9.6 percent, respectively, with 10 percent increase in the product price.

2) Sensitivity to Plant Construction Cost

FIRROI (after tax) and FIRROE (after tax) increase by 1.8 and 3.2 percent, respectively, with 10 percent decrease in the plant construction cost.

3) Sensitivity to Raw Material Cost

FIRROI (after tax) and FIRROE (after Tax) increase by 2.1 and 4.0 percent with 10 percent decrease in the raw material cost.

4) Sensitivity to Financial Condition

Variation of this parameter affects FIRROE (after tax) very much. FIRROE after tax increases by 3.5 percent in case the interest rate is 5.0 percent per year. However, FIRROE after tax decreases by 6.6 percent in the case that the interest rate is 16 percent per year.

5) Sensitivity to Debt/Equity Ratio

The effect of this parameter is marginal.

6) Operating Rate

The effects of decrease in operating rate on the profitability are significant. FIRROI (after tax) and FIRROE (after tax) decrease to 7.6 percent and 7.3 percent, respectively, at the operating rates indicated in Case B.

15-4 Summary of Financial Analysis

The following is the conclusion of the financial analysis and Table 15-13 shows the results of sensitivity analysis.

- (1) The pilot plant itself, Case 1, is evaluated as financially unfeasible, although the capital requirement as well as operation deficit are small when compared with large industrial projects.
- (2) The financial feasibility of Case 1, in which both the pilot plant

and the commercial plant will be running, the latter starting up five years after the pilot plant, is not considered financially adequate.

- (3) The financial feasibility of the above case is improved by the suspension of the operation of the pilot plant. However, the improvement in the financial feasibility is not substantial by just one commercial plant of 50,000 tons.
- (4) A commercial plant of 50,000 tons per year of lignite briquettes without installing the pilot plant is judged as financially feasible.

Table 15-13 Summary of Sensitivity Analysis

(Unit: percent)

Parameter	. 1	FIRROI	ग्राच	ROE		
1 at ancoci	B/T	A/T	В/Т	A/T		
Case	11.6	10.0	14.3	11.7		
Lignite Briquettes	, percent				:	
+10	16.7	15.1	23.4	21.3		
-10	5.9	4.3	3.9	0.6		
Plant Cost, percer	nt					
+10	10.1	8.4	11.6	8.9	1 -	
-10	13.4	11.8	17.4	14.9		
Raw Materials, per	cent					
+10	9.4	7.8	10.5	7.7		
-10	13.7	12.1	18.1	15.7	· · · · · · · · · · · · · · · · · · ·	71
Operating Rate,	lst year	2nd year	3rd year	4th year	5-15th	
(percent/year)					year	·
Case A	20	40	60	80	100	
Case B	30	50	70	90	100	
Case C	40	60	80	100	100	
Case A	7.9	6.0	7.5	3.8		
Case B	9.4	7.6	10.4	7.3		
Case C	10.7	9.0	12.6	9.8		
Interest Rate, per	cent (Cons	stant Price)				
2			19.9	17.9		
5			17.5	15.2		
16			8.5	5.1		

1. COST OF GOODS SOLD — CASE 1 1. Fig. 178 118 118 118 118 118 118 118 118 118		2014 176 2, 530 0	1,747 369 590 2,806	1, 373 370 1, 743	2, 682 1, 824 2, 012 6, 517	900	000	11, 067	553	11, 620	0,000,000,000,000,000,000,000,000,000,	
CAST FOR GOODS SOLD - CASE 1 CHAIR MARKETING FOR THE ACCOUNT OF SOLD - CASE 1 CHAIR MARKETING		2013 176 2, 806 176		1, 373 0 370 0 1, 743		680	000	11.067	553 553	11,067	1,000 1,000	
COST OF GOODS SOLD				1.373 370 1.743	2, 582 1, 824 2, 012 6, 517	000	909	290	553 553	11,067		
Construction Cons		17888		1,373 370 1,743	2, 582 1, 824 2, 012 6, 517	900	900	290	553	11, 067	1,000 1,000	
Cost Colores Sold Cost		010 178 806 178		1, 373 370 1, 743		000	000	. 290	573 553	11,086		
T. COST OF GOODS SOLD — CASE 1 CAST PRIOR PLANT WITH A CAMACUTY OF 1 DOOT 1707 CAST PRIOR PLANT WITH OF 1 DOOT 1707 CAST PRIOR PLANT WITH OFF PACKET A CAMACUTY OF 1 DOOT 1707 CAST PRIOR PLANT WITH OFF PACKET A CAMACUTY OFF PACKET WITH WITH WITH A CAMACUTY OFF PACKET WITH WITH WITH WITH A CAMACUTY OFF PACKET WITH WITH WITH A CAMACUTY OFF PACKET WITH WITH WITH WITH WITH WITH WITH WIT		2009 176 2, 806 176		1, 373 370 1, 743		39.0	383	11,450	573			
CLOST OF GOODS SOLD - CASE 1		2008 176 2.806 176		1,373		393	393	460	573 573		3.000 3.000 0.2.0 0.2.0 1.2.0	
CAST OF GOODS SOLD - CASE 1 CAST OF GOODS SOLD - CASE 1 CAST OF GOODS SOLD - CASE 1 CAST OF CAST OF GOODS SOLD - CASE 1 CAST OF CAST				1,373 370 1,743		393 0	393	460	573 573	Ī	000 000 000 000 000 000 000 000 000 00	
Cost Of Goods Sold - CASE 1 Cost Of Goods Sold - CASE 1 Cost Of Cools Sold - CASE 1 Cost Of Color Plant Flat With A CAPACITY Of 3 DOT 1777 1395 1396		2006 1.806 1.76		1, 373 370 1, 743		393 0	3300	460	573 573	- 1	1,000 1,000 0,200 1,200	
CASE 1 CHANT PLANT WITH A CAPACITY OF 3 LOUDT LYN		2005 175 2, 806 176		1.373 370 1.743		383 0	393	460	809 573	•	1,000 1,000 1,000 1,000 1,000 1,000	
Cost Of Goods Sold - CASE 1 Cost Of Coods Sold - CASE 1 C		2004 176 2, 805 176		1, 373 370 1, 743		4, 728 393 0	0 0 5, 122		803 809	15, 189	3,000 5,40 1,20 1,72 1,72	
COST OF GOODS SOLD - CASE 1 CRIM Flat Manager Cost of Goods Cost of Go				1, 373 370 1, 743		4, 728 393 0	0 0 5, 122	16, 189	827 809	16, 206	000 5.00 7.2.5.5 7.2.5	
COST OF GOODS SOLD - CASE 1 CASE CPLIOT PLANT WITH A CAPACITY OF 3 000717/) CASE CPLIOT PLANT WITH A CAPACITY OF 3 000717/) CASE		2002 176 2, 806 176		1, 373 370 1, 743					827 827	16, 533	3.000 5.55 1.2.0.9 1.8.2.6	
COST OF GOODS SOLD - CASE 1 CASE PRINT WITH A CAPACITY OF 3.000T T/Y New WHERLAL DEGIUSED		2001 175 2, 806 176		1, 373 0 370 1, 743		4, 728 393 345			827 827	16, 533		
COST OF GOODS SOLD						4, 728 393 345		16, 533	916	16, 523		
COST OF GOODS SOLD - CASE 1 CHILDT PLANT WITH A CAPACITY OF 3 DOUT IX) 1995 1996 1997 176				1, 373 370 1, 743		4, 728 393 345		18, 321	915 916	18, 321		
COST OF GOODS SOLD - CASE 1		1998 176 2, 806 176	1, 747 369 690 2, 806	1, 373 370 1, 743	2, 582 1, 824 2, 012 6, 517	4, 728 393 345	1, 251 537 7, 254		916	18, 321	2,200 6,00 7,22 6,00 7,22 7,23	
COST OF GOODS SOLD - CASE 1		1997 176 2, 806 176	1, 747 359 690 2, 806	1, 373 370 1, 743	2, 682 1, 824 2, 012 5, 517	4, 728 393 345	1, 251 537 7, 254		916 916	18, 321	3,000 6,1 2,2 4,2 4,4	
I. COST OF GOODS SOLD — CAPACITY OF 3.0007 1777) CASE I CHLOT PLANT WITH A CAPACITY OF 3.0007 1777 Very MATERIAL PURCHASED Light Raw material Inventory at End Light COST Light Ray Material Inventory at End Light COST Light Ray Sub-total Sub-total		1996 176 2.806 176	1, 747 369 690 2, 806	1. 373 370 1, 743	2, 682 1, 824 2, 012 6, 517	4.728 393 345	1,251	- 1	873 916	18, 279	2, 970 6, 2 0, 8 2, 2, 2 7, 2	:
	CAS		1, 398 295 552 2, 245	1, 157 0 296 0 1, 453	2, 682 1, 824 2, 912 6, 517	4, 728 393 345	1, 251 537 7, 254	17, 470	873	16, 596	2, 280 7, 3 1, 0 0, 6 3, 2	
		N 1000										
	SOLI	TY OF 3. Beg. End								***************************************		
	Saoc	A CAPACI tory at tory at				č			it Beg. It End		/Year) (3ht/kg) ht/kg) ht/kg) ht/kg)	
		NT WITH al Inven IMSED al Inven			Tax	ORTIZATI t'n	Sost	Total)	roduct a	6	(Torse (19) 20) 20 (19) 10	
		W materi	ilal cost traw d'lime	OPE-COST icity ortation o-total	-cost fer Cost ins. & sad	TION & AN istion ant Se & Cons	opetion -total	N COST	Inished I	SODS SO	LUME NOF GOOK NATERIAL LABLE OP! RED OP!	
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		ا ۱۹۸۸ و تیپ								-		,
		: :				·				-		

II. PROFIT LOSS STATEMENT - CASE 1

Year 1995 1996 1997 SALES	1395	1996	1997	1998	1999	2000	100Z	2002	2003	2004	2005	2006	2007	2008	2003	102 102		: <u> </u> :	7	2011 2012 2013
SALES REVENUE SALES TAY (14)	4.948	4, 948 6, 475 6, 508	8, 503 66	S. 530	5, 890	8, 720 67	6, 780	6, 870	5, 930 50	6, 990	7,050	7, 140	7, 230	7, 290		7, 380	7, 380 7, 470	-	7, 470	7, 470 7, 560 7.
Net Sales Revenue	4, 898	6,410	6, 534	5, 564	5, 623	5, 653	6, 712	6, 801	6, 861	6, 920	6, 980	7, 059	7, 158	7,217		38	. 7.	7,395	7,395 7,484 7.	7, 395 7, 484 7, 574
COST OF GOODS SOLD	16, 596 18, 279 18, 321 18,	18, 279	18, 321	18, 321	18, 321	15, 523	16, 533	16, 533	16, 206	16, 189	11, 697	11, 460	11, 460	11,460	11, 460	8	60 11,086	≓	11,086	11,086 11,067
GROSS PROFIT ON SALES	-11, 698 -11, 869 -11, 787 -11,	11,869 -	11, 787 -	358	-11, 698	-9, 970	-9, 821	-9, 732	-9, 345	-9, 269	-4,717	-4, 392	-4, 303	-4, 243	-4, 154	70"	4 -3, 691	Ç	-3, 691 -3,	-3, 691 -3, 582
EXPENSES General Expenses	671	671	671	671	671	671	671	671	173	671	671	129	671	129	671		671	671 675		675
Northerest for Short Term Loan Sub-total	3, 509 3, 509 0 898 4, 180 5, 078	3, 509 898 5, 078	3, 158 1, 789 5, 618	2,807 3,056 6,534	2, 457 4, 400 7, 527	2, 106 5, 829 8, 606	1, 755 7, 353 9, 778	1, 404 8, 976 11, 051	1, 053 10, 707 12, 430	702 12, 556 13, 929	351 14, 535 15, 556	16, 655 17, 325	18, 926 19, 596	21. 043 21. 713	23, 344 24, 015		25, 845 26, 516		0 845 28, 516 29,	0 0 845 28.564 31, 516 29,234 32,
INCOME BEFORE INCOME TAX	-15, 878 -15, 947 -17, 405 -18,	15, 947	17, 405 -	291	-19, 225	-18,576 -	-19, 598 -	-20, 783 -	-21, 775	-23, 197	-20, 273	-21, 717	-23, 899	-25, 956	-28, 169		-30, 207	207 -32,817	207 -32, 817 -35, 582	207 -32,817 -35,
INCOME TAX	0	0 0	0	0	0	0	0	G	0	0	0	0	0	0	0		0	0	0 0 0	
INCOME AFTER INCOME TAX	-15,878 -16,947 -17,405 -18,	16, 947	17, 405	291	-19, 225	-18, 576	-19,599 -	-20, 783 -	-21, 776	-23, 197	-20, 273	-21, 717	-23, 899	-25, 956	-28, 169	1	-30, 207	207 -32, 817	207 -32, 817 -35, 682	207 -32, 817 -35,
CUMUL INCOME AFTER INCOME TAX	-15, 878 -32, 825 -50, 230 -68	32, 825	50, 230	68, 521	87,747	106322	125921	146704	168480	191677	-211950	-233667	-257566	-283522	-311691	1 1	341888	341898 -374715	341898 -374715 -410397	341898 -374715 -410397 -44923
UNIT COST OF GOODS SOLD (Bht/Ag)		6.2	6.1	6.1					8,0 2,4	A 67	3,9			9,3				7 3.	7 3.7 3.	7 3.7 3.7 3. 2 0.2 0.2 0.
UNIT INTEREST FOR LONG TERM LOANS (BAL/AS) LINIT INTEREST FOR SHORT TERM LOANS (BAL/AS)	0.0		 			10 10 10 10 10	, 20,91	0.6	9 9 9 8	Ç4 121 €	104 1-8	.0% .0%		0.0	7.8		0.00		10 si	0 0 0 0 0 0 0 0 0 0
UNIT COSTS & EXPENSES (Bht/kg)		-	0	e ∞					un on	10.0				11 1		13		E)	13.4	5 13.4 14.4 15.

III. CASH FLOW STATMENT - CASE 1

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-3, 691	66	375 0 683	. 00	00	671	0 0	845	1290	90	-4, 357 -4, 357 0
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-9, 821	5,467	93	00		631	3, 899 1, 755 81, 695	7, 353	•		-5,035
-9, 970	5,467	81, 695 77, 192	00	00	671	3, 899 2, 106 54, 771	5,829	25° C	0 0	-5, 090 -5, 090 0
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11, 787 -	8, 718 537	33, 950 0 29, 417	00	00						-5, 761 -5, 761 -0
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IV. PROJECTED BALANCE SHEET - CASE 1

CASE I (PILOT PLANT WITH A CAPACITY OF 3,000T T/Y)	APACITY OF 3	3,000T T/Y) 1994 1995	Y) 1995	1996	1997	1998	1999	2000	7007	2002	2003	2004	2005	2006	2003	2008	2003	Un 2010	Unit: 1.00 2011	000 Bahts 2012	2013	2014
ASSETS CURREN ASSETS Cash Working Capital Total	004	447 1, 670 2, 117	3, 403 3, 850	447 3, 701 4, 148	447 3, 721 4, 168	3, 726 4, 173	447 3, 736 4, 183	3, 652 4, 099	447 1, 662 4, 109	447 3, 677 4, 124	447 3, 670 4, 117	3, 580 4, 127	3, 453 3, 900	447 3,468 3,915	3, 483 3, 930	447 3, 493 3, 940	3, 508 3, 955	3, 504 3, 504 3, 951	447 3,519 3,966	3, 534 3, 981	447 3, 544 3, 991	000
FIXED ASSETS(Less Depr.)	24, 228	65, 926	58, 671	51, 417	44, 152	36, 508	29, 654 2	24, 187	18, 720 1	13, 254	8, 132	3, 010	2, 617	2, 223	1,830	1, 436	1.043	1,043	1.043	1, 043	i. 043	1.043
TOTAL ASSETS 24 228 58,043 LIABILITIES AND SHAREHOULDERS EQUITY SKORT-TERM LOAN ACCOUNT PAYABLE 0 0	24, 228 DERS' EQUITY 0	58, 043 0 0	62, 522 9, 983 374	55, 564 19, 879 468	55, 564 48, 331 41, 082 19, 879 33, 950 48, 891 468 468 468		33, 837 2 64, 771 8 468	28, 286, 2 81, 695, 9 468	22, 830 1 99, 737 11 468	17, 378 1 118, 967 13 458	12, 248 39, 513 16 468	7, 137	6, 517 85, 050 21 468	6, 139 210, 288 23 468	5, 760 233, 809, 25 468	5, 377 259, 382, 28 468	4, 998 287 172 31 468	4, 994 7, 375 468	5, 909 350, 206 36	5, 024 385, 904 42 468	5, 034 424, 749, 46 468	1, 043 463, 636
LONG-TERM LOAN	11, 186	38, 993	38, 993	38, 993	35, 094	31, 194	27, 295 2	23, 396	19, 496	15, 597	11, 698	7, 799	3, 899	0	0	0	C	0	- 6	6	0	Ģ
Sinneidoder s Equity Capital Retained Earning Total Equity	13, 042 0 13, 042	29, 05(29, 05(29, 050 29, 050 1-15, 878 - 32, 825 13, 172 - 3, 775	29, 050 -32, 825 -3, 775	29, 050 29, 050 5 -50, 230 -68, 521 5 -21, 181 -39, 472		29, 050 2 87, 747 -1 58, 697 -7	29, 050 2 106322 -1 77, 273 -9	29, 050 2 -125921 -1 -96, 872 -1	29, 050 2 146704 -1	29,050 2 -158480 -1 -139430 -1	29, 050 2 -191677 -2 -162627 -1	29, 050 2 211950 -2 182900 -2	29, 050 2 233657 -2 204617 -2	29,050 2 -257566 -2 -228516 -2	29, 050 2 283522 -3 254473 -2	29, 050 2 -311591 -3 -282642 -3	29,050 2 341898 -3 -312849 -3	29, 050 374715	29,050 2410397	29, 050 2 -449233 -4 -420183 -4	29, 050 -491643 -452593
TOTAL LIABILITIES	24, 228	58, 043	58,043 62,522 55,564 48,331 41,082	55, 564	48, 331		33, 837	28, 285 2	22, 830 1	17, 378	12, 249	7, 137	6, 517	6, 139	5, 760	5, 377	4, 998	4, 994	5,009	5, 024	5, 034	1,043
((Working Capital Table))	1993	1894	1994 1995 1996 1998	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2008	2007	2008	2003	2010	2011	2012	2013	2014
CURRENT ASSETS Initial Working Capital Cash Spare Parts Raw Material Inventory	. 00,0	447 1529 141	447 1529 141	1529 141	1529	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	447 1529 141	9
Numning Morking Capital Raw Material Inventory Product Inventory Account Receivable Total	0000	2,117	35 873 825 3,855	35 1, 079 4, 148	35 916 1, 100 4, 168	35 1, 105 4, 173	35 916 1,115 4,183	35 827 1, 120 4, 099	35 1, 130 4, 109	35 827 1, 145 4, 124	35 808 1,155 4,117	35 309 1, 165 4, 127	35 573 1, 175 3, 900	35 573 1, 190 3, 915	35 573 1, 205 3, 930	35 573 3, 940	35 573 1, 230 3, 955	35 553 1, 245 3, 951	35 1.260 3.986	35 553 1, 275 3, 981	3. 991	0000
CURRENT LIABILITIES Account Payable			374	488	468	458	458	458	468	468	468	468	468	468	468	468	468	468	468	458	458	
TOTAL WORKING CAPITAL		2, 117	3, 476	3, 680	3, 701	3, 706	3, 716	3, 631	3, 641	3, 656	3, 649	3, 859	3, 433	3, 448	3, 463	3,473	3, 488	3, 483	3,498	3, 513	3, 523	¢

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I. COST OF GOODS SOLD - CASE 2

2014 113 0	, 870 , 519 , 579	8, 710 0 6, 535 9, 225	6,813 7,755 5,110 9,679	. 547 0	0 0	, 275	4, 754 0	, 039	 0.0.9 4.0.0 0.0 0.0
Bahts 2013 2 1,466 1, 49,579 48, 1,465	30, 870 30, 6, 519 6, 12, 190 12, 13, 579 49,	8,710 8 0 0 6,535 6 24,470 24	6, 813 7, 756 5, 110 13, 579	1.547	1,547	95, 275 95,	4, 764	95, 275 10(53, 000 55, 1. 8 0. 5 0. 5 0. 4
1,000 2012 1,466 9,579 1,466	30, 870 6, 519 12, 190 49, 578	8, 710 6, 535 9, 225 24, 470	5, 812 5, 756 5, 110	1.547	0 0 1,547	95, 275	4, 764	95, 275	53, 000 8, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Unit: 2011 1,466 49,579 4,579	30, 870 3 6, 519 12, 190 1	8,710 6,535 9,225 24,470	6, 813 7, 755 5, 110 9, 679	1.547	0 0 1, 547	95, 275	4, 764	95, 275	53.00.00.00.00.00.00.00.00.00.00.00.00.00
1, 466 1, 466 1, 466 1, 466	30, 870 3 6, 519 12, 190 1	8, 710 6, 535 9, 225 24, 470	6, 813 7, 756 5, 110 9, 679	1, 547	0 0 1,547	35, 275	5, 571	96, 083	53 000 1000 1000 1000 1000
2009 1, 466 49, 579 1, 466	30, 870 3 6, 519 12, 190 1	8, 710 0 6, 535 - 9, 225 24, 470	6, 813 7, 756 5, 110 19, 679	15, 761 1, 940 0	0 0 17. 701	111. 429	5, 571	111, 429	53 000 00.2 00.0 00.3 00.3
2008 1. 465 43, 579 1. 466	30, 870 6, 519 12, 190 49, 579	8, 710 6, 535 9, 225 24, 470	6, 813 7, 756 5, 110 19, 679	15, 761 1, 940	17, 701	11, 429 1	5, 500 5, 571	11, 457	53,000 2,1 0,0 0,5 0,3
2007 1. 456 1. 456 1. 456	30, 870 6, 519 12, 190 49, 579	8, 710 6, 535 9, 225 24, 470	6, 813 7, 756 5, 110 19, 679	15, 761 1, 940 575	0 0 18, 275	112, 003 13	5, 600 5, 500	2,003 1	00.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
2006 1, 456 49, 579 1, 466	30, 870 6, 519 12, 190 49, 579	8, 710 6, 535 9, 225 24, 470	5, 813 7, 755 5, 110	15, 761 1, 940 575	0 0 18, 275	112,003 11	5, 600 5, 600	2,003	53,000 2,2,1 0,5 0,3
2005 1, 466 49, 579 1, 466	30, 870 6, 519 12, 190 49, 579	8, 710 6, 535 9, 225 24, 470	5, 813 7, 755 5, 110 9, 679	15, 761 1, 940 575	0 0 18, 275	112, 000 11	5, 933 5, 600	112, 397 1	53,000
2004 1, 465 49, 579 1, 456	30, 870 3 6, 519 12, 130 1	8, 710 6, 535 9, 225 24, 470	6, 813 7, 758 5, 110 9, 679	20, 489 1 1, 940 575	1, 480 1, 654 26, 138	119,866 11	5, 993 5, 993	9,866 11	5.000 2.000 2.000 2.000 2.000
2003 1, 466 49, 579 1, 466	30, 870 3 6, 519 12, 190 1	8, 710 6, 535 9, 225 24, 470	6, 813 7, 756 5, 110 9, 679	20, 489 2 1, 940 575	1, 480 1, 654 26, 138 2	119,866 11	6. 011 5. 993	9,883 11	53.000 6.93 6.64 6.55
2002 1, 466 19, 579 1, 466	30, 870 3 6, 519 12, 190 1	8,710 6,535 9,225 24,470	6, 813 7, 756 5, 110 19, 679	20, 489 1, 940 919	1, 480 1, 654 26, 483	120, 211 11	5, 011 5, 011	120,211 11	53,000 0.2,3 0.6 0.5 0.5
2001 1, 466 49, 579 1, 466	30, 870 36, 519 12, 190 1	8, 710 0 6, 535 9, 225 24, 470	5, 813 7, 756 5, 110 9, 679	20, 489 2 1, 940 919	1, 480 1, 654 25, 483	120, 211 13	4, 430 s	118, 630 17	52, 500 2, 3 2, 3 0, 9 0, 5 0, 5
2000 1,031 40,659 1,466	5, 045 5, 289 9, 890	7, 554 5, 302 7, 380 20, 236	6, 813 7, 756 5, 110 9, 679	20, 489 7 1, 940 919	1, 480 1, 854 26, 483	106, 622 12	916	103, 108, 1	11.000 12.50 12.50 10.50 10.50
1999 176 1,661	1, 747 2 369 690 2, 806	1, 373 370 1, 743	2, 682 1, 824 2, 012 6, 517	4, 728 393 345	1, 251 537 7, 254	18, 321 10	916 916	18, 321 10	2,22.00
1998 176 2, 806 176	1, 747 369 690 2, 806	1, 373 370 1, 743	2, 682 1, 824 2, 012 6, 517	4, 728 393 345	1, 251 537 7, 254	18, 321	915	8, 321	0.00 0.00 12.22 2.44
1997 1997 176 2. 806 176	1, 747 369 590 2, 806	1, 373 0 370 0 1, 743	2, 682 1, 824 2, 012 6, 517	4,728 393 345	1, 251 537 7, 254	18, 321	916	18, 321 18,	3, 900 6, 1 2, 2 2, 2 2, 4
2, 806 2, 801 177 2, 806 2, 806 176 176 176 176 176 176 176 176 176 17	1, 747 369 590 2, 806	1. 373 370 0 1. 743	2, 682 1, 824 2, 012 6, 517	4, 728 393 345	1, 251 537 7, 254	18, 321	873 916	18, 279	2. 9.70 0. 9 2. 2 2. 2
	1, 398 295 552 2, 245	1, 157 0 296 0 0 1, 453	2, 682 1, 824 2, 012 6, 517	4, 728 393 345	1, 251 537 7, 254	17, 470 1	873	16, 596 1	2, 280 7, 3 0, 6 13, 2
CASE 2 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY (Far. 1995) (+) Raw material Inventory at Bog. 176 (-) Raw MATERIAL PURCIANSED 2. 280 (-) Raw Material Inventory at End 176 176		•						-	
PLANT #							٠.		
YEE 2 (PILOT PLANT and COGNERCIAL PART (*) Raw material Inventory at Beg. N. MATERIAL PURCHASED (*) Raw Material Inventory at End							Seg. End		M/Year) (Bht/kg) (Bht/kg) (Bht/kg) (Bht/kg) (Bht/kg)
and COM Invento ED Invento				12AT 10N	د	a])	(+) Finished Product at(-) Finished Product at		(ton/kear) 019 (Bht/kg) ST (Bht/kg) ST (Bht/kg) ST (Bht/kg)
PLANT erial URCSMS	<u>.</u>	OST ion	st & Tax 1	AMORT n onst.n	. ფ — ავე	T. (Tot	d Prod	SOLD	174L CO 0PE-CO 0PE-CO 0PE-CO
(PILOT law mat RIAL P	MAIENITE Lignite Rice straw Slacked Lime Sub-total	MABLE OPE-COST Electricity Water Fuel Transportation Sub-total	ED OPE-COST Manpower Cost Maint. Ins: & Tax Overhead Sub-total	RECIATION & AMORTI Depreciation Plant Bldg & Const'n Vehicles	Amortization Preopetion Cost 10C Sub-total	SOS KO	inishe inishe	90 80 80 80 80 80 80 80 80 80 80 80 80 80	COST OF GOODS SOLI FAW MATERIAL COST VARIABLE OPE-COST FIEXED OPE-OCST FIEXED OPE-OCST
CASE 2 (Year (+) RAW KATE (-) R	MAKERIAL UNS Lignite Rice straw Slacked Lime Sub-total	VARIABLE OPE-COS Electricity Water Fuel Transportation	FIXED OPE-COS Manpower Co Maint. Ins. Overhead Sub-tot	DEPRECIATION & AMORTIZATION Depreciation Plant Bldg & Const'n Valieles	2 2 2 3	PRODUCTION COST (Total)	EC	COST OF COODS SOLD	SALES YOLUME WHIT COST OF COODS SOLD UNIT RAW MATERIAL COST (B UNIT YARIABLE OPE-COST (B UNIT FIEXED OPE-COST (B UNIT FIEXED OPE-COST (B
ပ) : α		> 1 1 1	15_96	· =		(3.		ပ္	<u> </u>

II. PROFIT LOSS STATEMENT - CASE 2

III. CASH FLOW STATMENT - CASE 2

2014	43, 205	8,075 -8,265 44,562		-1, 172 -6, 937	1, 703 1	60, 657 5, 459	-4, 754 -4, 764 -22, 706 12, 615 44, 552		70, 655 58, 041 12, 615 0
Bahts 2013	39, 573	60, 657 101, 777	. 00	661	1, 703	81.854 7.357		00	39, 240 28, 564 10, 676
2012	38, 524 1, 547	81, 854 0 0 0 21, 924	00	000	1, 703	91, 151 9, 104		.00	38, 102 28, 401 9, 701
Unit: 2011	36, 950 1, 547	0 0 101, 151 139, 648	00	000	1,730	12, 551 -0 13, 321 10, 199		00	36, 528 34, 919 1, 609 0
2010	34, 568 1, 547	0 13, 321 49, 435	. 00	000	1,703	12, 551 12, 481 11, 130 11, 131	200 200 435 435	00	34, 954 34, 954 0
5002	17, 647	0 0 123, 481 1 158, 829 1		000	1,703	12, 551 2, 259 30, 322 1 11, 729	0 265 0 0 0 158, 829 1	ි ල <i>ස</i>	33, 380 33, 380 0
2008	16,045 17,701	0 0 130, 322 1 164, 067 1	60	001	250	12, 551 3, 388 34, 198 12, 078	-23 177 067 1	00	31, 894 31, 894 0
2007	14, 449 18, 275	0 134, 199 1 0 156, 524 1		000	1, 703	12, 551 4, 518 135, 676 1 12, 211	265 0 265 0 0 166, 924 1	00	30, 756 30, 756 0
2008	12, 875 18, 275	0 0 135, 676 1 166, 826 1		00	ء ق	16, 450 5, 648 30, 973 11, 788	265 265 10 826 1	00	29, 182 29, 182 0
2005	16, 908 18, 275	0 30, 973 0 60, 156	္ကေတ	00	_ප දි;	16, 450 7, 128 23, 937 1 11, 154		00	27, 696 27, 696 0
2004	2, 389 26, 138	0 0 23, 937 1 52, 464 1	္	00	1, 703	16, 450 8, 609 15, 161 10, 364	0 177 177 52, 464 1	.00	24, 993 24, 993 0
. 2003	1, 322 26, 138	0 115, 161 1 0 0 142, 621 1	00	000		5450 94,788 94,788 131		00	23, 943 23, 943 0
2002	-54 26, 483	04, 788 1	00	000		16, 430 11, 570 92, 638 8, 343		00	22. 617 22. 617 0
2001	-1, 167	92, 698 .1 1, 559 119, 573	80	900	1, 703	3, 859 7, 050 7, 833	1, 580 4, 469 119, 573	00 ·	17, 468 17, 468 0
2000	-12, 186 26, 483	87, 037 6, 238 107, 571		000	1,703	54,771 5,829 5,829	258 514 195 0 571	00	-790 -790 0
1999	7, 254	56, 436 95, 721 64, 771 0 0 212, 485	137, 031 1, 624	1, 031		4, 831 4, 460	0 0 10 212, 485	00	150308 150308 56, 436
1998	11, 758	25, 123 29, 784 48, 891 0 99, 296	48, 371 5, 775	000		3, 887 3, 887 9, 950	99, 296 39, 296	20	59, 862 59, 852 25, 123 25, 123
1997	7, 254	0 33, 958 29, 417	00	00	671	1, 889 1, 158 19, 879 1, 789	0 0 21 0 0 29, 417	ဝုဝ	-5, 761 -59, 8 -5, 761 -59, 8 -0 -25, 1 -0 -25, 1
934 1895 1996 1997	0 -11, 698 -11, 869 -11, 787 -11, 0 7, 254 7	0 19, 879 94 15, 358		60	671	9, 50 9, 30 9, 383 9, 383		00	-6, 025 -6, 025 0
1995 1995	-11, 698 - 7, 254	9, 983 374 5, 913		60	671	3,509 0 0	35 873 825 0 0 5,913	60	-7,010 -7,010
1994 1994		15, 008 27, 807 0 0 40, 815	38, 820 480	1, 976	2, 338 0	-	0 0 0 0 0 43, 815	00	41, 417 41, 417 16, 008 16, 008
L PLANT 1993	96	13, 042 16, 008 11, 186 27, 807 0 0 24, 228 40, 815	18, 167	00	288 0	0000	0 0 0 0 24, 228	00	1x-23, 942 -41, 417 5x-23, 942 -41, 417 2x-13, 042 -16, 008 -13, 042 -16, 008
COMMERC 17	tion	ayable		 	netion	Loan Loan Loan	ceivable		-7.3.4 2.3.5 3.3.8.8.8.8.8.8.8.8.8.8.8.8.8.8.8.8.8.8
CASE 2 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OF 50, 000 T/Y Veat 1995 1995 1995	NCE FUNDS: Gross Profit on Sales Depreciation/Amortization	cquity Loan Short-lerm Loan Increase in Account Payable Total Source:	Sat Sast	Raw Material Inventory Others	Interest During Construction General Expense	Repayment on Long-Term Loan Interest for Long Term Loan Repayment on Short-Term Loan Interest for Short Term Loan	increase in Inventory Raw Material Products Froducts forcease in Acc. Receivable Income Tax Total Application:	CASH SURPLUS CURLLATIVE CASH SURPOLUS	Tax) Tax) Tax) Tax)
<u>101 PLJ</u>	DS: rofit c ation/#	Equity Long-term Loan Short-Term Loan Increase in Acco	LICATION OF FUND Plant Investment Preoperation Cost	ateria S	Interest During C General Expenese	4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	crease in Inventor Naw Material Products Increase in Acc. R Come Tax Total Application:	CASH	(ROT B, (ROI A, (ROE B,
ASE 2 (PI	SOURCE FUNDS: Gross Prod Depreciati	Equity Long-te Short-1 Increas	APPLICATION OF FUND Plant Investment Preoperation Cos	Raw Mat	Interes General	Repayme Interes Repayme Interes	Increase in Raw Mater Products Increase Income Tax Total App	CASH SURPLUS	Cash Flow (ROI B/Tax) Cash Flow (ROI A/Tax) Cash Flow (ROE B/Tax) Cash Flow (ROE A/Tax)
ঠা	S		\$2					39	ខិត្តកិត្ត

PROJECTED BALANCE SHEET - CASE 2 IV.

						<u>.</u>	ž -		÷		
2014	000	1.043	1,043 8,075	.	110, 510 -117642 -7, 033	1,043	2014	666	0000	0	0
2013	1, 136 34, 735 35, 872	2 390	38, 462 50, 557 8, 265	0	110, 610 1 -141070 -30, 460	38, 452	2013	1, 136 5, 801 1, 172	293 4, 754 22, 706 35, 872	8, 265	27, 607
2012	1, 136 34, 560 35, 696	4, 136	39, 832 81, 854 8, 265	P	110, 610 -160896 - -50, 287 -	39, 832	2012	1, 136 5, 801 1, 172	293 4, 764 22, 530 35, 696	8, 265	27, 431
2011	1, 136 34, 294 35, 430	5, 683	41, 113 101, 151 8, 265	9	110, 610 1 -178912 -68, 303 -	41, 113	2011	1, 136 5, 801 1, 172	293 4, 764 22, 264 35, 430	8, 265	27, 166
2010	1, 136 34, 029 35, 165	7, 230	42, 395 113, 321 8, 265	12,551	110, 510 1 -202351 -91, 741	42, 395	2010	1, 136 5, 801 1, 172	293 4, 764 21, 999 35, 165	8, 265	26, 901
2003	1, 138 34, 572 35, 708	8,776	44, 484 123, 481 8, 265	25, 101	10, 610 222372 112363	44, 484	2003	1, 136 5, 801 1, 172	293 5, 571 21, 734 35, 708	8, 265	27, 443
2008	1, 136 34, 307 35, 443	26, 477	61, 920 130, 322 1 8, 265	37,652	110, 610, 110, 610 -224928 -222972 -114319 -112363	61, 920	2008	1, 136 5, 801 1, 172	293 5, 571 21, 469 35, 443	8, 265	27, 178
2007	1, 136 34, 159 35, 295	44, 178	79, 473 134, 199 8, 265	50, 202	110, 610 1 -223803 -113194	79, 473	2007	1, 136 5, 801 1, 172	293 5, 600 21, 293 35, 295	8, 265	27, 030
2006	1, 136 33, 894 35, 030	62, 453	97, 483 135, 676 8, 265	62, 753	110, 610 -219820 -109211	97, 483	2008	1, 136 5, 801 1, 172	293 5, 600 21, 028 35, 030	8, 265	25, 765
2005	1, 136 33, 629 34, 765	80, 728	115, 493 130, 973 8, 265	79, 203	110, 610 -213557 -102947	115, 493	2005	1, 136 5, 801 1, 172	293 5, 600 20, 762 34, 765	8, 265	26, 500
2004	1, 136 33, 845 34, 981	98, 003	133, 985 123, 937 8, 265	95, 653	110, 610 -204479 -93, 869	133, 985	2004	1, 136 5, 801 1, 172	293 5, 993 20, 586 34, 981	8, 265	26, 717
2003	1, 136 33, 669 34, 805	125, 141	159, 946 115, 161 8, 265	112, 102	110, 610 -185192 -75, 582	159, 946	2003	1, 136 5, 801 1, 172	293 20, 409 34, 805	8, 265	26, 540
2002	1, 136 33, 509 34, 645	151, 279	185, 924 104, 788 8, 265	128, 552	110, 510 -156291 -55, 681	185, 924	2002	1, 135 5, 801 1, 172	293 6, 011 20, 232 34, 645	8, 265	26, 380
2001	1, 136 33, 056 34, 192	177, 762	211, 954 92, 698 8, 265	145, 002	110, 610 -144621 -34, 011	211, 954 185, 924	2001	1, 136 5, 801 1, 172	293 6,011 19,779 34,192	8, 265	25, 927
2000	1, 136 27, 006 28, 142	204, 244	232, 387 87, 037 6, 705	148, 901	110, 610 -120867 -10, 257	232, 387	2000	1, 136 5, 801 1, 172	293 4, 430 15, 310 28, 142	6, 705	21, 437
1998	1, 136 9, 040 10, 176	230, 727	10, 903 34, 771 468	301	110, 610 -87, 747 22, 863	10, 903	1999	1, 136 5, 801 1, 172	35 916 1, 115 10, 176	468	9, 708
1998	447 3,726 4,173	91,816	95, 989_2, 48, 891 468	50, 979 152,	5 -50, 230 -58, 521 -50, 230 -68, 521 -51, 181 -14, 348	95, 989	1998	447 1, 529 141	35 916 1, 105 4, 173	468	3, 705
1997	447 3,721 4,158	44 162	48, 331 33, 950 468	35, 094	29, 050 50, 230 -21, 181	48, 331	1987	447 1, 529 141	35 916 1, 100 4, 168	468	3, 701
00 50,00 1996	3,701 4,148	51, 417	55, 554 19, 879 468	38, 993	29, 050 32, 825 -3, 775	55, 564	1996	447 1, 529 141	35 1,079 4,148	458	3,476 3,580
CAPACITY 0D 1995	3, 447 3, 463 3, 850	58, 671	62, 522. 9, 983	38, 993	29, 050 29, 050 29, 050 0 0 -15, 878 -32, 825 29, 050 13, 172 -3, 775	62, 522	1594 1995 1996 1997 1998	1, 529	3, 850 3, 850	374	
WITH A (447 1, 670 2, 117	65, 926	:	38, 993	29, 050 0 29, 050	68, 043	1994	447 1, 529 141	0 0 2, 117	0	2, 117
CIAL PLANT WITH A 1993 1994	606	24, 228	24, 228 EQUITY	11, 186	13, 042 0 13, 042	24, 228 68, 043 62, 522 55, 564 48, 331 95, 989 2.		000	0000		0
OMMERCI)	·		OULDERS								
NT and (. Depr.)	O SHARE	*, *) ITY		1 Table	Capital	capitai nventory ory able	EE .	PITAL
1LOT PLA	ASSETS RRENT ASSETS Cash Working Capital Total	ETS (Less	ETS TTIES AN M LOAN AYABLE	LOAN	AREHOLDER'S EQUIVERISE SEQUIVER RELATING TOTAL	BILITIES	(Working Capital Table))	UNDEKT ASSETS Initial Working Capital Cash Spare Parts Raw Material Inventory	Minning Morking Capital Raw Material Inventory Product Inventory Account Receivable Total	RRENT LIABILITI Account Payable	TKING CA
CASE 2 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OD 50,000 T/Y) Vear	ASSETS CURRENT ASSETS Cash Working Capi Total	FIXED ASSETS(Less Depr.)	TOTAL ASSETS LIABILITIES AND SHAREHOULDERS EQUITY SHORT-TERM LOAN ACCOUNT PAYABLE 0 0	LONG-TERM LOAN	SUAREIDLDER'S EQUITY Capital Retained Earning Total Equity	TOTAL LIABILITIES	(Workin	CURRENT ASSETS Initial Worki Cash Spare Parts Raw Material	Raw Mat Product Account Total	CURRENT LIABILITIES Account Payable	TOTAL WORKING CAPITAL
.	. —	-		_	5-26	- 1					

I. COST OF GOODS SOLD - CASE 2-1

	2013 2014 2013 2014 289 1, 289 773 45, 483	123 29, 123 150 6, 150 500 11, 500 773 46, 773	337 7, 337 0 0 165 6, 165 225 9, 225 727 22, 727	131 4, 131 930 5, 933 098 3,098 162 13,162	0 0 647 1, 547 0	0 0 0 0 547 1,547	208 84, 208	210 4,210 210 0	208 88, 418	00 52,500 .7 1,7 .9 0.9 .5 0.4
	8	82 m = 1 m	7, 29,65,	<u> ಸ್ಪಣ್ಣಪ್ಪ</u>	0 47 1, 5, 0		84,	حيّ حيّ	84	50 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	201 201 1. 28 46, 77 1. 28	29, 123 6, 150 111, 500 46, 773	6, 165 9, 225 122, 727	4, 131 5, 933 3, 698 13, 162	بة. بيا	0 0 7 1.547	3 84, 208	3 4,210	3 84, 208	88 80 90 90 90 90 90 90 90 90 90 90 90 90 90
	201 1, 28 46, 77 1, 28	29, 123 6, 150 11, 500 46, 773	7, 337 0, 165 9, 225 22, 727	4, 131 3, 933 13, 162	1,547 0	0 0 1, 547	84, 208	4, 210	84, 208	50,000 1.7 0.0 5.0 0.0
	2010 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 0 6, 165 9, 225 22, 727	4, 131 5, 933 3, 098 13, 162	1, 547 0	1. 547	84, 208	4, 998	84, 986	50, 000 1.7 0.9 0.3
	2008 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 0 8, 165 9, 225 22, 727	4, 131 5, 933 3, 098 13, 162	15, 761 1, 940 0	0 0 17. 701	100, 362	4, 938	100, 362	50,000 0.20 0.90 2.00 2.00 2.00
	2008 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 0 6, 165 9, 225 22, 727	4, 131 5, 933 3, 098 13, 152	15,761 1,940	0 0 17, 701	100, 362	5,027 4,998	100, 391	50, 000 2, 0 0, 9 0, 3 0, 3
	2007 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 0 6, 165 9, 225 22, 727	4, 131 3, 933 13, 162	15, 761 1, 940 575	. 0 0 18, 275	100, 937	5,027 5,027	100, 937	50, 000 2, 0 0, 9 0, 3 0, 3
	2006 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 0 6, 165 9, 225 22, 727	4, 131 5, 933 3, 098 13, 152	15, 761 1, 940 575	0 6 18, 275	100, 937	5, 027	100, 937	00 20 20 20 20 20 20 20 20 20 20 20 20 2
	2005 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 0 6, 165 9, 225 22, 727	4, 131 5, 933 3, 098 13, 162	15, 761 1, 940 575	0 0 18, 275	100, 937	5, 184 5, 027	101, 093	50,000 2,0 0,9 0,5 0,5 4
	2004 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 6, 165 9, 225 22, 727	4, 131 5, 933 3, 098 13, 162	20,489 1,940 575	1, 480 1, 654 26, 138	108, 739	5, 184 5, 184	108, 799	50.00 2.2 0.9 0.9 5.0 5.0 5.0
	2003 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 6, 165 9, 225 22, 727	4, 131 5, 933 3, 098 13, 162	20, 489 1, 940 575	1, 480 1, 654 26, 138	108, 799	5, 184 5, 184	108, 799	50.00 2.20 0.00 0.00 0.00 0.00 0.00
	2002 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 6, 165 9, 225 22, 727	4, 131 5, 933 3, 098 13, 162	20, 489 1, 940 919	1, 480 1, 654 26, 483	109, 144	5, 184 5, 184	109, 144	50, 000 2, 2, 2 0, 9 0, 5 0, 5
	2001 1, 289 46, 773 1, 289	29, 123 6, 150 11, 500 46, 773	7, 337 6, 165 9, 225 22, 727	4, 131 5, 933 3, 098 13, 162	20, 489 1, 940 919	1, 480 1, 654 26, 483	109, 144	3, 604 5, 184	107, 564	49, 500 2, 2 0, 3 0, 3 0, 3
	2000 1,031 37,676 1,289	23, 298 4, 920 9, 200 37, 418	6, 180 0 4, 932 7, 380 18, 492	4, 131 5, 933 3, 098 13, 162	20, 489 1, 940 919	1, 480 1, 654 26, 483	95, 555	3, 504	91, 952	38, 000 2, 4 1, 0 0, 3 0, 3
	1999 176 3, 661 1, 031	1, 747 369 690 2, 806	1, 373 0 370 1, 743	2, 682 1, 824 2, 012 6, 517	4, 728 393 345	1, 251 537 7, 254	18, 321	916	19, 237	3,000 6.4 0.9 2,2 2,2
	1998 176 2, 806 176	1, 747 369 690 2, 806	1, 373 0 370 0 1, 743	2, 682 1, 824 2, 012 6, 517	4, 728 393 345	1,251 537 7,254	18, 321	916	18, 321	3,000 6,11 2,22 7,12 8,11 1,12 1,13 1,13 1,13 1,13 1,13 1,13 1
н	2.806 176 176 2.806	1, 747 369 680 2, 806	1, 373 370 1, 743	2,682 1,824 2,012 6,517	4, 728 393 345	1,251 537 7,254	18, 321	916	18, 321	3,000 6,1 0,9 2,2 4,2
-2 -2	0F 50, 1936 176 2, 806 176	1, 747 368 690 2, 806	1, 373 370 1, 743	2, 582 1, 824 2, 012 6, 517	4, 728 393 345	1, 251 537 7, 254	18, 321	873 916	18, 279	2, 970 6, 2 0, 3 2, 2 4, 4
CASE	2, 280 176	1, 398 295 2, 245	1, 157 0 296 0 1, 453	2, 682 1, 824 2, 012 6, 517	4, 728 393 345	1, 251 537 7, 254	17,470	873	16, 596	2,280 7.3 1.0 0.6 2.9
١	NT WITH									
SOLD	GIAL PLA Beg. End		•							
goods	d COMMEN ntory at ntory at	1. 14.			NOI	e.		at Beg. at End		(ton/Year) D (Bht/kg) I (Bht/kg) I (Bht/kg) I (Bht/kg)
0 F G	PLANT and Tall Three CHASED		سو سو	Tax	MORTIZAI stn	Cost	(Total)	Product Product	61	05 SOLD L COST (E-COST (E-OCST (
COST	E 2-1 (PILOT PLANT and COMMERCIAL) Year (4) Raw material Inventory at Beg MATERIAL PURCHASED (-) Raw Material Inventory at End	Mataila Lignite Rice straw Slacked Lime Sub-total	IABLE OPE-COST Electricity Water Fuel Transportation Sub-total	ED OPE-COST Mannower Cost Maint, Ins. & Overhead Sub-total	RECIATION & AMORT Depreciation Plant Bldg & Const'n Vehicles	Preopetion Cost 1DC Sub-total	JN COST	(+) Finished Product at (-) Finished Product at	COODS SO	S YOLUME COST OF GOODS SOLD RAW MATERIAL COST I VARIABLE OPE-COST I FLEXED OPE-OCST OFP. & AMORT. COST
Ū Į	CASE 2-1 (PILOT PLANT and COMMERCIAL PLANT WITH Year (*) Raw material Inventory at Beg. RAW MATERIAL PURCHASED (-) Raw Material Inventory at End (-) Raw Material Inventory at End	iow waltwink cos Lignite Rice straw Slacked Lime Sub-total	VARIABLE OPE-COST Electricity Mater Fuel Transportation Sub-total	FIXED OPE-COST Manpower Cc Maint. Ins. Overhead Sub-tota	DEPRECIATION & AMORTIZATION Depreciation Plant Bldg & Const'n Vehicles	E E E	PRODUCTION COST (Total)	EC	COST OF COODS SOLD	SALES VOLUME (INIT COST OF GOODS SOLD UNIT RAW MATERIAL COST UNIT VARIABLE OPE-COST UNIT FIEKED OPE-COST UNIT PEP. & AMORT. COST
	· [15-		=				;	· · · · · · · · · · · · · · · · · · ·

II. PROFIT LOSS STATEMENT - CASE 2-1

CASE 2-1 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OF 50,000 1/Y) Year	TH A CAPACIT 1995	у оғ 50. 1996	000 1/Y) 1997	ኅ) 1998	1939	2000	2001	2002	2003	2004	2005	2006	2007	2008	2003	2010	Unit: 2011	1,000 Bal 2012	Bahts 2013	2014
SALES Sales Revenue Sales Tax Not. Sales Revenue	4, 948 4, 898 4, 898	4, 948 5, 475 5, 600 49 65 65 4, 898 6, 410 6, 534	5, 600 68 6, 534	6, 530 6, 554	. 690 67 623				115, 500 116, 1, 155 1. 114, 345 115,	6, 500 117, 1, 165 1, 5, 335 116,	500 325 325		120, 500 121, 1, 205 119, 295 120,	500 215 285						136, 500 1, 365 135, 135
COST OF GOODS SOLD	16, 596	18, 279	16, 596 18, 279 18, 321 18, 321		19, 237	91, 952 10	107, 564 10	109, 144 10	108, 799 108,	8, 799, 101,	093	100, 937 10	100, 937 100,	381	100, 352 8	84, 995	84, 208	84, 208 8	84, 208	88, 418
GROSS PROFIT ON SALES	-11, 698 -11, 869 -11, 787 -11, 7	11, 869 -	-11, 787 -	52	-12, 614 -	-7, 681	3, 188	4, 211	5, 546	6, 536	15, 232 1	15, 873	18, 358 1	19,894 2	21. 408 3	38, 259	10, 532	42,017 4	43, 807	46,717
n EXPENSES General Expenses	671	671	671	671	671	1, 033	1. 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033
5 Non-operating Expense Interest for Long Term Loan Interest for Short Term Loan Sub-total	3, 509 0 4, 180	3, 509 898 5, 078	3, 158 1, 789 5, 618	2, 807 3, 056 5, 534	2, 457 1 4, 400 7, 527 2	13, 401 1 5, 577 20, 011 2	13, 050 1 7, 101 21, 184 1	11, 570 1 7, 091 19, 693 1	10, 089 7, 621 18, 743	8, 609 7, 952 17, 593	7, 128 8, 090 16, 251	5, 648 8, 018 14, 699	4, 518 7, 681 13, 232	3, 389 6, 727 11, 148	2, 259 5, 488 8, 780	1, 130 3, 911 6, 073	2, 590 3, 622	-0 1, 443 2, 476	1, 033	0 0 1, 033
INCOME BEFORE INCOME TAX	-15,878 -16,947 -17,405 -18,291	16, 947	-17,405 -		-20, 141 -2	-27. 694 -17.	966	-15, 482 -1	-13, 197 -11,	057	-1,019	2, 175	5, 127	8,746	12, 628	32, 186	35, 910	39 541 4	1,974	45, 684
I NOOME TAX	0 0	0	0	0	0	0	0	0	0	0	6	6	0	0	0	7,038	12, 918	13, 839 1	14, 691	15, 989
INCOME AFTER INCOME TAX	-15,878 -16,947 -17,405 -18,2	16, 947	-17, 405 -	55	-20, 141 -2	-27, 694 -1	-17, 996 -1	-15, 482 -1	-13, 197 -1	-11,057	-1,019	2, 175	5, 127	8, 745	12, 628	25, 148	23, 391	25, 702 2	27, 283	29, 695
CUMUL. INCOME AFTER INCOME TAX -15,878 -32,825 -50,230 -68,5	-15,878 -	32, 825	-50, 230	68, 521 -88,	663	-116357 -1	34353 -1	-149835 -1	63032	-174090 -1	-175109 -1	-172934 -1	67808	-159061 -1	46434 -	-121286	-97295	-71593	-44310	-14615
UNIT COST OF GODOS SOLD (BNL/Ag) UNIT GENERAL EXPENSES (BNL/Ag) UNIT INTEREST FOR LONG TERM LOANS (BNL/Ag) UNIT INTEREST FOR SHORT TERM LOANS (BNL/Ag) UNIT COSTS & EXPENSES (BNL/Ag)	7,000,7,	6.000.00 6.000.00	000000 000000	00000 00000	00000 40000 00000	2.4 0.0 0.1 2.7	2,2 0,0 2,1 4	20002 20114	2.2 0.0 2.1 4.1 1.4	20002	0.00	20000	200002	20000	20002	10001	100001	000- 	1.0001 7.0001	1.00007

III. CASH FLOW STATMENT - CASE 2-1

IV. PROJECTED BALANCE SHEET - CASE 2-1

Year 1985 1985 1987 1984 1985 1985 1987	ASSETS CURRENT ASSETS 0 447 447 Working Capital 0 1,670 3,403 Total 0 2,117 3,850	FIXED ASSETS(Less Depr.) 24,228 65,926 58,671	007AL ASSETS 24 228 68,043 62,522 LIABILITIES AND SIMPEROULDERS EQUITY 68,043 62,523 SHORT-TERM LOAN 0 9,993 ACCOUNT PAYABLE 0 374	LONG-TERM LOAN 11, 186 38, 993 38, 993	SUMMEROLDER'S EQUITY 13,042 29,050 29,050 Capital Retained Earning 0 0 -15,878 Total Equity 13,042 29,050 13,172	TOTAL LIABILITIES 24, 228 68, 043 62, 522 55, 554 48, 331.	((Working Capital Table)) 1893 1994 1995 1996 1997	CURRENT ASSETS Initial Working Capital 0 447 447 Cash 0 1,529 1,529 Spare Parts 0 1,529 1,529 Raw Material Inventory 0 141 141	Munital Working, Japital An Alderial Inventory	CURRENT LIABILITIES Account Payable 0 0 374	TOTAL WORKING CAPITAL 0 2, 117 3, 478
5 11 or 30, 00 5 1985	447 3, 701 4, 148	51, 417	55, 564 19, 879 468	38, 993	29, 050	2 55,554 48	5 1996	7 447 9 1,529 1 1 141	5 35 35 1, 079 1 4, 148 4	4 458	3,680
1907 199	447 44 3,721 3,72 4,168 4,1	44, 162 91, 83	\$. 8	35, 094 60, 91	58. 14.	Ę,	1997	447 4 529 1.5	35 915 100 1.10 1.68 4, 1	458 4	3, 701 - 3, 7
1999	447 689 726 5, 303 173 5, 992	816 230, 727	989 236,719 891 61,972 468 0	979 152, 801	173 110, 510 521 -88, 653 348 21, 947	989 236, 719	1999	447 689 529 4, 272 141 1, 031	35 0 816 0 105 0 173 5,992	468 0	708 5 992
2000	889 23, 354 24, 043	204, 244	228, 288 78, 896 6, 238	148, 901	110, 610 -115357 -5, 747	228, 288	2000	689 4, 272 1, 031	258 3,504 14,190 24,043	6, 238	17. ROS
2001	589 29, 394 30, 083	177, 762 1	207, 844 1 78, 789 7, 797	145, 002 1	110, 610 1 -134353 - -23, 743 -	207, 844 181, 800	2001	689 4, 272 1, 031	258 5, 184 18, 649 30, 083	7, 797	22 226
2002	689 29, 832 30, 521	151, 279 12	181, 800 1 84, 577 7, 797	128, 552 11	110, 610 1; -149835 -39, 226	81,800 1	2002	689 4, 272 1, 031	258 5, 184 19, 087 30, 521	7, 797	22 724
2003	683 29, 999 30, 688	125, 141 91	155, 829, 129, 88, 352, 89, 7, 797, 7,	112, 102 9	110, 610 111 -153032 -1 -52, 423 -6	155, 829, 12	2003	689 4, 272 1, 031	258 5.184 19,254 30,688	7, 797	22 801 -2
2004	689 30, 166 30, 30, 855 30,	99, 003 80,	29, 858 111, 89, 868 89, 7, 797 7,	95, 653 79,	110, 610 110 -174090 -17 -63, 4805	129, 858, 111	2004	689 4, 272 1, 031	258 5, 184 5, 19, 421 19, 30, 855 30,	7, 787 7	22 059 22
2005	689 176 30, 865 31,	, 728 62,	. 593 93, . 092 85, . 797 7,	, 203 62,	110, 610 110, -175109 -17, -54499 -5	111, 593 93,	2002	689 272 031 1	258 . 027 5. . 587 19. . 865 31.	7, 797 7.	050 93
2006 2	689 426 30, 115 31,	453 44,	567 75, 342 74, 797 7,	753 50,	110, 610 110, -172934 -1673 -62325 -57	567 75,	2006 2	689 272 031 1,	258 .027 .837 20, .115 31.	197	210 92
02 20	689 675 30, 8 365 31, 54	178 25,4	542 57,980 741 60,983 797 7.797	202 37,6	610 110, 610 1808 -159061 198 -48452	542 57, 980	200	683 5 272 4.2 031 1.0	258 2 027 4.9 067 20.2 365 31.5	7,797 7,797	668 22 7
200	689 689 814 31.064 503 31,753	477 8.776	980 40,528 983 43,455 797 7,797	652 25, 101	10 110, 610 51 -146434 52 -35824	30 40, 529	78 200	589 639 272 4, 272 031 1, 031	258 258 998 4, 998 254 20, 504 503 31, 753	7, 797	200 74 056
20102	9 689 4 30,525 3 31,215	6 7,230	9 38,444 5 28,773 7 7,797	1 12, 551	0 110,610 4 -121286 4 -10,876	9 38, 141	9 2910	9 689 2 4, 272 1 1, 031	48.5	7 7,797	017 60
2011	689 30, 776 31, 465	5, 683	37, 148 16, 036 7, 797	P	110, 610 -97295 13, 315	37, 148	2011	4, 272 1, 031	4, 210 21, 004 31, 485	7,797	99 550
2012	11, 651 31, 026 42, 677	4, 135	45,814 7,797	Ģ	110, 610 -71593 39, 017	45, 814	2012	689 4, 272 1, 031	258 4,210 21,254 31,715	7, 797	0+0
2013	40.315 31.192 71.507	2, 590	74,097	0	110, 610, 110, 610 -44310 -14615 66, 300 95, 994	74, 097	2013	689 4, 272 1, 031	258 4, 210 21, 421 31, 881	7, 797	100

I. COST OF GOODS SOLD - CASE 3

I inventory at	AN MATERIAL COST LISHIA LISHIA Rice straw Slacked Lime Sub-total	WARIABLE OPE-COST Electricity Water Fuel Transportation Sub-total	FIXED OPE-COST Manpower Cost Maint. Ins. & Tax Overhead Sub-total	DEPRECIATION & AMORTIZATION Depreciation Plant 91dg & Const'n Vehicles	Amortization Preopetion Cost NC Sub-total	PRODUCTION COST (Total)	(+) Finished Product at Beg. (-) Finished Product at End	COST OF GOODS SOLD	\$ALES YOLUME (ton/kear) UNIT COST OF GOODS SOLD (8ht/kg) UNIT WARIABLE OPE-COST (8ht/kg) UNIT YARIABLE OPE-COST (8ht/kg) UNIT FIEXED OPE-COST (8ht/kg) UNIT DEP. & AMORT, COST (8ht/kg)
1995 0 0	, 6666	- ଇପ୍ଲପର	0000	. 600	000	0	00	0	888888
1996 0 0		50606	5000	500	000	©		0	000000
1 0 0 0	5 <i>6</i> 600	00000	0000	500	000	0	00	O	000000
998 0 0	5 5550	00000	6000	800	000	0	00	0	00000
999 2 0 1. 0 37.	- 22 4.0.E		0000 4466	0 15. 0 15.	0 0 117 0 117	0 90,	0 O .	0 86,	000000
2000 2 031 1. 576 46.	. %. ==	* -	131 4, 956 5, 098 3, 195 13,	761 15, 547 1, 575	480 1, 669 1, 031 21,	137 103.	0.3, 605.5,	531 102,	000 2.3 1.0 0.5 0.3
289 L 773 46	289 1. 123 29 1. 150 6. 773 46.	7 9 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	131 4, 966 5, 098 3, 195 13,	761 15. 547 1. 575	480 1. 669 1. 031 21.	726 103,	605 5, 186 5,	145 103,	500 50, 2, 1 0, 9 0, 3
2002 2 289 1. 773 46,	- 88.0 H &		131 4, 986 5, 195 3,	761 15, 547 1, 575	480 1. 569 1. 631 21.	726_103,	186 5, 186 5,	725 103,	000 50. 0.3 0.3 0.3
2003 2 . 289 1. . 773 46.	- 20 H	7. 8.	131 986 55 198 3,	761 15, 547 1.	480 1. 589 1. 031 21.	726 103,	186 5, 186 5,	725 103,	200 2.1 0.9 0.3 4
2004 2 289 1, 773 46,	23 T	7.	131 4, 966 5, 195 13,	761 15. 547 1. 575	480 669 031 17.	726 100,	186 5, 186 5,	726 100,	000 2.2.2.0 0.3.5.9 0.3.5.9
2005 20 289 1, 2 773 46, 7	28 7 7 6	7. 9.9.	131 4, 1 966 5, 6 098 3, 0	761 15.7 547 1.5 575	0 0 882 17, 8	576 100, 5	185 S, 0 029 S, 0	734 100	22.0 22.0 20.9 0.9 0.3 0.3
006 20 289 1, 2 773 46, 7	22 14	, 7, 5, 9, 5,	131 4, 1 966 5, 9 098 3, 0 195 13, 1	761 15,7 547 1,5 575	0 0 882 17,8	576 100, 5	029 5, 0 029 5, 0	576 100, 5	2,000 2,000 0,900 4,000 0,34
2007 20 289 1.2 3,773 46,7	. 23 	, ng 22	131 4, 1 966 5, 6 098 1, 0	761 15.7 547 1.8 575	0 0 882 17. :	576 100, 0	029 5, [029 5, [576 100,0	22.0 20.0 6.3 6.3 6.3
289 1, 2 773 46, 7	23 11 65 451	7. 99.22	131 4,1 966 5,9 098 3,0 195 13,1	761 15.7 547 1.5	0 0 307 17,3	902 100, D	028 5,0 000 5,0	031 100,0	200 50.0 0.0 50.0 0.0 50.0 0.0 50.0
2009 20 289 1, 2, 773 46, 7	2, 62, 14	7.	131 966 5,9 038 3,0 195 13,1	761 547 1,5 0	0 0 307 1.5	002 84.2	000 5, 0 000 4, 2	002 85,0	0.000 0.00 0.00 0.00 0.00 0.00 0.00 0.
2010 20 , 289 1, 20 , 773 45, 7	- 88.23	7.	131 4.1 966 5.9 098 3.0 195 13.1	547 1.5	0 0 547 1, 5	241 84, 2	000 4.2 212 4.2	029 84, 2	000 - 000 -
2011 20 . 289 1. 2 . 773 46, 7	46.11.63	7. 5.22.52	131 4, 1 965 5, 9 038 3, 0 195 13, 1	.0 .0 .0	0 0 547 1.5	241 84, 2	212 4, 2 212 4, 2	241 84,2	000 50.9 1.7 1.0 1.9 0 0.3 0 0.3 0
012 2013 289 1. 289 773 46, 773	- 53 5	r. a.a.5	131 4, 1: 955 5, 90 098 3, 00 185 13, 11	55.7 1.55	0 0 547 1, 54	241 84, 24	212 4,2 212 4,2	241 84 24	00 - 10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
13 2014 39 1, 289 73 45, 483	22 -11 -62		131 4, 131 966 5, 966 098 3, 098 195 13, 195	0 547 1.547 0 0	0 0 0 547 1.547	241 84, 241	212 4.212 212 0	241 88, 453	000 52, 500 1.7 1.7 0.9 0.9 0.5 0.4 0.3 0.4 0.0 0.0

II. PROFIT LOSS STATEMENT - CASE 3

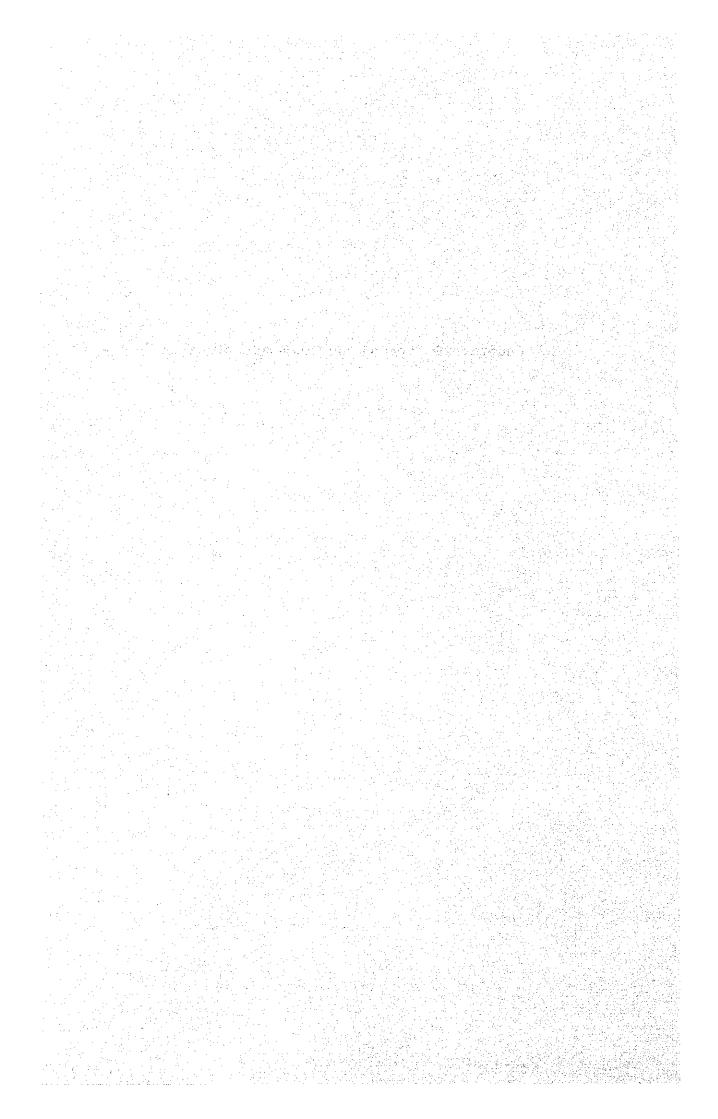
CASE 3 (COMMERCIAL PLANT WITH A CAPACITY OF SO, 000T 1/Y) Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2000	2007	2008	2003	2010	Unit: 1,000 2011 2	000 Baints 2012	2013	2014
SALES Sales Revenue Sales Tax (1%) Net Sales Revenue	000	000	900	000	0 85.	120 851 263	111, 870 1 1, 119 110, 751 1	114, 500 11 1, 145 112, 355 11	115, 500 1 1, 155 114, 345 1	116, 500 1 1, 165 115, 335 1	117, 500 1 1, 175 116, 325 1	119,000 1 1,190 117,810 1	120, 500 1 1, 205 119, 295 1	121, 500 1, 215 120, 285	123, 000 1, 230 121, 770	124, 500 1, 245 123, 255	126, 080 1, 260 124, 740	127, 500 1, 275 126, 225	128, 500 1, 285 127, 215	136, 500 1, 365 135, 135
COST OF GOODS SOLD	D	0	ຍ	٥	0 85.	231	102, 145 10	103, 726 10	103, 726 10	103, 726 1	100, 734 1	100, 576 1	100, 576 1	100,031	100,002	85, 029	84, 241	84, 241	84, 241	88, 453
GROSS PROFIT ON SALES	0	0	0	0	0 -2,	2, 263	8, 607	9, 629	10, 519	11, 609	15, 591	17, 234	18, 719	20, 254	21, 768	38, 226	40, 499	41, 984	12, 974	46, 582
EXPENSES General Expenses	0	٥	0	C	0	1, 033	1, 033	1, 033	1, 033	1,033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1, 033	1. 033
Non-operating Expense Interest for Long Term Loan Interest for Short Term Loan Sub-total	000		000	000	0 11, 0 12,	359 0 391	11, 359 489 12, 881	10, 223 0 11, 255	9, 087 0 10, 120	7, 951 0 8, 984	6, 815 0 7, 848	5, 679 0 6, 712	4, 543	3,408	2, 272	1, 136 2, 169	1, 633	1, 033	0 0 1. 033	1.033
INCOME BEFORE INCOME TAX	0	0	o	0	0 -14,	654	-4, 274	-1, 526	200	2, 625	7,743	10, 522	13, 142	15, 814	18, 464	36, 057	39, 466	40, 951	41.9:11	45, 648
INCOME TAX	0	0	0	O	O	Ø	O	6	0	Ø	. ⇔	0	0	5, 535	6, 452	12, 620	13, 813	14, 333	14, 679	15, 977
INCOME AFTER INCOME TAX	0	0	0	0	0 -14.	654	-4.274	-1, 525	200	2, 526	7,743	10, 522	13, 142	10, 279	12,001	23, 437	25, 653	25, 618	27, 262	29, 572
CUMUL. INCOME AFTER INCOME TAX	0	0	0	0	0 -14	2	-18, 928	-20, 554 -	-20,054 -	-17, 428	-9, 685	837	13, 979	24, 258	36, 259	59, 697	85, 349	111.967	139, 229	168, 901
UNIT COST OF GOODS SOLD (Bht/Ag) UNIT GENERAL EXPENSES (Bht/Ag) UNIT INTEREST FOR LONG TERM LOANS (Bht/Ag) UNIT INTEREST FOR SHORT TERM LOANS (Bht/Ag)	0000	0000	0000 0000	0000	0000 0000	2000	4000 4000	4000 4000	4000 4000	00.00	0000 0000	0000 0000	2006 2006	2000	7000	1.7 0.0 0.0	1000	0.00 0.00	1.7 0.0 0.0	1000 000 000
UNIT COSTS & EXPENSES (Bht/kg)	0.0	0.0	0.0	0	0	5.6	23		2,3			- 2		7.7	- 7	-		1.7		

CASE 3 (CONNERCIAL PLANT WITH A CAPACITY OF 50,0007	Year	SOUNCE FUNDS: Gross Profit on Sales	Depre. & Amoti, for L. L. Amorti, for Short Term L	Equity Long-term Loan	Increase in Account Payable Total Source:	APPLICATION OF FUND Plant Investment Preoperation Cost	intilal Morking Lapital Raw Material Inventory Others Interest During Construction	General Expenses Repayment on Long-Term Lo Interest for Long-Term Lo Repayment on Short-Term Lo Interest for Short Term Lo	دی سے	Total Application: CASH SURPLUS CUMULATIVE CASH SURPOLUS	Cash Flow (ROI B/Tax) Cash Flow (ROI A/Tax) Cash Flow (ROE B/Tax) Cash Flow (ROE A/Tax)	1863	(ROI B/Tax) (ROE B/Tax) (ROE A/Tax)	Discounted Cash Flow 12% Cash Flow (RO) B/Tax)
I A CAPACITY	1993	0	Loan 0					Loan Loan Loan Loan	Je 00	6 66	11. 63 10. 03 14. 33 17. 0			
OF 50, Of	1994		00		200	50			8008	0 00	0000			
00T T/Y)	1995	်ပ			000	. 00	000	ಬರಿಧರ್	8055	00	0000			
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IV. PROJECTED BALANCE SHEET - CASE 3

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그는 그 전에 눈으로 돌아가 하고 바라는 그 가는 그 때문에 되는
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Chapter 16 Social and Page
Chapter 16 Social and Economic Analysis
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Chapter 16 Social and Economic Analysis

This chapter evaluates the pilot plant project from the viewpoints of social and economic benefits and costs. As is the case with the financial analysis, the pilot plant project can only be properly evaluated together with the effects by the commercial stage, because of the very nature of the pilot plant being a precursor to commercialization.

Quantitative and qualitative analyses were done; the former develops economic cash flows and the economic internal rates of return, or EIRR's; the latter discusses and evaluates the effects of the project in terms of its impacts upon society and economy, on conservation of environment including the forest protection in particular. The quantitative analysis is done both of the pilot plant and a 50,000 ton-per-year commercial plant. The qualitative analysis was done of lignite briquette production on a rather large commercial scale only, because the pilot plant project, or even one or two commercial plants, would be too small to be studied in terms of the socio-economic effect.

16-1 Quantitative Analysis

16-1-1 Method

(1) General

There are two methods of quantitative economic analysis extensively accepted to calculate EIRR's; these are:

Little & Mirrlees Method, and UNIDO Method

This study basically follows the UNIDO theory in the development of EIRR.

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In the process of calculating EIRR's, the financial prices used to estimate the costs and revenues for the financial analysis are converted into economic prices. The economic prices are estimated first by ex-

cluding from the financial cost items all transfer elements such as taxes, customs duties, and interest payments, and second by calculating labor costs in terms of their opportunity costs, and thirdly by adjusting the foreign currency portion reflecting the shadow exchange rate (SER) of Bahts. The product prices used to estimate the project benefits are adjusted to reflect their opportunity prices.

(2) Conversion to Economic Price

1) Customs Duties and Import Taxes

All payments for customs duties and associated import taxes are excluded from the cost of imported goods. The customs duties and import taxes on the foreign components of the prices of the domestic goods are disregarded.

2) Corporate Income Tax

The corporate income tax is one type of transfer payments; therefore, this is not included in the economic cost.

3) Interest Payment

All interest payments including interest during construction, interest on loans, and all interest charges are excluded from the economic cost.

4) Insurance

The payments for insurance are regarded as a transfer payment and are not included in the economic cost.

5) Foreign Currency Exchange Rate

EIRR is calculated in terms of the domestic currency, or Bahts in the case of this study. The net economic values should be adjusted by an appropriate foreign exchange premium, higher or lower than indicated by the official exchange rate, if the real value of the domestic currency is higher or lower than the official value. The following equation is a typical one generally used to obtain a shadow exchange rate (SER).

SER/OER = $(IMP(1+Tax^{Imp} + TQ^{Imp}) + EX(1-Tax^{ex})) / (IMP + EX)$

where:

SER = Shadow exchange rate

OER = Official exchange rate

IMP = C.I.F. value of import

EX = F.O.B. value of export

Taximp = Weighted average of import tax rate

TQimp = Import tax rate equivalent to import restriction value

Taxex = Weighted average of export tax rate

The data available for estimating the SER are the Standard Factor Costs (SFC) in Thailand, and the SFC of 0.863 was used, based on a report by the World Bank.

SFC is defined by the following equation:

SFC = (IMP + EX) / (IMP(1 +
$$Tax^{imp} + TQ^{imp}$$
) + EX(1- Tax^{ex}))

It may be noted that the SER/OER is an inversion of the equation which defines SFC. Consequently, SER/OER is 1.159 when SFC is 0.863. Accordingly, an SER/OER of 1.159 is used in this economic analysis.

6) Wage

There is unemployment of unskilled labors, but shortage of various trades of skilled labors in Thailand now.

The project will mainly employ skilled labors, labors with occupational training and experience of practical nature, and a small number of unskilled labors as well. If there is any adjustment needed in terms of economic values, that is on the employment of previously unemployed labors, or unskilled labors. In view of the prevailing wage levels of unskilled labors in the rural area around the plant site, it may be considered that the project will be paying the unskilled labors, to be employed as "unskilled workers" for the plant construction and for miscellaneous works, shadow wages, or wage corrected to economic value, equivalent to 90 percent of the nominal wages.

One the other hand, the shadow wages for skilled labors are estimated

to be equal to the nominal wages. In this study, the shadow wage rate for the skilled labors is specified as unity.

16-1-2 Quantitative Economic Analysis of the Pilot Plant

This section conducts a quantitative economic analysis of the 3,000 tonper-year pilot plant.

(1) Economic Benefits and Costs

The following economic benefits and costs are identified in the course of calculating EIRR.

Economic benefits: Direct benefits, and

Economic costs: Plant costs and operation costs

1) Economic Benefits

The direct benefits of the project are the economic value of lignite briquettes.

The economic price of lignite briquettes is the price of lignite briquettes at which consumers are willing to buy them. As described in Chapter 5, 60 percent of the potential consumers will accept lignite briquettes at a price 60 percent of that of charcoal. Therefore, the market price of lignite briquettes, set at 60 percent of that of charcoal, is considered as the economic benefits of lignite briquettes.

Table 16-1 shows the economic price of lignite briquettes.

Table 16-1 Direct Economic Benefits

(Unit: 1,000 Bahts) 1995 2000 2005 2010 Lignite Briquettes 2,400 3,000 3,000 3,000 Production, tons/year Unit Economic Price of 2.78 2.86 2.98 3.14Lignite Briquettes, Bahts/kg 6,672 9,420 Direct Economic Benefit 8,580 8,940

2) Economic Investment Cost

Economic investment cost consists of the construction cost of the pilot plant, preoperating cost and cost of spareparts. These costs were calculated from the financial investment costs of the preceding chapter by adjustments for an SER/OER of 1.159 for the foreign currency portion. The import duties and taxes are, of course, excluded from the foreign portion of the plant cost. The costs of the unskilled labors, a local portion, are corrected using a shadow wage rate of 0.9 for the unskilled labor. Table 16-2 shows the economic plant cost along with the financial plant cost, the latter for the purpose of reference.

3) Economic Operation Cost

Operation costs include such items as raw materials, utilities, manpower cost, maintenance cost, overhead and general expenses. Interest and loan repayments are not included in the economic analysis. The economic costs of imported materials are derived by multiplying the foreign costs by the shadow exchange rate, and excluding tax and duty from the costs. As personnel required for plant operation must be skilled labors, the shadow price is not used for the cost of operators; however, a shadow price rate of 0.9 is applied to the unskilled labors. 30 percent of the maintenance cost is estimated to be foreign currency portion, which is adjusted for the shadow exchange rate and deducted of the duty and tax elements. In the case of financial analysis, the sales price of lignite briquettes are set at ex-plant; therefore, the distribution/marketing cost is not included in the financial cost. However, in the case of this economic analysis, the distribution/ marketing cost of 0.635 Bahts per kilogram in large bag is counted in the economic calculation.

4) Results of Calculation of EIRR

Economic internal rate of return is calculated from the economic benefits and costs explained above. Table 16-3 lists economic benefits and costs of the pilot plant. The EIRR for the pilot plant is calculated using the economic benefits and costs listed in Table 16-3.

How high an EIRR should be in order to justify a project economically, or cut-off rate, varies depending upon the nature of the project. Ac-

cording to guidelines provided by various international organizations, the cut-off-rate of EIRR varies within a range between 8 and 12 percent for industrial project. The EIRR obtained for the pilot plant project shows a negative value. Therefore, the pilot plant alone is not justifiable from the standpoint of the economic return.

16-1-3 Economic Analysis of the Commercial Plant (Quantitative)

A quantitative economic analysis is made here of a commercial plant of 50,000 tons per year capacity.

(1) Economic Benefits and Costs

The method for calculating economic benefits and costs is the same as that used for the pilot plant. Table 16-4 summarizes the economic plant costs. Table 16-5 shows the economic benefits and costs of the commercial plant project.

(2) EIRR, Economic Internal Rate of Return

Table 16-6 shows EIRR's of the commercial plant obtained for the base case and the sensitivity cases, the latter cases for 10 percent variations of the economic benefits and costs.

The values of EIRR's for the commercial plant only are generally high enough to justify in economic terms. Since the pilot plant is a necessary step toward commercialization on a large scale, construction of a number of plants. The pilot plant may be considered as justifiable from this viewpoint.

Table 16-2 Financial Plant Cost and Economic Plant Cost (Pilot Plant)

Financial Plant Cost

			i		İ			İ										Unit: 1.0	SO Bht
					DOMESTIC	10 COMPO	KENT						FOREIGN	EXCHINACI	E COMPONENT	ENT			GRAND
		1ST YEAR (1993)	(1993)				ZNO YEAR	_				1ST YEAR	(1993)			2ND YEAR ((1394)		TOTAL
	U.S. L.	U.S.L. S.D.E	T V	TAX&DUTY	TOTAL	I.S.L.	SDE	MAT. L	TAX&DUTY	TOTAL	PESN' L	MAT	TAXEDITY	TOTAL	PESW L	MAT.	TAXABUTY	TOTAL	
1) Land aquisition	0	0	0	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Site preparation	192	769	0	33	983	0	0	-	0,	0	0		0	0	0	0	0	(2)	933
Machinery and equix	G	_	202	~	212	0	0	450	15	475	0	7, 499	1, 297	8, 797	0	17, 325	2, 997	20, 322	29, 805
 Inland Transportatx 	0	0	0	0	-	¢	~	366	13	409	0	0	⇔	c	0	0	~	0	403
5) Vehicles	0	0	0	0	0	0	0	2, 543	8	2, 626	⇔	-	0	0	=	=	~	0	2, 625
6) Erection x	0	~	0	0	0	138	2, 922	0	101	3, 161	0	0	0	0	0	0	0	c	3, 161
 Structures and civil work 	0	0	0	0	0	33	1, 396	3, 310	180	5, 62.	0	~	0	0	0	6	-	0	5, 521
8) Electrical Work x	156	383	813	45	1, 403	348	874	1, 825	101	3, 149	0	0	0	6	0	0	0	0	4, 552
9) Engineering x	0	308	0	10	318	0	74	C.	2	. 92	5, 131	270	178	5, 579	0	0	0	0	5, 973
10) Supervision x	0	€	0	0	0	0	0	0	0	0	0	0	0	0	621	Ċ.	Z	672	219
11) Commissioning x	0	0	0	0	0	<u>.</u>	0	-	0	Ö	0	0	0	ඌ	446	0	ដ	450	460
12) Physical contingency	_	23	51	r.	146	5	263	427	52	776	257	383	74	713	S.	998	152	1,073	2, 714
13) Price contingency	9	192	134	12	384	218	933	1, 522	88		163	247	47	457	43	738	129	915	4, 523
Total Plant Cost:	411	1, 732	1, 203	110	3, 456	1, 503	6, 468	10, 481	609	19,060	5,550	8, 405	1.596	15, 552	1, 198	18, 930	3, 314	23, 442	61, 510
Total Plant Cost (1990 Price)	365	1, 540	1, 969	88	3,072	1, 284	5, 529	8, 959	520		5, 387	8, 158	1, 549		1, 151	18, 191	3, 185	22, 527	56, 987

Economic Plant Cost

					DOMEST	IC COMPO	NENT						FOREIGN	FOREIGN EXCHINAGE COMPONENT	COMPONE	NT			GRAND
		1CT VEAR	(1993)				2ND YEAR ((1994)				1ST YEAR (1993)	(1993)		. 4	2ND YEAR (1994)	1994)		TOTAL
•	U.S.L.	I.S. L. S. D. E. MAT' L	MAT L	TAX&DUTY	TOTAL	U. S. L.	S. D. E	MAT. L	TAX&DUTY	TOTAL	PESN' L	MAT L 1	LAX&DUTY	TOTAL	PESN' L	MAT L TA	24	TOTAL	
1 tond agricultion	<i>c</i>	U	٥		le I	0	O	0	0	<u>ح</u>	0	0	o	0	0	-	0	0	=
I) Della edetat cion	,	5	• 0	·	0,00	-	¢	_	_	-	~	0	~	c	_	~	_	-	942
2) Site preparation	7	80/	-	3	750	-	9	,	۰ د		5 6		0	,	•	200		000	
1) Hacking and Amiloner	Ç	c	205	æ	202	-	c	450	-	460	=	8, 582	5	3, 032	<u>.</u>	20,020	. ·	70, 080	63.4.0
	•	• •	3			-	c	196	~	396	_	:	C	C.	c	ċ	_	0	396
 4) inland Iransportation 	-	> +	۰ د	۰ د	> 0	•	•		9 6	2	•	•		•				c	2/3 6
5) Nobicles	Ç.	c	0	=>	>	9	9	7, 393	>	5,040	⇒	-	>	5	>	>	•	,	
2007101	• •			_	-	125	665 6	_	c	3.046	<u>-</u>	C	<u>_</u>	_	0	-	c	(3,046
o) rection	3	5	٠.	•	3 (1 6				000			·¢	· C	· c	c	c	C	250
7) Structures and civil work	0	0		∍	⇒	700	1, 330	, 3, U	٠ •	200	.		,	> 1	ا د	>	٥ د	> (200
0) 510444500 9000	140	380	200	=	1, 343	315	874	1.825	0	3.013	-	0	0	=	~	=>	⇒	¬	4, 35b
o) Frechted and	7	3	3		000		7.	<u></u>	_	7.6	370 %		C	2 350	¢	_	¢	_	5.541
9) Engineering	⇒	308	9	2	200	> 0		•	-	ŗ	2	3	•	3	1	oc	• •	716	722
10) Supervision	0	-	~	0	=	>	>	→	-	:	>	-	-	۰ د	# C /	5	-	# (2.0
	· C	-	<u>_</u>	_	c	0	0	0	0	-	0	0	0	0	516	-	0	516	210
TT) COMMISSION TO	,	,	'n	• •	7	, K	253	197	· C	745	207	027	c	748	29	1 004	c	1.058	2, 700
12) Physical contingency	9	3	'n	>	25.7	3		-	3	2	?	2	,						
ŧ	120	570	1 069	_	2 938	156	5,529	8, 959	0	15,644	6, 244	3, 455	0	15, 588	1, 334	21, 084	-	27, 418	56, 538
CONTRACT CONTRACT	777	1, 4	1	,			١												

Table 16-3 Economic Benefit and Cost (Pilot Plant)

Unit: 1.000 Bht

	E1RR (%): -												i	i	i	1						
Year	1893	1994	1995	1996	1997	1998	1999	2000	2003	2002	2003	2004	2002	2006	2002	2008	2003	2010	2011	2012	2013	2014
Economic Benefit Lgnite Briquettes	0	0	5, 672	8, 370	8, 400	8, 460	8, 520	8, 580	8, 540	8, 700	8, 790	8, 850	8, 940	9, 030	9, 420	9, 210	3, 300	9, 420	9, 510	9, 600	9, 590	9, 730
Economin Cost Investment																						
Plant Cost Preoperation Cost	18, 636 6, 642	38, 061 476	-	00	~ ~	00		00	00	00	00	00	00	တဇာ	00		00	00	00	00	00	ಅ೦
Spare Parts	0	⊷î	0	0	o	O	0	0	0	0	0	0	0	0	0	0	0	O	ငာ	a	0	0
Operation Raw Materials	0	0	2, 245		2,805	2,806	2,806	2, 806	2, 806	2, 806	2, 806		2,806	2, 806	2,806	2,806	2, 806		2,806	2,806	2, 806	2,806
Utilities		=	1, 453	1, 743	1,743	1,743	1,743	I, 743	1, 743	1, 743	1, 743	1, 743	1, 743	1, 743	1, 743	1,743	1,743	1,743	1, 743	1, 743	1, 743	1, 743
Manpower Cost		0	2, 628		2, 628	2, 628	2, 628	2, 628	2, 528	2, 628	2, 628		2, 628	2, 628	2, 628	2, 628	2, 628			2, 528	2, 628	2, 628
Maintenance Cost	0	0	1, 419		1, 419	1, 419	1,419	1,419	1, 419	1, 418	1, 419			1, 419	1, 419	1, 419	1,419			1, 419	1, 413	1, 413
Plant Overhead	0	φ	1.971		1, 971	1, 971	1, 971	1, 971	1, 971	1, 971	1, 971	1, 971	1, 971	1.971	1, 971	1, 971	1. 971			1,971	1,971	1, 971
General Expenses	0	ය	657		557	657	657	657	. 627	927	657	657	657	923	657	657	657		657	657	657	657
Distribution Cost	0	0	1, 524	٠÷	1, 905	1, 905	1, 305	1, 905	302	1, 305	902	305	905	305	303	302	302	305	905	905	99	1, 305
Total	25, 279	40,047	11,897	13, 129	13, 129	13, 128	13, 129	13, 129		13, 129		13, 129		13, 129 1	-	13, 129 1	13, 129 1	_		• •		13, 129
Balance	-25, 279	-25, 279 -40, 047 -5, 225 -4, 759 -4, 729 -4, 669	-5, 225	-4, 759	-4, 729	-4, 669	-4, 609	-4,549	-4, 489	-4, 429 -4, 339		-4, 279	-4, 189	-4,089	-3, 709	-3 919 -	-3,829 -	-3, 709	-3, 619 -3, 529		-3,439	-3,349

Table 16-4 Financial Plant Cost and Economic Plant Cost (Commercial Plant)

Financial Plant Cost

									,		i							Unit: 1,	300 Bht	
					DOMESTI	C COMPONENT	ENI ENI						FORE I G	EXCHINAGE	Service Services	KENT			SEAN	
		IST YEAR (1998)	(1398)				IND YEAR	(1999)				IST YEAR	(1938)			2ND YEAR	(1833)		TOTAL	
	U. S. L.	S. D. E.	MAT" L	FAXSDUTY	TOTAL	U. S. E.	S.D.E	MAT L	TAXADUTY	TOTAL	PESN' L	MAT	TAXEDUTY	TOTAL	PESN' L	MATL	FAXZOUTY	TOTAL		
1) Land aquisition	0	0	0	0	0	 	C	0	0	 	0	0	0	0	0	с э	⇔	0	0	
2) Site preparation	192	769	c	33	SS	-	0	0	0	0	c	0	0	_	0	0	0			. '
3) Machinery and equipment	0	0	12, 025	387	12, 422	0	~	26, 979	880	27, 869	-	20,956	3, 625	24, 581	6	48, 413	8,375	56, 783	121, 661	
4) Inland Transportation	0	0	0	0	0	0	0	846	28	874	-	0	0	0	-		-	0	874	
5) Vehicles		0	ς.	-	0	0	-	4, 238	140	4 378	0	c>	¢	0	(2)	0	c	co	4, 378	
6) Erection	0	(=)	0	-	0	416	9, 597	0	8	10, 343	0	0	G	0	0	0	G	c	10, 343	
7) Structures and civil work	0	0	0	0	0	1, 942	9, 153	10, 295	306	22, 095	~	ø	~	c >	0	©	0	0	22, 095	
8) Electrical Work	457	175	1, 359	88	3, 089	1,025	2, 635	3,048	221	6.929	0	0	0	0	0	C	0	0	10,018	
9) Engineering	0	335	0	13	387	0	35	□	<i>د</i> ى	9	5 131	23	178	5, 579	0	œ	Ö		5, 072	÷
10) Supervision	0	0	0	-	=	0	6	0	0	⇔	0	0	0	Ö	651	0	21	672	572	
11) Commissioning	0	0	0	0	0	0	<i>ت</i>	⇔ ∵	6	0	ت	_	0	6	446	~	ij	480	460	
12) Physical contingency	S	116	699	17	845	169	1,074	2, 270	116		257	1,061	130	1, 508	S	2, 421	421	2,886	8,878	
13) Price contingency	251	901	5, 179	ŝ		 8			1, 031		445	1.847	331	2, 524	108	4, 762	827	5, 538	47, 124	
Total Plant Cost:	933	3,346	19, 232	776	24, 286	5 055	32, 098	67, 858	3, 465	108, 476	5,833	24, 134	4, 325	34, 292	1,259	55, 586	9, 660	55, 515	233, 570	
Total Plant Cost (1990 Price)	681	2, 445	14,053	567		3.55		47 676	2, 435		5, 387	22, 287	3, 994	31.668	1, 151	50 834	8,832	60, 817	186, 445	

Economic Plant Cost

Economic Investment Cost

1ST YEAR (1998) S. D. E. MAT'L

Unit: 1.000 Bht

Table 16-5 Economic Benefit and Cost (Commercial Plant)

0 114, 400 144, 000 145, 000 146, 500 147, 500 169, 000 150, 500 157, 000 153, 500 155, 000 157, 000 158, 500 160, 000 161, 500 162, 500 2012 2013 7 22,727 22,727 7 4,077 4,077 2 4,642 4,642 8 3,058 3,058 9 1,019 1,019 0 31,750 31,750 5 114,045 114,045 1 955 000 46, 773 46, 773 22, 727 22, 727 4, 677 4, 677 4, 642 5, 64 2003 36, 455 34, 955 29, 955 30, 955 000 -55, 828 -139515 20, 294 1999 133, 675 1, 620 4, 220 49, 185 6, 642 0 0 EIRR(%): Economin Cost
Investment
Plant Cost
Preoperation Cost
Spare Parts
Operation
Raw Materials
Utilities
Manpower Cost
Maintenance Cost
Plant Overhead
General Expenses conomic Benefit Lgnite Briquettes

Table 16-6 Results of Calculation for EIRR

(Unit: Percent)

Commercial plant	Sensitivity	EIRR	
	0	14.5	
Lignite Briquettes Price	+10	21.3	
•	-10	6.6	
Plant Investment	+10	12.9	
	-10	16.3	
Operation Cost	+10	8.6	
	-10	19.8	

16-2 Qualitative Economic Analysis

16-2-1 Effects on the Protection of Environment

Lignite briquettes, of all the environmental aspects, concern mainly the issue of forest conservation. This project is conceived against a background of ever-worsening deforestation, for which consumption of wood fuel is largely responsible. Among a variety of consequences of deforestation, loss of the reservoir of water the forests have provided by their sponge effects will hit the nation hardest in a short term. Floods, landslides, droughts result from the forests having lost their ability to preserve water and gradually release it. The ability of the forests to conserve water could never be more important than in a country like Thailand where agriculture is the mainstay of the economy on which the majority of the population depends, where the precipitation is not evenly distributed throughout the year, downpours lasting only a couple of hours a day in the rainy season only but not a drop of rain during the rest of the year. In a longer term, deforestation will have adverse and irreversible effects upon the local and global climates.

The number of trees cut down every day in Thailand to provide firewood and charcoal is calculated to be about 500,000, each weighing between 100 and 150 kilograms, an enormous number. This constitutes a major cause of deforestation.

When discussing the merits of lignite briquettes from the angle of protection of the environment, there is also a problem of air pollution caused by the emission of sulfur oxides associated with consumption of fuels. Sulfur oxides are discharged into atmosphere by burning fuels containing sulfur; lignite is one of them. Acid rain results from atmospheric pollution involving sulfur.

From a viewpoint of their contribution to the protection of forests and amelioration of air pollution, the merits of lignite briquettes are discussed below.

(1) Tropical Forest

The forests of Thailand mostly fall into what are collectively called tropical forests, distributed in the tropical zone. The tropical forests have provided sources of firewood and charcoal, lumber, food, and raw materials for industrial activities, besides their role as a reservoir of water. In addition, the tropical forests have come to be regarded as an important source of a large variety of genes of of life; belonging either to the animal kingdom or the vegetable kingdom. These genes are considered important in the development of new varieties of crops or medicines.

1) Features of the Forest of Thailand

The forests of Thailand can be divided into four general types: tropical evergreen, mixed deciduous, dry dipterocarp and pine forest.

The forests of Thailand have been diminishing at an alarming rate as shown in Table 16-7. In 1961, for example, some 53 percent of the country, or 270 thousand square kilometers, was covered by forest, a proportion which declined dramatically to the 1988 figure of 28 percent, or 140 thousand square kilometers. In other words, Thailand had lost about 130 thousand square kilometers of its forest over a period of 27 years, or at a rate of 4,800 square kilometers per year. If deforestation continues at this rate, the forests in Thailand will disappear in about 30 years.

Table 16-7 Forest Area in Thailand, 1961-1988.

(Unit: %)

	and the second second							
Area	1961	1973	1976	1978	1982	1985	1988	
North	68.54	66.96	60.32	55.96	51.75	49.59	47,37	
Northeast	41.90	30.01	24.57	18.49	15.33	15.15	14.03	
South	41.89	26.07	28.46	24.89	23.25	21.90	20.69	
Central	52.91	35.50	32.38	30.31	27.47	26.24	25.59	
East 3	57.98	41.19	34.00	30.24	21.92	21.89	21.46	
Whole Kingdom	53.33	43.21	38.07	34.15	30.52	29.05	28.03	

Source: Royal Forestry Department

2) Influence of Destruction of Tropical Forest

The tropical forest is a very fragile ecosystem. This is because as much as nearly 90 percent of the nourishment of the forest is contained in the vegetation. The top soil is in general very thin. The soil contains a very small portion of the total nourishment of the forest. The entire ecosystem is very vulnerable to total destruction, once the soil is stripped of the plant cover, and exposed and weathered. Their extreme fragility and vulnerability should always be remembered when dealing with tropical forests.

Tropical forests, once destroyed, are very difficult or almost impossible to restore. All the wealth of the forests, on which the human race as well as other creatures on the earth depend so much, will be lost for good. The naked top soil is very easy to be washed away by tropical or subtropical showers, leaving barren land.

The role of the tropical forests to keep carbon dioxide from becoming thick in the atmosphere is of vital importance. Carbon dioxide, if allowed to become thick in the atmosphere, will cause atmospheric warming which eventually leads to a total global climatic disruption.

The forests of Thailand should be protected before it is too late. On the other hand, however, it is important to remember the fact that the majority of the population now depend on wood fuel for cooking, and this habit cannot be changed overnight.

3) Major Causes of Deforestation

The major causes of deforestation in Thailand are as follows:

(a) Agricultural Expansion

Until recently, encroachment of forests for the purpose of expanding farmland had been the main cause for deforestation. Farmers in Thailand traditionally converted forest into farm land in order to increase harvests. The lowland farmers, for example, contributed to the deforestation of the upland by clearing woods in order to expand farm land. At the time when trees were cut down by simple hand tools like ax, deforestation by clearing was not a serious problem. However, the introduction of chain saws speeded up destruction of forest. The promotion of growing cash crops for export also contributed to deforestation to some extent. The shifting agriculture by mountain tribes was also a cause of deforestation.

(b) Firewood and Charcoal Production

A large amount of wood has been consumed in order to obtain firewood and charcoal. Today, this is recognized as the major cause of deforestation. About 500,000 trees weighing between 100 and 150 kilograms are cut down every day, or about 8.5 million TOE per year, to provide wood fuel, charcoal and firewood. This amount corresponds to about three to four times the sustainable supply from the existing forests. Allowing such a practice to continue simply means further destruction of the forests.

(c) Overcutting

Economics are often pursued so much that overcutting, illegal in some cases, may result. Overcutting disrupts the reforestation programs of the forest and eventually leads to a decrease in the forest area.

4) Reforestation

Systematic forest protection started with the implementation of the Forest Act in 1960 and the National Forest Reserve Act in 1964. Other important acts concerning forest protection include the Wild Animal Reservation and Protection Act of 1960, and the National Park Act of 1961. The government has set forth a number of policies, regulations

and rules which should help provide the legal and administrative framework for forest management. Commitments to forest protection were made in every National Development Plan. The Sixth Five-year Plan includes the following forestry objectives:

- (1) To increase the forest area from 29 to 40 percent,
- (2) To divide forest into two categories: protected forest and economic forest and to increase the former to 15 percent and the latter to 25 percent of the country,
- (3) To revise the laws and regulations governing the management of forest, and to encourage private sector initiatives,
- (4) To develop coherent short-, medium- and long-term plans for fostering forests and the forest industry,
- (5) To review forest administration in line with the above plans,
- (6) To introduce new technologies designed to boost reforestation,
- (7) To promote public awareness programs so as to educate and inform people about the importance of forest resources.

Recently, the deforested areas, including those remote from the places where deforestation actually takes place and seemingly unrelated, suffer from floods, landslides and droughts, with increasing frequency, which gives rise to serious social problems. Under these circumstances, in January 1989, the government announced a ban on the cutting down of trees.

16-2-2 Merits of Lignite Briquettes in Environmental Conservation

Here, the contributions to be made by lignite briquettes to prevention of deforestation and to prevention of sulfur emission are discussed.

(1) Prevention of Deforestation

From the foregoing discussions, it is evident that an adequate substitute for wood fuel must be made available to people in order to prevent the forests from further destruction. The policy of restricting logging would be incomplete without a cheap and easy-to-use substitute fuel. Most people, except those who afford LPG, have to use wood fuel for cooking, regardless of the effects consumption of wood fuel could have on the environment, and eventually on their very livelihood.

The results of this study indicates that, although lignite briquettes cannot be a substitute for firewood because of the very cheap price of firewood, lignite briquettes can be a substitute for a good portion of charcoal. Commercialization of lignite briquettes on a large scale would certainly decrease the consumption of wood fuel and thereby help preserve the forest.

The difference in the forest area between Table 5-21 and Table 5-23, 52,345 square kilometers in 2010 for example, is the area of forest to be saved by substitute fuels for charcoal, of which 60 percent, or 31,407 square kilometers would be credited to lignite briquettes. The value of this area of forest defies any attempt to express it in terms of monetary value, against the background of serious effects of deforestation: floods, droughts, land slides, salt attacks, etc. The forest area of 31,407 square kilometers represent 23 percent of the total forest area of 1989. Just a small portion of the total benefit of the forest saved, the cost of replantation saved on account of 31,407 square kilometer is calculated to be 39,300 million Bahts by using a unit cost of 2,000 Bahts per rai.

Should there not be lignite briquettes, LPG would be the only practical alternative to make up for the forecast demand of lignite briquettes, supposing the wood fuel is not allowed to be used any more than forecast consumption of this study. In 2010, 831,000 tons more LPG would have to be imported, the total cost of which would be 125 million US Dollars at a price 150 US Dollars per ton of LPG. Lignite briquettes

would save the foreign currency cost of LPG that would have to be imported without lignite briquettes.

(2) Prevention of Sulfur Emission

This project would perhaps be the first of its kind to burn lime-containing lignite briquettes, for the purpose of reducing the emission of sulfur oxides to atmosphere. If utilization of sulfur-containing coal, or lignite, is promoted without a practical measure to reduce the emission of sulfur dioxide being taken, a serious environmental disruption will inevitably result.

Supposing that 831,000 TOE of lignite briquettes, or 1.6 million tons are consumed in 2010 as forecast by the market study and the raw material lignite contains two percent sulfur on dry base, the amount of sulfur to be caught by the desulfurization agent blended into lignite briquettes is 16,600 tons. The average cost of desulfurization by means of flue gas desulfurization is about 42,000 Bahts per ton sulfur; therefore, the cost of desulfurization saved will be 700 million Bahts. The cost of desulfurization agent, or slaked lime, is estimated at about 350 million Bahts; there will still be saved 350 million Bahts after deduction of the cost of desulfurization agent.

Thus, the lignite briquettes project would be very meaningful from the standpoints of the prevention of deforestation as well as reduction of sulfur emission.

16-3 Economic Comparison with Other Fuels

Lignite briquettes are not meant to be a substitute for modern fuels like natural gas, gasoline, diesel fuel, LPG, and electricity. Technically, lignite briquettes could be a substitute for firewood, charcoal and lignite. Lignite briquettes, however, cannot economically compete with firewood and lignite. Moreover, the furnaces now burning firewood or lignite need substantial modifications in order to be able to burn lignite briquettes. Table 16-8 compares prices of various kinds of fuels in 1990. In economical terms, lignite briquettes can compete only

with charcoal and LPG for cooking purpose. The retail price of charcoal is about 7 US\$/MMBTU in small bags, 4 US\$/MMBTU in large bags, and that of LPG is 9 US\$/MMBTU. As is described in Chapter 5, the price of lignite briquettes is set to be competitive with charcoal both at wholesale and retail stages. At the same time, manufacturing of lignite briquettes is made financially and economically feasible at the commercial stage. Lignite briquettes are naturally competitive with LPG as far as the price is concerned. However, the conditions in which LPG is burned are significantly different from the conditions in which lignite briquettes will be burned, and therefore LPG is not a target for substitution.

Table 16-8 Retail Price of Various Fuels (1990)

Fuel	Retai Pr	ice	Note
	Sales Price	US\$/MMBTU	
Charcoal	5 B/kg	6.9	Bangkok/Chiang Mai Retail
	5 B/1.2kg	5.8	Phitsanulok Retail
•	150 B/38kg	5.5	Phitsanulok Retail
	110 B/38kg	4.0	Phitsanulok Retail
	120 B/38kg	5.5	Chiang Mai Market
	5 B/1.5kg	4.6	Mahasarakham Retail
	80 B/24kg	4.6	Mahasarakham Retail
	5 B/1.5kg	4.6	Khon Kaen Retail
	16 B/4.5kg	4.9	Nakhon Rachasima Retail
	3 B/kg	4.2	Nakhon Si Thammarat Retail
Firewood	1,900 B/3m3	2.5	Chiang Mai Pottery
•	530 B/3.55m3	0.6	Chiang Mai Brick Burner
	10 B/8.1kg		Chiang Mai Retail
Bagasse	25 B/ton	1.1	Chiang Mai Sugar Mill
Coal Briquettes	8 B/3kg	3.9	Chiang Mai Retail
	4 B/0.6kg	9.7	Chiang Mai Retail
Coconut Shell	300 B/ton	0.65	Chiang Mai Wholesale
Rice Husks	300 B/ton	0.19	Phitsanulok Retail
LPG	480 B/48kg	8.8	Chiang Mai Retail

Note:

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(i) Net heating value for calculating	lon, kcal/kg
Charcoal	7,000
Firewood	3,500
Bagasse, 50% moisture	2,115
Coal Briquettes	6,667
Coconuts Shell	4,500
Rice Husk, 8.7% moisture	3,820
LPG	11,000
Rice Husk, 8.7% moisture	4,500 3,820

- (2) Firewood density used for calculation: 0.70gr/cm³
- (3) Exchange Rate: One US Dollar is 26 Bahts.

16-4 Environmental Consideration on Production and Utilization

The conceptual design of the pilot plant as well as that of the commercial plant incorporate provisions for environmental conservation. First and foremost, the site is selected sufficiently apart from the residential area. The possible causes for environmental disruption are dust of lignite and gas from the de-smoker. Bag filters are installed where dusts could be generated to catch them. The gas generated from the de-smoker is burned in the furnace of the de-smoker and also in the hot gas generator for drying lignite. The above provisions will prevent pollutants from escaping the plant and also conserve the working conditions for the operators. The process of manufacturing lignite briquettes is a dry process and does not produce a foul effluent stream. However, in order not to allow lubricating oil or tar, that has found its way to the sewage, to leave the site with rain water, a detention pond is provided at the outlet of the sewage system.

In consideration of the environmental aspect associated with utilization, the conceptual design incorporates a provision for reducing generation of smoke when lignite briquettes are burned. By this, generation of smoke could be reduced markedly. An analysis of the ash of lignite briquettes indicates that the content of cadmium is lower than 5 ppm, the standard set for Japanese fertilizers. Chromium VI was not detected by the analysis of ash. Lignite briquettes generate carbon monoxide when they burn but not more than charcoal does. Sulfur originally contained in lignite is converted into sulfur oxides and find its way in the combustion gas. By adding slaked lime in the lignite briquettes, about 70 percent of sulfur oxides is caught before they can be released in the combustion gas. With this, smell of sulfur oxides is hardly recognizable by the human senses. Anyhow, smoke, soot, sulfur oxides and carbon monoxide are generated upon combustion; therefore, lignite briquettes are not suited to be burned in a closed quarter. The houses of ordinary Thai people are of a structure which allows ventilation; and cooking is usually done in a place where ventilation is particularly good. In modern houses of a closed structure, LPG and electricity are used. This study gives consideration as explained above to the environmental aspect of consumption.

16-5 Contribution to Coal Utilization Policy of the Government

The basic policy of the government of Thailand with respect to energy is to promote development of domestic resources, to increase the degree of self-sufficiency, and to diversify the sources of supply. In line with this basic policy, the government has been encouraging development and utilization of the natural gas and coal resources. With the natural gas resources anticipated to be exhausted around the beginning of the 21st century, the development and utilization of coal have become even more important. The government places particular emphasis on the development and utilization of rich lignite resources.

Although lignite has already found extensive use as fuel for minemouth power generation and cement plants, lignite is not used as household fuel. Effective utilization of lignite for household purpose should be promoted in the light of a large amount of wood fuel still consumed and sharply increasing consumption of LPG.

Lignite as mined, however, is prone to autogenous ignition, generates sulfur oxides upon combustion, easily breaks down into small sizes upon weathering, and is not uniform in size. All these make lignite undesirable as household fuel. This project will solve all these inherent disadvantages to lignite and open a new outlet of lignite as household fuel; this will, of course, meet the basic policy of the government of Thailand.

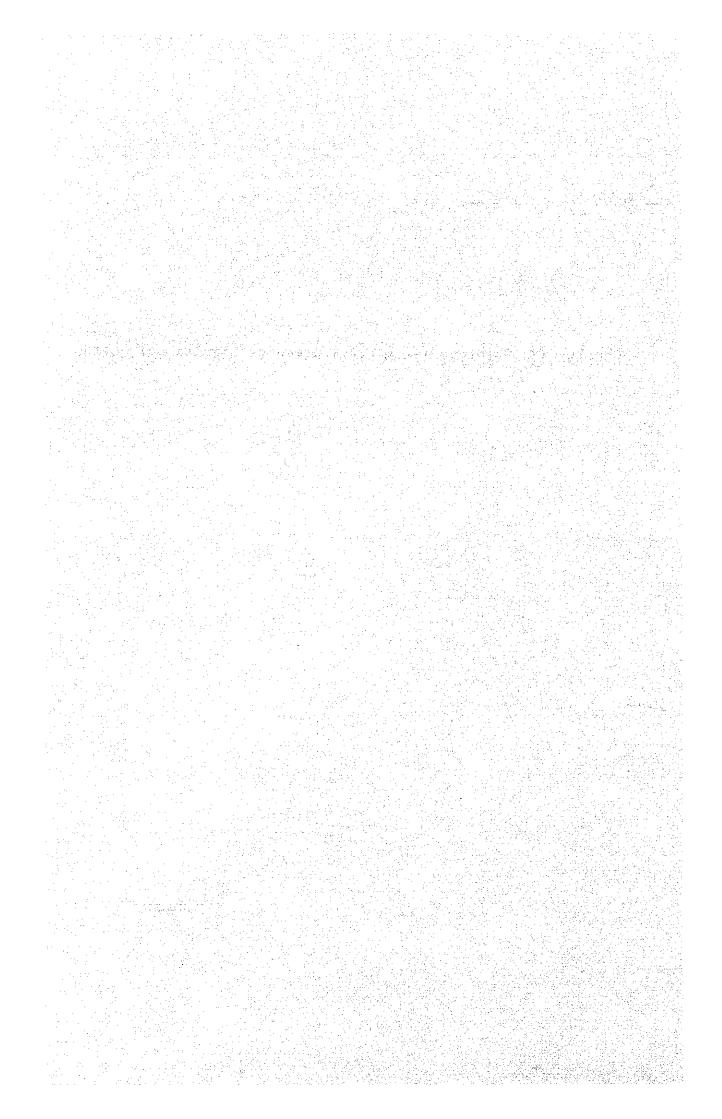
16-6 Social Benefits

Besides protection of the forest and preventions of the hazards directly and indirectly attributable to deforestation, prevention of sulfur emission and other contributions already mentioned, lignite briquettes would have the following benefits.

- (1) Diversification of the sources of energy supply,
- (2) Effective utilization of lignite briquettes, or low-quality coal,

- (3) Effective utilization of unused domestic resources: rice straws and slaked lime,
- (4) Creation of job opportunities in job-scarce rural areas as a results of construction of lignite briquettes plants,
- (5) Transfer of technology relative to the manufacture of lignite briquettes and to the design and fabrication of machines needed by the lignite briquette plants.

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Chapter 17 Strategy for Dissemination of Lignit	
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Chapter 17 Strategy for Dissemination of Lignite Briquettes

17-1 Basic Understanding on Lignite Briquettes Project

The government of Thailand fully realizes the seriousness of deforestation, for which the consumption of charcoal and firewood has been greatly responsible, as explained in Chapter 1 and Chapter 3, as well as the importance of the dissemination of lignite briquettes as a means of ameliorating the ever-worsening situation of deforestation. It is recommended that, in concluding this study, concrete measures be taken to disseminate lignite briquettes among the people of Thailand. As will be explained, the government has very important roles to play, without which the successful dissemination of lignite briquettes would hardly be conceivable.

17-2 Lignite Briquettes as a New Commodity

Lignite briquettes are intended chiefly to be a substitute for charcoal as cooking fuel. The potential consumers of lignite briquettes are therefore those who now purchase and consume charcoal for cooking. The upper thin layer of socially and economically privileged people consume LPG and electricity only. In 1989, LPG accounted for only 15 percent of the total cooking fuel consumed in Thailand. The residents of western-style houses in Bangkok and Chiang Mai use exclusively LPG and electricity. However, many other LPG users also use charcoal and electricity together with LPG depending on the purpose. In 1989, charcoal accounted for 37.8 percent of the total consumption of cooking fuel, a significant share along with firewood which accounted for 42.1 percent. Charcoal users represent the majority of the population, while they also use LPG, electricity and firewood depending upon the purpose, income level and where they live.

Compared to charcoal, lignite briquettes have drawbacks stemming from the quality of the raw materials: lower heating values, slower ignition, and the generation of smoke. To compensate for such drawbacks, consumers' price of lignite briquettes should be lower than that of charcoal. The results of the monitoring survey indicate that about 60

percent of the consumption of charcoal could be replaced by lignite briquettes, provided that the price of lignite briquettes is 60 percent of that of charcoal. In line with this result, this study sets the consumer price of lignite briquettes at 60 percent of that of charcoal. Furthermore, the quality of lignite briquettes is designed in such a way that they may be used without forcing consumers to change their lifestyles or cooking habits.

This does not mean in the least, however, that lignite briquettes will sell well automatically. In Thailand, lignite briquettes are a new commodity known only to very few people. Among the very few who know of lignite briquettes, there is the preconceived idea that lignite briquettes generate so much smoke and odor that they can hardly be used as cooking fuel. Since lignite briquettes are a new commodity, everything has to start from scratch. Firstly, consumers have to be informed of the existence of lignite briquettes, how to use them and their advantages. All incorrect and misguided preoccupations have to be corrected. Secondly, as lignite briquettes are a new commodity, there is no established distribution and marketing channel for them. Thirdly, since they are a new commodity without an established reputation, lignite briquettes will be very vulnerable to earning a bad reputation. Fourthly, and conversely because lignite briquettes are a new commodity, they will be very responsive to the strenuous efforts made to disseminate them; in other words, efforts well made will be well rewarded. The resources and skills the government has among the related ministries and departments, should therefore be rallied so that concerted efforts may be made for the promotion of lignite briquettes; these efforts should include the allocation of necessary budgets.

17-3 Essence of Efforts towards Dissemination

The efforts toward dissemination should correspond well to the four characteristics of lignite briquettes mentioned above while they should also be properly scheduled. The dissemination efforts to be made before the start of the pilot plant, after the start of the pilot plant but before the start of the commercial plant, and after the commercial production, should be distinguished and adequately timed.

The dissemination efforts should be timed according to the following three periods:

- (1) Before the start of the pilot plant (1st Period),
- (2) After the start of the pilot plant but before the start of the commercial plant (2nd Period),
- (3) Commercial stage (3rd Period).

17-3-1 Efforts toward Dissemination for the 1st Period

(1) Outline

The recommendations here apply to the period before the start of the pilot plant. It is recommended first of all that a policy committee and an executive committee be created consisting of the representatives of the related ministries and departments. The bench-scale plant installed at the Fuel Test Center in Rangsit should be modified to enable continuous operation. The continuous operation of the bench-scale plant would produce a maximum of 1,000 tons of lignite briquettes a year; an amount corresponding nearly to the total cooking fuel consumed by 5,000 persons a year. However, the bench-scale plant would also have to be used for the purpose of research and development; the maximum amount the plant could produce would therefore be about 500 tons a year, equivalent to the cooking fuel for about 2,500 persons.

At the beginning of the dissemination activities, lignite briquettes must be distributed free of charge among potential consumers. During this period, the available amount of lignite briquettes will be small; therefore, dissemination efforts should be focused on a designated area in order to be effective. The designated area, referred to as the "model market" for the sake of convenience, would be a local community with a population of about 25,000, consuming 10 times as much cooking fuel as the bench-scale plant will be producing.

The model market should preferably be identified in Central Region, the

most prospective market because of the scarcity of forests, among the communities where the dependence on charcoal is high and the penetration of LPG is not significant.

The dissemination activities will be done chiefly by a task force. In addition to the staff of NEA, the officers of the Department of Agricultural Extension and the Cooperative Promotion Department, the Ministry of Agriculture and Co-operatives should be the members of the task force. As is detailed in 17-4-5 and 17-4-6, the Department of Agricultural Extension has done a marvelous job in promoting biogas among farming societies in addition to popularizing new varieties of crops, agricultural chemicals, fertilizers, and new agricultural technology. The Cooperative Promotion Department works closely with farmers. Initially, lignite briquettes are distributed free of charge.

When it comes close to the start of the pilot plant, say, six months before the start, the bench-scale plant should increase production so as to expand the promotion activities to the communities surrounding the model market.

(2) Dissemination Program

The first period of the dissemination activities will be for three years from the beginning of 1992 to the end of 1994. At the beginning of 1995 the pilot plant will start according to the recommended schedule. The modification of the bench-scale plant will be finished at the end of 1992. During the year 1992, NEA does not have lignite briquettes with which to start dissemination activities; this period is nonetheless important. The success of the dissemination activities in 1993 and 1994 depends greatly upon how well these activities are planned, prepared and organized during 1992. Establishment of the task force, modification of the bench-scale plant, selection of the model market, stage setting at the model market, improvement of the stoves and their parts and public education are some of the important things that should be done well during this period.

In 1993 and 1994 NEA will have 500 to 1,000 tons of lignite briquettes

produced by the bench-scale plant. The dissemination activities will be in full swing. The task force will be in the fields. Demonstrations and distribution of lignite briquettes to the people will be daily routines of the task force during the first half of 1993. The latter half of 1993, the task force will be attending the consumers converted to lignite briquettes while vigorously converting other people. The year 1994 will be the year for expansion of the model market.

(3) Establishment of Task Force

The task force should be appointed by the executive committee. This is one of the things that should be done first. The task force should consist of manufacturing team and market team, the former in charge of manufacturing lignite briquettes on the bench-scale plant and the latter development of the market. The market team should include members of the Department of Agricultural Extension and the Cooperative Promotion Department in addition to the staff of NEA. These two organizations have closer relations with farming societies than any other governmental organizations.

(4) Modification of the Bench-scale Plant

Assuming the whole process of modification takes nearly a year, this is also one of the things that should be done immediately. The bench-scale plant at Rangsit should be modified so that the plant may be able to run continuously and to produce smoke-reduced lignite briquettes. The list of equipment and works to be done are shown at the end of this chapter. However, this should be taken as an example of many possible versions of modifications. As long as the modification achieves continuous operation and reduction of smoke safely and economically, any version of modification would meet the purpose.

(5) Selection of the Model Market

This study recommends that the model market be identified in Central Region where scarcity of the forest resources is serious. In addition to the scarcity of the forest resources, Central Region would be a con-

venient choice because of the closeness to the location of the bench-scale plant. As mentioned before, the model market would be a local community with a population of about 25,000 persons, consuming 10 times as much cooking fuel as bench-scale plant will produce. In the model market the dependence on charcoal should be high and penetration of LPG should not be significant.

(6) Stage Setting at the Model Market

Given that the model market has been selected, the stage must be set in the model market so that the dissemination activities are effective. The task force should be provided with an office room, communication facilities, means of transportation, and houses so that they can settle down in the model market. The governor of the province, the head of the district, the chiefs of the villages, heads of the local extension service offices and farmers cooperatives should be fully aware of the importance of the dissemination activities in the model market. All the influential people, the government officers, doctors, school teachers, etc. must be well informed of the importance of dissemination activities.

(7) Improved Stove

Although the quality of the lignite briquettes has been designed to burn well in the common Thai clay cooking stoves, improvement of the stoves or their parts in line with the recommendations presented in Chapter 19 would facilitate the dissemination activities. Therefore, making improved stoves or improved parts available in the model market before lignite briquettes are actually distributed among people is recommended. The expansion of the perforated area of the partition plates is easy and proved in the burning test to be effective. Small chimneys about 50 centimeters high made of clay or steel plate are effective in facilitating ignition and, therefore, should be made available. NEA has done a great deal of study in the improvement of stoves and is in an ideal position to produce and popularize improved stoves or their parts.

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(8) Education

Both extensive education towards the general populace and intensive education targeted to the people living in the model market will be needed. For the formers mass media like television, radio and newspaper should be employed. It is important that general populace know the seriousness of deforestation, the need for the development and use of appropriate substitute fuels in place of charcoal and firewood. Channel 5, a government-run station, should be employed.

In the model market more intensive education is also necessary. The members of the task force have to work to men of the house and housewives and persuade them to use lignite briquettes. How lignite briquettes can be best lit and burned should be explained in plain language to the housewives. The influential people like those mentioned in above (6), Stage Setting at the Model Market, should be asked to join force to the cause of protecting the environment. The school teachers, public officers in the case of Thailand, are in the best position to impress on the young minds the importance of the protection of the forests and the meaning of lignite briquettes against such a background.

The most effective methods must be devised by the task force. As they learn more from the experience in the field activities, they will certainly revise their teaching methods. Delivering the lignite briquettes in a bag on which are printed how to use lignite briquettes and the cause of this project could be effective.

(9) Field Dissemination Activities

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The field activities before and after the completion of the modification of the bench-scale plant would be different. Before the completion of the modification, the field activities would be of preparatory nature. It is not recommended that lignite briquettes be distributed among the potential consumers, because the existing bench-scale plant does not have a provision to reduce generation of smoke and soot. Smoke and soot, and also odors associated with smoke, are the crucial items of the

quality to which the potential consumers may react negatively, if smoke and soot are produced at their first trial burning in their kitchens. Once the potential consumers harbor bad impressions about the quality of lignite briquettes, it would be difficult to correct them. During this period, a good portion of 1992, the task force should concentrate upon education of the consumers.

After the bench-scale plant has been modified and NEA has de-smoked lignite briquettes, the task force can begin distributing lignite briquettes. At first, lignite briquettes should be distributed free of charge. The lignite briquettes should be packed in small and mediumsized plastic bags, the former weighing about one kilogram and the latter about 10 kilograms. The Agricultural Extension Department officers working in and around the model market are counted on for using their close relation with the people to influence them. The distribution of lignite briquettes should go along with public demonstration of cooking with lignite briquettes on Thai clay stoves, or improved Thai clay cook-Lignite briquettes must be given to the same families not ing stoves. just once but several times until they get used to lignite briquettes. The task force and the Agricultural Extension Department officers should visit the consumers and give instructions as to the right way of burning lignite briquettes. These activities will be done mainly in 1993 and 1994.

(10) Involvement of the Charcoal Dealers

While the above dissemination activities are under way, commercial distribution and marketing should start in preparation for the operation of the pilot plant. Lignite briquettes will be delivered and sold in bulk to the selected charcoal wholesalers in the model market and also to the Agricultural Cooperatives' shops. There, unskilled labors are employed to pack them in plastic bags for retailing at the Agricultural Cooperatives' shops and charcoal retailers. The retail price of lignite briquettes should be about 60 percent of that of charcoal. Such a narrow distribution and marketing channel will expand substantially when the commercial production starts.

(11) Expansion of the Model Market

The size of the market will have to be expanded to greater than 3,000 tons per year before the start of the pilot plant. This means that the demands for lignite briquettes in the model market, or the aggregated amounts the consumers in the model market wish to buy, must grow to 3,000 tons or more. The model market has a population of about 25,000 persons; therefore, the demands for cooking fuel are about 2,500 tons oil equivalent, or 5,000 tons if expressed in terms of lignite briquettes. It would be too much to expect that the entire production of the pilot plant, or 3,000 tons per year, or 60 percent of the consumption of cooking fuel in the model market, will be absorbed in the model market. Therefore, the activities of the task force should be expanded to the peripheries of the model market. Such possibility should be taken into consideration when the model market is selected in the first place.

(12) Intensification of Public Education

After having scored a good success in the model market, the experience of the model market should be publicized throughout the nation. The announcements in the form of a TV commercial, for example, should be repeated over and over again to bring home to the public minds the seriousness of the deforestation and the effects of lignite briquettes in curbing the deforestation. This would certainly facilitate the dissemination activities in the 2nd period.

17-3-2 Efforts toward Dissemination for the 2nd Period

(1) Outline

The dissemination efforts in this period represent the preparations necessary for the commercialization of lignite briquettes. In a way, this period is crucial to the success of the dissemination of lignite briquettes. The pilot plant will produce 3,000 tons of lignite briquettes, an amount equivalent to the total cooking fuel consumed by about 15,000 persons. The model market, with a population of 25,000,

could absorb a good portion of the amount produced by the pilot plant, provided that the dissemination efforts in the 1st period have been successfully carried out. However, the efforts during this period should be concentrated rather on the geographical expansion of the consumers of lignite briquettes in preparation for commercialization. The media, such as television and radio, should be made good use of.

The distribution and marketing network must be established and strengthened during this period. Building an entirely new distribution and marketing channel reaching the end consumers, specifically to lignite briquettes, would not be a realistic option, because this option would need too much economic and human resources to be justifiable. As mentioned in Chapter 5, lignite briquettes should ride on the existing distribution and marketing channels for charcoal from wholesalers down to retailers. Free distribution by the Agricultural Extension Department officers should continue on the one hand, while commercial marketing on the charcoal distribution and marketing channel should be promoted on the other; the volume for commercial distribution and marketing should be expanded. This would serve as a form of compensation to the charcoal dealers for the diminishing sales of charcoal. The charcoal dealers should be given enough incentive to make them keen on lignite briquettes by affording them the same margin of profit as they obtain from charcoal.

(2) Expansion of Market Area

Now that the pilot plant has become onstream, the government of Thailand has tools to develop the market. The 2nd period is crucial to the success of the commercialization in the subsequent stage.

The production of 3,000 tons per year will be absorbed in and around the model market in a way as if the model market were geographically expanding in every direction, provided the 1st period activities have been done well. The government of Thailand cannot afford to be satisfied with just selling the entire production of the pilot plant. The market must be developed in preparation for the commercialization. The pilot plant starts at the beginning of 1995 and the 50,000-ton-per-

year commercial plant at the beginning of 2000, at a five-year interval. This means that the market, not potential but real, must grow at a very high rate of 75.5 percent a year. There is a dilemma in this period that, while the market must be vigorously developed on one hand, there is no lignite briquettes to satisfy the demand being developed.

The executive committee must establish several strategic marketing areas. The criteria for the selection of the strategic marketing area would be the same as that for the selection of the model market: a local community with a high rate of dependence on charcoal and a low rate of LPG penetration. Some of the strategic areas must be selected near the regional energy centers of NEA at Chiang Mai, Ratchaburi, Ubon Ratchatani, and Mahasarakham so that these energy centers could serve as depots and distribution centers as well as the bases for the task forces.

The number of task forces should be increased so that every model market may be well attended to. Perhaps, one task force to each regional energy center would be needed. Unlike the first task force created during the 1st period, these new task forces need not have persons in charge of manufacturing. The staff of the regional energy centers, the Department of Agricultural Extension officers and the Cooperative Promotion Department officers could form the task forces. Once in a while the newly developed market should be supplied with the lignite briquettes, at first free of charge and later on a commercial base through the distribution and marketing channel for charcoal. Thus, the consumers in the strategic areas would be kept interested in and exposed to lignite briquettes until a large quantity of lignite briquettes become available by commercialization.

(3) Distribution and Marketing Channel

As is repeatedly mentioned throughout this report, creation of distribution and marketing channels specifically for lignite briquettes is not recommended. Instead, it is recommended that the existing distribution and marketing channels for charcoal be utilized for lignite briquettes. The success of dissemination of lignite briquettes among

people depends crucially upon how effective these existing channels will be in the marketing of lignite briquettes. During this 2nd period, the charcoal dealers must be prepared for lignite briquettes. They will partly be motivated by economic interest, because the price structure recommended by this study would give the present wholesalers and retailers the same margins of profits they are now getting from charcoal. This will be particularly so with the prospect that the supply of charcoal will be becoming ever more difficult. It would nonetheless take the task force persuasion and education of the charcoal wholesalers and retailers to get them interested in dealing in lignite briquettes.

17-3-3 Commercial stage (3rd Period)

The dissemination efforts during this period should be oriented toward a quantitative and geographical expansion of market on the one hand, and perhaps more importantly on the other hand, toward creating an environment in which the business of lignite briquettes becomes self-sustainable, or financially feasible. If a fair margin of profit can be expected from the lignite briquette business, there will be private entrepreneurs entering this business. This is the only way that lignite briquettes will take off as a sound business. The production of lignite briquettes will increase whereby the substitution of charcoal will proceed so as to achieve the objective of curbing the destruction of the forests.

The role of the government lies in helping create an environment where the lignite briquette business can stand on its own feet financially rather than supporting it indefinitely as a dependent industry, mainly by the following provisions.

- (1) The electric power generation and cement have taken priority in the proration of lignite. Lignite briquettes should take priority in the proration of high-quality lignite.
- (2) The lignite briquette industry should have its income tax

reduced by the amount equivalent to the contribution made to the savings in replantation costs realized by the lignite briquettes it produces.

- (3) The domestic machine industry should be fostered so that future plants may be constructed at lower costs using mainly domestic machines. The machines to be used for such lignite briquette plants should be exempted from the 3.3 percent sales tax.
- (4) The manufacturers of lignite briquettes should be guided so as to maintain the quality of lignite briquettes at the level proposed by this study as a standard quality.
- (5) Controls on the production and sales of charcoal should be intensified in keeping pace with the production of lignite briquettes, without straining the supply of cooking fuel.

17-4 Roles of the Government

This study sets the consumer price of lignite briquettes at a level competitive with that of charcoal in conformity with the results of the monitoring survey. However, although the size of the potential market is large, it must be remembered that the market is still only a potential one, not a real one. So that the market for lignite briquettes may become a real one and grow to an economical size, the development of the market under the minute care of the government is indispensable. The lignite briquette development project has so many versatile aspects that the concerted efforts of a number of government offices are essential for its successful realization. The nation needs this industry to help protect the environment, so this project deserves attentive care by the government until it can stand on its own feet.

At the central administration, the policy committee and the executive committee should be established to coordinate government works. In the field, task forces should be set up. The administrative authorities at the levels of province, district, and village must support the dis-

semination activities.

17-4-1 Government Committee

NEA and the Ministry of Science, Technology and Energy should coordinate with other ministries to establish a policy committee and an executive committee consisting of the representatives of the related offices of the government. The following organizations may be considered to have roles to play and should therefore be represented in the committees. NEA, the promoter of this pilot plant project; the Ministry of Science, Technology and Energy to which NEA belongs; the Office of the National Environmental Board; the Ministry of Agriculture and Cooperatives and its important executive arms, the Department of Agricultural Extension and the Cooperative Promotion Department; the Royal Forestry Department; the Ministry of Industry; the Department of Mineral Resources; the Ministry of Interior; the Office of the Prime Minister, and two of its functional arms, the National Economic and Social Development Board and the Department of Technical and Economic Cooperation.

The policy committee will have the following roles to play:

- To appoint the members of the executive committee; the committee members should be capable officers with practical experience and knowledge,
- (2) To approve the expenditure recommended by the executive committee and applications of budget to the Ministry of Finance,
- (3) To review periodically the dissemination activities and make corrections if necessary,
- (4) To conduct PR activities to educate the people on a wide scale,
- (5) To appraise the capabilities available in Thailand and decide

on the necessity of assistances from abroad, and

(6) To mobilize the capabilities of the organization to which each committee member belongs for the sake of promoting lignite briquettes.

The executive committee will have the following functions:

- (1) To support the activities of NEA for the promotion of lignite briquettes,
- (2) To analyze and resolve any problems that may occur in the procurement and transportation of the raw materials, production, storage and transportation of the product lignite briquettes, distribution, marketing, quality, consumer behavior, financial status of the project, and all other problems that may hinder smooth dissemination, and
- (3) To keep the policy committee well informed so that the policy committee may be able to respond adequately.

17-4-2 Cooperation from Other Ministries

This project is so versatile in nature that the Ministry of Science, Technology and Energy cannot cover everything. For a successful realization, cooperation from other ministries and departments is needed. At the initial stage, lignite briquettes must be distributed among potential consumers free of charge. Arrangements must be made to cover the cost of production and transportation. In this connection, the understanding of the Ministry of Finance will be necessary. The public must be educated about the seriousness of deforestation. The mass media, TV and radio, owned by the government must work in this direction. The administrative channels through the provinces, districts and down to the villages must work effectively. The Department of Agricultural Extension and the Cooperative Promotion Department of the Ministry of Agriculture and Co-operatives would be the only effective organizations that could work directly with potential customers in

rural communities. The Royal Forestry Department should put an effective ban on the production of charcoal and firewood, and is in a position to support this project in a positive manner for the purpose of protecting the forests.

17-4-3 Budget

The following budgets will be necessary for this project.

		Period	(Unit: Bahts)
			32,000,000
	ı.		
	2.	Distribution of lignite briquettes	4,500,000
(2)	2nd	i Period	
		Investment in the pilot plant	68,043,000
		Distribution of lignite briquettes	
	3.	Compensation for the loss by the pilot plant	64,471,000

(3) 3rd Period

1. Investment in the commercial plant

270,066,000

The loss by the pilot plant will be recovered by the commercial plant. The costs incurred by the media owned by the government and the services of the government officers are not included.

17-4-4 Mass Education

As a result of the monitoring survey, it was learned that ordinary people are not fully aware of the seriousness of deforestation and the adverse effects the deforestation could have on the nation and the people. Ordinary people must be educated about these points, as well

as about lignite briquettes. Visual presentations would be most impressive, so television should be made full use of. Nearly 50 percent of the households own television sets, which means that television would prove to be very effective.

17-4-5 Agricultural Extension Service

The Department of Agricultural Extension and the Cooperative Promotion Department of the Ministry of Agriculture and Cooperatives are in a best position to be able to offer constructive cooperation to the dissemination of lignite briquettes. The Department of Agricultural Extension has 73 provincial offices and 725 district offices covering the entire kingdom in addition to its mighty central administration. primary missions are dissemination of advanced agricultural technology, improvement of agricultural productivity, increase in the income of farmers and improvement of their living standards, control of plant diseases and pests, harmonious development of agriculture, forestry, animal husbandry and fishery, introduction and dissemination of highyielding varieties of crops, education of farmers. It has in its central administration a division dedicated to the training of its staff and farmers. It is worth mentioning that the Department of Agricultural Extension had installed 2,896 biogas facilities throughout Thailand since 1980 until 1990.

Table 17-1 Biogas Plants Constructed by DOAE

Region t	o 1985	1986	1987	1988	1989	1990	Total
North	384	54	130	89	31	44	732
North East	495	41	42	61	17	. 11.	667
Central	196	19	30	22	29	22	318
East	257	36	46	43	14	-	396
West	232	13	14	18	- 6	4	287
South	386	43	23	44			496
Total	1,950	206	285	277	97	81	2,896

Recently, the pace of installation has been declining due to the lack of cow dungs. This achievement may be considered as a demonstrated capability of the Department of Agricultural Extension in the field of household fuels, which may as well be expected to be very effective in the promotion of lignite briquettes. The Department of Agricultural Extension should be the members of the task forces for the promotion of lignite briquettes.

The organization of the Department of Agricultural Extension is shown in Figure 17-1.

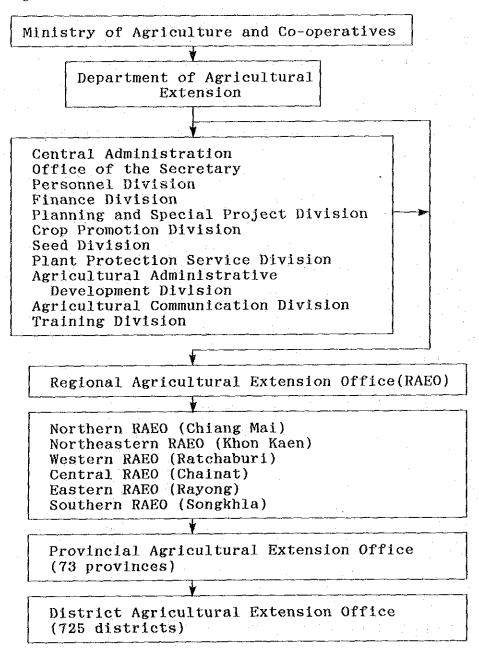


Figure 17-1 Organization Chart of Department of Agricultural Extension

As shown in Table 17-2 the Department of Agricultural Extension has a staff of more than 10,000, of which more than 9,500 are assigned to the fields.

Table 17-2 Manpower of Department of Agricultural Extension
(As of 20, April 1988)

	Central Administration	Provincial Administration	Total
Doctoral degree	8	-	8
Master's degree	173	61	234
Bachelor's degree	740	2,037	2,777
Agricultural Certificat and Diploma	e 738	5,698	6,436
Vocational Certificate	414	1,702	2,116
Vocational Rice Certifi	cate	21	21
Elementary		23	23
Total	2,073	9,542	11,615

17-4-6 Agricultural Cooperatives and the Cooperative Promotion Department

The Agricultural Cooperatives of Thailand is a huge nation-wide organization firmly and deeply rooted in the rural farming society. As of 1990 the number of local cooperatives is 1,472, holding a membership of 995,733 families, or an average of 676 families for a cooperative. The well-known missions are collection of paddy from the farmers, advancement of loans to the farmers, loans of rice and fertilizers. The cooperatives also sell daily necessities at their local offices. The cooperatives are supported at every level by the Cooperative Promotion Department of the Ministry of Agriculture and Cooperatives. The Bank for Agriculture and Agricultural Cooperatives, a bank directly controlled by the Ministry of Finance, facilitates credits to the cooperatives.

The vertical structure of the Agricultural Cooperatives of Thailand is shown in Figure 17-2 below; at every level it is supported by the Cooperative Promotion Department of the Ministry of Agriculture and Co-Operatives.

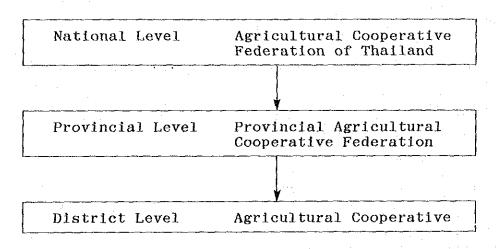


Figure 17-2 Vertical Structure of Agricultural Cooperatives

Figure 17-3 shows the organization of the Cooperative Promotion Department of the Ministry of Agriculture and Cooperatives. Like the Department of Agricultural Extension, it is a nation-wide organization with 73 provincial offices and 695 district offices, in close contact with the target consumers of lignite briquettes, or present charcoal consumers in the local communities. They could sell lignite briquettes just as they are selling fertilizers and agricultural chemicals, or other daily necessities. Their staff should be the members of the task forces.

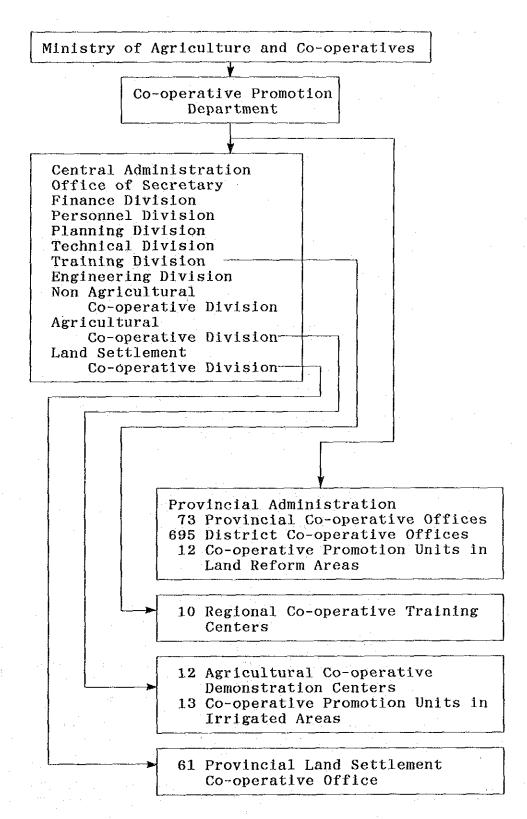


Figure 17-3 Organization Chart of Cooperative Promotion Department

17-4-7 Organization Chart

The recommended organization of the government for the dissemination of lignite briquettes is shown in Figure 17-4.

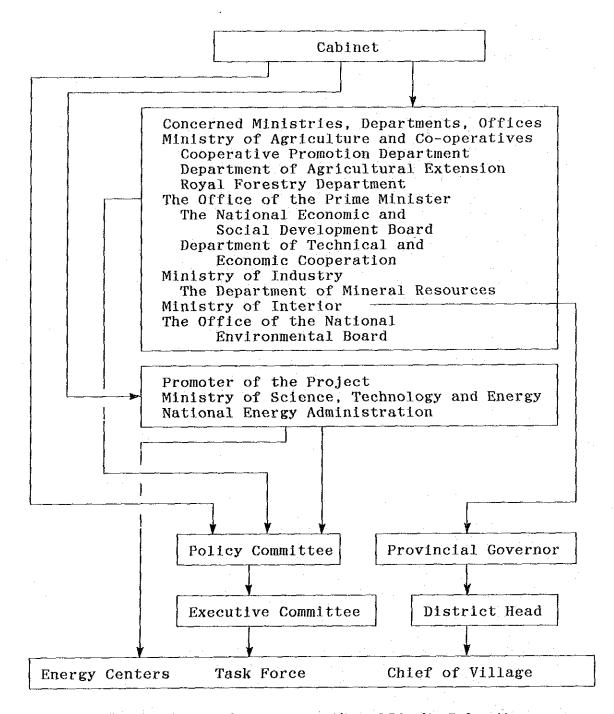


Figure 17-4 Organization for Promotion of Lignite Briquettes

17-5 Modification of the Bench-scale Plant

The proposed modification to the bench-scale plant is given below. The following estimates of the cost is based on the assumption that all machines and equipment are designed and manufactured in Japan and imported into Thailand.

(Unit: 1,000 bahts)

De-smoking and associated facilities	9,000
Raw material pretreatment and associated facilities	1,900
Hot air generator and associated facilities	1,700
Feeders and silos, associated facilities	3,500
Supervision on installation	1,700
Ocean transportation	700
Domestic portion	13,500
Total	32,000

17-6 Dissemination Activities in Perspective

Figure 17-5 shows sequence of activities in terms of the period, promoter, plant in operation, organization and incentives.

		1st Period				2nd P	2nd Period					3rd Period	eriod	:
Year	1	2	3	4	5		9	7	8		· os		10	11 and on
Promo- ter				National Energy Administration supported by Policy Committee	rgy Adminis	tratio	roddns u	ted by Pol	icy Com	mittee				
Plant in Operat'n	BS Plant	Modified BS Plant	BS Plant			Pilot	Pilot Plant				ပိ	Commercial	al Plant	دب
Organi- zation	Policy committee . Executive committee . Task force . Model market	y committee utive committee k force . Model market						.More task forces .Wore model markets	orces	Ø				
Major Activity	Establish policy of Establish executions. Form task force Start mass educe . Select model . Prepare model . Start model .	Establish policy committee .Establish executive committee .Form task force .Start mass education .Select model market .Prepare model market .Start modified BS Plant .Start modified Nord disk	ttee owmittee n et arket jed BS Plant Expand dis	semination a ensify disse	ion sctivity around the model dissemination activity . Intensify mass education . Start intensifying . Intensify marketin . Establis	und thativity in the second six of the second si	e model ucation sifying arketin stablis	y around the model market on activity activity seducation Start intensifying geographical expansion Intensify marketing on the charcoal marketing Intensify marketing for the charcoal marketing Form more task forces . Select more model markets	ial expa larcoal lity sta lask for	nsion marketin ndards o ces markets	channel lígnite	briquettes	ئ د د د د	
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Figure 17-5 Sequence of Activities for Dissemination of Lignite Briquettes

Chapter 18 Experimental Production of Lignite Birquettes

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Chapter 18 Experimental Production of Lignite Briquettes

18-1 Purpose and Method of the Experimental Production

The purpose of the experimental production of lignite briquettes was to experimentally confirm, in Japan prior to the monitoring survey, the technical feasibility of manufacturing lignite briquettes which would satisfy the quality required by the market, from the raw materials under consideration: Ban Pa Kha lignite, Thai domestic biomass -- bagasse, rice straws, rice husks -- and a Thai domestic desulfurizing agent. In other words, the purpose was to establish the raw material compositions and operating conditions that would make this possible. The required quality was represented by the tentative quality design of lignite briquettes which was established during the first-phase field survey of the first-stage study. The tentative quality design was developed based on the surveys upon the lifestyles and cooking habits of the Thai people, in such a way as to enable lignite briquettes to become a substitute for charcoal. The quality design is detailed in Chapter 6. Of all the attributes of quality, the experimental production attached particular importance to the following items:

- (1) Ease of ignition,
- (2) Reduced generation of smoke,
- (3) Control of irritation to the throat and eyes by smoke, and suppression of the generation of sulfur dioxide,
- (4) Sufficient strength of the lignite briquettes to allow easy transportation and storage,
- (5) Greater heating value, and
- (6) Water-repellence.

To make the best use of the limited quantities of the samples of raw materials, the experimental production was executed in three steps consecutively on larger scales; small tablets were produced on a very small scale at first, and then briquettes were produced by a bench-scale plant and finally by a commercial plant. The experiment using tablets determined promising ranges of the composition of the raw materials. The experiment at the bench-scale plant confirmed by ac-

tually producing briquettes the raw material composition and operating conditions in which the desired briquettes could be obtained. The experiment at the commercial plant finally established the raw material composition and operating conditions. The experiments at the bench-scale plant and commercial plant produced sufficient amounts of briquettes to enable various tests including burning tests to be conducted concurrently. The results of these tests were studied immediately and the conditions of the experimental production were adjusted to produce lignite briquettes that could better meet the requirements. The burning test is detailed in the next chapter.

18-2 Achievements of the Experimental Production

As a result of the experimental production conducted in Japan, the feasibility of producing from Thai domestic raw materials lignite briquettes satisfying virtually all the quality requirement has been confirmed; in other words, the raw material composition and operating conditions have been determined. However, this statement is not exactly correct in that samples of Japanese rice straws and rice husks were used in place of their Thai counterparts which could not be imported on account of certain statutory restrictions in Japan. Therefore, it remained unconfirmed at the stage of the experimental production that the results of the experimental production could apply to Thai rice straws and rice husks.

This question was dismissed during the second-phase field survey when the bench-scale plant installed in Thailand reproduced similar results with Thai rice straws and rice husks.

The lignite briquettes experimentally produced in Japan failed to satisfy certain items of the tentative quality design. They satisfy, however, the definitive quality design finalized during the second-phase field survey, reflecting the results of the monitoring survey. The results of the experimental production detailed in the following pages conclude that the standard composition of the raw materials to achieve the required quality is 80 percent for lignite and 20 percent for biomass, plus zero to 30 parts of the desulfurizing agent,

preferably slaked lime, to 100 parts of the above blend. This blending formula was finally revised as per explained in 18-11.

18-3 Technology Employed for the Experimental Production

The following four schools of technology are currently employed for the production of coal briquettes.

- (1) Carbonization process
- (2) Wet process
- (3) Binder process
- (4) High-pressure compression process with biomass

This experimental production employed the high-pressure compression process with biomass for the following reasons.

The carbonization process eliminates any volatile matter and impurities like sulfur by virtually carbonizing the feed coal through heating. This process has an important advantage in that briquettes of good quality may be obtainable even from feed coal of low quality. The drawback to this process is that the volatile matter constituting a significant portion of the energy of coal will be lost in addition to the higher costs of equipment and operation.

The wet process produces briquettes by extruding a dough of coal particles and drying the extrudates. This process may be characterized by the lower costs of equipment and operation. However, the quality of the briquettes is generally poor.

The binder process generally uses coal fines. The coal fines are blended with a binder like starch, pitch or, clay, and then molded. In this process, the quality of the briquettes varies depending upon the binder employed. Expensive binders must be used to produce briquettes of good quality.

The high-pressure compression process with biomass produces briquettes by compressing under high pressures a blend of coal particles, biomass and a desulfurizing agent like slaked lime. The biomass acts as a binder and helps combustion. The advantage of this process is the lower cost of equipment and operation. The briquettes are generally easy to burn. However, the optimum operating conditions are difficult to fix. Therefore, it is necessary to confirm the quality of the products and the optimum operating conditions through experimental production prior to the adoption of this process.

It is considered best to use the high-pressure compression process with biomass in the case of this project in consideration of the characteristics of these four processes and the required quality of the product briquettes.

18-4 Tests on Raw Material Samples

18-4-1 Samples for the Experimental Production

(1) Quantities of Samples

The following quantities of samples were imported and delivered to the test site in Japan.

(1)	High-quality Ban Pa Kha lignite, ton	3.0
(2)	Low-quality Ban Pa Kha lignite, ton	1.0
(3)	Bagasse, ton	1.0
(4)	Slaked lime, ton	0.5

(2) Lignites

The samples are high-quality and low-quality lignites from the Ban Pa Kha Mine situated in Northern Region of Thailand. The samples were taken in the presence of an officer of the mine and the study team. The samples were then transported to Japan in sealed drums.

(3) Biomass

Thailand's agriculture is very versatile, so there is a variety of

biomass. Bagasse, rice straws and rice husks were selected as candidates in view of their availability, prices, present applications, and ease of collection. The bagasse sample was collected near Bangkok and sent to Japan. However, rice straws and rice husks were not imported to Japan because of certain statutory restrictions; the experimental production used Japanese rice straws and rice husks as substitutes. The bagasse sample arrived frozen at the test site; presumably a portion of moisture was lost during transportation.

(4) Desulfurizing Agent

The lignites, the main raw materials, contain sulfur and therefore produce sulfur dioxide upon combustion. Accordingly, it is necessary to add a desulfurizing agent like slaked lime or calcium carbonate which can fix the sulfur dioxide when generated.

Thailand is rich in lime, and slaked lime is produced in large quantities; slaked lime is selected as the desulfurizing agent. The samples of slaked lime were transported in a sealed drum. However, it contained moisture at 25 percent. As will be explained later, Japanese slaked lime was also used for the experimental production, because the sample of slaked lime, although dubbed as slaked lime, proved to consist mainly of calcium carbonate which is less effective in desulfurization than actual slaked lime.

18-4-2 Preparation of the Samples for Briquetting

(1) Lignite

Both lignites were dried to a moisture content of less than two percent, and then crushed to less than two millimeters. Each sample was thoroughly mixed and stored in drums.

(2) Biomass

The biomass samples were dried to a moisture content of about four percent, and then cut to less than two millimeters or less than three

millimeters by a cutting crusher equipped with classifying screens.

(3) Desulfurizing Agent

The sample of the Thai desulfurizing agent was dried to a moisture content of about one percent, and then ground and screened to less than 0.5 millimeters. The Japanese slaked lime was used as purchased.

The moisture contents of the samples as received and the pH values of the separated water are shown in Tables 18-1 and 18-2, respectively. The particle distribution of the crushed lignite samples and biomass samples are shown in Tables 18-3 and 18-4, respectively.

Table 18-1 Analysis of Moisture of the Samples, wt%

q	uality	Low- quality lignite	slaked	Bagasse	Rice straw	Rice husks
	22.8	17.6	24.6	41.22	7.4	15.4

Table 18-2 pH Value of the Separated Water from the Samples

•	quality	Bagasse	Rice straws	Rice	husks	
4.7	5.4	7.1	7.2	6.2	. :	1

Table 18-3 Particle Distribution of the Lignite Samples

	Particle size, mm	High- quality lignite	Low- quality lignite	÷	
	2.0mln.	0.18	0.20		
	1.0/2.0	7.26	7.25		
	0.5/1.0	26.30	28.54	$(-1) \forall -1$	- 11
	0.25/0.5	29.78	27.77		
	0.25max.	36.48	36.25	<u> </u>	
Bulk der	nsity, g/cm ⁸	0.75	0.77		

Table 18-4 Particle Distribution of the Biomass Samples

Biomass mmMax.	Bagas- se 3	Bagas- se 2		Rice straws 2	Rice husks 3	Rice husks 2	Raw bagas- se	Raw rice husks
2.0 min.	0.16	0.00	0.30	0.00	0.41	0.00	52.21	72.47
1.0/2.0	29.52	15.84	22.23	9.97	9,01	3.49	27.18	24.74
0.5/1.0	39.81	45.69	35.92	37.32	42.83	56.98	12.79	1.78
0.25/0.5	21.89	37.94	26.51	34.22	29.71	30.70	6.00	0.79
0.25 max.	8.62	0.53	15.03	18.50	18.04	8.83	1.82	0.22
Bulk densit	y 0.125	0.196	0.152	0.189	0.353	0.355		

18-4-3 Analysis of the Samples

(1) Lignites

Table 18-5 shows the analyses of the high-quality and low-quality lignites.

Table 18-5 Analysis of the Lignite Samples

Sample		High-quality lignite		Low-quality lignite		
Base	Wet	Dry	Wet	Dry		
Moisture,%	12.6		9.5	_		-
Ash,%	10.7	12.2	19.5	21.5		
Volatile matter,%	39.5	45.2	38.7	42.8		
Fixed carbon,%	37.2	42.6	32.3	35.7		
Gross heating	5,590	6,396	5,260	5,812		
value, kcal/kg						
Sulfur,% Total		1.03		2.08		
	bustible	0.27		0.45		
Combu	stible	0.76		1.63		*
Carbon,%		63.7		57.2		
Hydrogen,%		4.44		4.27		
Nitrogen,%	•	0.97		0.80		
Oxygen,%	**	18.11	1.1	14.50		:
HGI	38		52	18 18		

The heating value, ash content, sulfur content and Hardgrove Grindability Index are particularly important from the viewpoint of manufacturing briquettes. These attributes are shown below for both types of lignite.

Lignite	High-quality	Low-quality
Ash, wt%	12.2	21.5
Total sulfur, wt%	1.03	2.08
Combustible sulfur, wt%	0.76	1.63
Gross heating value, kcal/kg	6,396	5,812
Hardgrove Grindability Index	38	. 52

The high-quality lignite contains little ash and sulfur and has a higher heating value; the high-quality lignite should be a good raw material for briquettes. However, the low Hardgrove Grindability Index may suggest low moldability. By contrast, the low-quality lignite would be better in moldability, but would be inferior as a raw material; the use of low-quality lignite may make it difficult to meet the required quality.

Figures 18-1 and 18-2 show the X-ray diffraction of both lignite samples. The X-ray diffraction indicates that both lignites contain pyrite which generates sulfur dioxide on combustion. Table 18-6 gives the sulfur in the lignites by type of compound. The sulfate sulfur is incombustible, while the pyrite sulfur and organic sulfur are combustible.

(2) Biomass

Table 18-7 presents the analyses of biomass. The ash content of bagasse is 3.5 percent which is less than that of rice straws and rice husks. Its heating value is relatively high at 4,985 Kcal/kg. The sulfur contents are less than 0.1 percent for all types of biomass.

As far as these analyses can indicate, bagasse promises to be the best biomass raw material among the three; however, bagasse normally has a high content of moisture at about 50 percent, and the cost associated with drying should be taken into account when assessing biomass raw materials.

Table 18-6 Distribution of Sulfur in Lignites by Type of Compound, wt%

	High-quality lignite	Low-quality lignite	
Total sulfur	1.0	1.8	
Sulfate sulfur	0.0	0.1	
Pyrite sulfur	0.3	0.8	
Organic sulfur	0.7	0.9	•

Table 18-7 Analysis of the Biomass Samples

Sample	Baga	Bagasse		Rice straws		Rice husks	
Base	Wet	Dry	Wet	Dry	Wet	Dry	
Moisture,%	2.5	_	2.2	_	1.2	_	
Ash,%	3.4	3.5	16.6	17.0	15.8	16.0	
Volatile matter,%	83.3	85.4	66.8	68.3	67.7	68.5	
Fixed carbon,%	10.8	11.1	14.4	14.7	15.3	15.5	
Gross heating	4,860	4,985	3,910	3,998	4,070	4,119	
value, kcal/kg							
Sulfur,%							
Total		0.06		0.16	3	0.06	
Incombustible		0.03		0.08	3	0.02	
Combustible		0.03		0.08	3	0.04	
Carbon,%		48.00		41.80)	42.20	
Hydrogen,%		5.89		5.13	5	5.10	
Nitrogen,%		0.23		0.64	1	0.35	
Oxygen,%		42.35	•	35.30)	36,31	

(3) Desulfurizing Agent

Table 18-8, and Figures 18-3 and 18-4 show respectively the analysis of the desulfurizing agent, X-ray diffractions of the Thai sample, and the slaked lime of Japanese origin. The X-ray diffraction of the Thai sample indicates a peak of calcium carbonate, but does not indicate the peak of calcium hydroxide which is clearly indicated by the Japanese

slaked lime. It may therefore be concluded that the sample of Thai slaked lime consisted mainly of calcium carbonate. This is presumably because, during the production, the temperature of calcination did not reach 900 C at which calcite, the main component of limestone, decomposes.

Table 18-8 Analysis of the Desulfurizing Agents, wt%

	Thai slaked lime	Japanese slaked lime
Moisture	0.65	
Ignition loss	41.24	-
SiO ₂	3.94	- ' ' '
Al ₂ 0 ₃	0.13	-
Fe ₂ 0 ₃	0.08	- '
Ca0	49.69	71.1
MgO	2.01	-
Na ₂ O	2.98	•
K20	0.06	•
S0s	0.09	*
Purity	65.4	96.1

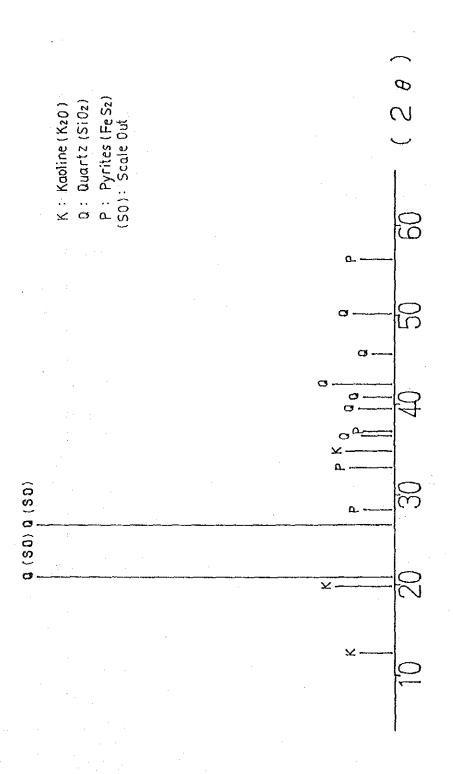


Figure 18-1 X-ray Diffraction Pattern of High-quality Lignite

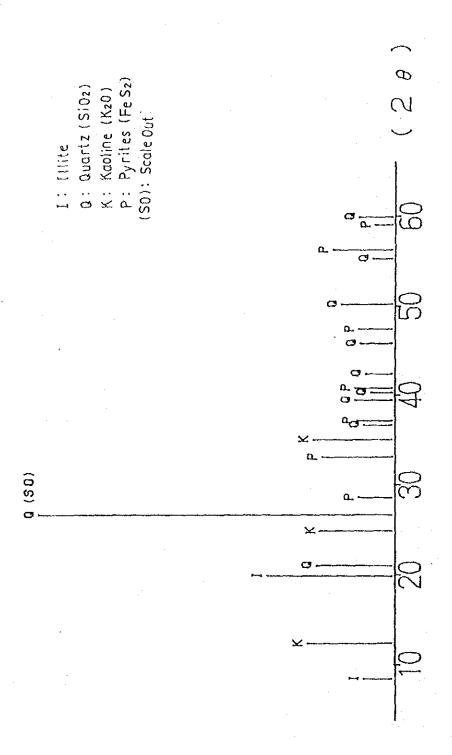


Figure 18-2 X-ray Diffraction Pattern of Low-quality Lignite

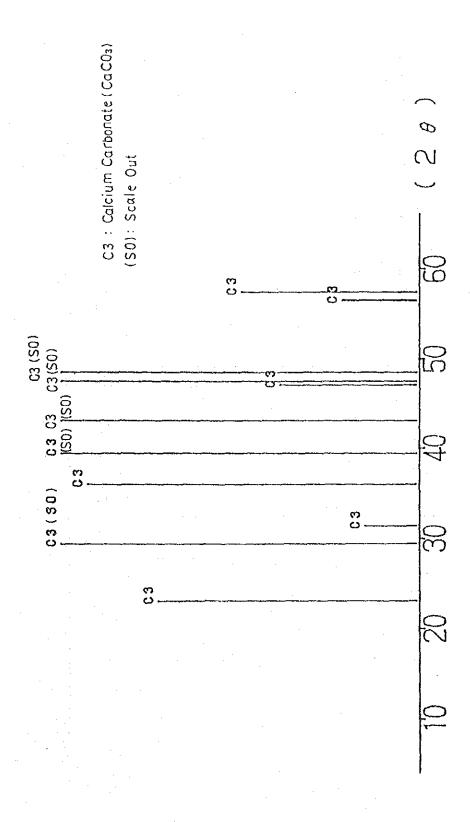


Figure 18-3 X-ray Diffraction Pattern of Slaked Lime Sample

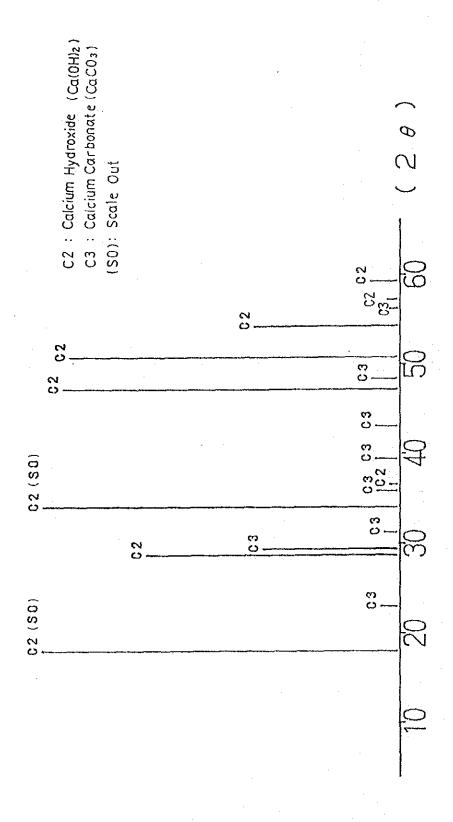


Figure 18-4 X-ray Diffraction Pattern of Japanese Slaked Lime

18-5 Tablet Test

18-5-1 Test Method

Before attempting to produce lignite briquettes, tablets were produced as a preliminary test to find the optimum composition of the raw materials. The breaking strength and spring-back ratio were measured as the criteria of quality. This test consumes only a very small amount of raw material and is simple to conduct; the tablet test is indispensable as a preliminary step in briquette manufacturing.

Figure 18-5 shows the mold used for making the tablets. The blended powdered samples were compressed to form tablets. The composition ranged from 60 to 100 percent for the lignite and 0 to 40 percent for the biomass. Table 18-9 shows the conditions for making tablets.

Table 18-9 Tabletting Condition

Sample, grams	3.0
Diameter, mm	15
Sample temperature, C	20, 50, 80
Compression pressure, tons/cm ²	2.4
Compression time, second	10

As shown in Figure 18-6, a steel ball with a diameter of 20 millimeters is placed on a tablet in a universal tester and the ball is forced down onto the tablet until the tablet breaks. The breaking strength is the force applied on the tablet in kilograms at which the tablet breaks.

The molded tablet expands a little in size after the compression is relieved. The extent of the expansion, or spring-back ratio, is closely associated with the strength of the briquettes and the moldability of the material; generally, the smaller the spring-back ratio is, the stronger the briquette will be and the better the moldability will be. The spring-back ratio is given by the following equation:

Spring-back ratio = $(T_1 - T_0)/T_0$

where To: Thickness of tablet after compression

T₁: Thickness of tablet after the compression is relieved

18-5-2 Breaking Strength

Figures 18-7 and 18-8 show the breaking strength of the tablets prepared from high-quality and low-quality lignites, respectively. The breaking strength becomes increasingly higher for both lignites as the content of the biomass increases. This trend decreases in the order of bagasse, rice straws and rice husks. Both lignites show similar trends with bagasse and rice straws, but behave differently when rice husks are blended. The blending ratio of the biomass which achieves a breaking strength of 100 Kgf, a strength considered to meet the quality requirement, is 13 and 20 percent with bagasse and rice straws, respectively, for both lignites, and 30 and 40 percent with rice husks for high-quality lignite and low-quality lignite, respectively.

18-5-3 Spring-back Ratio

Figures 18-9 and 18-10 show the spring-back ratio of the tablets prepared from high-quality and low-quality lignites, respectively. When bagasse is blended, the spring-back ratio is nearly constant at 27 percent up to a blending ratio of 25 percent; the spring-back ratio begins to increase as the blending ratio of the biomass is further increased. With other biomass, the spring-back ratio increases as the blending ratio increases. The low-quality lignite shows slightly higher spring-back ratios than the high-quality lignite.

18-5-4 Heated Tablet Test

Heating the raw materials before briquetting is an effective way to increase the breaking strength and to decrease the spring-back ratio. Tests were conducted with high-quality lignite, bagasse and slaked lime according to the blending ratios shown in Table 18-10. The results of the tests are shown in Figures 18-11 and 18-12.

Table 18-10 Mixing Ratios of the Samples for Tabletting (Heating Test)

High-quality lignite, wt%	75	80	
Bagasse, wt%	25	20	
Slaked lime, external %	5	5	
· ·			

The figures show an increasing breaking strength and a decreasing spring-back ratio with temperature. This is attributable to the enhancement of the plastic deformation of the biomass by heat.

18-5-5 Tablet Test with a Mixed Biomass

Making tablets with rice husks and lignite alone was difficult, because the spring-back ratio became too high at blending ratios of rice husks high enough to provide a sufficient breaking strength. Bagasse and rice straws are the preferred biomass. However, bagasse is not available in a large quantity in Thailand. Blends of rice husks with bagasse and rice straws were tested in blending ratios shown in Table 18-11.

Table 18-11 Mixing Ratio of Samples for Tablets (Biomass Evaluation), wt%

	80 80	80	80	80	80
Document					
Bagasse 0 5 10 15 2	20 -		-	-	
Rice straws	- 0	5	10	15	20
Rice husks 20 15 10 5	0 20	15	10	5	0

Figures 18-13 to 18-16 show the results of these tests. Spring-back ratios of less than 25 percent are obtained for all the blends, indicating a good moldability. A breaking strength of greater than 100 Kgf is obtained when bagasse or rice straws is blended at more than five percent. It follows that rice husks may be used with other biomass.

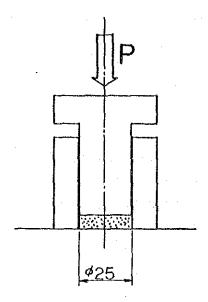


Figure 18-5 Mold Used for Tabletting

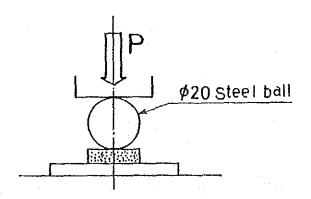


Figure 18-6 Universal Testing Machine with a Jig

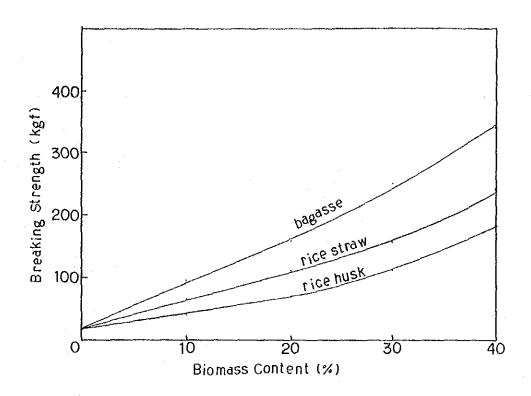


Figure 18-7 Breaking Strength of Tablet with High-quality Lignite

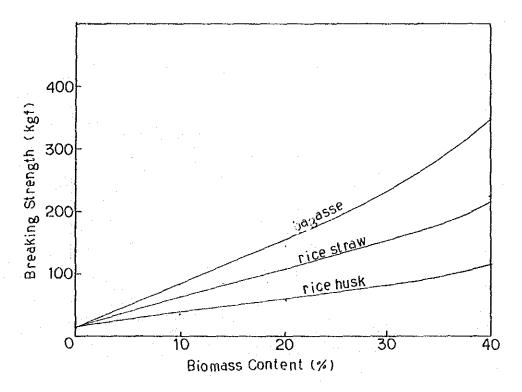


Figure 18-8 Breaking Strength of Tablet with Low-quality Lignite

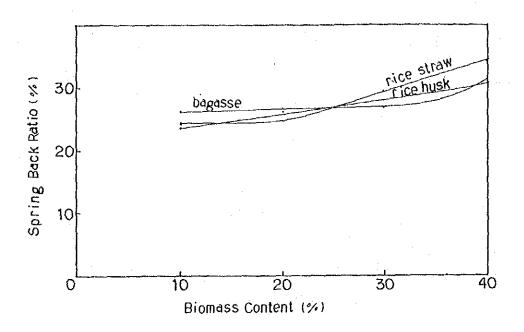


Figure 18-9 Spring Back Ratio of Tablet with High-quality Lignite

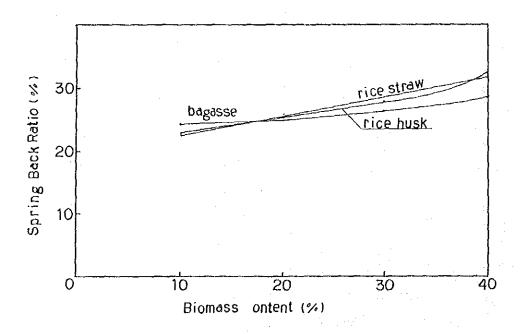


Figure 18-10 Spring Back Ratio of Tablet with Low-quality Lignite

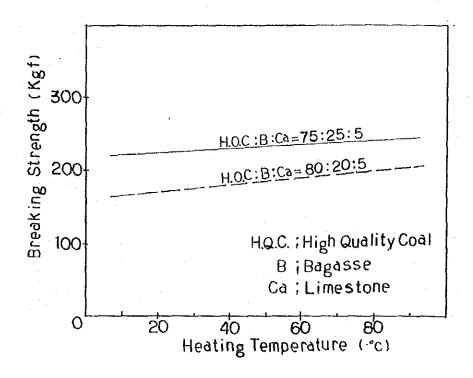


Figure 18-11 Effect of Material Heating on Breaking Strength

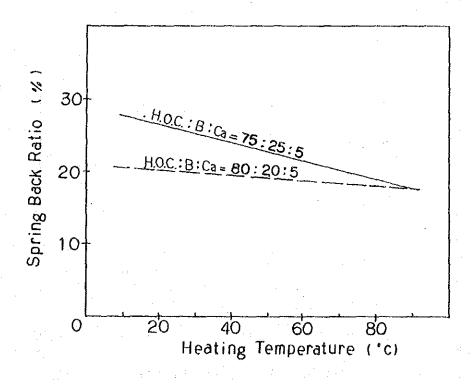


Figure 18-12 Effect of Material Heating on Spring Back Ratio

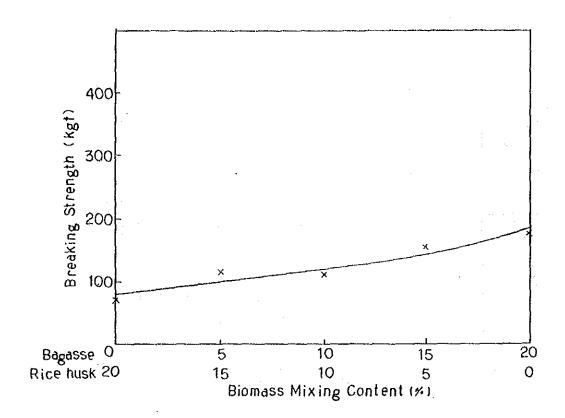


Figure 18-13 Breaking Strength of Tablet with High-quality Lignite

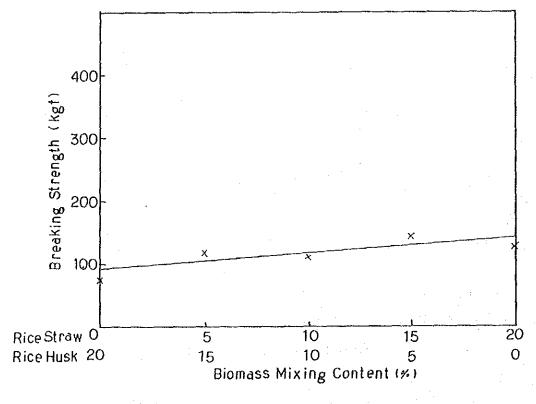


Figure 18-14 Breaking Strength of Tablet with Low-quality Lignite

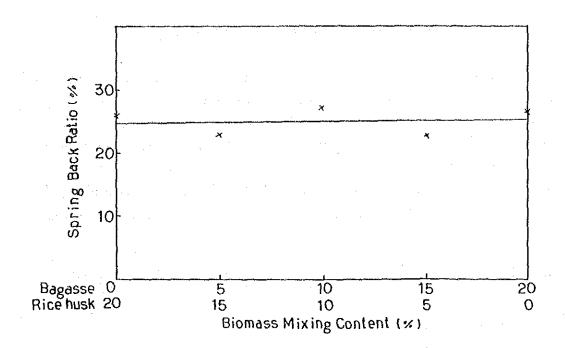


Figure 18-15 Spring Back Ratio of Tablet with High-quality Lignite

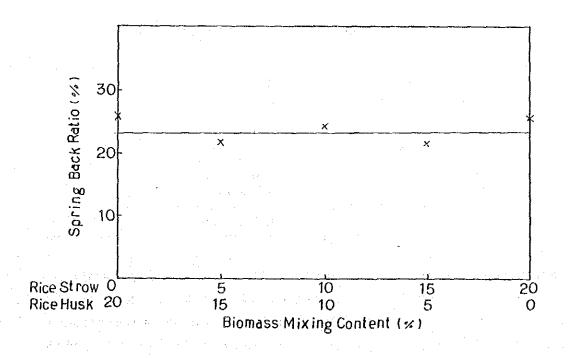


Figure 18-16 Spring Back Ratio of Tablet with Low-quality Lignite