nominal gross fixed capital formation = Real gross fixed capital formation * GDP deflator

Nominal exports = Real exports * GDP deflator

Nominal import = Real import * GDP deflator

Nominal statistical discrepancy = Real statistical discrepancy* GDP deflator

Nominal GDE= Nominal final consumption+ Nominal gross fixed capital formation+ Nominal exports- Nominal import + Nominal Statistical discrepancy

i. rGDE at 2005 price

The components of Real GDE at 2005 price are calculated by the components of Nominal GDE and GDP deflator.

j. Shares of rGDP

The component shares of Real GDP are calculated.

k. nGDP by sector at current price

Sectoral Nominal GDP are calculated by “Sectoral Real GDP* Deflator”.

l. rGDP at 2005 price

Sectoral Real GDP are calculated by the followings.

Sectoral Real GDP = Sectoral Real GDP (1) * Growth rate of Real GDP by sector

m. GDP growth rate .

Growth rates of Sectoral GDP are exogenous.

.(3) Conversion Factor, Power Efficiency, Energy Price, Crude oil export and Petroleum import

Table 4-7 Structure of Conversion Factor, Power Efficiency, Energy Price, Crude oil export and Petroleum import

F	H	I	Y	Type	X1	X2
142	Conversion factor to KTOE	Standard OIl(10000Kcal/kg)	COFASCO	=	COFASCO	
143		Coal(5600Kcal/kg)	COFACOA	=	COFACOA	
144		Gasoline(10500Kcal/kg)	COFAGAS	=	COFAGAS	
145		Kerosene (10320Kcal/kg)	COFAKER	=	COFAKER	
146		Diesel (10150Kcal/kg)	COFADIE	=	COFADIE	
147		Petroluem Products	COFAPET	=	COFAPET	
148		Fuel oil (9910Kcal/Kg)	COFAFUE	=	COFAFUE	
149		Natural gas (9000Kcal/m3)	COFANAG	=	COFANAG	
150		Renewable energy (3302Kcal/Kg)	COFAREW	=	COFAREW	
151		Electricity (860Kcal/KWh)	COFAELE	=	COFAELE	
152						
153	Power efficiency	Power from Thermal(Coal)	COPOCOA	=	COPOCOA	
154		Power from Thermal(FO)	COPOFOT	=	COPOFOT	
155		Power from Gasturbine(FO)	COPOFOB	=	COPOFOB	
156		Power from Gasturbine(GAS)	COPOGAB	=	COPOGAB	
157		Power from Gas steam	COPODAS	=	COPODAS	
158		Power from Diesel	COPODIE	=	COPODIE	
159						
160	Energy price	IEA world export price	EPRCWTI	=	EPRCWTI	
161		Crude oil export price of VN	EPRCRD	=	EPRCRD	
162		Coal FOB (For Power)	EPRCOL	=	EPRCOL	
163		Asian LNG CIF	EPRLNG	=	EPRLNG	
164		NG price (Non Associated)	EPRNGNA	=	EPRNGNA	
165		NG price(Associated)	EPRNGAS	=	EPRNGAS	
166		Gasoline retail price (RON 92)	EPRGAS92	=	EPRGAS92	
167		Gasoline retail price (RON 90)	EPRGAS90	=	EPRGAS90	
168		Kerosene retail price	EPRKER	=	EPRKER	
169		Diesel retail price (1%S)	EPRDIE	=	EPRDIE	
170		Fuel oil price in Vietnam	EPRFO	=	EPRFO	
171		LPG price in Vietnam	EPRLPG	=	EPRLPG	
172		Electricity for Agriculture use	EPRELA	=	Lag1.EPRELA*IF(GRPRCRD>0, 0.5*(1+GRPRCRD/100)+0.5*(1+(GDFGR-0.3*LAPMGR)/100), 0.5+0.5*(1+(GDFGR-0.3*LAPMGR)/100))	
173		Electricity for Residential use	EPRELR	=	Lag1.EPRELR*IF(GRPRCRD>0, 0.5*(1+GRPRCRD/100)+0.5*(1+(GDFGR-0.3*LAPMGR)/100), 0.5+0.5*(1+(GDFGR-0.3*LAPMGR)/100))	
174		Electricity for Industry use	EPRELI	=	Lag1.EPRELI*IF(GRPRCRD>0, 0.5*(1+GRPRCRD/100)+0.5*(1+(GDFGR-0.3*LAPMGR)/100), 0.5+0.5*(1+(GDFGR-0.3*LAPMGR)/100))	
175		Electricity for Commercial use	EPRELC	=	Lag1.EPRELC*IF(GRPRCRD>0, 0.5*(1+GRPRCRD/100)+0.5*(1+(GDFGR-0.3*LAPMGR)/100), 0.5+0.5*(1+(GDFGR-0.3*LAPMGR)/100))	
176						
177	G.R of Energy prices	World export price	GRPRWTI	=	IF(Lag1.EPRCWTI>0,(EPRCWTI/Lag1.EPRCWTI-1)*100,0)	
178		Crude oil Price in Vietnam	GRPRCRD	=	IF(Lag1.EPRCRD>0,(EPRCRD/Lag1.EPRCRD-1)*100,0)	
179		NG price (Non Associated)	GRPRNGNA	=	IF(Lag1.EPRNGNA>0,(EPRNGNA/Lag1.EPRNGNA-1)*100,0)	
180		NG price(Associated)	GRPRNGAS	=	IF(Lag1.EPRNGAS>0,(EPRNGAS/Lag1.EPRNGAS-1)*100,0)	
181		Gasoline retail price (RON 92)	GRPRGAS9	=	IF(Lag1.EPRGAS92>0,(EPRGAS92/Lag1.EPRGAS92-1)*100,0)	
182		Gasoline retail price (RON 90)	GRPRGAS9	=	IF(Lag1.EPRGAS90>0,(EPRGAS90/Lag1.EPRGAS90-1)*100,0)	
183		Kerosene price in vietnam	GRPRKER	=	IF(Lag1.EPRKER>0,(EPRKER/Lag1.EPRKER-1)*100,0)	
184		Diesel price in Vietnam	GRPRDIE	=	IF(Lag1.EPRDIE>0,(EPRDIE/Lag1.EPRDIE-1)*100,0)	
185		Fuel oil price in Vietnam	GRPRFO	=	IF(Lag1.EPRFO>0,(EPRFO/Lag1.EPRFO-1)*100,0)	
186		LPG price in Vietnam	GRPLPG	=	IF(Lag1.EPRLPG>0,(EPRLPG/Lag1.EPRLPG-1)*100,0)	
187		Electricity for Agriculture use	GRPRAGR	=	IF(Lag1.EPRELA>0,(EPRELA/Lag1.EPRELA-1)*100,0)	
188		Electricity for Residential use	GRPRELR	=	IF(Lag1.EPRELR>0,(EPRELR/Lag1.EPRELR-1)*100,0)	
189		Electricity for Industry use	GRPRELI	=	IF(Lag1.EPRELI>0,(EPRELI/Lag1.EPRELI-1)*100,0)	
190		Electricity for Commercial use	GRPRELC	=	IF(Lag1.EPRELC>0,(EPRELC/Lag1.EPRELC-1)*100,0)	
191						
192	Crude oil export Product im					
193		Production	FTCRDP	=	FTCRDP	
194		Consumption in VN	FTCRDT	=	FTCRDT	
195		Export	FTCRDE	=	FTCRDP*0.99-FTCRDT	
196		Export value	FTCRDUS	=	FTCRDE/0.85/0.159*EPRCRD/1000	
197		Export value	FTCRDDN	=	FTCRDUS*ECEXC/1000	
198						
199		Consumption	FTPECP	$CA	RGDP	
200		Domestic supply	FTPEPL	=	FTPEPL	
201		Import	FTPEIM	=	FTPECP/0.75-FTPEPL	
202		Average Petroleum product prices	FTPEPAV	=	ECEXC*EPRCRD/159*1.6*(1+0.3*LAPMGR/100)	
203		Import value	FTPEPDN	=	FTPEIM*FTPEPAV/1000	
204						
205	Real value (2005 p)	Crude oil export	FTCRDRE	=	FTCRDDN/100*100	
206		Oil product import	FTPEPRM	=	FTPEPDN/100*100	
207						

a. Conversion factor to KTOE

Physical energy units (such as kg, m3 and kWh) are converted to KTOE. The factors are used during the starting year(1990) and final year(2025) The calories of the energies in the conversion factor table are set as follows;

Table 4-8 Conversion factor

Energies	Calorie	KTOE
Standard Oil	10,000Kcal/kg	1000t=1KTOE
Coal	5,600Kcal/kg	1000t=0.56KTOE
Gasoline	1,0500Kcal/kg	1000t=1.05KTOE
Kerosene	10,320Kcal/kg	1000t=1.032KTOE
Diesel	10,150Kcal/kg	1000t=1.015KTOE
Fuel oil	9,910Kcal/Kg	1000t=0.991KTOE
Natural gas	9,000Kcal/m3	Million m3=0.9KTOE
Renewable energy	3,300cal/Kg	1000t=0.3300
Electricity	860Kcal/KWh	1GWh=0.086KTOE

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b. Power efficiency

Thermal power efficiencies are given by thermal power generation types (such as coal fired power generator, fuel oil fired power generator, fuel oil gas turbine, gas turbine, gas steam and diesel). The efficiencies are used at calculating the energies used in the generators.

Table 4-9 Power efficiency

Thermal power generator	Efficiency	Expressions
Power from Thermal(Coal)	35%	2.28(GWh/1000t)=5600*0.35/860
Power from Thermal(FO)	35%	4.03(GWh/1000t)=9910*0.35/860
Power from Gas-turbine(FO)	48%	5.53(GWh/1000t)=9910*0.48/860
Power from Gas-turbine(GAS)	48%	5.02(GWh/1000t)=9000*0.48/860
Power from Gas steam	40%	4.19(GWh/Mil m3)=9000*0.40/860
Power from Diesel	36%	4.25(GWh/1000t)=10,150*0.36/860

c. Energy price

The petroleum prices and electricity tariffs are inputted in the table.

Petroleum products are imported from Asian oil market. Future petroleum prices depend on international crude oil prices.

The electricity tariffs are inputted by consumer category. The future electricity tariffs are decided not only petroleum prices, but also energy policy. In the model, it is assumed that the future electricity tariffs by consumer category depend on the production costs, electric tariffs are effected by the fuel oil prices. Electric tariffs are calculated by the following expressions.

Electricity for Agriculture use

=Electricity for Agriculture use(1) *((1+0.5*GR of Fuel oil price in Vietnam)
+ 0.3 *GR of Labor productivity))

Electricity for Residential use

=Electricity for Residential use(1) *((1+0.5*GR of crude oil price in Vietnam)
+ 0.3 *GR of Labor productivity))

Electricity for Industry use

=Electricity for Industry use (1) *((1+0.5*GR of Fuel oil price in Vietnam)

+ 0.3 *GR of Labor productivity))

Electricity for Commercial use

=Electricity for Commercial use (1)*((1+0.5*GR of Fuel oil price in Vietnam)

+ 0.3 *GR of Labor productivity))

d. Crude oil export & Oil products import

Vietnam has a plan to construct Refinery plans in future, after constructing the refinery plants, crude oil export and oil product import are changed. In the area, future crude oil export and future oil product import are inputted and calculated.

(4) Passenger car, Truck, Motorbike and Vessel

Table 4-10 Structure of Passenger car, Truck, Motorbike and Vessel

F	H	I	Y	Type	X1	X2
208	Passenger & Freight	Passenger of Bus Car and Bike	PFPASSG	$CA	Lag1.PFPASSG*(1+(2.4-(time-2005)/50)*RGDPGR/100)	
209		Ratio of Bus & Car	PFOBUS	=	100-PFOMOT	
210		Ratio of Bus	PFOBAC	$CA	Lag1.PFOBUS*10/(Lag1.PFPBUS*10+Lag1.PFPCAR)*100	
211		Ratio of Motorbike	PFOMOT	$CA	Lag1.PFVBIK/(Lag1.PFVBIK+Lag1.PFPBUS+Lag1.PFPCAR)	
212		Freight transporation	PFFREIG	$CA	Lag1.PFFREIG*(1+(1.3-(Time-2005)/100)*RGDPGR/100)	
213		Ratio of truck	PFOTRK	=	PFOTRK	
214		Ratio of Railway	PFORAL	=	PFORAL	
215		Passenger transport	PFPAST	=	PFPASSG-PFVATT	
216		DO for Bus & Cars	PFPDO	=	173/71979*PFPBUS*((TRNNCOR/100)^(1/2))	
217		Gasoline for Cars	PFPGAS	=	233/178210*PFPCAR*TRNNCOR/100	
218		Number of Bus	PFPBUS	=	Lag1.PFPBUS+(POPNUM/400*1000000-Lag1.PFPBUS)*0.05*((PFPASSG/Lag1.PFPASSG)^2)	
219		Number of Car	PFPCAR	=	LAG1.PFPCAR*((PFPASSG/Lag1.PFPASSG)^(1.5-(Time-2005)/50))	
220		Freight transport	PFFRTT	=	PFFREIG*PFOTRK/100	
221		DO for Trucks	PFFDO	=	1825/278320*PFFTRK*(TRNNCOR/100)	
222		Number of Trucks	PFFTRK	=	Lag1.PFFTRK*((PFFRTT/Lag1.PFFRTT)^1.2)	
223		Private transport	PFVATT	=	PFPASSG*PFOMOT/100	
224		Gasoline for Motorbike	PFVAGAS	=	2065/16905*PFVBIK*((TRNNCOR/100)^(1/3))	
225		Number of Bike in use	PFVBIK	=	Lag1.PFVBIK+(POPNUM*0.35*1000-(Lag1.PFVBIK+Lag1.PFPCAR/1000))*0.2-(PFPCAR-Lag1.PFPCAR)/1000*2	
226		Boat and Vessel use				
227		DO for Boat & Vessel	PFBDO	$CA	PFFREIG*TRNNCOR/100	
228		FO for Boat & Vessel	PFBFO	$CA	PFFREIG*TRNNCOR/100	
229		Railway	PFRATT	$CA	PFPASSG+PFFREIG	
230		DO	PFRDO	$CA	PFRATT*TRNNCOR/100	
231		Total				
232		Gasoline After EE	PFTOGA	=	PFPGAS+PFVAGAS	
233		DO After EE	PFTODO	=	PFPDO+PFFDO+PFBDO+PFRDO	
234		FO After EE	PFTOFO	=	PFBFO	
235						

a. Passenger of Bus, Car and Bike

The passenger transportation (million passenger km) and shares of Bus, Car and Bike are inputted and calculated in the area.

b. Freight transportation

The Freight transportation (million ton km) and shares of Truck and Railway are inputted and calculated in the area.

c. Passenger Transport

Diesel for Bus and Cars, Gasoline for Cars, number of Bus and number of Cars are inputted and calculated.

d. Freight transport

Diesel for truck and number of truck are inputted and calculated inn the area.

e. Private transport

Gasoline for motorbike and number of motorbike are inputted and calculated in the area.

f. Boat and Vessel use

Diesel and fuel oil for Boat & Vessel are inputted and calculated in the area.

g. Railway

Diesel for railway is inputted and calculated in the area.

h. Total

Total of Gasoline, Diesel and fuel consumption in transportation sector are calculated.

(5) Energy demand in Agriculture sector

Table 4-11 Structure of Energy demand in Agriculture sector

F	H	I	Y	Type	X1	X2
236	Agriculture.&Forestry	Energy demand in Agri sector	PAENTOL	$CA	(RGPAGR)*(RGEGF/Lag1.RGEGF)	
237		Power ratio	PAENELR	=	PAENELR	
238	Energy demand	Energy conservation rate	PANNCOR	=	Lag1.PANNCOR*(1+PANNTEC/100)*IF(GRPRDIE>0, (1+PANNEVP*(GRPRDIE)/100), (1+PANNEVP*(GRPRDIE)/100))	
239		Technical Improvement	PANNTEC	=	PANNTEC	
240		Elasticity to Energy price	PANNEVP	=	PANNEVP	
241		Energy intensity to GDP	PANNEFF	=	PANNDEA/RGDP*1000	
242		Energy demand before E.save	PANNDEM	$CA	PAENTOL-PAENELA/(PAENECO/100)*0.086	
243		Energy demand after E.save	PANNDEA	=	PANNDEM*PANNCOR/100	
244	Power demand	Power conservation rate	PAENECO	=	Lag1.PAENECO*(1+PAENETE/100)*IF(GRPRAGR>0, (1+PAENEEV*(GRPRAGR)/100), (1+PAENEEV*(GRPRAGR)/100))	
245		Technical Improvement	PAENETE	=	PAENETE	
246		Elasticity to Power price	PAENEEV	=	PAENEEV	
247		Power intensity to GDP	PAENELF	=	PAENELA/RGDP*1000	
248		Power demand before E.save(GWh)	PAENELE	$CA	PAENTOL/0.086*(PAENELR/100)	
249		Power demand after E.save(GWh)	PAENELA	=	PAENELE*PAENECO/100	
250		Power demand (kTOE)	PAENELT	=	PAENELA*0.086	
251						
252	ED before Adjust	Coal demand	PADMCOA	=	(PANNDEA-PADMREW)*PASMCOA/100	
253		LPG demand	PADMLPG	=	(PANNDEA-PADMREW)*PASMLPG/100	
254		Gasoline demand	PADMGAS	=	(PANNDEA-PADMREW)*PASMGAS/100	
255		Jetfuel demand	PADMJET	=	(PANNDEA-PADMREW)*PASMJET/100	
256		Kerosene demand	PADMKER	=	(PANNDEA-PADMREW)*PASMKER/100	
257		Diesel demand	PADMDIE	=	(PANNDEA-PADMREW)*PASMDIE/100	
258		Fuel oil demand	PADMFUL	=	(PANNDEA-PADMREW)*PASMFUL/100	
259		Natural gas demand	PADMNG	=	(PANNDEA-PADMREW)*PASMNG/100	
260		Noncommercial energy demand	PADMREW	=	PADMREW	
261		Total	PADMTOT	=	PADMCOA+PADMLPG+PADMGAS+PADMJET+PADMKER+PADMDIE+PADMFUL+PADMNG+PADMREW	
262						
263	Energy shares	Coal demand	PASMCOA	=	PASMCOA	
264		LPG demand	PASMLPG	=	PASMLPG	
265		Gasoline demand	PASMGAS	=	PASMGAS	
266		Jetfuel demand	PASMJET	=	PASMJET	
267		Kerosene demand	PASMKER	=	PASMKER	
268		Diesel demand	PASMDIE	=	PASMDIE	
269		Fuel oil demand	PASMFUL	=	PASMFUL	
270		Natural gas demand	PASMNG	=	PASMNG	
271		Total	PASMTOT	=	PASMTOT	
272						
273	ED after Adjust	Coal demand	PAAMCOA	=	PADMCOA*(PANNDEA-PADMREW)/(PADMTOT-PADMREW)	
274		LPG demand	PAAMLPG	=	PADMLPG*(PANNDEA-PADMREW)/(PADMTOT-PADMREW)	
275		Gasoline demand	PAAMGAS	=	PADMGAS*(PANNDEA-PADMREW)/(PADMTOT-PADMREW)	
276		Jetfuel demand	PAAMJET	=	PADMJET*(PANNDEA-PADMREW)/(PADMTOT-PADMREW)	
277		Kerosene demand	PAAMKER	=	PADMKER*(PANNDEA-PADMREW)/(PADMTOT-PADMREW)	
278		Diesel demand	PAAMDIE	=	PADMDIE*(PANNDEA-PADMREW)/(PADMTOT-PADMREW)	
279		Fuel oil demand	PAAMFUL	=	PADMFUL*(PANNDEA-PADMREW)/(PADMTOT-PADMREW)	
280		Natural gas demand	PAAMNG	=	PADMNG*(PANNDEA-PADMREW)/(PADMTOT-PADMREW)	
281		Noncommercial energy demand	PAAMREW	=	PADMREW	
282		Total	PAAMTOT	=	PAAMCOA+PAAMLPG+PAAMGAS+PAAMJET+PAAMKER+PAAMDIE+PAAMFUL+PAAMNG+PAAMREW	
283						

a. Energy demand in Agriculture

Final energy demand including power and fossil energies in Agriculture sector are inputted in the area. The final energy demand in the sector is forecasted by the following regression equation.

Energy demand = f(GDP in Agriculture * (Fixed formation / Fixed Formation (1))

b. Energy conservation rate

Energy conservation rate in the actual term is 100%. The future energy conservation rate is calculated by change of energy prices and ratio of technical improvement.

c. Technical Improvement

Energy consumption is saved by technical improvement. After the first oil crisis, Japan had energy conservation improvement with 2% per year. Most of the reasons are improvement of the production line and installation of new equipment. Both of them are included in technical improvement in the model.

d. Elasticity to Energy price

Another factor for energy conservation is energy price hikes. When energy prices and electricity tariffs increases, usually energy consumption are saved. According to Japanese experiences, energy demand elasticity to energy price is the ranges from –0.1 to –1.0. In the model, For Agriculture sector, the assumption of energy demand elasticity to energy price is –0.01.

e. Energy intensity to GDP

Energy intensity in Agriculture sector to GDP is calculated by using energy demand in Agriculture sector and GDP in the whole country. It is used for the evaluation of the future energy demand in Agriculture sector.

f. Energy demand before energy saving

Energy demand in Agriculture sector is forecasted in the area. First, the energy demand before energy conservation is calculated in the area.

g. Energy demand after energy saving

Energy demand after energy conservation in Agriculture sector is forecasted in the area. It is calculated by using "Energy demand before energy conservation (1) and energy conservation rate".

h. Power ratio

Power ratio is an electricity share in final energy demand in Agriculture sector. Power ratio is exogenous. The values are estimated after referring other countries' electricity ratio.

Table 4-12 International Electricity ratio of Agriculture sector

Agriculture sector %

	1995	1996	1997	1998	1999	2000
Japan	2.7	2.8	2.9	3.0	3.2	2.1
Taiwan	1.7	1.8	2.1	2.3	2.3	2.1
Australia	1.5	1.5	1.5	1.5	1.5	1.5
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0
Korea	0.9	1.0	0.9	1.0	1.1	1.2
China	12.8	13.2	13.5	12.8	13.7	13.7
Vietnam	6.0	6.4	6.7	7.1	8.5	9.2
Thailand	0.6	0.6	0.5	0.7	0.5	0.5
Pilippines	19.8	16.7	18.1	13.8	20.1	10.1

Source: APERC Energy Data Base

i. Power demand before energy saving

Power demand in Agriculture sector is forecasted in the area. First, the power demand before energy conservation is calculated in the area.

j. Power demand after energy saving

Power demand after energy conservation in Agriculture sector is forecasted in the area. It is calculated by using “Power demand before energy conservation (1) and Power conservation rate”.

k. Fossil energy demand before adjusted

As fossil energies used in Agriculture sector, Coal, Gasoline, Diesel and Fuel oil are calculated with total energy demand and fossil energy ratio in Agriculture sector.

l. Fossil energy demand ratio

Fossil energy demand ratios are exogenous. The future values of fossil energy demand ratio are decided by the energy supply policies of Vietnam.

m. Fossil energy demand after adjusted

Fossil energy demands after adjusted are calculated with adjusting the total ratio to meet to 100.

(6) Energy demand in Light industry sector

Table 4-13 Structure of Energy demand in Light industry sector

F	H	I	Y	Type	X1	X2
284	Industry (Light)	Energy demand in Industry sector	MANNTOL	$CA	RGPMAN	DUM.2004..
285		Power ratio	MAENELR	=	MAENELR	
286	Energy demand	Energy conservation rate	MANNCOR	=	Lag1.MANNCOR*(1+MANNTEC/100)*IF(GRPRDIE>0, (1+MANNEVP*(GRPRDIE)/100), (1+MANNEVP*(GRPRDIE)/100))	
287		Technical Improvement	MANNTEC	=	MANNTEC	
288		Elasticity to Energy price	MANNEVP	=	MANNEVP	
289		Energy intensity to GDP	MANNEFF	=	MANNDEA/RGDP*1000	
290		Energy demand before E.save	MANNDEM	$CA	MANNTOL-MAENELA/(MAENECO/100)*0.086	
291		Energy demand after E.save	MANNDEA	=	MANNDEM*(MANNCOR/100)	
292	Power demand	Power conservation rate	MAENECO	=	Lag1.MAENECO*(1+MAENETE/100)*IF(GRPRELI>0, (1+MAENEEV*(GRPRELI)/100), (1+MAENEEV*(GRPRELI)/100))	
293		Technical Improvement	MAENETE	=	MAENETE	
294		Elasticity to Power price	MAENEEV	=	MAENEEV	
295		Power intensity to GDP	MAENELF	=	MAENELA/RGDP*1000	
296		Power demand before E.save(GWh)	MAENELE	=	MANNTOL/0.086*(MAENELR/100)	
297		Power demand after E.save(GWh)	MAENELA	=	MAENELE*MAENECO/100	
298		Power demand (k TOE)	MAENELT	=	MAENELA*0.086	
299						
300	ED before Adjust	Coal demand	MADMCOA	=	(MANNDEA-MADMREW)*MASMCOA/100	
301		LPG demand	MADMLPG	=	(MANNDEA-MADMREW)*MASMLPG/100	
302		Gasoline demand	MADMGAS	=	(MANNDEA-MADMREW)*MASMGAS/100	
303		Jetfuel demand	MADMJET	=	(MANNDEA-MADMREW)*MASMJET/100	
304		Kerosene demand	MADMKER	=	(MANNDEA-MADMREW)*MASMKER/100	
305		Diesel demand	MADMDIE	=	(MANNDEA-MADMREW)*MASMDIE/100	
306		Fuel oil demand	MADMFUL	=	(MANNDEA-MADMREW)*MASMFUL/100	
307		Natural gas demand	MADMNG	=	(MANNDEA-MADMREW)*MASMNG/100	
308		Noncommercial energy demand	MADMREW	=	MADMREW	
309		Total	MADMTOT	=	MADMCOA+MADMLPG+MADMGAS+MADMJET+MADMKER+MADMDIE+MADMFUL+MADMNG+MADMREW	
310						
311	Energy shares	Coal demand	MASMCOA	=	MASMCOA	
312		LPG demand	MASMLPG	=	MASMLPG	
313		Gasoline demand	MASMGAS	=	MASMGAS	
314		Jetfuel demand	MASMJET	=	MASMJET	
315		Kerosene demand	MASMKER	=	MASMKER	
316		Diesel demand	MASMDIE	=	MASMDIE	
317		Fuel oil demand	MASMFUL	=	MASMFUL	
318		Natural gas demand	MASMNG	=	MASMNG	
319		Total	MASMTOT	=	MASMTOT	
320						
321	ED after Adjust	Coal demand	MAAMCOA	=	MADMCOA*(MANNDEA-MADMREW)/(MADMTOT-MADMREW)	
322		LPG demand	MAAMLPG	=	MADMLPG*(MANNDEA-MADMREW)/(MADMTOT-MADMREW)	
323		Gasoline demand	MAAMGAS	=	MADMGAS*(MANNDEA-MADMREW)/(MADMTOT-MADMREW)	
324		Jetfuel demand	MAAMJET	=	MADMJET*(MANNDEA-MADMREW)/(MADMTOT-MADMREW)	
325		Kerosene demand	MAAMKER	=	MADMKER*(MANNDEA-MADMREW)/(MADMTOT-MADMREW)	
326		Diesel demand	MAAMDIE	=	MADMDIE*(MANNDEA-MADMREW)/(MADMTOT-MADMREW)	
327		Fuel oil demand	MAAMFUL	=	MADMFUL*(MANNDEA-MADMREW)/(MADMTOT-MADMREW)	
328		Natural gas demand	MAAMNG	=	MADMNG*(MANNDEA-MADMREW)/(MADMTOT-MADMREW)	
329		Noncommercial energy demand	MAAMREW	=	MADMREW	
330		Total	MAAMTOT	=	MAAMCOA+MAAMLPG+MAAMGAS+MAAMJET+MAAMKER+MAAMDIE+MAAMFUL+MAAMNG+MAAMREW	
331						

a. Energy demand in Light Industry

Final energy demand including power and fossil energies in Light Industry are inputted in the area. The final energy demand in the sector is forecasted by the following regression equation.

Energy demand=f(GDP in Light industry, Dummy 2004)

b. Energy conservation rate

Energy conservation rate in the actual term is 100%. The future energy conservation rate is calculated by "Change of energy prices and Ratio of technical improvement".

c. Technical Improvement

Energy consumption is saved by technical improvement. After the first oil crisis, Japan had energy conservation improvement with 2% per year. Most of the reasons are improvement of the production line and installation of new equipment. Both of them are included in technical improvement in the model.

d. Elasticity to Energy price

Another factor for energy conservation is energy price hikes. When energy prices and electricity tariffs increase, usually energy consumption are saved. According to Japanese experiences, energy demand elasticity to energy price is the ranges from –0.1 to –1.0. In the model, for Light industry sector, the assumption of energy demand elasticity to energy price is –0.3.

e. Energy intensity to GDP

Energy intensity in Light industry sector to GDP is calculated by using energy demand in Light industry sector and GDP in the whole country. It is used for the evaluation of the future energy demand in Light industry sector.

f. Energy demand before energy saving

Energy demand in Light industry sector is forecasted in the area. First, the energy demand before energy conservation is calculated in the area.

g. Energy demand after energy saving

Energy demand after energy conservation in Light industry sector is forecasted in the area. It is calculated by using "Energy demand before energy conservation (1) and Energy conservation rate".

h. Electricity ratio

Electricity ratio is an electricity share of the energy demand in Light industry sector. The ratio is exogenous. The values are estimated after referring other countries' electricity ratio.

Table 4-14 International Electricity ratio of Industry sector

Industry %

	1995	1996	1997	1998	1999	2000
Japan	26.5	26.8	27.1	27.4	26.7	26.6
Taiwan	22.1	22.2	22.9	23.3	24.4	26.2
Australia	20.3	19.9	20.0	21.4	21.9	22.0
Indonesia	12.4	11.9	14.3	13.8	13.9	12.9
Korea	19.0	19.6	19.4	19.2	19.4	20.0
China	5.1	5.3	5.5	5.8	6.0	6.1
Vietnam	12.8	14.1	13.4	14.0	15.1	17.0
Thailand	22.7	20.6	22.5	22.4	23.9	25.4
Malaysia	18.0	19.8	21.4	21.4	23.1	22.2
Pilippines	19.7	19.7	20.2	26.9	20.4	31.7

i. Power demand before energy saving

Power demand in Light industry sector is forecasted in the area. First, the power demand before energy conservation is calculated in the area.

j. Power demand after energy saving

Power demand after energy conservation in Light industry sector is forecasted in the area. It is calculated by using "Power demand before energy conservation (1) and Power conservation rate".

k. Fossil energy demand before adjusted

As fossil energies used in Light industry sector, Coal, LPG, Gasoline, Diesel and Fuel oil are calculated with total energy demand and fossil energy ratio in Light industry sector.

l. Fossil energy demand ratio

Fossil energy demand ratios are exogenous. The future values of fossil energy demand ratio are decided by the energy supply policies of Vietnam.

m. Fossil energy demand after adjusted

Fossil energy demands after adjusted are calculated with adjusting the total ratio to meet to 100.

(7) Energy demand in Heavy industry sector

Table 4-15 Structure of Energy demand in Heavy industry sector

F	H	I	Y	Type	X1	X2
332	Industry (Heavy)	Energy demand in the sector	NONNTOL	$CA	RGPMAH	
333		Power ratio	NOENELR	=	NOENELR	
334	Energy demand	Energy conservation rate	NONNCOR	=	Lag1.NONNCOR*(1+NONNTEC/100)*IF(GRPRDIE>0, (1+NONNEVP*(GRPRDIE)/100), (1+NONNEVP*(GRPRDIE)/100))	
335		Technical Improvement	NONNTEC	=	NONNTEC	
336		Elasticity to Energy price	NONNEVP	=	NONNEVP	
337		Energy intensity to GDP	NONNEFF	=	NONNDEA/RGDP*1000	
338		Energy demand before E.save	NONNDEM	=	NONNTOL-NOENELT	
339		Energy demand after E.save	NONNDEA	=	NONNDEM*(NONNCOR/100)	
340	Power demand	Power conservation rate	NOENECO	=	Lag1.NOENECO*(1+NOENETE/100)*IF(GRPRELI>0, (1+NOENEEV*(GRPRELI)/100), (1+NOENEEV*(GRPRELI)/100))	
341		Technical Improvement	NOENETE	=	NOENETE	
342		Elasticity to Power price	NOENEEV	=	NOENEEV	
343		Power intensity to GDP	NOENELF	=	NOENELA/RGDP*1000	
344		Power demand before E.save(GWh)	NOENELE	=	NONNTOL/0.086*NOENELR/100	
345		Power demand after E.save(GWh)	NOENELA	=	NOENELE*NOENECO/100	
346		Power demand (kTOE)	NOENELT	=	NOENELA*0.086	
347						
348	ED before Adjust	Coal demand	NODMCOA	=	(NONNDEA-NODMREW)*NOSMCOA/100	
349		LPG demand	NODMLPG	=	(NONNDEA-NODMREW)*NOSMLPG/100	
350		Gasoline demand	NODMGAS	=	(NONNDEA-NODMREW)*NOSMGAS/100	
351		Jetfuel demand	NODMJET	=	(NONNDEA-NODMREW)*NOSMJET/100	
352		Kerosene demand	NODMKER	=	(NONNDEA-NODMREW)*NOSMKER/100	
353		Diesel demand	NODMDIE	=	(NONNDEA-NODMREW)*NOSMDIE/100	
354		Fuel oil demand	NODMFUL	=	(NONNDEA-NODMREW)*NOSMFUL/100	
355		Natural gas demand	NODMNG	=	(NONNDEA-NODMREW)*NOSMNG/100	
356		Noncommercial energy demand	NODMREW	=	NODMREW	
357		Total	NODMTOT	=	NODMCOA+NODMLPG+NODMGAS+NODMJET+NODMKER+NODMDIE+NODMFUL+NODMNG+NODMREW	
358						
359	Energy shares	Coal demand	NOSMCOA	=	NOSMCOA	
360		LPG demand	NOSMLPG	=	NOSMLPG	
361		Gasoline demand	NOSMGAS	=	NOSMGAS	
362		Jetfuel demand	NOSMJET	=	NOSMJET	
363		Kerosene demand	NOSMKER	=	NOSMKER	
364		Diesel demand	NOSMDIE	=	NOSMDIE	
365		Fuel oil demand	NOSMFUL	=	NOSMFUL	
366		Natural gas demand	NOSMNG	=	NOSMNG	
367		Total	NOSMTOT	=	NOSMTOT	
368						
369	ED after Adjust	Coal demand	NOAMCOA	=	IF(NODMTOT>0,NODMCOA*(NONNDEA-NODMREW)/(NODMTOT-NODMREW),0)	
370		LPG demand	NOAMLPG	=	IF(NODMTOT>0,NODMLPG*(NONNDEA-NODMREW)/(NODMTOT-NODMREW),0)	
371		Gasoline demand	NOAMGAS	=	IF(NODMTOT>0,NODMGAS*(NONNDEA-NODMREW)/(NODMTOT-NODMREW),0)	
372		Jetfuel demand	NOAMJET	=	IF(NODMTOT>0,NODMJET*(NONNDEA-NODMREW)/(NODMTOT-NODMREW),0)	
373		Kerosene demand	NOAMKER	=	IF(NODMTOT>0,NODMKER*(NONNDEA-NODMREW)/(NODMTOT-NODMREW),0)	
374		Diesel demand	NOAMDIE	=	IF(NODMTOT>0,NODMDIE*(NONNDEA-NODMREW)/(NODMTOT-NODMREW),0)	
375		Fuel oil demand	NOAMFUL	=	IF(NODMTOT>0,NODMFUL*(NONNDEA-NODMREW)/(NODMTOT-NODMREW),0)	
376		Natural gas demand	NOAMNG	=	IF(NODMTOT>0,NODMNG*(NONNDEA-NODMREW)/(NODMTOT-NODMREW),0)	
377		Noncommercial energy demand	NOAMREW	=	NODMREW	
378		Total	NOAMTOT	=	NOAMCOA+NOAMLPG+NOAMGAS+NOAMJET+NOAMKER+NOAMDIE+NOAMFUL+NOAMNG+NOAMREW	
379						

a. Energy demand in Heavy Industry

Final energy demand including power and fossil energies in Heavy Industry are inputted in the area. The final energy demand in the sector is forecasted by the following regression equation.

Energy demand=f(GDP in Heavy industry)

b. Energy conservation rate

Energy conservation rate in the actual term is 100%. The future energy conservation rate is calculated by "Change of energy prices and Ratio of technical improvement".

c. Technical Improvement

Energy consumption is saved by technical improvement. After the first oil crisis, Japan had energy conservation improvement with 2% per year. Most of the reasons are improvement of the production line and installation of new equipment. Both of them are included in technical improvement in the model.

d. Elasticity to Energy price

Another factor for energy conservation is energy price hikes. When energy prices and electricity tariffs increases, usually energy consumption is saved. According to Japanese experiences, energy demand elasticity to energy price is the ranges from –0.1 to –1.0. In the model, For Agriculture sector, the assumption of energy demand elasticity to energy price is –0.3.

e. Energy intensity to GDP

Energy intensity in Heavy industry sector to GDP is calculated by using energy demand in Heavy industry sector and GDP in the whole country. It is used for the evaluation of the future energy demand in Heavy industry sector.

f. Energy demand before energy saving

Energy demand in Heavy industry sector is forecasted in the area. First, the energy demand before energy conservation is calculated in the area.

g. Energy demand after energy saving

Energy demand after energy conservation in Heavy industry sector is forecasted in the area. It is calculated by using "energy demand before energy conservation and energy conservation rate".

h. Electricity ratio

Electricity ratio is an electricity share of the energy demand in Heavy industry sector. The ratio is exogenous. The values are estimated after referring other countries' electricity ratio.

Table 4-16 International Electricity ratio of Industry sector

Industry %

	1995	1996	1997	1998	1999	2000
Japan	26.5	26.8	27.1	27.4	26.7	26.6
Taiwan	22.1	22.2	22.9	23.3	24.4	26.2
Australia	20.3	19.9	20.0	21.4	21.9	22.0
Indonesia	12.4	11.9	14.3	13.8	13.9	12.9
Korea	19.0	19.6	19.4	19.2	19.4	20.0
China	5.1	5.3	5.5	5.8	6.0	6.1
Vietnam	12.8	14.1	13.4	14.0	15.1	17.0
Thailand	22.7	20.6	22.5	22.4	23.9	25.4
Malaysia	18.0	19.8	21.4	21.4	23.1	22.2
Pilippines	19.7	19.7	20.2	26.9	20.4	31.7

i. Power demand before energy saving

Power demand in Heavy industry sector is forecasted in the area. First, the power demand before energy conservation is calculated in the area.

j. Power demand after energy saving

Power demand after energy conservation in Heavy industry sector is forecasted in the area. It is calculated by "Power demand before energy conservation and Power conservation rate".

k. Fossil energy demand before adjusted

As fossil energies used in Heavy industry sector, Coal, Diesel, Fuel oil and Natural gas are calculated with total energy demand and fossil energy ratio in Heavy industry sector.

l. Fossil energy demand ratio

Fossil energy demand ratios are exogenous. The future values of fossil energy demand ratio are decided by the energy supply policies of Vietnam.

m. Fossil energy demand after adjusted

Fossil energy demands after adjusted are calculated with adjusting the total ratio to meet to 100.

(8) Energy demand in Transportation sector

Table 4-17 Structure of Energy demand in Transportation sector

F	H	I	Y	Type	X1	X2
380	Transportation	Energy demand in Transp sector	TRNNTOL	=	TRNNDEA+TRENELE	
381		Power ratio	TRENELR	=	TRENELR	
382	Energy demand	Energy conservation rate	TRNNCOR	=	Lag1.TRNNCOR*(1+TRNNTEC/100)*IF(GRPRDIE>0, (1+TRNNEVP*(GRPRDIE)/100), (1+TRNNEVP*(GRPRDIE)/100))	
383		Technical Improvement	TRNNTEC	=	TRNNTEC	
384		Elasticity to Energy price	TRNNEVP	=	TRNNEVP	
385		Energy intensity to GDP	TRNNEFF	=	TRNNDEA/RGDP*1000	
386		Energy demand before E.save	TRNNDEM	$CA	(PFTOGA+PFTODO+PFTOFO)/(TRNNCOR/100)	
387		Energy demand after E.save	TRNNDEA	=	TRNNDEM*TRNNCOR/100	
388	Power demand	Power conservation rate	TRENECO	=	Lag1.TRENECO*(1+TRENETE/100)*IF(GRPRELR>0, (1+TRENEEV*(GRPRELR)/100), (1+TRENEEV*(GRPRELR)/100))	
389		Technical Improvement	TRENETE	=	TRENETE	
390		Elasticity to Power price	TRENEEV	=	TRENEEV	
391		Power intensity to GDP	TRENELF	=	TRENELA/RGDP*1000	
392		Power demand before E.save(GWh)	TRENELE	$CA	PFRATT	
393		Power demand after E.save(GWh)	TRENELA	=	TRENELE*TRENECO/100	
394		Power demand (k TOE)	TRENELT	=	TRENELA*0.086	
395						
396	ED after Adjus	Coal demand	TRDMCOA	=	(TRNNDEA-TRDMREW)*TRSMCOA/100	
397		LPG demand	TRDMLPG	=	(TRNNDEA-TRDMREW)*TRSMLPG/100	
398		Gasoline demand	TRDMGAS	=	Lag1.TRDMGAS*(PFTOGA/Lag1.PFTOGA)	
399		Jetfuel demand	TRDMJET	=	Lag1.TRDMJET*(1+(0.9-(Time-2005)/100)*RGDPGR/100)	
400		Kerosene demand	TRDMKER	=	(TRNNDEA-TRDMREW)*TRSMKER/100	
401		Diesel demand	TRDMDIE	=	Lag1.TRDMDIE*(PFTODO/LAG1.PFTODO)	
402		Fuel oil demand	TRDMFUL	=	LAG1.TRDMFUL*(PFTOFO/LAG1.PFTOFO)	
403		Natural gas demand	TRDMNG	=	(TRNNDEA-TRDMREW)*TRSMNG/100	
404		Noncommercial energy demand	TRDMREW	=	TRDMREW	
405		Total	TRDMTOT	=	TRDMCOA+TRDMLPG+TRDMGAS+TRDMJET+TRDMKER+TRDMDIE+TRDMFUL+TRDMNG+TRDMREW	
406						
407	Energy shares	Coal demand	TRSMCOA	=	TRSMCOA	
408		LPG demand	TRSMLPG	=	TRSMLPG	
409		Gasoline demand	TRSMGAS	=	TRSMGAS	
410		Jetfuel demand	TRSMJET	=	TRSMJET	
411		Kerosene demand	TRSMKER	=	TRSMKER	
412		Diesel demand	TRSMDIE	=	TRSMDIE	
413		Fuel oil demand	TRSMFUL	=	TRSMFUL	
414		Natural gas demand	TRSMNG	=	TRSMNG	
415		Total	TRSMTOT	=	TRSMTOT	
416						
417	ED after Adju	Coal demand	TRAMCOA	=	TRDMCOA	
418		LPG demand	TRAMLPG	=	TRDMLPG	
419		Gasoline demand	TRAMGAS	=	TRDMGAS	
420		Jetfuel demand	TRAMJET	=	TRDMJET	
421		Kerosene demand	TRAMKER	=	TRDMKER	
422		Diesel demand	TRAMDIE	=	TRDMDIE	
423		Fuel oil demand	TRAMFUL	=	TRDMFUL	
424		Natural gas demand	TRAMNG	=	TRDMNG	
425		Noncommercial energy demand	TRAMREW	=		
426		Total	TRAMTOT	=	TRAMCOA+TRAMLPG+TRAMGAS+TRAMJET+TRAMKER+TRAMDIE+TRAMFUL+TRAMNG+TRAMREW	
427						

a. Energy conservation rate in Transportation sector

Energy conservation rate in the actual terms is 100%. The energy conservation rate is affected by "Changes of energy prices and Ratio of technical improvement".

b. Technical Improvement

Energy consumption is saved by technical improvement. Major factors for energy conservation in transportation are new technologies. Those are included in technical improvement.

c. Elasticity to Energy price

Another factor for energy conservation is energy price hikes. When energy prices increases, fuels in the sector are saved. According to Japanese experiences, energy demand elasticity to energy price in Transportation sector is the ranges from –0.1 to –1.0. In the model, For Transportation sector, the assumption of energy demand elasticity to energy price is –0.1.

d. Energy intensity to GDP

Energy intensity in Transportation sector to GDP is calculated by using energy demand in Transportation sector and GDP in the whole country. It is used for the evaluation of the future energy demand in Transportation sector.

e. Energy demand before Energy saving

Energy demand in Transportation sector is forecasted in the area. The energy demand before energy conservation is calculated in the area.

f. Energy demand after energy saving

Energy demand after energy conservation in Transportation sector is forecasted in the area.

g. Power ratio

Power ratio is an electricity share of the energy demand in Transportation sector. The ratio is exogenous. In the future, a subway is planned in Ho-Chi-Min city. Electricity for transportation sector will be supplied to the subway.

h. Power demand before energy conservation

Power demand is forecasted by the following Regression equation.

Power demand =f(Railway transportation).

i. Power demand after energy conservation

Power demand is forecasted with "Energy demand before energy conservation * Power conservation rate".

j. Fossil energy demand before adjusted

As fossil energies used in Transportation sector, Gasoline, Jet-fuel, Diesel, Fuel oil are calculated with total energy demand and fossil energy ratio in Transportation sector.

Gasoline is calculated from number of vehicle

Jet-fuel is calculated from Jet fuel ratio in the total fuel energies

Diesel is calculated from number of vehicle and consumption in Power sector

Fuel oil is calculated from number of vessel and consumption in Power sector

k. Fossil energy demand ratio

Fossil energy demand ratios are exogenous. The future values of fossil energy demand ratio are decided by the energy supply policies of Vietnam.

l. Fossil energy demand after adjusted

Fossil energy demands after adjusted are calculated with adjusting the total ratio to meet to 100.

(9) Energy demand in Commercial & Service sector

Table 4-18 Structure of Energy demand in Commercial & Service sector

F	H	I	Y	Type	X1	X2
428	Commercials & Service	Energy demand in Comm sector	COMNTOL	$CA	(RGPTRA+RGPSER)*(RGEGF/Lag1.RGEGF)	
429		Power ratio	COENELR	=	COENELR	
430	Energy demand	Energy conservation rate	COMNCOR	=	Lag1.COMNCOR*(1+COMNTEC/100)*IF(GRPRDIE>0, (1+COMNEVP*(GRPRDIE)/100), (1+COMNEVP*(GRPRDIE)/100))	
431		Technical Improvement	COMNTEC	=	COMNTEC	
432		Elasticity to Crude oil price	COMNEVP	=	COMNEVP	
433		Energy intensity to GDP	COMNEFF	=	COMNDEA/RGDP*1000	
434		Energy demand before E.save	COMNDEM	=	COMNTOL-COENELA/(COENECO/100)*0.086	
435		Energy demand after E.save	COMNDEA	=	COMNDEM*(COMNCOR/100)	
436	Power demand	Power conservation rate	COENECO	=	Lag1.COENECO*(1+COENETE/100)*IF(GRPRELC>0, (1+COENEEV*(GRPRELC)/100), (1+COENEEV*(GRPRELC)/100))	
437		Technical Improvement	COENETE	=	COENETE	
438		Elasticity to Power price	COENEEV	=	COENEEV	
439		Power intensity to GDP	COENELF	=	COENELA/RGDP*1000	
440		Power demand before E.save(GWh)	COENELE	=	(COMNTOL)/0.086*(COENELR/100)	
441		Power demand after E.save(GWh)	COENELA	=	COENELE*COENECO/100	
442		Power demand (kTOE)	COENELT	=	COENELA*0.086	
443						
444	ED before Adjust	Coal demand	CODMCOA	=	(COMNDEA-CODMREW)*COSMCOA/100	
445		LPG demand	CODMLPG	=	(COMNDEA-CODMREW)*COSMLPG/100	
446		Gasoline demand	CODMGAS	=	(COMNDEA-CODMREW)*COSMGAS/100	
447		Jetfuel demand	CODMJET	=	(COMNDEA-CODMREW)*COSMJET/100	
448		Kerosene demand	CODMKER	=	(COMNDEA-CODMREW)*COSMKER/100	
449		Diesel demand	CODMDIE	=	(COMNDEA-CODMREW)*COSMDIE/100	
450		Fuel oil demand	CODMFUL	=	(COMNDEA-CODMREW)*COSMFUL/100	
451		Natural gas demand	CODMNG	=	(COMNDEA-CODMREW)*COSMNG/100	
452		Noncommercial energy demand	CODMREW	=	CODMREW	
453		Total	CODMTOT	=	CODMCOA+CODMLPG+CODMGAS+CODMJET+CODMKER+CODMDIE+CODMFUL+CODMNG+CODMREW	
454						
455	Energy shares	Coal demand	COSMCOA	=	COSMCOA	
456		LPG demand	COSMLPG	=	COSMLPG	
457		Gasoline demand	COSMGAS	=	COSMGAS	
458		Jetfuel demand	COSMJET	=	COSMJET	
459		Kerosene demand	COSMKER	=	COSMKER	
460		Diesel demand	COSMDIE	=	COSMDIE	
461		Fuel oil demand	COSMFUL	=	COSMFUL	
462		Natural gas demand	COSMNG	=	COSMNG	
463		Total	COSMTOT	=	COSMTOT	
464						
465	ED after Adjust	Coal demand	COAMCOA	=	CODMCOA*(COMNDEA-CODMREW)/(CODMTOT-CODMREW)	
466		LPG demand	COAMLPG	=	CODMLPG*(COMNDEA-CODMREW)/(CODMTOT-CODMREW)	
467		Gasoline demand	COAMGAS	=	CODMGAS*(COMNDEA-CODMREW)/(CODMTOT-CODMREW)	
468		Jetfuel demand	COAMJET	=	CODMJET*(COMNDEA-CODMREW)/(CODMTOT-CODMREW)	
469		Kerosene demand	COAMKER	=	CODMKER*(COMNDEA-CODMREW)/(CODMTOT-CODMREW)	
470		Diesel demand	COAMDIE	=	CODMDIE*(COMNDEA-CODMREW)/(CODMTOT-CODMREW)	
471		Fuel oil demand	COAMFUL	=	CODMFUL*(COMNDEA-CODMREW)/(CODMTOT-CODMREW)	
472		Natural gas demand	COAMNG	=	CODMNG*(COMNDEA-CODMREW)/(CODMTOT-CODMREW)	
473		Noncommercial energy demand	COAMREW	=	CODMREW	
474		Total	COAMTOT	=	COAMCOA+COAMLPG+COAMGAS+COAMJET+COAMKER+COAMDIE+COAMFUL+COAMNG+COAMREW	
475						

a. Energy demand in Commercial & Service sector

Final energy demand including power and fossil energies in Commercial & Service sector are inputted in the area. The final energy demand in the sector is forecasted by the following regression equation.

Energy demand = f(GDP in Commercial & Service * (Fixed formation / Fixed Formation (1)))

b. Energy conservation rate in Commercial & Services sector

Energy conservation rate in the actual terms is 100%. The energy conservation rate is affected by "Changes of energy prices and Ratio of technical improvement".

c. Technical Improvement

Energy consumption is saved by technical improvement. Major reasons for energy conservation are installation of new equipment. Those are included in technical improvement.

c. Elasticity to Energy price

Another factor for energy conservation is energy price hikes. When energy prices increase, energies in the sector are saved. Energy demand elasticity to energy price is the ranges from –0.1 to –1.0. In the model, for Commercial & Services sector, the assumption of energy demand elasticity to energy price is –0.2.

e. Energy intensity to GDP

Energy intensity in Commercial & Services sector to GDP is calculated by using energy demand in Commercial & Services sector and GDP in the whole country. It is used for the evaluation of the future energy demand in Commercial & Services sector.

f. Energy demand before Energy saving

Energy demand in Commercial & Services sector is forecasted in the area. First, the energy demand before energy conservation is calculated in the area.

g. Energy demand after energy saving

Energy demand after energy conservation in Commercial & Services sector is forecasted in the area. It is calculated by "Energy demand before energy conservation and Energy conservation rate".

h. Power ratio

Power ratio is an electricity share of the energy demand in Commercial & Services sector. The ratio is exogenous. The values are estimated after referring other countries' electricity ratio.

Table 4-19 International Electricity ratio of Commercial & Residential sector

Commercial & Residential %

	1995	1996	1997	1998	1999	2000
Japan	43.9	43.9	45.4	47.1	47.8	44.8
Taiwan	64.5	63.6	65.9	66.2	65.8	67.2
Australia	52.3	53.0	53.7	54.4	55.3	55.5
Indonesia	3.8	4.3	4.8	5.3	5.4	5.8
Korea	18.0	19.3	21.0	25.7	24.0	27.6
China	6.3	7.0	8.0	9.5	10.0	10.0
Vietnam	30.5	29.9	33.5	35.9	35.7	35.6
Thailand	70.5	70.3	72.6	75.0	72.2	71.2
Malaysia	55.2	49.7	65.0	68.2	61.0	63.4
Pilippines	39.0	40.6	47.2	45.2	43.7	40.0

i. Power demand before energy saving

Power demand in Commercial & Services sector is forecasted in the area. First, the power demand before energy conservation is calculated in the area.

j. Power demand after energy saving

Power demand after energy conservation in Commercial & Services is forecasted in the area. It is calculated by "Power demand before energy conservation and Energy conservation rate".

k. Fossil energy demand before adjustment

As fossil energies used in Commercial & Services sector, Coal, LPG, Diesel and Kerosene are calculated with total energy demand and fossil energy ratio in Commercial & Services sector.

l. Fossil energy demand ratio

Fossil energy demand ratios are exogenous. The future values of fossil energy demand ratio are decided by the energy supply policies of Vietnam.

m. <u>Fossil energy demand after adjustment</u>

Fossil energy demands after adjustment are calculated with adjusting the total ratio to meet to 100

(10) Energy demand in Residential sector

Table 4-20 Structure of Energy demand in Residential sector

F	H	I	Y	Type	X1	X2
476	Residentials	Energy demand in Comm sector	RESNTOL	$CA	HHUBN*(RGEFC/POPNUM)	DUM.2005..
477		Power ratio(Exclusive Non-commerce)	RESNELR	=	RESNELR	
478	Energy demand	Energy conservation rate	RESNCOR	=	Lag1.RESNCOR*(1+RESNTEC/100)*IF(GRPLPG>0, (1+RESNEVP*(GRPLPG)/100),(1+RESNEVP*(GRPLPG)/100))	
479		Technical Improvement	RESNTEC	=	RESNTEC	
480		Elasticity to Energy price	RESNEVP	=	RESNEVP	
481		Energy intensity to GDP	RESNEFF	=	RESNDEA/RGDP*1000	
482		Energy demand before E.save	RESNDEM	=	RESNTOL-REENELA/(REENECO/100)*0.086	
483		Energy demand after E.save	RESNDEA	=	RESNDEM*(RESNCOR/100)	
484	Power demand	Power conservation rate	REENECO	=	Lag1.REENECO*(1+REENETE/100)*IF(GRPRELR>0,(1+REENEEV*(GRPRELR)/100), (1+REENEEV*(GRPRELR)/100))	
485		Technical Improvement	REENETE	=	REENETE	
486		Elasticity to Power price	REENEEV	=	REENEEV	
487		Power intensity to GDP	REENELF	=	REENELA/RGDP*1000	
488		Power demand before E.save(GWh)	REENELE	=	RESNTOL*(RESNELR/100)/0.086	
489		Power demand after E.save(GWh)	REENELA	=	REENELE*REENECO/100	
490		Power demand (k TOE)	REENELT	=	REENELA*0.086	
491						
492	ED before Adjust	Coal demand	REDMCOA	=	(RESNDEM-0)*RESMCOA/100	
493		LPG demand	REDMLPG	=	Lag1.REDMLPG+0.7*((RESNDEM-0)*RESMLPG/100-Lag1.REDMLPG)	
494		Gasoline demand	REDMGAS	=	(RESNDEM-0)*RESMGAS/100	
495		Jetfuel demand	REDMJET	=	(RESNDEM-0)*RESMJET/100	
496		Kerosene demand	REDMKER	=	(RESNDEM-0)*RESMKER/100	
497		Diesel demand	REDMDIE	=	(RESNDEM-0)*RESMDIE/100	
498		Fuel oil demand	REDMFUL	=	(RESNDEM-0)*RESMFUL/100	
499		Natural gas demand	REDMNG	=	Lag1.REDMNG+0.7*((RESNDEM-0)*RESMNG/100-Lag1.REDMNG)	
500		Noncommercial energy demand	REDMREW	=	Lag1.REDMREW*(POPNUM-POPUBN)/(Lag1.POPNUM-LAG1.POPUBN)-(RESNDEA-Lag1.RESNDEA)*0.20*5	
501		Total	REDMTOT	=	REDMCOA+REDMLPG+REDMGAS+REDMJET+REDMKER+REDMDIE+REDMFUL+REDMNG+REDMREW	
502						
503	Energy shares	Coal demand	RESMCOA	=	RESMCOA	
504		LPG demand	RESMLPG	=	RESMLPG	
505		Gasoline demand	RESMGAS	=	RESMGAS	
506		Jetfuel demand	RESMJET	=	RESMJET	
507		Kerosene demand	RESMKER	=	RESMKER	
508		Diesel demand	RESMDIE	=	RESMDIE	
509		Fuel oil demand	RESMFUL	=	RESMFUL	
510		Natural gas demand	RESMNG	=	RESMNG	
511		Total	RESMTOT	=	RESMTOT	
512						
513	ED after Adjust	Coal demand	REAMCOA	=	REDMCOA*(RESNDEA-0)/(RESNDEM-0)	
514		LPG demand	REAMLPG	=	REDMLPG*(RESNDEA-0)/(RESNDEM-0)	
515		Gasoline demand	REAMGAS	=	REDMGAS*(RESNDEA-0)/(RESNDEM-0)	
516		Jetfuel demand	REAMJET	=	REDMJET*(RESNDEA-0)/(RESNDEM-0)	
517		Kerosene demand	REAMKER	=	REDMKER*(RESNDEA-0)/(RESNDEM-0)	
518		Diesel demand	REAMDIE	=	REDMDIE*(RESNDEA-0)/(RESNDEM-0)	
519		Fuel oil demand	REAMFUL	=	REDMFUL*(RESNDEA-0)/(RESNDEM-0)	
520		Natural gas demand	REAMNG	=	REDMNG*(RESNDEA-0)/(RESNDEM-0)	
521		Noncommercial energy demand	REAMREW	=	REDMREW	
522		Total	REAMTOT	=	REAMCOA+REAMLPG+REAMGAS+REAMJET+REAMKER+REAMDIE+REAMFUL+REAMNG+REAMREW	
523						

<u>a. Energy demand in Residential sector</u>

Final energy demand including power, fossil energies and non-commercial energy in Residential sector are inputted in the area. The final energy demand exclusive non-commercial energy is forecasted by the following regression equation.

Energy demand =f(Household in Urban * (Private consumption / Population, Dummy 2005)

<u>b. Energy conservation rate in Residential sector</u>

Energy conservation rate in the actual terms is 100%. The energy conservation rate is affected by "Changes of energy prices and Ratio of technical improvement".

c. Technical Improvement

Energy consumption is saved by technical improvement. Major reasons for energy conservation are installation of new equipment. Those are included in technical improvement.

ｄ. Elasticity to Energy price

Another factor for energy conservation is energy price hikes. When energy prices and electricity tariffs increases, energy consumption in the sector are saved. Energy demand elasticity to energy price is the ranges from –0.1 to –1.0. In the model, for Residential sector, the assumption of energy demand elasticity to energy price is –0.1.

e. Energy intensity to GDP

Energy intensity in Residential sector to GDP is calculated by using energy demand in Residential sector and GDP in the whole country. It is used for the evaluation of the future energy demand in Residential sector.

f. Energy demand before Energy saving

Energy demand in Residential sector is forecasted in the area. First, the energy demand before energy conservation is calculated in the area.

g. Energy demand after energy saving

Energy demand after energy conservation in Residential sector is forecasted in the area. It is calculated by "Energy demand before energy conservation and Energy conservation rate".

h. Power ratio

Power ratio is an electricity share of the energy demand in Residential sector. The ratio is exogenous. The values are estimated after referring other countries' electricity ratio. (Refer to table 4-19)

i. Power demand before energy saving

Power demand in Residential sector is forecasted in the area. First, the power demand before energy conservation is calculated in the area.

j. Power demand after energy saving

Power demand after energy conservation in Residential sector is forecasted in the area. It is calculated by "Power demand before energy conservation and Power conservation rate".

k. Fossil energy demand before adjusted

As fossil energies used in Residential sector, Coal, LPG, Kerosene and Diesel are calculated with total energy demand and fossil energy ratio in Residential sector .

Non-commercial energy demand is forecasted by the following expression.

Non commercial = Non-commercial(1)*(Rural population) / (Rural population(1))

- (Energy demand in Residential - (Energy demand in Residential(1))*0.20*5

Where 0.20 : 20% of incremental energy demand in Residential replaces Non-commercial

5 : Fossil energy is 5 times more efficient to Non–commercial energy

l. Fossil energy demand ratio

Fossil energy demand ratios are exogenous. The future values of fossil energy demand ratio are decided by the energy supply policies of Vietnam.

m. Fossil energy demand after adjusted

Fossil energy demands after adjusted are calculated with adjusting the total ratio to meet to 100

(11) Results area for Power demand and energy demand in the whole sectors

Table 4-21 Results area for Power demand and energy demand in the whole sectors

F	H	I	Y	Type	X1	X2
524	Power demand	Agriculture.Forestry.Fishery	PWDMPA	=	PAENELA	
525	in final use	Industry Light	PWDMMN	=	MAENELA	
526		Industry Heavy	PWDMMH	=	NOENELA	
527		Transportation	PWDMTR	=	TRENELA	
528		Commercials.Banking..Services.	PWDMCM	=	COENELA	
529		Residentials	PWDMRE	=	REENELA	
530		Other	PWDMNO	=	Lag1.PWDMNO*(1+0.7*(RGDPGR)/100)	
531		Total	PWDMTOT	=	PWDMPA+PWDMMN+PWDMMH+PWDMTR+PWDMCM+PWDMRE+PWDMNO	
532						
533	Energy Demand	Coal demand	DEDCOA	=	PAAMCOA+MAAMCOA+TRAMCOA+COAMCOA+REAMCOA+NOAMCOA	
534		LPG demand	DEDLPG	=	PAAMLPG+MAAMLPG+TRAMLPG+COAMLPG+REAMLPG+NOAMLPG	
535		Gasoline demand	DEDGAS	=	PAAMGAS+MAAMGAS+TRAMGAS+COAMGAS+REAMGAS+NOAMGAS	
536		Jetfuel demand	DEDJET	=	PAAMJET+MAAMJET+TRAMJET+COAMJET+REAMJET+NOAMJET	
537		Kerosene demand	DEDKER	=	PAAMKER+MAAMKER+TRAMKER+COAMKER+REAMKER+NOAMKER	
538		Diesel demand	DEDDIE	=	PAAMDIE+MAAMDIE+TRAMDIE+COAMDIE+REAMDIE+NOAMDIE	
539		Fuel oil demand	DEDFUE	=	PAAMFUL+MAAMFUL+TRAMFUL+COAMFUL+REAMFUL+NOAMFUL	
540		Petroleum total	DEDSTO	=	DEDLPG+DEDGAS+DEDJET+DEDKER+DEDDIE+DEDFUE	
541		Natural gas demand	DEDNG	=	PAAMNG+MAAMNG+TRAMNG+COAMNG+REAMNG+NOAMNG	
542		Noncommercial energy demand	DEDREW	=	PAAMREW+MAAMREW+TRAMREW+COAMREW+REAMREW+NOAMREW	
543		Power	DEDPOW	=	PWDMTOT*0.086	
544		Total(Coal+Petro+Renew+Power)	DEDTOT	=	DEDCOA+DEDSTO+DEDREW+DEDPOW+DEDNG	
545						

a. Power demand in final use

The power demands by sector are forecasted in sectoral energy demand blocks. For making the total power demand in a country, the power demands of all sectors are summed up.

b. Energy Demand

Final energy demands by sector are forecasted in sectoral energy demand blocks. For making the total final energy demand in a country, final energy demands of all sectors are summed up by energy.

(12) Power supply and Power resources

Table 4-22 Structure of Power supply and Power resources

F	H	I	Y	Type	X1	X2
546	Power supply	Power distribution loss	PWGELOR	=	PWGELOR	
547		Demand, Generation Gap	PWOWNOR	=	PWOWNOR	
548		Power distribution loss (GWh)	PWLOSSG	=	(PWDMTOT*Lag1.PWDERAT-PWOWNG)*PWGELOR/100	
549		Own use in Power sector(GWh)	PWOWNG	=	(PWDMTOT*Lag1.PWDERAT)*PWOWNOR/100	
550		Power distribution loss (KTOE)	PWLOSST	=	PWLOSSG*0.086	
551		Own use in Power sector(KTOE)	PWOWNT	=	PWOWNG*0.086	
552						
553		Power from Hydro	PWGEHYD	=	PWGEHYD	
554		Power from Fossil	PWGEFOS	=	PWGETOT-PWGEHYD-PWGEBAL-PWGENEW-PWGENCL	
555		Power foreign trade balance	PWGEBAL	=	PWGEBAL	
556		Power from Renewable energy	PWGENEW	=	PWGENEW	
557		Power from Nuclear	PWGENCL	=	PWGENCL	
558		Total of power generation	PWGETOT	=	PWDMTOT+PWLOSSG+PWOWNG	
559		(Generation/Demand)	PWDERAT	=	PWGETOT/PWDMTOT	
560		Power from Thermal(Coal)	PWGECOA	=	PWGEFOS*PWSCCOA/100	
561		Power from Thermal(FO)	PWGEFOT	=	PWGEFOS*PWSCFOT/100	
562		Power from Gasturbine(FO)	PWGEFOB	=	PWGEFOS*PWSCFOB/100	
563		Power from Gasturbine(GAS)	PWGEGAB	=	PWGEFOS*PWSCGAT/100	
564		Power from Gas steam	PWGEGAS	=	PWGEFOS*PWSCGAB/100	
565		Power from Diesel	PWGEDIE	=	PWGEFOS*PWSCDIE/100	
566		Power from Fossil	PWGEFTT	=	PWGECOA+PWGEFOT+PWGEFOB+PWGEGAB+PWGEGAS+PWGEDIE	
567						
568	Power resources	Coal consumption for Thermal	PWCCCOA	=	PWGECOA*(860/10000)/COPOCOA	
569		FO consumption for Thermal	PWCCFOT	=	PWGEFOT*(860/10000)/COPOFOT	
570		FO consumption for Gasturbine	PWCCFOB	=	PWGEFOB*(860/10000)/COPOFOB	
571		NG & AG consumption for Turbine	PWCCGAT	=	PWGEGAB*(860/10000)/COPOGAB	
572		NG & AG consumption for Gas steam	PWCCGAB	=	PWGEGAS*(860/10000)/COPODAS	
573		Diesel consumption for Diesel engine	PWCCDIE	=	PWGEDIE*(860/10000)/COPODIE	
574		Total	PWCCTOT	=	PWCCCOA+PWCCFOT+PWCCFOB+PWCCGAT+PWCCGAB+PWCCDIE	
575						
576		Power from Thermal(Coal)	PWSCCOA	=	PWSCCOA	
577		Power from Thermal(FO)	PWSCFOT	=	PWSCFOT	
578		Power from Gasturbine(FO)	PWSCFOB	=	PWSCFOB	
579		Power from Gasturbine(GAS)	PWSCGAT	=	PWSCGAT	
580		Power from Gas steam	PWSCGAB	=	PWSCGAB	
581		Power from Diesel	PWSCDIE	=	PWSCDIE	
582		Power from Fossil	PWSCTOT	=	PWSCTOT	
583						

a. Power Transmission and distribution loss in Power sector

T/D loss is calculated by using "T/D lose rate and power demand". The T/D lose rate is exogenous and the future rates planned by EVN are selected. The actual values of T/D loss are inputted in the actual term. The future power distribution losses are calculated by the following expression.

T/D loss =Power demand * Power loss rate.

b. Power supply

The total power generation is calculated by the following expression.

The total power generation = Power demand + Power T/D loss

As Hydro power, Nuclear power, Power from Renewable energy and Purchasing power from abroad are exogenous, thermal power generation is calculated by the following expression.

Thermal power generation = Total power generation

- Hydro power generation - Nuclear power generation

- Power from Renewable energy - Purchasing power from abroad

c. Thermal power generation by generator

Thermal power generation by generator is calculated by using "Thermal power generation and Shares of the thermal power generators". As the thermal power generator, the six thermal power generators that are Coal fired power station, Fuel oil fired power station, Fuel oil gas –turbine, Gas turbine, Gas steam and Diesel engine are prepared.

d. Power Resources

Coal, Fuel oil, Natural gas and Diesel are consumed in the power stations. The fuels are calculated in line with generation of the thermal power stations. Types of the thermal power stations are follows;

Coal consumption for Thermal	Fuel consumption for Thermal
Fuel consumption for Gas-turbine	NG & AG consumption for Turbine
NG & AG consumption for Gas steam	Diesel consumption for Diesel engine

e. Shares of Thermal power generation by generator

The shares of thermal power generator are calculated in "Power sheet". And the values are set in the future area. The thermal power generation is calculated in line with the share of the thermal power generators.

(13) Results area for Energy demand by energy

Table 4-23 Results area for Energy demand by energy

F	H	I	Y	Type	X1	X2
584	Coal total demand	Final demand	COACDEM	=	DEDCOA	
585		Consumption in Power sector	COACPOW	=	PWCCCOA	
586		Domestic total	COACDTO	=	COACDEM+COACPOW	
587						
588	LPG demand	Final demand	LPGCDEM	=	DEDLPG	
589		Consumption in Power sector	LPGCPOW	=		
590		Domestic total	LPGCTOT	=	LPGCDEM+LPGCPOW	
591						
592	Gasoline demand	Final demand	GASCDEM	=	DEDGAS	
593		Consumption in Power sector	GASCPOW	=		
594		Domestic total	GASCTOT	=	GASCDEM+GASCPOW	
595						
596	Jetfuel demand	Final demand	JETCDEM	=	DEDJET	
597		Consumption in Power sector	JETCPOW	=		
598		Domestic total	JETCTOT	=	JETCDEM+JETCPOW	
599						
600	Kerosene demand	Final demand	KERCDEM	=	DEDKER	
601		Consumption in Power sector	KERCPOW	=		
602		Domestic total	KERCTOT	=	KERCDEM+KERCPOW	
603						
604	Diesel demand	Final demand	DIECDEM	=	DEDDIE	
605		Consumption in Power sector	DIECPOW	=	PWCCDIE	
606		Domestic total	DIECTOT	=	DIECDEM+DIECPOW	
607						
608	Fuel oil demand	Final demand	FULCDEM	=	DEDFUE	
609		Consumption in Power sector	FULCPOW	=	PWCCFOT+PWCCFOB	
610		Domestic total	FULCTOT	=	FULCDEM+FULCPOW	
611						
612	NG & AG demand	Final demand	NAGCDEM	=	DEDNG	
613		Consumption in Power sector	NAGCPOW	=	PWCCGAT+PWCCGAB	
614		Domestic total	NAGCTOT	=	NAGCDEM+NAGCPOW	
615						
616	Noncommercial energy dema	Final demand	OTHCDEM	=	DEDREW	
617		Consumption in Power sector	OTHCPOW	=		
618		Domestic total	OTHCTOT	=	OTHCDEM+OTHCPOW	
619						
620	Other petroleum	Final demand	OPETDEM	=	OPETDEM	
621		Consumption in Power sector	OPETPOW	=		
622		Domestic total	OPETTOT	=	OPETDEM+OPETPOW	
623						
624	Energy Demand	Domestic final demand	EGSCDFD	=	COACDEM+LPGCDEM+GASCDEM+JETCDEM+KERCDEM+DIECDEM+FULCDEM+NAGCDEM +OTHCDEM+OPETDEM	
625		Consumption in Power sector	EGSCPOW	=	PWCCTOT	
626		Domestic Energy Demand	EGSCTOT	=	EGSCDFD+EGSCPOW	
627						
628	Energy Demand	Domestic final demand	WGSCDFD	=	COACDEM+LPGCDEM+GASCDEM+JETCDEM+KERCDEM+DIECDEM+FULCDEM+NAGCDEM +OPETDEM	
629	Without Renewable &	Consumption in Power sector	WGSCPOW	=	EGSCPOW	
630		Domestic Energy Demand	WGSCTOT	=	WGSCDFD+WGSCPOW	
631						

The above energy demands do not include export.

LPG, Gasoline, Jet fuel, Kerosene, Non-commercial energy and other energy demands are consisted of sectoral final demand.

Coal, Diesel, Fuel oil and Natural gas & AG are consisted of sectoral final demand and fuel consumption in Power sector.

4.3 Summary of Simulation Results

Summary of Simulation Results are described in Summary Sheet. Power demand, Final energy demand and Primary energy demand are shown.

(1) Summary of power demand by sector

The power demands by sector are brought from Simulation sheet. The trends of the actual and forecasting values by Agriculture, Light industry, Heavy Industry Transportation, Commercials & Service, Residential and other sector are shown.

Table 4-24 Summary of power demand by sector

			2005	2010	2015	2020	2025	25/05
Power demand	(1)Agriculture	GWh	574	1,034	1,441	1,916	2,683	8.0
in Final use	(2)Industry (Light)	GWh	17,248	33,769	51,365	84,582	121,804	10.3
	(3)Industry (Heavy)	GWh	4,054	6,109	8,799	12,197	16,057	7.1
	(4)Transportation	GWh	337	738	1,145	1,765	2,563	10.7
	(5)Commercials & Service	GWh	2,162	4,565	7,682	11,663	17,933	11.2
	(6)Residentials	GWh	19,831	37,745	59,382	88,214	128,130	9.8
	(7)Others	GWh	1,397	1,764	2,355	3,144	4,129	5.6
	Total	GWh	45,603	85,723	132,169	203,481	293,299	9.8
Shares	(1)Agriculture	%	1.3	1.2	1.1	0.9	0.9	
	(2)Industry (Light)	%	37.8	39.4	38.9	41.6	41.5	
	(3)Industry (Heavy)	%	8.9	7.1	6.7	6.0	5.5	
	(4)Transportation	%	0.7	0.9	0.9	0.9	0.9	
	(5)Commercials & Service	%	4.7	5.3	5.8	5.7	6.1	
	(6)Residentials	%	43.5	44.0	44.9	43.4	43.7	
	(7)Others	%	3.1	2.1	1.8	1.5	1.4	
	Total	%	100.0	100.0	100.0	100.0	100.0	
Elasticity	Total		2.0	1.6	1.1	1.1	0.9	1.2

(2) Summary of final energy demand by sector without Non-commercial energy

The final energy demand by sector are brought from Simulation sheet. The trends of the actual and forecasting values by Agriculture, Light industry, Heavy Industry Transportation, Commercials & Service, Residential and other sector are shown in the table, Non-commercial energies are not included..

Table 4-25 Summary of final energy demand by sector without Non-commercial energy

			2005	2010	2015	2020	2025	25/05
Energy demand	(1)Agriculture	KTOE	570	716	830	946	1,159	3.6
without Noncommercial	(2)Industry (Light)	KTOE	5,626	8,903	14,452	24,822	36,661	9.8
	(3)Industry (Heavy)	KTOE	4,922	6,638	8,586	10,883	13,296	5.1
	(4)Transportation	KTOE	6,687	9,592	12,708	16,549	20,781	5.8
	(5)Commercials & Service	KTOE	1,322	1,874	2,410	2,974	3,868	5.5
	(6)Residentials	KTOE	3,341	5,325	7,529	10,435	14,535	7.6
	(7)Others	KTOE	120	152	203	270	355	5.6
	Total	KTOE	22,590	33,199	46,717	66,880	90,655	7.2
Shares	(1)Agriculture	%	2.5	2.2	1.8	1.4	1.3	
	(2)Industry (Light)	%	24.9	26.8	30.9	37.1	40.4	
	(3)Industry (Heavy)	%	21.8	20.0	18.4	16.3	14.7	
	(4)Transportation	%	29.6	28.9	27.2	24.7	22.9	
	(5)Commercials & Service	%	5.9	5.6	5.2	4.4	4.3	
	(6)Residentials	%	14.8	16.0	16.1	15.6	16.0	
	(7)Others	%	0.5	0.5	0.4	0.4	0.4	
	Total	%	100.0	100.0	100.0	100.0	100.0	
Elasticity	Total		1.7	0.9	0.8	0.9	0.8	0.9

(3) Summary of final energy demand by sector with Non-commercial energy

The table format is the same as the above , Non-commercial energies are included..

Table 4-26 Summary of final energy demand by sector with Non-commercial energy

			2005	2010	2015	2020	2025	25/05
Energy demand	(1)Agriculture	KTOE	570	716	830	946	1,159	3.6
with Noncommercial	(2)Industry (Light)	KTOE	8,763	12,040	17,589	27,959	39,798	7.9
	(3)Industry (Heavy)	KTOE	4,922	6,638	8,586	10,883	13,296	5.1
	(4)Transportation	KTOE	6,687	9,592	12,708	16,549	20,781	5.8
	(5)Commercials & Service	KTOE	1,322	1,874	2,410	2,974	3,868	5.5
	(6)Residentials	KTOE	14,898	16,494	18,297	20,583	23,516	2.3
	(7)Others	KTOE	120	152	203	270	355	5.6
	Total	KTOE	37,284	47,505	60,622	80,165	102,773	5.2
Shares	(1)Agriculture	%	1.5	1.5	1.4	1.2	1.1	
	(2)Industry (Light)	%	23.5	25.3	29.0	34.9	38.7	
	(3)Industry (Heavy)	%	13.2	14.0	14.2	13.6	12.9	
	(4)Transportation	%	17.9	20.2	21.0	20.6	20.2	
	(5)Commercials & Service	%	3.5	3.9	4.0	3.7	3.8	
	(6)Residentials	%	40.0	34.7	30.2	25.7	22.9	
	(7)Others	%	0.3	0.3	0.3	0.3	0.3	
	Total	%	100.0	100.0	100.0	100.0	100.0	
Elasticity	Total		0.9	0.6	0.6	0.7	0.6	0.6

(4)) Summary of final energy demand by energy

The final energy demand by energy is brought from Simulation sheet. The trends of the actual and forecasting values by Agriculture, Light industry, Heavy Industry Transportation, Commercials & Service, Residential and other sector are shown in the table, Non-commercial energies are included..

Table 4-27 Summary of final energy demand by energy

			2005	2010	2015	2020	2025	25/05
Final Energy demand	Coal demand	KTOE	6,133	7,690	9,550	12,015	14,094	4.2
	LPG demand	KTOE	963	1,971	3,641	6,475	10,355	12.6
	Gasoline demand	KTOE	2,687	3,697	4,516	5,491	6,657	4.6
	Jetfuel demand	KTOE	534	736	1,031	1,415	1,872	6.5
	Kerosene demand	KTOE	332	342	373	423	511	2.2
	Diesel demand	KTOE	5,149	7,456	10,294	14,089	18,301	6.5
	Fuel oil demand	KTOE	1,616	2,020	2,742	3,939	5,295	6.1
	Natural gas demand	KTOE	1,254	1,916	3,204	5,534	8,346	9.9
	Power	KTOE	3,922	7,372	11,367	17,499	25,224	9.8
	Commercial Total	KTOE	22,590	33,199	46,717	66,880	90,655	7.2
	Non commercial	KTOE	14,694	14,305	13,905	13,285	12,119	-1.0
	Energy Total	KTOE	37,284	47,505	60,622	80,165	102,773	5.2
Shares	Coal demand	%	27.1	23.2	20.4	18.0	15.5	
	LPG demand	%	4.3	5.9	7.8	9.7	11.4	
	Gasoline demand	%	11.9	11.1	9.7	8.2	7.3	
	Jetfuel demand	%	2.4	2.2	2.2	2.1	2.1	
	Kerosene demand	%	1.5	1.0	0.8	0.6	0.6	
	Diesel demand	%	22.8	22.5	22.0	21.1	20.2	
	Fuel oil demand	%	7.2	6.1	5.9	5.9	5.8	
	Natural gas demand	%	5.6	5.8	6.9	8.3	9.2	
	Power	%	17.4	22.2	24.3	26.2	27.8	
	Commercial Total	%	100.0	100.0	100.0	100.0	100.0	
	Non commercial	%	39.4	30.1	22.9	16.6	11.8	
	Energy Total	%	100.0	100.0	100.0	100.0	100.0	
Elasticity	Total		1.7	0.9	0.8	0.9	0.8	

(5) Intensity by sector

The intensities are calculated by the following expressions**.**

Manufacturing(Agriculture +Light industry +Heavy Industry) sector

--> Final energy consumption to GDP. in the sector,

Passenger transportation

--> Gasoline consumption to Million Passenger km

Freight transportation

--> Diesel consumption in transportation sector to Million ton km

Commercial & Service

--> Final energy consumption to GDP. in the sector

Residential sector

--> Final consumption to 1000Person

Total energy consumption

--> Final energy consumption in the country to GDP

Table 4-28 Structure of Intensity by sector

			2005	2010	2015	2020	2025	25/00
Intensity	Manufacturinng	toe/ BillionDon	114.1	92.3	74.2	62.2	53.0	-3.03
	Passenger	Gas-ton/ Million passenger km	9.4	7.5	5.3	3.8	2.9	-4.32
	Freight	Diesel-ton/ Million ton km	90.4	89.1	83.5	76.4	69.1	-1.03
	Commercial Services	toe/ BillionDon	3.2	2.9	2.5	2.1	1.8	-2.85
	Residential	toe/ 1000 person	179.3	187.9	197.4	210.2	230.8	1.33
	Total	toe / Billion Don	44.5	37.7	32.0	28.1	24.6	-2.47

Chapter 5. Simple E and PC configuration

5.1 Compatible software for Simple E

Simple E. (*Simple Econometric Simulation System*) has been developed to assist econometric modeling to concentrate on data preparation and model specifications. The processes of regression and forecast simulation are automated to the maximum possible extent. The increasing popularity of data manipulation in spreadsheets with the emergence of powerful PCs and sophisticated spreadsheet software has resulted in the increasing pressure to perform analysis within the spreadsheet itself. *Simple E.* was designed in response to this need; this software is designed to be fully compatible with a spreadsheet.

Simple E. is an ***Add-In* application for *Microsoft Excel 2000-2003***. It exploits all the advantages of the native spreadsheet functions as well as the open interfaces with other *Windows* applications. Simultaneously, it integrates the processes of data input, modeling, testing, and forecast simulations. It requires no programming. The graphical and visual operations make *Simple E.* easy to use and learn. The users can concentrate on the most demanding tasks of modeling and simulations with the advantages of full transparency and compatibility with other data and program interfaces within ***Windows***.(2000, XP).

Simple E. is equipped with various estimation options such as ordinary least square (OLS), auto-regression, and non-linear estimation method. Groups (systems) of equations can include various forms of regression models and defined equations. Each time series variable or its model is assigned to one row of worksheets. Each time period or each case of variables is assigned to one column of worksheets. Therefore, the number of equations or models can extend up to 65534 depending on the limit of the number of spreadsheet rows. The number of cases or observations for each variable can extend up to 245 depending on the limit of the number of spreadsheet columns.

5.2 Installation and Un-installation

(1) Installation

a) Copy "*Simple_E.xla*" to your favorite hard disk directory.
b) Open "Add-In" menu from "Tools" menu in *MS-Excel*. (Figs. 5-1 and 5-2)
c) If "*Simple_E.xla*" has been copied to the "Library" directory of *MS-Office* (C:¥Program Files¥Microsoft Office¥Office¥Library¥), you can find *Simple_E.* in the "Add-In" Menu. Otherwise, open "Browse" to find and select *Simple_E.*
d) Check the box next to *Simple_E.* in the "Add-In" menu and click "OK." (Fig. 5-2)

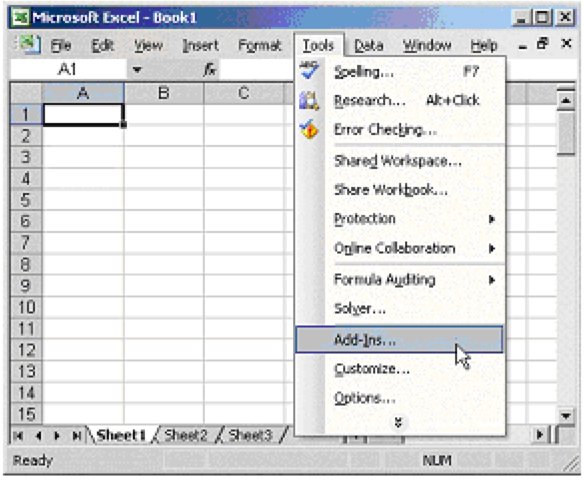


Fig. 5-1 "Tools" menu of Excel

Fig. 5-2 "Add-In" menu of Excel

The program *Simple E.* will be loaded and the five buttons of the *Simple E.* toolbar will be displayed at the upper-left corner of the screen as follows:

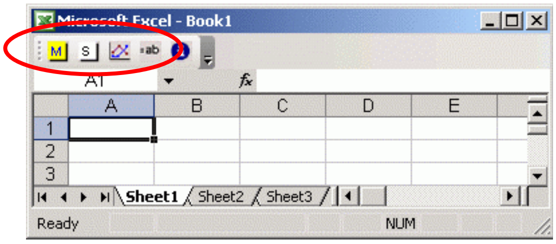


Fig. 5-3 *Simple E.* Toolbar

(2) Un-installation

a) To uninstall, uncheck the checkbox for *Simple_E.* in the "Add-In" menu and click "OK." The program will be uninstalled and the toolbar will disappear.

b) To remove the program, delete or remove the program from the directory in which it was installed and delete *Simple_E.* from the "Add-In" menu.

Appendix-5

Manual for Energy Supply/Demand Optimization Model

- Contents -

1 Summary of Supply and Demand Optimization Model

1.1 Objectives

The objective of the energy demand and supply optimization model (hereinafter called as the "optimization model") is to calculate a logically correct and consistent supply and demand balance of various energies. Demand is forecasted by the demand forecasting model and given to this model as input data. This optimization model decides the amount of each energy supply with minimum total cost under the condition that the given demand should be satisfied. Linear Programming theory is used as the optimization method. Furthermore, this optimization model can be used as a tool for examination how the energy balance would change under various conditions. In order to facilitate easy comparison study, the program is designed to produce summary sheets of the calculation results.

1.2 Objectives of Optimization Model

1.2.1Objective energies

Since the objective of developing the optimization model is to provide basis for formulating the Energy Master Plan of Vietnam, any energy to be used in the country in principle becomes the objective of this optimization model. Thus, 38 types of energy are incorporated in this model, which are as follows.

・Crude oil : Domestic crude oil 1, Import crude oil 4（Dubai, Sumatra light, Arabian light, Arabian heavy）

・Coal: Domestic (raw coal, high quality coal, medium quality coal, low quality coal)
Import (import coal)

・Gas: domestic (raw gas) and import (PNG, LNG)

・Petroleum products : LPG, LPG substitute（kerosene）,gasoline, Light naphtha, kerosene, jet fuel, gas oil, heavy oil, bitumen

・by product at refinery : off gas, whole range naphtha, heavy naphtha, condensate, raw kerosene, fine kerosene, raw gas oil, fine gas oil, atmosphere residue by feed, vacuum gas oil, vacuum residue, light cycle oil

・electricity

・Renewable energy

・bio (bio-ethanol, bio diesel)

1.2.2 Objective facilities(（Energy transforming facilities）

Four kinds of energy transforming facilities are incorporated in the model; they are oil refinery, power plant, coal plant (preparation) and gas processing plant.

- Oil refinery

An oil refinery composes of topper (atmospheric pressure distillation unit), vacuum distillation unit, reformer, cracking unit, hydro-desulfurization unit, and etc. They make up an oil refinery as a package. This model contains the first refinery currently under construction, the second refinery under designing, the third refinery under study, plus hypothetical No4, 5, 6 oil refineries.

- Power Plants

Power plants are classified into eight kinds based on the energy source as follows.

Hydro, domestic coal, import coal, gas, fuel oil, diesel, nuclear, and renewable energies

- Coal Preparation Plant (coal processing)

  At a preparation plant, raw coal will be separated into high-, medium- and low-quality coals. 10% of the raw coal will be void as waste.

- Gas Processing Plant

  At the gas processing plant, raw natural gas sent from offshore is processed. At first, condensate (C5+) is extracted and then the rest of the gas will be separated into LPG (C3, C4) and natural gas (C1, C2).

1.2.3 Objective period

The objective period is 21 years from 2005 through 2025 to be covered by the Master Plan.

1.2.4 Decision items

These items are called as variables in the optimization model. The optimization model shall decide the value of these variables in order that the objective function gives the optimum value. These variables are typically production, consumption, import, export and cost of each energy items. The energy consumption quantity calculated by the model indicates the quantity fed to each transformation plant plus those straightly directed to the final consumption.

1.2.5 Objective function

In the standard case such as the Reference Case, the objective function is defined as the net present value at 2005 of the total cost incurred during the projection period. This objective function can be defined applying other criterion subject to the purpose of analysis.

1.3 Energy flow

Energy flow is the basic information in compiling an optimization model and is supposed to explain the current and future energy flow of Vietnam. Of course, consideration is made on simplification and easiness to understand. Primary energy is produced from mines or oil/gas fields and transformed to secondary energies before delivered to the users via several routes and finally consumed. The energy flow chart illustrates such flow of energy. As it is difficult to show all of them in one figure, they are shown in several figures stage by stage hierarchically in Figure1.1-1～Figure1.1-4.

1.3.1 Total model flow

Fig1.1-1 shows the total flow incorporated in this optimization model. This figure shows that demand data is given as input from the result separately forecasted by the Energy Demand Forecasting model.

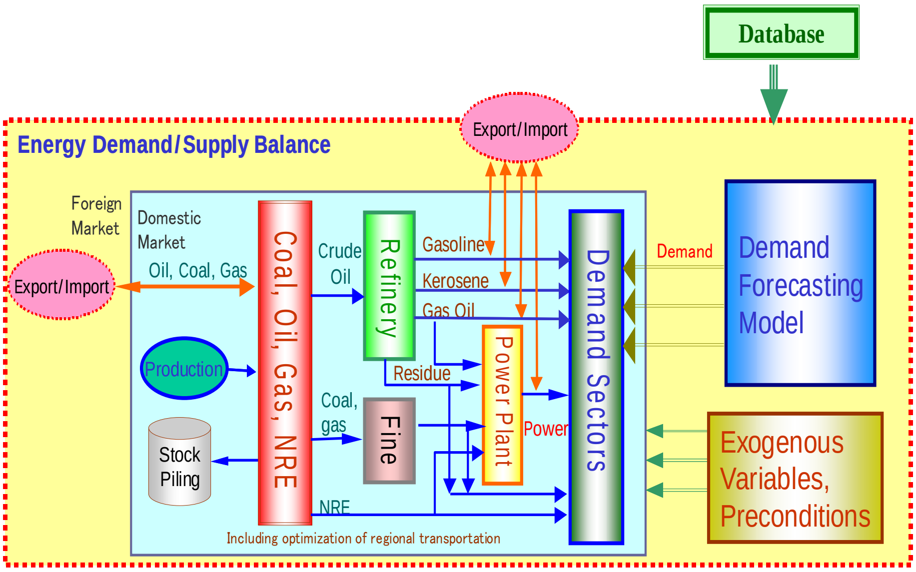


Fig1.1-1 Energy demand and supply optimization model total flow

1.3.2 Model flow by energy sector

The refinery part is composed of six plants from No1 to No6. Fig1.1-2 represents the process flow of the first refinery currently under construction at Dung Quat. Fig1.1-3 shows the hypothetical flow of No.3 through No.6 refineries incorporated in the model assuming processing of import crude oils.

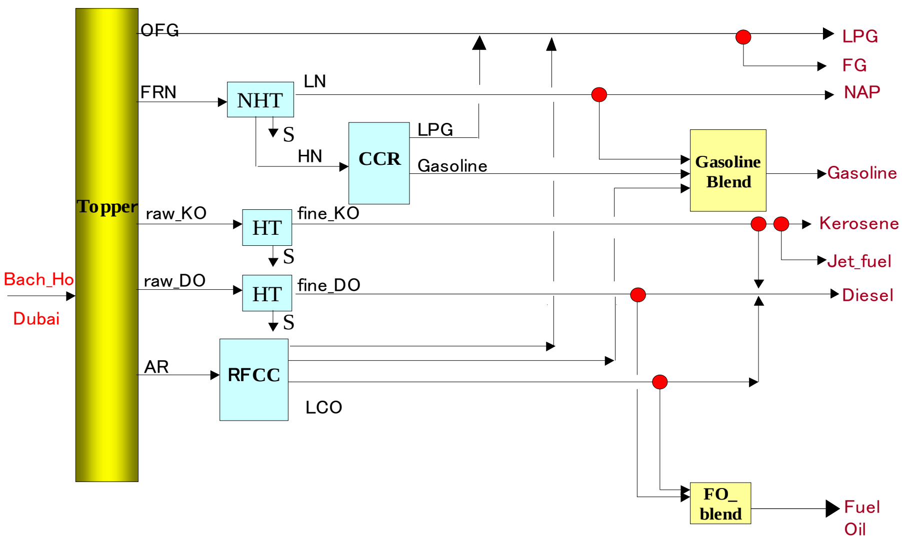


Fig1.1-2 No.1 Oil refinery model flow

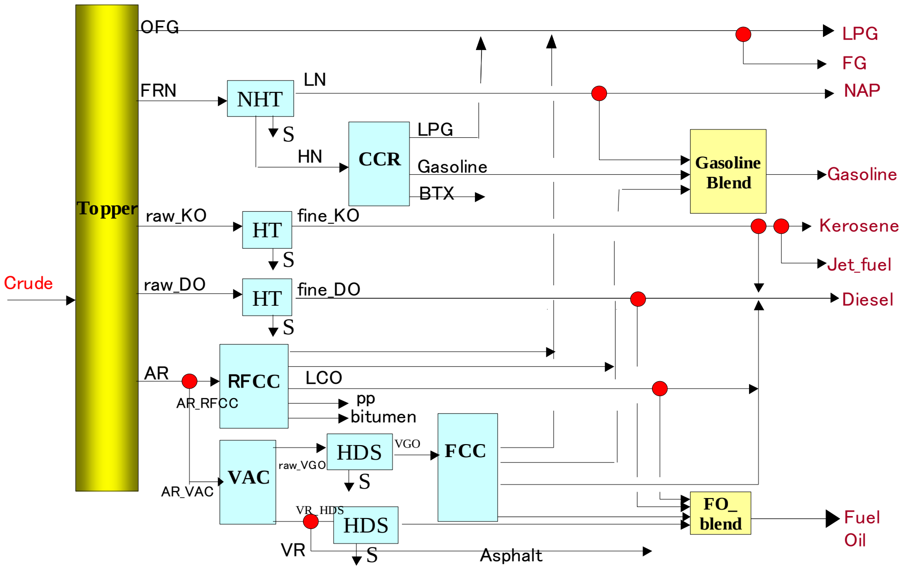


図 1.1.3 No3～No6 virtual refinery plan

Fig1.1-4 is the flow chart including flows of coal, natural gas and power plants. As shown here, produced domestic coal will be segregated by quality, and high quality PCI coal will be directed for export (for mainly Japan) while medium and low quality coal will be directed to domestic use at power plants and general users. The raw natural gas is separated at gas processing plant into condensate, LPG and natural gas. Among them, the flow chart shows that natural gas will be consumed at power plants and end users.

It is of course possible that, subject to future study, items and types of input/output energies and composition of transforming plants would be changed and the energy flow chart should be modified. Then, the supply optimization model should also be revised to these adjustments, accordingly.

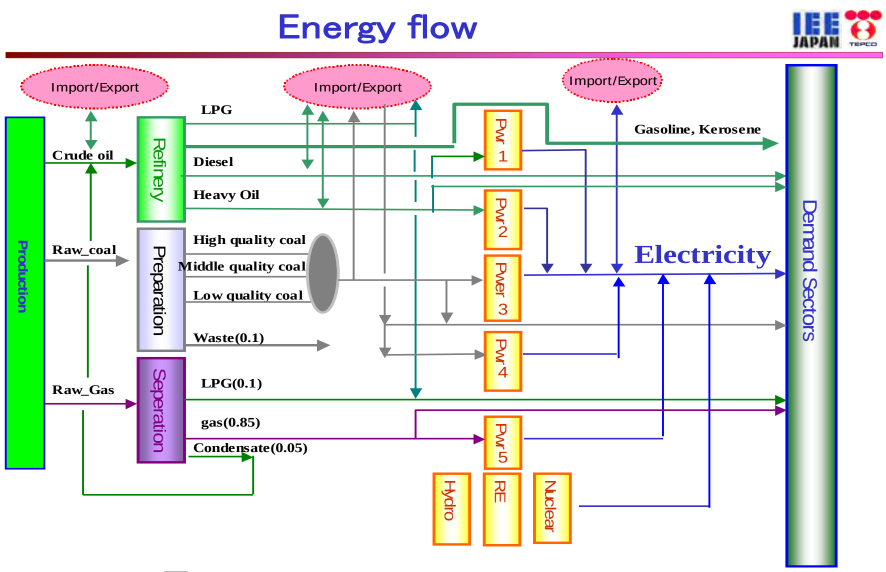


図 1.1-4 Coal, Gas, Electricity energy flow

1.3.3 Special treatment

In this model, special treatments for simplification purpose are made in expression of flows of several energies as follows.

1) As there is no firm plan to utilize propylene produced from RFCC, they are delivered in the model to gasoline and diesel gas oil by 50/50 percents.
2) Whole quantity of BTX produced in the refining process is converted into gasoline.
3) Whole quantity of condensate produced at the gas processing plant is merged to light naptha.
4) Though bitumen is produced processing atoms residue at Vacuum Distillation Unit, the model is written as if bitumen is produced directly from RFCC with an adjustment of yields corresponding to the actual complex process.

1.4 Modeling tool

The basic theory of modeling is LP (linear Programming). In this LP model, all constraints and one objective function should be represented in the form of linear equation. The solution in which an objective function is maximum or minimum under conditions of satisfying all constraints is called the optimum solution. In case of linear analysis, the solution is mathematically guaranteed as optimal. In case of non-linear analysis, however, there is no mathematical assurance of optimum.

GAMS is used as a modeling tool. GAMS stands for General Algebraic Modeling System and is a product of GAMS Company. A commercial contract is required to use the GAMS official version, while the company distributes a student version GAMS as a free ware soft. Though we can handle a huge model with the official version, there is a limitation on size for the student version, maximum 300 variables and 300 constraints. This model is designed that if we operate it only for one year, we can handle it by the student version for demonstration. This aims to make the technical transfer easier and familiarization of the Counterpart faster.

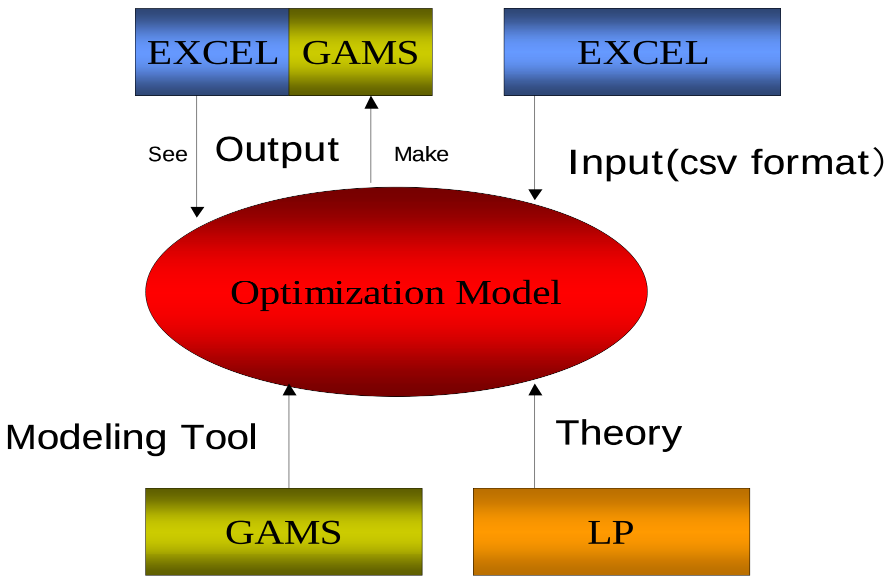


Figure 1.1-5 tool for model building

Input file is written in EXCEL. One sheet contains one data item. These sheets are housed in one book and there are 36 sheets. As GAMS cannot directly handle a book form of EXCEL, we need to convert them from an EXCEL sheet to a CSV (Comma Separated Value) file one by one. To make this easier, a macro program is added in this input EXCEL book with a function to automatically convert one sheet to one CSV file by one click.

Regarding the output file, over 10 output tables are generated in the CSV file form so that it is easy to read the output tables by EXCEL. The configuration of these tools is shown in Figure1.1-5.

1.5 System block flow

Fig 1.1-6 shows the system block flow from receiving the demand forecast results to obtaining the final solutions

Extraction from the forecasting model and PDPAT can be done by converting from EXCEL file to csv file through MACRO program. The data from the forecasting model are as follows;

1) Demand by energy, by year
2) Crude oil production (fix)
3) FOB price（crude oil and other energy）
4) Exchange rate

The data from the PDPAT are as follows;

1) Generation by power plant type
2) Fuel consumption by fuel
3) Capacity by power plant type
4) Thermal efficiency and plant factor
5) Operation cost by power plant type

The other data are peculiar to optimization model and should be inputted through key-in.

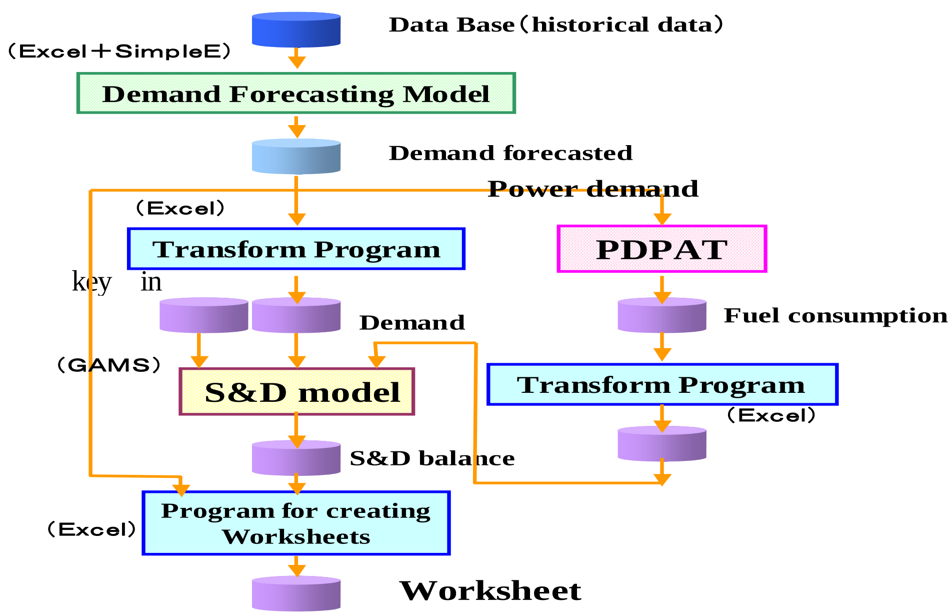


Fig1.1-6 system flow

1.6 Input data

There are 38 kinds of data. It is shown by Fig 1.1.1. The left column 'file name' is the name of input file to GAMS model with extension name 'csv'. The right column is 'data input file name' with extension 'xls'.

'input-data.xls' file should be created by hand.

'input-tepco.xls' file is created by coping the file of PDPAT.

'out-summary-ws.xls' file is created by coping the file of the forecasting model with the tan name 'WS'.

The above EXCEL file is EXCEL book and has many sheets. Each sheet has macro command icon and csv file with the same sheet name is automatically created by clicking the icon.

Table 1.1-1 List of the Input Data

NO	file name	content	data input file name
1	dummy-control.csv	Control whether balance includes dummy variable.	input-data.xls
2	el-data-control.csv	Control whether PDPAT data is used or not	input-data.xls
3	cost-unit.csv	Define the ubit of cost in output	input-data.xls
4	SG.csv	specific gravity	input-data.xls
5	mining-max.csv	max of production of fossil domestic energy	input-data.xls
6	imp-crude-ratio	min/max of import-crude-oil ratio	input-data.xls
7	capacity.csv	capacity of facility exclude power plant	input-data.xls
8	own-use-crude	fuel amount used in refinery	input-data.xls
9	import.csv	import min/max	input-data.xls
10	import-set	set definition of import.csv	input-data.xls
11	export.csv	export min/max	input-data.xls
12	export-set	set definition of export.csv	input-data.xls
13	own-use.csv	own-use ration in power plant	input-data.xls
14	dist-loss	distribution loss of electricity	input-data.xls
15	heat-value.csv	heat_value of energy	input-data.xls
16	yield.csv	yield of facility	input-data.xls
17	bio	bio-ethanol and bio-diesel including ratio	input-data.xls
18	CO2-max.csv	CO2 emission max in regulation	input-data.xls
19	co2-emission.csv	co2 emission rate	input-data.xls
20	S-content	sulphur content ratio	input-data.xls
21	stock-init.csv	initial value of oil stockpiling	input-data.xls
22	stock-day.csv	oil stockpiling day	input-data.xls
23	cost-op.csv	Operation/maintenance cost in facility	input-data.xls
24	cost-Freight	cost of freight	input-data.xls
25	interest.csv	interest by year	input-data.xls
26	capacity-EP	capacity of power plant	input-tepco.xls
27	el-sup-fossil	power generation by fossil fuel	input-tepco.xls
28	el-sup-fix	power generation by hydro, RE, nuclear =fix	input-tepco.xls
29	fuel-consumtion.csv	fuel consumption from PDPAT	input-tepco.xls
30	p-factor.csv	plant factor of power plant	input-tepco.xls
31	therm-eff.csv	thermal efficiency of power plant	input-tepco.xls
32	cost-op-EP	cost of operation of power plant	input-tepco.xls
33	exchange-rate.csv	exchange rate	out_summary_ws.xls
34	crude-production	crude production =fix	out_summary_ws.xls
35	demand-sec.csv	Demand of energy exclude power	out_summary_ws.xls
36	cost-crude-FOB	cost of FOB	out_summary_ws.xls
37	cost-other-FOB	cost of FOB	out_summary_ws.xls

All data file are always required. Each data has following meanings.

1) dummy-control.csv : In order to avoid infeasibilities, dummy variables are incorporated in a balance equation. Mainly this dummy variables are used in oil product balance equation.

2) el-data-control.csv : Basically generation and fuel consumption data are given by PDPAT. In this case these data are all fixed. But sometimes power source allocation should be free and the model should select the best power allocation. This control data indicates whether PDPAT data is used or not.

3) cost-unit.csv: These data are for output and means the pair of cost name and unit.

4) SG. csv : The energy which is usually measured by volume should be converted to weight base. In order to convert the unit from volume to weight, the SG (Specific gravity) is used.

5) mining-max.csv: It means the maximum of production of crude oil, coal, gas per year.

6) imp-crude-ratio.csv: This data is regarding an oil refinery. It means the minimum and maximum of import crude oil ratio to total feed to topper.

7) capacity.csv: This data are the capacity of each facility/unit excluding power plant.

8) own-use-crude.csv: The oil refinery uses oil as fuel, which the oil refinery produces by it self. This data means the ratio of crude oil to be used for fuel in its oil refinery.

9) import.csv: the minimum and maximum of import energy

10) import-set.csv: This term is used for convenient to program and can be created by extracting the part of set in import.csv.

11) export.csv : the minimum and maximum of export energy

12) export-set .csv : This term is used for convenient to program and can be created by extracting the part of set in export.csv.

13) own-use.csv: The power plant uses electricity to be generated in itself as utility. Own use data is given as ratio to total generation. But generation is measured at sending end, so this data is always 0.

14) dist-loss.csv: Some of electricity distributed is lossed during sending electricity.
This amount is also proportional to generation, so this data is ratio to generation.

15) heat-value.csv: Every energy emits heat when it is burnt. That is heat value. This data is used for unit conversion from weight/volume to toe or calculating fuel consumption in power plant. But in the case that PDPAT is used, this calculation is not done.

16) yield.csv : Yield means the ratio of products to one unit feed. for example, if 1 bbl crude oil feeds into topper, the amount of gasoline produced is yield.

17) bio.csv: This data means the percentage content of bio energy in gasoline or diesel.

18) CO2_max.csv: The specified value of CO2 emission max as regulation. If there is no regulation, this value should be very large.

19) CO2-emission.csv: In order to calculate total co2 emission, the CO2 emission rate of each energy per unit weight is required.

20) S-content.csv: In order to calculate SO2 emission, the sulfur emission rate of each energy per unit weight is required.

21) stock-init.csv: In order to calculate the oil stockpiling, the inventory of oil at the previous year whenoil stockpiling calculation begins should be given as initial stock(inventory)

22) stock-day.csv: The oil should be stocked for specified days of total consumption of oil products. This specified day is called stock day.

23) cost-op.csv : Cost of operation / maintenance of facilities

24) cost-freight.csv : cost of freight

25) interest.csv : interest by year

26) capacity-EP.csv : capacity of power plant (EP: Electric Power)

27) el-sup-fossil.csv : generation by power plant with fossil fuel(oil, coal, gas)
28) el-sup-fix.csv : generation by power plant(hydro, nuclear, RE)
29) fuel-consumption.csv : fuel consumption by fuel in power plant type
30) p-factor.csv : plant factor by power plant class (P-factor means the percentage of capacity use)
31) therm-eff : thermal efficiency by power plant type
32) cost-op-EP : cost of operation and maintenance cost of power plant
33) exchange-rate.csv : exchange rate by year
34) crude-production.csv : crude production (fixed)
35) demand-sec.csv : demand by secor or total demand by energy
36) cost-crude-FOB : FOB(Freight on Board) of crude oil
37) cost-other-FOB : FOB of energy excluding crude oil

1.7 Constraints

There are 37 kinds of constraints. Tab 1.1.2 shows all constraint list. All these constraints are not always used. Sometimes some equations are not used. For example if PDPAT is used, generation and fuel consumption are fixed. So the relation between generation and fuel consumption is not needed. Sometimes the constraint is defined, but it has no meaning. For example if there is no co2 emission regulation, input data co2 emission max is very large value. So CO2 max constraints is substantially useless.

The rule , a blue letter means the variable which the model can decide with optimal objective function, and a black letter means data given as input data, can be applied to every explanation of each equation of followings.

(1) **eq_yield** (target : topper, coal, gas plant)

production = yield * feed to plant * (1-own_use_crude/100)

In the case of oil refinery the feed is crude oil. In the case of coal plant, the feed is raw coal. In the feed of gas plant, the feed is raw gas. The oil refinery uses oil as fuel, which is produced in oil refinery and used in oil refinery itself. This self use oil is assumed to be crude oil as linear proportion to total feed crude oil. Initially this proportional rate is assumed 6%. But own-use-crude data is defined for only topper, so own-use-crude is 0 in the case of coal and gas plant.

coding:
```
eq_yield(y,r,p,xc,c)$(target_year(y)          And
                      (topp(p)                 Or
                       coal_plant(p)           Or
                       gas_plant(p))           And
                       set_yield5(y,r,p,xc,c))..
       Xprd(y,r,p,xc,c)
       =e=
    yield(y,r,p,xc,c)*Xcon(y,r,p,xc)*(1-own_use_crude(p)/100);
```

Table 1.1.2 constraint list

No	name	target	content
1	eq_yield	topper, coal, gas	production = yield*(feed to plant)*(1-own_use_crude)
2	eq_yield_ref	oil refinery unit	production calculate refinery units excl. topper
3	eq_branch	oil products with branch	production calculation by branch in oil refinery
4	eq_imp_crude_ratio_min	crude oil	min of import crude oil feed to total feed
5	eq_imp_crude_ratio_max	crude oil	max of import crude oil feed to total feed
6	eq_prd_coal	domestic coal	production :coal = H_coal+M_coal+L_coal
7	eq_imp_coal	import coal	import coal >= consumption in EP plant
8	eq_exp_Hcoal	H_coal	export of Hcoal >= 7% * coal production
9	eq_exp_coal_min	coal	total export of coal >= export minimum
10	eq_exp_coal_max	coal	total export of coal <= export maximum
11	eq_power_sum_coal_dom	domestic coal & EP	generation by coal = sum of generation by H,M,Lcoal
12	eq_power_coal_dom	domestic coal & EP	Relation between coal consumption and generation
13	eq_power coal_HL	HL coal	Average calorie of coal to EP plant = 5500
14	eq_power	electrcity	relation between fuel consumption and generation
15	eq_own_use	electrcity	own use = generation * own-use ratio
16	eq_dist_loss	electrcity	loss=loss rate*((generatio-own-use)+import+export)
17	eq_bal_el	electrcity	generation+import=demand+export+own-use+loss
18	eq_bal_ref	oil products	prd. + (from branch)+ import=demand*(1-bio ratio)+(to branch
19	eq_bal_gasoline	gasoline	prd.+(from LN)+inport=demand*(1-bio ratio)+export
20	eq_bal_LN	light naptha	prd.+prd(condensate)=export+(to gasoline)
21	eq_bal_LPG	LPG	prd(refinery+gas)+import(LPG+substitute)=demand+export
22	eq_connect_ref	oil products	(intermediate oil product) production=consumption
23	eq_connect_RFCC	oil products	(intermediate oil product) prd(from branch)=consumption
24	eq_bal_crude_dom	domestic crude	prod. of crude dom = consumption in topper + export
25	eq_bal_dubai	dubai crude	import=feed to topper
26	eq_bal_arabian	arabian crude	import=to oil stockpiling
27	eq_stock_piling	arabian crude	oilstock*0.95=demand(oil products)*stock_day/365
28	eq_bal_coal	coal	(prd.+import)*heat_value=(cons.in EP)*heat_value+demand+expo
29	eq_bal_gas	gas	prd./SG+import=(cons.in EP)+demand+export
30	eq_bal_raw_gas_coal	raw gas and coal	production = consumption
31	eq_co2_coal	CO2 domestic coal	CO2 emission from domestic coal
32	eq_co2_oil_gas	CO2 oil prodcts	CO2 emission from oil products
33	eq_co2_ethanol	CO2 ethanol	CO2 emission from ethanol
34	eq_co2_max	CO2	total co2 emission <= maximum of co2 emission regulation
35	eq_so2	SO2	so2 emission calculation
36	eq_cost	cost	cost by each year
37	eq_obj_cost	cost	total cost= objective function

(2) **eq_yield_ref** (target :refinery plant excluding topper)

production = yield * feed of raw material into secondary facilities of the oil refinery

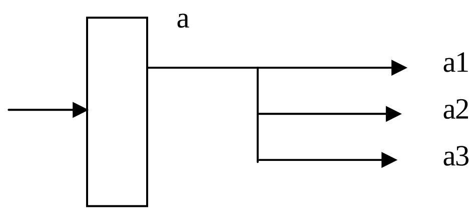
This equation cannot be defined in eq_yield because check, whether topper and second facilities like cracking has positive capacity or not, is necessary.

```
coding: eq_yield_ref(y,r,p,xp,xc,c)$(target_year(y)     And
                     set_yield5(y,r,p,xc,c)            And
                     top_group(xp,p)                   And
                     set_capacity3(y,r,xp)             And
                     set_capacity3(y,r,p)              And
                     not topp(p))..
        Xprd(y,r,p,xc,c) =e= yield(y,r,p,xc,c)*Xcon(y,r,p,xc);
```

3) **eq_branch** (target : material which branches into over 2 materials)

Example-1 : kerosene can be evaluated kerosene, jet fuel, diesel and fuel oil based on objective function.

Example-2 : Some of the residue from topper goes to RFCC, some go to Vacuum distiller.



production of a = sum(branch amount ai)

coding: eq_branch(y,r,p,xc,c)$(target_year(y) And
branch_base(c) And
set_capacity3(y,r,p) And
set_yield5(y,r,p,xc,c))..

Xprd(y,r,p,xc,c) =e= sum(xxc$branch(c,xxc),Xbrn(y,r,p,xc,c,xxc));

4) **eq_imp_crude_ratio_min** (target : topper1 and topper2)

total import crude oil >= import min ratio * (domestic crude + import crude)

coding : eq_imp_crude_ratio_min(y,r,p)$(target_year(y) And (top1(p) or top2(p)) And set_capacity3 (y,r,p))..

```
sum(c$(dubai(c) And pair_pc(p,c)),Xcon(y,r,p,c))
=g=
(sum(c$(dom_crude(c) And pair_pc(p,c)),Xcon(y,r,p,c)) +
sum(c$(dubai(c) And pair_pc(p,c)),Xcon(y,r,p,c)))*top_imp_ratio(y,p,'min');
```

5) **eq_imp_crude_ratio_max** (target : topper1 and topper2)

total import crude oil <= import max ratio * (domestic crude + import crude)

coding : eq_imp_crude_ratio_max(y,r,p)$(target_year(y) And (top1(p) or top2(p)) And
set_capacity3(y,r,p))..

```
sum(c$(dubai(c) And pair_pc(p,c)),Xcon(y,r,p,c))
=l=
(sum(c$(dom_crude(c) And pair_pc(p,c)),Xcon(y,r,p,c)) +
sum(c$(dubai(c) And pair_pc(p,c)),Xcon(y,r,p,c))) * top_imp_ratio(y,p,'max');
```

6) **eq_prd_coal** (target : domestic coal)

production of coal from coal preparation = production of (H_coal + M_coal + L_coal)

coding : eq_prd_coal(y,r,p,c)$(target_year(y) And coal_plant(p) And coal_rep(c))..

```
sum(xc$raw_coal(xc),Xprd(y,r,p,xc,c)) =e=
sum((xc,xxc)$(raw_coal(xc) And coal_dom_HML(c,xxc)),Xprd(y,r,p,xc,xxc));
```

note) H_coal = High quality coal
M_coal = Medium quality coal
L_coal = Low quality coal

7) **eq_imp_coal** (target : import coal)

import coal >= consumption in power plant import coal is used for both power plant and general user in the case of short of domestic coal. If domestic coal amount is sufficient, then import coal is used for only power plant.

coding : eq_imp_coal(y,r,p,c)$(target_year(y) And coal_imp(c) And EP_coal_imp(p))..

Ximp(y,r,c)=g= Xcon(y,r,p,c);

8) **eq_exp_Hcoal** (target : Hcoal)

export of H coal >= 0.07 * raw coal production

coding : eq_exp_Hcoal(y,r,c)$(target_year(y) And H_coal(c)).. Xexp(y,r,c)=g= 0.07*Xprd(y,r,'mine','earth','raw_coal');

9) **eq_exp_coal_min**(target : coal)

total export of coal >= minimum export of coal

coding : eq_exp_coal_min(y,r)$target_year(y)..

sum(c$HML_coal(c),Xexp(y,r,c))=g= Xexp.lo(y,r,'coal');

10) **eq_exp_coal_max**(target : coal)

total export of coal <= maximum export of coal

coding : eq_exp_coal_max(y,r)$target_year(y)..

sum(c$HML_coal(c),Xexp(y,r,c))=l= Xexp.up(y,r,'coal');

11) **eq_power_sum_coal_dom**(target : electricity from coal)

generation from coal = generation from (H_coal + M_coal + L_coal)

There is no variable of generation from coal. But this value is necessary in output routine. So this variables is defined.

coding : eq_power_coal_dom(y,r,p)$(target_year(y) And EP_coal_dom(p)).. sum(c$HML_coal(c),Xprd(y,r,p,c,'el')) =e= Xprd(y,r,p,'coal','el');

12) **eq_power_coal_dom**(target : coal dom)

generation from each coal = consumption in EP * heat_value * thermal efficiency / 860

coding : eq_power_coal_dom(y,r,p,c)$(target_year(y) And EP_coal_dom(p) And HML_coal(c) And pair_pc(p,c))..

Xprd(y,r,p,c,'el') =e= Xcon(y,r,p,c)*heat_value(y,c)*therm_eff(y,p,c)/860 ;

13) **eq_power_coal_HL**(target : H and L coal)

heat_value*Hcoal consumption in EP + heat value*Lcoal consumption in EP = 5500*(Hcoal consumption in EP +Lcoal consumption in EP)

This equation means that coal to be used in power plant should have the heat value of 5500kcal/kg.

H_col has higher and L_coal has lower heat value, and that the heat value of mixed coal (H + L) as an average should have 5500kcal. M_coal is deemed to have 5500 kacl/kg originally.

coding : eq_power_coal_HL(y,r,p,c,xc)$(target_year(y) And EP_coal_dom(p) And

H_coal(c) And L_coal(xc))..
heat_value(y,c)*Xcon(y,r,p,c) + heat_value(y,xc)*Xcon(y,r,p,xc)
=e= 5500*(Xcon(y,r,p,c) + Xcon(y,r,p,xc));

14) **eq_power** (target : electricity)

fuel consumption=generation * 860/(heat value*thermal efficiency)

This equation is only used for free power allocation.

Usually PDPAT is being used. Both fuel consumption and generation are fixed and this equation is automatically in this case is not created because el_flag = 0.

coding : eq_power(y,r,p,c)$(target_year(y) And el_source(c) And elp(p) And
pair_pc(p,c) And therm_eff(y,p,c)>0)..
el_flag*Xcon(y,r,p,c) =e=
el_flag*Xprd(y,r,p,c,'el')*860/(heat_value(y,c)*therm_eff(y,p,c));

15) **eq_own_use** (target : electricity)

own use power = own_ use_ * generation

In this model generation is measured at the sending end. So this equation is not necessary.

So own_use = 0, then automatically own use power becomes to be 0. But if power generation amount is measured at the generator end, this equation will become necessary.

coding : eq_own_use(y,r)$target_year(y)..
Xown(y,r) =e=
sum((p,c)$(elp(p) And pair_pc(p,c)),Xprd(y,r,p,c,'el')*own_use(p)/100) +
sum((p,c)$(elp(p) And base_el(p,c)),base_sup_el(y,r,p,c)*own_use(p)/100);

16) **eq_dist_loss**(target : electricity)

distribution loss = loss rate*((generation -own_use) + import + export)

coding : eq_dist_loss(y,r)$target_year(y)..
Xlos(y,r) =e= dist_loss(y,r)/100* ((sum((p,c,xc)$(elp(p) And el(c) And
pair_pc(p,xc)),Xprd(y,r,p,xc,c)) - Xown(y,r)) +
sum((p,c,xc)$(elp(p) And el(c) And base_el(p,xc)), base_sup_el(y,r,p,xc)-Xown(y,r)) +
sum(c$el(c),Ximp(y,r,c)+Xexp(y,r,c))) ;

17) **eq_bal_el** (target : electricity)

This equation is the balance equation of electricity defined as follows;

generation + import = demand + export + own-use + distribution loss + dummy

Usually all information excluding distribution is given by input data. So the balance cannot be strictly realized. So dummy variable should be implemented. If free power source allocation is adopted, this dummy variable is automatically deleted.

coding : eq_bal_el(y,r,c)$(target_year(y) And el(c))..
sum((p,xc)$(elp(p) And pair_pc(p,xc) And not coal_rep(xc)),Xprd(y,r,p,xc,c)) +

sum((p,xc)$(elp(p) And base_el(p,xc)),base_sup_el(y,r,p,xc)) + Ximp(y,r,c)
=e= sum(s,dem_el(y,r,s)) + Xexp(y,r,c) + Xown(y,r) + Xlos(y,r) + (1-el_flag)*Xdum_el(y,r);

18) **eq_bal_ref** (oil products exclude gasoline, LPG)

This equation is the balance equation of oil products defined as follows;

production + production from branch + import = demand*(1-bio)+consumption in power plant + export + dummy

If import or export has min/max, it may occur infeasible. In order to avoid infeasibility, dummy variable should be implemented. Bio is define for diesel(bio diesel). Consumption in power plant is defined for diesel and fuel oil.

coding : eq_bal_ref(y,r,c)$(target_year(y) And refc2(c) And not gasoline(c) And not LPG(c))..
sum((p,xc)$(set_capacity3(y,r,p) And set_yield5(y,r,p,xc,c)),Xprd(y,r,p,xc,c)) + sum((xc,xxc,p)$((refp(p) Or topp(p)) And set_capacity3(y,r,p) And set_yield5(y,r,p,xxc,xc) And branch(xc,c)),Xbrn(y,r,p,xxc,xc,c)) + Ximp(y,r,c)
=e= sum(s,demand_kt(y,r,c,s))*(1-bio(y,c)*0.05/100) + sum(p$pair_pc(p,c),Xcon(y,r,p,c)) + sum((xc,xxc,p)$((refp(p) Or topp(p)) And set_yield5(y,r,p,xxc,xc) And branch(c,xc)),Xbrn(y,r,p,xxc,c,xc)) + Xexp(y,r,c) + coeff_dum(c)*Xdum(y,r,c);

19) **eq_bal_gasoline** (target : gasoline)

This equation is the balance equation of gasoline defined as follows;

production + production from light naphtha + import = demand * (1- bio) + export + dummy

If import or export has min/max, it may occur infeasible. In order to avoid infeasibility, dummy variable should be implemented. Bio is define by bio ethanol.

coding : eq_bal_gasoline(y,r,c)$(target_year(y) And gasoline(c))..
sum((p,xc)$(set_capacity3(y,r,p) And set_yield5(y,r,p,xc,c)),Xprd(y,r,p,xc,c)) + Xmrg(y,r,'LN',c) + Ximp(y,r,c)
=e=
sum(s,demand_kt(y,r,c,s))*(1-bio(y,c)*0.05/100) + Xexp(y,r,c) + coeff_dum(c)*Xdum(y,r,c);

20) **eq_bal_LN**(target : light naptha)

This equation is the balance equation of light naptha defined as follows;

production + production from condensate = export + merge to gasoline

Light naptha, condensate and gasoline have similar characteristics. So Light naptha and condensate are evaluated as gasoline.

coding : eq_bal_LN(y,r,c,xc)$(target_year(y) And LN(c) And FRN(xc))..
sum((p,xp)$(pair_pc(xp,xc) And top_group(p,xp) Andset_cpacity3(y,r,p)),Xprd(y,r,xp,xc,c)) + Xprd(y,r,'gas_plant','raw_gas','condensate')
=e=
Xexp(y,r,c) + Xmrg(y,r,c,'gasoline');

21) **eq_bal_LPG** (target : LPG)

This equation is the balance equation of LPG defined as follows;

production from oil refinery + production from gas plant + import + import of LPG substitute
= demand + export + dummy

LPG can be produced from 2 kind plants. One is oil refinery , one is gas separation. LPG demand is large. But it is not easy to import by sufficient amount. So LPG substitute should be defined as LPG.

In this model kerosene is assumed as LPG substitute. The amount of LPG substitute is calculated by applying the heat equivalent to that of LPG.

coding : eq_bal_LPG(y,r,c,xxxc)$(target_year(y) And LPG(c) And KO_LPG(xxxc))..
sum((p,xc)$(set_yield5(y,r,p,xc,c) And set_capacity3(y,r,p) And not gas_plant(p)), Xprd(y,r,p,xc,c)) + sum((p,xc)$(gas_plant(p) And pair_pc(p,xc)),Xprd(y,r,p,xc,c)) + Ximp(y,r,c) + Ximp(y,r,xxxc)*heat_value(y,xxxc)/heat_value(y,c)
=e= sum(s,demand_kt(y,r,c,s)) + Xexp(y,r,c) + coeff_dum(c)*Xdum(y,r,c);

22) **eq_connect_ref** (target : oil products)

Oil products are usually produced and used as feed material to some facilities. In this case the relation of this fact should be defined. If this relation is dropped, feed material to facilities can be produced from nothing.

production = consumption

coding : eq_connect_ref(y,r,c,xp)$(target_year(y) And medium(c) And topp(xp) And set_cpacity3(y,r,xp))..
sum((p,xc)$(top_group(xp,p) And set_capacity3(y,r,p) And set_yield5(y,r,p,xc,c)), Xprd(y,r,p,xc,c))
=e= sum(p$(top_group(xp,p) And pair_pc(p,c)),Xcon(y,r,p,c));

23) **eq_connect_RFCC**(target intermediates of topper residue)

Topper residue is branched to 2 facilities. One is RFCC, one is Vacuum Distiller.

Production from branch of residue from topper = consumption in (RFCC + vacuum distiller)

coding : eq_connect_RFCC(y,r,c,xxp)$(target_year(y) And medium2(c) And topp(xxp) And set_capacity3(y,r,xxp))..
sum((xp,xc,xxc)$(top_group(xxp,xp) And pair_pc(xxp,xxc) And
set_yield5(y,r,xp,xxc,xc) And RFCC(xp,c) And
branch(xc,c)),Xbrn(y,r,xp,xxc,xc,c))
=e= sum(p$(top_group(xxp,p) And pair_pc(p,c) And set_capacity3(y,r,p)),Xcon(y,r,p,c));

24) **eq_bal_crude_dom** (target : domestic crude oil)

This equation is the balance equation of domestic crude oil defined as follows;

production from oil field = consumption in topper + export

coding : eq_bal_crude_dom(y,r,c)$(target_year(y) And dom_crude(c)).. sum(p$mine_pc(p,c),Xprd(y,r,p,'earth',c))

=e= sum(p$(set_capacity3(y,r,p) And pair_pc(p,c)),Xcon(y,r,p,c)) + Xexp(y,r,c);

25) **eq_bal_dubai**(target : import crude oil = dubai)

This equation is the balance equation of import crude oil defined as follows;

import = consumption in topper

coding : eq_bal_dubai(y,r,c)$(target_year(y) And dubai(c))..

Ximp(y,r,c) =e= sum(p$(set_capacity3(y,r,p) And pair_pc(p,c)),Xcon(y,r,p,c));

26) **eq_balance_Arabian** (target : Arabian light crude oil)

This equation is the balance equation of import Arabian light crude oil defined as follows;

import = oil stockpiling in this year

In this model oil used in oil stockpiling is assumed by Arabian light.

coding : eq_bal_arabian(y,r,c)$(target_year(y) And arabian_L(c))..

Ximp(y,r,c) =e= Xstk(y,r,c)-Xstk(y-1,r,c);

27) **eq_stock_piling** (target : Arabian light crud oil)

oil stock piling * 0.95 = stock day * demand of refinery

95% of crude oil is evaluated to be the equivalent to total demand of oil products per day * stock day. This amount of crude oil should be stocked as oil stock piling (95% is the Japanese specification).

coding : eq_stock_piling(y,r,c)$(target_year(y) And Arabian_L(c))..

Xstk(y,r,c)*0.95 =g= demand_tot_ref(y,r)*stock_day(y,r,'crude')/365;

28) **eq_bal_coal**(target : coal)

This equation is the balance equation of coal defined as follows;

This balance equation is created as the heat balance.

heat value * coal production + heat_value +coal import= heat value *consumption of coal_dom in EP +heat value *consumption of coal_imp in EP + demand +heat value*export

coding : eq_bal_coal(y,r)$target_year(y). sum((p,c,xxc)$(HML_coal(c) And not coal_rep(c) And raw_coal(xxc) And coal_plant(p)), Xprd(y,r,p,xxc,c)*heat_value(y,c)/10000) + Ximp(y,r,'coal_imp')*heat_value(y,'coal_imp')/10000

=e= sum((p,c)$(EP_coal_dom(p) And pair_pc(p,c) And not coal_rep(c) And set_capacity3(y,r,p)), Xcon(y,r,p,c)*heat_value(y,c)/10000) +

sum((p,c)$(EP_coal_imp(p) And pair_pc(p,c) And set_capacity3(y,r,p)), Xcon(y,r,p,c)*heat_value(y,c)/10000) +

sum(c$coal_rep(c),demand_tot_ktoe(y,r,c)) +

sum(c$HML_coal(c),Xexp(y,r,c)*heat_value(y,c)/10000);

29) **eq_bal_gas** (target : natural gas)

This equation is the balance equation of natural gas defined as follows;

production of gas + import = consumption in EP + demand + export coding : eq_bal_gas(y,r,c,xc)$(target_year(y) And gas_rep(c) And gas_imp(xc))..

sum((p,xxc)$(gas_plant(p) And raw_gas(xxc)),Xprd(y,r,p,xxc,c)/SG(c)) + Ximp(y,r,xc)

=e=sum(p$(pair_pc(p,c) And set_capacity3(y,r,p)),Xcon(y,r,p,c)) +

sum(p$(pair_pc(p,xc) And set_capacity3(y,r,p)),Xcon(y,r,p,xc)) + demand_tot_kt(y,r,c) + Xexp(y,r,c);

30) **eq_bal_raw_gas_coal** (target : raw gas and raw coal)

This equation is the balance equation of raw gas and raw coal defined as follows;

production = consumption

coding : eq_bal_raw_coal_gas(y,r,c)$(target_year(y) And coal_gas_raw(c))..

sum(p$mine_pc(p,c),Xprd(y,r,p,'earth',c)) =e= sum(p$pair_pc(p,c),Xcon(y,r,p,c));

31) **eq_co2_coal** (target :coal)

This equation calculates the total co2 emission by domestic coal.

co2 emission = emission rate * (production of coal + import coal - export)*44/12

This result is measured by CO2 kton.

coding : eq_co2_coal(y,r,p,c)$(target_year(y) And coal_plant(p) And (HML_coal(c) or coal_imp(c)))..

Xco2(y,r,c) =e= co2_emission(y,c)*(Xprd(y,r,p,'raw_coal',c)+Ximp(y,r,c)-Xexp(y,r,c))*44/12;

32) **eq_co2_oil_gas** (target : oil products exclude gasoline, diesel and gas)

This equation calculates the total co2 emission by some of oil product and gas

co2 emission = emission rate * (demand + consumption in EP) * 44/12

This result is measured by CO2 kton.

coding : eq_co2_oil_gas(y,r,c)$(target_year(y) And not HML_coal(c) And not coal_imp(c) And co2_emission(y,c) > 0)..

Xco2(y,r,c) =e= co2_emission(y,c)*(demand_tot_kt(y,r,c) + sum(p$pair_pc(p,c),Xcon(y,r,p,c)))*44/12 - demand_tot_kt(y,r,c) *bio(y,c) *0.05/100 * co2_emission(y,c) *44/12;

33) **eq_co2_ethanol**(target : ethanol)

This equation calculates the total co2 emission by bio-ethanol and bio-diesel

co2 emission = emission rate * consumption of (bio-ethanol + bio-diesel) * 44/12

This result is measured by CO2 kl.

coding : eq_co2_ethanol(y,r,c)$(target_year(y) And ethanol(c))..

Xco2(y,r,c) =e= sum(xc$(gasoline(xc) or diesel(xc)), demand_tot_kt(y,r,xc) *bio(y,xc)) *0.05/100 * co2_emission_data(y,c) / SG(c);

34) **eq_co2_max**(target : co2)

This equation is the constraint of co2 max by government regulation

total co2 emission <= maximum of co2 emission coding :eq_co2_max(y,r)$target_year(y)..

sum(c$(co2_emission(y,c) > 0),Xco2(y,r,c)) =l= CO2_max(y);

35) **eq_so2** (target : so2)

This equation calculate total so2 emission.

total so2 emission= 32/16*sulfur content ratio * (demand + consumption in EP)

coding : eq_so2(y,r,c)$(target_year(y) And s_content(y,c)>0)..

Xso2(y,r,c) =e= 32/16*s_content(y,c)/100*(demand_tot_kt(y,r,c) + sum(p$pair_pc(p,c),Xcon(y,r,p,c)));

36) **eq_cost** (target : cost)

This equation calculates the cost by year

cost = import cost*import + acquisition cost*production + operation cost*feed to facility + export price * export

coding : eq_cost(y)$target_year(y)..

Xcost(y) =e=

sum((r,c)$(crude(c) Or refc(c) Or import_gas_coal(c) Or el(c)), Ximp(y,r,c)*cost_imp(y,r,c)) + sum((r,p,c)$(mine(p) And mine_pc(p,c)),Xprd(y,r,p,'earth',c)*cost_prd(y,c)) + sum((r,p,c)$(pair_pc(p,c) And elp(p)),cost_op(y,r,p)) +

sum((r,p,c)$(pair_pc(p,c) And not elp(p)), Xcon(y,r,p,c)*cost_op(y,r,p)) -

sum((r,c)$export(c),Xexp(y,r,c)*sale_exp(y,r,c));

37) **eq_obj_cost** (target : objective function)

This equation defines objective function.

obj_cost = sum(total cost by year)

coding : eq_obj_cost..

Obj_cost =e= sum(y$target_year(y),Xcost(y)/(1+interest(y)/100)**(ord(y)-1));

38) **eq_coal_dem** (target: coal)

This equation constraint that consumption of each cola in general sector should be non negative.

consumption of coal in general sector = production + import – export – consumption in power plant

coding : eq_coal_dem(y,r,c)..

eq_coal_dem(y,r,c)$(target_year(y) And HML_coal(c))..

Xprd(y,r,'coal_plant','raw_coal',c)+Ximp(y,r,c)-Xexp(y,r,c)-

sum(p$pair_pc(p,c),Xcon(y,r,p,c)) =g=0;

1. 8 Output data table

GAMS automatically creates a text file, which includes all information about model such as code, input data, constraints, solution and statistics. This text file has the extension name .lst. It is big size file and it is not easy to analyze the result. Then this system built in the JICA project has function to create 15 kind of tables in order to analyze the result correspondent to the purpose. These tables are as follows;

1)Energy balance table（typical table used in energy field）
2)summary table with unit ktoe (used for comparing some cases)
3)summary table with unit kton/MMm3(used for analyzing in time series)
4)Refinery result(balance data in oil refinery with yield data)
5)electric result (generation, fuel consumption, technical data etc)
6)list of import(amount list of import energy as result) for check
7)list of export (amount list of export energy as result) for check
8)list of product(amount of production as result) for check
9)list of consumption(amount of consumption in plant as result) for check
10)demand table(input data)
11)list of unit cost(input data with unit change)
12)cost result(cost, amount of flow, total cost)
13)worksheet(total summary output with whole country energy status)

1.9 Program structure

Main program : Vietnam.gms

Sub program	1) set_definition	: Define various index, parameter, table
	2) Unit_constant	: Define the constant
	3) data_read.inc	: Read input data
	4) unit_change.inc	: Change the unit
	5) set_definition2.inc	: Define new sets based on input data
	6) eq_definition.inc	: Define constraints
	7) bound_set.inc	: Set the bound of variables
	9) after_process.inc	: Treat the solution for output
	10) output.inc	: Create various outputs in kton
	11) kt_ktoe.inc	: Unit change from kton to ktoe
	12) output_ktoe	: Create various outputs in ktoe

These files are all text file. So they can easily be read by usual text editor.
Extension gms is fixed by GAMS system. But extension inc is free. these inc files are read into main program “Vietnam.gms” by $include, so for convenience the extension inc is used.

1. 10 Model size and execution time

The size of a LP model can be measured by the number of variables and constraints incorporated. Now there are less 3,000 variables and 2500 constraints covering 21 years in standard model. Should the energy flow change, new plants be installed or new energy item be added, the model size would greatly increase. At this moment, the execution time of this 21 year model is less than 1 second. This execution time would also increase if constraints overlapping years are levied or strong constrain are added. At any rate, however, the execution time would not become a serious problem.

1.11 Functions and operations of the optimization model

This energy supply optimization model has following functions.

1.11.1 Information created (main function)

a. To calculate the logically correct demand and supply balance of each energy comprehensively satisfying the energy demands given as input data. They are for example,

- Raw material feed amount into each facility at oil refinery
- Petroleum products production amount
- Converted amount of petroleum products to another energy, e.g., from kerosene to jet fuel or diesel gas oil

b. To calculate the minimum total cost as the net present value at 2005

1.11.2 Service functions for convenience of users

c. To automatically convert from a sheet in a book of EXCEL to a CSV file (EXCEL macro)

d. To output tables to show the optimum solutions in various forms (CSV file)

e. To output four summary sheets for comparison study (EXCEL)

1.11.3 Functions of GAMS itself

f. To make a text file including all information of the model. The first file houses the following information.

- Original program created by modeler
- Input data
- Developed constraints
- Various statistics on the model (scale, execution time, etc)
- Solution itself

g. To show grammatical error message

h. To point an infeasible constraint or a variable as a cause of infeasible solution

i. To show the number of infeasibility if infeasible

j. To show name of the output table created

k. etc

2 Operations Procedure

For execution of the model, the basic flow of operation is as follows;

1) Create input data file

2) Execute the model

3) Analyze the model

In this document the only operation of the Vietnam model is explained. Regarding GAMS itself including the install GAMS, refer the GAMS Manual.

2.1 Input data source

In order to make a input file, there are 3 kinds of data souirce.

1) The first one is to collect data and key in them. (input-data.xls)

2) The second one is to copy from the output file of forecasting model. (out-summry-ws.xls)

3) The third one is to copy from output file of PDPAT. (input-TEPCO.xls)

2.1.1 Common operation------Make anew holder / How to create a csv file from EXCEL

At first you have to define the new holder name where the model , data and output file are stored. At the next step tou have to copy yhe standard model to this holder. At the third step, input file should be read and modified in EXCEL file. GAMS cannot read directly EXCEL file. So EXCEL file should be converted to csv form file. A csv file is the text file and each data is separated by comma. For example

```
*import,,,,
*year,, energy, min, max
2005*2025,whole,Dubai,0,100000
2005*2025,whole,Sumatra_l,0,100000
2005*2025,whole,Arabian_l,0,100000
2005*2025,whole,Arabian_h,0,100000
2005*2025,whole,coal_imp,0,20000000
```

GAMS can read the csv file. A csv file should be created by sheet in EXCEL file. There are many sheets in this EXCEL file. In order to create csv file, this conversion operation should be done many times by sheet. It is rather nuisance operation. So the macro which enables to create a csv file by one touch is prepared at each sheet. The csv file created has the same name to sheet name. In order to kick this macro, it is enough to click the following icon with name 'Save file', which can be seen on every sheet.

The function of this MACRO is as follows.

1) The original EXCEL file is overwritten with the same name.

The EXCEL asks you whether overwritten is permitted or not ?

You must answer 'yes'. If you answer no, the next csv file is not created.

2) The csv file is created . The file name is sheet name + .csv.

If the same name exists in the holder, EXCEL asks you whether overwritten is allowed or not? Then, you must answer 'yes'. If you answer no, the next csv file would not be created.

Note: In order that MACRO is executable,

1) You have to answer 'yes' against the question from EXCEL that enable MACRO when EXCEL starts?

2) You have to change that the security level is less than middle level the time EXCEL begins to work as follows; (in the case of Windows XP)

tool---macro--security

security level to middle.

The operation to create input files is outlined below

2.1.2 Key-in data

All data of input-data.xls in the column ' input data file name' in table1.1.1 should be inputted by key in operation.

(1) dummy-control.csv :

format : energy name, '1' or '0'

related place in program : constraint=eq_bal_ref

meaning : '1' : dummy variable is automatically inserted in the balance equation.

'0' : dummy variable is not used.

If oil products balance is considered to be rather difficult, 1 should be set otherwise 0.

For security it is recommended that '1' is set. So it is better not to change the base model.

(2) el-data-control.csv

format: the first line 'gen', '1' or '0'

the second line 'con', '1' or '0'

related place in program : el_flag definition in 'unit_change.inc'

eq_power in 'eq_definition.inc'

meaning : 'gen' ,'1' : generation data comes from PDPAT, so fixed

'0' : generation free

'con','1' : fuel consumption comes from PDPAT and so fixed

,'0' : generation free

el_flag = 0 at 'gen'=1 and 'con'=1

Relation between fuel consumption and generation cannot be defined.

=1 otherwise

relation between fuel consumption and generation is defined.

el_flag is automatically set according to el_data_control in 'unit_change.inc'.

(3) cost-unit.csv

format: energy name, unit

related place in program : 'output.inc'

meaning : used in heading

(4) SG.csv

format: energy name, specific gravity

related place in program : 'unit_change.inc', 'bound_set', 'after_process.inc', 'output.inc'

eq_bal_gas, eq_co2_ethanol in eq_definition.inc

meaning : used in unit change from volume unit to weight unit

(5) mining-max.csv : (used by parameter 'product-max' in program)

format: year, 'whole', energy, production maximum

related place in program : 'bound_set'

meaning : primary fossil energy production max by year

(6) capacity.csv

format: year, 'whole', plant, energy, capacity

related place in program : 'bound_set'

meaning : Plants cannot product or consume specified energy over this value.

(7) own-use-crude.csv

format: topper name, %

related place in program : eq_yield in 'eq_definition.inc'

meaning : Oil refinery uses fuel which it produces by itself. It is the ratio to total feed of crude oil. NO1 refinery produces fuel gas and off gas, This gas is considered to be used for fuel. So this ratio is not defined in No1 refinery in this model

(8) imp-crude-ratio.csv

format: year, topper name, min of import crude ratio, max of import crude ratio

related place in program : eq_imp_crude_ratio_min, eq_imp_crude_ratio_max in 'eq_definition.inc'

meaning : The min and max of ratio of import crude oil to total feed crude oil

(9) import.csv (used by table import_minmax in program)

format: year, energy name, min of import, max of import

related place in program : 'bound.inc'

meaning : min and max of import

(10) import-set.csv

format: year, energyr name

related place in program : 'bound.inc'

meaning : this file This data is used for convenience, but not used data processing.

This content is exactly same to the first 2 column in import.csv. So in order to create this file, it is enough to copy it from import.csv.

(11) export.csv (used by table export_minmax in program)

format: year, energy name, min of export, max of export

related place in program : 'bound.inc'

meaning : min and max of export

(12) export-set.csv

format: year, energyr name

related place in program : 'bound.inc'

meaning : this file This data is used for convinience, but not used data processing.

This content is the exactly same to the first 2 column in export.csv

So in order to create this file, it is enough to copy from export.csv.

(13) own-use.csv

format: power plant name, own use ratio

related place in program : eq_own_use in 'eq_definition.inc'

meaning : A power plant uses electricity which it generates by itself. But generation is measured at sending end in this model. So this input term should always be 0.

But if this rule will change in future, this input term is defined.

(14) dist-loss.csv

format: year, 'whole', loss rate(%)

related place in program : eq_dist_loss in 'eq_definition.inc'

meaning : Sending electricity, electricity is loss through transmission-distribution line. It is proportional to sending electricity. This loss electricity should be considered in balance equation

(15) p-factor.csv

format: year, 'whole', power plant name, fuel name, plant factor

related place in program : 'bound.inc'

meaning : Each power plant has specific load (%), or this load is controlled by power policy.

Load means the percent of capacity use.

(16) heat-value.csv

format: year, energy, heat value

related place in program : 'unit_change.inc', 'output.inc'

eq_coal_dom, eq_power_coal_HL, eq_power, eq_bal_LPG, eq_bal_coal

in 'eq_definition.inc'

meaning : Considering energy issues, calorie unit is important. Changing unit from weight to calorie , heat value plays a base role.

Heat value depends on energy and country.

(17) therm-eff.csv

format: year, power plant name, fuel name, termal efficiency(%)

related place in program : 'bound.inc', 'output.inc'

eq_coal_dom, eq_power, in 'eq_definition.inc'

meaning : Each power plant has thermal efficiency (%). It depends on power plant, fuel plant, year.

(18) yield.csv

format: year, plant(facility), raw energy, product energy, yield related place in program : 'output.inc'

eq_yield, eq_yield_ref, in 'eq_definition.inc'

meaning : This means how much each product is produced against 1 unit raw material feed. This is the basic data in considering energy balance because energy produced is calculated based on the yield. The total yield in a facility should be always 1.

(19) bio.csv

format: year, energy, rate(%)

related place in program : 'output.inc'

eq_bal_ref, eq_co2_oil_gas, in 'eq_definition.inc'

meaning : It means the mix rate of bio ethanol to gasoline and bio diesel to diesel.

E5 is used in this model as bio ethanol.

(20) CO2_max

format: year,max co2 emission to be permitted

related place in program : eq_co2_max in 'eq_definition.inc'

meaning : total co2 emission should be less than CO2_emission max which is decided by the government

(21) CO2_emission.csv

format: year,energy, CO2_emission rate

related place in program : 'unit_change.inc', 'output'.inc'

eq_set_definition2, eq_CO2_oil_gas, eq_ethanol in 'eq_definition.inc'

meaning : It means the emission amount of co2 when the energy is burned by 1 unit.

It is used in calculating co2 emission.

(22) S-content.csv

format: year,max so2 emission to be permitted

related place in program : 'output.inc'

eq_so2 in 'eq_definition.inc'

meaning : It means the emission amount of so2 when the energy is consumed by 1 unit.

It is used in calculating so2 emission.

(23) stock-init.csv

format: year,max so2 emission to be permitted

related place in program : 'bound.inc'

meaning : Considering oil stockpiling, the initial stockpiling should be given by data.

(24) stock-day.csv

format: year, 'whole', 'crude'

related place in program : 'output.inc'

eq_stock_piling in 'eq_definition.inc'

meaning : In this model oil stockpiling is calculated by following equation;

oil stockpiling*0.95 = stock_day * consumption of all oil products per day/365

This stock day can be decided by the oil security policy.

(25) cost-op.csv

format: year,max so2 emission to be permitted

related place in program : 'after_process', 'output.inc'

eq_cost in 'eq_definition.inc'

meaning : cost of operation cost and maintenance cost per 1 unit feed

But regarding power plant, operation cost is given per year and including maintenance cost by PDPAT

(26) cost-freight.csv

format: year, 'whole', cost of (Dubai, Sumatra-light, Arabian Light, Arabian Heavy, coal, gas, gasoline, kerosene, diesel, fuel oil)

related place in program : 'unit_change.inc'

meaning : crude oil and coal unit : US$/ton

gas unit : US$/MMbtu

oil products unit : cent / litre

This cost is added to FOB cost and handled as import cost.

So total cost equation does not barely include this freight cost.

(27) interest.csv

format: year, interest

related place in program : 'after_process.inc'

eq_obj_cost in eq_definition

meaning : interest (it depends on year)

2.1.3 From forecasting model file

The forecasting model gives the output file for optimization model. This output file has some sheets. There is one sheet with a name 'Wsheet'.

operation 1. copy 'Wsheet'

operation 2. paste into sheet 'forecast' in the out_summry_ws.xls

operation 3. click the icon 'Save file' of the next sheet in the out_summry_ws.xls

crude-production

cost-crude-FOB

cost-other FOB

demand-sec

exchange-rate

Then these 5 files are automatically created in the form of xxxxxx.csv because each cell of above 5 sheets has the formula from sheet name 'forecast'.

(28) crude-production.csv

format: year, 'whole', 'dom_crude', production

related place in program : 'bound.inc'

meaning : crude oil production is fixed.

ref) Crude production itself is not used for forecasting model.

But the forecasting model has many kinds of information. So the optimization model gets information from the forecasting model.

(29) cost-crude-FOB.csv

format: year,FOB of (domestic crude, Dubai, Sumatra Light, Arabian Light, Arabian Heavy)

related place in program : ‘unit_change.inc’, ‘output.inc

meaning : cost of crude oil FOB(Freight on Board)

unit $/Bbl

(30) cost-other-FOB.csv

format: year, FOB of (coal, gas, gasoline, kerosene, diesel, fuel oil, el, LPG, jet fuel)

related place in program : ‘bound’

meaning : cost of crude oil FOB(Freight on Board)

unit $/ t : coal

$/MMbtu : gas

Dong/litre : gasoline, kerosene, diesel, fuel oil, jet fuel

Dong/kg : LPG

(31) demand-sec.csv

format: year,’whole’,’whole’, demand of (coal, LPG, gasoline, jet fuel, kerosene, diesel, fuel oil, gas, RE, electricity)

related place in program : ‘unit_change.inc’, ‘output.inc’

meaning : demand of each energy

The forecasting model forecasts the demand in future by sector, by energy

But the optimization model requires the total demand by energy.

So The out_summary_ws.xls extracts only total demand.

(32) exchange-rate.csv

format: year, exchange rate

related place in program : ‘unit_change.inc’, ‘output.inc’

meaning : exchange rate in future by year

2.1.4 From PDPAT file

The forecasting model gives the output file for optimization model . This output file has some sheets. There is one sheet with name ‘xxxxxx summary’. xxxxx means the case name.

operation 1. copy ‘xxxxxx summry ’ from line no87 to no158

operation 2. paste into sheet ‘tepco’ in the input-tepco.xls.

operation 3. click the icon ‘Save file’ of the next sheet in the input-tepco.xls.

p-factor

therm-eff

cost-op-EP

capacity-EP
fuel-consumption
el-sup-fossil
el-sup-fix

Then these 7 files are automatically created in the form of xxxxxx.csv because each cell of above 7 sheets has the formula from sheet name 'tepco'.

If each sheet has '#VALUE!' in some cells, it means that there are no data in the sheet 'tepco'. Then replace the '#VALUIE!' by 0.

2.2 Procedure of execution

After preparing all input data, the model can be executed following the procedure as below

2.2.1 Load GAMS into memory and Execute the model

(1) Double click the following icon IDE on the desktop

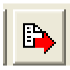
IDE is the interface of GAMS. By using this interface, the various actions are possible as follows

1) GAMS coding
2)Kick the GAMS
3)Execute model by GAMS
4)Get all information of results

Note: IDE icon is automatically created on the desktop by installing GAMS system.

(2) Move the holder to one in which the model exists.
1) Click the 'file' in the tool bar.
2) Click the name in the drop down in sequence project-new project
3) Select the holder name in which the model and data exits.
4) Key in the project name.
Project name is the file name to control the model.
So 1 project corresponds 1 model.
The name can be defined freely and has automatically the extension name 'gpr'.

(3) Click the 'file' in the tool bar and 'open'
(4) Select the model text file name with the extension name '.gms' you coded. (Vietnam.gms)
(5) One Click the following execution icon.



Note: If this icon is not colored "red", the model cannot work. In order to work the GAMS, click the tab with the name 'Vietnam.gms'. Then this icon becomes red.

(6) GAMS automatically runs and creates the output file with the name 'Vietnam.lst' called list file.

note) Refer the GAMS manual regarding lst file

(7) 13 kinds of output are automatically created under the same holder as desscribed above.

These outputs are created by this model itself not by GAMS itself. They are created in order to analyze and check the various results. Later how to use these outputs are described.

2.2.2 In case any error happens.

There are 2 kinds of errors anticipated. One is grammatical error and the other is infeasible/unbounded error.

(1) Grammatical errors

In case of grammatical error, there are some grammatical errors in the model coding. You have to fix them according to the GAMS grammar. The place where the error happens is pointed by '****', so you can easily fine the error place in the list file. Also the list file gives the error contents by the code. The meaning of the code is written after the model coding.

The error message are, for example as follows;

```
     17   put out_testt;
****                 $140,294
```

The error meaning are, for example, as follows;

140 Unknown symbol

294 No external file assigned - A file has to be made current by using the name on a put statement, i.e. PUTxxx fname ....

Note: Refer to the GAMS manual regarding the detail grammar

(2) Infeasible/Unbounded error

1) Infeasible error

There is no royal road to find the real cause of this infeasible error. It depends on the experience. But there is a basic procedure to find the cause. Many data are required in LP model. Man kind is apt to be mistake. So errors happen from input data error with probability over 80%.

The list file created by GAMS points the row(constraint) names or variable names where infeasible errors happen. When the infeasible error happens in the constraint, the constraint cannot be satidfied. When the infeasible error happens in the variable, the variable(solution) cannotexits between the minimum and maximum.So at first the most important method to find the infeasible error is to check the input data regarding row and variables where they happen. Especially lower and upper bound data, fixed data are apt to make errors. If even checking input data, you cannot find the cause of infeasible, check the equation developed by GAMS itself. Check whether the equation developed is one you intended or not.

Example of REPORT SUMMARY)

**** REPORT SUMMARY : 0 NONOPT
12 INFEASIBLE (INFES)
SUM 9994.526
MAX 4830.000
MEAN 832.877
0 UNBOUNDED

Example of infeasible error in the constraint)

2025.whole.EP_coal_dom.L_coal . . . . INFES

Example of infeasible error in the variable)

2018.whole.EP_gas .gas
.el . 73333.524 72567.840 . INFES

Especially check the index and coefficients consisting equations. Usually you can find the error cause by easy checking data and equations over 80%. Even doing so, if you cannot find the error cause, imagine the solution you think to be correct and fix the variable by its value. Check what happens. You may find questionable results. Analyze the solution in detail. Sometimes you may be able to find the cause. The model creates many kinds of output. There are some output files for checking such as list of production, consumption, import, export, bound of variable, refinery results and electricity results. You may be able to find questionable results in these checking these output files. So you may be able to find the error cause. The checking above described have to be done in detail many times.

2) Unbounded error

This error means that objective function value can go to the infinity. As one example, this case may come from the phenomenon such that the material can be sold at infinity with cost 0. If you meet this unbounded error, you should check the cost definition.

2.2.3 After processing the execution of the model

After executing the model, even if there are no errors, the solution may not be correct. The solution is apparently optimal. But it often happens that the solution is not one you expect. So detail check should be done by dong following procedures.

(1)Open the out_summary_kton.xls.

(2)Click the icon name ‘Macro Execute’

--Macro content--

1) Open the out_summary.csv. (Double click this file name)

This file includes almost all energy balance information by year and is automatically created by the model. This file uses the unit by kton or MMm3.

2) Copy data of all E column out_summary.csv.

3) Paste into E column of the sheet name ‘out_summary’ in the out_summary_kton.xls.

4) Click tool-macro-macro and select ‘Macro1’ and click run (R)

5) This file automatically draws graph of each energy balance.

This graph is drawn on each sheet by energy. (Each sheet name is the same to the energy name.) So check the graph whether questionable trends exist or not. If you find any questionable results, fix them and execute the model again till you are satisfied.

(3) Open the out_summary_ktoe.xls.

(4) Click the icon name 'Macro Execute'

--Macro content--

1) Open the out_summary_ktoe.csv. (Double click this file name)

2) Copy data of all E column in out_summary_ktoe.csv.

3) Paste into E column of the sheet name 'out_summary' in the out_summary_ktoe.xls.

4) Click tool-macro-macro and select 'Macro1' and click run (R)

(5) Open the out_summary_ws.xls in order to create the Worksheet and Appendix. This file is used for creating input file from forecasting model and creating a work sheet.

(6) Click the icon name 'Macro Execute' of sheet name 'control' in out_summary_ws.xls.

--Macro content--

1) Copy datafrom the sheet name 'out_summary' in out_summary_kton.xls.

2) Paste into teh sheet name 'out_summry_kton' in out_summary_ws.xls.

3) Copy datafrom the sheet name 'out_summary' in out_summary_ktoe.xls.

4) Paste into teh sheet name 'out_summry_ktoe' in out_summary_ws.xls.

5) Open out_CO2_SO2.csv

6) Copy all data out_CO2_SO2.csv

7) Paste into sheet name 'CO2' in out_summary_ws.xls

8) Open out_coal.csv

9) Paste into sheet name 'out-coal' in out_summary_ws.xls

10) Open capacity-EP.csv

11) Copy all data of sheet name 'capacity-EP' in input-tepco.xls

12) Paste into sheet name 'capacity-EP' in out_summary_ws.xls

(7) Key in the case name into A2 cell of sheet name 'WS' in out_summary_ws.xls. This information is automatically copied to another appropriate cell in work sheet.

(8) Key in the title into D4 cell of sheet name 'Appendix' in out_summary_ws.xls

Then the work sheet and appendix are automatically created.

2.2.4 Execute case studies（1）

After creating the basic model, you can do many case studies. Procedures of case study are as follows;

(1) Make sure that what is difference between the basic model and case study you want to do.

This difference should be represented as input data or model.

(2) Make a new holder under the holder which the original model exists.

(3) Copy all files under the original model holder to new holder for case study.

(4) Change the data or GAMS model according to conditions of case studies.

(5) Execute the case study

(6) Do usual analysisof the case study

(7) In order to compare the case studies(ex: case A and case B)

1) Open the out_summary.csv of case A

2) File save as xxxxxxx.xls

3) Open the out_summry.csv of case B

4) Copy all column E data in case B into column F in xxxxxx.xls

5) Calculate the difference from the data E column (case A)minus the data F column(case B)

6) Analyze the difference by sorting or thinking

2.2.5 Execute case studies（2）

There are some types of case studies by classifying the procedure of GAMS as follows;

(1) Calculate the only specified year(only one year)

1) Click the IDE icon

2) Move the specified holder (refer 2.2.1 (1), (2))

3) File-open

file type = Includes files(*.inc)

select set_definition.inc

4) Find the line

```
set target_year /
2005*2025
/;
```

5) In case that target year is 2010

change 2005*2025 into 2010*2010

6) Execute the case study

(2) Only key in data change is required.

For example CO2 max value is required to be changed.

1) Open the input-data.xls

2) Click the sheet name 'CO2-max'

3) Input a new data of CO2-max

4) Click the icon 'Save file'

5) Execute the case study

(3)Demand data are changed

If some assumptions like GDP growth rate that affect energy demand are changed,

1) The demand forecasting model should be re-executed.

2) Furthermore it also gives the affect to the electricity.

So PDPAT should be executed.

3) Then, input these outcomes and execute the case study. (Refer to 2.2.1)

(4) Demand is no change, but electricity situation is changed.

1) PDPAT is executed

2) Execute the case study (ref 2.2.1)

(5) Constraints is required to be changed.

If energy flow changes, consequently the constraint should be changed. For example, the current model has the flow that the condensate merges into light naphtha. But if the condensate merges directly into gasoline, the balance equation of light naphtha balance and the gasoline balance equation should be changed.

1) Click the IDE icon

2) Move the specified holder (refer 2.2.1 (1), (2)) and define project name

3) file-open

file type = Includes files(*.inc)

select eq_definition.inc

4) Modify the equation in eq_definition according to new assumption.

5) Execute the case study

(6) An objective function is required to be changed.

1) Click the IDE icon

2) Move the specified holder (refer 2.2.1 (1), (2))

3) file-open

file type = Includes files(*.inc)

select eq_definition.inc

4) Define the new objective function

5) file-open

main program = Vietnam.gms

6) Modify the objective function name by new name

solve vietnam_1 using LP minimizing obj_cos-→solve vietnam_1 using LP minimizing xxxxx

7) Execute the case study.

2.3 A regional model

The current model is a whole country model. This comes from the reason why it is very difficult to get the data by region. But if the statistics in Vietnam will develop, it becomes possible to get various data of energy. Then it is better to change this model into the regional model.

(1)This model has the “set r” as region. now the element is only one ‘whole’. This set should be changed . If one (1) region is divided into three (3) regions, elements are defined like northern, central and southern. Then, all data with “set r” should be changed by region.

current coding	modified coding
set r/	set r/
whole	whole
*north	north
*central	central
*south	south
/;	/;

Note: The asterisk(*) in a current coding means comment.

(2) The original file from PDPAT does not have regional name. So ask staffs responsible for PDPAT to

insert the regional name into the original file. According to it, change input-tepco.xls.

(3) You should insert the transportation of energy amount into balance equation by energy. The transportation of energy should be inserted into production side of the region which receives energy, and consumption side of region which sends energy in the balance equation.

The transportation variable Xtrn(y,r,xr,c) is define in the current model.

Xtrn(y,r,xr,c) : amount of transportation energy c from region r into region xr

ex) current general balance equation over whole country is as follows;

production + import +from branch = consumption in general sectors + consumption in transform sector + export + to branch

This equation should be changed to the equation by region as follows;

production + import +from branch + **to transportation** = consumption in general sectors + consumption in transform sector + export + to branch + **from transportation**

(4) The forecasting model already has the demand by region. But the sheet with name 'WS' is current the demand for a whole country. So ask staffs responsible for the forecasting model to change the demand of a whole country to one by region. According to it, you have to change the formula of each cell extracting data from the sheet with name 'FORECAST'.

- End -

Appendix-6

Method of Strategic Environmental Assessment

BAU (Business as Usual Case)

Oil & Gas Sector **ESI = 1144** for **BAU** Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item: BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Vi: Rank by Item	Weight Item	Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Wi: Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	BAU													
Range			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	490.9	CO2 Emission	4.5	3.5	6	1	2.6	3.5	4.5	7	4.6	5	4	4	1	13.0	10.6	3	4	4	11.0	10.1
G2		TPED(Gas)	4.9	4.3	6	1	3.2	4.3	4.9	3		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil), NCE	4.5	3.3	6	1	2.4	3.3	4.5	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1	311.4	TPED(Oil/Gas), SO_2 FD(Transp)	4.3	3.5	6	1	2.5	3.5	4.3	8	4.4	3	4	3	1	10.0	7.8	2	4	3	9.0	9.2
A2		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	4.5	3		1	3	3	0.6	4.2		4	4	3	11.0	
A3		TPED(Oil), FD(Heavy I)	4.7	3.5	6	1	2.3	3.5	4.7	1		0	1	1	0.2	0.4		2	2	1	5.0	
W1	97.7	TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	4.5	8	4.2	2	2	2	0.6	3.6	3.3	2	2	1	5.0	7.1
W2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	1	3	0.6	3.6		3	4	3	10.0	
W3		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	4.5	2		3	3	3	0.6	5.4		2	4	3	9.0	
W4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		2	3	2	0	0.0		2	3	3	8.0	
W5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	3	2	0.3	2.1		3	4	3	10.0	
W6		TPED(Oil)	4.2	3.2	6	1	2	3.2	4.2	1		2	3	2	0	0.0		2	2	1	5.0	
F1	54.6	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	3	3	3	0.2	1.8	1.7	4	3	3	10.0	9.0
F2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.2	1.6		4	2	3	9.0	
F3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.2	1.8		3	2	3	8.0	
S1	104.4	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	2	3	2	0.4	2.8	3.7	4	3	3	10.0	8.0
S2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.3	2.7		4	2	4	10.0	
S4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	3	3	0.5	3.5		3	2	1	6.0	
S5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	2	3	1	8.0		2	1	3	6.0	
T1	85.4	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4	3.8	2	2	2	0.4	2.4	2.7	2	2	3	7.0	8.5
T2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	5		2	4	5	0.1	1.1		4	4	4	12.0	
T3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	4	4	0.2	2.0		3	3	3	9.0	
T4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		1	3	5	0.4	3.6		3	3	2	8.0	
T5		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	4.5	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		TPED(Oil)	4.2	3.2	6	1	2	3.2	4.2	3		2	3	3	0.8	6.4		3	3	2	8.0	
T7		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	4.5	3		2	3	3	0.3	2.4		3	2	2	7.0	
T8		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	4.5	1		1	2	1	0.4	1.6		2	3	1	6.0	
T9		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		1	3	2	0.3	1.8		2	2	3	7.0	
T10		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	4.5	0		2	3	2	0.4	2.8		2	2	2	6.0	
T11		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	3	5	0.3	3.0		2	2	4	8.0	

BAU (Business as Usual Case)

Coal Sector ESI = 1308 for BAU Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item: BAU Case (BAU)	Rank by Item: Reference Case (R)	Rank by Item: High Growth Case (HG)	Rank by Item: Low Growth Case (LG)	Rank by Item: High Price Case (HP)	Rank by Item: Low Price Case (LP)	Vi: Rank by Item (BAU)	Vi: Weight Item	Vi: Rank by Indctr	Vi: W-ing in reach of impacts	Vi: W-ing in duration of impacts	Vi: W-ing in irreversibility of impacts	Vi: W-ing in significance (probability of incidence)		Wi: Weight of Indicator	Wi: Technical mitigation difficulty	Wi: Economic mitigation difficulty	Wi: Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	324.2	CO2 Emission	4.5	3.5	6	1	2.6	3.5	4.5	5	4.7	5	4	4	0.7	9.1	7.2	3	4	4	11.0	9.8
G2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	2		2	1	1	0.5	2.0		2	3	2	7.0	
A1	249.0	TPED(Coal), SO_2	4.7	3.4	6	1	2.5	3.4	4.7	5	4.8	3	3	3	0.8	7.2	7.3	2	4	3	9.0	7.1
A2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	7		2	3	3	1	8.0		2	3	1	6.0	
A3		TPED(Coal), FD(Heavy I	4.8	3.5	6	1	2.6	3.5	4.8	1		1	3	1	0.6	3.0		2	2	1	5.0	
W1	230.0	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1	4.9	2	3	3	0.8	6.4	6.4	4	3	1	8.0	7.3
W2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1		2	3	3	0.9	7.2		2	3	2	7.0	
W3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1		2	3	3	0.7	5.6		3	3	1	7.0	
F1	113.2	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1	4.9	3	3	3	0.2	1.8	2.6	4	3	3	10.0	9.0
F2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1		2	3	3	0.4	3.2		4	2	3	9.0	
F3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1		3	3	3	0.3	2.7		3	2	3	8.0	
S1	139.5	Circulation = TPED(Coa	4.9	3.5	6	1	2.7	3.5	4.9	2	4.7	2	3	3	0.8	6.4	3.8	3	3	3	9.0	7.9
S2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1		1	2	2	0.5	2.5		1	2	2	5.0	
S3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	2		2	3	3	0.2	1.6		4	2	4	10.0	
S4		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	4.9	1		2	3	3	0.5	4.0		3	2	1	6.0	
S5		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	4.9	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	4.9	2		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	4.9	1		3	3	2	0.5	4.0		2	2	4	8.0	
S8		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	2	3	1	8.0		2	1	3	6.0	
T1	252.2	Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	2	4.9	1	2	2	0.4	2.0	6.1	2	2	3	7.0	8.4
T2		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	3		2	4	5	0.8	8.8		4	4	4	12.0	
T3		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1		2	4	4	0.8	8.0		3	3	3	9.0	
T4		Devel. Land = TPED(Coa	4.9	3.5	6	1	2.7	3.5	4.9	1		1	4	5	0.5	5.0		4	3	3	10.0	
T5		Mining Site = TPED(Coa	4.9	3.5	6	1	2.7	3.5	4.9	1		2	3	4	0.1	0.9		2	2	2	6.0	
T6		Abandoned Site = TPED(Coal)	4.9	3.5	6	1	2.7	3.5	4.9	1		2	4	3	1	9.0		3	3	1	7.0	
T7		Circulation = TPED(Coa	4.9	3.5	6	1	2.7	3.5	4.9	2		2	3	3	0.8	6.4		3	3	2	8.0	
T8		Circulation = TPED(Coa	4.9	3.5	6	1	2.7	3.5	4.9	1		2	3	5	0.3	3.0		2	2	4	8.0	
T9		Circulation = TPED(Coa	4.9	3.5	6	1	2.7	3.5	4.9	1		1	3	4	1	8.0		3	3	1	7.0	
T10		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	4.9	1		2	4	4	1	10.0		2	3	2	7.0	
T11		Dev. & Circ. = TPED(Co	4.9	3.5	6	1	2.7	3.5	4.9	1		2	3	1	0.8	4.8		2	2	2	6.0	

BAU (Business as Usual Case)

Electric Power Sector ESI = 1604 for **BAU** Case

Ind.	ESI by indicator	Index on Table	Rank by Item: BAU Case (BAU)	Reference Case (R)	High Growth Case (HG)	Low Growth Case (LG)	High Price Case (HP)	Low Price Case (LP)	Vi: Rank by Item (BAU)	Weight Item	Rank by Indctr	Wi: W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	494.8	CO2 Emission	4.5	3.5	6	1	2.6	3.5	4.5	5	4.6	5	4	4	1	13.0	10.7	3	4	4	11.0	10.1
G2		TPED(Gas/Ren.)	4.9	4.3	6	1	3.2	4.3	4.9	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil/Ren)	4.6	3.4	6	1	2.4	3.4	4.6	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1	272.0	FD(Elec), SO_2	4.3	3.3	6	1	2.4	3.3	4.3	10	4.3	3	3	3	1	9.0	7.7	2	4	3	9.0	8.1
A2		TPED(Coal), FD(Elec)	5.2	3.8	6	1	2.9	3.9	5.2	4		2	3	3	0.7	5.6		2	3	1	6.0	
A3		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4		2	5	5	1	12.0		4	4	1	9.0	
A4		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	1		0	1	1	0.1	0.2		2	2	1	5.0	
A5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	3		1	3	1	0.6	3.0		2	3	3	8.0	
W1	204.4	TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	6	4.0	2	3	3	1	8.0	6.1	3	3	4	10.0	8.3
W2		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	3		2	2	2	0.7	4.2		2	3	1	6.0	
W3		FD(Elec), TPED(Coal)	5.2	3.8	6	1	2.9	3.9	5.2	2		2	3	3	0.7	5.6		2	3	2	7.0	
W4		FD(Elec), TPED(Oil/Gas	4.5	3.6	6	1	2.6	3.6	4.5	1		2	2	2	0.6	3.6		2	3	2	7.0	
W5		FD(Elec), TPED(Ren)	4.4	3.4	6	1	2.6	3.5	4.4	1		2	3	3	0.3	2.4		3	3	2	8.0	
W6		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	1	12.0		4	3	2	9.0	
W7		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	1		2	2	2	0.6	3.6		2	2	1	5.0	
W8		TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.3	2.4		5	4	3	12.0	
W9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	1		2	3	2	0.3	2.1		2	2	3	7.0	
F1	235.0	TPED(Hydro), FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	1	4.2	3	4	4	0.3	3.3	5.9	4	3	3	10.0	9.5
F2		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	1		2	3	3	0.6	4.8		4	2	3	9.0	
F3		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	1		3	3	3	0.4	3.6		3	2	3	8.0	
F4		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	5	5	1	12.0		4	3	4	11.0	
S1	158.6	Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2	3.5	2	3	2	0.7	4.9	5.2	3	3	3	9.0	8.6
S2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	3	3	0.3	2.7		4	2	4	10.0	
S4		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.4	3.2		3	2	2	7.0	
S5		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.3	1.2		1	2	3	6.0	
S6		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	0.2	2.4		4	3	3	10.0	
S7		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	3	3	1	9.0		2	1	3	6.0	
S8		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		5	2	2	1	9.0		4	3	5	12.0	
T1	239.0	Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3	3.8	2	2	2	0.7	4.2	6.1	3	3	4	10.0	10.2
T2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	4	5	0.2	2.2		4	4	4	12.0	
T3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	4	4	0.4	4.0		3	3	3	9.0	
T4		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	4	5	0.4	4.0		3	3	2	8.0	
T5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	3		2	3	3	0.8	6.4		3	3	3	9.0	
T7		Total Devl. = same for a	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	5	0.3	3.0		2	2	4	8.0	
T8		TPED(Hydro, Ren)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	2	0.3	2.1		2	2	2	6.0	
T9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	3		2	3	3	0.3	2.4		3	3	3	9.0	
T10		FD(Elec)	4.4	3.4	6	1	2.6	3.5	4.4	1		2	2	1	0.8	4.0		2	2	2	6.0	
T11		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		4	4	4	12.0	
T12		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		5	5	5	15.0	
T13		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		4	5	5	1	14.0		5	5	5	15.0	

Ref (Reference Case)

Oil & Gas Sector | ESI = 969 | for R Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item						Vi								Wi					Mi
			BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Rank by Item	Weight Item	Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	R													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1		CO2 Emission	4.5	3.5	6	1	2.6	3.5	3.5	7	3.7	5	4	4	1	13.0	10.6	3	4	4	11.0	10.1
G2	394.1	TPED(Gas)	4.9	4.3	6	1	3.2	4.3	4.3	3		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil), NCE	4.5	3.3	6	1	2.4	3.3	3.3	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1		TPED(Oil/Gas), SO_2 FD(Transp)	4.3	3.5	6	1	2.5	3.5	3.5	8	3.6	3	4	3	1	10.0	7.8	2	4	3	9.0	9.2
A2	252.2	TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	3		1	3	3	0.6	4.2		4	4	3	11.0	
A3		TPED(Oil), FD(Heavy I)	4.7	3.5	6	1	2.3	3.5	3.5	1		0	1	1	0.2	0.4		2	2	1	5.0	
W1		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	8	3.6	2	2	2	0.6	3.6	3.3	2	2	1	5.0	7.1
W2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	1	3	0.6	3.6		3	4	3	10.0	
W3	84.5	TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	2		3	3	3	0.6	5.4		2	4	3	9.0	
W4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		2	3	2	0	0.0		2	3	3	8.0	
W5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	3	2	0.3	2.1		3	4	3	10.0	
W6		TPED(Oil)	4.2	3.2	6	1	2	3.2	3.2	1		2	3	2	0	0.0		2	2	1	5.0	
F1		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	3	3	3	0.2	1.8	1.7	4	3	3	10.0	9.0
F2	54.6	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.2	1.6		4	2	3	9.0	
F3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.2	1.8		3	2	3	8.0	
S1		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	2	3	2	0.4	2.8	3.7	4	3	3	10.0	8.0
S2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.3	2.7		4	2	4	10.0	
S4	104.4	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	3	3	0.5	3.5		3	2	1	6.0	
S5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	2	3	1	8.0		2	1	3	6.0	
T1		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4	3.5	2	2	2	0.4	2.4	2.7	2	2	3	7.0	8.5
T2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	5		2	4	5	0.1	1.1		4	4	4	12.0	
T3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	4	4	0.2	2.0		3	3	3	9.0	
T4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		1	3	5	0.4	3.6		3	3	2	8.0	
T5		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6	79.0	TPED(Oil)	4.2	3.2	6	1	2	3.2	3.2	3		2	3	3	0.8	6.4		3	3	2	8.0	
T7		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	3		2	3	3	0.3	2.4		3	2	2	7.0	
T8		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	1		1	2	1	0.4	1.6		2	3	1	6.0	
T9		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		1	3	2	0.3	1.8		2	2	3	7.0	
T10		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	0		2	3	2	0.4	2.8		2	2	2	6.0	
T11		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	3	5	0.3	3.0		2	2	4	8.0	

Ref (Reference Case)

Coal Sector ESI = 953 for R Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item: BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Vi: Rank by Item	Weight Item	Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Wi: Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	R													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	244.0	CO2 Emission	4.5	3.5	6	1	2.6	3.5	3.5	5	3.5	5	4	4	0.7	9.1	7.2	3	4	4	11.0	9.8
G2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	2		2	1	1	0.5	2.0		2	3	2	7.0	
A1	179.0	TPED(Coal), SO_2	4.7	3.4	6	1	2.5	3.4	3.4	5	3.5	3	3	3	0.8	7.2	7.3	2	4	3	9.0	7.1
A2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	7		2	3	3	1	8.0		2	3	1	6.0	
A3		TPED(Coal), FD(Heavy I	4.8	3.5	6	1	2.6	3.5	3.5	1		1	3	1	0.6	3.0		2	2	1	5.0	
W1	164.3	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1	3.5	2	3	3	0.8	6.4	6.4	4	3	1	8.0	7.3
W2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	3	0.9	7.2		2	3	2	7.0	
W3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	3	0.7	5.6		3	3	1	7.0	
F1	80.9	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1	3.5	3	3	3	0.2	1.8	2.6	4	3	3	10.0	9.0
F2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	3	0.4	3.2		4	2	3	9.0	
F3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		3	3	3	0.3	2.7		3	2	3	8.0	
S1	104.6	Circulation = TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	2	3.5	2	3	3	0.8	6.4	3.8	3	3	3	9.0	7.9
S2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		1	2	2	0.5	2.5		1	2	2	5.0	
S3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	2		2	3	3	0.2	1.6		4	2	4	10.0	
S4		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	3	0.5	4.0		3	2	1	6.0	
S5		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	2		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S8		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	2	3	1	8.0		2	1	3	6.0	
T1	180.1	Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	2	3.5	1	2	2	0.4	2.0	6.1	2	2	3	7.0	8.4
T2		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	3		2	4	5	0.8	8.8		4	4	4	12.0	
T3		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	4	4	0.8	8.0		3	3	3	9.0	
T4		Devel. Land = TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		1	4	5	0.5	5.0		4	3	3	10.0	
T5		Mining Site = TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	4	0.1	0.9		2	2	2	6.0	
T6		Abandoned Site = TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	4	3	1	9.0		3	3	1	7.0	
T7		Circulation = TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	2		2	3	3	0.8	6.4		3	3	2	8.0	
T8		Circulation = TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	5	0.3	3.0		2	2	4	8.0	
T9		Circulation = TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	1		1	3	4	1	8.0		3	3	1	7.0	
T10		Total Devel. = TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		2	4	4	1	10.0		2	3	2	7.0	
T11		Dev. & Circ. = TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	1	0.8	4.8		2	2	2	6.0	

Ref (Reference Case)

Electric Power Sector ESI = 1352 for R Case

Ind.	ESI by indicator	Index on Table	Rank by Item: BAU Case (BAU)	Rank by Item: Reference Case (R)	Rank by Item: High Growth Case (HG)	Rank by Item: Low Growth Case (LG)	Rank by Item: High Price Case (HP)	Rank by Item: Low Price Case (LP)	Vi: Rank by Item (R)	Vi: Weight Item	Vi: Rank by Indctr	Wi: W-ing in reach of impacts	Wi: W-ing in duration of impacts	Wi: W-ing in irreversibility of impacts	Wi: W-ing in significance (probability of incidence)	Wi	Wi: Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty	Mi	Mi: Mitigation difficulty of Indicator
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	389.7	CO2 Emission	4.5	3.5	6	1	2.6	3.5	3.5	5	3.6	5	4	4	1	13.0	10.7	3	4	4	11.0	10.1
G2		TPED(Gas/Ren.)	4.9	4.3	6	1	3.2	4.3	4.3	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil/Ren)	4.6	3.4	6	1	2.4	3.4	3.4	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1	216.1	FD(Elec), SO_2	4.3	3.3	6	1	2.4	3.3	3.3	10	3.4	3	3	3	1	9.0	7.7	2	4	3	9.0	8.1
A2		TPED(Coal), FD(Elec)	5.2	3.8	6	1	2.9	3.9	3.8	4		2	3	3	0.7	5.6		2	3	1	6.0	
A3		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4		2	5	5	1	12.0		4	4	1	9.0	
A4		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	1		0	1	1	0.1	0.2		2	2	1	5.0	
A5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	3		1	3	1	0.6	3.0		2	3	3	8.0	
W1	177.2	TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	6	3.5	2	3	3	1	8.0	6.1	3	3	4	10.0	8.3
W2		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	3		2	2	2	0.7	4.2		2	3	1	6.0	
W3		FD(Elec), TPED(Coal)	5.2	3.8	6	1	2.9	3.9	3.8	2		2	3	3	0.7	5.6		2	3	2	7.0	
W4		FD(Elec), TPED(Oil/Gas	4.5	3.6	6	1	2.6	3.6	3.6	1		2	2	2	0.6	3.6		2	3	2	7.0	
W5		FD(Elec), TPED(Ren)	4.4	3.4	6	1	2.6	3.5	3.4	1		2	3	3	0.3	2.4		3	3	2	8.0	
W6		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	1	12.0		4	3	2	9.0	
W7		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	1		2	2	2	0.6	3.6		2	2	1	5.0	
W8		TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.3	2.4		5	4	3	12.0	
W9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	1		2	3	2	0.3	2.1		2	2	3	7.0	
F1	192.8	TPED(Hydro), FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	1	3.4	3	4	4	0.3	3.3	5.9	4	3	3	10.0	9.5
F2		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	1		2	3	3	0.6	4.8		4	2	3	9.0	
F3		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	1		3	3	3	0.4	3.6		3	2	3	8.0	
F4		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	5	5	1	12.0		4	3	4	11.0	
S1	158.6	Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2	3.5	2	3	2	0.7	4.9	5.2	3	3	3	9.0	8.6
S2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	3	3	0.3	2.7		4	2	4	10.0	
S4		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.4	3.2		3	2	2	7.0	
S5		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.3	1.2		1	2	3	6.0	
S6		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	0.2	2.4		4	3	3	10.0	
S7		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	3	3	1	9.0		2	1	3	6.0	
S8		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		5	2	2	1	9.0		4	3	5	12.0	
T1	217.2	Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3	3.5	2	2	2	0.7	4.2	6.1	3	3	4	10.0	10.2
T2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	4	5	0.2	2.2		4	4	4	12.0	
T3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	4	4	0.4	4.0		3	3	3	9.0	
T4		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	4	5	0.4	4.0		3	3	2	8.0	
T5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	3		2	3	3	0.8	6.4		3	3	3	9.0	
T7		Total Devl. = same for a	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	5	0.3	3.0		2	2	4	8.0	
T8		TPED(Hydro, Ren)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	2	0.3	2.1		2	2	2	6.0	
T9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	3		2	3	3	0.3	2.4		3	3	3	9.0	
T10		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.4	1		2	2	1	0.8	4.0		2	2	2	6.0	
T11		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		4	4	4	12.0	
T12		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		5	5	5	15.0	
T13		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		4	5	5	1	14.0		5	5	5	15.0	

GH (High Economic Growth Case)

Oil & Gas Sector ESI = 1444 for HG Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item						Vi			Wi										Mi
			BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Rank by Item	Weight Item	Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	HG													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	639.0	CO2 Emission	4.5	3.5	6	1	2.6	3.5	6	7	6.0	5	4	4	1	13.0	10.6	3	4	4	11.0	10.1
G2		TPED(Gas)	4.9	4.3	6	1	3.2	4.3	6	3		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil), NCE	4.5	3.3	6	1	2.4	3.3	6	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1	426.3	TPED(Oil/Gas), SO_2 FD(Transp)	4.3	3.5	6	1	2.5	3.5	6	8	6.0	3	4	3	1	10.0	7.8	2	4	3	9.0	9.2
A2		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	6	3		1	3	3	0.6	4.2		4	4	3	11.0	
A3		TPED(Oil), FD(Heavy I)	4.7	3.5	6	1	2.3	3.5	6	1		0	1	1	0.2	0.4		2	2	1	5.0	
W1	122.3	TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	6	8	5.2	2	2	2	0.6	3.6	3.3	2	2	1	5.0	7.1
W2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	1	3	0.6	3.6		3	4	3	10.0	
W3		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	6	2		3	3	3	0.6	5.4		2	4	3	9.0	
W4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		2	3	2	0	0.0		2	3	3	8.0	
W5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	3	2	0.3	2.1		3	4	3	10.0	
W6		TPED(Oil)	4.2	3.2	6	1	2	3.2	6	1		2	3	2	0	0.0		2	2	1	5.0	
F1	54.6	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	3	3	3	0.2	1.8	1.7	4	3	3	10.0	9.0
F2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.2	1.6		4	2	3	9.0	
F3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.2	1.8		3	2	3	8.0	
S1	104.4	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	2	3	2	0.4	2.8	3.7	4	3	3	10.0	8.0
S2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.3	2.7		4	2	4	10.0	
S4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	3	3	0.5	3.5		3	2	1	6.0	
S5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	2	3	1	8.0		2	1	3	6.0	
T1	97.0	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4	4.3	2	2	2	0.4	2.4	2.7	2	2	3	7.0	8.5
T2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	5		2	4	5	0.1	1.1		4	4	4	12.0	
T3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	4	4	0.2	2.0		3	3	3	9.0	
T4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		1	3	5	0.4	3.6		3	3	2	8.0	
T5		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	6	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		TPED(Oil)	4.2	3.2	6	1	2	3.2	6	3		2	3	3	0.8	6.4		3	3	2	8.0	
T7		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	6	3		2	3	3	0.3	2.4		3	2	2	7.0	
T8		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	6	1		1	2	1	0.4	1.6		2	3	1	6.0	
T9		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		1	3	2	0.3	1.8		2	2	3	7.0	
T10		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	6	0		2	3	2	0.4	2.8		2	2	2	6.0	
T11		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	3	5	0.3	3.0		2	2	4	8.0	

GH (High Economic Growth Case)

Coal Sector **ESI =** 1624 for **HG** Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item: BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Vi: Rank by Item	Weight Item	Rank by Indctr	Wi: W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	HG													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	418.3	CO2 Emission	4.5	3.5	6	1	2.6	3.5	6	5	6.0	5	4	4	0.7	9.1	7.2	3	4	4	11.0	9.8
G2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	2		2	1	1	0.5	2.0		2	3	2	7.0	
A1	310.3	TPED(Coal), SO_2	4.7	3.4	6	1	2.5	3.4	6	5	6.0	3	3	3	0.8	7.2	7.3	2	4	3	9.0	7.1
A2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	7		2	3	3	1	8.0		2	3	1	6.0	
A3		TPED(Coal), FD(Heavy I	4.8	3.5	6	1	2.6	3.5	6	1		1	3	1	0.6	3.0		2	2	1	5.0	
W1	281.6	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1	6.0	2	3	3	0.8	6.4	6.4	4	3	1	8.0	7.3
W2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1		2	3	3	0.9	7.2		2	3	2	7.0	
W3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1		2	3	3	0.7	5.6		3	3	1	7.0	
F1	138.6	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1	6.0	3	3	3	0.2	1.8	2.6	4	3	3	10.0	9.0
F2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1		2	3	3	0.4	3.2		4	2	3	9.0	
F3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1		3	3	3	0.3	2.7		3	2	3	8.0	
S1	166.9	Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	6	2	5.6	2	3	3	0.8	6.4	3.8	3	3	3	9.0	7.9
S2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1		1	2	2	0.5	2.5		1	2	2	5.0	
S3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	2		2	3	3	0.2	1.6		4	2	4	10.0	
S4		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	6	1		2	3	3	0.5	4.0		3	2	1	6.0	
S5		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	6	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	6	2		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	6	1		3	3	2	0.5	4.0		2	2	4	8.0	
S8		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	2	3	1	8.0		2	1	3	6.0	
T1	308.8	Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	2	6.0	1	2	2	0.4	2.0	6.1	2	2	3	7.0	8.4
T2		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	3		2	4	5	0.8	8.8		4	4	4	12.0	
T3		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1		2	4	4	0.8	8.0		3	3	3	9.0	
T4		Devel. Land ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	6	1		1	4	5	0.5	5.0		4	3	3	10.0	
T5		Mining Site ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	6	1		2	3	4	0.1	0.9		2	2	2	6.0	
T6		Abandoned Site ≒ TPED(Coal)	4.9	3.5	6	1	2.7	3.5	6	1		2	4	3	1	9.0		3	3	1	7.0	
T7		Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	6	2		2	3	3	0.8	6.4		3	3	2	8.0	
T8		Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	6	1		2	3	5	0.3	3.0		2	2	4	8.0	
T9		Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	6	1		1	3	4	1	8.0		3	3	1	7.0	
T10		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	6	1		2	4	4	1	10.0		2	3	2	7.0	
T11		Dev. & Circ. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	6	1		2	3	1	0.8	4.8		2	2	2	6.0	

GH (High Economic Growth Case)

Electric Power Sector ESI = 1972 for HG Case

Ind.	ESI by indicator	Index on Table	Rank by Item: BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Vi: Rank by Item	Weight Item	Rank by Indctr	Wi: W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	HG													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1		CO2 Emission	4.5	3.5	6	1	2.6	3.5	6	5	6.0	5	4	4	1	13.0	10.7	3	4	4	11.0	10.1
G2	649.4	TPED(Gas/Ren.)	4.9	4.3	6	1	3.2	4.3	6	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil/Ren)	4.6	3.4	6	1	2.4	3.4	6	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1		FD(Elec), SO_2	4.3	3.3	6	1	2.4	3.3	6	10	5.5	3	3	3	1	9.0	7.7	2	4	3	9.0	8.1
A2		TPED(Coal), FD(Elec)	5.2	3.8	6	1	2.9	3.9	6	4		2	3	3	0.7	5.6		2	3	1	6.0	
A3	347.8	TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4		2	5	5	1	12.0		4	4	1	9.0	
A4		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	1		0	1	1	0.1	0.2		2	2	1	5.0	
A5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	3		1	3	1	0.6	3.0		2	3	3	8.0	
W1		TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	6	4.8	2	3	3	1	8.0	6.1	3	3	4	10.0	8.3
W2		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	3		2	2	2	0.7	4.2		2	3	1	6.0	
W3		FD(Elec), TPED(Coal)	5.2	3.8	6	1	2.9	3.9	6	2		2	3	3	0.7	5.6		2	3	2	7.0	
W4		FD(Elec), TPED(Oil/Gas	4.5	3.6	6	1	2.6	3.6	6	1		2	2	2	0.6	3.6		2	3	2	7.0	
W5	240.1	FD(Elec), TPED(Ren)	4.4	3.4	6	1	2.6	3.5	6	1		2	3	3	0.3	2.4		3	3	2	8.0	
W6		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	1	12.0		4	3	2	9.0	
W7		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	1		2	2	2	0.6	3.6		2	2	1	5.0	
W8		TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.3	2.4		5	4	3	12.0	
W9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	1		2	3	2	0.3	2.1		2	2	3	7.0	
F1		TPED(Hydro), FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	1	5.4	3	4	4	0.3	3.3	5.9	4	3	3	10.0	9.5
F2	302.5	FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	1		2	3	3	0.6	4.8		4	2	3	9.0	
F3		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	1		3	3	3	0.4	3.6		3	2	3	8.0	
F4		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	5	5	1	12.0		4	3	4	11.0	
S1		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2	3.5	2	3	2	0.7	4.9	5.2	3	3	3	9.0	8.6
S2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	3	3	0.3	2.7		4	2	4	10.0	
S4	158.6	Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.4	3.2		3	2	2	7.0	
S5		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.3	1.2		1	2	3	6.0	
S6		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	0.2	2.4		4	3	3	10.0	
S7		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	3	3	1	9.0		2	1	3	6.0	
S8		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		5	2	2	1	9.0		4	3	5	12.0	
T1		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3	4.4	2	2	2	0.7	4.2	6.1	3	3	4	10.0	10.2
T2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	4	5	0.2	2.2		4	4	4	12.0	
T3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	4	4	0.4	4.0		3	3	3	9.0	
T4		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	4	5	0.4	4.0		3	3	2	8.0	
T5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	3		2	3	3	0.8	6.4		3	3	3	9.0	
T7	273.9	Total Devl. = same for a	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	5	0.3	3.0		2	2	4	8.0	
T8		TPED(Hydro, Ren)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	2	0.3	2.1		2	2	2	6.0	
T9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	3		2	3	3	0.3	2.4		3	3	3	9.0	
T10		FD(Elec)	4.4	3.4	6	1	2.6	3.5	6	1		2	2	1	0.8	4.0		2	2	2	6.0	
T11		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		4	4	4	12.0	
T12		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		5	5	5	15.0	
T13		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		4	5	5	1	14.0		5	5	5	15.0	

LG (Low Economic Growth Case)

Oil & Gas Sector ESI = 439 for LG Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item						Vi								Wi					Mi
			BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Rank by Item	Weight Item	Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	LG													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	106.5	CO2 Emission	4.5	3.5	6	1	2.6	3.5	1	7	1.0	5	4	4	1	13.0	10.6	3	4	4	11.0	10.1
G2		TPED(Gas)	4.9	4.3	6	1	3.2	4.3	1	3		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil), NCE	4.5	3.3	6	1	2.4	3.3	1	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1	71.0	TPED(Oil/Gas), SO_2 FD(Transp)	4.3	3.5	6	1	2.5	3.5	1	8	1.0	3	4	3	1	10.0	7.8	2	4	3	9.0	9.2
A2		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	1	3		1	3	3	0.6	4.2		4	4	3	11.0	
A3		TPED(Oil), FD(Heavy I)	4.7	3.5	6	1	2.3	3.5	1	1		0	1	1	0.2	0.4		2	2	1	5.0	
W1	41.8	TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	1	8	1.8	2	2	2	0.6	3.6	3.3	2	2	1	5.0	7.1
W2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	1	3	0.6	3.6		3	4	3	10.0	
W3		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	1	2		3	3	3	0.6	5.4		2	4	3	9.0	
W4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		2	3	2	0	0.0		2	3	3	8.0	
W5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	3	2	0.3	2.1		3	4	3	10.0	
W6		TPED(Oil)	4.2	3.2	6	1	2	3.2	1	1		2	3	2	0	0.0		2	2	1	5.0	
F1	54.6	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	3	3	3	0.2	1.8	1.7	4	3	3	10.0	9.0
F2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.2	1.6		4	2	3	9.0	
F3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.2	1.8		3	2	3	8.0	
S1	104.4	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	2	3	2	0.4	2.8	3.7	4	3	3	10.0	8.0
S2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.3	2.7		4	2	4	10.0	
S4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	3	3	0.5	3.5		3	2	1	6.0	
S5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	2	3	1	8.0		2	1	3	6.0	
T1	60.9	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4	2.7	2	2	2	0.4	2.4	2.7	2	2	3	7.0	8.5
T2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	5		2	4	5	0.1	1.1		4	4	4	12.0	
T3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	4	4	0.2	2.0		3	3	3	9.0	
T4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		1	3	5	0.4	3.6		3	3	2	8.0	
T5		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	1	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		TPED(Oil)	4.2	3.2	6	1	2	3.2	1	3		2	3	3	0.8	6.4		3	3	2	8.0	
T7		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	1	3		2	3	3	0.3	2.4		3	2	2	7.0	
T8		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	1	1		1	2	1	0.4	1.6		2	3	1	6.0	
T9		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		1	3	2	0.3	1.8		2	2	3	7.0	
T10		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	1	0		2	3	2	0.4	2.8		2	2	2	6.0	
T11		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	3	5	0.3	3.0		2	2	4	8.0	

LG (Low Economic Growth Case)

Coal Sector ESI = 285 for LG Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item						Vi			Wi										Mi
			BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Rank by Item	Weight Item	Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	LG													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	69.7	CO2 Emission	4.5	3.5	6	1	2.6	3.5	1	5	1.0	5	4	4	0.7	9.1	7.2	3	4	4	11.0	9.8
G2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	2		2	1	1	0.5	2.0		2	3	2	7.0	
A1	51.7	TPED(Coal), SO_2	4.7	3.4	6	1	2.5	3.4	1	5	1.0	3	3	3	0.8	7.2	7.3	2	4	3	9.0	7.1
A2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	7		2	3	3	1	8.0		2	3	1	6.0	
A3		TPED(Coal), FD(Heavy I	4.8	3.5	6	1	2.6	3.5	1	1		1	3	1	0.6	3.0		2	2	1	5.0	
W1	46.9	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1	1.0	2	3	3	0.8	6.4	6.4	4	3	1	8.0	7.3
W2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1		2	3	3	0.9	7.2		2	3	2	7.0	
W3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1		2	3	3	0.7	5.6		3	3	1	7.0	
F1	23.1	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1	1.0	3	3	3	0.2	1.8	2.6	4	3	3	10.0	9.0
F2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1		2	3	3	0.4	3.2		4	2	3	9.0	
F3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1		3	3	3	0.3	2.7		3	2	3	8.0	
S1	42.3	Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	1	2	1.4	2	3	3	0.8	6.4	3.8	3	3	3	9.0	7.9
S2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1		1	2	2	0.5	2.5		1	2	2	5.0	
S3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	2		2	3	3	0.2	1.6		4	2	4	10.0	
S4		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	1	1		2	3	3	0.5	4.0		3	2	1	6.0	
S5		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	1	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	1	2		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	1	1		3	3	2	0.5	4.0		2	2	4	8.0	
S8		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	2	3	1	8.0		2	1	3	6.0	
T1	51.5	Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	2	1.0	1	2	2	0.4	2.0	6.1	2	2	3	7.0	8.4
T2		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	3		2	4	5	0.8	8.8		4	4	4	12.0	
T3		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1		2	4	4	0.8	8.0		3	3	3	9.0	
T4		Devel. Land ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	1	1		1	4	5	0.5	5.0		4	3	3	10.0	
T5		Mining Site ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	1	1		2	3	4	0.1	0.9		2	2	2	6.0	
T6		Abandoned Site ≒ TPED(Coal)	4.9	3.5	6	1	2.7	3.5	1	1		2	4	3	1	9.0		3	3	1	7.0	
T7		Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	1	2		2	3	3	0.8	6.4		3	3	2	8.0	
T8		Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	1	1		2	3	5	0.3	3.0		2	2	4	8.0	
T9		Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	1	1		1	3	4	1	8.0		3	3	1	7.0	
T10		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	1	1		2	4	4	1	10.0		2	3	2	7.0	
T11		Dev. & Circ. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	1	1		2	3	1	0.8	4.8		2	2	2	6.0	

LG (Low Economic Growth Case)

Electric Power Sector ESI = 728 for LG Case

Ind.	ESI by indicator	Index on Table	Rank by Item: BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Rank by Item	Weight Item	Vi: Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Wi: Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	LG													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	108.2	CO2 Emission	4.5	3.5	6	1	2.6	3.5	1	5	1.0	5	4	4	1	13.0	10.7	3	4	4	11.0	10.1
G2		TPED(Gas/Ren.)	4.9	4.3	6	1	3.2	4.3	1	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil/Ren)	4.6	3.4	6	1	2.4	3.4	1	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1	91.2	FD(Elec), SO_2	4.3	3.3	6	1	2.4	3.3	1	10	1.5	3	3	3	1	9.0	7.7	2	4	3	9.0	8.1
A2		TPED(Coal), FD(Elec)	5.2	3.8	6	1	2.9	3.9	1	4		2	3	3	0.7	5.6		2	3	1	6.0	
A3		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4		2	5	5	1	12.0		4	4	1	9.0	
A4		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	1		0	1	1	0.1	0.2		2	2	1	5.0	
A5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	3		1	3	1	0.6	3.0		2	3	3	8.0	
W1	113.7	TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	6	2.3	2	3	3	1	8.0	6.1	3	3	4	10.0	8.3
W2		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	3		2	2	2	0.7	4.2		2	3	1	6.0	
W3		FD(Elec), TPED(Coal)	5.2	3.8	6	1	2.9	3.9	1	2		2	3	3	0.7	5.6		2	3	2	7.0	
W4		FD(Elec), TPED(Oil/Gas	4.5	3.6	6	1	2.6	3.6	1	1		2	2	2	0.6	3.6		2	3	2	7.0	
W5		FD(Elec), TPED(Ren)	4.4	3.4	6	1	2.6	3.5	1	1		2	3	3	0.3	2.4		3	3	2	8.0	
W6		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	1	12.0		4	3	2	9.0	
W7		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	1		2	2	2	0.6	3.6		2	2	1	5.0	
W8		TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.3	2.4		5	4	3	12.0	
W9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	1		2	3	2	0.3	2.1		2	2	3	7.0	
F1	91.5	TPED(Hydro), FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	1	1.6	3	4	4	0.3	3.3	5.9	4	3	3	10.0	9.5
F2		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	1		2	3	3	0.6	4.8		4	2	3	9.0	
F3		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	1		3	3	3	0.4	3.6		3	2	3	8.0	
F4		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	5	5	1	12.0		4	3	4	11.0	
S1	158.6	Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2	3.5	2	3	2	0.7	4.9	5.2	3	3	3	9.0	8.6
S2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	3	3	0.3	2.7		4	2	4	10.0	
S4		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.4	3.2		3	2	2	7.0	
S5		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.3	1.2		1	2	3	6.0	
S6		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	0.2	2.4		4	3	3	10.0	
S7		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	3	3	1	9.0		2	1	3	6.0	
S8		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		5	2	2	1	9.0		4	3	5	12.0	
T1	164.9	Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3	2.6	2	2	2	0.7	4.2	6.1	3	3	4	10.0	10.2
T2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	4	5	0.2	2.2		4	4	4	12.0	
T3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	4	4	0.4	4.0		3	3	3	9.0	
T4		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	4	5	0.4	4.0		3	3	2	8.0	
T5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	3		2	3	3	0.8	6.4		3	3	3	9.0	
T7		Total Devl. ≈ same for a	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	5	0.3	3.0		2	2	4	8.0	
T8		TPED(Hydro, Ren)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	2	0.3	2.1		2	2	2	6.0	
T9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	3		2	3	3	0.3	2.4		3	3	3	9.0	
T10		FD(Elec)	4.4	3.4	6	1	2.6	3.5	1	1		2	2	1	0.8	4.0		2	2	2	6.0	
T11		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		4	4	4	12.0	
T12		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		5	5	5	15.0	
T13		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		4	5	5	1	14.0		5	5	5	15.0	

HP (High Price Case)

Oil & Gas Sector | ESI = 767 | for HP Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item: BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Vi: Rank by Item	Weight Item	Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Wi: Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	HP													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	292.4	CO2 Emission	4.5	3.5	6	1	2.6	3.5	2.6	7	2.7	5	4	4	1	13.0	10.6	3	4	4	11.0	10.1
G2		TPED(Gas)	4.9	4.3	6	1	3.2	4.3	3.2	3		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil), NCE	4.5	3.3	6	1	2.4	3.3	2.4	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1	178.2	TPED(Oil/Gas), SO_2 FD(Transp)	4.3	3.5	6	1	2.5	3.5	2.5	8	2.5	3	4	3	1	10.0	7.8	2	4	3	9.0	9.2
A2		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	2.6	3		1	3	3	0.6	4.2		4	4	3	11.0	
A3		TPED(Oil), FD(Heavy I)	4.7	3.5	6	1	2.3	3.5	2.3	1		0	1	1	0.2	0.4		2	2	1	5.0	
W1	66.7	TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	2.6	8	2.8	2	2	2	0.6	3.6	3.3	2	2	1	5.0	7.1
W2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	1	3	0.6	3.6		3	4	3	10.0	
W3		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	2.6	2		3	3	3	0.6	5.4		2	4	3	9.0	
W4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		2	3	2	0	0.0		2	3	3	8.0	
W5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	3	2	0.3	2.1		3	4	3	10.0	
W6		TPED(Oil)	4.2	3.2	6	1	2	3.2	2	1		2	3	2	0	0.0		2	2	1	5.0	
F1	54.6	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	3	3	3	0.2	1.8	1.7	4	3	3	10.0	9.0
F2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.2	1.6		4	2	3	9.0	
F3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.2	1.8		3	2	3	8.0	
S1	104.4	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	2	3	2	0.4	2.8	3.7	4	3	3	10.0	8.0
S2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.3	2.7		4	2	4	10.0	
S4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	3	3	0.5	3.5		3	2	1	6.0	
S5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	2	3	1	8.0		2	1	3	6.0	
T1	70.8	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4	3.1	2	2	2	0.4	2.4	2.7	2	2	3	7.0	8.5
T2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	5		2	4	5	0.1	1.1		4	4	4	12.0	
T3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	4	4	0.2	2.0		3	3	3	9.0	
T4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		1	3	5	0.4	3.6		3	3	2	8.0	
T5		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	2.6	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		TPED(Oil)	4.2	3.2	6	1	2	3.2	2	3		2	3	3	0.8	6.4		3	3	2	8.0	
T7		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	2.6	3		2	3	3	0.3	2.4		3	2	2	7.0	
T8		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	2.6	1		1	2	1	0.4	1.6		2	3	1	6.0	
T9		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		1	3	2	0.3	1.8		2	2	3	7.0	
T10		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	2.6	0		2	3	2	0.4	2.8		2	2	2	6.0	
T11		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	3	5	0.3	3.0		2	2	4	8.0	

HP (High Price Case)

Coal Sector ESI = 732 for HP Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item: BAU Case (BAU)	Reference Case (R)	High Growth Case (HG)	Low Growth Case (LG)	High Price Case (HP)	Low Price Case (LP)	Vi: Rank by Item (HP)	Weight Item	Rank by Indctr	Wi: W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	183.9	CO2 Emission	4.5	3.5	6	1	2.6	3.5	2.6	5	2.6	5	4	4	0.7	9.1	7.2	3	4	4	11.0	9.8
G2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	2		2	1	1	0.5	2.0		2	3	2	7.0	
A1	135.3	TPED(Coal), SO_2	4.7	3.4	6	1	2.5	3.4	2.5	5	2.6	3	3	3	0.8	7.2	7.3	2	4	3	9.0	7.1
A2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	7		2	3	3	1	8.0		2	3	1	6.0	
A3		TPED(Coal), FD(Heavy I	4.8	3.5	6	1	2.6	3.5	2.6	1		1	3	1	0.6	3.0		2	2	1	5.0	
W1	126.7	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1	2.7	2	3	3	0.8	6.4	6.4	4	3	1	8.0	7.3
W2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1		2	3	3	0.9	7.2		2	3	2	7.0	
W3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1		2	3	3	0.7	5.6		3	3	1	7.0	
F1	62.4	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1	2.7	3	3	3	0.2	1.8	2.6	4	3	3	10.0	9.0
F2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1		2	3	3	0.4	3.2		4	2	3	9.0	
F3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1		3	3	3	0.3	2.7		3	2	3	8.0	
S1	84.7	Circulation ≈ TPED(Coa	4.9	3.5	6	1	2.7	3.5	2.7	2	2.8	2	3	3	0.8	6.4	3.8	3	3	3	9.0	7.9
S2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1		1	2	2	0.5	2.5		1	2	2	5.0	
S3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	2		2	3	3	0.2	1.6		4	2	4	10.0	
S4		Total Devel. ≈ TPED(Co	4.9	3.5	6	1	2.7	3.5	2.7	1		2	3	3	0.5	4.0		3	2	1	6.0	
S5		Total Devel. ≈ TPED(Co	4.9	3.5	6	1	2.7	3.5	2.7	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Total Devel. ≈ TPED(Co	4.9	3.5	6	1	2.7	3.5	2.7	2		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Total Devel. ≈ TPED(Co	4.9	3.5	6	1	2.7	3.5	2.7	1		3	3	2	0.5	4.0		2	2	4	8.0	
S8		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	2	3	1	8.0		2	1	3	6.0	
T1	139.0	Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	2	2.7	1	2	2	0.4	2.0	6.1	2	2	3	7.0	8.4
T2		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	3		2	4	5	0.8	8.8		4	4	4	12.0	
T3		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1		2	4	4	0.8	8.0		3	3	3	9.0	
T4		Devel. Land ≈ TPED(Co	4.9	3.5	6	1	2.7	3.5	2.7	1		1	4	5	0.5	5.0		4	3	3	10.0	
T5		Mining Site ≈ TPED(Coa	4.9	3.5	6	1	2.7	3.5	2.7	1		2	3	4	0.1	0.9		2	2	2	6.0	
T6		Abandoned Site ≈ TPED(Coal)	4.9	3.5	6	1	2.7	3.5	2.7	1		2	4	3	1	9.0		3	3	1	7.0	
T7		Circulation ≈ TPED(Coa	4.9	3.5	6	1	2.7	3.5	2.7	2		2	3	3	0.8	6.4		3	3	2	8.0	
T8		Circulation ≈ TPED(Coa	4.9	3.5	6	1	2.7	3.5	2.7	1		2	3	5	0.3	3.0		2	2	4	8.0	
T9		Circulation ≈ TPED(Coa	4.9	3.5	6	1	2.7	3.5	2.7	1		1	3	4	1	8.0		3	3	1	7.0	
T10		Total Devel. ≈ TPED(Co	4.9	3.5	6	1	2.7	3.5	2.7	1		2	4	4	1	10.0		2	3	2	7.0	
T11		Dev. & Circ. ≈ TPED(Co	4.9	3.5	6	1	2.7	3.5	2.7	1		2	3	1	0.8	4.8		2	2	2	6.0	

HP (High Price Case)

Electric Power Sector | ESI = 1132 | for HP Case

Ind.	ESI by indicator	Index on Table	Rank by Item: BAU Case (BAU)	Reference Case (R)	High Growth Case (HG)	Low Growth Case (LG)	High Price Case (HP)	Low Price Case (LP)	Vi: Rank by Item (HP)	Weight Item	Rank by Indctr	Wi: W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1		CO2 Emission	4.5	3.5	6	1	2.6	3.5	2.6	5	2.7	5	4	4	1	13.0	10.7	3	4	4	11.0	10.1
G2	287.6	TPED(Gas/Ren.)	4.9	4.3	6	1	3.2	4.3	3.2	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil/Ren)	4.6	3.4	6	1	2.4	3.4	2.4	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1		FD(Elec), SO_2	4.3	3.3	6	1	2.4	3.3	2.4	10	2.7	3	3	3	1	9.0	7.7	2	4	3	9.0	8.1
A2		TPED(Coal), FD(Elec)	5.2	3.8	6	1	2.9	3.9	2.9	4		2	3	3	0.7	5.6		2	3	1	6.0	
A3	171.1	TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4		2	5	5	1	12.0		4	4	1	9.0	
A4		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	1		0	1	1	0.1	0.2		2	2	1	5.0	
A5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	3		1	3	1	0.6	3.0		2	3	3	8.0	
W1		TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	6	3.1	2	3	3	1	8.0	6.1	3	3	4	10.0	8.3
W2		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	3		2	2	2	0.7	4.2		2	3	1	6.0	
W3		FD(Elec), TPED(Coal)	5.2	3.8	6	1	2.9	3.9	2.9	2		2	3	3	0.7	5.6		2	3	2	7.0	
W4		FD(Elec), TPED(Oil/Gas	4.5	3.6	6	1	2.6	3.6	2.6	1		2	2	2	0.6	3.6		2	3	2	7.0	
W5	155.8	FD(Elec), TPED(Ren)	4.4	3.4	6	1	2.6	3.5	2.6	1		2	3	3	0.3	2.4		3	3	2	8.0	
W6		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	1	12.0		4	3	2	9.0	
W7		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	1		2	2	2	0.6	3.6		2	2	1	5.0	
W8		TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.3	2.4		5	4	3	12.0	
W9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	1		2	3	2	0.3	2.1		2	2	3	7.0	
F1		TPED(Hydro), FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	1	2.8	3	4	4	0.3	3.3	5.9	4	3	3	10.0	9.5
F2	159.0	FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	1		2	3	3	0.6	4.8		4	2	3	9.0	
F3		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	1		3	3	3	0.4	3.6		3	2	3	8.0	
F4		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	5	5	1	12.0		4	3	4	11.0	
S1		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2	3.5	2	3	2	0.7	4.9	5.2	3	3	3	9.0	8.6
S2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	3	3	0.3	2.7		4	2	4	10.0	
S4	158.6	Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.4	3.2		3	2	2	7.0	
S5		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.3	1.2		1	2	3	6.0	
S6		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	0.2	2.4		4	3	3	10.0	
S7		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	3	3	1	9.0		2	1	3	6.0	
S8		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		5	2	2	1	9.0		4	3	5	12.0	
T1		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3	3.2	2	2	2	0.7	4.2	6.1	3	3	4	10.0	10.2
T2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	4	5	0.2	2.2		4	4	4	12.0	
T3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	4	4	0.4	4.0		3	3	3	9.0	
T4		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	4	5	0.4	4.0		3	3	2	8.0	
T5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	3		2	3	3	0.8	6.4		3	3	3	9.0	
T7	199.8	Total Devl. ≈ same for a	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	5	0.3	3.0		2	2	4	8.0	
T8		TPED(Hydro, Ren)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	2	0.3	2.1		2	2	2	6.0	
T9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	3		2	3	3	0.3	2.4		3	3	3	9.0	
T10		FD(Elec)	4.4	3.4	6	1	2.6	3.5	2.6	1		2	2	1	0.8	4.0		2	2	2	6.0	
T11		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		4	4	4	12.0	
T12		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		5	5	5	15.0	
T13		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		4	5	5	1	14.0		5	5	5	15.0	

LP (Low Price Case)

Oil & Gas Sector | ESI = 969 | for LP Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item							Vi							Wi				Mi
			BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Rank by Item	Weight Item	Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	LP													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	394.1	CO2 Emission	4.5	3.5	6	1	2.6	3.5	3.5	7	3.7	5	4	4	1	13.0	10.6	3	4	4	11.0	10.1
G2		TPED(Gas)	4.9	4.3	6	1	3.2	4.3	4.3	3		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil), NCE	4.5	3.3	6	1	2.4	3.3	3.3	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1	252.2	TPED(Oil/Gas), SO_2 FD(Transp)	4.3	3.5	6	1	2.5	3.5	3.5	8	3.6	3	4	3	1	10.0	7.8	2	4	3	9.0	9.2
A2		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	3		1	3	3	0.6	4.2		4	4	3	11.0	
A3		TPED(Oil), FD(Heavy I)	4.7	3.5	6	1	2.3	3.5	3.5	1		0	1	1	0.2	0.4		2	2	1	5.0	
W1	84.5	TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	8	3.6	2	2	2	0.6	3.6	3.3	2	2	1	5.0	7.1
W2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	1	3	0.6	3.6		3	4	3	10.0	
W3		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	2		3	3	3	0.6	5.4		2	4	3	9.0	
W4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		2	3	2	0	0.0		2	3	3	8.0	
W5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	3	2	0.3	2.1		3	4	3	10.0	
W6		TPED(Oil)	4.2	3.2	6	1	2	3.2	3.2	1		2	3	2	0	0.0		2	2	1	5.0	
F1	54.6	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	3	3	3	0.2	1.8	1.7	4	3	3	10.0	9.0
F2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.2	1.6		4	2	3	9.0	
F3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.2	1.8		3	2	3	8.0	
S1	104.4	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1	3.5	2	3	2	0.4	2.8	3.7	4	3	3	10.0	8.0
S2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	3	0.3	2.7		4	2	4	10.0	
S4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	3	3	0.5	3.5		3	2	1	6.0	
S5		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	2	3	1	8.0		2	1	3	6.0	
T1	79.0	Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4	3.5	2	2	2	0.4	2.4	2.7	2	2	3	7.0	8.5
T2		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	5		2	4	5	0.1	1.1		4	4	4	12.0	
T3		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		2	4	4	0.2	2.0		3	3	3	9.0	
T4		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		1	3	5	0.4	3.6		3	3	2	8.0	
T5		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		TPED(Oil)	4.2	3.2	6	1	2	3.2	3.2	3		2	3	3	0.8	6.4		3	3	2	8.0	
T7		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	3		2	3	3	0.3	2.4		3	2	2	7.0	
T8		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	1		1	2	1	0.4	1.6		2	3	1	6.0	
T9		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	0		1	3	2	0.3	1.8		2	2	3	7.0	
T10		TPED(Oil/Gas)	4.5	3.7	6	1	2.6	3.7	3.7	0		2	3	2	0.4	2.8		2	2	2	6.0	
T11		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	3	5	0.3	3.0		2	2	4	8.0	

LP (Low Price Case)

Coal Sector ESI = 953 for LP Case

Ind.	ESI by indicator	Index from Case Study	Rank by Item: BAU Case	Rank by Item: Reference Case	Rank by Item: High Growth Case	Rank by Item: Low Growth Case	Rank by Item: High Price Case	Rank by Item: Low Price Case	Vi: Rank by Item	Vi: Weight Item	Vi: Rank by Indctr	Wi: W-ing in reach of impacts	Wi: W-ing in duration of impacts	Wi: W-ing in irreversibility of impacts	Wi: W-ing in significance (probability of incidence)	Wi	Wi: Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mi: Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	LP													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2,…	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1	244.0	CO2 Emission	4.5	3.5	6	1	2.6	3.5	3.5	5	3.5	5	4	4	0.7	9.1	7.2	3	4	4	11.0	9.8
G2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	2		2	1	1	0.5	2.0		2	3	2	7.0	
A1	179.0	TPED(Coal), SO_2	4.7	3.4	6	1	2.5	3.4	3.4	5	3.5	3	3	3	0.8	7.2	7.3	2	4	3	9.0	7.1
A2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	7		2	3	3	1	8.0		2	3	1	6.0	
A3		TPED(Coal), FD(Heavy I	4.8	3.5	6	1	2.6	3.5	3.5	1		1	3	1	0.6	3.0		2	2	1	5.0	
W1	164.3	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1	3.5	2	3	3	0.8	6.4	6.4	4	3	1	8.0	7.3
W2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	3	0.9	7.2		2	3	2	7.0	
W3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	3	0.7	5.6		3	3	1	7.0	
F1	80.9	TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1	3.5	3	3	3	0.2	1.8	2.6	4	3	3	10.0	9.0
F2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	3	0.4	3.2		4	2	3	9.0	
F3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		3	3	3	0.3	2.7		3	2	3	8.0	
S1	104.6	Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	2	3.5	2	3	3	0.8	6.4	3.8	3	3	3	9.0	7.9
S2		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		1	2	2	0.5	2.5		1	2	2	5.0	
S3		TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	2		2	3	3	0.2	1.6		4	2	4	10.0	
S4		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	3	0.5	4.0		3	2	1	6.0	
S5		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		1	2	1	0.1	0.4		1	2	3	6.0	
S6		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	2		2	5	5	0.1	1.2		4	3	3	10.0	
S7		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S8		Facility, Same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	2	3	1	8.0		2	1	3	6.0	
T1	180.1	Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	2	3.5	1	2	2	0.4	2.0	6.1	2	2	3	7.0	8.4
T2		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	3		2	4	5	0.8	8.8		4	4	4	12.0	
T3		Facility, TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	4	4	0.8	8.0		3	3	3	9.0	
T4		Devel. Land ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	1		1	4	5	0.5	5.0		4	3	3	10.0	
T5		Mining Site ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	4	0.1	0.9		2	2	2	6.0	
T6		Abandoned Site ≒ TPED(Coal)	4.9	3.5	6	1	2.7	3.5	3.5	1		2	4	3	1	9.0		3	3	1	7.0	
T7		Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	2		2	3	3	0.8	6.4		3	3	2	8.0	
T8		Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	5	0.3	3.0		2	2	4	8.0	
T9		Circulation ≒ TPED(Coa	4.9	3.5	6	1	2.7	3.5	3.5	1		1	3	4	1	8.0		3	3	1	7.0	
T10		Total Devel. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		2	4	4	1	10.0		2	3	2	7.0	
T11		Dev. & Circ. ≒ TPED(Co	4.9	3.5	6	1	2.7	3.5	3.5	1		2	3	1	0.8	4.8		2	2	2	6.0	

LP　(Low Price Case)

Electric Power Sector　　ESI = 1362　　for　LP　Case

Ind.	ESI by indicator	Index on Table	Rank by Item						Vi								Wi					Mi
			BAU Case	Reference Case	High Growth Case	Low Growth Case	High Price Case	Low Price Case	Rank by Item	Weight Item	Rank by Indctr	W-ing in reach of impacts	W-ing in duration of impacts	W-ing in irreversibility of impacts	W-ing in significance (probability of incidence)		Weight of Indicator	Technical mitigation difficulty	Economic mitigation difficulty	Sociopolitical mitigation difficulty		Mitigation difficulty of Indicator
			BAU	R	HG	LG	HP	LP	LP													
Range of Value			1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	1≦R≦6	W=0,1,2, …	1≦R≦6	0≦W≦5	0≦W≦5	0≦W≦5	0≦W≦1		0<W≦15	0≦W≦5	0≦W≦5	0≦W≦5		1≦W≦15
G1		CO2 Emission	4.5	3.5	6	1	2.6	3.5	3.5	5	3.6	5	4	4	1	13.0	10.7	3	4	4	11.0	10.1
G2	389.7	TPED(Gas/Ren.)	4.9	4.3	6	1	3.2	4.3	4.3	1		4	3	4	0.7	7.7		3	3	3	9.0	
G3		TPED(Coal/Oil/Ren)	4.6	3.4	6	1	2.4	3.4	3.4	1		2	1	1	0.5	2.0		2	3	2	7.0	
A1		FD(Elec), SO_2	4.3	3.3	6	1	2.4	3.3	3.3	10	3.5	3	3	3	1	9.0	7.7	2	4	3	9.0	8.1
A2		TPED(Coal), FD(Elec)	5.2	3.8	6	1	2.9	3.9	3.9	4		2	3	3	0.7	5.6		2	3	1	6.0	
A3	218.4	TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4		2	5	5	1	12.0		4	4	1	9.0	
A4		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	1		0	1	1	0.1	0.2		2	2	1	5.0	
A5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	3		1	3	1	0.6	3.0		2	3	3	8.0	
W1		TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	6	3.6	2	3	3	1	8.0	6.1	3	3	4	10.0	8.3
W2		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	3		2	2	2	0.7	4.2		2	3	1	6.0	
W3		FD(Elec), TPED(Coal)	5.2	3.8	6	1	2.9	3.9	3.9	2		2	3	3	0.7	5.6		2	3	2	7.0	
W4		FD(Elec), TPED(Oil/Gas	4.5	3.6	6	1	2.6	3.6	3.6	1		2	2	2	0.6	3.6		2	3	2	7.0	
W5	179.4	FD(Elec), TPED(Ren)	4.4	3.4	6	1	2.6	3.5	3.5	1		2	3	3	0.3	2.4		3	3	2	8.0	
W6		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	1	12.0		4	3	2	9.0	
W7		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	1		2	2	2	0.6	3.6		2	2	1	5.0	
W8		TPED(Hydro)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.3	2.4		5	4	3	12.0	
W9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	1		2	3	2	0.3	2.1		2	2	3	7.0	
F1		TPED(Hydro), FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	1	3.5	3	4	4	0.3	3.3	5.9	4	3	3	10.0	9.5
F2	197.0	FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	1		2	3	3	0.6	4.8		4	2	3	9.0	
F3		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	1		3	3	3	0.4	3.6		3	2	3	8.0	
F4		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	5	5	1	12.0		4	3	4	11.0	
S1		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2	3.5	2	3	2	0.7	4.9	5.2	3	3	3	9.0	8.6
S2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		3	3	2	0.5	4.0		2	2	4	8.0	
S3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	3	3	0.3	2.7		4	2	4	10.0	
S4	158.6	Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	3	0.4	3.2		3	2	2	7.0	
S5		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	2	1	0.3	1.2		1	2	3	6.0	
S6		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	5	5	0.2	2.4		4	3	3	10.0	
S7		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3		3	3	3	1	9.0		2	1	3	6.0	
S8		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		5	2	2	1	9.0		4	3	5	12.0	
T1		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3	3.5	2	2	2	0.7	4.2	6.1	3	3	4	10.0	10.2
T2		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		2	4	5	0.2	2.2		4	4	4	12.0	
T3		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	4	4	0.4	4.0		3	3	3	9.0	
T4		Facility, same for all	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		1	4	5	0.4	4.0		3	3	2	8.0	
T5		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	1		2	2	2	0.1	0.6		2	2	2	6.0	
T6		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	3		2	3	3	0.8	6.4		3	3	3	9.0	
T7	219.4	Total Devl. ≈ same for a	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	5	0.3	3.0		2	2	4	8.0	
T8		TPED(Hydro, Ren)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	1		2	3	2	0.3	2.1		2	2	2	6.0	
T9		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	3		2	3	3	0.3	2.4		3	3	3	9.0	
T10		FD(Elec)	4.4	3.4	6	1	2.6	3.5	3.5	1		2	2	1	0.8	4.0		2	2	2	6.0	
T11		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		4	4	4	12.0	
T12		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		3	5	5	1	13.0		5	5	5	15.0	
T13		TPED(Nuclear)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2		4	5	5	1	14.0		5	5	5	15.0	