(5) Review about IDC

For hydropower project, interest during construction makes significant influence for increasing the total project cost. In this study, IDC is calculated for the project by the following manner.

$$IDC = 0.4 \times R \times T \times \text{Investment Cost}$$

where, R ; rate of interest
T ; Construction Term (year)

In this review, above equation is checked to be appropriate or not in Viet Nam, using data of Son La project studied in "Pre-F/S". In this report, construction term of the project is considered to be 14 years, and yearly progress ratio by investment cost is shown in Table 6.2-11.

Supposing that yearly interest ratio is equal to 10%, and that investment cost is equal to 100, calculated IDC based on yearly disbursement schedule becomes 58 as shown in that table.

If IDC is under same condition, that is R=10%, and T=14 years, by above equation, it is calculated by the above equation as follows;

$$IDC = 0.4 \times 0.1 \times 14 \times 100 = 56$$

Therefore, it can be appreciated to estimate IDC by the above equation.

6.2.3 Assessment of Hydropower Projects

(1) Scope of Assessment

Assessment of hydropower projects is made based on the planned figures submitted by IEV (PIDC1) and result of JICA Study Team's review described in 6.2.2.

In this section, the assessment is made by employing several indexes, those are "B/C" and "Levelized Unit Energy Cost".

However, the following should be kept in mind as the initial condition for making assessment of hydropower projects;

(a) In the calculation, the benefits for other sector/s such as flood control, irrigation, etc. of the multipurpose projects have not been considered, so that the project cost has not been allocated to other sector/s, and the power sector has to bear all the project cost, except several projects ordered by IEV.

(b) For the calculation of benefit, electricity is quoted from 6.2.2 for the reviewed project. For other projects, electricity offered by IEV as shown in Table 6.2-1 is applied.

(c) In assessment of the new hydropower projects and Power Development Planning Study in chapter 8, investment costs offered by IEV are applied. Among the new projects, IEV notified JICA Study Team, that the investment cost of Ban Mai project, Dong Nai 4 project, and Dai Ninh project should be changed to figures which they offered.

(d) According to IEV, part of power discharge of Dai Ninh project reviewed in 6.2.2 is not used for power generation, but irrigation. Though influence to projects downstream is not changed, annual energy of Dai Ninh project becomes different. As there is no information about this matter, annual output for assessment is quoted from the figure shown in Table 6.2-1 for Dai Ninh project, that is 1,218 GWh generated by the project itself, and 1,175 GWh, considering the influence to energy production of Tri Anh hydropower plant downstream.

(2) Basic Concept of Assessment

Assessment described here is to evaluate hydropower project from economic aspect. One of the economic evaluations of a hydropower project is made based on the benefit-cost analysis comparing its cost with that of an alternative thermal power project with the equivalent power supply functions. In this study, annual benefit and equalized annual cost is adopted for evaluation. These matters are described later. Also the hydropower projects are evaluated by levelized unit energy cost (U$/kWh).

A coal thermal power project is adopted, because coal can be supplied economically and stably in Viet Nam, comparing with oil, natural gas, and other fuel materials as described in 3.5.

(3) Equalized Annual Cost

The equalized annual cost of a hydropower project consists of depreciation and operation-maintenance (OM) cost. This is estimated by multiplying the annual cost factor by the investment cost assuming a discount rate of 10% and the following conditions;

- Service Life:

Civil Facility	50 years
Hydro-mechanical Facility	25 years
Electro-mechanical Facility	25 years

- Rate of Operation and Maintenance Cost to Direct Project Cost:

Civil Facility	1.5%
Hydro-mechanical Facility	1.5%
Electro-mechanical Facility	1.5%

The method of calculation of equalized annual cost is shown in Appendix 6.2.6.

(4) Levelized Unit Energy Cost

Using equalized annual cost and results of electricity calculation in 6.2.2 or electricity shown in Table 6.2-1, "Levelized Unit Energy Cost" is also calculated by next equation. IDC is considered here as described in 6.2.2.

Levelized Unit Energy Cost = Equalized Annual Cost x (1 + 0.4 x R x T) / Annual Energy

(5) Annual Benefit

The annual benefit of hydropower projects is provided according to the cost of the alternative thermal power project composed of capital cost, OM cost and fuel cost. Those costs are divided into fixed cost and variable cost, and converted to unit kW and unit kWh cost at the receiving end of power and energy. The figures are shown in Table 6.2-12.

The annual benefit of hydropower project is obtained by next equation.

$$\text{Annual Benefit} = \text{kW value} \times Pf \times 24 / Tp + \text{kWh value} \times E$$

where, Pf: Firm capacity (MW)
Tp: Peak Operation time (hour)
E: Annual Output (kWh)

In this matter, benefit of hydropower project varies depending on "Tp". In this study, "Tp" is basically assumed to be 8 hours to evaluate capacity value of hydropower.

For some projects, however, value of "Pf x 24/Tp " becomes larger than installed capacity of the project, if "Tp" is shortened. In this case, therefore, peak firm capacity, that is the value of "Pf x 24/Tp", is set with limitation of installed capacity in the calculation of annual benefit. Here, firm capacity is defined as the capacity which can be supplied more than 95% of the calculation term.

(6) Results of Assessment

Using the method described as clauses (1)~(5), hydropower projects are evaluated economically by "B/C" and "Levelized Unit Energy Cost".

(a) Results of the projects along the Da river, the Sesan river, and the Dong Nai river

The results of the assessment of reviewed projects in case of peak operation of 24 hours and 8 hours are shown in Table 6.2-13. Comparing the values in this table, findings of the assessment are as follows;

In the assessment of hydropower project by "B/C", kW value makes large influence in B/C value. B/C can be larger by employing shorter peak time. If peak time operation is not considered, that means "24" hour peak operation, the projects of which B/C is larger than 1.0 are only Son La (L), Plei Krong and Sesan 3 projects.

If peak operation time is supposed to be 8 hours, B/C of almost all the projects become larger than 1.0. Even in this case, however, B/C of Dong Nai 8 is less than 1.0.

Compared with B/C of three river systems, that of the Da river systems is highest. Though B/C of the Dong Nai river systems is the lowest, projects along the Dong Nai river systems could be developed not only as important hydropower resource in Southern region, but also multi-purpose project to make effective use of water resource.

For individual projects along these three river systems, Son La, Huoi Quang, Thuong Kontum, Plei Krong, and Sesan 3 project can be highly appreciated.

For the Dong Nai river basin, Dai Ninh project can be highly appreciated.

(b) Comparative Study about the Da river basin development scheme

There are two alternatives for the Da river development scheme in this study. Compared with two alternatives, combination of Son La (S) and Huoi Quang scheme is highly appreciated in levelized unit energy cost. But compared by B/C value, Son La (L) scheme is highly appreciated in 24 hours peak operation, and Son La (S) and Huoi Quang scheme is highly appreciated in 8 hours peak operation as shown in Table 6.2-13. So, B/C value of these two alternatives are compared by varying peak operation time, those are 24, 12, 10, 8, 6 hours. The results are shown in Table 6.2-14 and Figure 6.2-3.

These data shows that Son La (L) scheme is highly appreciated under the condition of more than 10 hours peak operation, and Son La (S) and Huoi Quang scheme is highly appreciated under the condition of less than 10 hours peak time operation.

Considering above matter, Son La (L) project supplies power mainly for base demand, and Son La (S) and Huoi Quang scheme can be oriented to a power supply mainly for peak demand. Role of the project in electricity demand and load curve after the commissioning year should be taken into consideration to determine the development scale of Son La project. This matter is studied in Power Development Planning Study in chapter 8.

(c) Assessment of Individual New Hydropower Projects

Assessment of individual new hydropower projects is made, using the same method described above. The result of study in 24, 12, 10, 8, 6 hours peak operations are shown in Table 6.2-15. In the table, electricity values are quoted from Table 6.2-1 for the projects not reviewed in 6.2.2. Rankings of the projects under varying peak operation time and levelized energy unit cost are shown in Table 6.2-16. Besides this study, individual projects are assessed by using reviewed investment cost. The results are shown in Appendix 6.2.7.

Findings of the study are as follows:

The projects of which B/C is larger than 1.0 under 24 hour peak time operation are Sesan 3, Ban Mai, Son La (L), and Plei Krong projects. If studied by reviewed investment cost, B/C of Ban Mai project becomes less than 1.0. These projects can be highly appreciated as hydropower energy generator.

Considered by peak operation, B/C of all the projects except Dong Nai 8 and Can Don project becomes larger than 1.0. But B/C of Cua Dat and Song Con 2 projects also becomes less than 1, using reviewed investment cost.

By shortening peak operation hour, B/C of Thuong Kontum and Dai Ninh project becomes larger, and ranked as high class. This shows that these projects are suitable mainly for power supply for peak electricity demands. But ranking becomes lower, if considering reviewed investment cost.

By shortening peak operation hours, B/C of Son La (L) and Plei Krong projects are ranked lower. It is because the ratio between firm capacity and installed capacity is so high that peak firm capacity, that means firm capacity multiplied by "24/Tp" becomes larger than installed capacity by shortening peak operation hours, and benefit by kW is limited.

As shown in Table 6.2-16, levelized unit energy cost of Ham Thuan/Da Mi project is 0.0524 U$/kWh. Considering this fact, projects ranked less than Song Con 2 in Table 6.2-16 seem to be expensive in levelized unit energy cost. Projects of which levelied unit energy cost is less than 0.0600 U$/kWh, that is a kind of criterion of levelized unit energy cost, are recommendable to be developed. But eight projects are considered to be expensive, in the condition with JICA Team's reviewed cost, as shown in Appendix 6.2.7.

Son La, Huoi Quang, Sesan 3, Dai Thi, and Ban Mai projects are ranked in higher class than Ham Thuan & Da Mi project in Table 6.2-16. They can be highly appreciated as promising projects. But, considered with JICA Team's reviewed investment cost, Ban Mai project is ranked lower.

(7) Conclusion

Considered in Viet Nam as the whole area, projects along the Da river and Dai Thi projects are highly appreciated in Northern region. In Central region, projects along the Sesan river are highly appreciated. In Southern region, Dai Ninh project can be highly appreciated under peak operation as the next project to be developed after Ham Thuan/Da Mi project. For these projects, collecting basic data is necessary for further study.

As shown in Table 6.2-16, Son La, Huoi Quang, Dai Thi, and Sesan 3 projects are confirmed to be promising projects.

Among 4 projects, Sesan 3 project is now studied only at the desk level. Also, there are five projects planned in the Sesan river basin including Yaly project under construction. Therefore, master plan study along the Sesan river basin will be necessary at first, before it's F/S. But master planning study should be started as soon as possible to make sure of promising project and development scale, because Sesan 3 project which is ranked first in the ranking table, is expected to be commissioned after 2002 and before 2010 by IEV.

For Dai Thi project, F/S will be necessary. But Dai Thi project is not expected to be commissioned until 2010 by IEV. According to IEV, it is multipurpose project. Therefore, the following matters should be studied, besides general technical matters;

(a) Amount of monthly or daily water supplying plan
(b) Distribution of effective volume of reservoir for each purpose, for example, irrigation, energy generation, flood control, etc.
(c) Reservoir operation rule with water supply

Pre-F/S of Son La project along the Da river has already been finished by PIDC-1. First generating unit of Son La project is expected to be commissioned in 2007 by IEV. Considering the construction schedule, construction work should be started at least by the beginning of 2000's. And F/S and definite design work should be finished before construction work. Therefore, F/S should be started as soon as possible.

Considering above matters, F/S of Son La project should be promoted positively, if official development assistance for Viet Nam in energy sector is considered to be made.

In F/S, determining the development scale is one of the basic problems for Son La project. According to the study in this section, Son La (S) project (2400MW) is confirmed to be suitable mainly for a power supply for peak demands, and Son La (L) project (3600MW) is confirmed to be suitable mainly for a power supply for base demands. Development scale will be selected as a result of this stage of study, by the result of optimum power development planning study described in chapter 8.

For the purpose of F/S on Son La project, items to be confirmed are summarized in Appendix 6.2.8. Additionally, comments on Son La project are described in next section.

(8) Comments on Son La Project

Since the Son La project is planned with a range of installed capacity of 2,400 MW to 3600 MW, and, therefore, has significant impact on power system development of Viet Nam, general description of the Son La hydropower project is given below to clarify its present status for the purpose of the study.

The development plan of Son La project was established in 1978. "General Report on the Multipurpose Use of the Da River" approved by the Vietnamese government specifies the exploitation of Da River by two hydropower projects, the Hoa Binh hydropower plant with a normal reservoir level of 115 m in the 1st stage and Son La (Ta Bu Site) with a normal reservoir level of 260 m estimated in the 2nd stage.

After that, the pre-F/S was implemented by PIDC1 and approved by the government in 1992. The pre-feasibility report clearly shows the concept of the project and findings to be cleared in the F/S. The report shows the study on 3 cases of the project scale depending on the high water level of the reservoir, large scale with EL 265 m, middle scale with EL 240 m and small scale with EL 215 m. Four candidate dam sites of the project are proposed for each case. But technical matters on site selection and development are not described in detail in the report.

Four candidate dam sites of the reservoir are called Pa Vinh, Ta Bu, Ban Pau, and Ban Ta from upstream. For Son La project, dam is considered to be constructed at Ban Ta site by PIDC-1. But elevation level of Ban Ta site is lower than High Water Level of Hoa Binh reservoir downstream. Therefore, High Water Level of Hoa Binh reservoir will be set lower by 20 ~ 30 m during construction of Son La project. In this case, energy of Hoa Binh hydropower plant will be decreased by 40~50%, considering the effective head of Hoa Binh hydropower plant. This matter should be taken into consideration in the study of dam site selection and optimum development scale study. Geological information about Son La project is shown in Appendix 6.2.9.

Sedimentation is now one of the big problems at the Da river systems. According to IEV, sedimentation level of Hoa Binh reservoir back water becomes almost the same as the planned level after impounding of Hoa Binh reservoir by only a few years. Unfortunately, these data were not offered by IEV. For Hoa Binh project, sedimentation was estimated with the method of former USSR. Sedimentary inflow might have been estimated lower than the actual sediment inflow. This matter should be reviewed in detail in F/S. This is an important factor for determining Low Water Level of reservoir of Son La project, and can make some influence for development scale.

For rockfill dam construction, materials for embankment were also studied. In pre-F/S report by PIDC-1, however, borrow area for soil materials and quarry site for rock materials are not described. In F/S, location of borrow area and quarry should be studied at first. And amount of embankment materials of each borrow area or quarry should be estimated taking quantities of embankment and type of dam into consideration.

Because of the long term of required construction period, construction plan and schedule is important aspect for project economy.

Environmental issues are a concern because of the wide area at High Water Level of Son La project, those are 275 km^2 in Son La (S) project, and 508 km^2 for Son La (L) project. As recommended in the pre-F/S report, the north-western part is constituted by flat terraces with elevation of about 230~240 m. These areas will be under High Water Level of reservoir in case of Son La (L) project, that is 265m at present. The small scale development of the project is preferable from environmental view point. Avoiding the resettlement of too many people and wishes of minority people to conserve their old lands are taken into consideration in environmental impact assessment of the project.

Table 6.2-1 Specification of Hydro Power Projects

Project Name		Unit	The Northern Region						The Center Region											The Southern Region					
			Son La (S)	Son La (L)	Huoi Quang	Dai Thi	Cua Dat	Ban Mai	Yaly	Song Con2	Song Hinh	An Khe	Plei Krong	Sesan 3	Sesan 4	Thuong Kontum	Buon Cuop	Rao Quan		Ham Thuan	Da Mi	Dong Nai 8	Dong Nai 4	Cau Don	Dai Ninh
River System		-	Da	Da	Da	Logam	Chu	Ca	Se San	Thubon	Ba	Ba	Sesan	Sesan	Sesan	Sesan	Srepoc	T.Han	T.Han	Langa	Langa	Dong Nai	Dong Nai	Be	Dong Nai
Catchment Area		km^2	45,730	45,730	2,930	15,250	6,000	14,250	7,455	242	772	1,270	3,224	8,009	10,920	350	7,983	163	28	1,280	1,360	9,047	4,530	3,482	1,933
Generation	Maximum Power	MW	2,400	3,600	800	250	105	350	720	60	70	116	120	220	366	260	81	-	80	300	172	192	200	50	300
	Firm Power	MW	763	1,518	499	86	35	151	227	17	26.2	41.7	53.2	101.5	163.9	111	23	-	30.2	71	43	41.2	53.75	23.7	96.2
	Annual Energy	GWh	9,647	14,812	2,580	1,300	331	1,550	3,589	271	253	482	466	990	1,652	987	479	-	286	957	580	856	956.5	200	1,218
Discharge	Maximum	m^3/s	3,177	3,060	368	460	270	516	408	26.8	57.3	41.4	217.8	515.9	734.3	33.4	214	-	25	136	136	492.3	133	301	57
	Firm	m^3/s	925	1,302	92	216	70	244		7.6	21.7	14.7	90.2	235.6	330.3	16.7	60.2	-	9	30.5	34	102.1	39.5	71.2	17.5
Effective Head	Maximum	m	113	157	243	76	72	97	212.3	290	153	361	72	53	68	831	50	-	394	278	150	55	190	27	674
	Design	m	83	129	220	62	62	84	190	280	141	350	60	53	62	800	48	-	365	250	142	49	167	21	611
Reservoir	Capacity	10^6m^3	11,620	30,750	2,008	3,000	1,500	7,424	1,037	265	357	642	1,871.5	343	3,267.8	422	92.4	245.8	-	695	141	1,327	345.4	228	320
	Effective Capacity	10^6m^3	7,410	19,612	1,067	1,900	1,075	4,536	779	229	353	561	1,292.6	-	1,315.3	357	42.4	220.9	-	523	18	847	261.8	184	252
	H.W.L.	m	215	265	440	115	100	155	515	340	209	440	585	305	235	1,194	410	465	470	605	325	120	480	110	880
	L.W.L.	m	180	215	410	90	68	125	490	305	196	425	560	305	225	1,150	405	430	460	575	323	110	430	100	860
Main Dam	Type	-	R	R	A	R	C	R	R	R	E	E	R	R	R	R	E	R	R	R	R	R	R	R	E
	Length	m	930	900	436	375	350	405	1,460	275	880	3,443	455	410	1,700	410	1,207	720	725	550	494	1,700	513	350	1,700
	Height	m	136	192	160	115	95	123	65	60	43	38	77	63	77	95	36	57	25	91	69	45	126	35	45
	Volume	10^6m^3	27,665	66,400	-	5,127	500			1,230	5,465	5,223	5,117	2,999	12,442	4,170	1,335	2,093	1,013	9,965	3,183	19,940	6,462	1,103	9,062
Headrace Channel	Bottom Width	m	-	-	-	-	-			6	8	10	-	-	-	-	20	-	-	5	14	30	10	20	-
	Length	m	-	-	-	-	-			500	1540	5900	-	-	-	-	600	-	-	560	-	1,850	870	930	-
Tunnel	Number	-	10	12	2	3	-	2	2	1	1	1	2	-	3	1	-	1	1	1	1	-	1	-	1
	Length	m	315	604	3,670	357	-	330	3,674.4	4,750	1,458	1,870	342	-	140	11,421	-	6,800	1,400	3,050	2,403	-	4,570	-	1,460
Penstock	Number	-	-	-	4	-	3		4	1	1	3	-	2	3	2	3	-	1	1	2	3	3	2	2
	Length	m	-	-	587	-	-		526	450	558	840	-	183	145	3,500	420	-	600	880	400	620	180	150	1,900
Power House	Type	-	Open	Open	Open	Open	Open	Open	Under ground	Open	Open	Open	Open	Open	Open	Open	Open	Underground		Open	Open	Open	Open	Open	Open
	Number of unit	-	10	12	4	3	3	4	4	2	2	3	2	2	3	4	3	-	3	2	2	3	3	2	2
	Unit Power	MW	240	300	200	83	35	87.5	180	30	35	38.7	60	110	122	65	27	-	26.7	150	86	64	66	25	150

Source: PIDC-1

Remarks: R: Rockfill
A: Arch
C: Concrete
E: Earthfilll

Table 6.2-2 Review about the Projects along the Da river

Case		Hoa Binh	Son La(S)	Huoi Quang	Total	Hoa Binh	Son La(L)	Total
1	Pf	423			423	423		423
	E	8,797			8,797	8,797		8,797
	d Pf							
	d E							
	Pf Total	423				423		
	E Total	8,797				8,797		
2	Pf	583	569		1,152	1,011	1,159	2,170
	E	9,659	9,942		19,601	11,113	15,080	26,193
	d Pf	160			160	588		
	d E	862			862	2,316		
	Pf Total		729				1,747	
	E Total		10,804				17,396	
3	Pf	608	605	186	1,399			
	E	9,753	10,044	2,788	22,585			
	d Pf	25	36		61			
	d E	94	102		196			
	Pf Total			247				
	E Total			2,984				

Pf Shows "Firm Capacity", and E shows "Annual Energy", d Pf and d E shows the difference caused by new project
"Case 1" is the present situation, that is, Hoa Binh project is operated.
"Case 2" is the situation after Son La project is completed.
"Case 3" is the situation after Huoi Quang project is completed, if Son La (S) project is developped.

Table 6.2-3 Review about the Projects along the Sesan river

Case		Plei Krung	T. Kontum	Yaly	Sesan 3	Sesan 4	Total
1	Pf			199			199
	E			3,591			3,591
	d Pf						
	d E						
	Pf Total			199			
	E Total			3,591			
2	Pf	36		271			307
	E	562		3,814			4,376
	d Pf			72			
	d E			223			
	Pf Total	108					
	E Total	785					
3	Pf	36	89	264			389
	E	562	866	3,684			5,112
	d Pf			-7			
	d E			-130			
	Pf Total		82				
	E Total		736				
4	Pf	36	81	264	77		458
	E	562	787	3,684	1,079		6,112
	d Pf						
	d E						
	Pf Total				77		
	E Total				1,079		
5	Pf	36	81	264	77	124	582
	E	562	787	3,684	1,079	1,810	7,922
	d Pf						
	d E						
	Pf Total					124	
	E Total					1,810	

"Case 1" is the situation after Yaly project is completed, which is now under construction.
"Case 2" is the situation after Plei Krong project is completed.
"Case 3" is the situation after Thuong Kontum project is completed.
"Case 4" is the situation after Sesan 3 project is completed.
"Case 5" is the situation after Sesan 4 project is completed.

Table 6.2-4 Review about the Projects along the Dong Nai river

Case	Da Nhim	Dai Ninh	Dong Nai 4	Dong Nai 8	Ham Thuan	Da Mi	Tri Anh	Total
1	99 1,159							99 1,159
	99 1,159							
2	99 1,159						98 1,883	197 3,042
							98 1,883	
3	99 1,159				80 929	49 551	118 1,926	346 4,565
							20 42	
					100 972			
4	99 1,159	100 1,733			80 929	49 551	98 1,883	426 6,255
							-20 -43	
		81 1,690						
5	99 1,159	100 1,733	42 950		80 929	49 551	98 1,883	468 7,205
							0 0	
			42 950					
6	99 1,159	100 1,733	42 950	50 931	70 1,101	41 646	138 1,897	540 8,418
				40 15				
				90 1,021				

"Case 1" is the situation after Da Nhim project is completed.
"Case 2" is the present situation after Tri Anh project is completed.
"Case 3" is the situation after Ham Thuan and Da Mi projects are completed.
"Case 4" is the situation after Dai Ninh project is completed.
"Case 5" is the situation after Dong Nai 4 project is completed.
"Case 6" is the situation after Dong Nai 8 project is completed.

Table 6.2-5 Investment Cost of the Projects (1/2)

(1,000US$)

Project Name		Son La (S)		Son La (L)		Huoi Quang		Dai Thi		Cua Dat		Ban Mai		Song Con 2		An Khe		Plei Krong		Sesan 3	
Item	Unit	Cost	Cost/I.C.	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Civil works	1,000US$	1,133,957	55.31%	2,043,412	58.61%	423,047	57.55%	132,779	44.04%	115,909	57.95%	208,924	50.55%	59,137	59.05%	70,797	41.31%	146,788	58.50%	92,500	49.16%
Hydro-Mechanical Works	1,000US$	82,353	4.02%	89,734	2.57%	22,152	3.01%	13,095	4.34%	12,089	6.04%	50,960	12.33%	6,583	6.57%	16,645	9.71%	9,669	3.85%	13,246	7.04%
Electro-Mechanical Works	1,000US$	424,320	20.70%	636,480	18.26%	149,760	20.37%	50,185	16.65%	18,892	9.45%	32,172	7.78%	9,947	9.93%	20,509	11.97%	21,590	8.60%	45,760	24.32%
Transmission Line	1,000US$	0	0.00%	0	0.00%	22,080	3.00%	12,075	4.01%	5,175	2.59%	33,120	8.01%	4,140	4.13%	10,263	5.99%	10,120	4.03%	7,245	3.85%
Contigency	1,000US$	76,413	3.73%	128,356	3.68%	27,652	3.76%	9,092	3.02%	6,724	3.36%	12,854	3.11%	3,490	3.49%	5,047	2.94%	8,175	3.26%	7,080	3.76%
Land	1,000US$	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Admiistration and engineering Fee	1,000US$	171,704	8.37%	289,798	8.31%	62,261	8.47%	20,516	6.80%	15,361	7.68%	30,491	7.38%	7,916	7.90%	11,300	6.59%	18,623	7.42%	15,859	8.43%
Compensation	1,000US$	161,562	7.88%	298,448	8.56%	28,176	3.83%	63,743	21.14%	25,850	12.93%	44,800	10.84%	8,930	8.92%	36,836	21.49%	35,948	14.33%	6,462	3.43%
Investment Cost	1,000US$	2,050,309	100.00%	3,486,228	99.99%	735,128	99.99%	301,485	100.00%	200,000	100.00%	413,321	100.00%	100,143	99.99%	171,397	100.00%	250,913	99.99%	188,152	99.99%
I.D.C.	1,000US$	984,148		2,091,737		205,836		72,356		48,000		99,197		24,034		41,135		60,219		45,156	
Total	1,000US$	3,034,457		5,577,965		940,964		373,841		248,000		512,518		124,177		212,532		311,132		233,308	
Construction Term	year	12		15		7		6		6		6		6		6		6		6	

Source: IEV

Table 6.2-6 Investment Cost of the Projects (2/2)

(1,000US$)

Project Name		Sesan 4		Thuong Kontum		Buon Cuop		Rao Quan		Dong Nai 8		Dong Nai 4		Cau Don		Dai Ninh	
Item	Unit	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Civil works	1,000US$	260,988	50.72%	151,710	55.06%	67,436	58.94%	85,104	61.49%	280,202	59.27%			54790	46.86%	225292	55.15%
Hydro-Mechanical Works	1,000US$	20,939	4.07%	26,439	9.60%	9,017	7.88%	4,153	3.00%	25,232	5.34%			10,274	8.79%	27,777	6.80%
Electro-Mechanical Works	1,000US$	76,127	14.80%	45,967	16.68%	14,321	12.52%	15,066	10.89%	33,945	7.18%			8,996	7.69%	61,864	15.14%
Transmission Line	1,000US$	10,867	2.11%	8,452	3.07%	2,070	1.81%	8,970	6.48%	10,350	2.19%			11,730	10.03%	34,914	8.55%
Contigency		16,505	3.21%	10,454	3.79%	4,205	3.68%	4,794	3.46%	15,581	3.30%			3,432	2.94%	14,630	3.58%
Land	1,000US$	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%			0	0.00%	0	0.00%
Admiistration and engineering Fee	1,000US$	37,456	7.28%	23,457	8.51%	9,498	8.30%	10,911	7.88%	35,496	7.51%			7,749	6.63%	32,956	8.07%
Compensation	1,000US$	91,650	17.81%	9,047	3.28%	7,872	6.88%	9,400	6.79%	71,968	15.22%			19,945	17.06%	11,102	2.72%
Investment Cost	1,000US$	514,532	100.00%	275,526	99.99%	114,419	100.01%	138,398	99.99%	472,774	100.01%	250,000	0.00%	116,916	100.00%	408,535	100.01%
I.D.C.	1,000US$	123,488		66,126		27,461		33,216		113,466		60,000		28,060		98,048	
Total	1,000US$	638,020		341,652		141,880		171,614		586,240		310,000		144,976		506,583	
Construction Term	year	6		6		6		6		6		6		6		6	

Source: IEV

Table 6.2-7 Relation between Area at HWL and Compensation Cost

Project Name	Area at HWL (km^2)	Compensation Cost (1,000US$)	Remarks
Son La(S)	275.00	161,562	
Son La(L)	508.00	298,448	
Huoi Quang	48.00	28,176	
Dai Thi	108.50	63,743	
Cua Dat	44.00	25,850	
Ban Mai	194.00	44,800	
Song Con 2	15.20	8,930	
Song Hinh	41.00	24,087	
An Khe	62.70	36,836	
Plei Krong	79.50	35,948	
Sesan 3	11.00	6,462	
Sesan 4	156.00	91,650	
Thuong Kontum	15.40	9,047	
Buon Cuop	13.40	7,872	
Ham Thuan	25.20	12,227	
Da Mi	6.30	2,736	
Rao Quan	16.10	9,400	
Dong Nai 8	122.50	71,968	
Dong Nai 4	9.00	5,258	
Cau Don	34.00	19,945	
Dai Ninh	18.80	11,102	

Table 6.2-8 Comparison on Environmental Factors between Son La (L) and Son La (S)

Environmental factor	Unit	Son La (large)	Son La (small)	(L)/(S)
1. Area of submerged cultivated land	ha	14,500	7,251	2.0
2. Area of submerged forest	ha	47,850	21,800	2.2
3. Length of submerged roads	km	415	170	2.44
4. Number of submerged villages	number of villages	233	183	1.27
5. Resettlement of people				
(1) In the year 2000 (estimated)	households	24,190	17,786	1.36
	persons	142,860	105,170	1.36
(2) In the year 2010 (estimated)	household	32,950	24,185	1.36
	persons	185,550	137,300	1.35
6. Compensation amount (estimated)	x 10^6 US$	298.45	161.56	1.85
7. Remarks				
(1) Surface area at HWL	km^2	508.0	275.0	1.85
(2) Max. power output	MW	3,600	2,400	1.50

Remarks:

Population in the year 1990 at HWL
1) In case of Son La (L): 106,530 persons (17,652 households)
2) In case of Son La (S) 77,900 persons (12,845 households)

Table 6.2-9 Total Difference Investment Cost by JICA Team's Review

Project Name	Investment Cost (1,000US$)	Reviewed Investment Cost (1,000US$)	Difference (1,000US$)	Remarks
Son La (S)	2,050,309	2,001,331	-48,978	-2.39%
Son LA (L)	3,486,228	3,376,826	-109,402	-3.14%
Huoi Quang	735,128	876,200	141,072	19.19%
Dai Thi	301,485	335,796	34,311	11.38%
Ban Mai	413,321	626,582	213,261	51.60%
Song Con 2	100,143	183,346	83,203	83.08%
Cua Dat	200,000	260,569	60,569	30.28%
An Khe	171,397	223,593	52,196	30.45%
Plei Krong	250,913	237,969	-12,944	-5.16%
Sesan 3	188,152	175,003	-13,149	-6.99%
Sesan 4	514,532	448,799	-65,733	-12.78%
Thuong Kontum	275,526	369,499	93,973	34.11%
Buon Cuop	114,419	150,506	36,087	31.54%
Rao Quan	138,398	157,835	19,437	14.04%
Dong Nai 8	472,774	502,397	29,623	6.27%
Dong Nai 4	250,486	499,467	248,981	99.40%
Cau Don	116,916	139,412	22,496	19.24%
Dai NInh	408,535	526,659	118,124	28.91%
TOTAL	10,188,662	11,091,789	903,127	8.86%

Table 6.2-10 Review of Construction Term

Project Name	Pmax	Dam Volume	Construction Work	Road Work	Afford	Total
	MW	1,000m^3	year	year	year	year
Son La (S)	2,400	27,655	7	2	3	12
Son La(L)	3,600	66,400	9	2	4	15
Huoi Quang	800	1,880	3	2	2	7
Dai Thi	250	5,127	4	2	0	6
Cua Dat	105	500	3	2	1	6
Ban Mai	375	5,577	4	2	0	6
Song Con2	60	1,230	3	2	1	6
An Khe	116	5,223	4	2	0	6
Plei Krong	120	5,117	4	2	0	6
Sesan 3	220	2,999	3	2	1	6
Sesan 4	366	12,442	5	1	0	6
Thuong Kontum	260	4,170	4	2	0	6
Buon Cuop	81	1,335	3	2	1	6
Rao Quan	80	3,108	3	2	1	6
Dong Nai 8	192	4,940	4	2	0	6
Dong Nai 4	200	6,462	4	2	0	6
Cau Don	50	1,103	3	2	1	6
Dai Ninh	300	9,062	4	2	0	6

Table 6.2-11 Review of Interest During Construction

Year	Progress by Cost (million VND)	Progress Ratio	Cumulative Total	Interest (R=10%)
1	547.32	2.97%	2.97%	0.10%
2	698.83	3.80%	6.77%	0.50%
3	784.2	4.26%	11.03%	0.90%
4	921.07	5.01%	16.04%	1.40%
5	974.32	5.29%	21.33%	1.90%
6	1,059.29	5.76%	27.09%	2.40%
7	1,172.42	6.37%	33.46%	3.00%
8	1,615.43	8.78%	42.24%	3.80%
9	2,338.58	12.71%	54.95%	4.90%
10	2,056.16	11.17%	66.12%	6.10%
11	1,859.77	10.11%	76.23%	7.10%
12	1,659.58	9.02%	85.25%	8.10%
13	1,610.40	8.75%	94.00%	9.00%
14	1,104.68	6.00%	100.00%	9.70%
Total	18,402.05	100.00%		58.90%

Under equation "0.4 x R x T"
IDC=0.4 x 0.1 x 14 = 0.56 56%

Table 6.2-12 Unit Cost of Alternative Thermal Power Plant

Item	Unit	Figures			
Plant Type		Coal Thermal		Combined Cycle	
Fuel		Coal		Gas	
Installed Capacity	MW	300		300	
Annual Plant Factor	%	68		80	
Annual energy	GWh	1,785		*1,890	
Construction Cost	US$/kW	1,250		800	
Service Life	Years	25		20	
Capital Recovery Factor	-	0.1102		*0.1175/0.9	
O/M Cost	%	5.0		5.0	
Averaged Efficiency	%	34.0		45.0	
Fuel Caloric Rate	-	5,500 kcal/kg		9,000 kcal/m^3	
Fuel Heat Rate	kcal/kWh	2,529		1,911	
Fuel Price		34 $/t		2.5 $/MBTU	
Unit Fuel Cost	Cent/kWh	1,563		1,896	
Annual Cost		Fixed	Variable	Fixed	Variable
	10^6US$	58.21	29.76	42.13	37.03
Capital Cost	10^6US$	41.33	-	31.33	-
O/M Cost	10^6US$	16.88	1.87	10.80	1.20
Fuel Cost	10^6US$	-	27.89	-	35.83

Adjustment Factor for power and energy (unit: %)

	Loss of Power			Loss of Energy		
	Hydro	Coal Thermal	C/C	Hydro.	Coal Thermal	C/C
Station service	0.5	6.0	1.5	0.5	6.0	1.5
Scheduled outage ratio	1.0	10.0	12.0	-	-	-
Forced outage ratio	0.5	8.0	6.0	-	-	-
Transmission line	5.0	2.0	2.0	3.5	1.0	1.0

Coal thermal	kW adjustment factor	=	$\frac{(1-0.05)(1-0.005)(1-0.005)(1-0.01)}{(1-0.06)(1-0.10)(1-0.08)(1-0.02)}$	= 1.2207
	kWh adjustment factor	=	$\frac{(1-0.035)(1-0.005)}{(1-0.06)(1-0.01)}$	= 1.0318
C/C system	kW adjustment factor	=	$\frac{(1-0.05)(1-0.005)(1-0.005)(1-0.01)}{(1-0.015)(1-0.12)(1-0.06)(1-0.02)}$	= 1.1661
	kWh adjustment factor	=	$\frac{(1-0.035)(1-0.05)}{(1-0.015)(1-0.01)}$	= 0.9846
Coal thermal	kW cost	=	$\frac{58.21 \times 10^6 \text{ US\$}}{300{,}000 \text{ kW}} \times 1.2207$	= 236.86$
	kWh cost	=	$\frac{29.76 \times 10^6 \text{ US\$}}{1{,}785 \times 10^6 \text{ kWh}} \times 1.0318$	= 0.0172$
C/C system	kW cost	=	$\frac{42.13 \times 10^6 \text{ US\$}}{300{,}000 \text{ kW}} \times 1.1661$	= 163.76$
	kWh cost	=	$\frac{37.03 \times 10^6 \text{ US\$}}{1{,}890 \times 10^6 \text{ kWh}} \times 0.9846$	= 0.0193$

Table 6.2-13 Result of Assement about the Reviewed Projects (under 24 and 8 hour Operation)

Project	Unit	The Da River			The Sesan River				The Dong Nai River				
		Son La (L)**	Son La (S)**	Huoi Quang	Thuong Kontum	Plei Krung	Sesan 3	Sesan 4	Dai Ninh	Dong Nai 4	Dong Nai 8	Ham Thuan	Da Mi
Installed Capacity	MW	3,600	2,400	800	260	120	220	366	300	200	192	300	172
Firm Capacity	MW	1,747	729	247	82	108	77	124	81	42	90	100	49
Firm Capacity in case of isolated	MW	1,159	569	186	89	36	-	-	100	-	50	80	-
Annual Output	GWh	17,396	10,804	2,984	736	785	1,079	1,810	1,175	950	946	972	551
Annual Output in case of isolated		15,080	9,942	2,788	866	562	-	-	1,218	-	931	929	-
Annual Cost with IDC													
CRF	1,000US$	573,832	313,229	97,018	35,315	31,773	24,223	65,523	47,879		59,871	45,643	23,996
OMC	1,000US$	83,669	45,517	14,114	5,125	4,667	3,500	9,570	6,962		8,794	6,657	3,479
Total Annual Cost	1,000US$	657,501	358,746	111,132	40,440	36,440	27,723	75,093	54,841	36,361	68,665	52,300	27,475
under peak operation of 24 hours													
Annual Benefit	1,000US$	713,006	358,500	109,829	32,082	39,083	36,797	60,503	39,396	26,288	37,589	40,404	21,083
Annual Benefit in case of isolated		533,897	305,776	92,010	35,976	18,193	-	-	44,636	-	27,856	34,928	-
B/C	-	1.08	1.00	0.99	0.79	1.07	1.33	0.81	0.72	0.72	0.55	0.77	
*"B/C" estimated in isolated		0.81	0.85	0.83	0.89	0.50	-	-	0.81	-	0.41	0.70	
B-C	1,000US$	55,505	-246	-1,303	-8,358	2,643	9,074	-14,590	-15,445	-10,073	-31,076	-18,288	
*"B-C' estimated in isolated		-123,604	-52,970	-19,122	-4,464	-18,247	-	-	-10,205	-	-40,809	-23,764	
Total B/C	-	1.08	1		0.94				0.69				
Total B-C	1,000US$	55,505	-1,549		-11,231				-74,882				
under peak operation of 8 hours													
Annual Benefit	1,000US$	1,151,907	703,842	226,838	70,927	41,925	70,668	117,823	77,767	46,184	61,748	87,776	44,296
Annual Benefit in case of isolated		1,082,938	575,322	180,121	35,976	35,247	-	-	44,636	-	51,542	72,825	-
B/C	-	1.75	1.96	2.04	1.75	1.15	2.55	1.57	1.42	1.27	0.90	1.68	
*"B/C" estimated in isolated		1.65	1.60	1.62	0.89	0.97	-	-	0.81	-	0.75	1.39	
B-C	1,000US$	494,406	345,096	115,706	30,487	5,485	42,945	42,730	22,926	9,823	-6,917	35,476	
*"B-C' estimated in isolated		425,437	216,576	68,989	-4,464	-1,193	-	-	-10,205	-	-17,123	20,525	
Total B/C	-	1.75	1.98		1.68				1.33				
Total B-C	1,000US$	494,406	460,802		121,647				78,129				
Investment Cost per Installed Capacity	US$/kW	968.40	854.30	918.91	1,059.72	2,090.94	855.24	1,405.83	1,247.69	1,250.00	2,462.36	1,154.52	
Levelized Unit Cost	US$/kWh	0.0378	0.0332	0.0372	0.0549	0.0464	0.0257	0.0415	0.0467	0.0383	0.0726	0.0524	
*if estimated in isolated		0.0436	0.0361	0.0399	0.0467	0.0648	-	-	0.045	-	0.0738	0.0539	
Investment Cost per Installed Capacity	US$/kW	968.40	870.45		1,272.38				1,410.67				
Levelized Unit Cost	US$/kWh	0.0378	0.0341		0.0407				0.0522				

*:It is evaluated without considering influence of electricity of other projects!

**:In Investment Cost,cost for transmission line is not contained.

Table 6.2-14 Comparision of the Projects Along the Da River by Peak Operation

Project	Unit	24 hour Operation			12 hour peak Operation			10 hour peak Operation			8 hour peak Operation			6 hour Peak Operation		
		Son La (L)**	Son La (S)**	Huoi Quang	Son La (L)**	Son La (S)**	Huoi Quang	Son La (L)**	Son La (S)**	Huoi Quang	Son La (L)**	Son La (S)**	Huoi Quang	Son La (L)**	Son La (S)**	Huoi Quang
Installed Capacity	MW	3,600	2,400	800	3,600	2,400	800	3,600	2,400	800	3,600	2,400	800	3,600	2,400	800
Firm Capacity	MW	1,747	729	247	1,747	729	247	1,747	729	247	1,747	729	247	1,747	729	247
Firm Capacity in case of isolated	MW	1,159	569	186	1,159	569	186	1,159	569	186	1,159	569	186	1,159	569	186
Annual Output	GWh	17,396	10,804	2,984	17,396	10,804	2,984	17,396	10,804	2,984	17,396	10,804	2,984	17,396	10,804	2,984
Annual Output in case of isolated		15,080	9,942	2,788	15,080	9,942	2,788	15,080	9,942	2,788	15,080	9,942	2,788	15,080	9,942	2,788
Annual Benefit	1,000US$	713,006	358,500	109,829	1,126,800	531,171	168,334	1,151,907	600,239	191,735	1,151,907	703,842	226,838	1,151,907	754,293	240,813
Annual Benefit in case of isolated		533,897	305,776	92,010	808,417	440,549	136,066	918,226	494,458	153,688	1,082,938	575,322	180,121	1,112,072	710,096	224,177
Investment Cost		3,486,228	2,050,309	2,050,309	3,486,228	2,050,309	2,050,309	3,486,228	2,050,309	2,050,309	3,486,228	2,050,309	2,050,309	3,486,228	2,050,309	2,050,309
Civil Works	1,000US$	2,043,412	1,133,957	423,047	2,043,412	1,133,957	423,047	2,043,412	1,133,957	423,047	2,043,412	1,133,957	423,047	2,043,412	1,133,957	423,047
Hydro-mechanical equipment	1,000US$	89,734	82,353	22,152	89,734	82,353	22,152	89,734	82,353	22,152	89,734	82,353	22,152	89,734	82,353	22,152
Electric-mechanical equipment	1,000US$	636,480	424,320	149,760	636,480	424,320	149,760	636,480	424,320	149,760	636,480	424,320	149,760	636,480	424,320	149,760
Transmission Lines	1,000US$	0	0	22,080	0	0	22,080	0	0	22,080	0	0	22,080	0	0	22,080
Contigency	1,000US$	128,356	76,413	27,652	128,356	76,413	27,652	128,356	76,413	27,652	128,356	76,413	27,652	128,356	76,413	27,652
Land	1,000US$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Administration and Engineering Fee	1,000US$	289,798	171,704	62,261	289,798	171,704	62,261	289,798	171,704	62,261	289,798	171,704	62,261	289,798	171,704	62,261
Compensation	1,000US$	298,448	161,562	28,176	298,448	161,562	28,176	298,448	161,562	28,176	298,448	161,562	28,176	298,448	161,562	28,176
Annual Cost																
CRF	1,000US$	573,832	313,229	97,018	573,832	313,229	97,018	573,832	313,229	97,018	573,832	313,229	97,018	573,832	313,229	97,018
OMC	1,000US$	83,669	45,517	14,114	83,669	45,517	14,114	83,669	45,517	14,114	83,669	45,517	14,114	83,669	45,517	14,114
Total Annual Cost with IDC	1,000US$	657,501	358,746	111,132	657,501	358,746	111,132	657,501	358,746	111,132	657,501	358,746	111,132	657,501	358,746	111,132
B/C	-	1.08	1.00	0.99	1.71	1.48	1.51	1.75	1.67	1.73	1.75	1.96	2.04	1.75	2.10	2.17
*"B/C" estimated in isolated		0.81	0.85	0.83	1.23	1.23	1.22	1.40	1.38	1.38	1.65	1.60	1.62	1.69	1.98	2.02
B-C	1,000US$	55,505	-246	-1,303	469,299	172,425	57,202	494,406	241,493	80,603	494,406	345,096	115,706	494,406	395,547	129,681
*"B-C' estimated in isolated		-123,604	-52,970	-19,122	150,916	81,803	24,934	260,725	135,712	42,556	425,437	216,576	68,989	454,571	351,350	113,045
Investment Cost per Installed Capacity	US$/kW	968.40	854.30	2,562.89	968.40	854.30	2,562.89	968.40	854.30	2,562.89	968.40	854.30	2,562.89	968.40	854.30	2,562.89
Levelized Unit Cost	US$/kWh	0.0378	0.0332	0.0372	0.0378	0.0332	0.0372	0.0378	0.0332	0.0372	0.0378	0.0332	0.0372	0.0378	0.0332	0.0372
*if estimated in isolated		0.0436	0.0361	0.0399	0.0436	0.0361	0.0399	0.0436	0.0361	0.0399	0.0436	0.0361	0.0399	0.0436	0.0361	0.0399
Total B/C	-	1.08	1		1.71	1.49		1.75	1.69		1.75	1.98		1.75	2.12	
Total B-C	1,000US$	55,505	220,715		469,299	451,891		494,406	544,360		494,406	683,066		494,406	747,492	

*: It is evaluated without considering influence of electricity of other projects!

**: In Investment Cost,cost for transmission line is not contained.

Table 6.2-15 Result of Assesment about the Projects (Under Varying Peak Operation Time)

Project	Unit	Son La (S)	Son La (L)	Huoi Quang	Dai Thi*	Cua Dat*	Ban Mai*	Song Con2*	Song Hinh*	An Khe*	Plei Krung	Sesan 3	Sesan 4	Thuong Kontum	Buon Cuop*	Rao Quan*	Ham Thuan	Da Mi	Dong Nai 8	Dong Nai 4	Cau Don	Dai Ninh**
Installed Capacity	MW	2,400	3,600	800	250	105	350	60	70	116	120	220	366	260	81	80	300	172	192	200	50	300
Firm Power	MW	729	1747	247	86	35	151	17	26.2	41.7	108	77	124	82	23	30.2	100	49	90	42	23.7	81
Annual Output	GWh	10,804	17,396	2,984	1,300	507	1,777	271	253	482	785	1,079	1,810	736	479	286	972	551	946	950	200	1,175
Annual Benefit by Peak Operation Time																						
T=24 hr	1,000US$	358,500	713,006	109,829	42,730	17,011	66,330	8,688	10,557	18,167	39,083	36,797	60,503	32,082	13,687	12,072	40,404	21,083	37,589	26,288	9,054	39,396
T=12 hr	1,000US$	531,171	1,126,800	168,334	63,100	25,301	102,096	12,714	16,763	28,045	41,925	55,035	89,873	51,504	19,134	19,226	64,090	32,689	58,906	36,236	14,667	58,581
T=10 hr	1,000US$	600,239	1,151,907	191,735	71,248	28,617	113,465	14,325	19,245	31,995	41,925	62,331	101,622	59,273	21,313	22,087	73,565	37,332	61,748	40,215	15,283	66,256
T=8 hr	1,000US$	703,842	1,151,907	226,838	81,575	33,591	113,465	16,741	20,932	35,766	41,925	70,668	117,823	70,927	24,582	23,868	87,776	44,296	61,748	46,184	15,283	77,767
T=6 hr	1,000US$	754,293	1,151,907	240,813	81,575	33,591	113,465	18,873	20,932	35,766	41,925	70,668	117,823	74,243	27,424	23,868	87,776	50,217	61,748	56,132	15,283	91,268
Annual Cost with IDC																				***		
CRF	1,000US$	313,229	573,832	97,018	38,464	25,394	48,519	12,726	22,643	21,880	31,773	24,223	65,523	35,315	14,590	17,547	45,643	23,996	59,871	31,711	14,858	47,879
OMC	1,000US$	45,517	83,669	14,114	5,608	3,720	7,068	1,863	3,319	3,188	4,667	3,500	9,570	5,125	2,128	2,574	6,657	3,479	8,794	4,650	2,175	6,962
Total Annual Cost	1,000US$	358,746	657,501	111,132	44,072	29,114	55,587	14,589	25,962	25,068	36,440	27,723	75,093	40,440	16,718	20,121	52,300	27,475	68,665	36,361	17,033	54,841
B/C																						
T=24		1.00	1.08	0.99	0.97	0.58	1.19	0.60	0.41	0.72	1.07	1.33	0.81	0.79	0.82	0.60	0.77		0.55	0.72	0.53	0.72
T=12		1.48	1.71	1.51	1.43	0.87	1.84	0.87	0.65	1.12	1.15	1.99	1.20	1.27	1.14	0.96	1.21		0.86	1.00	0.86	1.07
T=10		1.67	1.75	1.73	1.62	0.98	2.04	0.98	0.74	1.28	1.15	2.25	1.35	1.47	1.27	1.10	1.39		0.90	1.11	0.90	1.21
T=8		1.96	1.75	2.04	1.85	1.15	2.04	1.15	0.81	1.43	1.15	2.55	1.57	1.75	1.47	1.19	1.66		0.90	1.27	0.90	1.42
T=6		2.10	1.75	2.17	1.85	1.15	2.04	1.29	0.81	1.43	1.15	2.55	1.57	1.84	1.64	1.19	1.73		0.90	1.54	0.90	1.66
Economicity																						
Investment Cost per installed Capacity	US$/kW	854	968	919	1,206	1,905	1,086	1,669	2,549	1,478	2,091	855	1,406	1,060	1,413	1,730	1,193	1,087	2,462	1,250	2,338	1,248
Levelized Unit Cost	US$/kWh	0.0332	0.0378	0.0372	0.0339	0.0574	0.0313	0.0538	0.1026	0.052	0.0464	0.0257	0.0415	0.0549	0.0349	0.0704	0.0538	0.0499	0.0726	0.0383	0.0852	0.0467

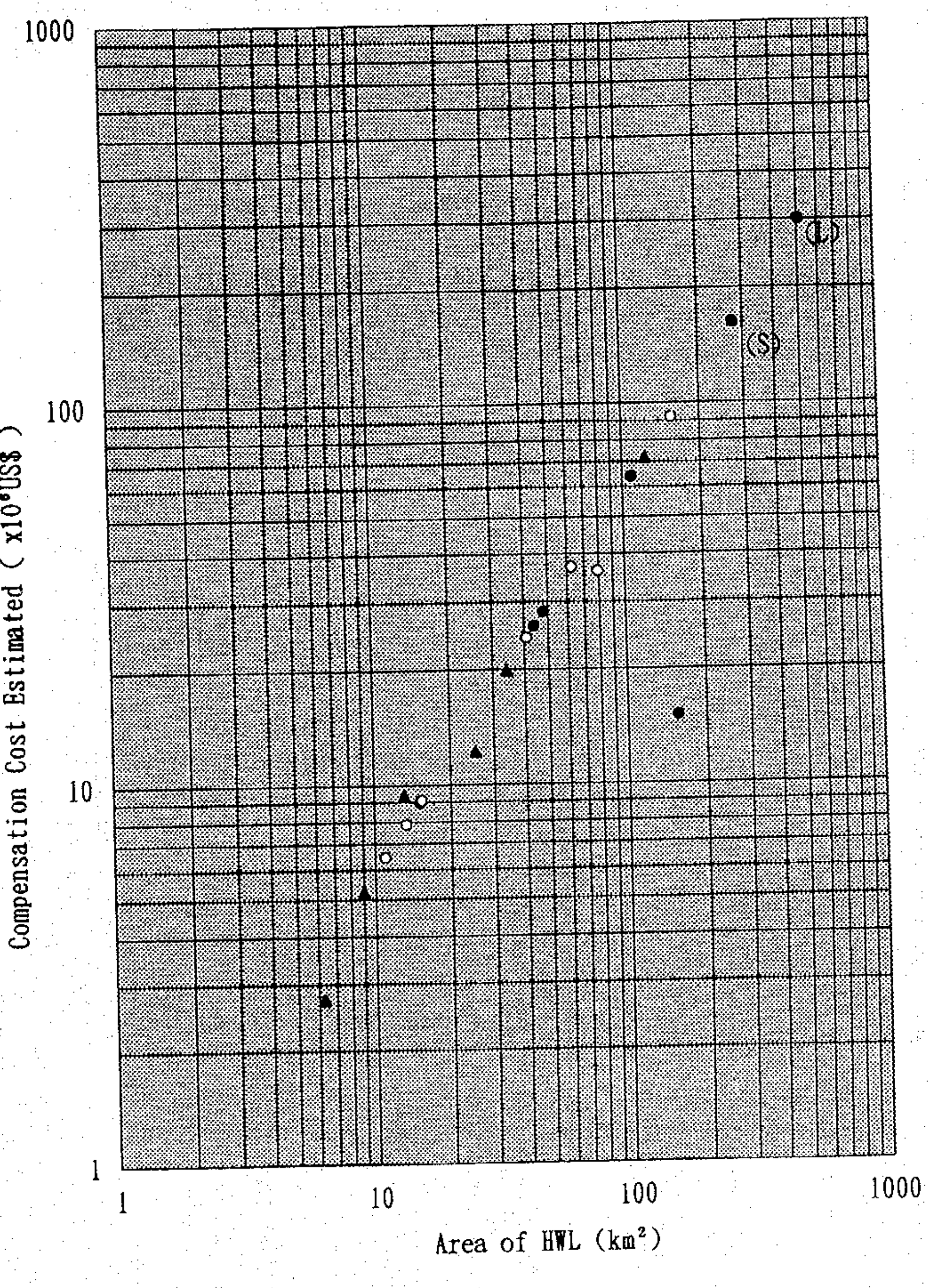
* Projects with "*" are not reviewed for electricity.Therefore,electricity values are quoted from those offered by PIDC-1./** Electricity is quoted from the value of IEV./***This investment cost is ordered to use for

Table 6.2-16 Result of the Ranking Study of the New Hydropower Projects in Viet Nam

	RANK	Levelized Unit Cost		Compared by "B/C" T=24		T=12		T=10		T=8		T=6		Remarks
		Project Name	($/kWh)	Project Name	B/C	Project Name	B/C	Project Name	B/C	Project Name	B/C	Project Name	B/C	
	1	Sesan 3	0.0257	Sesan 3	1.33	Sesan 3	1.99	Sesan 3	2.25	Sesan 3	2.55	Sesan 3	2.55	
	2	Ban Mai*	0.0313	Ban Mai*	1.19	Ban Mai*	1.84	Ban Mai*	2.04	Huoi Quang	2.04	Huoi Quant	2.17	
	3	Son La (S)	0.0332	Son La (L)	1.08	Son La (L)	1.71	Son La (L)	1.75	Ban Mai*	2.04	Son La (S)	2.10	"B/C" better than
	4	Dai Thi*	0.0339	Plei Krung	1.07	Huoi Quang	1.51	Huoi Quang	1.73	Son La (S)	1.96	Ban Mai*	2.04	"Ham Thuan & Da Mi" ↑
	5	Buon Cuop*	0.0349	Son La (S)	1.00	Son La (S)	1.48	Son La (S)	1.67	Dai Thi*	1.85	Dai Thi*	1.85	
	6	Huoi Quang	0.0372	Huoi Quang	0.99	Dai Thi*	1.43	Dai Thi*	1.62	Son La (L)	1.75	Thuong Kontum	1.84	
Cheaper than	7	Son La (L)	0.0378	Dai Thi*	0.97	Thuong Kontum	1.27	Thuong Kontum	1.47	Thuong Kontum	1.75	Son La (L)	1.75	
Ham Thuan	8	Dong Nai 4	0.0383	Buon Cuop*	0.82	Sesan 4	1.20	Sesan 4	1.35	Sesan 4	1.57	Dai Ninh**	1.66	
& Da Mi ↑	9	Sesan 4	0.0415	Sesan 4	0.81	Plei Krung	1.15	An Khe*	1.28	Buon Cuop*	1.47	Buon Cuop*	1.64	
	10	Plei Krung	0.0464	Thuong Kontum	0.79	Buon Cuop*	1.14	Buon Cuop*	1.27	An Khe*	1.43	Sesan 4	1.57	
	11	Dai Ninh**	0.0467	An Khe*	0.72	An Khe*	1.12	Dai Ninh**	1.21	Dai Ninh**	1.42	Dong Nai 4	1.54	
	12	An Khe*	0.0520	Dong Nai 4	0.72	Dai Ninh**	1.07	Plei Krung	1.15	Dong Nai 4	1.27	An Khe*	1.43	
	13	Song Con2*	0.0538	Dai Ninh**	0.72	Dong Nai 4	1.00	Dong Nai 4	1.11	Rao Quan*	1.19	Song Con2*	1.29	B/C > 1 ↑
	14	Thuong Kontum	0.0549	Song Con2*	0.60	Rao Quan*	0.96	Rao Quan*	1.10	Cua Dat*	1.15	Rao Quan*	1.19	
	15	Cua Dat*	0.0574	Rao Quan*	0.60	Cua Dat*	0.87	Cua Dat*	0.98	Song Con2*	1.15	Cua Dat*	1.15	
	16	Rao Quan*	0.0704	Cua Dat*	0.58	Song Con2*	0.87	Song Con2*	0.98	Plei Krung	1.15	Plei Krung	1.15	
	17	Dong Nai 8	0.0726	Dong Nai 8	0.55	Dong Nai 8	0.86	Dong Nai 8	0.90	Dong Nai 8	0.90	Dong Nai 8	0.90	
	18	Cau Don	0.0852	Cau Don	0.53	Cau Don	0.86	Cau Don	0.90	Cau Don	0.90	Cau Don	0.90	

IDC "Ham Thuan & Da Mi" 0.0524 $/kWh

B/C "Ham Thuan & Da Mi" T=24 0.77 T=12 1.21 T=8 1.39 T=6 1.73



Legend:

● The projects in Northern Region
○ The projects in Central Region
▲ The projects in Southern Region
(L) Son La (large)
(S) Son La (small)

Figure 6.2-1 The Tendency of the Environmental Costs Estimated for the Candidate Hydropower Project

Figure 6.2-2 Model of Development Work Schedule

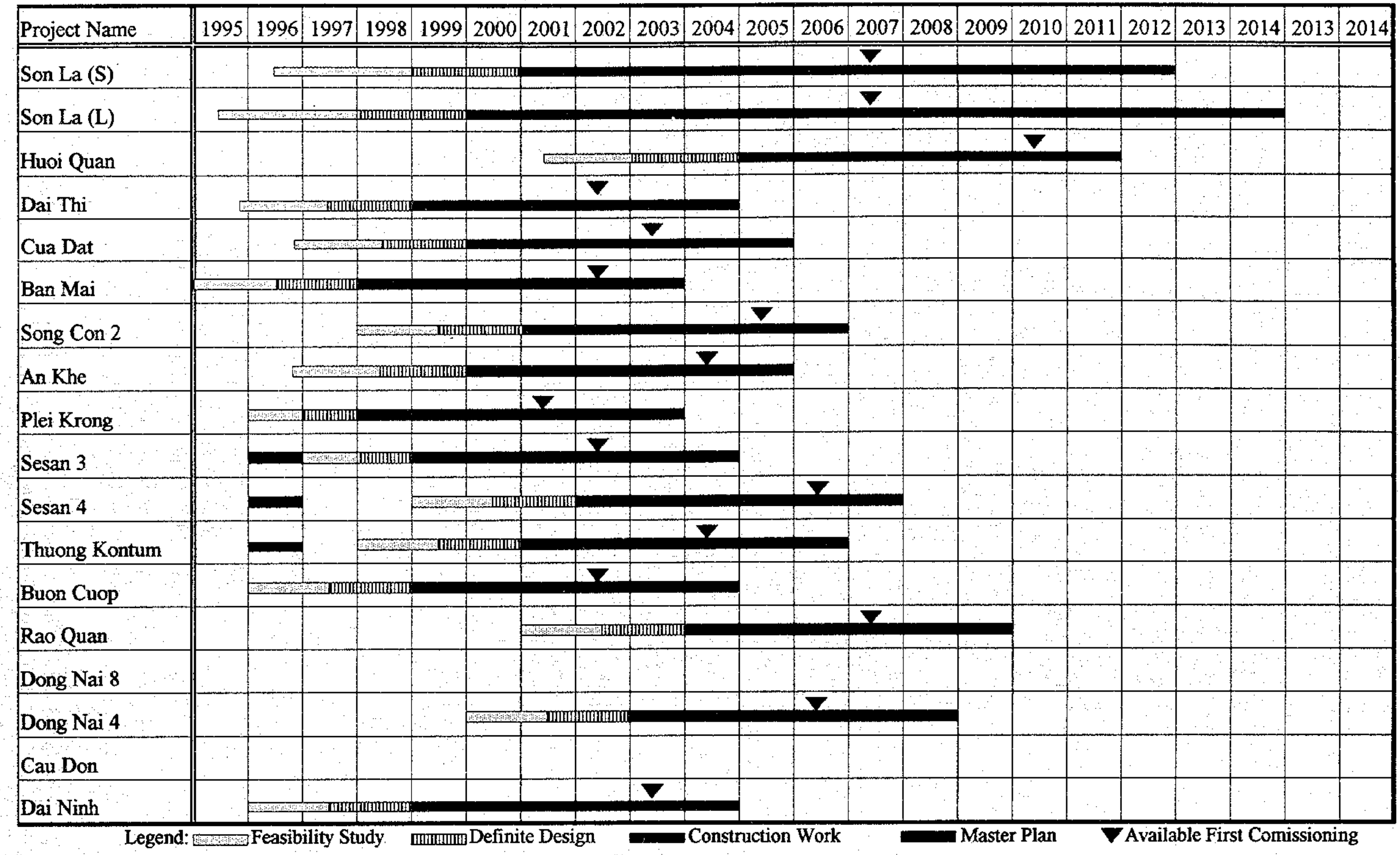
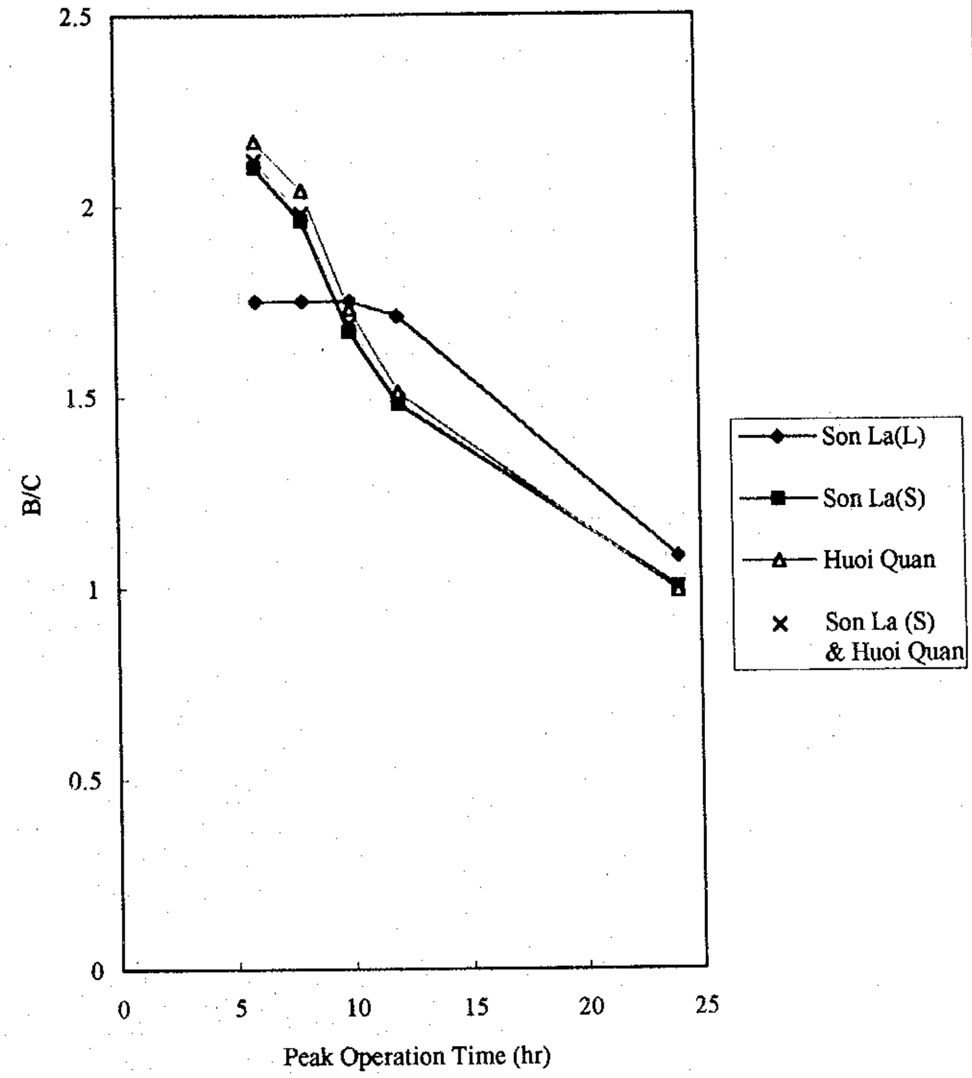


Figure 6.2-3 Relation between Peak Operation Time and B/C



CHAPTER 7

REVIEW AND ASSESSMENT OF ENERGY RESOURCES FOR POWER GENERATION

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7.1 Assessment of Availability of Energy Resources until the Year of 2010

7.1.1 Coal Resource Availability

Coal reserves in Viet Nam for thermal power generation are more than enough. At least, coal reserves theoretically fulfill the demand. In northern Viet Nam, Quang Ninh province, there are 3.1 billion tons of anthracite reserves, which is the total of surveyed reserves (A+B+C1+C2), to the depth of 300m. Total reserves of anthracite and semi-anthracite to the depth of 1,000 m are said to be 6.6 billion tons. Usually, when the development of a coal mine is being decided, coal reserves of A, B and half of Cl will be counted as recoverable. Among the surveyed reserves of coal, anthracite mineable reserves are 557 million tons (Refer to Table 7.1-1).

In Viet Nam, there are other coal reserves beside anthracite, 11.8 million tons of bituminous and 244.1 million tons of lignite and semi-bituminous of surveyed reserves category. Especially in the lower part of the Red-river, under the depth of 700m, there are about 20 billion tons of lignite reserves. However these estimated reserves of lignite are not yet proved, nor technically and economically possible to be exploited.

Coal reserves in Viet Nam are concentrated in her northern part, especially in Quang Ninh province, and anthracite reserves which are 92% of all kinds of total coal reserves lie in Quang Ninh province, about 3 billion tons or 97% of its total reserves. Among the northern coal reserves of 557 million tons mineable reserves, 538.5 million tons are in Quang Ninh province. There are three coal production areas; Uong Bi, Hong Gai and Cam Pha, in the north-east of Hai Phong in the province. There are four main coal sedimentary basins of these three and Bac Thai. In these basins or areas, there are the same names of the coal companies and they are exploring and extracting coal. There is 300 km coal belt area in northern part of Viet Nam, which makes possible the development of thermal power plants in north, but in middle and southern parts of the country coal production and supply to the thermal generation site will be rather high cost.

Coal quality in Viet Nam is good, although there are differences in each coal of coal mines. All of them are high heating value, low sulfur content and considerable small ash content. Adequate quality of coal for thermal power generation does not require high level of heating value. At present, No.8 and No.9 of Vietnamese category coal are supplied, and No.5 and No.4B coal of 4,000 - 5,000 Kcal/kg of low heating value will be supplied in future (Refer to Table 7.1-2).

Today, coal supply to the Pha Lai thermal power plant is from Uong Bi Coal; Mao Khe and Vang Danh mines, recoverable reserves of which are 91 million and 37.4 million tons each, and will be enough to supply for the future coal requirement. For the Pha Lai thermal power, coal supply from Hong Gai and Cam Pha Coal companies will be added, especially from Coc Sau mine of Cam Pha Coal; open pit mine of 25.4 million tons of recoverable reserves, is enough to exploit with its existing facilities. At the Cam Pha Coal, there are other mines which will be possible to supply coal in future.

Production capacity (designed capacity) of 4 state coal companies in Viet Nam are like as follows at present.

Cam Pha Coal Co.	5,750,000 tons (Raw Coal) 4,300,000 tons (Clean Coal)
Hong Gai Coal Co.	1,900,000 tons (R. C.) 1,600,000 tons (C. C.)
Uong Bi Coal Co.	1,250.000 tons (R. C.) 1,000,000 tons (C. C.)
Domestic (No.3) Coal Co.	1,510,000 tons (R. C.) 1,180,000 tons (C. C.)

There are several forecasts of coal demand for the thermal power plants in Viet Nam. According to the forecast prepared by the Institute of Energy, Viet Nam, coal demand for the thermal power plants in Viet Nam in 1994 is 500 thousand tons and it will increase 900 thousand tons in 1995, 1.7 million tons in 1996, 2.3 million tons in 1997, 2.4 million tons in 1998, 2.5 million tons in 1999 and 3.2 million tons in 2000, in the average case. There is another forecast of the coal demand for thermal power plants in the year of 2010; 4.8 - 6 million tons. In this average forecast case, total production of coal is 7.5 million tons in 2000 and 12 - 15 million tons in 2010, among which 42.7% and 40% will be supplied to the thermal power generation demand. Toward the above coal demand, the possible coal supply will be from the above state coal companies, especially Cam Pha Coal company will be the biggest supplier. However, this average forecast case consists rather low demand of coal for other industry except electricity and cement industries, where coal demand decreases one third from 1994 to 2000. Total demand of coal in Viet Nam will be more and the high case of this forecast may be adequate one. At this high case of forecast, total production of coal in 2000 is set at 10 million tons, and it will be necessary to finance the required investment to this supply capacity of coal in coal companies (Refer to Table 7.1-3 and 7.1-4)

Summing up the demand and supply of coal to the thermal power generation;

(1) Initial coal reserves in Viet Nam are enough to fulfill the coal demand under the current production plan in long term.

(2) Present coal production capacity of Viet Nam; 10 million tons of raw coal and 8 million tons of clean coal a year, will be possible to extract coal 8 million tons till 1997, with the productivity increase of coal mines.

(3) For the coal supply above 8 million tons of demand after 1998, new investment for coal production facilities is necessary.

(4) For the coal production and supply after 2000, new mine development and transportation facilities and others are essentially needed, and the investment for this should be in early stage and with large amount.

(5) Among the total coal production, thermal electricity coal demand and supply will be the largest, always, and electricity industry should be the protector to the coal industry especially on the coal price issue.

7.1.2 Natural Gas Resource Availability

(1) Forecast based on the Ultimate Recoverable Reserves

Oil and Gas exploration activity in on-land and off-shore Viet Nam is in an early stage of its history and the evaluation work of hydrocarbon reserves in various sedimentary basins in Viet Nam is not yet attained. Exploration work is at present concentrately carried out in Cuu Long and Nam Con Son basins southern off-shore from Ho Chi Minh city and probably is in its highest time in 1994 and 95. The state oil and gas company; Petro Viet Nam (here-in after referred PVN) had signed numbers of production sharing contracts with foreign oil companies, and they had carried out geophysical surveys in their contracted areas, discovered more than 300 structures after the analysis of processed data, drilled more than 70 exploration wells. However, it is rather difficult to estimate the ultimate recoverable reserves of hydrocarbon in exploration untouched sedimentary basin areas. Nevertheless, the ultimate recoverable reserves of oil and gas in all the sedimentary basins in Viet Nam is estimated at approximately 4 to 5 billion tons (30-37 billion barrels) in oil equivalent. Geologists are in tendency to conservatively evaluate resources, and this reserve estimation will be increased according to the exploration progress and supply of new geological data.

Natural gas ultimate recoverable reserves are estimated at 600-700 billion m^3, among all the hydrocarbon reserves. This figure is calculated from the above mentioned hydrocarbon reserves adopting with GOR (gas oil ratio) of 170, namely 170 m^3 of gas per one ton of oil.

Among the natural gas ultimate recoverable reserves of 600-700 billion m^3, only 100 billion m^3 are so far discovered. These reserve figures are natural gas from oil fields (associated gas) and from gas fields (non-associated gas). These figures will probably increase rapidly as the exploration activity progresses. So far, oil fields were discovered in Cuu Long basin and oil and gas fields were discovered in Nam Con Son basin. Numbers of these discovered fields are already developed or being developing. It can be said that there are gas prominent sedimentary basins in off-shore Viet Nam. Especially in Danang Basin in off-shore mid-Viet Nam, huge gas reserves were discovered while this gas contains large amount of carbon dioxide (CO2) and is not economically possible to develop and produce gas. In the Red-river basin in northern Viet Nam, there should be more exploration work aiming a gas discovery, and in Minh Hai basin of off-shore area of south-west, adjacent to the Cambodian and Malaysian boundary ocean area, large gas fields are expected to be discovered (Refer to Figure 7.1-1).

There is a close relationship between exploration progress and the shifting of the possible ultimate recoverable reserves to the proved reserves. And oil and gas discovery degree will be parallel with exploration speed. Exploration activity in off-shore Viet Nam is still in burgeoning stage in the large areas of sedimentary basins. Exploration is concentrated in the above mentioned two basins, and there is quite a lot of work of geophysical survey or exploration drilling in other basins. Therefore the available data to estimate the ultimate recoverable reserves in sedimentary basins is deviated, and the accurate evaluation of all the hydrocarbon in offshore Viet Nam is almost impossible to proceed at present. Nevertheless, with reviewing of the past ten years exploration results econometrically, there will be no doubt an estimation of another 100 billion m^3 of natural gas discovery in the coming ten years.

Natural gas discovery is watched in numbers of oil and gas fields in off-shore Viet Nam, and there are the associated gas in Cuu Long basin and non-associated gas in Nam Con Son basin. There are fields of under-evaluation of reserves with drilling of confirmation wells. Therefore, there are another 100-150 billion m^3 of estimated reserves in these fields, and if we add it to the above discovered reserves, the total reserves can be said between 200 to 250 billion m^3 in the discovered fields. With the drilling of confirmation wells, the accuracy of reserves is increasing and the reserve category of oil or gas will shift to the more accurate part. In the Vietnamese category which resembles the Russian one; A, B, C1, C2, D1 and D2, there will be more A and B shifted from C1 and C2.

(2) Discovery of Oil and Gas Fields and Natural Gas Supply

In Viet Nam, associated gas from Bach Ho oil field is being flared and burnt uselessly at present, at the oil production spot of Vietsovpetro had been planned to deliver to a thermal power plant inland as fuels with lying of off-shore gas pipeline. This 100 km pipeline from the field to inland near Vung Tau was nearly completed in October, 1994 and a gas processing plant and on-shore pipeline are under construction at present by the company, and probably gas will be delivered to Ba Ria thermal power plant within 1995. It will be the first time for huge gas utilization in Viet Nam of the Bach Ho associated gas use at the power plant.

Ba Ria thermal power plant will consume natural gas about 280 million m^3 annually while Bach Ho oil field's flared gas is 1,200 million m^3 and it will be enough to supply at present. Together with Bach Ho field, Rong oil and gas field lying south-west of Bach Ho field, is also in the development stage and gas of Rong field both associated and non-associated will be supplied in future with connection of a pipeline. The ultimate recoverable reserves of associated gas in Bach Ho field are confirmed as 20 billion m^3, and Rong field gas is 5 billion m^3 (Refer to Table 7.1-5).

The associated gas from both fields will be supplied also to Thu Duc thermal power plant north-east of Ho Chi Minh city and the inland pipeline lying for this supply of about 100 km is also accelerated. Thu Duc thermal power plant will consume about 300 million m^3 of gas annually. Other gas utilization of this flared gas is planned such as LPG manufacturing plant and chemical fertilizer factory. Gas sending capacity of this pipeline will be 1,200 million m^3 annually in initial stage, while the associated gas of Bach Ho field will be used as fuels on site of production, and as materials of the tertiary recovery of oil; gas lift method, in future.

Among the 20 billion m^3 of Bach Ho associated gas, total 4.7 billion m^3 of gas had been already flared and burnt at the end of 1994. Therefore there is 15.3 billion m^3 of remaining recoverable gas at this field. If we add the Rong field gas of 5 billion m^3 to this, 20.3 billion m^3 of gas is available which is theoretically only 17 years availability supporting the supply and consumption of 1.2 billion m^3 annually. Moreover, if the replacing of fuels of oil to gas at thermal power plants, especially such change in Thu Duc plant will not be realized in early time, the amount of flared gas uselessly by burning will be increased. When we expect long time gas supply, these two fields gas supply seem to be clearly not enough. Because of the associated gas production which is determined by the production of oil, it will not be possible to get 1.2 billion m^3 of gas constantly with these two fields when the oil fields production declined.

It was reported that the peak production year of Bach Ho oil field is 1995. Therefore, the associated gas of this field will be also in production peak in 1995, and then it declines.

The ultimate recoverable reserves of this field are 117 million tons of oil and 20 billion m^3 of gas. In Figure 7.1-2 (a), there are both oil and gas production declining curves, which accelerate after 2000 year, but gas production declining curve is rather moderate compared with oil production declining, due to that, after oil production comes to an end, gas reserves will still remain and continue production.

Bach Ho field gas production declining will be partly substituted by Rong field gas, but not completely. In Figure 7.1-2 (a), there are production forecast curves of additional gas supplied by fields beside the above two fields; Case A means the associated gas production from the nearby oil field, Case B (Figure 7.1-2(b)) means non-associated gas production. The supplying of 1.2 ~ 1.5 billion m^3 yearly of associated gas is not enough and non-associated gas production is essential. Especially after 2000, non-associated gas production will increase rapidly and will reach 6 billion m^3 production in 2010, half of which is BP/Statoil's production from their 2 gas fields.

Among the so far discovered oil or gas fields in off-shore Viet Nam, the field in which can fulfill supplying gas to Bach Ho field's declining is said to be Dai Hung field 100 km south from Bach Ho. However, this field's recoverable reserves were cleared rather smaller than originally estimated, after drilling of confirmation wells and determination of the structure. Associated gas of this field initially estimated as large with oil reserves of 500 - 600 million barrels, but it comes to a smaller amount as oil reserve estimations have shrunk to only 150 million barrels at present. Taking the GOR of 160, Dai Hung gas is estimated at about 3.2 billion m^3 of ultimate recoverable reserves which is smaller than Rong field gas reserves. Dai Hung field started its oil production in October, 1994, with early production facility and associated gas produced with oil burnt on site. The nearest oil field to Bach Ho field so far discovered is Rang Dong oil field in Mitsubishi oil company's contracted area but the delineation work of this field is in ahead and actual reserves are not yet determined. However, it is reported that the GOR of this field is rather high and the associated gas reserves are large. Petronas Carigali of Malaysia discovered Jade and Ruby fields in their contracted block, north-east of Back Ho field, but details of these discoveries are not yet reported because of lack of data.

Gas reserves are expected to be found in Nam Con Son basin which lies south of Cuu Long basin where Back Ho field is situated. In Nam Con Son basin, beside the above mentioned Dai Hung field, two gas fields were discovered by the British Petroleum/Statoil group (Refer to Figure 7.1-3).

This group of companies drilled three wells of exploration in 1993 to 94 and discovered Lan Tay and Lan Do gas fields. The structures of these fields are rather large and it can be estimated that the reserves of gas combining both fields is approximately 2-3 TCF (60 - 90 billion m^3). The British Petroleum Co., officially declared that reserves of these two fields was 2 TCF, in September, 1994. BP/Statoil group wishes to commercialize these two gas field discoveries associated with other company gas discoveries in nearby areas, because these offshore areas are rather deep water and distance from the shore is 270 km and the field's development cost is rather large. Companies engaged in exploration in these areas are jointly planning to lie another pipeline to the shore, 300 km totally, to send gas to onshore, but this plan is not yet finalized.

Natural gas supply in southern Viet Nam thermal power plants will be limited if it depends on only associated gas of oil fields. It is doubtful which field will be a supplier of gas when Bach Ho field associated gas declines its production except Rong field. The associated gas of Rang Dong field is the most expected one, but it will be decided by the result of future exploration work. Gas supply from Bach Ho and Rong fields will be declined to rather low levels in 10 years time and it is desired to discover and develop other will decline large fields in Cuu Long basin promptly.

It will be most important issue to develop gas fields discovered by BP/Statoil in Nam Con Son basin, together with the development of other company gas discoveries near by their fields, and to lie a new joint pipeline system. For this development work of natural gas supply, at least US$3/MMBTU should be approved and then gas production of 3~6 billion m^3 per year will be realized.

7.1.3 Petroleum Product Availability

Fuel oil consumption in thermal power plants in Viet Nam is not so large amount at present. Fuel oil used in thermal power plants such as Ba Ria in south Viet Nam is planned to to be replaced by natural gas in the future. In the remote area, where transmission line of electricity is not approached, diesel oil burning generation plant will be used. Heavy fuel oil co-burning at the coal fired power plants will continue but the demand forecast of these fuel oils is rather difficult. However it is estimated that the present consumption level of fuel oil will continue without much change; such as 700,000 tons of petroleum products to the thermal power plants a year, nearly half and half of heavy fuel oil and diesel oil.

It is rather easy to acquire these amounts of fuel oil from outside of the country, and companies in Singapore and Malaysia supplied fuel oil to Viet Nam. In future, Viet Nam will have her own petroleum refinery in the country and supply petroleum products domestically. PVN decided to build a refinery at Van Phong near Vung Tau, by the joint venture with CFP Total Co., of France and CPC of Taiwan and others. Refining capacity of this refinery is 6.5 million tons a year (130,000 BPSD) and it will be completed and commence production in 1999, with estimated construction cost of 1 - 1.3 billion dollars. This refinery will be filled with crude oil, Vietnamese produced at, Bach Ho and other fields, but a part of crude oil will be Middle Eastern crude. Vietnamese low sulfur crude oil can be sold at high price and Middle Eastern lower price crude of the refinery use attains high merit of economic value.

Beside the above refinery project, PVN plans to build another one or two refineries in future. All of these are in planning stage and the details of these, especially availability of fuel oil products, are not yet confirmed. Therefore, it is unknown at present how much petroleum products can be supplied domestically, but if 700,000 tons of fuel oil annually continue on the demand side, petroleum product to thermal power plants can be supplied without difficulty. However, in the year 2010, if thermal power plants replace their gas fuel to petroleum products in case of lacking of gas supply with production hintage, domestic fuel oil supply may become short and fuel oil imports will revive again.

Table 7.1-1 Coal Reserves in Viet Nam

(Unit: Million tons)

	Total Reserves	Surveyed Reserves (A+B+C1+C2)	Minerable Reserves		
			Total	O/C	U/G
Anthracite & Semi-anthracite	6,600	3,104	557	199	358
Quang Ninh Province	6,500	3,021	538	180	358
Uong Bi		1,268	201	20	181
Hong Gai		459	84	41	43
Cam Pha		1,294	254	119	135
Bac Thai Province	85	78	18	18	-
Lang Son Province	25	6			
Bituminous	25	12	7	-	7
North	12	6	6	-	6
Da River	10	5	-	-	-
Ca River	3	2	1	-	1
Lignite & Sub-bituminous		244	19	19	-
Lower Red River	20,000	146	-	-	-
Na Duong etc.	120	98	19	19	-

Source: IEV

Table 7.1-2 Quality and Reserves of Main Coal Mines in Viet Nam

Companies and Mines	Development Method	Kind of Coal	Ash (%)	Evaporation (%)	Sulfur (%)	Heating Value (kcal/kg)	Recoverable Reserves (1990 end.) (10^3 ton)
Uong Bi Coal Co.							
Uong Thuong-Dong Bong	O/C	Anthracite	15.0	6.0	0.4	7,900	20,400
Mao Khe	U/G	Anthracite	18-24	4-5	0.6	7,600	91,060
Vang Danh	U/G	Anthracite	13.6-15.7	4.5-4.7	1.0-1.1	8,090	37,412
Yen Tu	U/G	Anthracite	17.1	4.1	1.5	8,010	52,290
Hong Gai Coal Co.							
Nui Beo	O/C	Semi-Anthracite	17.0	9.8	0.6	8,600	26,127
Ha Tu	O/C	Semi-Anthracite	15.0	9.1	0.5	8,670	14,530
Ha Lam	U/G	Anthracite	14.9	9.0	0.4	8,500	30,796
Tan Lap	U/G	Anthracite	9.4	3.6	0.2-0.6	8,410	5,196
Nam Ha-Tu	U/G	Anthracite	10.5	6.3	0.4	7,530	6,596
Cam Pha Coal Co.							
Deo Nai	O/C	Anthracite	16.0	7.0	0.4	8,150	16,374
Coc Sau	O/C	Anthracite	16.0	5.6	0.4	8,400	25,410
Cao Son	O/C	Anthracite	15.0	5.7	0.6	8,300	55,600
Khe Cham	O/C	Anthracite	15.0	6.0	0.6	8,300	15,800
Khe Tam	O/C	Anthracite	16.0	7.0	0.5	8,350	5,880
Thong Nhat	U/G	Anthracite	9.2-14.5	5.9-6.7	0.4-0.6	8,130	18,439
Khe Cham	U/G	Anthracite	12.9	5.8	0.5-0.7	8,250	93,899
Mong Duong	U/G	Anthracite	12.5	7.6	1.2	8,310	22,664
No.3 Coal Co.							
Nui Hong	O/C	Semi-Anthracite	17.0	9.0	2.4	8,200	13,830
Khan Hoa	O/C	Semi-Anthracite	16.5	9.2	2.5	8,300	3,620
Na Duong	O/C	Lignite (L.F.C.)	37.0	46.9	6.6	7,330	18,683
Nong Son	O/C	Semi-Anthracite	24.0	7.0	2.4	7,910	955
Lang Cam	U/G	Bituminous	18.5	24.0	1.3	8,225	5,466
Khe Bo	U/G	Bituminous	19.2	23.2	1.7	6,890	1,029

Source: IEV

Table 7.1-3 Forecast of Coal Supply and Consumption

Average Case

(Unit: Million tons)

Location	1994	1995	1996	1997	1998	1999	2000
Total of Coal Sector	5.90	6.30	7.00	7.20	7.30	7.30	7.50
Ministry of Energy	4.90	5.10	5.80	5.90	6.00	6.00	6.20
Outside of MOE	1.00	1.20	1.20	1.30	1.30	1.30	1.30
Companies of MOE							
Cam Pha Coal Co.	2.00	2.10	2.30	2.30	2.30	2.30	2.30
Hong Gai Coal Co.	1.15	1.15	1.20	1.20	1.20	1.20	1.20
Uong Bi Coal Co.	0.82	0.90	1.00	1.00	1.00	1.00	1.00
Coal Construction and Production Co.	0.20	0.30	0.40	0.50	0.60	0.60	0.70
Domestic Coal Co.	0.60	0.70	0.70	0.70	0.70	0.70	0.80
Geological Co. & others	0.10	0.20	0.20	0.20	0.20	0.20	0.20
among these:							
Export	2.30	2.30	2.00	1.70	1.60	1.60	1.50
Domestic Supply	2.60	2.80	3.80	4.20	4.40	4.40	4.70
among these:							
Electricity	0.50	0.90	1.70	2.30	2.40	2.50	3.20
Cement	0.30	0.30	0.50	0.70	0.90	1.00	1.00
Others	1.80	1.60	1.60	1.20	1.10	0.90	0.50

High Case

(Unit: Million tons)

Location	1994	1995	1996	1997	1998	1999	2000
Total of Coal Sector	5.90	6.30	7.10	8.00	9.00	9.80	10.00
Ministry of Energy	4.90	5.10	5.80	6.50	7.50	8.30	8.50
Outside of MOE	1.00	1.20	1.30	1.50	1.50	1.50	1.50
Companies of MOE							
Cam Pha Coal Co.	2.00	2.10	2.30	2.60	3.10	3.50	3.50
Hong Gai Coal Co.	1.15	1.15	1.20	1.30	1.40	1.50	1.55
Uong Bi Coal Co.	0.82	0.90	1.00	1.10	1.20	1.30	1.35
Coal Construction and Production Co.	0.20	0.30	0.40	0.50	0.60	0.80	0.90
Domestic Coal Co.	0.60	0.70	0.75	0.80	0.90	0.90	0.90
Geological Co. & others	0.17	0.15	0.15	0.20	0.30	0.30	0.30
among these:							
Export	2.30	2.30	2.00	1.80	1.80	1.80	1.80
Domestic Supply	2.60	2.80	3.80	4.70	5.70	6.50	6.70
among these:							
Electricity	0.50	0.90	1.70	2.30	2.40	2.50	3.20
Cement	0.30	0.40	0.50	0.80	1.40	1.80	2.00
Others	1.80	1.50	1.60	1.60	1.90	2.20	1.50

Table 7.1-4 Oil and Gas Production in Viet Nam

	Crude Oil (Million tons)	Gas (Million m^3)	Estimated GOR of Bach Ho	Remarks
1981-1985		134.7		Tien Hai gas only
1986	0.04	42.4		Bach Ho associated gas production commenced
1987	0.21	66.7	(127)	
1988	0.69	128.0	(127)	
1989	1.52	287.3	(163)	
1990	2.70	491.6	(169)	
1991	3.95	712.5	(171)	
1992	5.50	880.0	(155)	
1993	6.30	1,200.00	(186)	
1994	6.70	(1,200.00)	(179)	
Cumulative Total	27.61	(1) 5,143	127	

(1) Tien Hai 400 Million m^3 (estimated) is included.
Source: Petrovietnam, Annual Report, 1993, 1994.

Table 7.1-5 Natural Gas Reserves in Viet Nam

Name of Field	Company	Kind of Field	Reserves (Ultimate Recoverable)
Red River Basin			
Tien Hai (On-Shore)	Petrovietnam	Gas	Small reserve (400 MMm^3)
Cuu Rong Basin			
Bach Ho	Vietsovpetro	Oil and Gas	Gas 20 Billion m^3, oil 117 MMt (Proved) GOR=170
Rong	Vietsovpetro	Oil and Gas/Gas zone	Gas 5 Billion m^3, Oil 11 MMt
Ruby and Jade	Petronas Carigali		D1-B1X(1,757 b/d, 5,200 b/d)
Rang Dong	Mitsubishi		GOR is high, 15-2RP1X (10,346 b/d, 4,949 b/d)
Nam Con Son Basin			
Lan Tay	BP/Statoil (ONGC)	Gas	2 TCF of Gas = 57 Billion m^3 (to be confirmed)
Lan Do	BP/Statoil (ONGC)	Gas	
Dai Hung	BHP	Oil and Gas	Gas, 3.2 Billion m^3 150 MM barrel Oil=20 MMt Oil (GOR=160)
Thang Rong (Blue Dragon)	Mobil		Probably Gas Prone (Carbon dioxide contamination?)
Flying Dragon	Pedco		Gas 26 MM cf/d
Rong Bai	British Gas	Gas	Gas showing
05-3-MT-1X Well	AEDC/Teikoku		Gas showing
Moc Tinh			
Da Nang Basin			
Two wells	BP	Gas	150 Billion m^3 of Gas (Carbon dioxide contamination 80%, 700 Billion m^3)

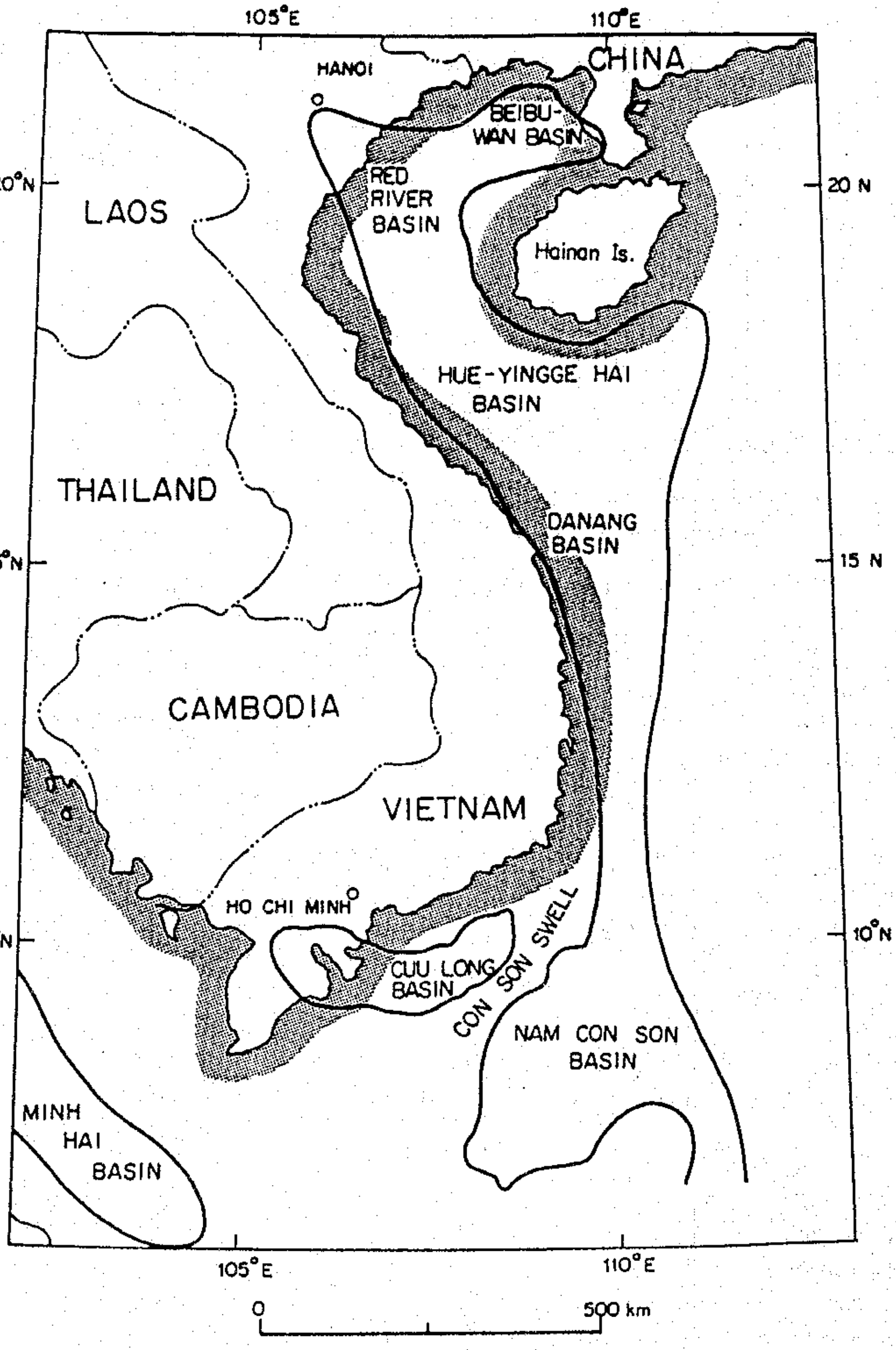

Figure 7.1-1 Sedimentary Basins in Viet Nam

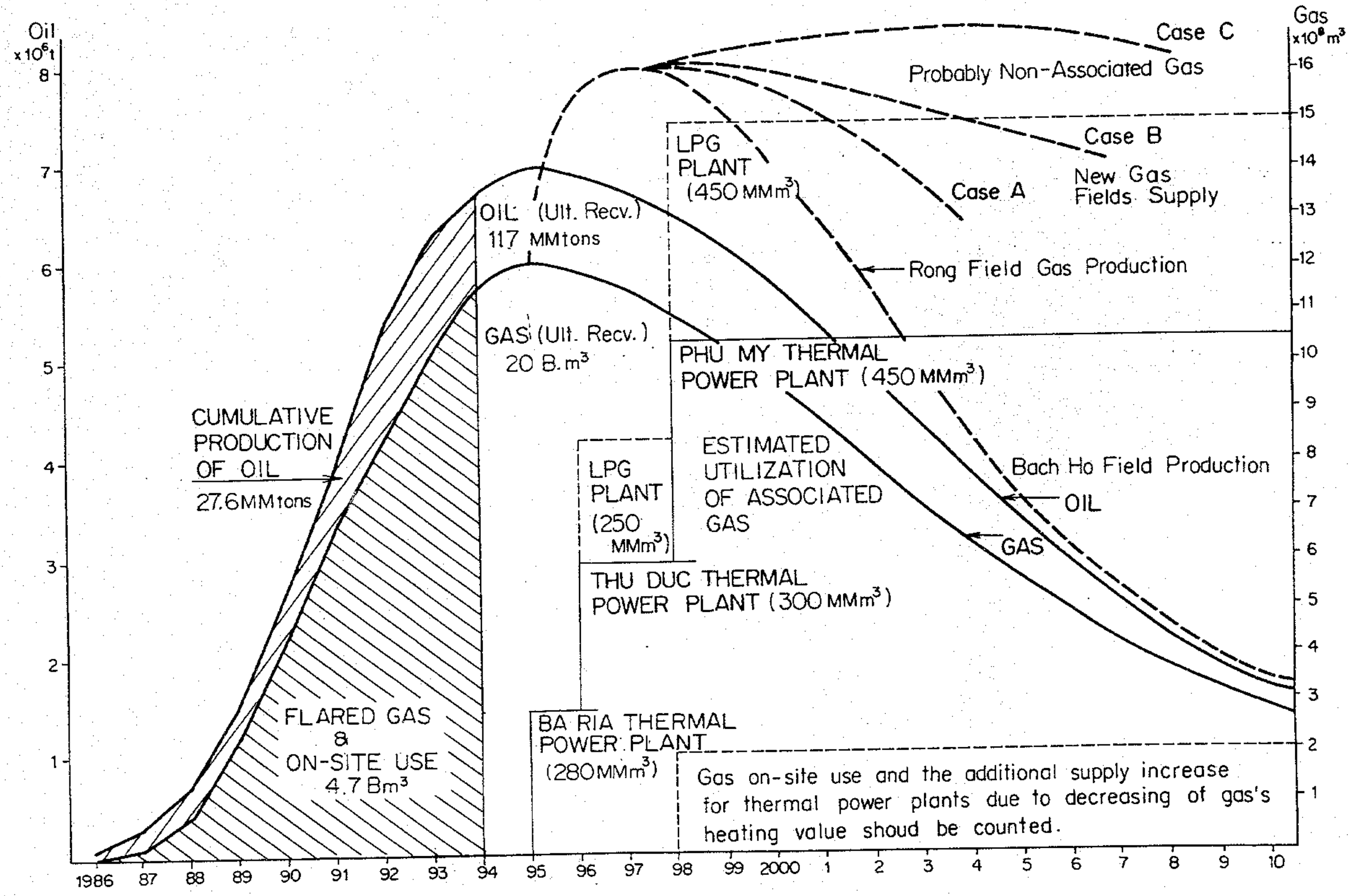

Figure 7.1-2(a) **Natural Gas Production and Consumption Forecast in South Viet Nam**

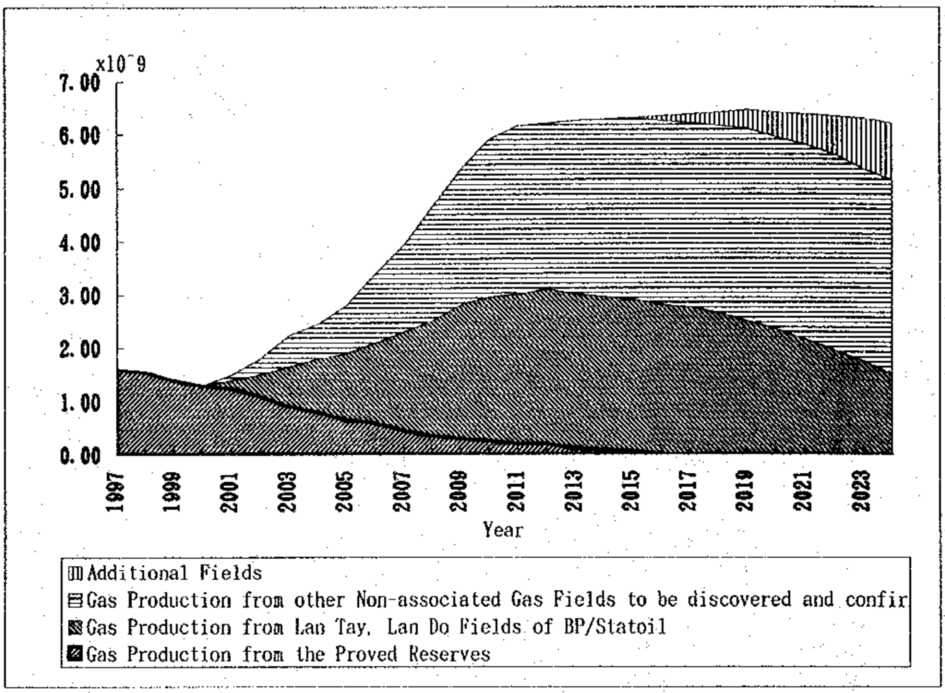

Figure 7.1-2(b) Forecast of Natural Gas Production in Viet Nam

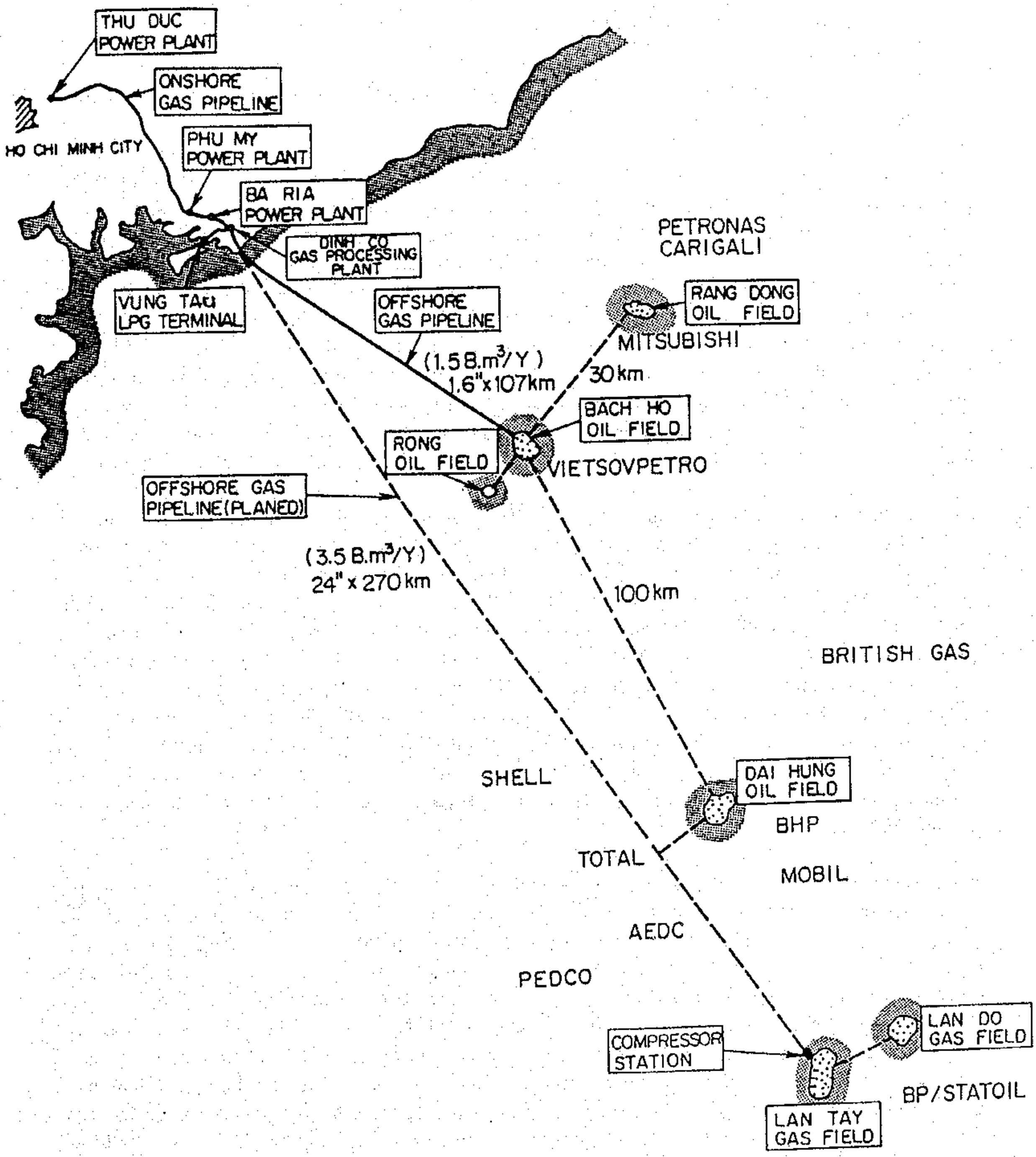

Figure 7.1-3 Natural Gas Development Plan Viet Nam

7.2 Technical and Economic Assessment of Energy Resources

7.2.1 Assessment of Coal Resources

There are several important issues on the assessment of technical and economical matters of availability of coal resources in Viet Nam.

First of all on coal reserves, even if there are enough coal reserves in Viet Nam to fulfill thermal power plants in coming decade, when we make long term forecast of demand and supply, these present proved reserves of coal can not be said to be completely enough. Coal exploration activity to determine proved reserves in Viet Nam in the last few years had tremendously decreased. The state four coal companies carried their coal exploration, stratigraphic well drilling in 1993, only 8,348 m which is one sixth of 10 years ago in 1984, 50,997 m. Other exploration work of the companies may be also declining even if data is not available. In the year 1993, 19,530 m of stratigraphic drilling had been planned but it was not achieved because of lack of investment found for exploration. This situation makes coal availability for thermal plants indefinite in 21st century. In the exploration planning, stratigraphic drilling in the year 2000 is expected 45,000 m and in 2005 it is designed 35,000 - 40,000 m, but it is doubtful if it can be achieved or not (Refer to Table 7.2-1).

Recoverable reserves of coal (anthracite) in Viet Nam are at present 557 million tons and this runs 111 years of coal supply in the level of production of 5 million tons a year. However, coal is expected to increase production; 10 million tons in 2000, 15 - 20 million tons in 2010. In such case, cumulative production amount till 2010 will be 170 - 200 million tons. Therefore, the remaining recoverable reserves is still more than 300 million tons in 2010 and there will be enough recoverable reserves according to the calculation of these factors. However, this production forecast of coal is rather moderate and if coal will exploit 40 - 50 million tons a year, this present proved reserves continue only 11 to 14 years. It will be impossible to establish such huge production systems promptly, however, if thermal power plants will be expanded rapidly and if huge natural gas supplies are be attained, establishment of large coal supply systems in Viet Nam will become the most necessary factor. For this purpose, exploration of coal to add new recoverable reserves is essentially needed.

Next issue is the timeworn of coal production facilities in Viet Nam and delaying of its rehabilitation of old facilities. It is needless to say on the actual situation of old production facilities of each mine relates to production decline and rising costs. For this rehabilitation it is necessary to invest tremendous amounts of capital or funds, while the financial situation of coal companies deteriorated and their new investment amounts decreased. Among the rehabilitation of coal facilities, coal clean facilities are the most important. Old cleaning coal unit of No.1 site of Cam Pha Coal, Hong Gai Coal, and out of dated facility of Uong Bi Coal are necessary to renew, then the additional value of coal will be increased and economically improved. Unless there will not be a revoluationary investment increase on coal development, production, loading, shipping and transportation facilities, coal production in Viet Nam will continue only at the current low level of production till 2000 with present old facilities, but after 2000 year there will be a tight situation of coal supply.

Coal investment plans have been made by companies, for each five years from 1991 to 2005, by two separate programs (Refer to Table 7.2-2). Total investment amount in 15 years is 3 trillion Dong ($280 million) in the first plan and 4.1 trillion Dong ($380 million) in the second plan, which is 20 - 30 million dollars investment program every year. In this investment plan, coal production facilities investment for Phu My thermal power plant is not included (in case the fuel for this power plant in future will be changed from natural gas to coal), and investment for the related infrastructure is also not summed up. However, the actual investment in the last few years was recorded at a far less amount than this program and should there be some sort of improvement, the present situation will be renewed. For the healthy development of coal industry, 40 - 60 million dollars yearly investment is necessary, and for the improvement of financial situation of coal companies, the raise in mine head coal prices and introduction of foreign investment in Vietnamese coal production should be necessary. Coal delivery prices were raised several times, but the present coal price in Viet Nam is still far lower than international price. Foreign coal companies also joined Vietnamese coal industry contracting the Production Sharing with state coal company, e.g an Indonesian firm's case, but there should be more foreign investment. However, the most important issue on coal companies investment program is strong support of the state with supplying domestic or foreign bank loans, and so on.

7.2.2 Assessment of Natural Gas Resources

The most important issue of technical and economic assessment on natural gas development and production is the establishment of resource reserves. The potential reserves of natural gas in Viet Nam are large, and it is estimated about 600 - 700 billion m^3 as stated in former page. The point at issue is the exploration of oil and gas and establishment of proven gas reserves.

The state oil company, PVA had offered off-shore oil exploration rights to foreign oil companies in international bidding and signed the Production Sharing contracts. There are nearly 30 PS contracts and the exploration work was carried out being by foreign oil companies with their risk bearing (Refer to Figure 7.2-1).

In the exploration procedure, oil companies aim to find oil and gas, with priority of finding oil and then finding gas subsequently. In case of Drill Stem Test (DST) of oil and gas during the exploration drilling, oil testing is presently carried out and even if there is a gas zone in the strata, gas testing will be the secondary case. On the PS contracted block of oil companies, there will be only several exploration wells drilled by the obligation clause and oil companies will withdraw from the contract area if their discovery is a marginal one, unless they find a large accumulation of oil or gas. Several oil companies have already withdrawn from off-shore Viet Nam or firmed out their contract rights to other companies.

Petroleum exploration technology is advanced day by day and the re-opened block to foreign oil companies where the former oil companies withdrew because of unsuccessful exploration work, may be a hopeful block. The new comer may be a finder of oil or gas with new technology or by new geological knowledge. The discovery of Rang Dong oil field by Mitsubishi Oil Co., is one such case, as their block was formerly explored by Deminex company of Germany and abandoned as not promising.

It is widely recognized that either the vast area of sedimentary basins is determined as rich oil and gas bearing area or not, there should be more than 200 exploration wells drilled. In off-shore Viet Nam, there are so far only 70-80 wells having been drilled and it is too early to determine such a definition. Therefore when three times more wells are drilled such a situation will be recognized. With taking the above mentioned fact, will sign more PS contracts with foreign oil companies in future or the company contract terms may be amended, the exploration work will be continued.

Oil or gas fields in Viet Nam, Bach Ho field being the most prominent, are known as geologically specialized fields where the oil accumulation is in fracture of basement rock (Refer to Figure 7.2-2 and 7.2-3).

This is an oil field named by Chinese of "Old Buried Mountain" or in English, "Buried Hill" type of field. Special features of this type of oil field are the difficulty of determination of the size of structures (in this case, fracture or cave) by analyzing work of the records of seismic survey and indefiniteness of reserve confirmation. Another specialty is that production of oil will be initially very large for several years but it will decline drastically in the subsequent years. Bach Ho field is a large one in such type of oil fields, and is producing large amounts of oil and gas, however its peak production will be in 1995 and then it will follow the declining curve of production. Rang Dong field is also a "Buried Hill" type and it is necessary to drill confirmation wells carefully. Because, there is a good case of reference; Dai Hung field which shrank its reserves by drilling of confirmation wells. However, in the case of "Buried Hill" type of oil field, whether its oil or gas reserves are large or not is difficult to be determined, and the trial and error had been performed during the development work of Bach Ho oil field by Vietsovpetro. Therefore, rashness of determination should be avoided and diligent exploration work should be performed even in the producing stage and we can find oil or gas even in the unexpected area.

It is too early to estimate or determine all the gas reserves in sedimentary basins in Viet Nam at this stage of exploration history. Whether natural gas supply to thermal power plants will be stable or not depends on solely future exploration results of oil and gas. With gas supply from so far discovered 100 billion m^3, theoretically it is enough to provide gas to the planned three gas fueled power plants. However, it will not be the situation of confirming these gas reserves in the coming several years.

Next issue of economical point of view is that it will be rather high cost of development of oil or gas fields in off-shore Viet Nam, especially in Nam Con Son basin, where the water depth is deep and the distance from the shore is more than 200 km or nearly 300 km. If discovered oil field is small a marginal, temporary or early production system will be performed, but in the case of large gas field development, the situation is different. There should be a large jacket constructed, or sub-sea completion and production facilities designed, and construction of gas compressor and gas processing facilities with long distance pipeline are prominent. Therefore the development cost of such large gas field in off-shore area is higher than usual case, and unless the circumstance will not be favorable, oil companies can proceed the development stage, otherwise companies will withdraw. BP/Statoil's two gas fields discovery is a typical such case, and they are looking for cooperation development partners of gas and pipeline constructor as their two gas field reserves of 2 TCF are a bit small for their sole development.

Summing up the demand and supply of natural gas to the thermal power generation;

(1) There are around 100 billion m^3 of natural gas reserves so far discovered in off-shore Viet Nam, which is total of all the gas in north, central and south of Viet Nam, while economical and technical development is disregarded. Progress of exploration activity will make discovery of natural gas reserves further more, and its amount will be another 100 billion m^3 in future.

(2) However, actual figure of proved recoverable reserves of natural gas in off-shore Viet Nam is not so large at present. The associated gas of Bach Ho field of Vietsovpetro is confirmed as 20 billion m^3, and Rong field gas is 5 billion m^3. Other gas reserves, especially BP / Statoil group's two gas fields discovery in Nam Con Son basin; Lan Tay and Lan Do, are not yet proved nor confirmed. Reserves of oil and gas of Bach Ho and Rong had been approved by the state Mine Reserve Committee of Viet Nam while gas reserves of Lan Tay and Lan Do are under the evaluation by the committee at present, and only declared reserves of 2 TCF (60 billion m^3) by the company are reported.

(3) Other fields discovered in off-shore Viet Nam, Dai Hun of BHP group, Rang Dong of Mitsubishi Oil Co. and other oil or gas showing of exploration wells in PS contracted areas of many foreign oil companies, have not yet confirmed their reserves, except Dai Hun

which had started the early production system's crude oil production, and its associated gas is estimated as 3.2 billion m^3.

(4) The associated gas of Bach Ho field will be sent to the shore and will be used as fuels of thermal power plants (Ba Ria, Thu Duk, and Phu My) simultaneously, totally 1.2 billion m^3 per year. While, Bach Ho field will have its production peak in 1995, and then it declines in oil and gas production. One of the replacement gas supplying fields for this decline is Rong field near Bach Ho. However Rong is not enough to replace all the declining, and there should be other fields developed and connected with a pipeline to Bach Ho. The most prominent one of them is the discovery of Mitsubishi Oil Co; Rang Dong, while it has not yet confirmed its reserves of oil or gas.

(5) Development cost of Lan Tay and Lan Do gas fields of BP / Statoil group is rather high because they are situated long distance from the shore and deep water-depth. Gas reserves of the group's announcement; 2 TCF is not so large amount and will not be enough to establish LNG plant economically and its gas is only for the domestic supply. With creating new gas demand, the group plans to develop the fields and lie a pipeline to shore, together with other foreign oil companies which are operating exploration and discovered gas near by the group's blocks.

(6) It is essentially needed to explore constantly for oil and gas to secure the proved oil or gas reserves, and for this purpose PVA will proceed the accelerated contract policy of Production Sharing with foreign oil companies, with taking foreign companies risky investment, with giving adequate reward to them.

(7) Exploration work of natural gas resources in off-shore Viet Nam is under way, and it is too early to determine the future availability of gas at present. We should be in careful stance to decide the available amount of natural gas for the thermal power plant. On the point of reserves, there is a definite view on coal rather than gas in Viet Nam.

Table 7.2-1 Coal Exploration Plan and Actual Result

(Unit: m)

Area	Company	Exploration Stage	Stratigraphic Drilling Length						
			1991	1992	1993	1994	1995	2000	2005
1. Mao Khe	Uong Bi	Detailed	3,120	4,000	4,000	4,000	-		
2. Vang Danh-Uong Thuong	Uong Bi	Preliminary	2,000	2,000	2,000	2,000	-		
3. Dong Nga Hai	Cam Pha	Preliminary	1,100	3,200	3,200	3,200	-		
4. Suoi Lai	Hong Gai	Preliminary	2,000	1,500	1,000	-	-		
5. Tay Le Tri	Cam Pha	Preliminary	1,400	1,500	-	-	-		
6. Quang La	Uong Bi	Finding	-	500	330	-	-		
7. Bang Thoug (Cai Bac)	Cam Pha	Finding	-	1,500	1,500	-	-		
8. Dong Thang Bac	Uong Bi	Finding	-	500	500	-	-		
9. Thung Luong	Uong Bi	Finding	-	500	-	-	-		
10. Lo Tri	Cam Pha	Finding	-	-	1,000	1,000	-		
11. Quang Ninh		Development	5,000	5,000	6,000	6,000	-		
Total			14,620	20,200	19,530	16,200	11,200	45,000	35,000-40,000
Actual Total:			10,159	9,197	8,348				

(Note: 1991-1994: planned and actual, 1995, 2000, 2005: plan)

Table 7.2-2 Capital Investment Plan in Coal Production Companies

Investment Item	Plan I		Plan II	
	(Million Dong)	%	(Million Dong)	%
Total	3,038,783	100	4,116,167	100
1. Kind of Investment	3,038,783	100	4,116,167	100
a. New Development	623,059	20.5	847,829	20.6
b. Sustaining Present Facilities	280,237	9.2	887,317	21.2
c. Strengthning of Present Facilities	2,135,487	70.3	2,381,021	57.9
2. Object of Investment	3,038,783	100	4,116,167	100
a. Coal Mine	1,856,152	62.8	2,662,493	66.2
b. Cleaning	609,992	20.7	712,557	17.7
c. Transportation	398,678	13.5	554,029	13.8
d. Machinery, Tool	29,714	1.0	30,436	0.8
e. Others	60,003	2.0	60,003	1.5
3. Companies	3,038,783	100	4,116,167	100
a. Uong Bi Coal C.	391,409	13.2	636,549	15.8
b. Hong Gai Coal C.	634,433	21.5	823,291	20.5
c. Cam Pha Coal C.	1,621,256	54.9	2,229,348	55.4
d. No.3 Coal C.	247,909	8.4	270,784	6.7
e. Coal Design Co.	21,821	0.7	21,821	0.6
f. Others	37,710	1.3	37,710	1.0
4. Period	3,038,783	100	4,116,167	100
a. 1991-1995	1,075,775	36.4	1,214,070	30.2
b. 1996-2000	1,031,305	34.9	1,557,466	38.8
c. 2001-2005	847,458	27.9	1,247,967	31.0

Source: Coal Investment and Design Co., Viet Nam.

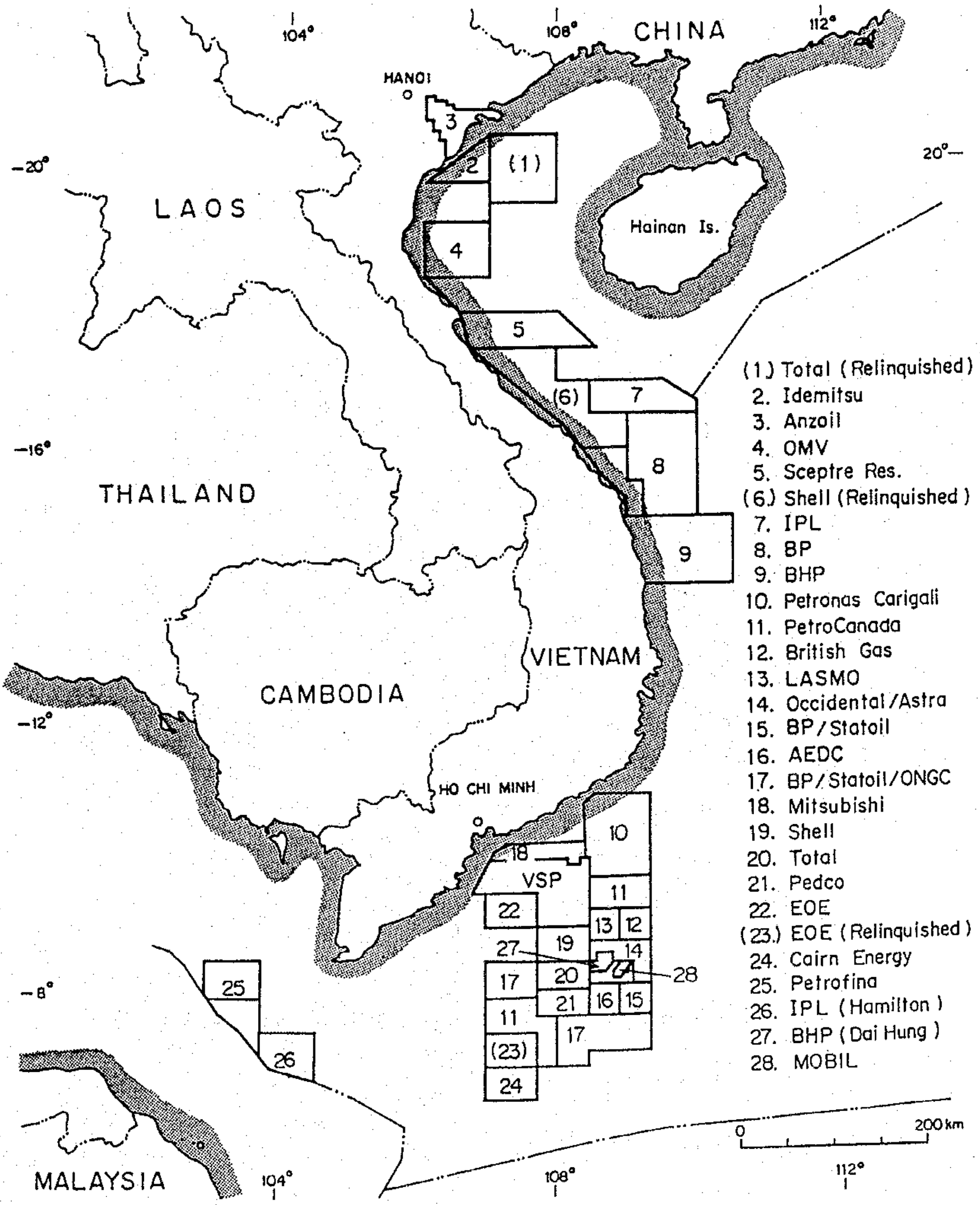

Figure 7.2-1 PS Contract Oil and Gas Exploration Blocks in Offshore Viet Nam

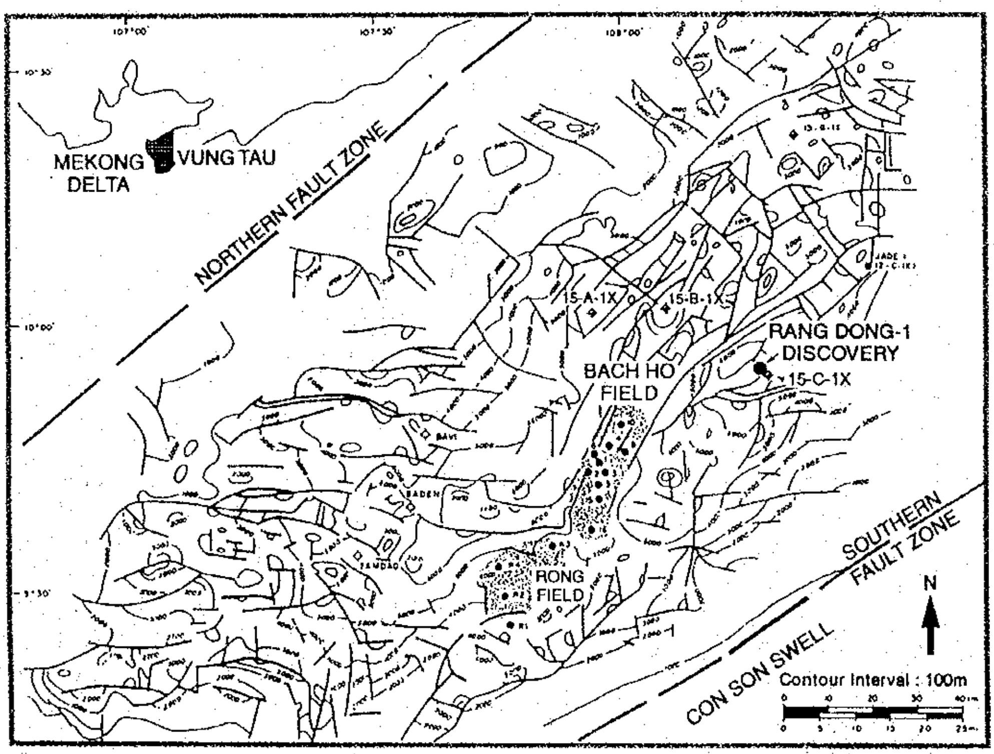

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Figure 7.2-2 Map of Basement Structure, Cuu Long Basin, Viet Nam

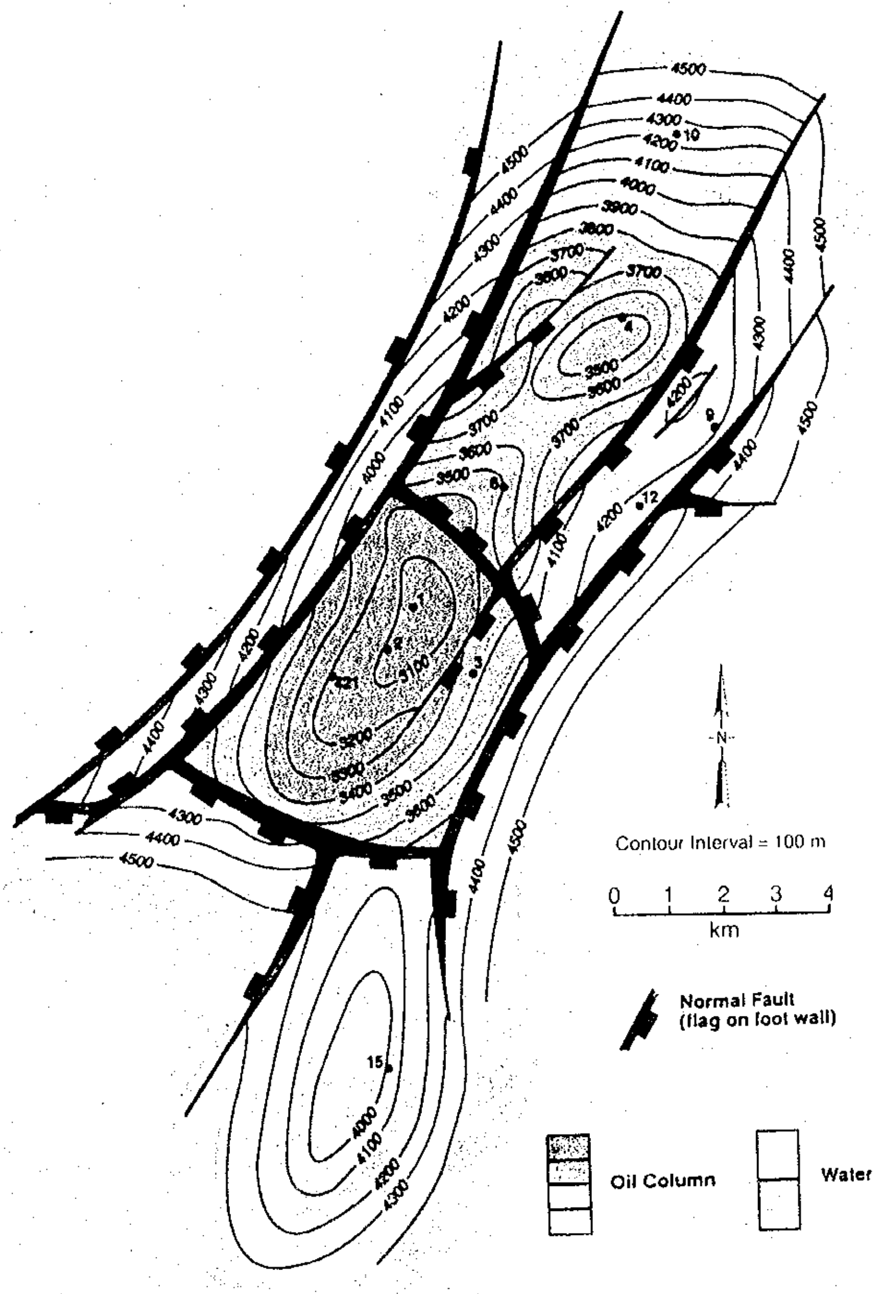

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Figure 7.2-3 Bach Ho Field Structure Map

CHAPTER 8

POWER DEVELOPMENT PLAN

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8.1 Basic Concept

This section examines the basic concept and condition arrangement for the establishment of the long term power development plan (PDP) by taking into account the prospect of the power generation energy resources and energy policy in Viet Nam.

(1) Resources limitation

The characteristics of the primary energy resources for power generation, except nuclear power, are enumerated in the following table;

Political Items	Large Hydro	Small Hydro	Coal	Natural Gas	Oil
a) Domestic Energy	○	○	○	○	X
b) Renewable Energy	○	○	X	X	X
c) Environment	△	○	△	△	△
d) Foreign Money Saving	○	○	○	○	X

Note ○ : Resources clear the constraint items
△ : Resources required countermeasures
X : Resources not conformed to the constraint items

From synthetic evaluation of policy items, hydropower, coal and natural gas can be regarded as energy resources for power generation.

(2) Resources development potential

Development potential of coal, natural gas and hydropower, which are limited energy resources, is shown in the following table.

Resource Factor	Coal (Anthracite)	Natural Gas: Associated	Natural Gas: Non-associated gas	Hydro
a) Proven Resources	557 x 10^6 ton	28.2 x 10^9 m^3	Not-Proven	100 TWh
b) Demand	Export, Power, Cement	Power Sector	Power Sector	Power Irrigation
c) Develop. Period	Short	Medium	Long	Medium
d) Develop. Risk	Small	Small	Large	Small

The resources development potential is determined with the above four factors mutually related. The development potential of non-associated gas is presently unconfirmed. However, the development potential of natural gas expands due to success in gas field drilling in future and new gas demands are expected (heavy chemical industry, public welfare and commerce).

In this situation, the following two proposals are considered as combinations of energy resources for the electric power sector.

Proposal (1) (Water power + coal + non-associated gas)
Proposal (2) (Water power + coal + associated gas + non-associated gas)

In this power development plan, proposal (l) is hereinafter called "gas small" and proposal (2) "gas large".

8.2 Precondition

8.2.1 Power Demand Forecast

The anticipated annual growth rate of power demand is 9% to 14% and the peak load is for lighting in the evening (18:00hrs to 20:00 hrs.). The daily load factor is from 60% to 70%. These values vary with season and region and the basic characteristics will make no great difference in the future.

This power resources development plan uses the daily load curve by region for every hour of the modified type on the basis of the 1993 values in order to meet the kW and kWh values of power demand as forecasted in Chapter 5. (Refer to the appendix for details.)

Demand forecast values to be used in the power development plan are shown in Table 8.2-1.

8.2.2 Power Development Project Site

(1) Development projects scheduled to start operation before 2000

Power resources development project sites planned or constructed for startup before 2000 are shown in Table 8.2-2.

(2) Development projects to be commissioned after 2001

For hydropower candidate sites, the top 15 projects where the B/C exceeds 1 are selected and used for simulation calculation (Refer to Table 8.2-3).

(3) **Matters for attention in hydropower projects**

(a) Development potential of three major rivers

Power Generation Potential of Three Major Rivers in Viet Nam

Item	Unit	Da (North)		Se San (Center)	Dong Nai (South)
		Son La (L)	Son La (S) +Huoi Quang		
1) Annual Output	GWh	17,396	13,788	4,331	4,163*
2) Investment	(US$ Mil)	3,485	2,785	1,229	1,346
3) Annual Cost	"	657	470	180	170
4) Annual Benefit	"	713	468	168	127
5) B/C		1.08	1.00	0.94	0.75
6) Unit Cost	(¢/kWh)	3.78	3.41	4.07	4.68
7) Affected Pollution	(thousand) in 1990	106	78	6.5	-

*Note) except for Don Nai 8

The macro development expenses and generation cost of the hydroelectric power generation project seen by three large rivers in Viet Nam (the Da, Se San and Don Nai). All are economically better than those of the thermal power projects. Of these, the generated electric energy and profitability at the River Da are excellent.

When a new power plant is constructed upstream, an increase or decrease of the electric energy generated by the downstream power plant is considered as a benefit for the new upstream power plant and is added to the generated electric energy.

(b) Son La hydropower project

As the Son La hydropower development, which is a very large project of the hydropower project points, exerts great influence on the overall development plan, the Son La development is based on the following two proposals.

1) Son La large-scale development (Son La (L)) places emphasis on power generation and flood control.

2) Son La small-scale development (Son La (S)) mainly places emphasis on power generation and the multi-staged development of the Da river.

In view of the role of this project as flood control and economical power generation cost, its commissioning will be hastened as much as possible and startup of the first plant is set for 2007 in the basic plan in view of construction process which extends over a long period. The Son La (S) case plans integrated development with the tributary upstream Huoi Quang power plant as one set (Refer to Table 8.2-4).

An approximate construction schedule of the Son La and Huoi Quang hydro projects is shown in Table 8.2-5.