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	FIRROI		FIRROE	
	B/T	A/T	B/T	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, percent				
+10	10.1	8.4	11.6	8.9
-10	13.4	11.8	17.4	14.9
Raw Materials, percent				
+10	9.4	7.8	10.5	7.7
-10	13.7	12.1	18.1	15.7

Operating Rate, (percent/year)	1st year	2nd year	3rd year	4th year	5-15th 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, percent (Constant Price)				
2			19.9	17.9
5			17.5	15.2
16			8.5	5.1

I. COST OF GOODS SOLD - CASE 1

CASE 1 (PILOT PLANT WITH A CAPACITY OF 3,000T T/Y) Unit: 1,000 Bahts

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
(+) Raw material Inventory at Beg.	141	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176
RAW MATERIAL PURCHASED	2,280	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	2,806	2,806	2,806	2,630
(-) Raw Material Inventory at End	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	0
RAW MATERIAL COST																				
Lignite	1,398	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747	1,747
Rice straw	295	369	369	369	369	369	369	369	369	369	369	369	369	369	369	369	369	369	369	369
Slacked Lime	552	690	690	690	690	690	690	690	690	690	690	690	690	690	690	690	690	690	690	690
Sub-total	2,245	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	2,806	2,806	2,806	2,806
VARIABLE OPE-COST																				
Electricity	1,157	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel	296	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370
Transportation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-total	1,453	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	1,743	1,743	1,743	1,743	1,743
FIXED OPE-COST																				
Manpower Cost	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682	2,682
Maint. Ins. & Tax	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824
Overhead	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012	2,012
Sub-total	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517	6,517
DEPRECIATION & AMORTIZATION																				
Depreciation																				
Plant	4,728	4,728	4,728	4,728	4,728	4,728	4,728	4,728	4,728	4,728	0	0	0	0	0	0	0	0	0	0
Bldg & Const'n	393	393	393	393	393	393	393	393	393	393	393	393	393	393	393	0	0	0	0	0
Vehicles	345	345	345	345	345	345	345	345	0	0	0	0	0	0	0	0	0	0	0	0
Amortization																				
Preopetion Cost	1,251	1,251	1,251	1,251	1,251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDC	537	537	537	537	537	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-total	7,254	7,254	7,254	7,254	7,254	5,467	5,467	5,467	5,122	5,122	393	393	393	393	393	0	0	0	0	0
PRODUCTION COST (Total)	17,470	18,321	18,321	18,321	18,321	16,533	16,533	16,533	16,189	16,189	11,460	11,460	11,460	11,460	11,460	11,067	11,067	11,067	11,067	11,067
(+) Finished Product at Beg.	0	873	916	916	916	916	827	827	827	809	809	573	573	573	573	573	553	553	553	553
(-) Finished Product at End	873	916	916	916	916	827	827	827	809	809	573	573	573	573	573	553	553	553	553	0
COST OF GOODS SOLD	16,596	18,278	18,321	18,321	18,321	16,623	16,533	16,533	16,206	16,189	11,697	11,460	11,460	11,460	11,460	11,086	11,067	11,067	11,067	11,620
SALES VOLUME (Ton/Year)	2,280	2,970	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,150
UNIT COST OF GOODS SOLD (Bht/kg)	7.3	6.2	6.1	6.1	6.1	5.5	5.5	5.5	5.4	5.4	3.9	3.8	3.8	3.8	3.8	3.7	3.7	3.7	3.7	3.7
UNIT RAW MATERIAL COST (Bht/kg)	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
UNIT VARIABLE OPE-COST (Bht/kg)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
UNIT FIEXED OPE-OCST (Bht/kg)	2.9	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.1
UNIT DEP.& AMORT. COST (Bht/kg)	3.2	2.4	2.4	2.4	2.4	1.8	1.8	1.8	1.7	1.7	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0

II. PROFIT LOSS STATEMENT - CASE 1

CASE 1 (PILOT PLANT WITH A CAPACITY OF 3,000T T/Y) Unit: 1,000 Bahts

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SALES																				
Sales Revenue	4,948	6,475	6,600	6,630	6,690	6,720	6,780	6,870	6,930	6,990	7,050	7,140	7,230	7,290	7,380	7,470	7,560	7,650	7,710	8,190
Sales Tax (1%)	49	65	66	66	67	67	68	69	69	70	71	71	72	73	74	75	76	77	77	82
Net Sales Revenue	4,898	6,410	6,534	6,564	6,623	6,653	6,712	6,801	6,861	6,920	6,980	7,069	7,158	7,217	7,306	7,395	7,484	7,574	7,633	8,108
COST OF GOODS SOLD	16,596	18,279	18,321	18,321	18,321	16,623	16,533	16,533	16,206	16,189	11,697	11,460	11,460	11,460	11,460	11,086	11,067	11,067	11,067	11,620
GROSS PROFIT ON SALES	-11,698	-11,869	-11,787	-11,758	-11,698	-9,970	-9,821	-9,732	-9,345	-9,269	-4,717	-4,392	-4,303	-4,243	-4,154	-3,691	-3,582	-3,493	-3,434	-3,512
EXPENSES																				
General Expenses	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671
Non-operating Expense																				
Interest for Long Term Loan	3,509	3,509	3,158	2,807	2,457	2,106	1,755	1,404	1,053	702	351	0	0	0	0	0	0	0	0	0
Interest for Short Term Loan	0	898	1,789	3,056	4,400	5,829	7,353	8,976	10,707	12,556	14,535	16,655	18,926	21,043	23,344	25,845	28,564	31,519	34,731	38,227
Sub-total	4,180	5,078	5,618	6,534	7,527	8,606	9,778	11,051	12,430	13,929	15,556	17,325	19,596	21,713	24,015	26,516	29,234	32,189	35,402	38,898
INCOME BEFORE INCOME TAX	-15,878	-16,947	-17,405	-18,291	-19,225	-18,576	-19,599	-20,783	-21,776	-23,197	-20,273	-21,717	-23,899	-25,956	-28,169	-30,207	-32,817	-35,682	-38,836	-42,410
INCOME TAX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INCOME AFTER INCOME TAX	-15,878	-16,947	-17,405	-18,291	-19,225	-18,576	-19,599	-20,783	-21,776	-23,197	-20,273	-21,717	-23,899	-25,956	-28,169	-30,207	-32,817	-35,682	-38,836	-42,410
CUMUL. INCOME AFTER INCOME TAX	-15,878	-32,825	-50,230	-68,521	-87,747	-106322	-125921	-146704	-168480	-191677	-211950	-233667	-257566	-283522	-311691	-341898	-374715	-410397	-449233	-491643
UNIT COST OF GOODS SOLD (Bht/kg)	7.3	6.2	6.1	6.1	6.1	5.5	5.5	5.5	5.4	5.4	3.9	3.8	3.8	3.8	3.8	3.7	3.7	3.7	3.7	3.7
UNIT GENERAL EXPENSES (Bht/kg)	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
UNIT INTEREST FOR LONG TERM LOANS (Bht/kg)	1.5	1.2	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIT INTEREST FOR SHORT TERM LOANS (Bht/kg)	0.0	0.3	0.6	1.0	1.5	1.9	2.5	3.0	3.6	4.2	4.8	5.6	6.3	7.0	7.8	8.6	9.5	10.5	11.6	12.1
UNIT COSTS & EXPENSES (Bht/kg)	9.1	7.9	8.0	8.3	8.6	8.4	8.8	9.2	9.5	10.0	9.1	9.6	10.4	11.1	11.8	12.5	13.4	14.4	15.5	16.0

III. CASH FLOW STATMENT - CASE 1

CASE 1 (PILOT PLANT WITH A CAPACITY OF 3,000T T/Y) Unit: 1,000 Bahts

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SOURCE FUNDS:																						
Gross Profit on Sales	0	0	-11,698	-11,869	-11,787	-11,758	-11,698	-9,970	-9,821	-9,732	-9,345	-9,269	-4,717	-4,392	-4,303	-4,243	-4,154	-3,691	-3,582	-3,493	-3,434	-3,512
Depreciation/Amortization																						
Depre. & Amoti. for L. Loan	0	0	6,718	6,718	6,718	6,718	6,718	5,467	5,467	5,467	5,122	5,122	393	393	393	393	393	0	0	0	0	0
Amorti. for Short Term Loan	0	0	537	537	537	537	537	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equity	13,042	16,008																				
Long-term Loan	11,186	27,807																				
Short-Term Loan	0	0	9,983	19,879	33,950	48,891	64,771	81,695	99,737	118,967	139,513	161,498	185,050	210,288	233,809	259,382	287,172	317,375	350,206	385,904	424,749	463,535
Increase in Account Payable	0	0	374	94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-468
Total Source:	24,228	43,815	5,913	15,358	29,417	44,388	60,328	77,192	95,382	114,702	135,290	157,351	180,727	206,290	229,899	255,532	283,411	313,683	346,624	382,410	421,315	459,555
APPLICATION OF FUND																						
Plant Investment	18,167	38,820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Preoperation Cost	5,775	480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Initial Working Capital																						
Raw Material Inventory	0	141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-141
Others	0	1,976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,976
Interest During Construction	286	2,398	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
General Expenese	0	0	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671	671
Repayment on Long-Term Loan	0	0	0	0	3,899	3,899	3,899	3,899	3,899	3,899	3,899	3,899	3,899	3,899	0	0	0	0	0	0	0	0
Interest for Long Term Loan	0	0	3,509	3,509	3,158	2,807	2,457	2,106	1,755	1,404	1,053	702	351	0	0	0	0	0	0	0	0	0
Repayment on Short-Term Loan	0	0	0	9,983	19,879	33,950	48,891	64,771	81,695	99,737	118,967	139,513	161,498	185,050	210,288	233,809	259,382	287,172	317,375	350,206	385,904	424,749
Interest for Short Term Loan	0	0	0	898	1,789	3,056	4,400	5,829	7,353	8,976	10,707	12,556	14,535	16,655	18,926	21,043	23,344	25,845	28,564	31,519	34,731	38,227
Increase in Inventory																						
Raw Material	0	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-35
Finished Products	0	0	873	43	0	0	0	-89	0	0	-17	0	-236	0	0	0	0	-20	0	0	0	-553
Increase in Acc. Receivable	0	0	825	255	21	5	10	5	10	15	10	10	10	15	15	10	15	15	15	15	10	-1,285
Income Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Application:	24,228	43,815	5,913	15,358	29,417	44,388	60,328	77,192	95,382	114,702	135,290	157,351	180,727	206,290	229,899	255,532	283,411	313,683	346,624	382,410	421,315	459,555
CASH SURPLUS	0	0	0	0	-0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CUMULATIVE CASH SURPOLUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cash Flow (ROI B/Tax)	-23,942	-41,417	-7,010	-6,025	-5,761	-5,715	-5,661	-5,090	-5,035	-4,951	-4,887	-4,827	-4,768	-4,684	-4,595	-4,530	-4,446	-4,357	-4,268	-4,179	-4,114	-660
Cash Flow (ROI A/Tax)	-23,942	-41,417	-7,010	-6,025	-5,761	-5,715	-5,661	-5,090	-5,035	-4,951	-4,887	-4,827	-4,768	-4,684	-4,595	-4,530	-4,446	-4,357	-4,268	-4,179	-4,114	-660
Cash Flow (ROE B/Tax)	-13,042	-16,008	0	0	-0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cash Flow (ROE A/Tax)	-13,042	-16,008	0	0	-0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

IV. PROJECTED BALANCE SHEET - CASE 1

CASE 1 (PILOT PLANT WITH A CAPACITY OF 3,000T T/Y) Unit: 1,000 Bahts

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ASSETS																						
CURRENT ASSETS																						
Cash	0	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	0
Working Capital	0	1,670	3,403	3,701	3,721	3,726	3,736	3,652	3,662	3,677	3,670	3,680	3,453	3,468	3,483	3,493	3,508	3,504	3,519	3,534	3,544	0
Total	0	2,117	3,850	4,148	4,168	4,173	4,183	4,099	4,109	4,124	4,117	4,127	3,900	3,915	3,930	3,940	3,955	3,951	3,966	3,981	3,991	0
FIXED ASSETS(Less Depr.)	24,228	65,926	58,671	51,417	44,162	36,908	29,654	24,187	18,720	13,254	8,132	3,010	2,617	2,223	1,830	1,436	1,043	1,043	1,043	1,043	1,043	1,043
TOTAL ASSETS	24,228	68,043	62,522	55,564	48,331	41,082	33,837	28,286	22,830	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
LIABILITIES AND SHAREHOULDERS' EQUITY																						
SHORT-TERM LOAN	0	0	9,983	19,879	33,950	48,891	64,771	81,695	99,737	118,967	139,513	161,498	185,050	210,288	233,809	259,382	287,172	317,375	350,206	385,904	424,749	463,636
ACCOUNT PAYABLE	0	0	374	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	0
LONG-TERM LOAN	11,186	38,993	38,993	38,993	35,094	31,194	27,295	23,396	19,496	15,597	11,698	7,799	3,899	0	0	0	0	0	0	0	0	0
SHAREHOLDER'S EQUITY																						
Capital	13,042	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050	29,050
Retained Earning	0	0	-15,878	-32,825	-50,230	-68,521	-87,747	-106322	-125921	-146704	-168480	-191677	-211950	-233667	-257566	-283522	-311691	-341898	-374715	-410397	-449233	-491643
Total Equity	13,042	29,050	13,172	-3,775	-21,181	-39,472	-58,697	-77,273	-96,872	-117654	-139430	-162627	-182900	-204617	-228516	-254473	-282642	-312849	-345665	-381348	-420183	-462593
TOTAL LIABILITIES	24,228	68,043	62,522	55,564	48,331	41,082	33,837	28,286	22,830	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))

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CURRENT ASSETS																						
Initial Working Capital																						
Cash	0	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	0
Spare Parts	0	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	1529	
Raw Material Inventory	0	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	
Running Working Capital																						
Raw Material Inventory	0	0	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	0
Product Inventory	0	0	873	916	916	916	916	827	827	827	809	809	573	573	573	573	573	553	553	553	553	0
Account Receivable	0	0	825	1,079	1,100	1,105	1,115	1,120	1,130	1,145	1,155	1,165	1,175	1,190	1,205	1,215	1,230	1,245	1,260	1,275	1,285	0
Total	0	2,117	3,850	4,148	4,168	4,173	4,183	4,099	4,109	4,124	4,117	4,127	3,900	3,915	3,930	3,940	3,955	3,951	3,966	3,981	3,991	0
CURRENT LIABILITIES																						
Account Payable	0	0	374	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	
TOTAL WORKING CAPITAL	0	2,117	3,476	3,680	3,701	3,706	3,716	3,631	3,641	3,656	3,649	3,659	3,433	3,448	3,463	3,473	3,488	3,483	3,498	3,513	3,523	0

I. COST OF GOODS SOLD - CASE 2

CASE 2 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OF 50,000 T/Y) Unit: 1,000 Bahts

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
(+) Raw material Inventory at Beg.	141	176	176	176	176	1,031	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466
RAW MATERIAL PURCHASED	2,280	2,806	2,806	2,806	3,661	40,659	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	48,113
(-) Raw Material Inventory at End	176	176	176	176	1,031	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,466	0
RAW MATERIAL COST																				
Lignite	1,398	1,747	1,747	1,747	1,747	25,045	30,870	30,870	30,870	30,870	30,870	30,870	30,870	30,870	30,870	30,870	30,870	30,870	30,870	30,870
Rice straw	295	369	369	369	369	5,289	6,519	6,519	6,519	6,519	6,519	6,519	6,519	6,519	6,519	6,519	6,519	6,519	6,519	6,519
Slacked Lime	552	690	690	690	690	9,890	12,190	12,190	12,190	12,190	12,190	12,190	12,190	12,190	12,190	12,190	12,190	12,190	12,190	12,190
Sub-total	2,245	2,806	2,806	2,806	2,806	40,224	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579	49,579
VARIABLE OPE-COST																				
Electricity	1,157	1,373	1,373	1,373	1,373	7,554	8,710	8,710	8,710	8,710	8,710	8,710	8,710	8,710	8,710	8,710	8,710	8,710	8,710	8,710
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel	296	370	370	370	370	5,302	6,535	6,535	6,535	6,535	6,535	6,535	6,535	6,535	6,535	6,535	6,535	6,535	6,535	6,535
Transportation	0	0	0	0	0	7,380	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225
Sub-total	1,453	1,743	1,743	1,743	1,743	20,236	24,470	24,470	24,470	24,470	24,470	24,470	24,470	24,470	24,470	24,470	24,470	24,470	24,470	24,470
FIXED OPE-COST																				
Manpower Cost	2,682	2,682	2,682	2,682	2,682	6,813	6,813	6,813	6,813	6,813	6,813	6,813	6,813	6,813	6,813	6,813	6,813	6,813	6,813	6,813
Maint. Ins. & Tax	1,824	1,824	1,824	1,824	1,824	7,756	7,756	7,756	7,756	7,756	7,756	7,756	7,756	7,756	7,756	7,756	7,756	7,756	7,756	7,756
Overhead	2,012	2,012	2,012	2,012	2,012	5,110	5,110	5,110	5,110	5,110	5,110	5,110	5,110	5,110	5,110	5,110	5,110	5,110	5,110	5,110
Sub-total	6,517	6,517	6,517	6,517	6,517	19,679	19,679	19,679	19,679	19,679	19,679	19,679	19,679	19,679	19,679	19,679	19,679	19,679	19,679	19,679
DEPRECIATION & AMORTIZATION																				
Depreciation																				
Plant	4,728	4,728	4,728	4,728	4,728	20,489	20,489	20,489	20,489	20,489	15,761	15,761	15,761	15,761	15,761	0	0	0	0	0
Bldg & Const'n	393	393	393	393	393	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,547	1,547	1,547	1,547	1,547
Vehicles	345	345	345	345	345	919	919	919	575	575	575	575	575	0	0	0	0	0	0	0
Amortization																				
Preopetion Cost	1,251	1,251	1,251	1,251	1,251	1,480	1,480	1,480	1,480	1,480	0	0	0	0	0	0	0	0	0	0
IDC	537	537	537	537	537	1,654	1,654	1,654	1,654	1,654	0	0	0	0	0	0	0	0	0	0
Sub-total	7,254	7,254	7,254	7,254	7,254	26,483	26,483	26,483	26,138	26,138	18,275	18,275	18,275	17,701	17,701	1,547	1,547	1,547	1,547	1,547
PRODUCTION COST (Total)	17,470	18,321	18,321	18,321	18,321	106,622	120,211	120,211	119,866	119,866	112,003	112,003	112,003	111,429	111,429	95,275	95,275	95,275	95,275	95,275
(+) Finished Product at Beg.	0	873	916	916	916	916	4,430	6,011	6,011	5,993	5,993	5,600	5,600	5,600	5,571	5,571	4,764	4,764	4,764	4,764
(-) Finished Product at End	873	916	916	916	916	4,430	6,011	6,011	5,993	5,993	5,600	5,600	5,600	5,571	5,571	4,764	4,764	4,764	4,764	0
COST OF GOODS SOLD	16,596	18,279	18,321	18,321	18,321	103,108	118,630	120,211	119,863	119,866	112,397	112,003	112,003	111,457	111,429	96,083	95,275	95,275	95,275	100,039
SALES VOLUME (ton/Year)	2,280	2,970	3,000	3,000	3,000	41,000	52,500	53,000	53,000	53,000	53,000	53,000	53,000	53,000	53,000	53,000	53,000	53,000	53,000	55,650
UNIT COST OF GOODS SOLD (Bht/kg)	7.3	6.2	6.1	6.1	6.1	2.5	2.3	2.3	2.3	2.3	2.1	2.1	2.1	2.1	2.1	1.8	1.8	1.8	1.8	1.8
UNIT RAW MATERIAL COST (Bht/kg)	1.0	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
UNIT VARIABLE OPE-COST (Bht/kg)	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4
UNIT FIEXED OPE-OCST (Bht/kg)	2.9	2.2	2.2	2.2	2.2	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
UNIT DEP.& AMORT. COST (Bht/kg)	3.2	2.4	2.4	2.4	2.4	0.6	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0

II. PROFIT LOSS STATEMENT - CASE 2

CASE 2 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OF 50,000 T/Y) Unit: 1,000 Bahts

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SALES																				
Sales Revenue	4,948	6,475	6,600	6,630	6,690	91,840	118,650	121,370	122,430	123,490	124,550	126,140	127,730	128,790	130,380	131,970	133,560	135,150	136,210	144,690
Sales Tax	49	65	66	66	67	918	1,187	1,214	1,224	1,235	1,246	1,261	1,277	1,288	1,304	1,320	1,336	1,352	1,362	1,447
Net Sales Revenue	4,898	6,410	6,534	6,564	6,623	90,922	117,464	120,156	121,206	122,255	123,305	124,879	126,453	127,502	129,076	130,650	132,224	133,799	134,848	143,243
COST OF GOODS SOLD	16,596	18,279	18,321	18,321	18,321	103,108	118,630	120,211	119,883	119,866	112,397	112,003	112,003	111,457	111,429	96,083	95,275	95,275	95,275	100,039
GROSS PROFIT ON SALES	-11,698	-11,869	-11,787	-11,758	-11,698	-12,186	-1,167	-54	1,322	2,389	10,908	12,875	14,449	16,045	17,647	34,568	36,950	38,524	39,573	43,205
EXPENSES																				
General Expenses	671	671	671	671	671	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703
Non-operating Expense																				
Interest for Long Term Loan	3,509	3,509	3,158	2,807	2,457	13,401	13,050	11,570	10,089	8,609	7,128	5,648	4,518	3,389	2,259	1,130	-0	-0	0	0
Interest for Short Term Loan	0	898	1,789	3,056	4,400	5,829	7,833	8,343	9,431	10,364	11,154	11,788	12,211	12,078	11,729	11,113	10,199	9,104	7,367	5,459
INCOME BEFORE INCOME TAX	-15,878	-16,947	-17,405	-18,291	-19,225	-33,120	-23,754	-21,670	-19,901	-18,287	-9,078	-6,263	-3,983	-1,125	1,956	20,622	25,047	27,717	30,503	36,042
INCOME TAX 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,609	9,701	10,676	12,615
INCOME AFTER INCOME TAX	-15,878	-16,947	-17,405	-18,291	-19,225	-33,120	-23,754	-21,670	-19,901	-18,287	-9,078	-6,263	-3,983	-1,125	1,956	20,622	23,438	18,016	19,827	23,427
CUMUL. INCOME AFTER INCOME TAX	-15,878	-32,825	-50,230	-68,521	-87,747	-120867	-144621	-166291	-186192	-204479	-213557	-219820	-223803	-224928	-222972	-202351	-178912	-160896	-141070	-117642
UNIT COST OF GOODS SOLD (Bht/kg)	7.3	6.2	6.1	6.1	6.1	2.5	2.3	2.3	2.3	2.3	2.1	2.1	2.1	2.1	2.1	1.8	1.8	1.8	1.8	1.8
UNIT GENERAL EXPENSES (Bht/kg)	0.3	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIT INTEREST FOR LONG TERM LOANS (Bht/kg)	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIT INTEREST FOR SHORT TERM LOANS (Bht/kg)	0.0	0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
UNIT COSTS & EXPENSES (Bht/kg)	7.8	6.6	6.6	6.7	6.7	2.7	2.5	2.5	2.5	2.5	2.3	2.3	2.3	2.3	2.3	2.0	1.9	1.9	1.9	1.9

III. CASH FLOW STATMENT - CASE 2

CASE 2 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OF 50,000 T/Y) Unit: 1,000 Bahts

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SOURCE FUNDS:																						
Gross Profit on Sales	0	0	-11,698	-11,869	-11,787	-11,758	-11,698	-12,186	-1,167	-54	1,322	2,389	10,908	12,875	14,449	16,045	17,647	34,568	36,950	38,524	39,573	43,205
Depreciation/Amortization	0	0	7,254	7,254	7,254	7,254	7,254	26,483	26,483	26,483	26,138	26,138	18,275	18,275	18,275	17,701	17,701	1,547	1,547	1,547	1,547	1,547
Equity	13,042	16,008	0	0	0	25,123	56,436	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Long-term Loan	11,186	27,807	0	0	0	29,784	95,721	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Short-Term Loan	0	0	9,983	19,879	33,950	48,891	64,771	87,037	92,698	104,788	115,161	123,937	130,973	135,676	134,199	130,322	123,481	113,321	101,151	81,854	60,657	8,075
Increase in Account Payable	0	0	374	94	0	0	0	6,238	1,559	0	0	0	0	0	0	0	0	0	0	0	0	-8,265
Total Source:	24,228	43,815	5,913	15,358	29,417	99,296	212,485	107,571	119,573	131,217	142,621	152,464	160,156	166,826	166,924	164,067	158,829	149,435	139,648	121,924	101,777	44,562
APPLICATION OF FUND																						
Plant Investment	18,167	38,820	0	0	0	48,371	137,031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Preoperation Cost	5,775	480	0	0	0	5,775	1,624	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Initial Working Capital																						
Raw Material Inventory	0	141	0	0	0	0	1,031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,172
Others	0	1,975	0	0	0	0	4,961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-6,937
Interest During Construction	286	2,398	0	0	0	762	7,510	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
General Expenese	0	0	671	671	671	671	671	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703	1,703
Repayment on Long-Term Loan	0	0	0	0	3,899	3,899	3,899	3,899	3,899	16,450	16,450	16,450	16,450	16,450	12,551	12,551	12,551	12,551	12,551	0	0	0
Interest for Long Term Loan	0	0	3,509	3,509	3,158	2,807	2,457	13,401	13,050	11,570	10,089	8,609	7,128	5,648	4,518	3,389	2,259	1,130	-0	-0	0	0
Repayment on Short-Term Loan	0	0	0	9,983	19,879	33,950	48,891	64,771	87,037	92,698	104,788	115,161	123,937	130,973	135,676	134,199	130,322	123,481	113,321	101,151	81,854	60,657
Interest for Short Term Loan	0	0	0	898	1,789	3,056	4,400	5,829	7,833	8,343	9,431	10,364	11,154	11,788	12,211	12,078	11,729	11,113	10,199	9,104	7,367	5,459
Increase in Inventory																						
Raw Material	0	0	35	0	0	0	0	258	0	0	0	0	0	0	0	0	0	0	0	0	0	-293
Products	0	0	873	43	0	0	0	3,514	1,580	0	-17	0	-393	0	0	-29	0	-808	0	0	0	-4,764
Increase in Acc. Receivable	0	0	825	255	21	5	10	14,195	4,469	453	177	177	177	265	265	177	265	265	265	265	177	-22,706
Income Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,609	9,701	10,676	12,615
Total Application:	24,228	43,815	5,913	15,358	29,417	99,296	212,485	107,571	119,573	131,217	142,621	152,464	160,156	166,826	166,924	164,067	158,829	149,435	139,648	121,924	101,777	44,562
CASH SURPLUS	0	0	0	0	-0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CUMULATIVE CASH SURPOLUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Cash Flow (ROI B/Tax) 4.1%	-23,942	-41,417	-7,010	-6,025	-5,761	-59,862	-150308	-790	17,468	22,617	23,943	24,993	27,696	29,182	30,756	31,894	33,380	34,954	36,528	38,102	39,240	70,655
Cash Flow (ROI A/Tax) 3.5%	-23,942	-41,417	-7,010	-6,025	-5,761	-59,862	-150308	-790	17,468	22,617	23,943	24,993	27,696	29,182	30,756	31,894	33,380	34,954	34,919	28,401	28,564	58,041
Cash Flow (ROE B/Tax) -7.2%	-13,042	-16,008	0	0	-0	-25,123	-56,436	0	0	0	0	0	0	0	0	0	0	0	1,609	9,701	10,676	12,615
Cash Flow (ROE A/Tax)	-13,042	-16,008	0	0	-0	-25,123	-56,436	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

IV. PROJECTED BALANCE SHEET - CASE 2

CASE 2 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OD 50,000 T/Y)

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ASSETS																						
CURRENT ASSETS																						
Cash	0	447	447	447	447	447	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	0
Working Capital	0	1,670	3,403	3,701	3,721	3,726	9,040	27,006	33,056	33,509	33,669	33,845	33,629	33,894	34,159	34,307	34,572	34,029	34,294	34,560	34,736	0
Total	0	2,117	3,850	4,148	4,168	4,173	10,176	28,142	34,192	34,645	34,805	34,981	34,765	35,030	35,295	35,443	35,708	35,165	35,430	35,696	35,872	0
FIXED ASSETS(Less Depr.)	24,228	65,926	58,671	51,417	44,162	91,816	230,727	204,244	177,762	151,279	125,141	99,003	80,728	62,453	44,178	26,477	8,776	7,230	5,683	4,136	2,590	1,043
TOTAL ASSETS	24,228	68,043	62,522	55,564	48,331	95,989	240,903	232,387	211,954	185,924	159,946	133,985	115,493	97,483	79,473	61,920	44,484	42,395	41,113	39,832	38,462	1,043
LIABILITIES AND SHAREHOULDERS' EQUITY																						
SHORT-TERM LOAN	0	0	9,983	19,879	33,950	48,891	64,771	87,037	92,698	104,788	115,161	123,937	130,973	135,676	134,199	130,322	123,481	113,321	101,151	81,854	60,657	8,075
ACCOUNT PAYABLE	0	0	374	468	468	468	468	6,705	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	0
LONG-TERM LOAN	11,186	38,993	38,993	38,993	35,094	60,979	152,801	148,901	145,002	128,552	112,102	95,653	79,203	62,753	50,202	37,652	25,101	12,551	-0	-0	0	0
SHAREHOLDER'S EQUITY																						
Capital	13,042	29,050	29,050	29,050	29,050	54,173	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610
Retained Earning	0	0	-15,878	-32,825	-50,230	-68,521	-87,747	-120867	-144621	-166291	-186192	-204479	-213557	-219820	-223803	-224928	-222972	-202351	-178912	-160896	-141070	-117642
Total Equity	13,042	29,050	13,172	-3,775	-21,181	-14,348	22,863	-10,257	-34,011	-55,681	-75,582	-93,869	-102947	-109211	-113194	-114319	-112363	-91,741	-68,303	-50,287	-30,460	-7,033
TOTAL LIABILITIES	24,228	68,043	62,522	55,564	48,331	95,989	240,903	232,387	211,954	185,924	159,946	133,985	115,493	97,483	79,473	61,920	44,484	42,395	41,113	39,832	38,462	1,043

((Working Capital Table))

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CURRENT ASSETS																						
Initial Working Capital																						
Cash	0	447	447	447	447	447	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	1,136	0
Spare Parts	0	1,529	1,529	1,529	1,529	1,529	5,801	5,801	5,801	5,801	5,801	5,801	5,801	5,801	5,801	5,801	5,801	5,801	5,801	5,801	5,801	0
Raw Material Inventory	0	141	141	141	141	141	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	0
Running Working Capital																						
Raw Material Inventory	0	0	35	35	35	35	35	293	293	293	293	293	293	293	293	293	293	293	293	293	293	0
Product Inventory	0	0	873	916	916	916	916	4,430	6,011	6,011	5,993	5,993	5,600	5,600	5,600	5,571	5,571	4,764	4,764	4,764	4,764	0
Account Receivable	0	0	825	1,079	1,100	1,105	1,115	15,310	19,778	20,232	20,409	20,586	20,762	21,028	21,293	21,469	21,734	21,999	22,264	22,530	22,706	0
Total	0	2,117	3,850	4,148	4,168	4,173	10,176	28,142	34,192	34,645	34,805	34,981	34,765	35,030	35,295	35,443	35,708	35,165	35,430	35,696	35,872	0
CURRENT LIABILITIES																						
Account Payable	0	0	374	468	468	468	468	6,705	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	8,265	0
TOTAL WORKING CAPITAL	0	2,117	3,476	3,680	3,701	3,706	9,708	21,437	25,927	26,380	26,540	26,717	26,500	26,765	27,030	27,178	27,443	26,901	27,166	27,431	27,607	0

I. COST OF GOODS SOLD - CASE 2-1

CASE 2-1 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OF 50,000 T/Y) Unit: 1,000 Bahts

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
(+) Raw material Inventory at Beg.	141	176	176	176	176	1,031	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289
RAW MATERIAL PURCHASED	2,280	2,806	2,806	2,806	3,661	37,676	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	45,483
(-) Raw Material Inventory at End	176	176	176	176	1,031	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	0
RAW MATERIAL COST																				
Lignite	1,398	1,747	1,747	1,747	1,747	23,298	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123
Rice straw	295	369	369	369	369	4,920	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150
Slacked Lime	552	690	690	690	690	9,200	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500
Sub-total	2,245	2,806	2,806	2,806	2,806	37,418	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773
VARIABLE OPE-COST																				
Electricity	1,157	1,373	1,373	1,373	1,373	6,180	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel	296	370	370	370	370	4,932	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165
Transportation	0	0	0	0	0	7,380	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225
Sub-total	1,453	1,743	1,743	1,743	1,743	18,492	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727
FIXED OPE-COST																				
Manpower Cost	2,682	2,682	2,682	2,682	2,682	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131
Maint. Ins. & Tax	1,824	1,824	1,824	1,824	1,824	5,933	5,933	5,933	5,933	5,933	5,933	5,933	5,933	5,933	5,933	5,933	5,933	5,933	5,933	5,933
Overhead	2,012	2,012	2,012	2,012	2,012	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098
Sub-total	6,517	6,517	6,517	6,517	6,517	13,162	13,162	13,162	13,162	13,162	13,162	13,162	13,162	13,162	13,162	13,162	13,162	13,162	13,162	13,162
DEPRECIATION & AMORTIZATION																				
Depreciation																				
Plant	4,728	4,728	4,728	4,728	4,728	20,489	20,489	20,489	20,489	20,489	15,761	15,761	15,761	15,761	15,761	0	0	0	0	0
Bldg & Const'n	393	393	393	393	393	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,547	1,547	1,547	1,547	1,547
Vehicles	345	345	345	345	345	919	919	919	575	575	575	575	575	0	0	0	0	0	0	0
Amortization																				
Preopetion Cost	1,251	1,251	1,251	1,251	1,251	1,480	1,480	1,480	1,480	1,480	0	0	0	0	0	0	0	0	0	0
IDC	537	537	537	537	537	1,654	1,654	1,654	1,654	1,654	0	0	0	0	0	0	0	0	0	0
Sub-total	7,254	7,254	7,254	7,254	7,254	26,483	26,483	26,483	26,138	26,138	18,275	18,275	18,275	17,701	17,701	1,547	1,547	1,547	1,547	1,547
PRODUCTION COST (Total)	17,470	18,321	18,321	18,321	18,321	95,555	109,144	109,144	108,799	108,799	100,937	100,937	100,937	100,362	100,362	84,208	84,208	84,208	84,208	84,208
(+) Finished Product at Beg.	0	873	916	916	916	0	3,604	5,184	5,184	5,184	5,184	5,027	5,027	5,027	4,998	4,998	4,210	4,210	4,210	4,210
(-) Finished Product at End	873	916	916	916	0	3,604	5,184	5,184	5,184	5,184	5,027	5,027	5,027	4,998	4,998	4,210	4,210	4,210	4,210	0
COST OF GOODS SOLD	16,596	18,279	18,321	18,321	19,237	91,952	107,564	109,144	108,799	108,799	101,093	100,937	100,937	100,391	100,362	84,996	84,208	84,208	84,208	88,418
SALES VOLUME (ton/Year)	2,280	2,970	3,000	3,000	3,000	38,000	49,500	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	52,500
UNIT COST OF GOODS SOLD (Bht/kg)	7.3	6.2	6.1	6.1	6.4	2.4	2.2	2.2	2.2	2.2	2.0	2.0	2.0	2.0	2.0	1.7	1.7	1.7	1.7	1.7
UNIT RAW MATERIAL COST (Bht/kg)	1.0	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
UNIT VARIABLE OPE-COST (Bht/kg)	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4
UNIT FIEXED OPE-OCST (Bht/kg)	2.9	2.2	2.2	2.2	2.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
UNIT DEP.& AMORT. COST (Bht/kg)	3.2	2.4	2.4	2.4	2.4	0.7	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0

II. PROFIT LOSS STATEMENT - CASE 2-1

CASE 2-1 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OF 50,000 T/Y) Unit: 1,000 Bahts

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SALES																				
Sales Revenue	4,948	6,475	6,600	6,630	6,690	85,120	111,870	114,500	115,500	116,500	117,500	119,000	120,500	121,500	123,000	124,500	126,000	127,500	128,500	136,500
Sales Tax	49	65	66	66	67	851	1,119	1,145	1,155	1,165	1,175	1,190	1,205	1,215	1,230	1,245	1,260	1,275	1,285	1,365
Net Sales Revenue	4,898	6,410	6,534	6,564	6,623	84,269	110,751	113,355	114,345	115,335	116,325	117,810	119,295	120,285	121,770	123,255	124,740	126,225	127,215	135,135
COST OF GOODS SOLD	16,596	18,279	18,321	18,321	19,237	91,952	107,564	109,144	108,799	108,799	101,093	100,937	100,937	100,391	100,362	84,996	84,208	84,208	84,208	88,418
GROSS PROFIT ON SALES	-11,698	-11,869	-11,787	-11,758	-12,614	-7,683	3,188	4,211	5,546	6,536	15,232	16,873	18,358	19,894	21,408	38,259	40,532	42,017	43,007	46,717
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
Non-operating Expense																				
Interest for Long Term Loan	3,509	3,509	3,158	2,807	2,457	13,401	13,050	11,570	10,089	8,609	7,128	5,648	4,518	3,389	2,259	1,130	-0	-0	0	0
Interest for Short Term Loan	0	898	1,789	3,056	4,400	5,577	7,101	7,091	7,621	7,952	8,090	8,018	7,681	6,727	5,488	3,911	2,590	1,443	0	0
Sub-total	4,180	5,078	5,618	6,534	7,527	20,011	21,184	19,693	18,743	17,593	16,251	14,699	13,232	11,148	8,780	6,073	3,622	2,476	1,033	1,033
INCOME BEFORE INCOME TAX	-15,878	-16,947	-17,405	-18,291	-20,141	-27,694	-17,996	-15,482	-13,197	-11,057	-1,019	2,175	5,127	8,746	12,628	32,186	36,910	39,541	41,974	45,684
INCOME TAX 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,038	12,918	13,839	14,691	15,989
INCOME AFTER INCOME TAX	-15,878	-16,947	-17,405	-18,291	-20,141	-27,694	-17,996	-15,482	-13,197	-11,057	-1,019	2,175	5,127	8,746	12,628	25,148	23,991	25,702	27,283	29,695
CUMUL. INCOME AFTER INCOME TAX	-15,878	-32,825	-50,230	-68,521	-88,663	-116357	-134353	-149835	-163032	-174090	-175109	-172934	-167808	-159061	-146434	-121286	-97295	-71593	-44310	-14615
UNIT COST OF GOODS SOLD (Bht/kg)	7.3	6.2	6.1	6.1	6.4	2.4	2.2	2.2	2.2	2.2	2.0	2.0	2.0	2.0	2.0	1.7	1.7	1.7	1.7	1.7
UNIT GENERAL EXPENSES (Bht/kg)	0.3	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIT INTEREST FOR LONG TERM LOANS (Bht/kg)	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIT INTEREST FOR SHORT TERM LOANS (Bht/kg)	0.0	0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
UNIT COSTS & EXPENSES (Bht/kg)	7.8	6.6	6.6	6.7	7.0	2.7	2.4	2.4	2.4	2.3	2.2	2.2	2.2	2.1	2.1	1.8	1.7	1.7	1.7	1.7

III. CASH FLOW STATMENT - CASE 2-1

CASE 2-1 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OF 50,000 T/Y) — Unit: 1,000 Bahts

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SOURCE FUNDS:																						
Gross Profit on Sales	0	0	-11,698	-11,869	-11,787	-11,758	-12,614	-7,683	3,188	4,211	5,546	6,536	15,232	16,873	18,358	19,894	21,408	38,259	40,532	42,017	43,007	46,717
Depreciation/Amortization	0	0	7,254	7,254	7,254	7,254	7,254	26,483	26,483	26,483	26,138	26,138	18,275	18,275	18,275	17,701	17,701	1,547	1,547	1,547	1,547	1,547
Equity	13,042	16,008	0	0	0	25,123	56,436	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Long-term Loan	11,186	27,807	0	0	0	29,784	95,721	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Short-Term Loan	0	0	9,983	19,879	33,950	48,891	61,972	78,896	78,789	84,677	88,352	89,888	89,092	85,342	74,741	60,983	43,455	28,773	16,036	0	0	0
Increase in Account Payable	0	0	374	94	0	0	-468	6,238	1,559	0	0	0	0	0	0	0	0	0	0	0	0	-7,797
Total Source:	24,228	43,815	5,913	15,358	29,417	99,296	208,302	103,933	110,018	115,370	120,036	122,562	122,599	120,491	111,375	98,578	82,564	68,579	58,115	43,564	44,554	40,466
APPLICATION OF FUND																						
Plant Investment	18,167	38,820	0	0	0	48,371	137,031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Preoperation Cost	5,775	480	0	0	0	5,775	1,624	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Initial Working Capital																						
Raw Material Inventory	0	141	0	0	0	0	1,031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,172
Others	0	1,976	0	0	0	0	2,844	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-4,820
Interest During Construction	286	2,398	0	0	0	762	7,510	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
General Expenese	0	0	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
Repayment on Long-Term Loan	0	0	0	0	3,899	3,899	3,899	3,899	3,899	16,450	16,450	16,450	16,450	16,450	12,551	12,551	12,551	12,551	12,551	0	0	0
Interest for Long Term Loan	0	0	3,509	3,509	3,158	2,807	2,457	13,401	13,050	11,570	10,089	8,609	7,128	5,648	4,518	3,389	2,259	1,130	-0	-0	0	0
Repayment on Short-Term Loan	0	0	0	9,983	19,879	33,950	48,891	61,972	78,896	78,789	84,677	88,352	89,888	89,092	85,342	74,741	60,983	43,455	28,773	16,036	0	0
Interest for Short Term Loan	0	0	0	898	1,789	3,056	4,400	5,577	7,101	7,091	7,621	7,952	8,090	8,018	7,681	6,727	5,488	3,911	2,590	1,443	0	0
Increase in Inventory																						
Raw Material	0	0	35	0	0	0	-35	258	0	0	0	0	0	0	0	0	0	0	0	0	0	-258
Products	0	0	873	43	0	0	-916	3,604	1,580	0	0	0	-157	0	0	-29	0	-788	0	0	0	-4,210
Increase in Acc. Receivable	0	0	825	255	21	5	-1,105	14,190	4,459	438	167	167	167	250	250	167	250	250	250	250	167	-21,421
Income Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,038	12,918	13,839	14,691	15,989
Total Application:	24,228	43,815	5,913	15,358	29,417	99,296	208,302	103,933	110,018	115,370	120,036	122,562	122,599	120,491	111,375	98,578	82,564	68,579	58,115	32,601	15,890	-14,859
CASH SURPLUS	0	0	0	0	-0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,962	28,663	55,326
CUMULATIVE CASH SURPOLUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,962	39,626	94,951
Cash Flow (ROI B/Tax) 5.7%	-23,942	-41,417	-7,010	-6,025	-5,761	-59,862	-147509	4,299	22,503	27,568	28,830	29,820	32,464	33,866	35,351	36,424	37,826	39,311	40,796	42,281	43,354	71,315
Cash Flow (ROI A/Tax) 4.6%	-23,942	-41,417	-7,010	-6,025	-5,761	-59,862	-147509	4,299	22,503	27,568	28,830	29,820	32,464	33,866	35,351	36,424	37,826	32,273	27,878	28,442	28,663	55,326
Cash Flow (ROE B/Tax) 2.4%	-13,042	-16,008	0	0	-0	-25,123	-56,436	0	0	0	0	0	0	0	0	0	0	7,038	12,918	24,802	43,354	71,315
Cash Flow (ROE A/Tax) -0.9%	-13,042	-16,008	0	0	-0	-25,123	-56,436	0	0	0	0	0	0	0	0	0	0	0	0	10,962	28,663	55,326

IV. PROJECTED BALANCE SHEET - CASE 2-1

CASE 2-1 (PILOT PLANT and COMMERCIAL PLANT WITH A CAPACITY OF 50,000 T/Y) Unit: 1,000 Bahts

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ASSETS																						
CURRENT ASSETS																						
Cash	0	447	447	447	447	447	689	689	689	689	689	689	689	689	689	689	689	689	689	11,651	40,315	94,951
Working Capital	0	1,670	3,403	3,701	3,721	3,726	5,303	23,354	29,394	29,832	29,999	30,166	30,176	30,426	30,675	30,814	31,064	30,526	30,776	31,026	31,192	0
Total	0	2,117	3,850	4,148	4,168	4,173	5,992	24,043	30,083	30,521	30,688	30,855	30,865	31,115	31,365	31,503	31,753	31,215	31,465	42,677	71,507	94,951
FIXED ASSETS(Less Depr.)	24,228	65,926	58,671	51,417	44,162	91,816	230,727	204,244	177,762	151,279	125,141	99,003	80,728	62,453	44,178	25,477	8,776	7,230	5,683	4,135	2,590	1,043
TOTAL ASSETS	24,228	68,043	62,522	55,564	48,331	95,989	236,719	228,288	207,844	181,800	155,829	129,858	111,593	93,567	75,542	57,980	40,529	38,444	37,148	46,814	74,097	95,994
LIABILITIES AND SHAREHOULDERS' EQUITY																						
SHORT-TERM LOAN	0	0	9,983	19,879	33,950	48,691	61,972	78,896	78,789	84,677	86,352	89,868	89,092	85,342	74,741	60,983	43,455	28,773	15,036	0	0	0
ACCOUNT PAYABLE	0	0	374	468	468	468	0	6,238	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	0
LONG-TERM LOAN	11,186	38,993	38,993	38,993	35,094	60,979	152,801	148,901	145,002	128,552	112,102	95,653	79,203	62,753	50,202	37,652	25,101	12,551	-0	-0	0	0
SHAREHOLDER'S EQUITY																						
Capital	13,042	29,050	29,050	29,050	29,050	54,173	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610	110,610
Retained Earning	0	0	-15,878	-32,825	-50,230	-68,521	-88,663	-116357	-134353	-149835	-163032	-174090	-175109	-172934	-167808	-159051	-146434	-121286	-97295	-71593	-44310	-14615
Total Equity	13,042	29,050	13,172	-3,775	-21,181	-14,348	21,947	-5,747	-23,743	-39,226	-52,423	-63,480	-64499	-62325	-57198	-48452	-35824	-10,676	13,315	39,017	66,300	95,994
TOTAL LIABILITIES	24,228	68,043	62,522	55,564	48,331	95,989	236,719	228,288	207,844	181,800	155,829	129,858	111,593	93,567	75,542	57,980	40,529	38,444	37,148	46,814	74,097	95,994

((Working Capital Table))

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CURRENT ASSETS																						
Initial Working Capital																						
Cash	0	447	447	447	447	447	689	689	689	689	689	689	689	689	689	689	689	689	689	689	689	0
Spare Parts	0	1,529	1,529	1,529	1,529	1,529	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272	4,272	0
Raw Material Inventory	0	141	141	141	141	141	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	0
Running Working Capital																						
Raw Material Inventory	0	0	35	35	35	35	0	258	258	258	258	258	258	258	258	258	258	258	258	258	258	0
Product Inventory	0	0	873	916	916	916	0	3,604	5,184	5,184	5,184	5,184	5,027	5,027	5,027	4,998	4,998	4,210	4,210	4,210	4,210	0
Account Receivable	0	0	825	1,079	1,100	1,105	0	14,190	18,649	19,087	19,254	19,421	19,587	19,837	20,087	20,254	20,504	20,754	21,004	21,254	21,421	0
Total	0	2,117	3,850	4,148	4,168	4,173	5,992	24,043	30,083	30,521	30,688	30,855	30,865	31,115	31,365	31,503	31,753	31,215	31,465	31,715	31,881	0
CURRENT LIABILITIES																						
Account Payable	0	0	374	468	468	468	0	6,238	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	0
TOTAL WORKING CAPITAL	0	2,117	3,476	3,680	3,701	3,706	5,992	17,806	22,286	22,724	22,891	23,058	23,068	23,318	23,568	23,706	23,956	23,418	23,668	23,918	24,084	0

I. COST OF GOODS SOLD - CASE 3

CASE 3 (COMMERCIAL PLANT WITH A CAPACITY OF 50,000T T/Y) Unit: 1,000 Bahts

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
(+) Raw material inventory at Beg.	0	0	0	0	0	1,031	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289
RAW MATERIAL PURCHASED	0	0	0	0	0	37,676	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	45,483
(-) Raw Material Inventory at End	0	0	0	0	0	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	1,289	0
RAW MATERIAL COST																				
Lignite	0	0	0	0	0	23,298	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123	29,123
Rice straw	0	0	0	0	0	4,920	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150
Slacked Lime	0	0	0	0	0	9,200	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500
Sub-total	0	0	0	0	0	37,418	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773
VARIABLE OPE-COST																				
Electricity	0	0	0	0	0	6,180	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337	7,337
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel	0	0	0	0	0	4,932	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165	6,165
Transportation	0	0	0	0	0	7,380	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225	9,225
Sub-total	0	0	0	0	0	18,492	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727
FIXED OPE-COST																				
Manpower Cost	0	0	0	0	0	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131	4,131
Maint. Ins. & Tax	0	0	0	0	0	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966
Overhead	0	0	0	0	0	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098	3,098
Sub-total	0	0	0	0	0	13,195	13,195	13,195	13,195	13,195	13,195	13,195	13,195	13,195	13,195	13,195	13,195	13,195	13,195	13,195
DEPRECIATION & AMORTIZATION																				
Depreciation																				
Plant	0	0	0	0	0	15,761	15,761	15,761	15,761	15,761	15,761	15,761	15,761	15,761	15,761	0	0	0	0	0
Bldg & Const'n	0	0	0	0	0	1,547	1,547	1,547	1,547	1,547	1,547	1,547	1,547	1,547	1,547	1,547	1,547	1,547	1,547	1,547
Vehicles	0	0	0	0	0	575	575	575	575	575	575	575	575	0	0	0	0	0	0	0
Amortization																				
Preopetion Cost	0	0	0	0	0	1,480	1,480	1,480	1,480	1,480	0	0	0	0	0	0	0	0	0	0
IDC	0	0	0	0	0	1,669	1,669	1,669	1,669	1,669	0	0	0	0	0	0	0	0	0	0
Sub-total	0	0	0	0	0	21,031	21,031	21,031	21,031	21,031	17,882	17,882	17,882	17,307	17,307	1,547	1,547	1,547	1,547	1,547
PRODUCTION COST (Total)	0	0	0	0	0	90,137	103,726	103,726	103,726	103,726	100,576	100,576	100,576	100,002	100,002	84,241	84,241	84,241	84,241	84,241
(+) Finished Product at Beg.	0	0	0	0	0	0	3,605	5,186	5,186	5,186	5,186	5,029	5,029	5,029	5,000	5,000	4,212	4,212	4,212	4,212
(-) Finished Product at End	0	0	0	0	0	3,605	5,186	5,186	5,186	5,186	5,029	5,029	5,029	5,000	5,000	4,212	4,212	4,212	4,212	0
COST OF GOODS SOLD	0	0	0	0	0	86,531	102,145	103,726	103,726	103,726	100,734	100,576	100,576	100,031	100,002	85,029	84,241	84,241	84,241	88,453
SALES VOLUME (ton/Year)	0	0	0	0	0	38,000	49,500	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	52,500
UNIT COST OF GOODS SOLD (Bht/kg)	0	0	0	0	0	2.3	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.0	1.7	1.7	1.7	1.7	1.7
UNIT RAW MATERIAL COST (Bht/kg)	0	0	0	0	0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
UNIT VARIABLE OPE-COST (Bht/kg)	0	0	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4
UNIT FIEXED OPE-OCST (Bht/kg)	0	0	0	0	0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
UNIT DEP. & AMORT. COST (Bht/kg)	0	0	0	0	0	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.0	0.0	0.0	0.0	0.0

II. PROFIT LOSS STATEMENT - CASE 3

CASE 3 (COMMERCIAL PLANT WITH A CAPACITY OF 50,000T T/Y) Unit: 1,000 Bahts

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SALES																				
Sales Revenue	0	0	0	0	0	85,120	111,870	114,500	115,500	116,500	117,500	119,000	120,500	121,500	123,000	124,500	126,000	127,500	128,500	136,500
Sales Tax (1%)	0	0	0	0	0	851	1,119	1,145	1,155	1,165	1,175	1,190	1,205	1,215	1,230	1,245	1,260	1,275	1,285	1,365
Net Sales Revenue	0	0	0	0	0	84,269	110,751	113,355	114,345	115,335	116,325	117,810	119,295	120,285	121,770	123,255	124,740	126,225	127,215	135,135
COST OF GOODS SOLD	0	0	0	0	0	86,531	102,145	103,726	103,726	103,726	100,734	100,576	100,576	100,031	100,002	85,029	84,241	84,241	84,241	88,453
GROSS PROFIT ON SALES	0	0	0	0	0	-2,263	8,607	9,629	10,619	11,609	15,591	17,234	18,719	20,254	21,768	38,226	40,499	41,984	42,974	46,682
EXPENSES																				
General Expenses	0	0	0	0	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	0	0	0	0	0	11,359	11,359	10,223	9,087	7,951	6,815	5,679	4,543	3,408	2,272	1,136	0	0	0	0
Interest for Short Term Loan	0	0	0	0	0	0	489	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-total	0	0	0	0	0	12,391	12,881	11,255	10,120	8,984	7,848	6,712	5,576	4,440	3,304	2,169	1,033	1,033	1,033	1,033
INCOME BEFORE INCOME TAX	0	0	0	0	0	-14,654	-4,274	-1,626	500	2,626	7,743	10,522	13,142	15,814	18,464	36,057	39,466	40,951	41,941	45,649
INCOME TAX	0	0	0	0	0	0	0	0	0	0	0	0	0	5,535	6,462	12,620	13,813	14,333	14,679	15,977
INCOME AFTER INCOME TAX	0	0	0	0	0	-14,654	-4,274	-1,626	500	2,626	7,743	10,522	13,142	10,279	12,001	23,437	25,653	26,618	27,262	29,672
CUMUL. INCOME AFTER INCOME TAX	0	0	0	0	0	-14,654	-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/kg)	0.0	0.0	0.0	0.0	0.0	2.3	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.0	1.7	1.7	1.7	1.7	1.7
UNIT GENERAL EXPENSES (Bht/kg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIT INTEREST FOR LONG TERM LOANS (Bht/kg)	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
UNIT INTEREST FOR SHORT TERM LOANS (Bht/kg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIT COSTS & EXPENSES (Bht/kg)	0.0	0.0	0.0	0.0	0.0	2.6	2.3	2.3	2.3	2.3	2.2	2.1	2.1	2.1	2.1	1.7	1.7	1.7	1.7	1.7

III. CASH FLOW STATMENT - CASE 3

CASE 3 (COMMERCIAL PLANT WITH A CAPACITY OF 50,000T T/Y) — Unit: 1,000 Bahts

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SOURCE FUNDS:																						
Gross Profit on Sales	0	0	0	0	0	0	0	-2,263	8,607	9,629	10,619	11,609	15,591	17,234	18,719	20,254	21,768	38,226	40,499	41,984	42,974	46,682
Depreciation/Amortization																						
Depre. & Amoti. for L. Loan	0	0	0	0	0	0	0	19,362	19,362	19,362	19,362	19,362	17,882	17,882	17,882	17,307	17,307	1,547	1,547	1,547	1,547	1,547
Amorti. for Short Term Loan	0	0	0	0	0	0	0	1,669	1,669	1,669	1,669	1,669	0	0	0	0	0	0	0	0	0	0
Equity	0	0	0	0	0	25,541	56,436	0														
Long-term Loan	0	0	0	0	0	30,427	95,779	0														
Short-Term Loan	0	0	0	0	0	0	0	5,438	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Increase in Account Payable	0	0	0	0	0	0	0	6,238	1,559	0	0	0	0	0	0	0	0	0	0	0	0	-7,797
Total Source:	0	0	0	0	0	55,967	152,215	30,444	31,197	30,660	31,650	32,640	33,473	35,115	36,600	37,562	39,075	39,772	42,045	43,530	44,520	40,431
APPLICATION OF FUND																						
Plant Investment	0	0	0	0	0	49,414	137,031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Preoperation Cost	0	0	0	0	0	5,775	1,624	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Initial Working Capital																						
Raw Material Inventory	0	0	0	0	0	0	1,031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,031
Others	0	0	0	0	0	0	4,961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-4,961
Interest During Construction	0	0	0	0	0	778	7,568	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
General Expenese	0	0	0	0	0	0	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
Repayment on Long-Term Loan	0	0	0	0	0	0	0	0	0	12,621	12,621	12,621	12,621	12,621	12,621	12,621	12,621	12,621	12,621	0	0	0
Interest for Long Term Loan	0	0	0	0	0	0	0	11,359	11,359	10,223	9,087	7,951	6,815	5,679	4,543	3,408	2,272	1,136	0	0	0	0
Repayment on Short-Term Loan	0	0	0	0	0	0	0	0	5,438	0	0	0	0	0	0	0	0	0	0	0	0	0
Interest for Short Term Loan	0	0	0	0	0	0	0	0	489	0	0	0	0	0	0	0	0	0	0	0	0	0
Increase in Inventory																						
Raw Material	0	0	0	0	0	0	0	258	0	0	0	0	0	0	0	0	0	0	0	0	0	-258
Products	0	0	0	0	0	0	0	3,605	1,581	0	0	0	-157	0	0	-29	0	-788	0	0	0	-4,212
Increase in Acc. Receivable	0	0	0	0	0	0	0	14,190	4,459	438	167	167	167	250	250	167	250	250	250	250	167	-21,421
Income Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,535	6,462	12,620	13,813	14,333	14,679	15,977
Total Application:	0	0	0	0	0	55,967	152,215	30,444	24,359	24,314	22,907	21,771	20,478	19,583	18,447	22,734	22,637	26,871	27,716	15,616	15,879	-14,873
CASH SURPLUS	0	0	0	0	0	0	0	0	6,838	6,346	8,744	10,869	12,995	15,533	18,154	14,828	16,438	12,901	14,329	27,915	28,642	55,305
CUMULATIVE CASH SURPOLUS	0	0	0	0	0	0	0	0	6,838	13,184	21,927	32,797	45,792	61,325	79,478	94,306	110,744	123,645	137,974	165,889	194,530	249,835
Cash Flow (ROI B/Tax) 11.6%	0	0	0	0	0	-55,189	-144647	4,251	22,455	27,520	28,782	29,772	32,431	33,833	35,318	36,391	37,793	39,278	40,763	42,248	43,321	71,282
Cash Flow (ROI A/Tax) 10.0%	0	0	0	0	0	-55,189	-144647	4,251	22,455	27,520	28,782	29,772	32,431	33,833	35,318	30,856	31,330	26,658	26,949	27,915	28,642	55,305
Cash Flow (ROE B/Tax) 14.3%	0	0	0	0	0	-25,541	-56,436	0	6,838	6,346	8,744	10,869	12,995	15,533	18,154	20,363	22,900	25,521	28,142	42,248	43,321	71,282
Cash Flow (ROE A/Tax) 11.7%	0	0	0	0	0	-25,541	-56,436	0	6,838	6,346	8,744	10,869	12,995	15,533	18,154	14,828	16,438	12,901	14,329	27,915	28,642	55,305

Discounted Cash Flow 10%	Total																		
Cash Flow (ROI B/Tax)	23,181	-55,189	-131498	3,513	16,871	18,796	17,871	16,805	16,642	15,783	14,978	14,030	13,246	12,515	11,807	11,125	10,371	15,513	
Cash Flow (ROI A/Tax)	-6	-55,189	-131498	3,513	16,871	18,796	17,871	16,805	16,642	15,783	14,978	11,896	10,981	8,494	7,806	7,351	6,857	12,036	
Cash Flow (ROE B/Tax)	34,973	-25,541	-51,306	0	5,137	4,334	5,429	6,135	6,669	7,246	7,699	7,851	8,026	8,132	8,152	11,125	10,371	15,513	
Cash Flow (ROE A/Tax)	11,786	-25,541	-51,306	0	5,137	4,334	5,429	6,135	6,669	7,246	7,699	5,717	5,761	4,111	4,151	7,351	6,857	12,036	
Discounted Cash Flow 12%																			
Cash Flow (ROI B/Tax)	-4,801	-55,189	-129150	3,389	15,983	17,489	16,331	15,083	14,670	13,664	12,736	11,717	10,864	10,082	9,342	8,645	7,915	11,628	
Cash Flow (ROI A/Tax)	-23,066	-55,189	-129150	3,389	15,983	17,489	16,331	15,083	14,670	13,664	12,736	9,935	9,007	6,842	6,176	5,712	5,233	9,021	
Cash Flow (ROE B/Tax)	16,462	-25,541	-50,390	0	4,867	4,033	4,961	5,507	5,878	6,273	6,546	6,556	6,583	6,551	6,449	8,645	7,915	11,628	
Cash Flow (ROE A/Tax)	-1,803	-25,541	-50,390	0	4,867	4,033	4,961	5,507	5,878	6,273	6,546	4,774	4,726	3,311	3,284	5,712	5,233	9,021	

IV. PROJECTED BALANCE SHEET - CASE 3

CASE 3 (PLANT WITH A CAPACITY OF 50,000T T/Y) Unit: 1,000 Bahts

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ASSETS																						
CURRENT ASSETS																						
Cash	0	0	0	0	0	0	689	689	7,527	13,873	22,616	33,486	46,481	62,014	80,167	94,995	111,433	124,334	138,663	166,578	195,219	249,835
Working Capital	0	0	0	0	0	0	5,303	23,356	29,396	29,835	30,001	30,168	30,177	30,427	30,677	30,815	31,065	30,527	30,777	31,027	31,194	0
Total	0	0	0	0	0	0	5,992	24,045	36,923	43,707	52,618	63,654	76,658	92,441	110,845	125,810	142,498	154,861	169,440	197,605	226,413	249,835
FIXED ASSETS(Less Depr.)	0	0	0	0	0	55,967	202,190	181,160	160,129	139,098	118,067	97,036	79,154	61,273	43,391	26,084	8,776	7,230	5,683	4,136	2,590	1,043
TOTAL ASSETS	0	0	0	0	0	55,967	208,183	205,205	197,052	182,805	170,685	160,690	155,812	153,713	154,235	151,894	151,275	162,091	175,123	201,742	229,003	250,878
LIABILITIES AND SHAREHOULDERS' EQUITY																						
SHORT-TERM LOAN	0	0	0	0	0	0	0	5,438	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ACCOUNT PAYABLE	0	0	0	0	0	0	0	6,238	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	0
LONG-TERM LOAN	0	0	0	0	0	30,427	126,206	126,206	126,206	113,585	100,964	88,344	75,723	63,103	50,482	37,862	25,241	12,621	0	0	0	0
SHAREHOLDER'S EQUITY																						
Capital	0	0	0	0	0	25,541	81,977	81,977	81,977	81,977	81,977	81,977	81,977	81,977	81,977	81,977	81,977	81,977	81,977	81,977	81,977	81,977
Retained Earning	0	0	0	0	0	0	0	-14,654	-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
Total Equity	0	0	0	0	0	25,541	81,977	67,323	63,049	61,423	61,923	64,549	72,292	82,814	95,956	106,235	118,237	141,674	167,326	193,945	221,206	250,878
TOTAL LIABILITIES	0	0	0	0	0	55,967	208,183	205,205	197,052	182,805	170,685	160,690	155,812	153,713	154,235	151,894	151,275	162,091	175,123	201,742	229,003	250,878

((Working Capital Table))

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CURRENT ASSETS																						
Initial Working Capital																						
Cash	0	0	0	0	0	0	689	689	689	689	689	689	689	689	689	689	689	689	689	689	689	0
Spare Parts	0	0	0	0	0	0	4272	4272	4272	4272	4272	4272	4272	4272	4272	4272	4272	4272	4272	4272	4272	0
Raw Material Inventory	0	0	0	0	0	0	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	1,031	0
Running Working Capital																						
Raw Material Inventory	0	0	0	0	0	0	0	258	258	258	258	258	258	258	258	258	258	258	258	258	258	0
Product Inventory	0	0	0	0	0	0	0	3,605	5,186	5,186	5,186	5,186	5,029	5,029	5,029	5,000	5,000	4,212	4,212	4,212	4,212	0
Account Receivable	0	0	0	0	0	0	0	14,190	18,649	19,087	19,254	19,421	19,587	19,837	20,087	20,254	20,504	20,754	21,004	21,254	21,421	0
Total	0	0	0	0	0	0	5,992	24,045	30,085	30,524	30,690	30,857	30,866	31,116	31,366	31,504	31,754	31,216	31,466	31,716	31,883	0
CURRENT LIABILITIES																						
Account Payable	0	0	0	0	0	0	0	6,238	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	7,797	0
TOTAL WORKING CAPITAL	0	0	0	0	0	0	5,992	17,808	22,288	22,727	22,893	23,060	23,069	23,319	23,569	23,707	23,957	23,419	23,669	23,919	24,086	0

Chapter 16 Social and Economic Analysis

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.

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

Tax^{imp} = Weighted average of import tax rate

TQ^{imp} = Import tax rate equivalent to import restriction value

Tax^{ex} = 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 ton-per-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 Production, tons/year	2,400	3,000	3,000	3,000
Unit Economic Price of Lignite Briquettes, Bahts/kg	2.78	2.86	2.98	3.14
Direct Economic Benefit	6,672	8,580	8,940	9,420

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

Unit: 1,000 Bht

	DOMESTIC COMPONENT										FOREIGN EXCHNAGE COMPONENT									GRAND TOTAL
	1ST YEAR (1993)					2ND YEAR (1994)					1ST YEAR (1993)					2ND YEAR (1994)				
	U.S.L.	S.D.E	MAT'L	TAX&DUTY	TOTAL	U.S.L.	S.D.E	MAT'L	TAX&DUTY	TOTAL	PESN'L	MAT'L	TAX&DUTY	TOTAL	PESN'L	MAT'L	TAX&DUTY	TOTAL		
1) Land aquisition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2) Site preparation	192	769	0	32	993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	993
3) Machinery and equix	0	0	205	7	212	0	0	460	15	475	0	7,499	1,297	8,797	0	17,325	2,997	20,322	29,805	
4) Inland Transportatx	0	0	0	0	0	0	0	396	13	409	0	0	0	0	0	0	0	0	409	
5) Vehicles	0	0	0	0	0	0	0	2,543	84	2,626	0	0	0	0	0	0	0	0	2,626	
6) Erection x	0	0	0	0	0	139	2,922	0	101	3,161	0	0	0	0	0	0	0	0	3,161	
7) Structures and civil work	0	0	0	0	0	735	1,396	3,310	180	5,621	0	0	0	0	0	0	0	0	5,621	
8) Electrical Work x	156	389	813	45	1,403	349	874	1,825	101	3,149	0	0	0	0	0	0	0	0	4,552	
9) Engineering x	0	308	0	10	318	0	74	0	2	76	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	0	651	0	21	672	672	
11) Commissioning x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	446	0	15	460	460	
12) Physical contingency	17	73	51	5	146	61	263	427	25	776	257	388	74	719	55	866	152	1,073	2,714	
13) Price contingency	46	192	134	12	384	218	939	1,522	88	2,767	163	247	47	457	47	739	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	1,069	98	3,072	1,284	5,529	8,959	520	16,293	5,387	8,158	1,549	15,094	1,151	18,191	3,185	22,527	56,987	

Economic Plant Cost

	DOMESTIC COMPONENT										FOREIGN EXCHNAGE COMPONENT									GRAND TOTAL
	1ST YEAR (1993)					2ND YEAR (1994)					1ST YEAR (1993)					2ND YEAR (1994)				
	U.S.L.	S.D.E	MAT'L	TAX&DUTY	TOTAL	U.S.L.	S.D.E	MAT'L	TAX&DUTY	TOTAL	PESN'L	MAT'L	TAX&DUTY	TOTAL	PESN'L	MAT'L	TAX&DUTY	TOTAL		
1) Land aquisition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2) Site preparation	173	769	0	0	942	0	0	0	0	0	0	0	0	0	0	0	0	0	0	942
3) Machinery and equipment	0	0	205	0	205	0	0	460	0	460	0	8,692	0	8,692	0	20,080	0	20,080	29,436	
4) Inland Transportation	0	0	0	0	0	0	0	396	0	396	0	0	0	0	0	0	0	0	396	
5) Vehicles	0	0	0	0	0	0	0	2,543	0	2,543	0	0	0	0	0	0	0	0	2,543	
6) Erection	0	0	0	0	0	125	2,922	0	0	3,046	0	0	0	0	0	0	0	0	3,046	
7) Structures and civil work	0	0	0	0	0	662	1,396	3,310	0	5,368	0	0	0	0	0	0	0	0	5,368	
8) Electrical Work	140	389	813	0	1,343	315	874	1,825	0	3,013	0	0	0	0	0	0	0	0	4,356	
9) Engineering	0	308	0	0	308	0	74	0	0	74	5,946	313	0	6,259	0	0	0	0	6,641	
10) Supervision	0	0	0	0	0	0	0	0	0	0	0	0	0	0	754	0	0	754	754	
11) Commissioning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	516	0	0	516	516	
12) Physical contingency	16	73	51	0	140	55	263	427	0	745	297	450	0	748	64	1,004	0	1,068	2,700	
Total Plant Cost	329	1,540	1,069	0	2,938	1,156	5,529	8,959	0	15,644	6,244	9,455	0	15,698	1,334	21,084	0	22,418	56,698	

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

EIRR(%): -

Unit: 1,000 Bht

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Economic Benefit																						
Lgnite Briquettes	0	0	6,672	8,370	8,400	8,460	8,520	8,580	8,640	8,700	8,790	8,850	8,940	9,030	9,420	9,210	9,300	9,420	9,510	9,600	9,690	9,780
Economin Cost																						
Investment																						
Plant Cost	18,636	38,061	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Preoperation Cost	6,642	476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spare Parts	0	1,510	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operation																						
Raw Materials	0	0	2,245	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	2,806	2,806	2,806	2,806
Utilities	0	0	1,453	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	1,743	1,743	1,743	1,743	1,743
Manpower Cost	0	0	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628	2,628
Maintenance Cost	0	0	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419
Plant Overhead	0	0	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	1,971	1,971	1,971
General Expenses	0	0	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657
Distribution Cost	0	0	1,524	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905
Total	25,279	40,047	11,897	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129	13,129
Balance	-25,279	-40,047	-5,225	-4,759	-4,729	-4,669	-4,609	-4,549	-4,489	-4,429	-4,339	-4,279	-4,189	-4,099	-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

Unit: 1,000 Bht

	DOMESTIC COMPONENT										FOREIGN EXCHNAGE COMPONENT									GRAND TOTAL
	1ST YEAR (1998)					2ND YEAR (1999)					1ST YEAR (1998)					2ND YEAR (1999)				
	U.S.L.	S.D.E	MAT'L	TAX&DUTY	TOTAL	U.S.L.	S.D.E	MAT'L	TAX&DUTY	TOTAL	PESN'L	MAT'L	TAX&DUTY	TOTAL	PESN'L	MAT'L	TAX&DUTY	TOTAL		
1) Land aquisition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2) Site preparation	192	769	0	32	993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	993
3) Machinery and equipment	0	0	12,025	397	12,422	0	0	26,979	890	27,869	0	20,956	3,625	24,581	0	48,413	8,375	56,788	121,661	
4) Inland Transportation	0	0	0	0	0	0	0	846	28	874	0	0	0	0	0	0	0	0	0	874
5) Vehicles	0	0	0	0	0	0	0	4,238	140	4,378	0	0	0	0	0	0	0	0	0	4,378
6) Erection	0	0	0	0	0	416	9,597	0	330	10,343	0	0	0	0	0	0	0	0	0	10,343
7) Structures and civil work	0	0	0	0	0	1,942	9,153	10,295	706	22,095	0	0	0	0	0	0	0	0	0	22,095
8) Electrical Work	457	1,175	1,359	99	3,089	1,025	2,635	3,048	221	6,929	0	0	0	0	0	0	0	0	0	10,018
9) Engineering	0	385	0	13	397	0	92	0	3	96	5,131	270	178	5,579	0	0	0	0	0	6,072
10) Supervision	0	0	0	0	0	0	0	0	0	0	0	0	0	0	651	0	21	672	672	
11) Commissioning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	446	0	15	460	460	
12) Physical contingency	32	116	669	27	845	169	1,074	2,270	116	3,629	257	1,061	190	1,508	55	2,421	421	2,896	8,878	
13) Price contingency	251	901	5,179	209	6,541	1,503	9,546	20,182	1,031	32,262	445	1,847	331	2,624	108	4,762	827	5,698	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	55,596	9,660	66,515	233,570	
Total Plant Cost (1990 Price)	681	2,445	14,053	567	17,746	3,551	22,552	47,676	2,435	76,214	5,387	22,287	3,994	31,668	1,151	50,834	8,832	60,817	186,445	

Economic Plant Cost

Economic Investment Cost

	DOMESTIC COMPONENT										FOREIGN EXCHNAGE COMPONENT									GRAND TOTAL
	1ST YEAR (1998)					2ND YEAR (1999)					1ST YEAR (1998)					2ND YEAR (1999)				
	U.S.L.	S.D.E	MAT'L	TAX&DUTY	TOTAL	U.S.L.	S.D.E	MAT'L	TAX&DUTY	TOTAL	PESN'L	MAT'L	TAX&DUTY	TOTAL	PESN'L	MAT'L	TAX&DUTY	TOTAL		
1) Land aquisition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2) Site preparation	173	769	0	0	942	0	0	0	0	0	0	0	0	0	0	0	0	0	0	942
3) Machinery and equipment	0	0	12,025	0	12,025	0	0	26,979	0	26,979	0	24,288	0	24,288	0	56,111	0	56,111	119,403	
4) Inland Transportation	0	0	0	0	0	0	0	846	0	846	0	0	0	0	0	0	0	0	0	846
5) Vehicles	0	0	0	0	0	0	0	4,238	0	4,238	0	0	0	0	0	0	0	0	0	4,238
6) Erection	0	0	0	0	0	374	9,597	0	0	9,971	0	0	0	0	0	0	0	0	0	9,971
7) Structures and civil work	0	0	0	0	0	1,747	9,153	10,295	0	21,195	0	0	0	0	0	0	0	0	0	21,195
8) Electrical Work	411	1,175	1,359	0	2,944	922	2,635	3,048	0	6,606	0	0	0	0	0	0	0	0	0	9,550
9) Engineering	0	385	0	0	385	0	92	0	0	92	5,946	313	0	6,259	0	0	0	0	0	6,736
10) Supervision	0	0	0	0	0	0	0	0	0	0	0	0	0	0	754	0	0	754	754	
11) Commissioning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	516	0	0	516	516	
12) Physical contingency	29	116	669	0	815	152	1,074	2,270	0	3,496	297	1,230	0	1,527	64	2,806	0	2,869	8,708	
Total Plant Cost (1990 Price)	613	2,445	14,053	0	17,111	3,196	22,552	47,676	0	73,424	6,244	25,831	0	32,075	1,334	58,917	0	60,251	182,860	

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

Unit: 1,000 Bht

EIRR(%): 14.5

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Economic Benefit																						
Lgnite Briquettes	0	0	0	0	0	0	0	114,400	144,000	145,000	146,500	147,500	149,000	150,500	157,000	153,500	155,000	157,000	158,500	160,000	161,500	163,000
Economin Cost																						
Investment																						
Plant Cost	0	0	0	0	0	49,185	133,675	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Preoperation Cost	0	0	0	0	0	6,642	1,620	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spare Parts	0	0	0	0	0	0	4,220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operation																						
Raw Materials	0	0	0	0	0	0	0	37,418	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773	46,773
Utilities	0	0	0	0	0	0	0	18,492	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727	22,727
Manpower Cost	0	0	0	0	0	0	0	4,077	4,077	4,077	4,077	4,077	4,077	4,077	4,077	4,077	4,077	4,077	4,077	4,077	4,077	4,077
Maintenance Cost	0	0	0	0	0	0	0	4,642	4,642	4,642	4,642	4,642	4,642	4,642	4,642	4,642	4,642	4,642	4,642	4,642	4,642	4,642
Plant Overhead	0	0	0	0	0	0	0	3,058	3,058	3,058	3,058	3,058	3,058	3,058	3,058	3,058	3,058	3,058	3,058	3,058	3,058	3,058
General Expenses	0	0	0	0	0	0	0	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019	1,019
Distribution Cost	0	0	0	0	0	0	0	25,400	31,750	31,750	31,750	31,750	31,750	31,750	31,750	31,750	31,750	31,750	31,750	31,750	31,750	31,750
Total	0	0	0	0	0	55,828	139,515	94,106	114,045	114,045	114,045	114,045	114,045	114,045	114,045	114,045	114,045	114,045	114,045	114,045	114,045	114,045
Balance	0	0	0	0	0	-55,828	-139515	20,294	29,955	30,955	32,455	33,455	34,955	36,455	42,955	39,455	40,955	42,955	44,455	45,955	47,455	48,955

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: %)

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	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 Price		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	3.4	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:
(1) Net heating value for calculation, 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

(2) Firewood density used for calculation: 0.70gr/cm^3
(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 mine-mouth 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.

Chapter 17 Strategy for Dissemination of Lignite Briquettes

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.

(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

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 medium-sized 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 cooking stoves. Lignite briquettes must be given to the same families not 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:

(1) 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.

	(Unit: Bahts)
(1) 1st Period	
1. Modification of the bench-scale plant	32,000,000
2. Distribution of lignite briquettes	4,500,000
(2) 2nd Period	
1. Investment in the pilot plant	68,043,000
2. Distribution of lignite briquettes	15,000,000
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. Their 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 high-yielding 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	to 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.

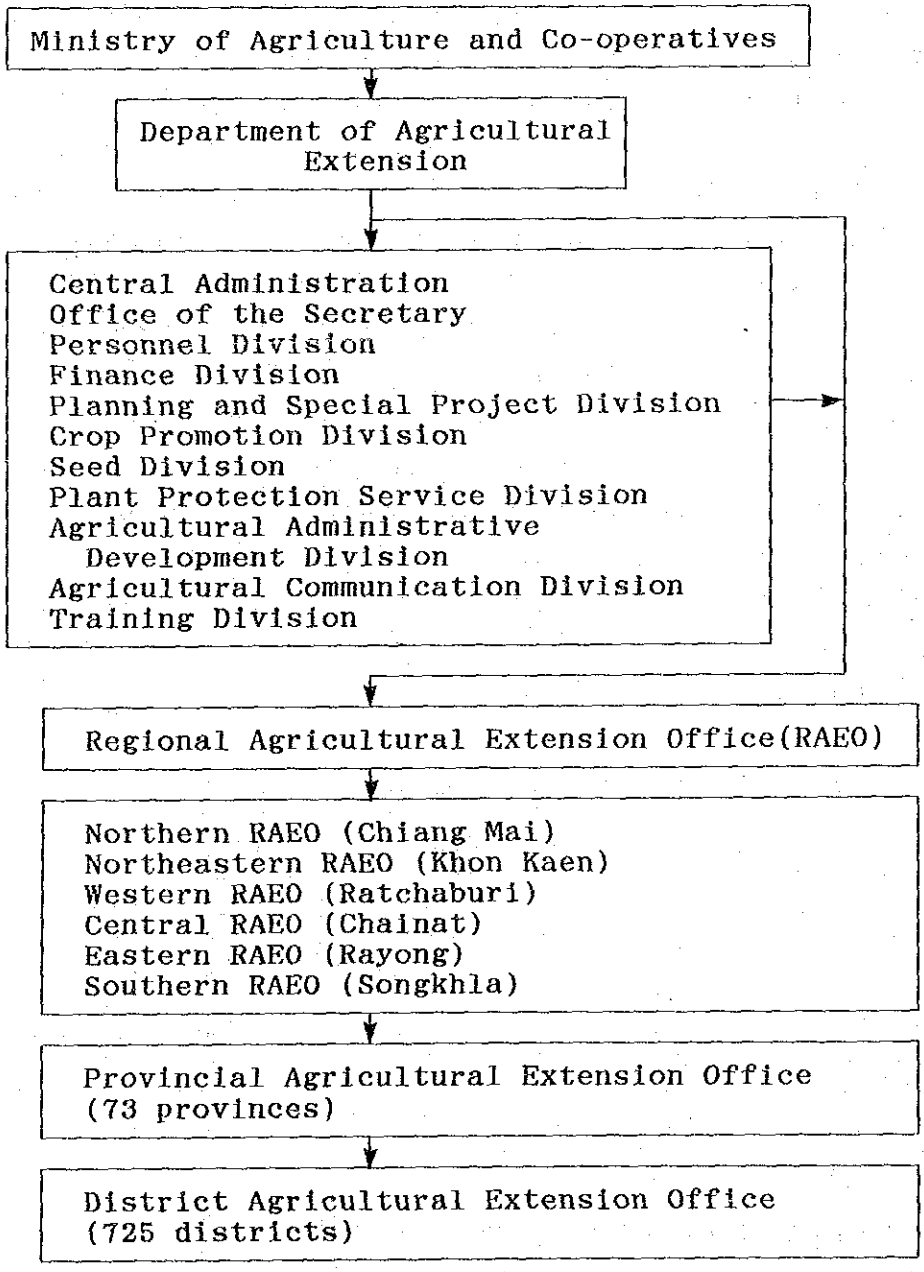

Figure 17-1 Organization Chart of Department of Agricultural Extension

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)

Academic Level	Central Administration	Provincial Administration	Total
Doctoral degree	8	-	8
Master's degree	173	61	234
Bachelor's degree	740	2,037	2,777
Agricultural Certificate and Diploma	738	5,698	6,436
Vocational Certificate	414	1,702	2,116
Vocational Rice Certificate		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.

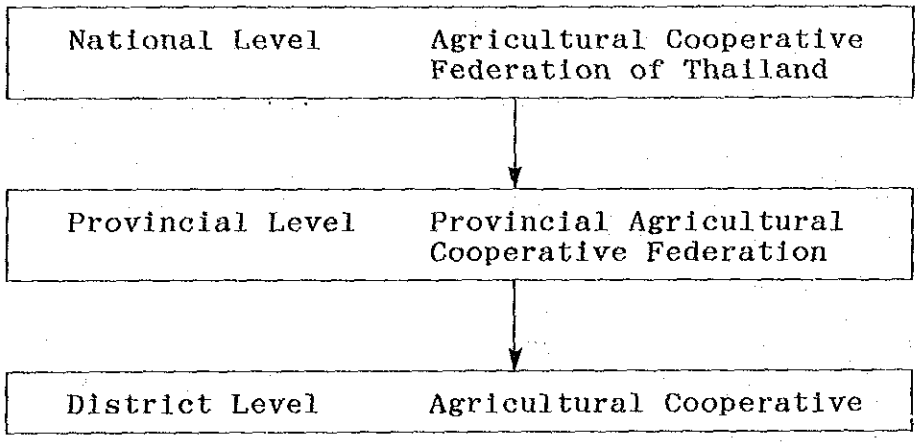

Figure 17-2 Vertical Structure of Agricultural Cooperatives

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.

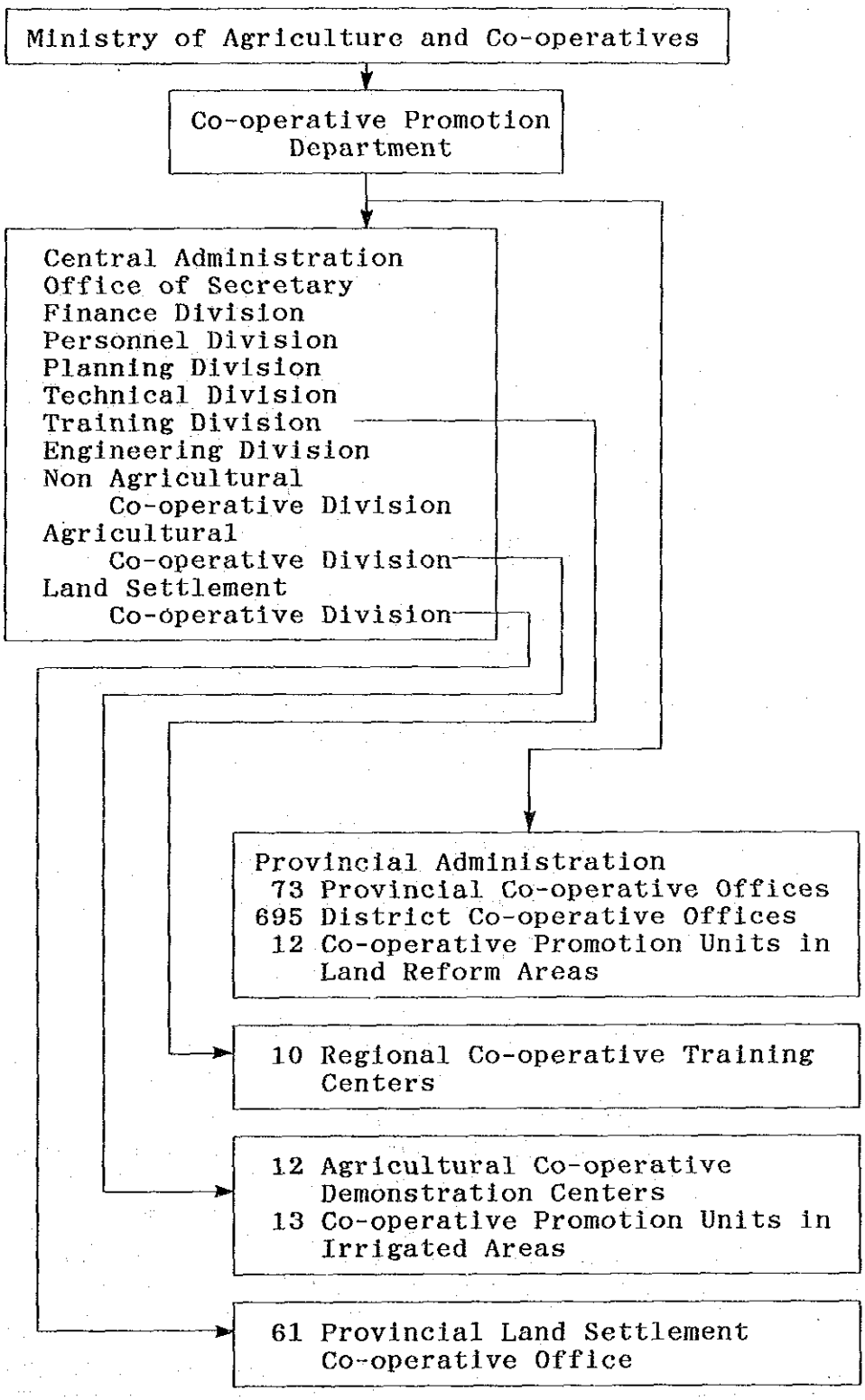

Figure 17-3 Organization Chart of Cooperative Promotion Department

17-4-7 Organization Chart

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

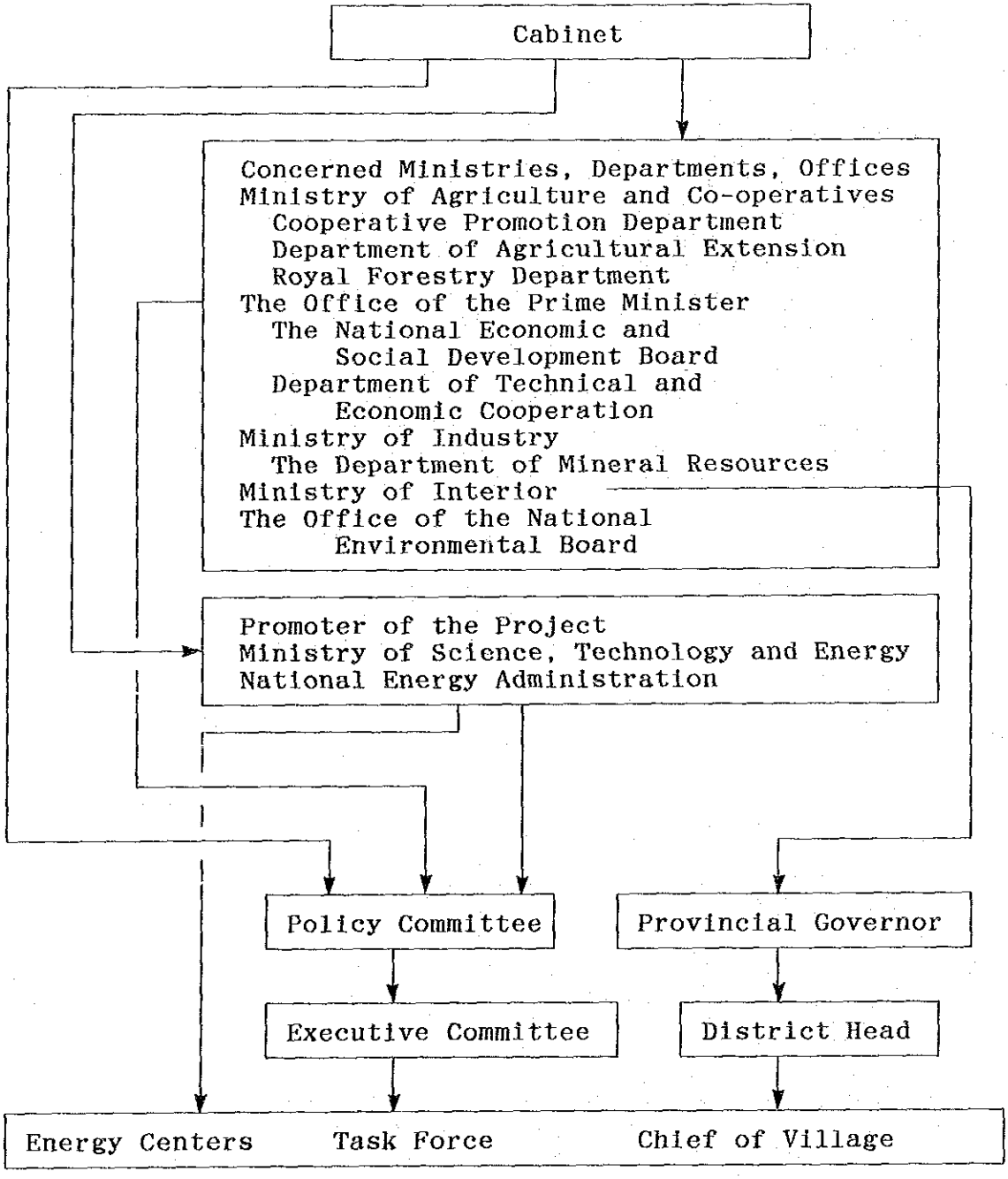

Figure 17-4 Organization for Promotion of Lignite Briquettes

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 Period					3rd Period		
Year	1	2	3	4	5	6	7	8	9	10	11 and on
Promoter	National Energy Administration supported by Policy Committee										
Plant in Operat'n	BS Plant	Modified BS Plant		Pilot Plant					Commercial Plant		
Organization	.Policy committee .Executive committee .Task force .Model market						.More task forces .More model markets				
Major Activity	.Establish policy committee .Establish executive committee .Form task force .Start mass education .Select model market .Prepare model market .Start modified BS Plant			.Expand dissemination activity around the model market .Intensify dissemination activity .Intensify mass education .Start intensifying geographical expansion .Intensify marketing on the charcoal marketing channel .Establish Thai quality standards of lignite briquettes .Form more task forces .Select more model markets							
Incentive				.Tax exemption for replantation cost .Tax exemption for machines							

Figure 17-5 Sequence of Activities for Dissemination of Lignite Briquettes

Chapter 18 Experimental Production of Lignite Birquettes

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%

High-quality lignite	Low-quality lignite	Thai slaked lime	Bagasse	Rice straws	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

High-quality lignite	Low-quality lignite	Bagasse	Rice straws	Rice husks
4.7	5.4	7.1	7.2	6.2

Table 18-3 Particle Distribution of the Lignite Samples

Particle size, mm	High-quality lignite	Low-quality lignite
2.0min.	0.18	0.20
1.0/2.0	7.26	7.25
0.5/1.0	26.30	28.54
0.25/0.5	29.78	27.77
0.25max.	36.48	36.25
Bulk density, g/cm^3	0.75	0.77

Table 18-4 Particle Distribution of the Biomass Samples

Biomass mmMax.	Bagas-se 3	Bagas-se 2	Rice straws 3	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 density g/cm^3	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 value, kcal/kg		5,590	6,396	5,260	5,812
Sulfur,%	Total		1.03		2.08
	Incombustible		0.27		0.45
	Combustible		0.76		1.63
Carbon,%			63.7		57.2
Hydrogen,%			4.44		4.27
Nitrogen,%			0.97		0.80
Oxygen,%			18.11		14.50
HGI		38		52	

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	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 value, kcal/kg	4,860	4,985	3,910	3,998	4,070	4,119
Sulfur,%						
Total		0.06		0.16		0.06
Incombustible		0.03		0.08		0.02
Combustible		0.03		0.08		0.04
Carbon,%		48.00		41.80		42.20
Hydrogen,%		5.89		5.15		5.10
Nitrogen,%		0.23		0.64		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_2O_3	0.13	-
Fe_2O_3	0.08	-
CaO	49.69	71.1
MgO	2.01	-
Na_2O	2.98	-
K_2O	0.06	-
SO_3	0.09	-
Purity	65.4	96.1

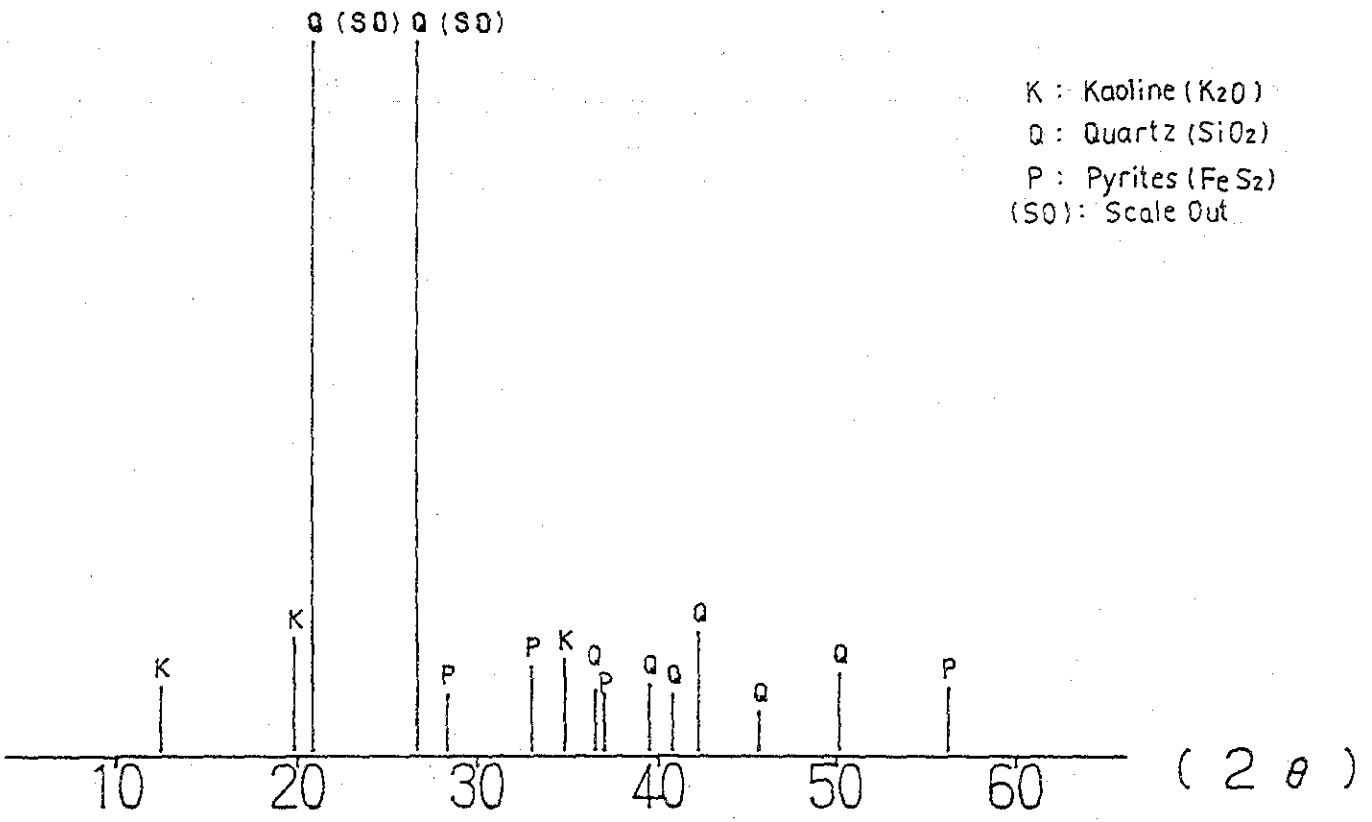

Figure 18-1 X-ray Diffraction Pattern of High-quality Lignite

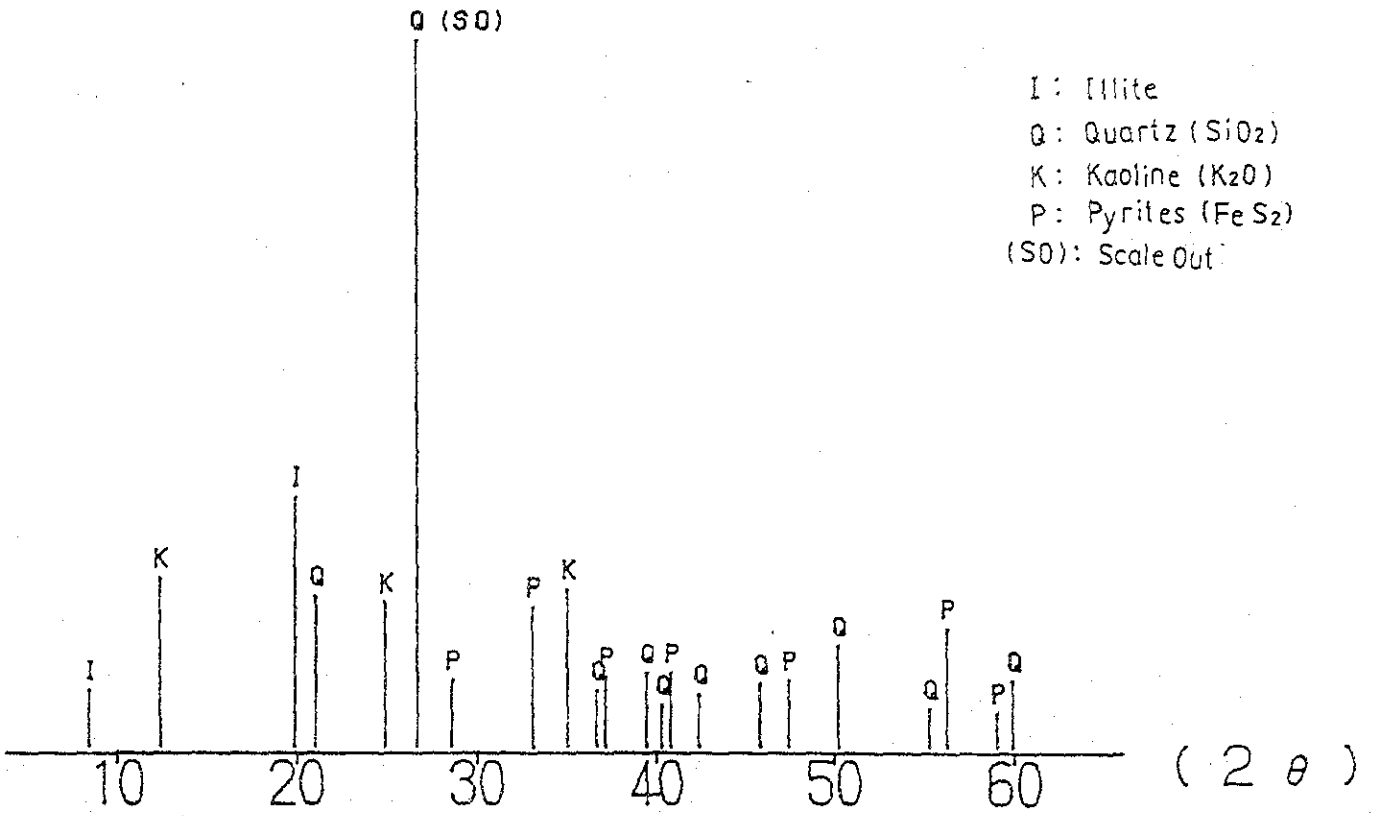

Figure 18-2 X-ray Diffraction Pattern of Low-quality Lignite

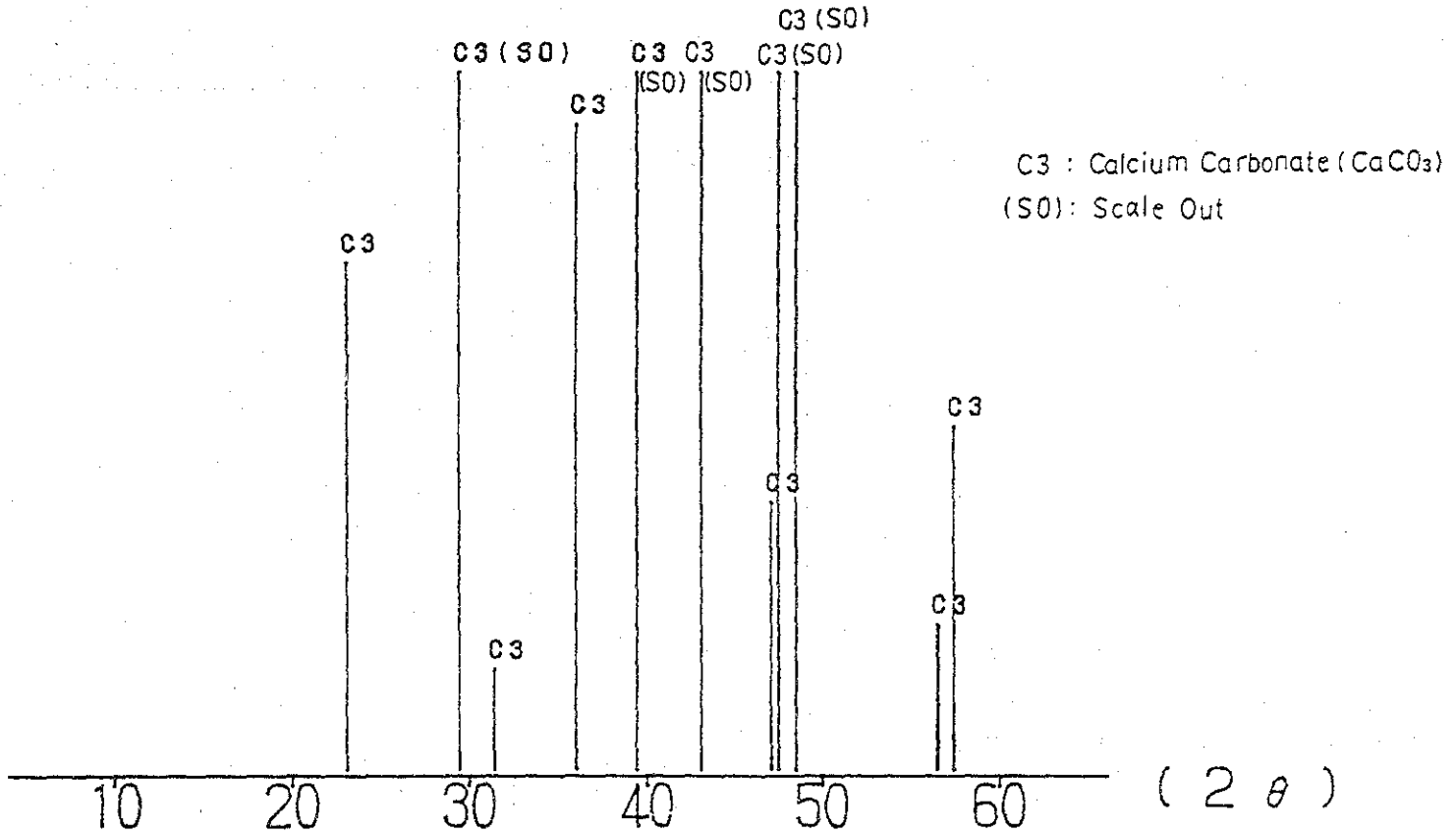

Figure 18-3 X-ray Diffraction Pattern of Slaked Lime Sample

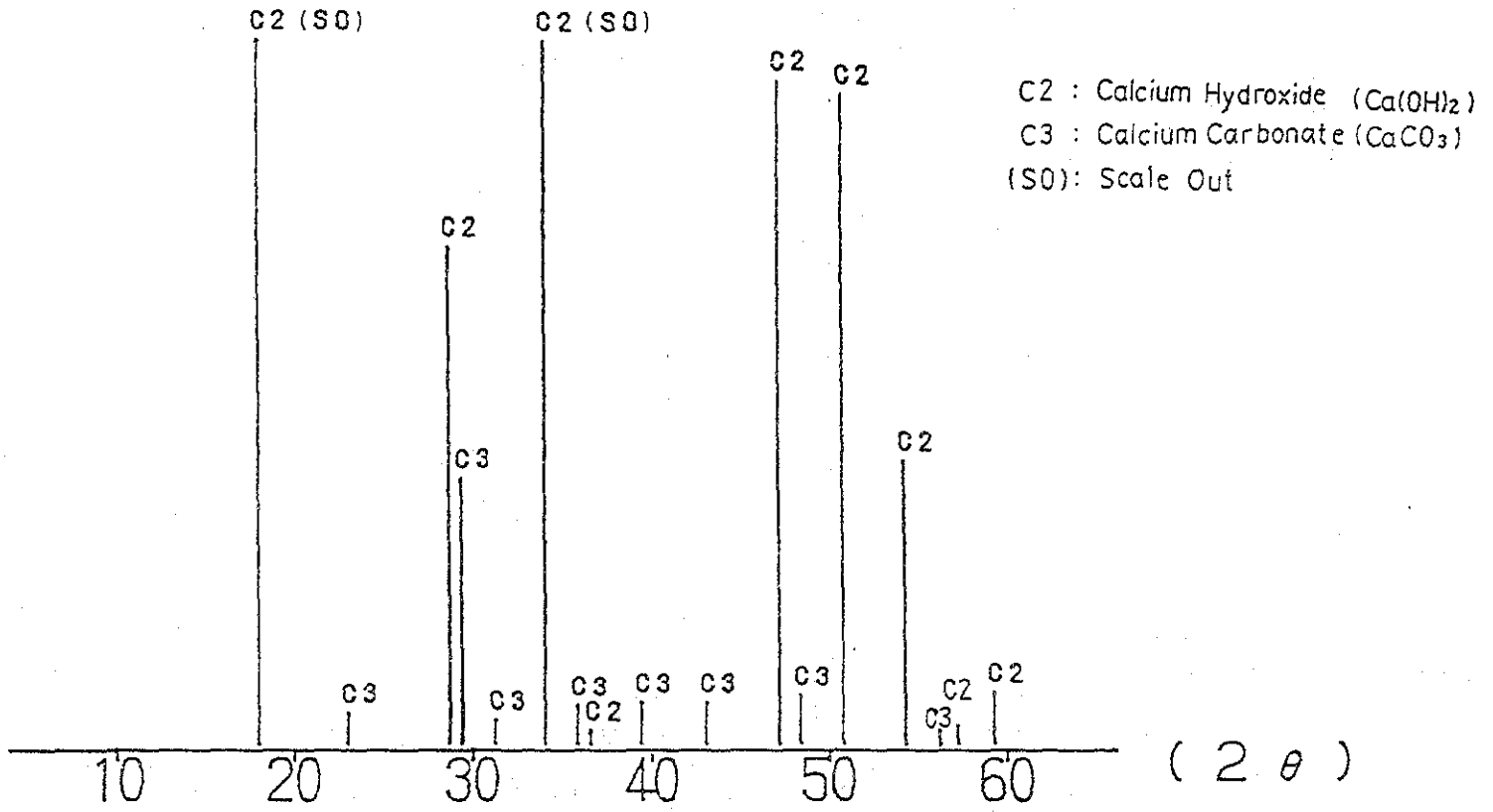

Figure 18-4 X-ray Diffraction Pattern of Japanese Slaked Lime

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 T_0: Thickness of tablet after compression

T_1: 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%

Lignite	80	80	80	80	80	80	80	80	80	80
Bagasse	0	5	10	15	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.

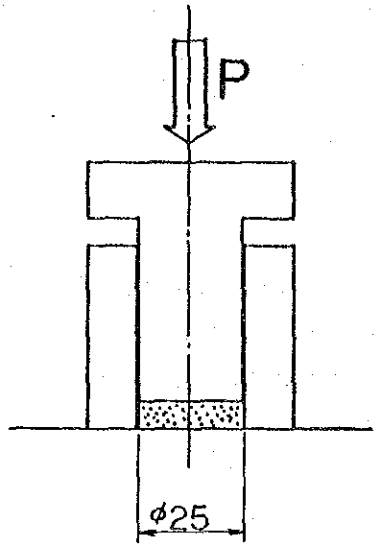

Figure 18-5 Mold Used for Tabletting

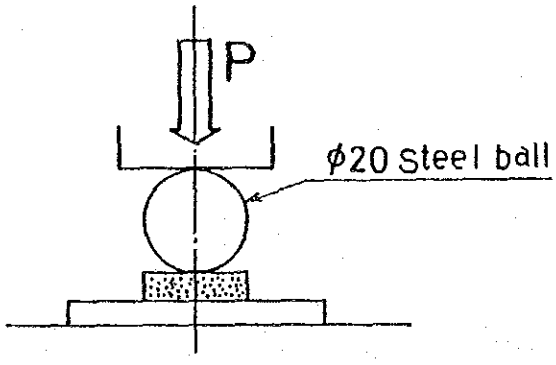

Figure 18-6 Universal Testing Machine with a Jig

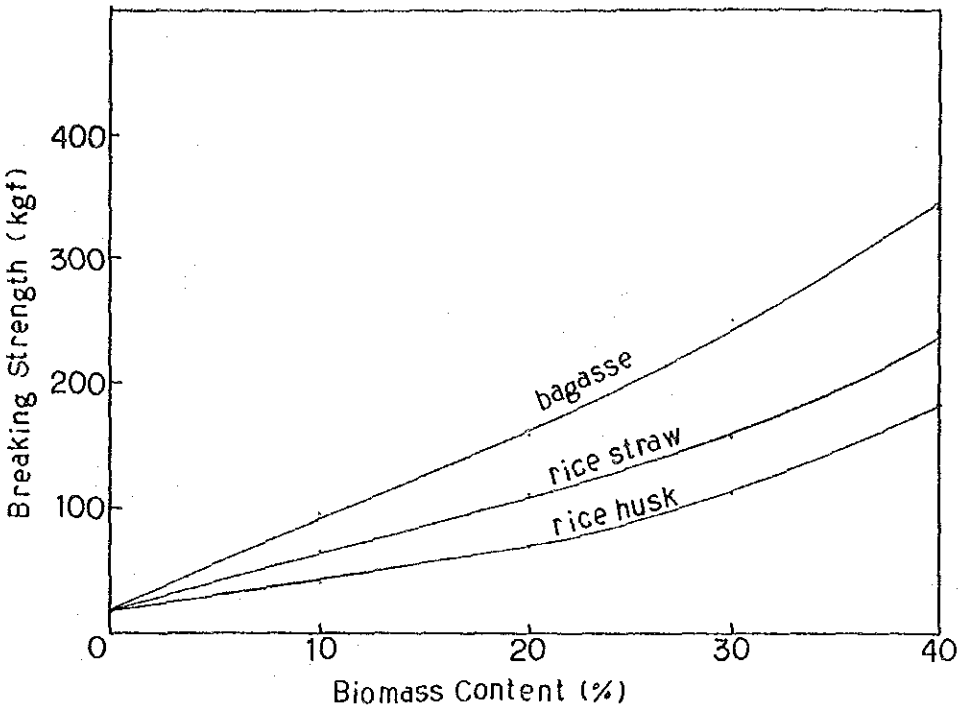

Figure 18-7 Breaking Strength of Tablet with High-quality Lignite

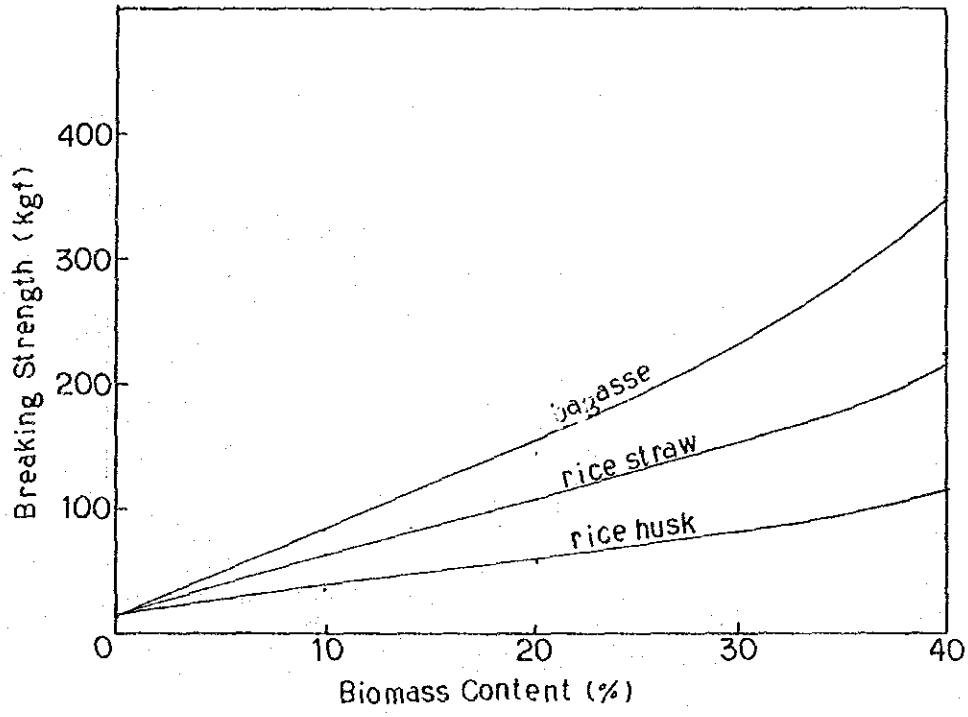

Figure 18-8 Breaking Strength of Tablet with Low-quality Lignite

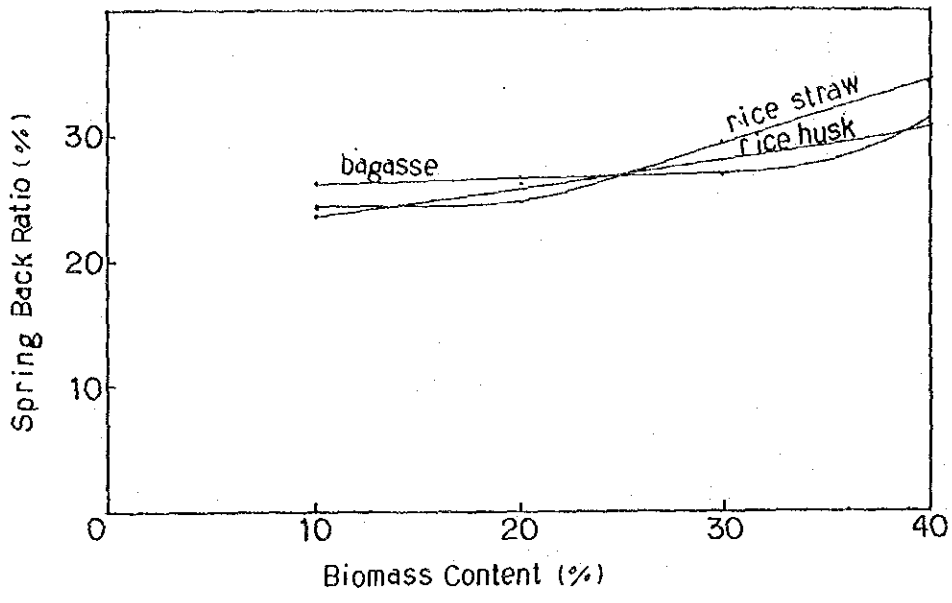

Figure 18-9 Spring Back Ratio of Tablet with High-quality Lignite

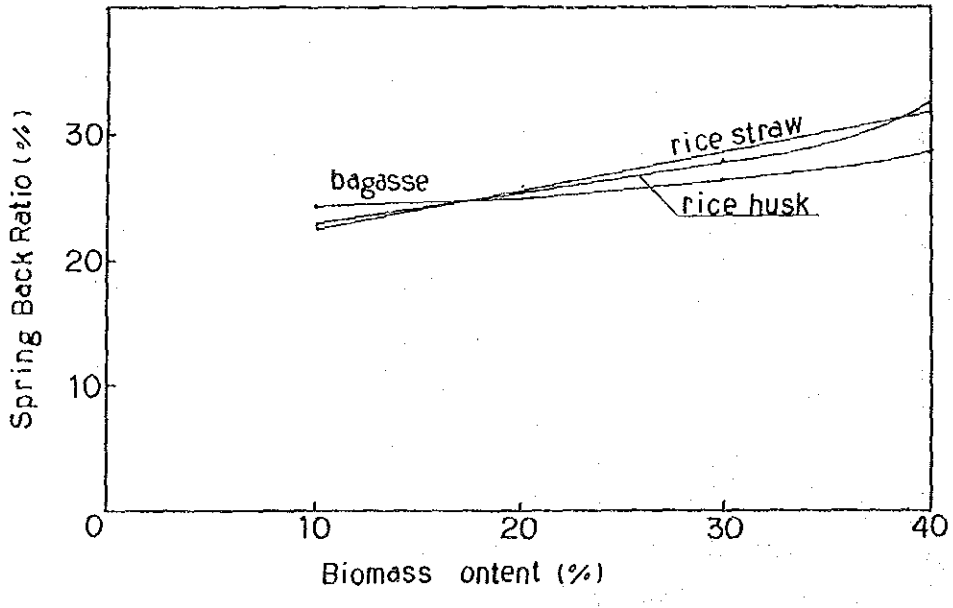

Figure 18-10 Spring Back Ratio of Tablet with Low-quality Lignite

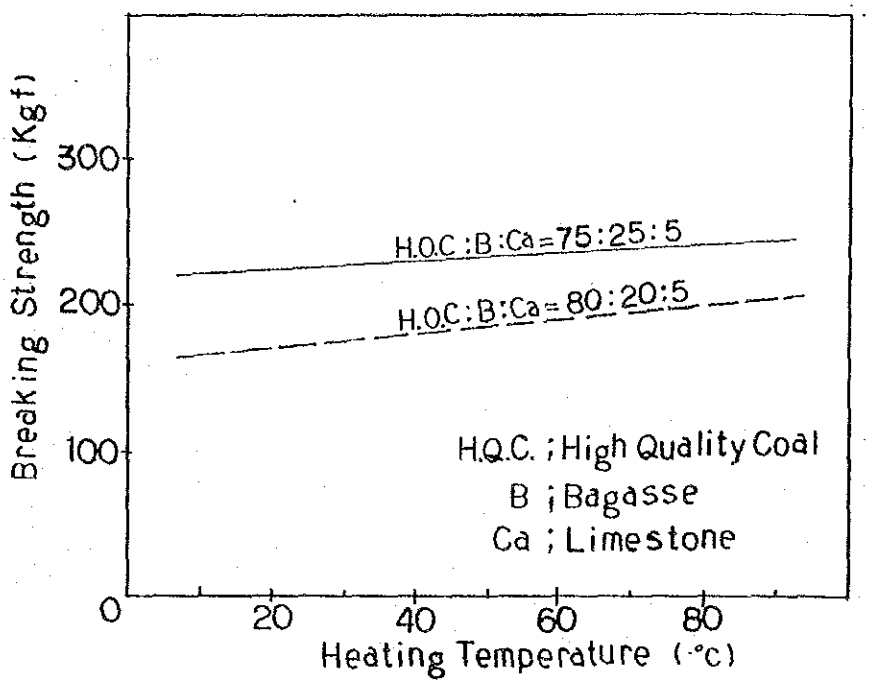

Figure 18-11 Effect of Material Heating on Breaking Strength

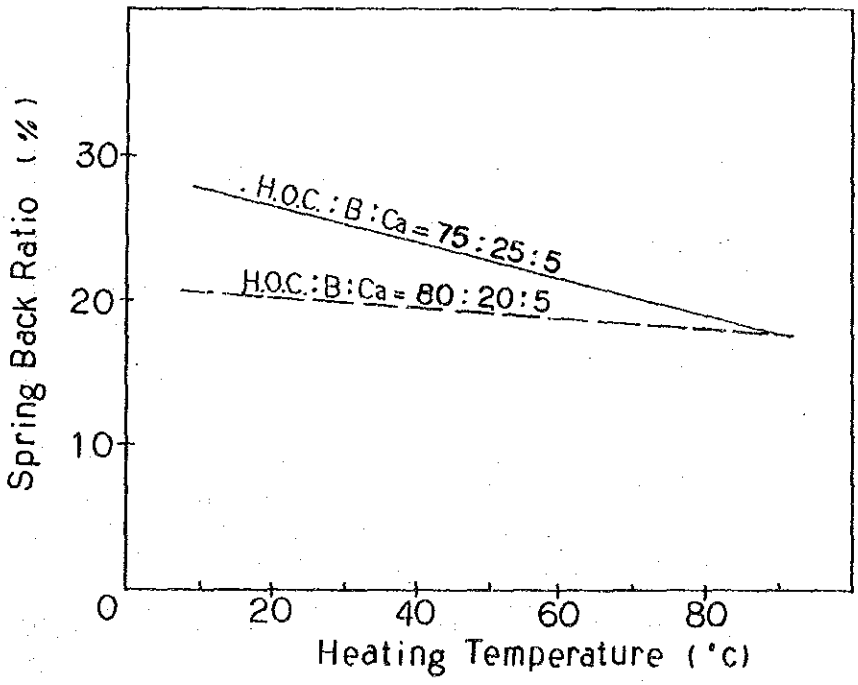

Figure 18-12 Effect of Material Heating on Spring Back Ratio

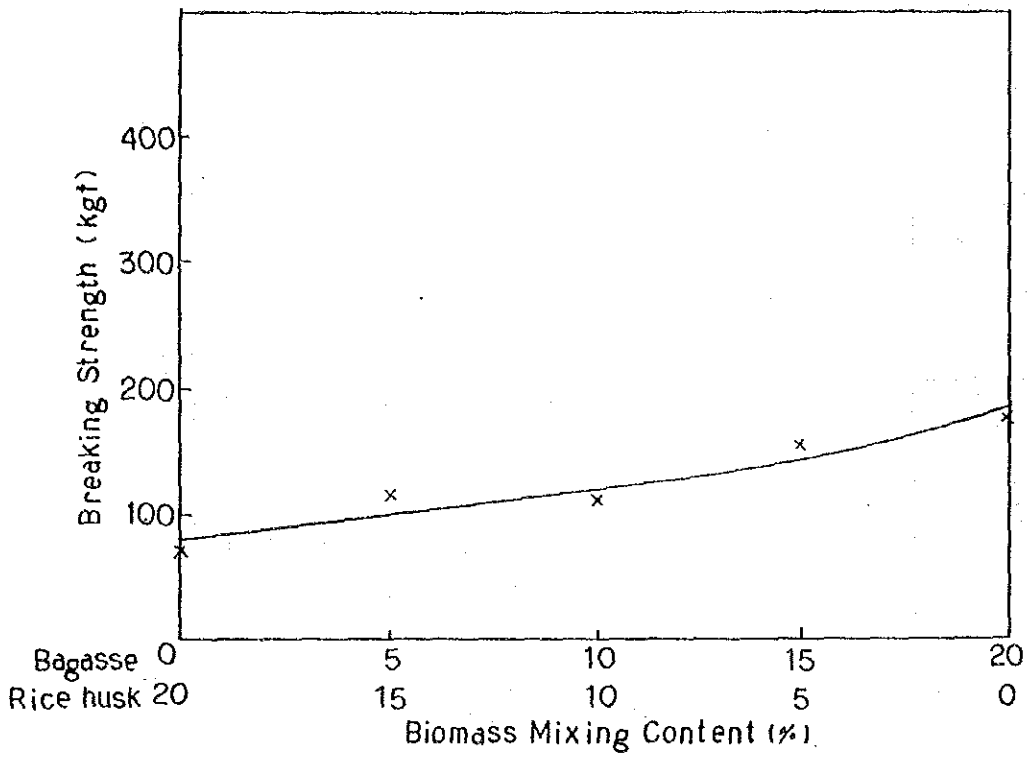

Figure 18-13 Breaking Strength of Tablet with High-quality Lignite

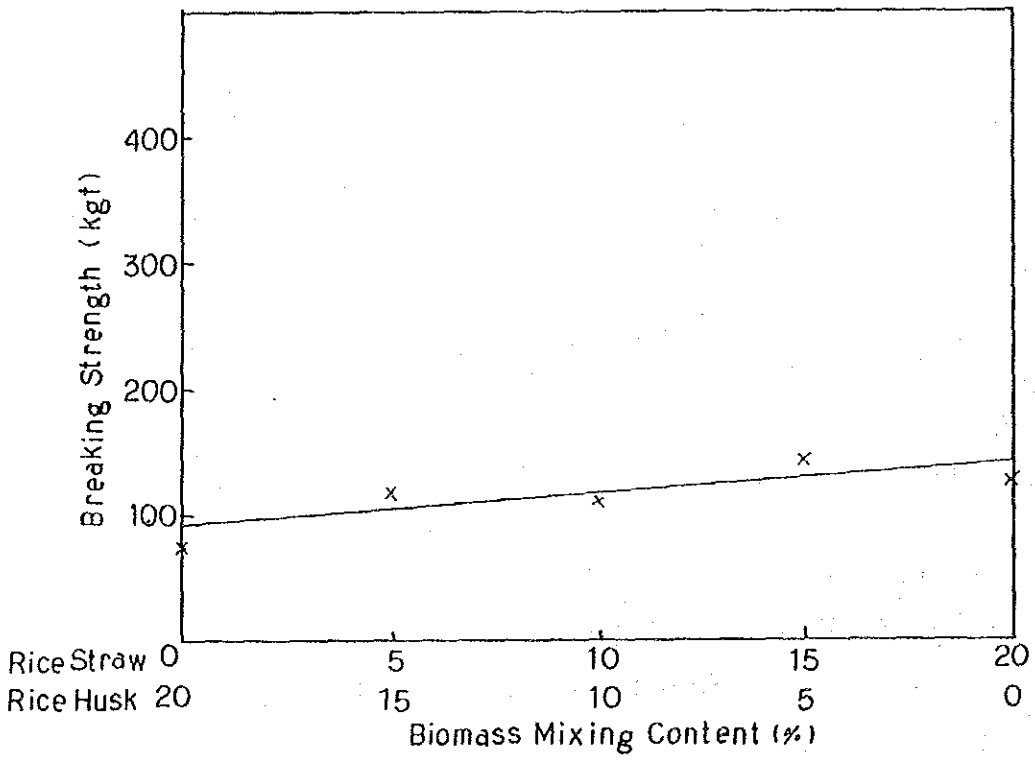

Figure 18-14 Breaking Strength of Tablet with Low-quality Lignite

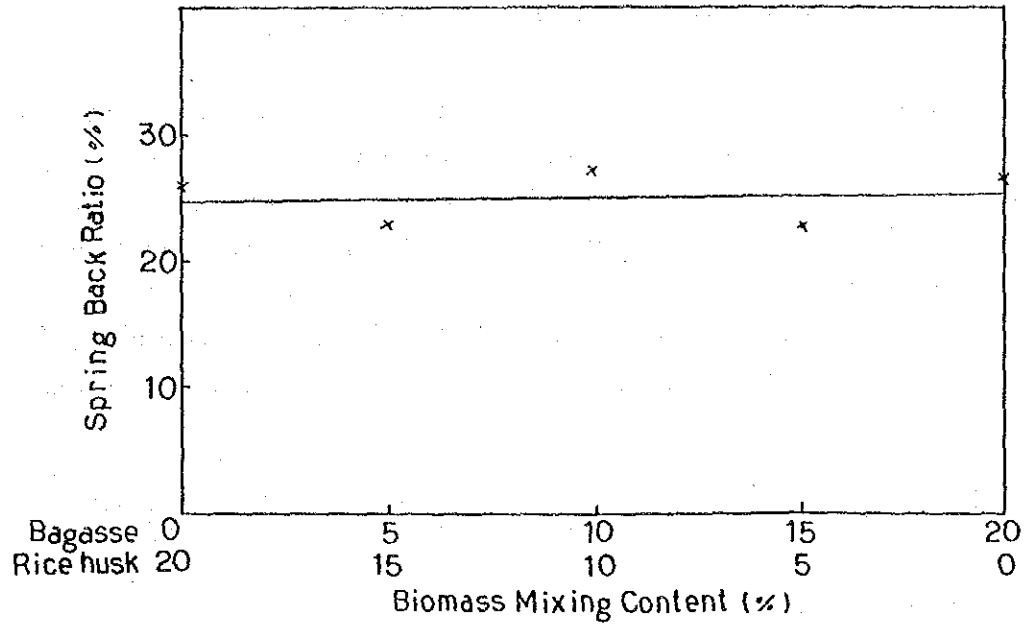

Figure 18-15 Spring Back Ratio of Tablet with High-quality Lignite

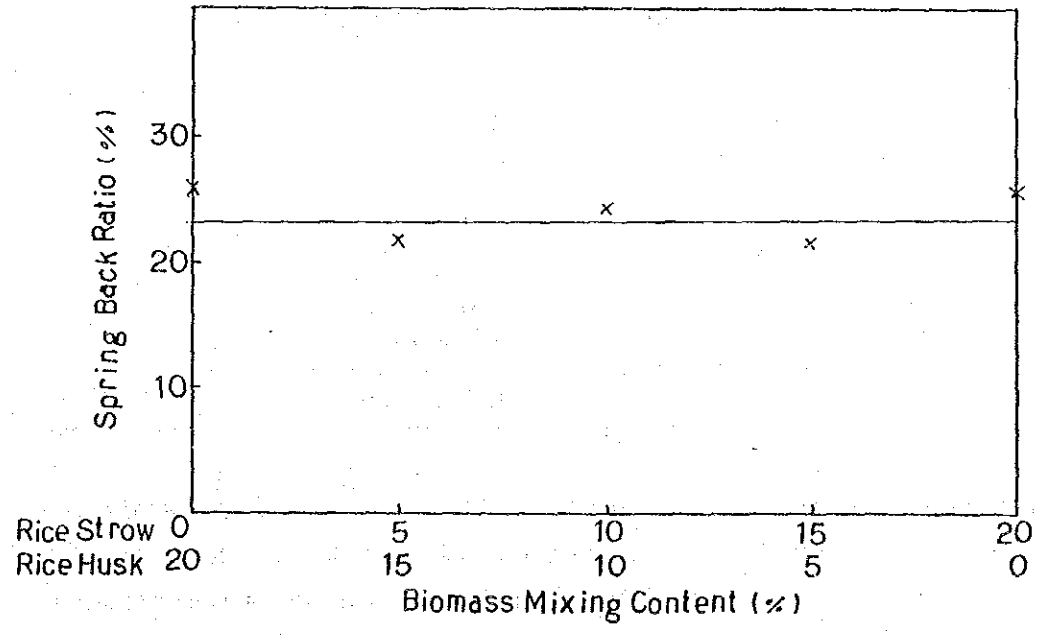

Figure 18-16 Spring Back Ratio of Tablet with Low-quality Lignite