APPENDICES

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APPENDIX A The life time of each replacement component

Energy Conservation Measure/ Equipment	**Median Life(yrs.)**	**Energy Conservation Measure/ Equipment**	**Median Life (yrs.)**
Air Conditioners		**Coils**	
Window unit	10	DX, water, or steam	20
Residential single or split	15	Electric	15
package		Heat Exchangers	
Commercial through-the-wal	15	Shell and tube	24
l Water-cooled package	15	**Compressors Chillers**	20
Single zone roof top Multi zone rooftop	15 (15)	Absorption Centrifugal	23 (23)
Heat Pumps Commercial air to air	15	Reciprocating	20
Commercial water to air	19	**Cooling Towers**	
Residential air to air	15 (24) (30)	Ceramic or FRP	34
Boilers, hot water (steam) Steel water tube		Galvanized metal	20
Steel fire-tube	25 (25)	Wood	20
Cast iron	35 (30)	**Condensers**	
Electric	15	Air-cooled	20
Burners	21	Evaporative	20
Furnaces		**Insulation**	
Gas or oil-fired	18	Molded	20
Unit Heaters		Blanket	24
Gas or electric Hot water or steam	13 20	**Pumps** Base mounted	20
Radiant Heaters		Condensate	15
Electric or gas	10	Pipe mounted	10
Hot water or steam	25	Sump and well	10
Air Terminals Diffuser, grilles, and registers	27	**Reciprocating Engines Steam turbines**	20 30
Induction and fan-coil units	20	**Electric Motors**	18
VAV and double-duct boxes	20	**Motor starters**	17
Air Washers	17	**Electric transformers**	30
Ductwork	30	**Controls**	
Dampers Fans	20	Electric Electronic	16 15
Centrifugal	25	Pneumatic	20
Axial	20	**Valve actuators**	
Propeller	15	Hydraulic	15
Ventilating, roof mounted	20	Pneumatic	20
		Self contained	10

APPENDIX B

Statement of cash flow

Table	Condition	Case
B.1	The community power plant only sell produced electricity	Base case of Rankine Steam Power System
B.2	The community power plant with extra benefit from tops and leaves products.	Case.1 (steam)
B.3	The community power plant with extra benefit from waste heat recovery 50% of the total waste heat for drying the agricultural products.	Case.2 (steam)
B.4	The community power plant with extra benefit from tops and leaves products and waste heat recovery 50% of the total waste heat for drying the agricultural products.	Case. 3 (steam)
B.5	The community power plant only sell produced electricity	Base case of Downdraft gasification system
B.6	The community power plant with extra benefit from tops and leaves products.	Case.1 (gasification)
B.7	The community power plant with extra benefit from charcoal.	Case.2 (gasification)
B.8	The community power plant with extra benefit from tops and leaves products and charcoal products.	Case. 3 (gasification)

B.1 The community power plant only sell produced electricity. (CASE. base steam)

Power capacity	50	kW
System	80	%
Plant Factor	30	Years
Life time	350,400	kWh/Year
electricity produced	10,512,000	kWh/Project
Fuel consumption	4.78	kg/kWh
Price of Electricity	3.32	Baht/kWh
Adder	0.5	Baht/kWh
Interest rate	8.7	%

Economic analysis result	
NPV(M Baht)	-6.68
Pay Back Preiod (	N/A
IRR	N/A

Item	ปีที่ 0 – 10										
	0	1	2	3	4	5	6	7	8	9	10
Cash Balance	0	200,000	-100,372	-233,492	-363,705	-491,135	-615,918	-838,200	-958,141	-1,245,995	-1,531,865
Cash received.											
investments.	4,660,000										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	0	1,163,328	1,186,595	1,210,326	1,234,533	1,259,224	1,284,408	1,310,096	1,336,298	1,363,024	1,390,285
Adder.	0	175,200	175,200	175,200	175,200	175,200	175,200	175,200	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0	0
Cabon credit.	0	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0	0
waste heat for drying	0	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0	0
Total	0	1,338,528	1,361,795	1,385,526	1,409,733	1,434,424	1,459,608	1,485,296	1,336,298	1,363,024	1,390,285
Total cash income	4,660,000	1,338,528	1,361,795	1,385,526	1,409,733	1,434,424	1,459,608	1,485,296	1,336,298	1,363,024	1,390,285
Cash payments.											
Fix cost											
Buildings power plants.	1,000,000	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	2,800,000	0	0	0	0	0	0	0	0	0	0
Gasification system	170,000	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	390,000	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0	0
Total payment.	4,660,000	0	0	0	0	0	100,000	0	0	0	0
Operation cost											
Cash paymentsfor loan	-	0	0	0	0	0	0	0	0	0	0
Plantation phase.											
fuel	0	438,632	409,698	421,989	434,649	447,688	461,119	474,953	489,201	503,877	518,993
Transportation phase.											
loading	0	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	0	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	0	1,653	2,204	2,204	2,204	2,204	2,204	2,204	2,204	2,204	2,204
Price per Unit (B/L).	0	29.83	31.32	32.89	34.53	36.26	38.07	39.98	41.97	44.07	46.28
Total fuel cost.	0	49,307.27	69,030.18	72,481.69	76,105.77	79,911.06	83,906.62	88,101.95	92,507.04	97,132.40	101,989.02
Total logistic cost	0	229,096.47	248,819.38	252,270.89	255,894.97	259,700.26	263,695.82	267,891.15	272,296.24	276,921.60	281,778.22
Preparation phase.											
Reduce cost	0	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	0	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	0	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.											
labor.	0	434,160	438,502	442,887	447,315	451,789	456,307	460,870	465,478	470,133	474,834
production cost	0	139,800	0	0	0	0	0	0	0	0	0
sales and administrative	0	39,505	40,189	40,886	41,597	42,322	43,062	43,816	39,470	40,255	41,056
Total Electrication phase.	0	613,465	478,690	483,772	488,912	494,111	499,369	504,686	504,948	510,388	515,890
Char carbons Production.		0	0	0	0	0	0	0	0	0	0
Heat recovery operation.		0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).		1,638,900	1,494,915	1,515,739	1,537,163	1,559,206	1,681,890	1,605,237	1,624,153	1,648,894	1,674,369
Net income per year (A) - (B).	4,660,000	-300,372	-133,120	-130,213	-127,430	-124,783	-222,282	-119,940	-287,855	-285,870	-284,084
Cash received (paid), net (cumulative).	200,000	-100,372	-233,492	-363,705	-491,135	-615,918	-838,200	-958,141	-1,245,995	-1,531,865	-1,815,949
Cash accumulated throughout the project.	100,000	-100,372	-233,492	-363,705	-491,135	-615,918	-838,200	-958,141	-1,245,995	-1,531,865	-1,815,949
Cash accumulated throughout the project.	200,000	-100,372	-233,492	-363,705	-491,135	-615,918	-838,200	-958,141	-1,245,995	-1,531,865	-1,815,949
Net Cash Flow	-4,460,000	-4,760,372	-4,893,492	-5,023,705	-5,151,135	-5,275,918	-5,498,200	-5,618,141	-5,905,995	-6,191,865	-6,475,949
NPV(Baht)	**-6,682,139**										
IRR	**N/A**										
Pay Back Preiod (Yrs)	**N/A**										

Item	ปีที่ 11 – 20									
	11	12	13	14	15	16	17	18	19	20
Cash Balance	-1,815,949	-2,398,462	-2,679,632	-2,959,707	-3,238,950	-3,517,642	-3,896,084	-4,174,597	-4,453,523	-4,733,225
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	1,418,090	1,446,452	1,475,381	1,504,889	1,534,987	1,565,686	1,597,000	1,628,940	1,661,519	1,694,749
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon credit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0
waste heat for drying	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0
Total	1,418,090	1,446,452	1,475,381	1,504,889	1,534,987	1,565,686	1,597,000	1,628,940	1,661,519	1,694,749
Total cash income	1,418,090	1,446,452	1,475,381	1,504,889	1,534,987	1,565,686	1,597,000	1,628,940	1,661,519	1,694,749
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	300,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	534,563	550,600	567,118	584,132	601,656	619,705	638,297	657,445	677,169	697,484
Transportation phase.										
loading	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	2,204	2,204	2,204	2,204	2,204	2,204	2,204	2,204	2,204	2,204
Price per Unit (B/L).	48.59	51.02	53.57	56.25	59.06	62.01	65.12	68.37	71.79	75.38
Total fuel cost.	107,088.47	112,442.89	118,065.03	123,968.29	130,166.70	136,675.04	143,508.79	150,684.23	158,218.44	166,129.36
Total logistic cost	286,877.67	292,232.09	297,854.23	303,757.49	309,955.90	316,464.24	323,297.99	330,473.43	338,007.64	345,918.56
Preparation phase.										
Reduce cost	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.										
labor.	479,583	484,379	489,222	494,115	499,056	504,046	509,087	514,178	519,319	524,513
production cost	0	0	0	0	0	0	0	0	0	0
sales and administrative	41,872	42,705	43,554	44,421	45,304	46,206	47,125	48,062	49,019	49,994
Total Electrication phase.	521,455	527,084	532,777	538,535	544,360	550,252	556,212	562,240	568,338	574,507
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	2,000,603	1,727,623	1,755,456	1,784,131	1,813,679	1,944,128	1,875,513	1,907,866	1,941,221	1,975,616
Net income per year (A) - (B).	-582,512	-281,171	-280,075	-279,243	-278,692	-378,442	-278,513	-278,926	-279,703	-280,867
Cash received (paid), net (cumulative).	-2,398,462	-2,679,632	-2,959,707	-3,238,950	-3,517,642	-3,896,084	-4,174,597	-4,453,523	-4,733,225	-5,014,092
Cash accumulated throughout the project.	-2,398,462	-2,679,632	-2,959,707	-3,238,950	-3,517,642	-3,896,084	-4,174,597	-4,453,523	-4,733,225	-5,014,092
Cash accumulated throughout the project.	-2,398,462	-2,679,632	-2,959,707	-3,238,950	-3,517,642	-3,896,084	-4,174,597	-4,453,523	-4,733,225	-5,014,092
Net Cash Flow	-7,058,462	-7,339,632	-7,619,707	-7,898,950	-8,177,642	-8,556,084	-8,834,597	-9,113,523	-9,393,225	-9,674,092

Item	ปีที่ 21 – 30									
	21	22	23	24	25	26	27	28	29	30
Cash Balance	-5,014,092	-5,596,535	-5,880,991	-6,167,925	-6,457,829	-6,751,227	-7,148,671	-7,450,747	-7,758,078	-8,071,319
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	1,728,644	1,763,217	1,798,481	1,834,451	1,871,140	1,908,563	1,946,734	1,985,669	2,025,382	2,065,890
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon credit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0
waste heat for drying	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	365,131
Total	1,728,644	1,763,217	1,798,481	1,834,451	1,871,140	1,908,563	1,946,734	1,985,669	2,025,382	2,431,021
Total cash income	1,728,644	1,763,217	1,798,481	1,834,451	1,871,140	1,908,563	1,946,734	1,985,669	2,025,382	2,431,021
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	-	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	300,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	718,408	739,961	762,159	785,024	808,575	832,832	857,817	883,552	910,058	937,360
Transportation phase.										
loading	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	2,204	2,204	2,204	2,204	2,204	2,204	2,204	2,204	2,204	2,204
Price per Unit (B/L).	79.15	83.11	87.26	91.62	96.20	101.01	106.07	111.37	116.94	122.78
Total fuel cost.	174,435.83	183,157.62	192,315.50	201,931.28	212,027.84	222,629.23	233,760.69	245,448.73	257,721.16	270,607.22
Total logistic cost	354,225.03	362,946.82	372,104.70	381,720.48	391,817.04	402,418.43	413,549.89	425,237.93	437,510.36	450,396.42
Preparation phase.										
Reduce cost	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.										
labor.	529,758	535,055	540,406	545,810	551,268	556,781	562,348	567,972	573,652	579,388
production cost	0	0	0	0	0	0	0	0	0	0
sales and administrative	50,989	52,004	53,038	54,094	55,171	56,269	57,389	58,531	59,696	60,884
Total Electrication phase.	580,747	587,059	593,444	599,904	606,439	613,049	619,737	626,503	633,348	640,273
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	2,311,087	2,047,673	2,085,415	2,124,355	2,164,537	2,306,007	2,248,811	2,292,999	2,338,623	2,385,736
Net income per year (A) - (B).	-582,443	-284,456	-286,934	-289,904	-293,397	-397,444	-302,077	-307,331	-313,241	45,285
Cash received (paid), net (cumulative).	-5,596,535	-5,880,991	-6,167,925	-6,457,829	-6,751,227	-7,148,671	-7,450,747	-7,758,078	-8,071,319	-8,026,034
Cash accumulated throughout the project.	-5,596,535	-5,880,991	-6,167,925	-6,457,829	-6,751,227	-7,148,671	-7,450,747	-7,758,078	-8,071,319	-8,026,034
Cash accumulated throughout the project.	-5,596,535	-5,880,991	-6,167,925	-6,457,829	-6,751,227	-7,148,671	-7,450,747	-7,758,078	-8,071,319	-8,026,034
Net Cash Flow	-10,256,535	-10,540,991	-10,827,925	-11,117,829	-11,411,227	-11,808,671	-12,110,747	-12,418,078	-12,731,319	-12,686,034

B.2 The community power plant with extra benefit from tops and leaves products.(CASE.1 steam)

Power capacity	50	kW
System	80	%
Plant Factor	30	Years
Life time	350,400	kWh/Year
electricity produced	10,512,000	kWh/Project
Fuel consumption	4.78	kg/kWh
Price of Electricity	3.32	Baht/kWh
Adder	0.5	Baht/kWh
Interest rate	8.7	%

Economic analysis result	
NPV(M Baht)	12.03
Pay Back Preiod (	3
IRR	27.53%

Item	ปีที่ 0 – 10										
	0	1	2	3	4	5	6	7	8	9	10
Cash Balance	0	200,000	-68,665	1,554,715	3,216,131	4,916,161	6,655,387	8,334,393	10,153,765	11,844,009	13,575,798
Cash received.											
investments.	4,660,000										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	0	1,163,328	1,186,595	1,210,326	1,234,533	1,259,224	1,284,408	1,310,096	1,336,298	1,363,024	1,390,285
Adder.	0	175,200	175,200	175,200	175,200	175,200	175,200	175,200	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	31,728	32,362	33,009	33,670	34,343	35,030	35,730	36,445	37,174	37,917
waste heat for drying	0	0	1,724,167	1,758,650	1,793,823	1,829,699	1,866,293	1,903,619	1,941,692	1,980,525	2,020,136
Salvage.	0	0	0	0	0	0	0	0	0	0	0
Total	0	1,370,256	3,118,323	3,177,186	3,237,226	3,298,466	3,360,931	3,424,646	3,314,435	3,380,724	3,448,338
Total cash income	4,660,000	1,370,256	3,118,323	3,177,186	3,237,226	3,298,466	3,360,931	3,424,646	3,314,435	3,380,724	3,448,338
Cash payments.											
Fix cost											
Buildings power plants.	1,000,000	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	2,800,000	0	0	0	0	0	0	0	0	0	0
Gasification system	170,000	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	390,000	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0	0
Total payment.	4,660,000	0	0	0	0	0	100,000	0	0	0	0
Operation cost											
Cash paymentsfor loan	-	0	0	0	0	0	0	0	0	0	0
Plantation phase.											
fuel	0	438,632	409,698	421,989	434,649	447,688	461,119	474,953	489,201	503,877	518,993
Transportation phase.											
loading	0	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	0	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	0	1,654	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205
Price per Unit (B/L).	0	29.83	31.32	32.89	34.53	36.26	38.07	39.98	41.97	44.07	46.28
Total fuel cost.	0	49,327.93	69,059.11	72,512.06	76,137.66	79,944.55	83,941.77	88,138.86	92,545.81	97,173.10	102,031.75
Total logistic cost	0	229,117.13	248,848.31	252,301.26	255,926.86	259,733.75	263,730.97	267,928.06	272,335.01	276,962.30	281,820.95
Preparation phase.											
Reduce cost	0	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	0	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	0	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.											
labor.	0	434,160	438,502	442,887	447,315	451,789	456,307	460,870	465,478	470,133	474,834
production cost	0	139,800	0	0	0	0	0	0	0	0	0
sales and administrative	0	39,505	40,189	40,886	41,597	42,322	43,062	43,816	39,470	40,255	41,056
Total Electrication phase.	0	613,465	478,690	483,772	488,912	494,111	499,369	504,686	504,948	510,388	515,890
Char carbons Production.		0	0	0	0	0	0	0	0	0	0
Heat recovery operation.		0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).		1,638,921	1,494,944	1,515,770	1,537,195	1,559,240	1,681,925	1,605,274	1,624,192	1,648,935	1,674,411
Net income per year (A) - (B).	4,660,000	-268,665	1,623,380	1,661,416	1,700,030	1,739,226	1,679,006	1,819,372	1,690,243	1,731,789	1,773,927
Cash received (paid), net (cumulative).	200,000	-68,665	1,554,715	3,216,131	4,916,161	6,655,387	8,334,393	10,153,765	11,844,009	13,575,798	15,349,724
Cash accumulated throughout the project.	100,000	-68,665	1,554,715	3,216,131	4,916,161	6,655,387	8,334,393	10,153,765	11,844,009	13,575,798	15,349,724
Cash accumulated throughout the project.	200,000	-68,665	1,554,715	3,216,131	4,916,161	6,655,387	8,334,393	10,153,765	11,844,009	13,575,798	15,349,724
Net Cash Flow	-4,460,000	-4,728,665	-3,105,285	-1,443,869	256,161	1,995,387	3,674,393	5,493,765	7,184,009	8,915,798	10,689,724
NPV(Baht)	12,025,975										
IRR	27.53%										
Pay Back Preiod (Yrs)	3.00										

Item	ปีที่ 11 – 20									
	11	12	13	14	15	16	17	18	19	20
Cash Balance	15,349,724	16,866,382	18,726,363	20,630,261	22,578,670	24,572,180	26,511,383	28,596,866	30,729,215	32,909,011
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	1,418,090	1,446,452	1,475,381	1,504,889	1,534,987	1,565,686	1,597,000	1,628,940	1,661,519	1,694,749
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	38,676	39,449	40,238	41,043	41,864	42,701	43,555	44,426	45,315	46,221
waste heat for drying	2,060,539	2,101,749	2,143,784	2,186,660	2,230,393	2,275,001	2,320,501	2,366,911	2,414,249	2,462,534
Salvage.	0	0	0	0	0	0	0	0	0	0
Total	3,517,305	3,587,651	3,659,404	3,732,592	3,807,244	3,883,389	3,961,056	4,040,278	4,121,083	4,203,505
Total cash income	3,517,305	3,587,651	3,659,404	3,732,592	3,807,244	3,883,389	3,961,056	4,040,278	4,121,083	4,203,505
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	300,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	534,563	550,600	567,118	584,132	601,656	619,705	638,297	657,445	677,169	697,484
Transportation phase.										
loading	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205
Price per Unit (B/L).	48.59	51.02	53.57	56.25	59.06	62.01	65.12	68.37	71.79	75.38
Total fuel cost.	107,133.34	112,490.01	118,114.51	124,020.23	130,221.24	136,732.31	143,568.92	150,747.37	158,284.74	166,198.97
Total logistic cost	286,922.54	292,279.21	297,903.71	303,809.43	310,010.44	316,521.51	323,358.12	330,536.57	338,073.94	345,988.17
Preparation phase.										
Reduce cost	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.										
labor.	479,583	484,379	489,222	494,115	499,056	504,046	509,087	514,178	519,319	524,513
production cost	0	0	0	0	0	0	0	0	0	0
sales and administrative	41,872	42,705	43,554	44,421	45,304	46,206	47,125	48,062	49,019	49,994
Total Electrication phase.	521,455	527,084	532,777	538,535	544,360	550,252	556,212	562,240	568,338	574,507
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	2,000,648	1,727,670	1,755,506	1,784,183	1,813,733	1,944,186	1,875,573	1,907,929	1,941,288	1,975,686
Net income per year (A) - (B).	1,516,657	1,859,981	1,903,898	1,948,409	1,993,511	1,939,203	2,085,483	2,132,349	2,179,795	2,227,819
Cash received (paid), net (cumulative).	16,866,382	18,726,363	20,630,261	22,578,670	24,572,180	26,511,383	28,596,866	30,729,215	32,909,011	35,136,830
Cash accumulated throughout the project.	16,866,382	18,726,363	20,630,261	22,578,670	24,572,180	26,511,383	28,596,866	30,729,215	32,909,011	35,136,830
Cash accumulated throughout the project.	16,866,382	18,726,363	20,630,261	22,578,670	24,572,180	26,511,383	28,596,866	30,729,215	32,909,011	35,136,830
Net Cash Flow	12,206,382	14,066,363	15,970,261	17,918,670	19,912,180	21,851,383	23,936,866	26,069,215	28,249,011	30,476,830

Item	ปีที่ 21 – 30									
	21	22	23	24	25	26	27	28	29	30
Cash Balance	35,136,830	37,113,245	39,438,821	41,814,118	44,239,687	46,716,070	49,143,799	51,723,395	54,355,369	57,040,215
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	1,728,644	1,763,217	1,798,481	1,834,451	1,871,140	1,908,563	1,946,734	1,985,669	2,025,382	2,065,890
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	47,146	48,088	49,050	50,031	51,032	52,053	53,094	54,155	55,239	56,343
waste heat for drying	2,511,785	2,562,021	2,613,261	2,665,527	2,718,837	2,773,214	2,828,678	2,885,252	2,942,957	3,001,816
Salvage.	0	0	0	0	0	0	0	0	0	365,131
Total	4,287,575	4,373,326	4,460,793	4,550,009	4,641,009	4,733,829	4,828,506	4,925,076	5,023,577	5,489,180
Total cash income	4,287,575	4,373,326	4,460,793	4,550,009	4,641,009	4,733,829	4,828,506	4,925,076	5,023,577	5,489,180
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	-	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	300,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	718,408	739,961	762,159	785,024	808,575	832,832	857,817	883,552	910,058	937,360
Transportation phase.										
loading	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205
Price per Unit (B/L).	79.15	83.11	87.26	91.62	96.20	101.01	106.07	111.37	116.94	122.78
Total fuel cost.	174,508.92	183,234.37	192,396.09	202,015.89	212,116.68	222,722.52	233,858.64	245,551.58	257,829.16	270,720.61
Total logistic cost	354,298.12	363,023.57	372,185.29	381,805.09	391,905.88	402,511.72	413,647.84	425,340.78	437,618.36	450,509.81
Preparation phase.										
Reduce cost	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.										
labor.	529,758	535,055	540,406	545,810	551,268	556,781	562,348	567,972	573,652	579,388
production cost	0	0	0	0	0	0	0	0	0	0
sales and administrative	50,989	52,004	53,038	54,094	55,171	56,269	57,389	58,531	59,696	60,884
Total Electrication phase.	580,747	587,059	593,444	599,904	606,439	613,049	619,737	626,503	633,348	640,273
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	2,311,160	2,047,750	2,085,496	2,124,440	2,164,626	2,306,100	2,248,909	2,293,102	2,338,731	2,385,849
Net income per year (A) - (B).	1,976,415	2,325,577	2,375,297	2,425,569	2,476,383	2,427,729	2,579,597	2,631,974	2,684,846	3,103,330
Cash received (paid), net (cumulative).	37,113,245	39,438,821	41,814,118	44,239,687	46,716,070	49,143,799	51,723,395	54,355,369	57,040,215	60,143,546
Cash accumulated throughout the project.	37,113,245	39,438,821	41,814,118	44,239,687	46,716,070	49,143,799	51,723,395	54,355,369	57,040,215	60,143,546
Cash accumulated throughout the project.	37,113,245	39,438,821	41,814,118	44,239,687	46,716,070	49,143,799	51,723,395	54,355,369	57,040,215	60,143,546
Net Cash Flow	32,453,245	34,778,821	37,154,118	39,579,687	42,056,070	44,483,799	47,063,395	49,695,369	52,380,215	55,483,546

B.3 The community power plant with extra benefit from waste heat recovery 50% of the total waste heat for drying the agricultural products.(CASE.2 steam)

Power capacity	50	kW
System	80	%
Plant Factor	30	Years
Life time	350,400	kWh/Year
electricity produced	10,512,000	kWh/Project
Fuel consumption	4.78	kg/kWh
Price of Electricity	3.32	Baht/kWh
Adder	0.5	Baht/kWh
Interest rate	8.7	%

Economic analysis result	
NPV(M Baht)	9.82
Pay Back Preiod (	4.02
IRR	24.36%

		ปีที่ 0 – 10									
Item	0	1	2	3	4	5	6	7	8	9	10
Cash Balance	0	200,000	1,482,972	2,964,856	4,481,945	6,034,763	7,623,832	9,149,678	10,812,827	12,343,722	13,912,976
Cash received.											
investments.	6,060,000										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	0	1,163,328	1,186,595	1,210,326	1,234,533	1,259,224	1,284,408	1,310,096	1,336,298	1,363,024	1,390,285
Adder.	0	175,200	175,200	175,200	175,200	175,200	175,200	175,200	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0	0
waste heat for drying	0	1,690,359	1,724,167	1,758,650	1,793,823	1,829,699	1,866,293	1,903,619	1,941,692	1,980,525	2,020,136
Salvage.	0	0	0	0	0	0	0	0	0	0	0
Total	0	3,028,887	3,085,961	3,144,176	3,203,556	3,264,123	3,325,901	3,388,916	3,277,990	3,343,550	3,410,421
Total cash income	6,060,000	3,028,887	3,085,961	3,144,176	3,203,556	3,264,123	3,325,901	3,388,916	3,277,990	3,343,550	3,410,421
Cash payments.											
Fix cost											
Buildings power plants.	1,000,000	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	2,800,000	0	0	0	0	0	0	0	0	0	0
Gasification system	170,000	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	390,000	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0	0
Heat recovery system	1,400,000	0	0	0	0	0	0	0	0	0	0
Total payment.	6,060,000	0	0	0	0	0	100,000	0	0	0	0
Operation cost											
Cash paymentsfor loan	-	0	0	0	0	0	0	0	0	0	0
Plantation phase.											
fuel	0	438,632	409,698	421,989	434,649	447,688	461,119	474,953	489,201	503,877	518,993
Transportation phase.											
loading	0	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	0	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	0	1,654	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205
Price per Unit (B/L).	0	29.83	31.32	32.89	34.53	36.26	38.07	39.98	41.97	44.07	46.28
Total fuel cost.	0	49,327.93	69,059.11	72,512.06	76,137.66	79,944.55	83,941.77	88,138.86	92,545.81	97,173.10	102,031.75
Total logistic cost	0	229,117.13	248,848.31	252,301.26	255,926.86	259,733.75	263,730.97	267,928.06	272,335.01	276,962.30	281,820.95
Preparation phase.											
Reduce cost	0	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	0	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	0	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.											
labor.	0	434,160	438,502	442,887	447,315	451,789	456,307	460,870	465,478	470,133	474,834
production cost	0	139,800	0	0	0	0	0	0	0	0	0
sales and administrative	0	39,505	40,189	40,886	41,597	42,322	43,062	43,816	39,470	40,255	41,056
Total Electrication phase.	0	613,465	478,690	483,772	488,912	494,111	499,369	504,686	504,948	510,388	515,890
Char carbons Production.		0	0	0	0	0	0	0	0	0	0
Heat recovery operation.		106,994	109,134	111,317	113,543	115,814	118,130	120,493	122,903	125,361	127,868
Total cash payment per year (B).		1,745,915	1,604,078	1,627,087	1,650,738	1,675,054	1,800,056	1,725,767	1,747,094	1,774,295	1,802,280
Net income per year (A) - (B).	6,060,000	1,282,972	1,481,883	1,517,090	1,552,818	1,589,069	1,525,846	1,663,149	1,530,895	1,569,254	1,608,141
Cash received (paid), net (cumulative).	200,000	1,482,972	2,964,856	4,481,945	6,034,763	7,623,832	9,149,678	10,812,827	12,343,722	13,912,976	15,521,117
Cash accumulated throughout the project.	100,000	1,482,972	2,964,856	4,481,945	6,034,763	7,623,832	9,149,678	10,812,827	12,343,722	13,912,976	15,521,117
Cash accumulated throughout the project.	200,000	1,482,972	2,964,856	4,481,945	6,034,763	7,623,832	9,149,678	10,812,827	12,343,722	13,912,976	15,521,117
Net Cash Flow	-5,860,000	-4,577,028	-3,095,144	-1,578,055	-25,237	1,563,832	3,089,678	4,752,827	6,283,722	7,852,976	9,461,117
NPV(Baht)	**9,817,081**										
IRR	**24.36%**										
Pay Back Preiod (Yrs)	**4.02**										

	ปีที่ 11 – 20									
Item	11	12	13	14	15	16	17	18	19	20
Cash Balance	15,521,117	15,468,673	17,156,171	18,884,137	20,653,093	22,463,564	24,216,065	26,111,113	28,049,217	30,030,884
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	1,418,090	1,446,452	1,475,381	1,504,889	1,534,987	1,565,686	1,597,000	1,628,940	1,661,519	1,694,749
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0
waste heat for drying	2,060,539	2,101,749	2,143,784	2,186,660	2,230,393	2,275,001	2,320,501	2,366,911	2,414,249	2,462,534
Salvage.	0	0	0	0	0	0	0	0	0	0
Total	3,478,629	3,548,202	3,619,166	3,691,549	3,765,380	3,840,688	3,917,501	3,995,851	4,075,768	4,157,284
Total cash income	3,478,629	3,548,202	3,619,166	3,691,549	3,765,380	3,840,688	3,917,501	3,995,851	4,075,768	4,157,284
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0
Heat recovery system	1,400,000	0	0	0	0	0	0	0	0	0
Total payment.	1,700,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	534,563	550,600	567,118	584,132	601,656	619,705	638,297	657,445	677,169	697,484
Transportation phase.										
loading	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205
Price per Unit (B/L).	48.59	51.02	53.57	56.25	59.06	62.01	65.12	68.37	71.79	75.38
Total fuel cost.	107,133.34	112,490.01	118,114.51	124,020.23	130,221.24	136,732.31	143,568.92	150,747.37	158,284.74	166,198.97
Total logistic cost	286,922.54	292,279.21	297,903.71	303,809.43	310,010.44	316,521.51	323,358.12	330,536.57	338,073.94	345,988.17
Preparation phase.										
Reduce cost	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.										
labor.	479,583	484,379	489,222	494,115	499,056	504,046	509,087	514,178	519,319	524,513
production cost	0	0	0	0	0	0	0	0	0	0
sales and administrative	41,872	42,705	43,554	44,421	45,304	46,206	47,125	48,062	49,019	49,994
Total Electrication phase.	521,455	527,084	532,777	538,535	544,360	550,252	556,212	562,240	568,338	574,507
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	130,425	133,034	135,695	138,409	141,177	144,000	146,880	149,818	152,814	155,870
Total cash payment per year (B).	3,531,073	1,860,704	1,891,200	1,922,592	1,954,910	2,088,186	2,022,453	2,057,747	2,094,102	2,131,556
Net income per year (A) - (B).	-52,444	1,687,498	1,727,965	1,768,957	1,810,470	1,752,502	1,895,048	1,938,104	1,981,666	2,025,728
Cash received (paid), net (cumulative).	15,468,673	17,156,171	18,884,137	20,653,093	22,463,564	24,216,065	26,111,113	28,049,217	30,030,884	32,056,611
Cash accumulated throughout the project.	15,468,673	17,156,171	18,884,137	20,653,093	22,463,564	24,216,065	26,111,113	28,049,217	30,030,884	32,056,611
Cash accumulated throughout the project.	15,468,673	17,156,171	18,884,137	20,653,093	22,463,564	24,216,065	26,111,113	28,049,217	30,030,884	32,056,611
Net Cash Flow	9,408,673	11,096,171	12,824,137	14,593,093	16,403,564	18,156,065	20,051,113	21,989,217	23,970,884	25,996,611

	ปีที่ 21 – 30									
Item	21	22	23	24	25	26	27	28	29	30
Cash Balance	32,056,611	32,426,893	34,542,213	36,703,049	38,909,867	41,163,124	43,363,265	45,710,722	48,105,913	50,549,241
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	1,728,644	1,763,217	1,798,481	1,834,451	1,871,140	1,908,563	1,946,734	1,985,669	2,025,382	2,065,890
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0
waste heat for drying	2,511,785	2,562,021	2,613,261	2,665,527	2,718,837	2,773,214	2,828,678	2,885,252	2,942,957	3,001,816
Salvage.	0	0	0	0	0	0	0	0	0	479,746
Total	4,240,429	4,325,238	4,411,743	4,499,978	4,589,977	4,681,777	4,775,412	4,870,920	4,968,339	5,547,452
Total cash income	4,240,429	4,325,238	4,411,743	4,499,978	4,589,977	4,681,777	4,775,412	4,870,920	4,968,339	5,547,452
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	-	0	0	0	0	0	0	0	0	0
Heat recovery system	1,400,000	0	0	0	0	0	0	0	0	0
Total payment.	1,700,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	718,408	739,961	762,159	785,024	808,575	832,832	857,817	883,552	910,058	937,360
Transportation phase.										
loading	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205
Price per Unit (B/L).	79.15	83.11	87.26	91.62	96.20	101.01	106.07	111.37	116.94	122.78
Total fuel cost.	174,508.92	183,234.37	192,396.09	202,015.89	212,116.68	222,722.52	233,858.64	245,551.58	257,829.16	270,720.61
Total logistic cost	354,298.12	363,023.57	372,185.29	381,805.09	391,905.88	402,511.72	413,647.84	425,340.78	437,618.36	450,509.81
Preparation phase.										
Reduce cost	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.										
labor.	529,758	535,055	540,406	545,810	551,268	556,781	562,348	567,972	573,652	579,388
production cost	0	0	0	0	0	0	0	0	0	0
sales and administrative	50,989	52,004	53,038	54,094	55,171	56,269	57,389	58,531	59,696	60,884
Total Electrication phase.	580,747	587,059	593,444	599,904	606,439	613,049	619,737	626,503	633,348	640,273
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	158,988	162,168	165,411	168,719	172,094	175,535	179,046	182,627	186,280	190,005
Total cash payment per year (B).	3,870,148	2,209,918	2,250,907	2,293,159	2,336,720	2,481,636	2,427,955	2,475,729	2,525,011	2,575,855
Net income per year (A) - (B).	370,281	2,115,320	2,160,836	2,206,818	2,253,257	2,200,141	2,347,457	2,395,191	2,443,328	2,971,597
Cash received (paid), net (cumulative).	32,426,893	34,542,213	36,703,049	38,909,867	41,163,124	43,363,265	45,710,722	48,105,913	50,549,241	53,520,838
Cash accumulated throughout the project.	32,426,893	34,542,213	36,703,049	38,909,867	41,163,124	43,363,265	45,710,722	48,105,913	50,549,241	53,520,838
Cash accumulated throughout the project.	32,426,893	34,542,213	36,703,049	38,909,867	41,163,124	43,363,265	45,710,722	48,105,913	50,549,241	53,520,838
Net Cash Flow	26,366,893	28,482,213	30,643,049	32,849,867	35,103,124	37,303,265	39,650,722	42,045,913	44,489,241	47,460,838

B.4 The community power plant with extra benefit from tops and leaves products and waste heat recovery 50% of the total waste heat for drying the agricultural products.(CASE.3 steam)

Power capacity	50	kW
System	80	%
Plant Factor	30	Years
Life time	350,400	kWh/Year
electricity produced	10,512,000	kWh/Project
Fuel consumption	4.78	kg/kWh
Price of Electricity	3.32	Baht/kWh
Adder	0.5	Baht/kWh
Interest rate	8.7	%

Economic analysis result	
NPV(M Baht)	10.19
Pay Back Preiod (	3.93
IRR	24.91%

Item	0	1	2	3	4	5	6	7	8	9	10
	ปีที่ 0 – 10										
Cash Balance	0	200,000	1,514,700	3,028,946	4,579,045	6,165,532	7,788,944	9,349,819	11,048,699	12,616,039	14,222,467
Cash received.											
investments.	6,060,000										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	0	1,163,328	1,186,595	1,210,326	1,234,533	1,259,224	1,284,408	1,310,096	1,336,298	1,363,024	1,390,285
Adder.	0	175,200	175,200	175,200	175,200	175,200	175,200	175,200	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	31,728	32,362	33,009	33,670	34,343	35,030	35,730	36,445	37,174	37,917
waste heat for drying	0	1,690,359	1,724,167	1,758,650	1,793,823	1,829,699	1,866,293	1,903,619	1,941,692	1,980,525	2,020,136
Salvage.	0	0	0	0	0	0	0	0	0	0	0
Total	0	3,060,615	3,118,323	3,177,186	3,237,226	3,298,466	3,360,931	3,424,646	3,314,435	3,380,724	3,448,338
Total cash income	6,060,000	3,060,615	3,118,323	3,177,186	3,237,226	3,298,466	3,360,931	3,424,646	3,314,435	3,380,724	3,448,338
Cash payments.											
Fix cost											
Buildings power plants.	1,000,000	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	2,800,000	0	0	0	0	0	0	0	0	0	0
Gasification system	170,000	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	390,000	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0	0
Heat recovery system	1,400,000	0	0	0	0	0	0	0	0	0	0
Total payment.	6,060,000	0	0	0	0	0	100,000	0	0	0	0
Operation cost											
Cash paymentsfor loan	-	0	0	0	0	0	0	0	0	0	0
Plantation phase.											
fuel	0	438,632	409,698	421,989	434,649	447,688	461,119	474,953	489,201	503,877	518,993
Transportation phase.											
loading	0	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	0	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	0	1,654	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205
Price per Unit (B/L).	0	29.83	31.32	32.89	34.53	36.26	38.07	39.98	41.97	44.07	46.28
Total fuel cost.	0	49,327.93	69,059.11	72,512.06	76,137.66	79,944.55	83,941.77	88,138.86	92,545.81	97,173.10	102,031.75
Total logistic cost	0	229,117.13	248,848.31	252,301.26	255,926.86	259,733.75	263,730.97	267,928.06	272,335.01	276,962.30	281,820.95
Preparation phase.											
Reduce cost	0	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	0	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	0	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.											
labor.	0	434,160	438,502	442,887	447,315	451,789	456,307	460,870	465,478	470,133	474,834
production cost	0	139,800	0	0	0	0	0	0	0	0	0
sales and administrative	0	39,505	40,189	40,886	41,597	42,322	43,062	43,816	39,470	40,255	41,056
Total Electrication phase.	0	613,465	478,690	483,772	488,912	494,111	499,369	504,686	504,948	510,388	515,890
Char carbons Production.		0	0	0	0	0	0	0	0	0	0
Heat recovery operation.		106,994	109,134	111,317	113,543	115,814	118,130	120,493	122,903	125,361	127,868
Total cash payment per year (B).		1,745,915	1,604,078	1,627,087	1,650,738	1,675,054	1,800,056	1,725,767	1,747,094	1,774,295	1,802,280
Net income per year (A) - (B).	6,060,000	1,314,700	1,514,245	1,550,099	1,586,487	1,623,412	1,560,876	1,698,879	1,567,340	1,606,428	1,646,059
Cash received (paid), net (cumulative).	200,000	1,514,700	3,028,946	4,579,045	6,165,532	7,788,944	9,349,819	11,048,699	12,616,039	14,222,467	15,868,526
Cash accumulated throughout the project.	100,000	1,514,700	3,028,946	4,579,045	6,165,532	7,788,944	9,349,819	11,048,699	12,616,039	14,222,467	15,868,526
Cash accumulated throughout the project.	200,000	1,514,700	3,028,946	4,579,045	6,165,532	7,788,944	9,349,819	11,048,699	12,616,039	14,222,467	15,868,526
Net Cash Flow	-5,860,000	-4,545,300	-3,031,054	-1,480,955	105,532	1,728,944	3,289,819	4,988,699	6,556,039	8,162,467	9,808,526
NPV(Baht)	**10,188,124**										
IRR	**24.91%**										
Pay Back Preiod (Yrs)	**3.93**										

Item	11	12	13	14	15	16	17	18	19	20
	ปีที่ 11 – 20									
Cash Balance	15,868,526	15,854,758	17,581,705	19,349,908	21,159,909	23,012,242	24,807,445	26,746,048	28,728,579	30,755,560
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	1,418,090	1,446,452	1,475,381	1,504,889	1,534,987	1,565,686	1,597,000	1,628,940	1,661,519	1,694,749
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	38,676	39,449	40,238	41,043	41,864	42,701	43,555	44,426	45,315	46,221
waste heat for drying	2,060,539	2,101,749	2,143,784	2,186,660	2,230,393	2,275,001	2,320,501	2,366,911	2,414,249	2,462,534
Salvage.	0	0	0	0	0	0	0	0	0	0
Total	3,517,305	3,587,651	3,659,404	3,732,592	3,807,244	3,883,389	3,961,056	4,040,278	4,121,083	4,203,505
Total cash income	3,517,305	3,587,651	3,659,404	3,732,592	3,807,244	3,883,389	3,961,056	4,040,278	4,121,083	4,203,505
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0
Heat recovery system	1,400,000	0	0	0	0	0	0	0	0	0
Total payment.	1,700,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	534,563	550,600	567,118	584,132	601,656	619,705	638,297	657,445	677,169	697,484
Transportation phase.										
loading	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205
Price per Unit (B/L).	48.59	51.02	53.57	56.25	59.06	62.01	65.12	68.37	71.79	75.38
Total fuel cost.	107,133.34	112,490.01	118,114.51	124,020.23	130,221.24	136,732.31	143,568.92	150,747.37	158,284.74	166,198.97
Total logistic cost	286,922.54	292,279.21	297,903.71	303,809.43	310,010.44	316,521.51	323,358.12	330,536.57	338,073.94	345,988.17
Preparation phase.										
Reduce cost	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.										
labor.	479,583	484,379	489,222	494,115	499,056	504,046	509,087	514,178	519,319	524,513
production cost	0	0	0	0	0	0	0	0	0	0
sales and administrative	41,872	42,705	43,554	44,421	45,304	46,206	47,125	48,062	49,019	49,994
Total Electrication phase.	521,455	527,084	532,777	538,535	544,360	550,252	556,212	562,240	568,338	574,507
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	130,425	133,034	135,695	138,409	141,177	144,000	146,880	149,818	152,814	155,870
Total cash payment per year (B).	3,531,073	1,860,704	1,891,200	1,922,592	1,954,910	2,088,186	2,022,453	2,057,747	2,094,102	2,131,556
Net income per year (A) - (B).	-13,768	1,726,947	1,768,204	1,810,000	1,852,334	1,795,203	1,938,603	1,982,531	2,026,981	2,071,949
Cash received (paid), net (cumulative).	15,854,758	17,581,705	19,349,908	21,159,909	23,012,242	24,807,445	26,746,048	28,728,579	30,755,560	32,827,509
Cash accumulated throughout the project.	15,854,758	17,581,705	19,349,908	21,159,909	23,012,242	24,807,445	26,746,048	28,728,579	30,755,560	32,827,509
Cash accumulated throughout the project.	15,854,758	17,581,705	19,349,908	21,159,909	23,012,242	24,807,445	26,746,048	28,728,579	30,755,560	32,827,509
Net Cash Flow	9,794,758	11,521,705	13,289,908	15,099,909	16,952,242	18,747,445	20,686,048	22,668,579	24,695,560	26,767,509

Item	21	22	23	24	25	26	27	28	29	30
	ปีที่ 21 – 30									
Cash Balance	32,827,509	33,244,936	35,408,345	37,618,231	39,875,080	42,179,370	44,431,563	46,832,114	49,281,460	51,780,026
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	1,728,644	1,763,217	1,798,481	1,834,451	1,871,140	1,908,563	1,946,734	1,985,669	2,025,382	2,065,890
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	47,146	48,088	49,050	50,031	51,032	52,053	53,094	54,155	55,239	56,343
waste heat for drying	2,511,785	2,562,021	2,613,261	2,665,527	2,718,837	2,773,214	2,828,678	2,885,252	2,942,957	3,001,816
Salvage.	0	0	0	0	0	0	0	0	0	479,746
Total	4,287,575	4,373,326	4,460,793	4,550,009	4,641,009	4,733,829	4,828,506	4,925,076	5,023,577	5,603,795
Total cash income	4,287,575	4,373,326	4,460,793	4,550,009	4,641,009	4,733,829	4,828,506	4,925,076	5,023,577	5,603,795
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	-	0	0	0	0	0	0	0	0	0
Heat recovery system	1,400,000	0	0	0	0	0	0	0	0	0
Total payment.	1,700,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	718,408	739,961	762,159	785,024	808,575	832,832	857,817	883,552	910,058	937,360
Transportation phase.										
loading	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789	19,789
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205	2,205
Price per Unit (B/L).	79.15	83.11	87.26	91.62	96.20	101.01	106.07	111.37	116.94	122.78
Total fuel cost.	174,508.92	183,234.37	192,396.09	202,015.89	212,116.68	222,722.52	233,858.64	245,551.58	257,829.16	270,720.61
Total logistic cost	354,298.12	363,023.57	372,185.29	381,805.09	391,905.88	402,511.72	413,647.84	425,340.78	437,618.36	450,509.81
Preparation phase.										
Reduce cost	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639	221,639
drying cost	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068	136,068
Total Preparation cost	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707	357,707
Electrification phase.										
labor.	529,758	535,055	540,406	545,810	551,268	556,781	562,348	567,972	573,652	579,388
production cost	0	0	0	0	0	0	0	0	0	0
sales and administrative	50,989	52,004	53,038	54,094	55,171	56,269	57,389	58,531	59,696	60,884
Total Electrication phase.	580,747	587,059	593,444	599,904	606,439	613,049	619,737	626,503	633,348	640,273
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	158,988	162,168	165,411	168,719	172,094	175,535	179,046	182,627	186,280	190,005
Total cash payment per year (B).	3,870,148	2,209,918	2,250,907	2,293,159	2,336,720	2,481,636	2,427,955	2,475,729	2,525,011	2,575,855
Net income per year (A) - (B).	417,427	2,163,409	2,209,886	2,256,849	2,304,289	2,252,194	2,400,551	2,449,346	2,498,566	3,027,940
Cash received (paid), net (cumulative).	33,244,936	35,408,345	37,618,231	39,875,080	42,179,370	44,431,563	46,832,114	49,281,460	51,780,026	54,807,967
Cash accumulated throughout the project.	33,244,936	35,408,345	37,618,231	39,875,080	42,179,370	44,431,563	46,832,114	49,281,460	51,780,026	54,807,967
Cash accumulated throughout the project.	33,244,936	35,408,345	37,618,231	39,875,080	42,179,370	44,431,563	46,832,114	49,281,460	51,780,026	54,807,967
Net Cash Flow	27,184,936	29,348,345	31,558,231	33,815,080	36,119,370	38,371,563	40,772,114	43,221,460	45,720,026	48,747,967

B.5 The community power plant only sell produced electricity (CASE.base)

Power capacity	100	kW
System	80	%
Plant Factor	30	Years
Life time	700,800	kWh/Year
electricity produced	21,024,000	kWh/Project
Fuel consumption	2.27	kg/kWh
Price of Electricity	3.32	Baht/kWh
Adder	0.5	Baht/kWh
Interest rate	8.7	%

Economic analysis result	
NPV(M Baht)	-3.20
Pay Back Preiod (	17
IRR	4.55%

Item	ปีที่ 0 – 10										
	0	1	2	3	4	5	6	7	8	9	10
Cash Balance	0	200,000	828,317	1,503,014	2,193,145	2,898,768	3,619,933	4,256,678	5,009,036	5,436,859	5,880,326
Cash received.											
investments.	9,890,000										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	0	2,326,656	2,373,189	2,420,653	2,469,066	2,518,447	2,568,816	2,620,193	2,672,596	2,726,048	2,780,569
Adder.	0	350,400	350,400	350,400	350,400	350,400	350,400	350,400	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0	0
waste heat for drying	0	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0	0
Total	0	2,677,056	2,723,589	2,771,053	2,819,466	2,868,847	2,919,216	2,970,593	2,672,596	2,726,048	2,780,569
Total cash income	9,890,000	2,677,056	2,723,589	2,771,053	2,819,466	2,868,847	2,919,216	2,970,593	2,672,596	2,726,048	2,780,569
Cash payments.											
Fix cost											
Buildings power plants.	1,000,000	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	8,200,000	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	390,000	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0	0
Total payment.	9,890,000	0	0	0	0	0	100,000	0	0	0	0
Operation cost											
Cash paymentsfor loan	-	0	0	0	0	0	0	0	0	0	0
Plantation phase.											
fuel	0	416,608	389,128	400,801	412,825	425,210	437,967	451,106	464,639	478,578	492,935
Transportation phase.											
loading	0	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	0	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	0	785	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	0	29.83	31.32	32.89	34.53	36.26	38.07	39.98	41.97	44.07	46.28
Total fuel cost.	0	23,415.80	32,782.12	34,421.22	36,142.28	37,949.40	39,846.87	41,839.21	43,931.17	46,127.73	48,434.11
Total logistic cost	0	202,211.40	211,577.72	213,216.82	214,937.88	216,745.00	218,642.47	220,634.81	222,726.77	224,923.33	227,229.71
Preparation phase.											
Reduce cost	0	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	0	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	0	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.											
labor.	0	434,160	438,502	442,887	447,315	451,789	456,307	460,870	465,478	470,133	474,834
production cost	0	577,422	589,986	602,927	616,256	629,985	644,126	658,691	673,693	689,145	705,061
sales and administrative	0	78,590	79,953	81,343	82,761	84,207	85,683	87,187	78,490	80,055	81,652
Total Electrication phase.	0	1,090,172	1,108,441	1,127,157	1,146,333	1,165,981	1,186,115	1,206,748	1,217,661	1,239,333	1,261,547
Char carbons Production.		0	0	0	0	0	0	0	0	0	0
Heat recovery operation.		0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).		2,048,739	2,048,893	2,080,922	2,113,843	2,147,683	2,282,471	2,218,235	2,244,773	2,282,581	2,321,459
Net income per year (A) - (B).	9,890,000	628,317	674,696	690,131	705,623	721,164	636,746	752,358	427,823	443,467	459,111
Cash received (paid), net (cumulative).	200,000	828,317	1,503,014	2,193,145	2,898,768	3,619,933	4,256,678	5,009,036	5,436,859	5,880,326	6,339,437
Cash accumulated throughout the project.	100,000	828,317	1,503,014	2,193,145	2,898,768	3,619,933	4,256,678	5,009,036	5,436,859	5,880,326	6,339,437
Cash accumulated throughout the project.	200,000	828,317	1,503,014	2,193,145	2,898,768	3,619,933	4,256,678	5,009,036	5,436,859	5,880,326	6,339,437
Net Cash Flow	-9,690,000	-9,061,683	-8,386,986	-7,696,855	-6,991,232	-6,270,067	-5,633,322	-4,880,964	-4,453,141	-4,009,674	-3,550,563
NPV(Baht)	**-3,199,398**										
IRR	**4.55%**										
Pay Back Preiod (Yrs)	**17.00**										

Item	ปีที่ 11 – 20									
	11	12	13	14	15	16	17	18	19	20
Cash Balance	6,339,437	6,714,179	7,204,529	7,710,449	8,231,888	8,768,781	9,221,047	9,788,589	10,371,293	10,969,029
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	2,836,181	2,892,904	2,950,762	3,009,778	3,069,973	3,131,373	3,194,000	3,257,880	3,323,038	3,389,498
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0
waste heat for drying	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0
Total	2,836,181	2,892,904	2,950,762	3,009,778	3,069,973	3,131,373	3,194,000	3,257,880	3,323,038	3,389,498
Total cash income	2,836,181	2,892,904	2,950,762	3,009,778	3,069,973	3,131,373	3,194,000	3,257,880	3,323,038	3,389,498
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	100,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	507,723	522,955	538,644	554,803	571,447	588,590	606,248	624,436	643,169	662,464
Transportation phase.										
loading	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	48.59	51.02	53.57	56.25	59.06	62.01	65.12	68.37	71.79	75.38
Total fuel cost.	50,855.82	53,398.61	56,068.54	58,871.97	61,815.57	64,906.35	68,151.66	71,559.25	75,137.21	78,894.07
Total logistic cost	229,651.42	232,194.21	234,864.14	237,667.57	240,611.17	243,701.95	246,947.26	250,354.85	253,932.81	257,689.67
Preparation phase.										
Reduce cost	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.										
labor.	479,583	484,379	489,222	494,115	499,056	504,046	509,087	514,178	519,319	524,513
production cost	721,454	738,338	755,730	773,643	792,094	811,098	830,672	850,833	871,600	892,989
sales and administrative	83,280	84,941	86,636	88,364	90,126	91,924	93,757	95,628	97,535	99,481
Total Electrication phase.	1,284,317	1,307,658	1,331,588	1,356,121	1,381,275	1,407,068	1,433,516	1,460,639	1,488,454	1,516,982
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	2,461,438	2,402,554	2,444,842	2,488,338	2,533,080	2,679,107	2,626,458	2,675,176	2,725,302	2,776,882
Net income per year (A) - (B).	374,742	490,350	505,920	521,439	536,893	452,266	567,542	582,704	597,735	612,616
Cash received (paid), net (cumulative).	6,714,179	7,204,529	7,710,449	8,231,888	8,768,781	9,221,047	9,788,589	10,371,293	10,969,029	11,581,645
Cash accumulated throughout the project.	6,714,179	7,204,529	7,710,449	8,231,888	8,768,781	9,221,047	9,788,589	10,371,293	10,969,029	11,581,645
Cash accumulated throughout the project.	6,714,179	7,204,529	7,710,449	8,231,888	8,768,781	9,221,047	9,788,589	10,371,293	10,969,029	11,581,645
Net Cash Flow	-3,175,821	-2,685,471	-2,179,551	-1,658,112	-1,121,219	-668,953	-101,411	481,293	1,079,029	1,691,645

Item	ปีที่ 21 – 30									
	21	22	23	24	25	26	27	28	29	30
Cash Balance	11,581,645	12,108,971	12,750,818	13,406,973	14,077,199	14,761,239	15,358,807	16,069,592	16,793,256	17,529,430
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	3,457,288	3,526,434	3,596,963	3,668,902	3,742,280	3,817,126	3,893,468	3,971,338	4,050,764	4,131,780
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0
waste heat for drying	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	793,300
Total	3,457,288	3,526,434	3,596,963	3,668,902	3,742,280	3,817,126	3,893,468	3,971,338	4,050,764	4,925,080
Total cash income	3,457,288	3,526,434	3,596,963	3,668,902	3,742,280	3,817,126	3,893,468	3,971,338	4,050,764	4,925,080
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	100,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	682,338	702,808	723,892	745,609	767,977	791,016	814,747	839,189	864,365	890,296
Transportation phase.										
loading	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	79.15	83.11	87.26	91.62	96.20	101.01	106.07	111.37	116.94	122.78
Total fuel cost.	82,838.77	86,980.71	91,329.75	95,896.23	100,691.05	105,725.60	111,011.88	116,562.47	122,390.59	128,510.12
Total logistic cost	261,634.37	265,776.31	270,125.35	274,691.83	279,486.65	284,521.20	289,807.48	295,358.07	301,186.19	307,305.72
Preparation phase.										
Reduce cost	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.										
labor.	529,758	535,055	540,406	545,810	551,268	556,781	562,348	567,972	573,652	579,388
production cost	915,020	937,712	961,084	985,158	1,009,954	1,035,494	1,061,800	1,088,896	1,116,804	1,145,549
sales and administrative	101,465	103,489	105,554	107,660	109,808	111,999	114,233	116,513	118,837	121,208
Total Electrication phase.	1,546,243	1,576,257	1,607,044	1,638,628	1,671,030	1,704,274	1,738,382	1,773,380	1,809,293	1,846,146
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	2,929,962	2,884,587	2,940,808	2,998,675	3,058,241	3,219,558	3,182,683	3,247,674	3,314,591	3,383,494
Net income per year (A) - (B).	527,327	641,847	656,154	670,227	684,040	597,568	710,785	723,664	736,174	1,541,586
Cash received (paid), net (cumulative).	12,108,971	12,750,818	13,406,973	14,077,199	14,761,239	15,358,807	16,069,592	16,793,256	17,529,430	19,071,015
Cash accumulated throughout the project.	12,108,971	12,750,818	13,406,973	14,077,199	14,761,239	15,358,807	16,069,592	16,793,256	17,529,430	19,071,015
Cash accumulated throughout the project.	12,108,971	12,750,818	13,406,973	14,077,199	14,761,239	15,358,807	16,069,592	16,793,256	17,529,430	19,071,015
Net Cash Flow	2,218,971	2,860,818	3,516,973	4,187,199	4,871,239	5,468,807	6,179,592	6,903,256	7,639,430	9,181,015

B.6 The community power plant with extra benefit from tops and leaves products. (CASE.1 gasification)

Power capacity	100	kW
System	80	%
Plant Factor	30	Years
Life time	700,800	kWh/Year
electricity produced	21,024,000	kWh/Project
Fuel consumption	2.27	kg/kWh
Price of Electricity	3.32	Baht/kWh
Adder	0.5	Baht/kWh
Interest rate	8.7	%

Economic analysis result	
NPV(M Baht)	-2.85
Pay Back Preiod (	16.17
IRR	5.06%

Item	ปีที่ 0 – 10										
	0	1	2	3	4	5	6	7	8	9	10
Cash Balance	0	200,000	858,452	1,563,886	2,285,369	3,022,971	3,776,754	4,446,771	5,233,065	5,695,503	6,174,278
Cash received.											
investments.	9,890,000										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	0	2,326,656	2,373,189	2,420,653	2,469,066	2,518,447	2,568,816	2,620,193	2,672,596	2,726,048	2,780,569
Adder.	0	350,400	350,400	350,400	350,400	350,400	350,400	350,400	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0	0
Cabon credit.	0	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	30,135	30,737	31,352	31,979	32,619	33,271	33,936	34,615	35,307	36,014
waste heat for drying	0	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0	0
Total	0	2,707,191	2,754,326	2,802,405	2,851,445	2,901,466	2,952,487	3,004,529	2,707,212	2,761,356	2,816,583
Total cash income	9,890,000	2,707,191	2,754,326	2,802,405	2,851,445	2,901,466	2,952,487	3,004,529	2,707,212	2,761,356	2,816,583
Cash payments.											
Fix cost											
Buildings power plants.	1,000,000	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	8,200,000	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	390,000	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0	0
Total payment.	9,890,000	0	0	0	0	0	100,000	0	0	0	0
Operation cost											
Cash paymentsfor loan	-	0	0	0	0	0	0	0	0	0	0
Plantation phase.											
fuel	0	416,608	389,128	400,801	412,825	425,210	437,967	451,106	464,639	478,578	492,935
Transportation phase.											
loading	0	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	0	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	0	785	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	0	29.83	31.32	32.89	34.53	36.26	38.07	39.98	41.97	44.07	46.28
Total fuel cost.	0	23,415.80	32,782.12	34,421.22	36,142.28	37,949.40	39,846.87	41,839.21	43,931.17	46,127.73	48,434.11
Total logistic cost	0	202,211.40	211,577.72	213,216.82	214,937.88	216,745.00	218,642.47	220,634.81	222,726.77	224,923.33	227,229.71
Preparation phase.											
Reduce cost	0	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	0	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	0	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.											
labor.	0	434,160	438,502	442,887	447,315	451,789	456,307	460,870	465,478	470,133	474,834
production cost	0	577,422	589,986	602,927	616,256	629,985	644,126	658,691	673,693	689,145	705,061
sales and administrative	0	78,590	79,953	81,343	82,761	84,207	85,683	87,187	78,490	80,055	81,652
Total Electrication phase.	0	1,090,172	1,108,441	1,127,157	1,146,333	1,165,981	1,186,115	1,206,748	1,217,661	1,239,333	1,261,547
Char carbons Production.		0	0	0	0	0	0	0	0	0	0
Heat recovery operation.		0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).		2,048,739	2,048,893	2,080,922	2,113,843	2,147,683	2,282,471	2,218,235	2,244,773	2,282,581	2,321,459
Net income per year (A) - (B).	9,890,000	658,452	705,434	721,483	737,602	753,783	670,017	786,294	462,438	478,774	495,124
Cash received (paid), net (cumulative).	200,000	858,452	1,563,886	2,285,369	3,022,971	3,776,754	4,446,771	5,233,065	5,695,503	6,174,278	6,669,402
Cash accumulated throughout the project.	100,000	858,452	1,563,886	2,285,369	3,022,971	3,776,754	4,446,771	5,233,065	5,695,503	6,174,278	6,669,402
Cash accumulated throughout the project.	200,000	858,452	1,563,886	2,285,369	3,022,971	3,776,754	4,446,771	5,233,065	5,695,503	6,174,278	6,669,402
Net Cash Flow	-9,690,000	-9,031,548	-8,326,114	-7,604,631	-6,867,029	-6,113,246	-5,443,229	-4,656,935	-4,194,497	-3,715,722	-3,220,598
NPV(Baht)	**-2,846,985**										
IRR	**5.06%**										
Pay Back Preiod (Yrs)	**16.17**										

Item	ปีที่ 11 – 20									
	11	12	13	14	15	16	17	18	19	20
Cash Balance	6,669,402	7,080,879	7,608,697	8,152,835	8,713,257	9,289,911	9,782,734	10,391,645	11,016,545	11,657,320
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	2,836,181	2,892,904	2,950,762	3,009,778	3,069,973	3,131,373	3,194,000	3,257,880	3,323,038	3,389,498
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon credit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	36,734	37,469	38,218	38,982	39,762	40,557	41,368	42,196	43,040	43,900
waste heat for drying	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0
Total	2,872,915	2,930,373	2,988,980	3,048,760	3,109,735	3,171,930	3,235,368	3,300,076	3,366,077	3,433,399
Total cash income	2,872,915	2,930,373	2,988,980	3,048,760	3,109,735	3,171,930	3,235,368	3,300,076	3,366,077	3,433,399
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	100,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	507,723	522,955	538,644	554,803	571,447	588,590	606,248	624,436	643,169	662,464
Transportation phase.										
loading	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	48.59	51.02	53.57	56.25	59.06	62.01	65.12	68.37	71.79	75.38
Total fuel cost.	50,855.82	53,398.61	56,068.54	58,871.97	61,815.57	64,906.35	68,151.66	71,559.25	75,137.21	78,894.07
Total logistic cost	229,651.42	232,194.21	234,864.14	237,667.57	240,611.17	243,701.95	246,947.26	250,354.85	253,932.81	257,689.67
Preparation phase.										
Reduce cost	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.										
labor.	479,583	484,379	489,222	494,115	499,056	504,046	509,087	514,178	519,319	524,513
production cost	721,454	738,338	755,730	773,643	792,094	811,098	830,672	850,833	871,600	892,989
sales and administrative	83,280	84,941	86,636	88,364	90,126	91,924	93,757	95,628	97,535	99,481
Total Electrication phase.	1,284,317	1,307,658	1,331,588	1,356,121	1,381,275	1,407,068	1,433,516	1,460,639	1,488,454	1,516,982
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	2,461,438	2,402,554	2,444,842	2,488,338	2,533,080	2,679,107	2,626,458	2,675,176	2,725,302	2,776,882
Net income per year (A) - (B).	411,476	527,818	544,138	560,421	576,655	492,823	608,910	624,900	640,775	656,516
Cash received (paid), net (cumulative).	7,080,879	7,608,697	8,152,835	8,713,257	9,289,911	9,782,734	10,391,645	11,016,545	11,657,320	12,313,836
Cash accumulated throughout the project.	7,080,879	7,608,697	8,152,835	8,713,257	9,289,911	9,782,734	10,391,645	11,016,545	11,657,320	12,313,836
Cash accumulated throughout the project.	7,080,879	7,608,697	8,152,835	8,713,257	9,289,911	9,782,734	10,391,645	11,016,545	11,657,320	12,313,836
Net Cash Flow	-2,809,121	-2,281,303	-1,737,165	-1,176,743	-600,089	-107,266	501,645	1,126,545	1,767,320	2,423,836

Item	ปีที่ 21 – 30									
	21	22	23	24	25	26	27	28	29	30
Cash Balance	12,313,836	12,885,941	13,573,462	14,276,204	14,993,950	15,726,459	16,373,466	17,134,679	17,909,779	18,698,418
Cash received.										
investments.										
loan (term of 7 years).	0	0	0	0	0	0	0	0	0	0
Income from sale of power.	3,457,288	3,526,434	3,596,963	3,668,902	3,742,280	3,817,126	3,893,468	3,971,338	4,050,764	4,131,780
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	0	0	0	0	0	0	0	0	0	0
Cabon credit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	44,778	45,674	46,587	47,519	48,470	49,439	50,428	51,436	52,465	53,514
waste heat for drying	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	793,300
Total	3,502,067	3,572,108	3,643,550	3,716,421	3,790,750	3,866,565	3,943,896	4,022,774	4,103,229	4,978,594
Total cash income	3,502,067	3,572,108	3,643,550	3,716,421	3,790,750	3,866,565	3,943,896	4,022,774	4,103,229	4,978,594
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	100,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Cash paymentsfor loan	0	0	0	0	0	0	0	0	0	0
Plantation phase.										
fuel	682,338	702,808	723,892	745,609	767,977	791,016	814,747	839,189	864,365	890,296
Transportation phase.										
loading	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	79.15	83.11	87.26	91.62	96.20	101.01	106.07	111.37	116.94	122.78
Total fuel cost.	82,838.77	86,980.71	91,329.75	95,896.23	100,691.05	105,725.60	111,011.88	116,562.47	122,390.59	128,510.12
Total logistic cost	261,634.37	265,776.31	270,125.35	274,691.83	279,486.65	284,521.20	289,807.48	295,358.07	301,186.19	307,305.72
Preparation phase.										
Reduce cost	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.										
labor.	529,758	535,055	540,406	545,810	551,268	556,781	562,348	567,972	573,652	579,388
production cost	915,020	937,712	961,084	985,158	1,009,954	1,035,494	1,061,800	1,088,896	1,116,804	1,145,549
sales and administrative	101,465	103,489	105,554	107,660	109,808	111,999	114,233	116,513	118,837	121,208
Total Electrication phase.	1,546,243	1,576,257	1,607,044	1,638,628	1,671,030	1,704,274	1,738,382	1,773,380	1,809,293	1,846,146
Char carbons Production.	0	0	0	0	0	0	0	0	0	0
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	2,929,962	2,884,587	2,940,808	2,998,675	3,058,241	3,219,558	3,182,683	3,247,674	3,314,591	3,383,494
Net income per year (A) - (B).	572,105	687,521	702,742	717,746	732,509	647,007	761,213	775,100	788,639	1,595,100
Cash received (paid), net (cumulative).	12,885,941	13,573,462	14,276,204	14,993,950	15,726,459	16,373,466	17,134,679	17,909,779	18,698,418	20,293,518
Cash accumulated throughout the project.	12,885,941	13,573,462	14,276,204	14,993,950	15,726,459	16,373,466	17,134,679	17,909,779	18,698,418	20,293,518
Cash accumulated throughout the project.	12,885,941	13,573,462	14,276,204	14,993,950	15,726,459	16,373,466	17,134,679	17,909,779	18,698,418	20,293,518
Net Cash Flow	2,995,941	3,683,462	4,386,204	5,103,950	5,836,459	6,483,466	7,244,679	8,019,779	8,808,418	10,403,518

B.7 The community power plant with extra benefit from charcoal. (CASE.2 gasification)

Power capacity	100	kW
System	Gasification	
Plant Factor	80	%
Life time	30	Years
electricity produced	700,800	kWh/Year
	21,024,000	kWh/Project
Fuel consumption	2.27	kg/kWh
Price of Electricity	3.32	Baht/kWh
Adder	0.5	Baht/kWh
Interest rate	8.7	%

Economic analysis result	
NPV(M Baht)	3.01
IRR	11.72%
Pay Back Preiod (Yrs)	7.79

Item	Year 0 – 10										
	0	1	2	3	4	5	6	7	8	9	10
Cash Balance	0	200,000	1,516,073	2,892,280	4,297,953	5,733,428	7,199,041	8,595,124	10,122,007	11,339,845	12,589,127
Cash received.											
investments.	11,090,000										
Income from sale of power.	0	2,326,656	2,373,189	2,420,653	2,469,066	2,518,447	2,568,816	2,620,193	2,672,596	2,726,048	2,780,569
Adder.	0	350,400	350,400	350,400	350,400	350,400	350,400	350,400	0	0	0
carbon bar	0	1,042,370	1,063,217	1,084,482	1,106,171	1,128,295	1,150,861	1,173,878	1,197,355	1,221,302	1,245,729
Cabon cradit.	0	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0	0
waste heat for drying	0	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0	0
Total	0	3,719,426	3,786,806	3,855,535	3,925,637	3,997,142	4,070,077	4,144,470	3,869,952	3,947,351	4,026,298
Total cash income	11,090,000	3,719,426	3,786,806	3,855,535	3,925,637	3,997,142	4,070,077	4,144,470	3,869,952	3,947,351	4,026,298
Cash payments.											
Fix cost											
Buildings power plants.	1,000,000	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	8,200,000	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	390,000	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	1,200,000	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0	0
Total payment.	11,090,000	0	0	0	0	0	100,000	0	0	0	0
Operation cost											
Plantation phase.											
fuel	0	416,608	389,128	400,801	412,825	425,210	437,967	451,106	464,639	478,578	492,935
Transportation phase.											
loading	0	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	0	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	0	785	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	0	29.83	31.32	32.89	34.53	36.26	38.07	39.98	41.97	44.07	46.28
Total fuel cost.	0	23,415.80	32,782.12	34,421.22	36,142.28	37,949.40	39,846.87	41,839.21	43,931.17	46,127.73	48,434.11
Total logistic cost	0	202,211.40	211,577.72	213,216.82	214,937.88	216,745.00	218,642.47	220,634.81	222,726.77	224,923.33	227,229.71
Preparation phase.											
Reduce cost	0	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	0	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	0	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.											
labor.	0	434,160	438,502	442,887	447,315	451,789	456,307	460,870	465,478	470,133	474,834
production cost	0	577,422	589,986	602,927	616,256	629,985	644,126	658,691	673,693	689,145	705,061
sales and administrative	0	109,027	110,999	113,010	115,061	117,154	119,288	121,464	113,453	115,717	118,027
Total Electrication phase.	0	1,120,609	1,139,487	1,158,824	1,178,633	1,198,927	1,219,720	1,241,025	1,252,624	1,274,995	1,297,922
Char carbons Production.		324,177	330,661	337,274	344,019	350,900	357,918	365,076	372,378	379,825	387,422
Heat recovery operation.		0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).		2,403,353	2,410,599	2,449,862	2,490,162	2,531,529	2,673,993	2,617,588	2,652,114	2,698,068	2,745,255
Net income per year (A) - (B).	11,090,000	1,316,073	1,376,207	1,405,672	1,435,475	1,465,613	1,396,083	1,526,882	1,217,838	1,249,282	1,281,042
Cash accumulated throughout the project.	100,000	1,516,073	2,892,280	4,297,953	5,733,428	7,199,041	8,595,124	10,122,007	11,339,845	12,589,127	13,870,170
Net Cash Flow	-10,890,000	-9,573,927	-8,197,720	-6,792,047	-5,356,572	-3,890,959	-2,494,876	-967,993	249,845	1,499,127	2,780,170
NPV(Baht)	**3,009,205**										
IRR	**11.72%**										
Pay Back Preiod (Yrs)	**7.79**										

Item	Year 11 – 20									
	11	12	13	14	15	16	17	18	19	20
Cash Balance	13,870,170	13,683,282	15,028,770	16,406,931	17,818,055	19,262,427	20,640,321	22,152,004	23,697,733	25,277,752
Cash received.										
investments.										
Income from sale of power.	2,836,181	2,892,904	2,950,762	3,009,778	3,069,973	3,131,373	3,194,000	3,257,880	3,323,038	3,389,498
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	1,270,643	1,296,056	1,321,977	1,348,417	1,375,385	1,402,893	1,430,951	1,459,570	1,488,761	1,518,536
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	0	0	0	0	0	0	0	0	0
waste heat for drying	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0
Total	4,106,824	4,188,960	4,272,739	4,358,194	4,445,358	4,534,265	4,624,951	4,717,450	4,811,799	4,908,035
Total cash income	4,106,824	4,188,960	4,272,739	4,358,194	4,445,358	4,534,265	4,624,951	4,717,450	4,811,799	4,908,035
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	1,200,000	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	1,500,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Plantation phase.										
fuel	507,723	522,955	538,644	554,803	571,447	588,590	606,248	624,436	643,169	662,464
Transportation phase.										
loading	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	48.59	51.02	53.57	56.25	59.06	62.01	65.12	68.37	71.79	75.38
Total fuel cost.	50,855.82	53,398.61	56,068.54	58,871.97	61,815.57	64,906.35	68,151.66	71,559.25	75,137.21	78,894.07
Total logistic cost	229,651.42	232,194.21	234,864.14	237,667.57	240,611.17	243,701.95	246,947.26	250,354.85	253,932.81	257,689.67
Preparation phase.										
Reduce cost	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.										
labor.	479,583	484,379	489,222	494,115	499,056	504,046	509,087	514,178	519,319	524,513
production cost	721,454	738,338	755,730	773,643	792,094	811,098	830,672	850,833	871,600	892,989
sales and administrative	120,383	122,786	125,237	127,737	130,287	132,888	135,541	138,247	141,007	143,822
Total Electrication phase.	1,321,420	1,345,503	1,370,190	1,395,495	1,421,437	1,448,032	1,475,300	1,503,258	1,531,926	1,561,324
Char carbons Production.	395,170	403,073	411,135	419,358	427,745	436,300	445,026	453,926	463,005	472,265
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	4,293,711	2,843,473	2,894,579	2,947,070	3,000,986	3,156,371	3,113,268	3,171,721	3,231,779	3,293,488
Net income per year (A) - (B).	-186,887	1,345,488	1,378,161	1,411,124	1,444,372	1,377,894	1,511,683	1,545,728	1,580,020	1,614,546
Cash accumulated throughout the project.	13,683,282	15,028,770	16,406,931	17,818,055	19,262,427	20,640,321	22,152,004	23,697,733	25,277,752	26,892,299
Net Cash Flow	2,593,282	3,938,770	5,316,931	6,728,055	8,172,427	9,550,321	11,062,004	12,607,733	14,187,752	15,802,299

Item	year 21 – 30										Sum
	21	22	23	24	25	26	27	28	29	30	
Cash Balance	26,892,299	27,041,594	28,725,849	30,445,260	32,200,008	33,990,259	35,716,163	37,577,851	39,475,436	41,409,009	585,796,049
Cash received.											-
investments.											-
Income from sale of power.	3,457,288	3,526,434	3,596,963	3,668,902	3,742,280	3,817,126	3,893,468	3,971,338	4,050,764	4,131,780	94,387,965
Adder.	0	0	0	0	0	0	0	0	0	0	2,452,800
carbon bar	1,548,907	1,579,885	1,611,483	1,643,712	1,676,587	1,710,118	1,744,321	1,779,207	1,814,791	1,851,087	42,286,945
Cabon cradit.	0	0	0	0	0	0	0	0	0	0	-
tops and leaves.	0	0	0	0	0	0	0	0	0	0	-
waste heat for drying	0	0	0	0	0	0	0	0	0	0	-
Salvage.	0	0	0	0	0	0	0	0	0	891,541	891,541
Total	5,006,195	5,106,319	5,208,446	5,312,614	5,418,867	5,527,244	5,637,789	5,750,545	5,865,556	6,874,408	140,019,252
Total cash income	5,006,195	5,106,319	5,208,446	5,312,614	5,418,867	5,527,244	5,637,789	5,750,545	5,865,556	6,874,408	140,019,252
Cash payments.											-
Fix cost											-
Buildings power plants.	0	0	0	0	0	0	0	0	0	0	-
Machinery and equipment	0	0	0	0	0	0	0	0	0	0	-
Gasification system	0	0	0	0	0	0	0	0	0	0	-
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0	-
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0	500,000
Dryers.	200,000	0	0	0	0	0	0	0	0	0	400,000
Reduce machine .	0	0	0	0	0	0	0	0	0	0	-
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	-
carbon processing machines.	1,200,000	0	0	0	0	0	0	0	0	0	2,400,000
Heat recovery system	0	0	0	0	0	0	0	0	0	0	-
Total payment.	1,500,000	0	0	0	0	100,000	0	0	0	0	3,300,000
Operation cost											-
Plantation phase.											-
fuel	682,338	702,808	723,892	745,609	767,977	791,016	814,747	839,189	864,365	890,296	18,012,512
Transportation phase.											
loading	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	563,868
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	4,800,000
fuel consumption (liter).	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	31,137
Price per Unit (B/L).	79.15	83.11	87.26	91.62	96.20	101.01	106.07	111.37	116.94	122.78	1,981.87
Total fuel cost.	82,838.77	86,980.71	91,329.75	95,896.23	100,691.05	105,725.60	111,011.88	116,562.47	122,390.59	128,510.12	2,066,486.11
Total logistic cost	261,634.37	265,776.31	270,125.35	274,691.83	279,486.65	284,521.20	289,807.48	295,358.07	301,186.19	307,305.72	7,430,354.13
Preparation phase.											
Reduce cost	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	6,315,322
drying cost	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	3,877,081
Total Preparation cost	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	10,192,403
Electrification phase.											
labor.	529,758	535,055	540,406	545,810	551,268	556,781	562,348	567,972	573,652	579,388	15,102,209
production cost	915,020	937,712	961,084	985,158	1,009,954	1,035,494	1,061,800	1,088,896	1,116,804	1,145,549	24,683,213
sales and administrative	146,693	149,622	152,609	155,656	158,764	161,934	165,167	168,465	171,829	175,260	4,077,139
Total Electrication phase.	1,591,471	1,622,389	1,654,100	1,686,624	1,719,986	1,754,209	1,789,316	1,825,333	1,862,285	1,900,198	43,862,560
Char carbons Production.	481,710	491,344	501,171	511,195	521,418	531,847	542,484	553,333	564,400	575,688	13,151,240
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0	
Total cash payment per year (B).	4,856,900	3,422,064	3,489,035	3,557,866	3,628,615	3,801,340	3,776,101	3,852,960	3,931,982	4,013,234	95,949,069
Net income per year (A) - (B).	149,295	1,684,255	1,719,411	1,754,748	1,790,251	1,725,904	1,861,688	1,897,584	1,933,573	2,861,174	44,070,183
Cash accumulated throughout the project.	27,041,594	28,725,849	30,445,260	32,200,008	33,990,259	35,716,163	37,577,851	39,475,436	41,409,009	44,270,183	-
Net Cash Flow	15,951,594	17,635,849	19,355,260	21,110,008	22,900,259	24,626,163	26,487,851	28,385,436	30,319,009	33,180,183	-

B.8 The community power plant with extra benefit from tops and leaves products and charcoal products. (CASE.3 gasification)

Power capacity	100	kW
System	Gasification	
Plant Factor	80	%
Life time	30	Years
electricity produced	700,800	kWh/Year
	21,024,000	kWh/Project
Fuel consumption	2.27	kg/kWh
Price of Electricity	3.32	Baht/kWh
Adder	0.5	Baht/kWh
Interest rate	8.7	%

Economic analysis result	
NPV(M Baht)	3.36
IRR	12.05%
Pay Back Preiod (Yrs)	7.59

Item	Year 0 – 10										
	0	1	2	3	4	5	6	7	8	9	10
Cash Balance	0	200,000	1,546,208	2,953,152	4,390,176	5,857,631	7,355,862	8,785,217	10,346,036	11,598,489	12,883,079
Cash received.											
investments.	11,090,000										
Income from sale of power.	0	2,326,656	2,373,189	2,420,653	2,469,066	2,518,447	2,568,816	2,620,193	2,672,596	2,726,048	2,780,569
Adder.	0	350,400	350,400	350,400	350,400	350,400	350,400	350,400	0	0	0
carbon bar	0	1,042,370	1,063,217	1,084,482	1,106,171	1,128,295	1,150,861	1,173,878	1,197,355	1,221,302	1,245,729
Cabon cradit.	0	0	0	0	0	0	0	0	0	0	0
tops and leaves.	0	30,135	30,737	31,352	31,979	32,619	33,271	33,936	34,615	35,307	36,014
waste heat for drying	0	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0	0
Total	0	3,749,561	3,817,544	3,886,887	3,957,616	4,029,761	4,103,348	4,178,407	3,904,567	3,982,658	4,062,311
Total cash income	11,090,000	3,749,561	3,817,544	3,886,887	3,957,616	4,029,761	4,103,348	4,178,407	3,904,567	3,982,658	4,062,311
Cash payments.											
Fix cost											
Buildings power plants.	1,000,000	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	8,200,000	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	390,000	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	1,200,000	0	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0	0
Total payment.	11,090,000	0	0	0	0	0	100,000	0	0	0	0
Operation cost											
Plantation phase.											
fuel	0	416,608	389,128	400,801	412,825	425,210	437,967	451,106	464,639	478,578	492,935
Transportation phase.											
loading	0	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	0	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	0	785	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	0	29.83	31.32	32.89	34.53	36.26	38.07	39.98	41.97	44.07	46.28
Total fuel cost.	0	23,415.80	32,782.12	34,421.22	36,142.28	37,949.40	39,846.87	41,839.21	43,931.17	46,127.73	48,434.11
Total logistic cost	0	202,211.40	211,577.72	213,216.82	214,937.88	216,745.00	218,642.47	220,634.81	222,726.77	224,923.33	227,229.71
Preparation phase.											
Reduce cost	0	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	0	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	0	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.											
labor.	0	434,160	438,502	442,887	447,315	451,789	456,307	460,870	465,478	470,133	474,834
production cost	0	577,422	589,986	602,927	616,256	629,985	644,126	658,691	673,693	689,145	705,061
sales and administrative	0	109,027	110,999	113,010	115,061	117,154	119,288	121,464	113,453	115,717	118,027
Total Electrication phase.	0	1,120,609	1,139,487	1,158,824	1,178,633	1,198,927	1,219,720	1,241,025	1,252,624	1,274,995	1,297,922
Char carbons Production.		324,177	330,661	337,274	344,019	350,900	357,918	365,076	372,378	379,825	387,422
Heat recovery operation.		0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).		2,403,353	2,410,599	2,449,862	2,490,162	2,531,529	2,673,993	2,617,588	2,652,114	2,698,068	2,745,255
Net income per year (A) - (B).	11,090,000	1,346,208	1,406,944	1,437,024	1,467,454	1,498,232	1,429,354	1,560,819	1,252,453	1,284,590	1,317,056
Cash accumulated throughout the project.	100,000	1,546,208	2,953,152	4,390,176	5,857,631	7,355,862	8,785,217	10,346,036	11,598,489	12,883,079	14,200,135
Net Cash Flow	-10,890,000	-9,543,792	-8,136,848	-6,699,824	-5,232,369	-3,734,138	-2,304,783	-743,964	508,489	1,793,079	3,110,135

Item	Year 11 – 20									
	11	12	13	14	15	16	17	18	19	20
Cash Balance	14,200,135	14,049,982	15,432,938	16,849,316	18,299,423	19,783,557	21,202,009	22,755,060	24,342,984	25,966,043
Cash received.										
investments.										
Income from sale of power.	2,836,181	2,892,904	2,950,762	3,009,778	3,069,973	3,131,373	3,194,000	3,257,880	3,323,038	3,389,498
Adder.	0	0	0	0	0	0	0	0	0	0
carbon bar	1,270,643	1,296,056	1,321,977	1,348,417	1,375,385	1,402,893	1,430,951	1,459,570	1,488,761	1,518,536
Cabon cradit.	0	0	0	0	0	0	0	0	0	0
tops and leaves.	36,734	37,469	38,218	38,982	39,762	40,557	41,368	42,196	43,040	43,900
waste heat for drying	0	0	0	0	0	0	0	0	0	0
Salvage.	0	0	0	0	0	0	0	0	0	0
Total	4,143,558	4,226,429	4,310,957	4,397,177	4,485,120	4,574,823	4,666,319	4,759,645	4,854,838	4,951,935
Total cash income	4,143,558	4,226,429	4,310,957	4,397,177	4,485,120	4,574,823	4,666,319	4,759,645	4,854,838	4,951,935
Cash payments.										
Fix cost										
Buildings power plants.	0	0	0	0	0	0	0	0	0	0
Machinery and equipment	0	0	0	0	0	0	0	0	0	0
Gasification system	0	0	0	0	0	0	0	0	0	0
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0
Dryers.	200,000	0	0	0	0	0	0	0	0	0
Reduce machine .	0	0	0	0	0	0	0	0	0	0
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0
carbon processing machines.	1,200,000	0	0	0	0	0	0	0	0	0
Heat recovery system	0	0	0	0	0	0	0	0	0	0
Total payment.	1,500,000	0	0	0	0	100,000	0	0	0	0
Operation cost										
Plantation phase.										
fuel	507,723	522,955	538,644	554,803	571,447	588,590	606,248	624,436	643,169	662,464
Transportation phase.										
loading	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
fuel consumption (liter).	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Price per Unit (B/L).	48.59	51.02	53.57	56.25	59.06	62.01	65.12	68.37	71.79	75.38
Total fuel cost.	50,855.82	53,398.61	56,068.54	58,871.97	61,815.57	64,906.35	68,151.66	71,559.25	75,137.21	78,894.07
Total logistic cost	229,651.42	232,194.21	234,864.14	237,667.57	240,611.17	243,701.95	246,947.26	250,354.85	253,932.81	257,689.67
Preparation phase.										
Reduce cost	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511
drying cost	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236
Total Preparation cost	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747
Electrification phase.										
labor.	479,583	484,379	489,222	494,115	499,056	504,046	509,087	514,178	519,319	524,513
production cost	721,454	738,338	755,730	773,643	792,094	811,098	830,672	850,833	871,600	892,989
sales and administrative	120,383	122,786	125,237	127,737	130,287	132,888	135,541	138,247	141,007	143,822
Total Electrication phase.	1,321,420	1,345,503	1,370,190	1,395,495	1,421,437	1,448,032	1,475,300	1,503,258	1,531,926	1,561,324
Char carbons Production.	395,170	403,073	411,135	419,358	427,745	436,300	445,026	453,926	463,005	472,265
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0
Total cash payment per year (B).	4,293,711	2,843,473	2,894,579	2,947,070	3,000,986	3,156,371	3,113,268	3,171,721	3,231,779	3,293,488
Net income per year (A) - (B).	-150,153	1,382,956	1,416,378	1,450,107	1,484,134	1,418,452	1,553,051	1,587,924	1,623,059	1,658,447
Cash accumulated throughout the project.	14,049,982	15,432,938	16,849,316	18,299,423	19,783,557	21,202,009	22,755,060	24,342,984	25,966,043	27,624,490
Net Cash Flow	2,959,982	4,342,938	5,759,316	7,209,423	8,693,557	10,112,009	11,665,060	13,252,984	14,876,043	16,534,490

Item	year 21 – 30										Sum
	21	22	23	24	25	26	27	28	29	30	
Cash Balance	27,624,490	27,818,564	29,548,493	31,314,491	33,116,758	34,955,480	36,730,823	38,642,938	40,591,959	42,577,997	601,719,292
Cash received.											-
investments.											-
Income from sale of power.	3,457,288	3,526,434	3,596,963	3,668,902	3,742,280	3,817,126	3,893,468	3,971,338	4,050,764	4,131,780	94,387,965
Adder.	0	0	0	0	0	0	0	0	0	0	2,452,800
carbon bar	1,548,907	1,579,885	1,611,483	1,643,712	1,676,587	1,710,118	1,744,321	1,779,207	1,814,791	1,851,087	42,286,945
Cabon cradit.	0	0	0	0	0	0	0	0	0	0	-
tops and leaves.	44,778	45,674	46,587	47,519	48,470	49,439	50,428	51,436	52,465	53,514	1,222,503
waste heat for drying	0	0	0	0	0	0	0	0	0	0	-
Salvage.	0	0	0	0	0	0	0	0	0	891,541	891,541
Total	5,050,974	5,151,993	5,255,033	5,360,134	5,467,336	5,576,683	5,688,217	5,801,981	5,918,021	6,927,923	141,241,755
Total cash income	5,050,974	5,151,993	5,255,033	5,360,134	5,467,336	5,576,683	5,688,217	5,801,981	5,918,021	6,927,923	141,241,755
Cash payments.											-
Fix cost											-
Buildings power plants.	0	0	0	0	0	0	0	0	0	0	-
Machinery and equipment	0	0	0	0	0	0	0	0	0	0	-
Gasification system	0	0	0	0	0	0	0	0	0	0	-
connection equipment to grid.	0	0	0	0	0	0	0	0	0	0	-
Office equipment	100,000	0	0	0	0	100,000	0	0	0	0	500,000
Dryers.	200,000	0	0	0	0	0	0	0	0	0	400,000
Reduce machine .	0	0	0	0	0	0	0	0	0	0	-
carbon credit consultants cost	0	0	0	0	0	0	0	0	0	0	-
carbon processing machines.	1,200,000	0	0	0	0	0	0	0	0	0	2,400,000
Heat recovery system	0	0	0	0	0	0	0	0	0	0	-
Total payment.	1,500,000	0	0	0	0	100,000	0	0	0	0	3,300,000
Operation cost											-
Plantation phase.											-
fuel	682,338	702,808	723,892	745,609	767,977	791,016	814,747	839,189	864,365	890,296	18,012,512
Transportation phase.											
loading	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	18,796	563,868
truck.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	4,800,000
fuel consumption (liter).	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	31,137
Price per Unit (B/L).	79.15	83.11	87.26	91.62	96.20	101.01	106.07	111.37	116.94	122.78	1,981.87
Total fuel cost.	82,838.77	86,980.71	91,329.75	95,896.23	100,691.05	105,725.60	111,011.88	116,562.47	122,390.59	128,510.12	2,066,486.11
Total logistic cost	261,634.37	265,776.31	270,125.35	274,691.83	279,486.65	284,521.20	289,807.48	295,358.07	301,186.19	307,305.72	7,430,354.13
Preparation phase.											
Reduce cost	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	210,511	6,315,322
drying cost	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	129,236	3,877,081
Total Preparation cost	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	339,747	10,192,403
Electrification phase.											
labor.	529,758	535,055	540,406	545,810	551,268	556,781	562,348	567,972	573,652	579,388	15,102,209
production cost	915,020	937,712	961,084	985,158	1,009,954	1,035,494	1,061,800	1,088,896	1,116,804	1,145,549	24,683,213
sales and administrative	146,693	149,622	152,609	155,656	158,764	161,934	165,167	168,465	171,829	175,260	4,077,139
Total Electrication phase.	1,591,471	1,622,389	1,654,100	1,686,624	1,719,986	1,754,209	1,789,316	1,825,333	1,862,285	1,900,198	43,862,560
Char carbons Production.	481,710	491,344	501,171	511,195	521,418	531,847	542,484	553,333	564,400	575,688	13,151,240
Heat recovery operation.	0	0	0	0	0	0	0	0	0	0	
Total cash payment per year (B).	4,856,900	3,422,064	3,489,035	3,557,866	3,628,615	3,801,340	3,776,101	3,852,960	3,931,982	4,013,234	95,949,069
Net income per year (A) - (B).	194,074	1,729,929	1,765,998	1,802,267	1,838,721	1,775,343	1,912,116	1,949,021	1,986,038	2,914,689	45,292,686
Cash accumulated throughout the project.	27,818,564	29,548,493	31,314,491	33,116,758	34,955,480	36,730,823	38,642,938	40,591,959	42,577,997	45,492,686	-
Net Cash Flow	16,728,564	18,458,493	20,224,491	22,026,758	23,865,480	25,640,823	27,552,938	29,501,959	31,487,997	34,402,686	-

NPV(Baht)	**3,361,617**
IRR	**12.05%**
Pay Back Preiod (Yrs)	**7.59**

Appendix C Survived data.

	Factory	ERDI's data base		Survived		Difference
		x (utm)	y (utm)	x (utm)	y (utm)	(m)
1	Swing Furniture	507433	2051442	507410	2051401	30
2	Sangad handicraft	504748	2037669	500441	2036933	30
3	Sutep handicraft	503496	2036029	503480	2036081	40
4	Witawat Suphanubon	500317	2036996	500321	2036963	30
5	Sman Keaw gart	503841	2036261	503846	2036254	10
6	Sunthorn Pa gart	504239	2036566	504210	2036545	0
7	Lamduan Keawgart	504455	2037488	504456	2037479	10
8	Boonthong Motharat	503977	2036345	504006	2036366	10
9	Giang Kham Sarakart	503735	2037461	503751	2037409	50
10	Jianphan Panyagart	502106	2036400	502135	2036421	10
11	Jitrcharoen Furniture	507048	2051350	507047	2051359	10
12	Kew Tarn gart	503066	2036902	503089	2036943	40
13	Prasit Fah udompernsak	506414	2038411	506430	2038359	50
14	Romance Keawgart	505206	2037967	505201	2037974	0
15	Sa – Ngad Jaigart	500540	2036880	500536	2036913	40
16	Sa – Nguansak Chaikeaw	510308	2039120	510309	2039111	0
17	Sakthong Rung Roeng Co.,Ltd.	487516	2054034	487532	2054068	30
18	Samchai Style Co.,Ltd.	513821	2084991	513817	2085003	0
19	Somsak Furniture	506870	2051889	506865	2051896	10
20	Somsak Tangart	506008	2037994	506007	2038003	10

Appendix C Survived data (Cont.)

Factory		ERDI's data base		Survived		Difference
		x (utm)	y (utm)	x (utm)	y (utm)	(m)
21	Songkham Furniture	507088	2050614	507101	2050618	0
22	Srira Duanggart	503776	2036166	503774	2036170	0
23	Sriton wood processing	511748	2089618	511760	2089626	20
24	Sriwan Sang-gart	504349	2036627	504360	2036631	0
	average					17.92

APPENDIX D

Computer code of Network analysis

```
Form 1
Option Explicit
Dim Conn As New ADODB.Connection
Dim cmd As New ADODB.Command
Dim rs1 As New ADODB.Recordset
Dim caseload, casevehicle As Integer
Dim init11 As Double
Dim casecal, casedistance As Integer
Public Sub OpenDataBase(DbfFile As String)
On Error GoTo Err_Handler

   Set Conn = New ADODB.Connection
   Conn.Open "Driver={Microsoft Visual FoxPro Driver};" & _
           "SourceType=DBF;" & _
           "SourceDB=" & DbfFile & ";"

   MsgBox "Connect DBF FoxPro already.", vbOKOnly + vbInformation, "Status"
   Exit Sub
Err_Handler:
   MsgBox "Error : " & Err.Number & " " & Err.Description
   End
End Sub

Private Sub Combo1_Click()
casevehicle = Combo1.ItemData(Combo1.ListIndex)
With vehicle1.Recordset
   .MoveFirst
   .Find "v_id =" & casevehicle & "", , adSearchForward

End With
End Sub

Private Sub Combo2_Click()
caseload = Combo2.ItemData(Combo2.ListIndex)
 ' MsgBox "select " & caseload & "dkd"
  ' If Combo2.ListIndex = 1 Then
   ' Text1.Visible = False
   ' Combo4.Visible = True
   'ElseIf Combo2.ListIndex = 0 Then
   ' Combo4.Visible = False
   ' Text1.Visible = True
  '  Text1.Text = ""
  ' End If
End Sub


Private Sub Combo4_Click()
casedistance = Combo4.ItemData(Combo4.ListIndex)
Text18.Text = Val(casedistance) * 1000
End Sub

Private Sub Command1_Click()
Dim Conn1 As ADODB.Connection
Dim sql1 As String
Dim totalcap1, totalcap2 As Double
Dim totalL1, totalL2 As Double
Dim rs1 As ADODB.Recordset
Dim sql2, sql3, sql4, sql5, sql6, sql7, sql8, sqlupdate As String
Dim tempnode1, tempnode2 As String
Dim i, ii, r, rflex, aa1, point1, lastpoint As Integer
Dim startnode, endnode, endnode1 As String
Dim cap_start, cap_end As Double
```

```
Dim L_start, L_end As Double
Dim strsearch As String
Dim initiaload As Double
Dim init1, init2 As Double
casecal = 1
Text17.Text = casecal
ii = 1
sql1 = "select sum(capacity)as totalcap  from pointfac"
   'Call OpenDataBase(App.Path & "\pointfac.dbf")
With Adodc4
   .RecordSource = sql1
   .Refresh
End With
If Adodc4.Recordset.RecordCount <> 0 Then
   init2 = Adodc4.Recordset!totalcap
End If
'Print init2
Select Case caseload
   Case 0
      If Text1.Text = "" Then
          MsgBox "please, enter thu nember of capacity ", vbOKOnly + vbInformation, "xxx"
            Exit Sub
       End If

      initiaload = Val(Text1.Text)
      init11 = init2 / initiaload
   Case 1
       If Text1.Text = "" Then
          MsgBox "please, enter thu nember of capacity ", vbOKOnly + vbInformation, "xxx"
            Exit Sub
       End If
       initiaload = Val(Text1.Text)
       init11 = init2 / initiaload
   Case 2
      If Text3.Text = "" Then
          MsgBox "please, enter thu nember of factory ", vbOKOnly + vbInformation, "xxx"
            Exit Sub
       End If
      init11 = Val(Text3.Text)
      initiaload = init2 / Val(Text3.Text)
End Select
'min(d.cost) as min_cost,
'Print initiaload
'Print init11

'
'loop 30 point
'
lastpoint = 30
For point1 = 1 To lastpoint


sql2 = "select capacity from pointfac where box_fac=" & point1 & ""
startnode = point1
Text10.Text = startnode
With Adodc4
   .RecordSource = sql2
   .Refresh
   If .Recordset.RecordCount <> 0 Then
         cap_start = .Recordset!capacity
         Text7.Text = cap_start
```

```
     End If
End With
 If cap_start > initiaload Then
       With Adodc7.Recordset
            .AddNew
            .Fields("Ori_point") = startnode
            .Fields("Des_point") = startnode
            .Fields("load_cap") = cap_start
            .Fields("load_road") = 0
            .Fields("pointS") = point1
            .Fields("temp") = 0
            .Update
        End With

   Else
   With Adodc7.Recordset
            .AddNew
            .Fields("Ori_point") = startnode
            .Fields("Des_point") = startnode
            .Fields("load_cap") = cap_start
            .Fields("load_road") = 0
            .Fields("pointS") = point1
            .Fields("temp") = 0
            .Update
        End With
   totalcap1 = cap_start
   L_start = Val(Text18.Text)
   sql3 = "select * from distance_allNew where evt_id=" & startnode & " and cost < " & Val(Text18.Text) & " order by cost
ASC"
   With Adodc5
      .RecordSource = sql3
      .Refresh
      If .Recordset.RecordCount <> 0 Then
         For i = 1 To .Recordset.RecordCount
       ' L_end = .Recordset!cost
        ' Do While (totalcap1 < initiaload) And (L_end < L_start)

          '   Print .Recordset!cost
            sql4 = "select capacity from pointfac where box_fac=" & .Recordset!fac_id & ""
            With Adodc4
               .RecordSource = sql4
               .Refresh
               If .Recordset.RecordCount = 1 Then
                  cap_end = .Recordset!capacity
               End If
            End With
            totalcap1 = totalcap1 + cap_end
            If totalcap1 < initiaload Then
            'Print totalcap1
             With Adodc7.Recordset
               .AddNew
               .Fields("Ori_point") = startnode
               .Fields("Des_point") = Adodc5.Recordset!fac_id
               .Fields("load_cap") = totalcap1
               .Fields("load_road") = Adodc5.Recordset!cost
               .Fields("pointS") = startnode
               .Fields("temp") = 0
               .Update
            End With
            Else

           End If
```

```
            .Recordset.MoveNext
          '  L_end = .Recordset!cost
          Next i
         ' Loop
   End If
   End With
End If

Next point1
Command3.Enabled = True
End Sub



Private Sub Command2_Click()
Unload Form1
Form5.Show
Form5.SetFocus
End Sub

Private Sub Command3_Click()
Dim sqlLoad, sql1, sql6, sqlcheck As String
Dim i, lasti, i1, i2 As Integer
Dim lcap, lroad, oricap_i, cap2, cap_end, k, cost_all, ll, cost_free, totalcost As Double
Dim cost_all1, cost_free1, totalcost1, lcap1 As Double
If Text12.Text = "" Then
   MsgBox "input fuel"
   Exit Sub
End If

sqlcheck = "select * from tempdb"
With Adodc9
   .RecordSource = sqlcheck
   .Refresh
   If .Recordset.RecordCount = 0 Then
   MsgBox "can not load Temp Data"
   Exit Sub
   End If
End With
Label7.Caption = "wait !"

'k= load / ton
If casecal = 1 Then
lasti = 30
For i = 1 To lasti
'Print casecal
'Print oricap_i
sqlLoad = "select * from tempdb where pointS=" & i & " "
With Adodc9
   .RecordSource = sqlLoad
   .Refresh
   If .Recordset.RecordCount <> 0 Then
  ' Print Adodc9.Recordset!loadcap1
   'Print Adodc9.Recordset!load_road
   For i1 = 1 To .Recordset.RecordCount
         sql6 = "select capacity from pointfac where box_fac=" & .Recordset!Des_point & ""
          With Adodc6
            .RecordSource = sql6
            .Refresh
            If .Recordset.RecordCount <> 0 Then
               cap_end = .Recordset!capacity
```

```
          End If
       End With
       lcap = .Recordset!load_cap
       cap2 = lcap1
       k = CInt(cap_end / Val(Text14.Text))
       lroad = .Recordset!load_road
       ll = lroad / 1000
       cost_all1 = (Val(Text16.Text) * (k * ll) * Val(Text14.Text)) * Val(Text12.Text)
       cost_free1 = (Val(Text15.Text) * (k * ll)) * Val(Text12.Text)
       totalcost1 = cost_all1 + cost_free1
       cost_all = cost_all + cost_all1
       cost_free = cost_free + cost_free1
       totalcost = totalcost + totalcost1
      ' lcap = lcap + lcap1
      ' Print cost_all
      .Recordset.MoveNext
  Next i1
    With Adodc10.Recordset
       .AddNew
       .Fields("Point") = i
       .Fields("Maxcp") = lcap
       .Fields("Maxroad") = 0
       .Fields("S") = 0
       .Fields("obj_cost") = cost_all
       .Fields("cost_free") = cost_free
       .Fields("totalcost") = totalcost
       .Update
     End With
  End If
End With


Next i
ElseIf casecal = 2 Then
  'MsgBox "xxxxxxxxxxxx"
  sqlLoad = "select Load_cap,load_road from tempdb where pointS=" & Text11.Text & " "
With Adodc9
  .RecordSource = sqlLoad
  .Refresh
  If .Recordset.RecordCount <> 0 Then
  ' Print Adodc9.Recordset!loadcap1
  'Print Adodc9.Recordset!load_road
  .Recordset.MoveFirst
  For i2 = 1 To .Recordset.RecordCount
       lcap = .Recordset!load_cap
       cap2 = lcap
       k = CInt(cap2 / Val(Text14.Text))
       lroad = .Recordset!load_road
       ll = lroad / 1000
       cost_all = (Val(Text16.Text) * (k * ll) * Val(Text14.Text)) * Val(Text12.Text)
       cost_free = (Val(Text15.Text) * (k * ll)) * Val(Text12.Text)
       totalcost = cost_all + cost_free
      ' Print cost_all
    With Adodc10.Recordset
       .AddNew
       .Fields("Point") = Text11.Text
       .Fields("Maxcp") = lcap
       .Fields("Maxroad") = lroad
       .Fields("S") = 0
       .Fields("obj_cost") = cost_all
       .Fields("cost_free") = cost_free
       .Fields("totalcost") = totalcost
```

```
        .Update
      End With
      .Recordset.MoveNext
    Next i2
   End If
End With

End If
Command4.Enabled = True
Label7.Caption = "complete !"
End Sub

Private Sub Command4_Click()
Form2.Text2.Text = init11
Form2.Text3.Text = casecal
Form2.Text5.Text = Text18.Text
Form2.Text6.Text = Text14.Text
Form2.Text7.Text = Text15.Text
Form2.Text8.Text = Text16.Text
Form2.Text9.Text = Text12.Text
Form2.Show
Form2.SetFocus
  Unload Form1

End Sub

Private Sub Command5_Click()
Unload Form1
Unload Form2
Form3.Show
Form3.SetFocus
End Sub




Private Sub Command6_Click()
  If MsgBox("are you sure exit program?", vbYesNo + vbQuestion, "information") = vbYes Then
      End
   End If
End Sub

Private Sub Command7_Click()
Dim box_id As Integer
Dim Conn As ADODB.Connection
Set Conn = New ADODB.Connection
casecal = 2
Text17.Text = casecal
box_id = Text11.Text
Conn.ConnectionString = Adodc11.ConnectionString
Conn.Open
Conn.Execute "delete from tempdb"
Conn.Close
Unload Me
DataGrid2.Refresh
DataGrid2.ReBind
Form1.Text11.Text = box_id
Form1.Show
Call loadcap(box_id)
Command3.Enabled = True
End Sub
```

```
Private Sub Form_Load()
With Combo1
   .AddItem "Ã¶ 6 ÅéÍ"
   .ItemData(.NewIndex) = 6
   .AddItem "Ã¶ 10 ÅéÍ"
   .ItemData(.NewIndex) = 10
   .AddItem "Ã¶ 18 ÅéÍ"
   .ItemData(.NewIndex) = 18

End With
With Combo2
   .AddItem "¡ÓË¹´µÒÁ¤ÇÒÁ¨ØâÃ§§Ò¹"
    .ItemData(.NewIndex) = 1
   .AddItem "¡ÓË¹´µÒÁ¨Ó¹Ç¹âÃ§§Ò¹"
    .ItemData(.NewIndex) = 2
End With
'Combo4.Visible = False
With Combo4
   .AddItem "äÁèà¡Ô¹ 20 ¡ÔâÅàÁµÃ"
   .ItemData(.NewIndex) = 20
   .AddItem "äÁèà¡Ô¹ 30 ¡ÔâÅàÁµÃ"
   .ItemData(.NewIndex) = 30
   .AddItem "äÁèà¡Ô¹ 40 ¡ÔâÅàÁµÃ"
   .ItemData(.NewIndex) = 40
   .AddItem "äÁèà¡Ô¹ 50 ¡ÔâÅàÁµÃ"
   .ItemData(.NewIndex) = 50
End With
Text17.Text = casecal
'Command3.Enabled = False
'Command4.Enabled = False
End Sub

Private Sub setmark()
Dim sqlmark As String
Dim str1 As String
     str1 = "àÃÔèÁ" & Text10.Text & "ÊÔé¹ÊØ´" & Text4.Text
   '   List1.AddItem str1
sqlmark = "select * from distance_allNew where evt_id=" & Text10.Text & " and fac_id=" & Text4.Text & " and mark2=1"
With Adodc6
   .RecordSource = sqlmark
   .Refresh
   If .Recordset.RecordCount <> 0 Then
      Label1.Caption = "ok1"
     End If

End With


End Sub
Private Sub loadcap(ByVal nodeDest As Integer)
Dim sql1 As String
Dim nodestart As Integer
Dim i As Integer
nodestart = nodeDest

sql1 = "select d.cost,p.capacity,d.fac_id from distance_allNew as d,pointfac as p where p.box_fac=d.fac_id and d.evt_id =" &
nodestart & ""
With Adodc12
      .RecordSource = sql1
      .Refresh
```

```
      If .Recordset.RecordCount <> 0 Then
     ' Print .Recordset.RecordCount
         .Recordset.MoveFirst
      For i = 1 To .Recordset.RecordCount

        With Adodc7.Recordset
            .AddNew
            .Fields("Ori_point") = nodestart
            .Fields("Des_point") = Adodc12.Recordset!fac_id
            .Fields("load_cap") = Adodc12.Recordset!capacity
            .Fields("load_road") = Adodc12.Recordset!cost
            .Fields("pointS") = nodestart
            .Fields("temp") = 0
            .Update
        End With
             Adodc12.Recordset.MoveNext
      Next i

      End If
   End With

End Sub
…………………………………………………………..

Form 2.
Option Explicit
Dim init1, init2 As Double
Private Sub Command1_Click()
Dim sql, sql1, sql2, sql3, sql4 As String
Dim pstart As String
Dim ip, ii, i3, i4, i, i1 As Integer
Dim loopint As Integer
Dim cap_end As Double

If Text3.Text = "" Then
   MsgBox "can not calculated"
   Exit Sub
End If
If Text3.Text = 1 Then
"case 1
loopint = Int(Val(Text2.Text))
If loopint < Val(Text2.Text) Then
   loopint = loopint + 5
'    Print loopint
End If
For i = 1 To loopint
sql = "select * from loaddb where S=0 ORDER BY maxcp DESC "
With Adodc3
   .RecordSource = sql
   .Refresh
   If .Recordset.RecordCount <> 0 Then
 '  Print .Recordset!maxcp
      sql1 = "select * from loaddb where maxcp=" & .Recordset!maxcp & " and S=0"
      With Adodc4
         .RecordSource = sql1
         .Refresh
         If .Recordset.RecordCount = 1 Then
            pstart = .Recordset!Point
            sql2 = "select * from tempdb where points=" & pstart & ""
            With Adodc6
               .RecordSource = sql2
               .Refresh
```

```
        If .Recordset.RecordCount <> 0 Then
          For i1 = 1 To .Recordset.RecordCount
          With Adodc1.Recordset
             .MoveFirst
             .Find "point = " & Adodc6.Recordset!Des_point & "", , adSearchForward
             .Fields("S") = 1
             .Update
          End With
           sql4 = "select * from resultload1 where des_point=" & Adodc6.Recordset!Des_point & " "
          With Adodc10
             .RecordSource = sql4
             .Refresh
             If .Recordset.RecordCount = 0 Then
                 With Adodc2.Recordset
                    .AddNew
                    .Fields("Ori_point") = Adodc6.Recordset.Fields("Ori_point").Value
                    .Fields("Des_point") = Adodc6.Recordset.Fields("Des_point").Value
                    .Fields("load_cap") = Adodc6.Recordset.Fields("load_cap").Value
                    .Fields("load_road") = Adodc6.Recordset.Fields("load_road").Value
                    .Fields("pointS") = pstart
                    .Update
                 End With
             End If
          End With
          .Recordset.MoveNext
          Next i1
        End If
    End With
'if more than 1
Else

'
 sql2 = "select * from loaddb where maxcp=" & Adodc3.Recordset!maxcp & " and S=0 order by totalcost ASC"
 With Adodc7
    .RecordSource = sql2
    .Refresh
    If .Recordset.RecordCount <> 0 Then
    pstart = .Recordset!Point
    sql3 = "select * from tempdb where points=" & pstart & ""
    With Adodc6
        .RecordSource = sql3
        .Refresh
        If .Recordset.RecordCount <> 0 Then
          For i1 = 1 To .Recordset.RecordCount
          With Adodc1.Recordset
             .MoveFirst
             .Find "point = " & Adodc6.Recordset!Des_point & "", , adSearchForward
             .Fields("S") = 1
             .Update
          End With
          sql4 = "select * from resultload1 where des_point=" & Adodc6.Recordset!Des_point & " "
          With Adodc10
             .RecordSource = sql4
             .Refresh
             If .Recordset.RecordCount = 0 Then

                 With Adodc2.Recordset
                    .AddNew
                    .Fields("Ori_point") = Adodc6.Recordset.Fields("Ori_point").Value
                    .Fields("Des_point") = Adodc6.Recordset.Fields("Des_point").Value
                    .Fields("load_cap") = Adodc6.Recordset.Fields("load_cap").Value
                    .Fields("load_road") = Adodc6.Recordset.Fields("load_road").Value
```

```
                  .Fields("pointS") = pstart
                  .Update
                End With
              End If
            End With
            .Recordset.MoveNext
            Next i1
          End If
        End With
        End If
      End With
      '
      End If
    End With

  End If
End With

Next i
'

Call result1
ElseIf Text3.Text = 2 Then
  sql = "select sum(totalcost)as total,sum(maxcp) as capacity,sum(maxroad) as lenght,point from loaddb Group By Point"
  With Adodc3
  .RecordSource = sql
  .Refresh
  If .Recordset.RecordCount <> 0 Then
    ' Text4.Text = .Recordset!total
    sql4 = "select capacity from pointfac where box_fac=" & .Recordset!Point & ""
        With Adodc4
          .RecordSource = sql4
          .Refresh
          If .Recordset.RecordCount = 1 Then
            cap_end = .Recordset!capacity
          End If
        End With
             With Adodc8.Recordset
                .AddNew
                .Fields("ori_point") = Adodc3.Recordset!Point
                .Fields("des_point") = 0
                .Fields("capacity") = Adodc3.Recordset!capacity + cap_end
                .Fields("lenght") = Adodc3.Recordset!lenght
                .Fields("totalcost") = Adodc3.Recordset!total
                .Update
              End With
  End If
  End With
End If

Call sumresult1
End Sub

Private Sub Command2_Click()
  Unload Form2
  Form1.Show
  Form1.SetFocus
End Sub

Private Sub Command3_Click()
Dim loopint As Integer
loopint = Int(Val(Text2.Text))
```

```
If loopint < Val(Text2.Text) Then
   loopint = loopint + 1
 '  Print loopint
End If
End Sub

Private Sub Command4_Click()
Dim sql, sql1, sql2, sql3, sql4 As String
Dim pstart As String
Dim ip, ii, i3, i4, i, i1 As Integer
Dim loopint As Integer

loopint = Int(Val(Text2.Text))
If loopint < Val(Text2.Text) Then
   loopint = loopint + 1
  ' Print loopint
End If
sql = "select * from loaddb where S=0 ORDER BY maxcp DESC "
With Adodc3
   .RecordSource = sql
   .Refresh
   If .Recordset.RecordCount <> 0 Then
   Print .Recordset!maxcp
      sql1 = "select * from loaddb where maxcp=" & .Recordset!maxcp & " and S=0"
      With Adodc4
         .RecordSource = sql1
         .Refresh
         If .Recordset.RecordCount = 1 Then
            pstart = .Recordset!Point
            sql2 = "select * from tempdb where points=" & pstart & ""
            With Adodc6
               .RecordSource = sql2
               .Refresh
               If .Recordset.RecordCount <> 0 Then
                  For i1 = 1 To .Recordset.RecordCount
                  With Adodc1.Recordset
                     .MoveFirst
                     .Find "point = " & Adodc6.Recordset!Des_point & "", , adSearchForward
                     .Fields("S") = 1
                     .Update
                  End With
                   sql4 = "select * from resultload1 where des_point=" & Adodc6.Recordset!Des_point & " "
                  With Adodc10
                     .RecordSource = sql4
                     .Refresh
                     If .Recordset.RecordCount = 0 Then
                         With Adodc2.Recordset
                           .AddNew
                           .Fields("Ori_point") = Adodc6.Recordset.Fields("Ori_point").Value
                           .Fields("Des_point") = Adodc6.Recordset.Fields("Des_point").Value
                           .Fields("load_cap") = Adodc6.Recordset.Fields("load_cap").Value
                           .Fields("load_road") = Adodc6.Recordset.Fields("load_road").Value
                           .Fields("pointS") = pstart
                           .Update
                         End With
                     End If
                  End With
                  .Recordset.MoveNext
                  Next i1
               End If
            End With
         'if more than 1
```

```
        Else
        '
         sql2 = "select * from loaddb where maxcp=" & Adodc3.Recordset!maxcp & " and S=0 order by totalcost ASC"
         With Adodc7
           .RecordSource = sql2
           .Refresh
           If .Recordset.RecordCount <> 0 Then
           pstart = .Recordset!Point
           sql3 = "select * from tempdb where points=" & pstart & ""
           With Adodc6
              .RecordSource = sql3
              .Refresh
              If .Recordset.RecordCount <> 0 Then
                 For i1 = 1 To .Recordset.RecordCount
                 With Adodc1.Recordset
                    .MoveFirst
                    .Find "point = " & Adodc6.Recordset!Des_point & "", , adSearchForward
                    .Fields("S") = 1
                    .Update
                 End With
                 sql4 = "select * from resultload1 where des_point=" & Adodc6.Recordset!Des_point & " "
                 With Adodc10
                    .RecordSource = sql4
                    .Refresh
                    If .Recordset.RecordCount = 0 Then

                       With Adodc2.Recordset
                          .AddNew
                          .Fields("Ori_point") = Adodc6.Recordset.Fields("Ori_point").Value
                          .Fields("Des_point") = Adodc6.Recordset.Fields("Des_point").Value
                          .Fields("load_cap") = Adodc6.Recordset.Fields("load_cap").Value
                          .Fields("load_road") = Adodc6.Recordset.Fields("load_road").Value
                          .Fields("pointS") = pstart
                          .Update
                       End With
                    End If
                 End With
                 .Recordset.MoveNext
                 Next i1
              End If
           End With
           End If
        End With
        '
        End If
     End With

   End If
End With
End Sub

Private Sub Command5_Click()
Dim sql1, sql2, sql3, sql4 As String
Dim i, i2, start1 As Integer
Dim capacity, lenght, cap_end, ll As Double
Dim cost_all, cost_free, totalcost, k As Double
sql1 = "select distinct(points) as point2 from resultload1"
With Adodc3
   .RecordSource = sql1
   .Refresh
   If .Recordset.RecordCount <> 0 Then
```

```
    For i = 1 To .Recordset.RecordCount
      sql2 = "select * from resultload1 where points=" & .Recordset!point2 & ""
  '  Print .Recordset!Point2
        start1 = .Recordset!point2
        With Adodc4
          .RecordSource = sql2
          .Refresh
          If .Recordset.RecordCount <> 0 Then
            For i2 = 1 To .Recordset.RecordCount
              sql3 = "select * from pointfac where box_fac =" & .Recordset!Des_point & ""
              With Adodc6
                .RecordSource = sql3
                .Refresh
                If .Recordset.RecordCount <> 0 Then
                  capacity = .Recordset!capacity
                End If
              End With
              lenght = .Recordset!load_road
              cap_end = capacity
               k = CInt(cap_end / Val(Text6.Text))
               ll = lenght / 1000
              cost_all = (Val(Text8.Text) * (k * ll) * Val(Text6.Text)) * Val(Text9.Text)
              cost_free = (Val(Text7.Text) * (k * ll)) * Val(Text9.Text)
              totalcost = cost_all + cost_free
              With Adodc8.Recordset
                .AddNew
                .Fields("ori_point") = start1
                .Fields("des_point") = Adodc4.Recordset!Des_point
                .Fields("capacity") = capacity
                .Fields("lenght") = lenght
                .Fields("totalcost") = totalcost
                .Update
              End With
              'hkkj
              .Recordset.MoveNext
            Next i2
          End If
        End With


      .Recordset.MoveNext
    Next i
  End If
End With
End Sub

Private Sub result1()
Dim sql1, sql2, sql3, sql4 As String
Dim i, i2, start1 As Integer
Dim capacity, lenght, cap_end, ll As Double
Dim cost_all, cost_free, totalcost, k As Double
sql1 = "select distinct(points) as point2 from resultload1"
With Adodc3
  .RecordSource = sql1
  .Refresh
  If .Recordset.RecordCount <> 0 Then
    For i = 1 To .Recordset.RecordCount
      sql2 = "select * from resultload1 where points=" & .Recordset!point2 & ""
  '  Print .Recordset!Point2
        start1 = .Recordset!point2
        With Adodc4
```

```
                .RecordSource = sql2
                .Refresh
                If .Recordset.RecordCount <> 0 Then
                   For i2 = 1 To .Recordset.RecordCount
                      sql3 = "select * from pointfac where box_fac ='" & .Recordset!Des_point & "'"
                      With Adodc6
                         .RecordSource = sql3
                         .Refresh
                         If .Recordset.RecordCount <> 0 Then
                            capacity = .Recordset!capacity
                         End If
                      End With
                      lenght = .Recordset!load_road
                      cap_end = capacity
                       k = CInt(cap_end / Val(Text6.Text))
                       ll = lenght / 1000
                      cost_all = (Val(Text8.Text) * (k * ll) * Val(Text6.Text)) * Val(Text9.Text)
                      cost_free = (Val(Text7.Text) * (k * ll)) * Val(Text9.Text)
                      totalcost = cost_all + cost_free
                      With Adodc8.Recordset
                         .AddNew
                         .Fields("ori_point") = start1
                         .Fields("des_point") = Adodc4.Recordset!Des_point
                         .Fields("capacity") = capacity
                         .Fields("lenght") = lenght
                         .Fields("totalcost") = totalcost
                         .Update
                      End With
                      'hkkj
                      .Recordset.MoveNext
                   Next i2
                End If
             End With



          .Recordset.MoveNext
       Next i
    End If
End With
End Sub
Private Sub sumresult1()
Dim sql1, sql2, sql3, sql4 As String
Dim i, i2, start1 As Integer
Dim capacity, lenght, cap_end, ll As Double
Dim cost_all, cost_free, totalcost, k As Double
sql1 = "select distinct(ori_point) as point2 from resultload2"
With Adodc3
   .RecordSource = sql1
   .Refresh
   If .Recordset.RecordCount <> 0 Then
      For i = 1 To .Recordset.RecordCount
         start1 = .Recordset!point2
         sql2 = "select sum(capacity) as sum1,sum(lenght) as sum2,sum(totalcost) as sum3 from resultload2"
         sql2 = sql2 & " where Ori_point=" & .Recordset!point2 & " Group By Ori_point "
         With Adodc4
               .RecordSource = sql2
               .Refresh
               If .Recordset.RecordCount <> 0 Then
                  With Adodc12.Recordset
                  .AddNew
                  .Fields("ori_point") = start1
```

```
                  .Fields("capacity") = Adodc4.Recordset!sum1
                  .Fields("lenght") = Adodc4.Recordset!sum2
                  .Fields("totalcost") = Adodc4.Recordset!Sum3
                  .Update
                  End With
               End If
         End With
         .Recordset.MoveNext
      Next i
   End If
End With
End Sub

Private Sub Command6_Click()
  With Adodc12.Recordset
      .MovePrevious
         If .BOF Then
            .MoveFirst
         End If
   End With
End Sub

Private Sub Command7_Click()
  With Adodc12.Recordset
      .MoveNext
         If .EOF Then
            .MoveLast
         End If
   End With
End Sub

Private Sub Command8_Click()
Form4.Show
Form4.SetFocus
End Sub
……………………………………………..
Form 3
Private Sub Command1_Click()
Dim sql1, sql2, sql3, sql4 As String
Label1.Caption = "wait !"
sql1 = "select * from distance_allNew"
   With Adodc1
      .RecordSource = sql1
      .Refresh
      If .Recordset.RecordCount <> 0 Then
        .Recordset.MoveFirst
        For i = 0 To .Recordset.RecordCount - 1
         .Recordset.Fields("Mark2") = 0
         .Recordset.Update
         .Recordset.MoveNext
         Next i
      End If
  End With
  'sql2 = "select * from tempdb"
  ' With Adodc2
   '   .RecordSource = sql2
   '   .Refresh
   '   If .Recordset.RecordCount <> 0 Then
   '     .Recordset.MoveFirst
   '     For i = 0 To .Recordset.RecordCount - 1
   '       .Recordset.Delete
   '       .Recordset.MoveNext
```

```
'       Next i
  '   End If
 ' End With
  Dim Conn4 As ADODB.Connection
Set Conn4 = New ADODB.Connection
Conn4.ConnectionString = Adodc4.ConnectionString
Conn4.Open
Conn4.Execute "delete from tempdb"
Conn4.Close

 ' sql3 = "select * from loaddb"
  'With Adodc3
 '    .RecordSource = sql3
 '    .Refresh
 '    If .Recordset.RecordCount <> 0 Then
 '       .Recordset.MoveFirst
 '       For i = 0 To .Recordset.RecordCount - 1
 '        .Recordset.Delete
 '        .Recordset.MoveNext
 '        Next i
' '    End If
 ' End With
     Dim Conn5 As ADODB.Connection
Set Conn5 = New ADODB.Connection
Conn5.ConnectionString = Adodc4.ConnectionString
Conn5.Open
Conn5.Execute "delete from loaddb"
Conn5.Close
 ' sql4 = "select * from resultload1"
 ' With Adodc4
  '   .RecordSource = sql4
  '   .Refresh
  '   If .Recordset.RecordCount <> 0 Then
  '      .Recordset.MoveFirst
  '      For i = 0 To .Recordset.RecordCount - 1
   '      .Recordset.Delete
  '       .Recordset.MoveNext
   '      Next i
  '   End If
 ' End With

 Dim Conn As ADODB.Connection
Set Conn = New ADODB.Connection
Conn.ConnectionString = Adodc4.ConnectionString
Conn.Open
Conn.Execute "delete from resultload1"
Conn.Close
  Dim Conn1 As ADODB.Connection
Set Conn1 = New ADODB.Connection
Conn1.ConnectionString = Adodc4.ConnectionString
Conn1.Open
Conn1.Execute "delete from resultload2"
Conn1.Close
  Dim Conn2 As ADODB.Connection
Set Conn2 = New ADODB.Connection
Conn2.ConnectionString = Adodc4.ConnectionString
Conn2.Open
Conn2.Execute "delete from sumresult2"
Conn2.Close

Label1.Caption = "complete !"
End Sub
```

```
Private Sub Command2_Click()
Dim Conn As ADODB.Connection
Set Conn = New ADODB.Connection
Conn.ConnectionString = Adodc4.ConnectionString
Conn.Open
Conn.Execute "delete from loaddb"
Conn.Close
End Sub

Private Sub Command3_Click()
  Unload Form3
  Form1.Show
  Form1.SetFocus
End Sub
```

Form 4.

```
Option Explicit
Dim box_id As Double

Private Sub Command1_Click()
Map1.CursorMode = cmPan
End Sub

Private Sub Command2_Click()
Map1.CursorMode = cmZoomOut
End Sub

Private Sub Command3_Click()
Map1.CursorMode = cmZoomIn
End Sub

Private Sub Command4_Click()
Map1.CursorMode = cmSelection
End Sub

Private Sub Command5_Click()
Unload Me
End Sub

Private Sub Command6_Click()
Map1.ZoomToMaxExtents
End Sub

Private Sub Command7_Click()
Dim sf2 As New Shapefile
Dim handle2 As Long
Dim Item As ListItem
sf2.Open App.Path & "\shp\distance_allnew.shp"
handle2 = Map1.AddLayer(sf2, True)
 Map1.LayerName(handle2) = sf2.FileName
 Set Item = lvLegend.ListItems.Add(1, , Map1.LayerName(handle2))
         Item.ListSubItems.Add , , handle2
         Item.Tag = handle2
         Item.Checked = True
Map1.ShapeLayerFillColor(handle2) = RGB(255, 0, 0)
Map1.ShapeLayerLineColor(handle2) = RGB(255, 0, 0)
End Sub

Private Sub Form_Load()
'Dim sf As New MapWinGIS.Shapefile
```

```
Dim sf As New Shapefile
Dim sf1 As New Shapefile
Dim sf2 As New Shapefile
Dim Item As ListItem
Dim handle, handle1 As Long

sf.Open App.Path & "\shp\pointfac.shp"
'Map1.AddLayer sf, True
sf1.Open App.Path & "\shp\roadz47.shp"
'Map1.AddLayer sf1, True
'sf2.Open App.Path & "\shp\Road_Wet.shp"
 handle = Map1.AddLayer(sf, True)
 handle1 = Map1.AddLayer(sf1, True)
'Map1.AddLayer sf2, True

 Map1.LayerName(handle) = sf.FileName
  Map1.LayerName(handle1) = sf1.FileName
   lvLegend.ColumnHeaders.Add , , "Name"
   lvLegend.ColumnHeaders.Add , , "Handle"
Set Item = lvLegend.ListItems.Add(1, , Map1.LayerName(handle))
            Item.ListSubItems.Add , , handle
            Item.Tag = handle
            Item.Checked = True
Set Item = lvLegend.ListItems.Add(2, , Map1.LayerName(handle1))
            Item.ListSubItems.Add , , handle1
            Item.Tag = handle1
            Item.Checked = True
Map1.ShapeLayerFillColor(handle) = RGB((255 - 1) * Rnd, (255 - 1) * Rnd, (255 - 1) * Rnd)
Map1.ShapeLayerLineColor(handle) = RGB((255 - 1) * Rnd, (255 - 1) * Rnd, (255 - 1) * Rnd)
End Sub

Private Sub lvLegend_ItemCheck(ByVal Item As MSComctlLib.ListItem)
  Dim handle As Long
    Dim i As Long

    'cycle through all of the layers to set visibility
    For i = 1 To lvLegend.ListItems.Count

        'get the handle of the layer
        handle = lvLegend.ListItems(i).Tag

        If (lvLegend.ListItems(i).Checked = True) Then
            Map1.LayerVisible(handle) = True
        Else
            Map1.LayerVisible(handle) = False
        End If
    Next
End Sub
…………………………………………….
Form 5
Private Sub Command1_Click()
 If (Text1.Text = "") Or (Text2.Text = "") Or (Text3.Text = "") Then
        MsgBox "¤Ø³ÂÑ§ãÊè¢éÍÁÙÅäÁè¤Ã°!", vbOKOnly + vbCritical, "¼Å¡ÒÃµÃÇ¨ÊÍº"
    Else
        Adodc1.Recordset.Update
        MsgBox "á¡éä¢àÃÕÂºÃéÍÂ"
    End If
End Sub

Private Sub Command2_Click()
Unload Form5
Form1.Show
```

```
Form1.SetFocus
End Sub
```

……………………………………………………………….

APPENDIX E The graphical full pages

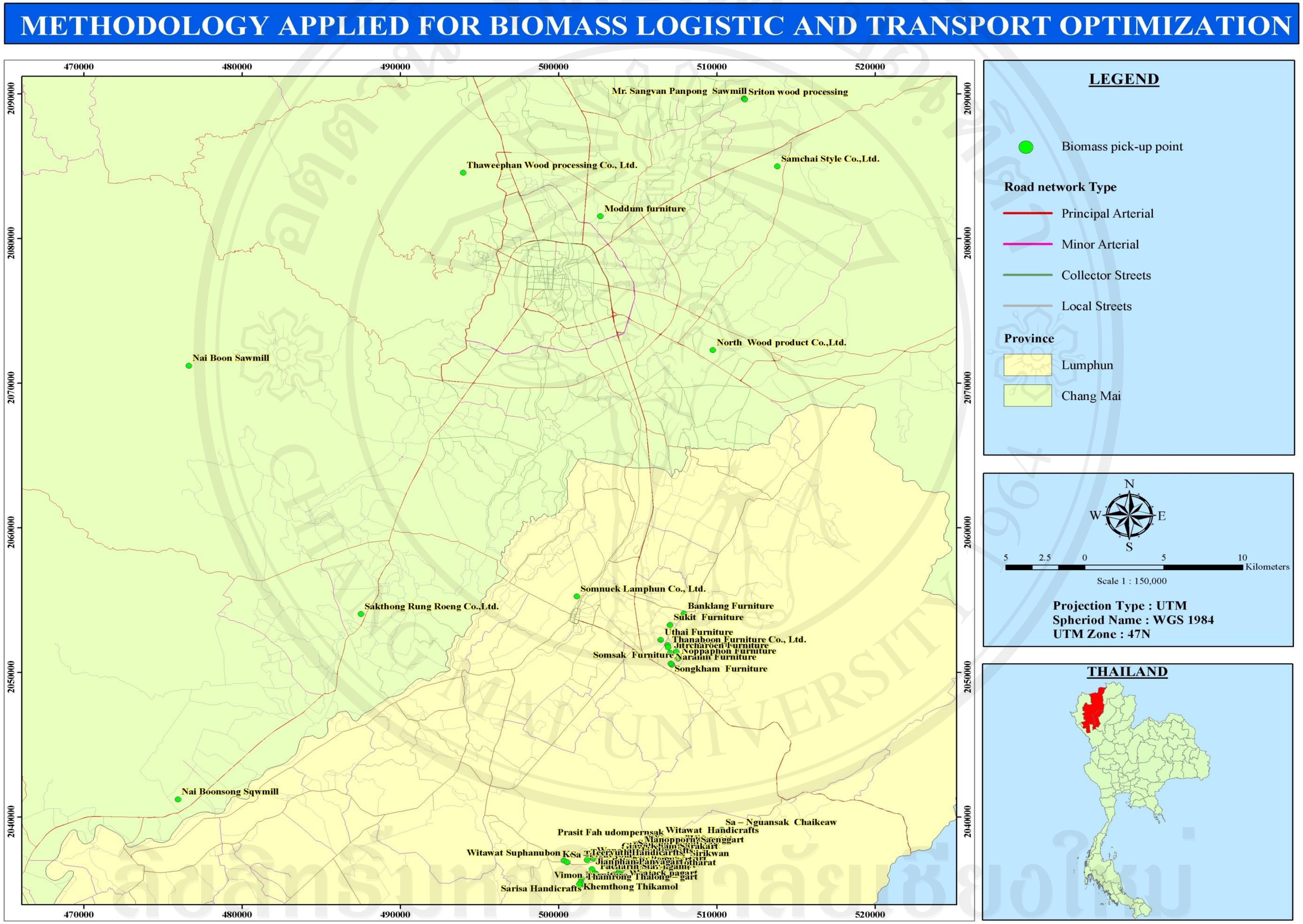


Figure E.1 The location of fuel supply source at Chiang Mai-Lamphun province.

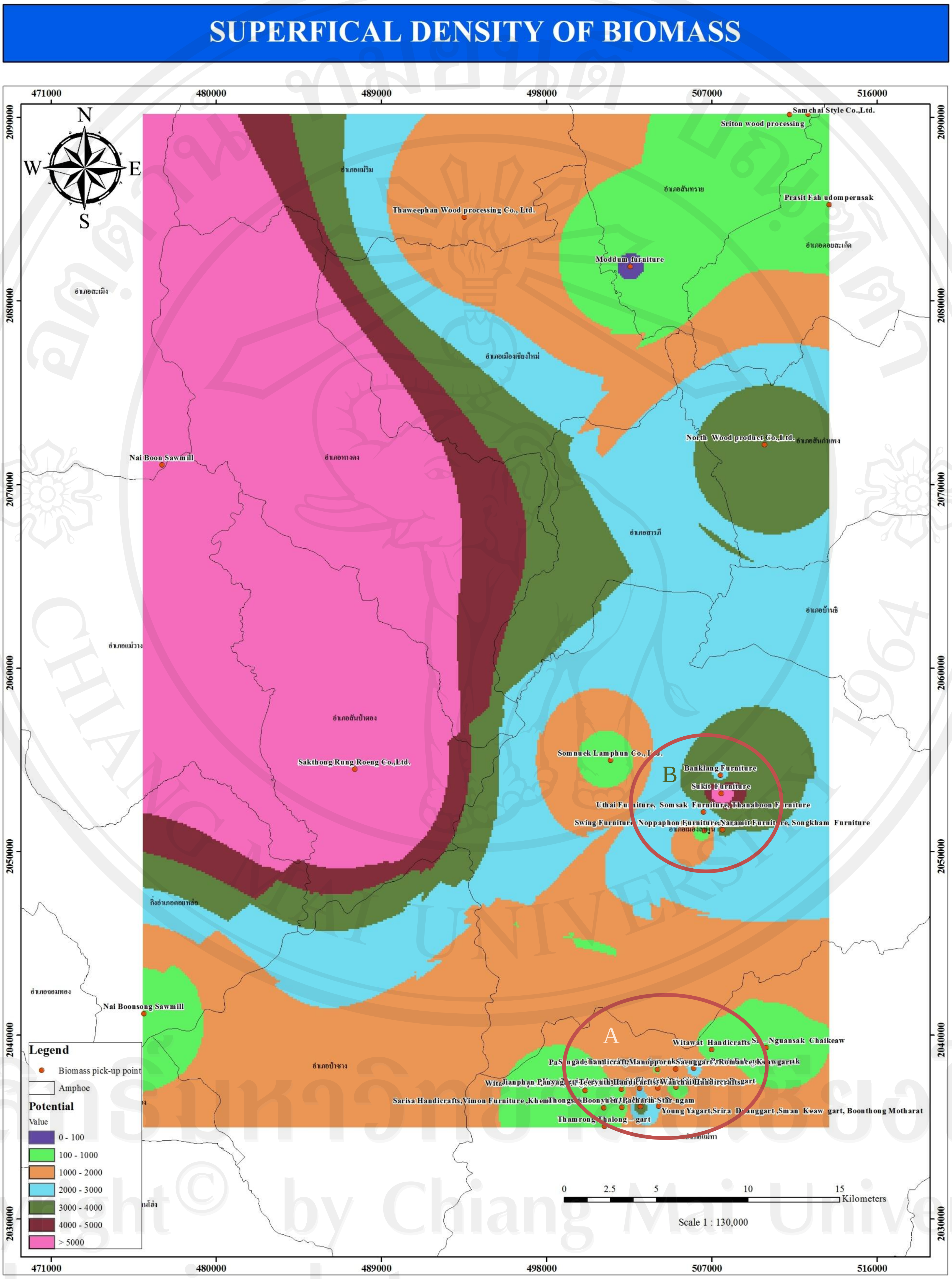


Figure E.2 The energy density of fuel supply source at Chiang Mai-Lamphun province

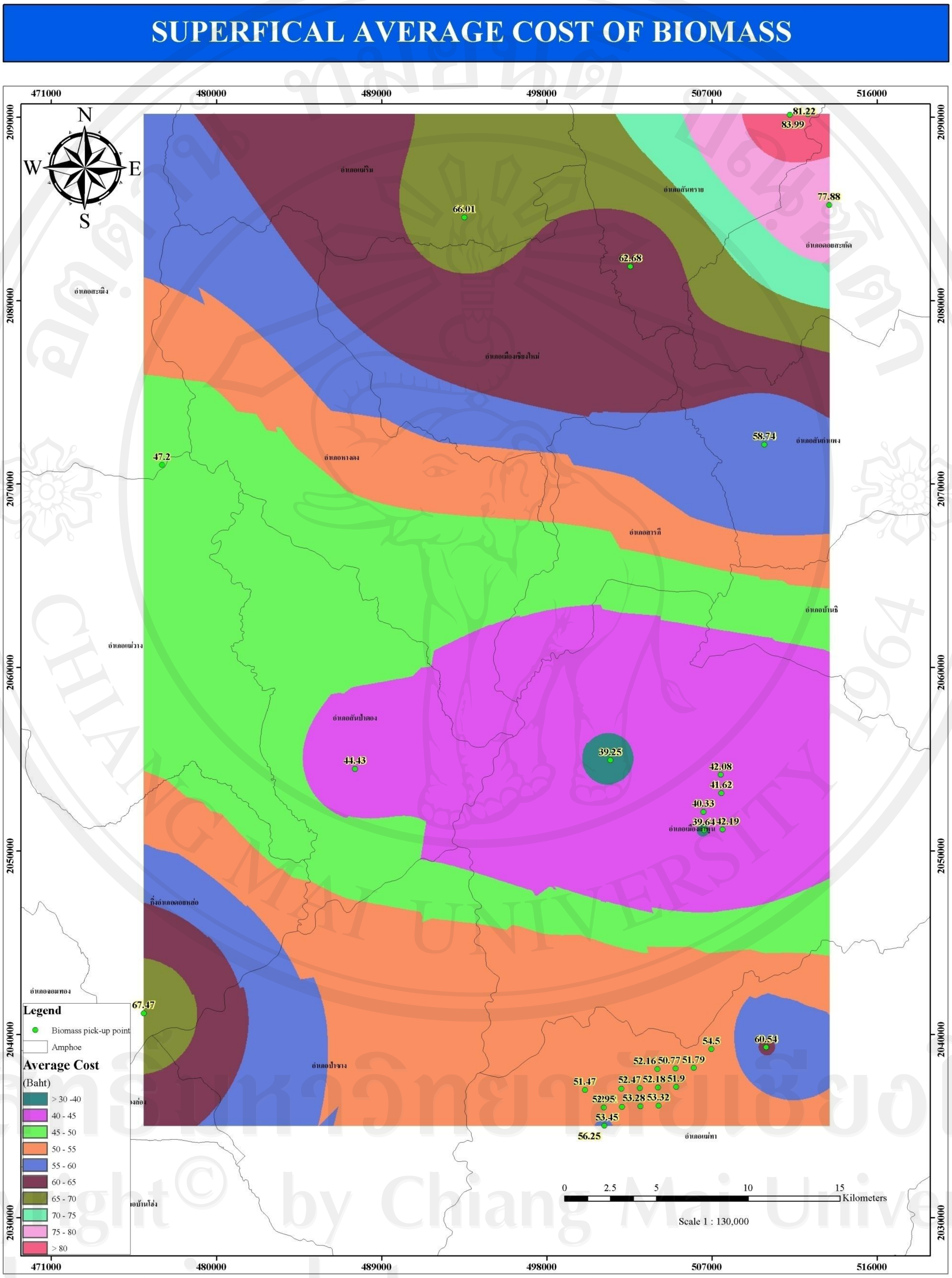


Figure E.3 The average fuel consumption for collect wood fuel at Chiang Mai-Lamphun province

METHODOLOGY APPLIED FOR BIOMASS LOGISTIC AND TRANSPORT OPTIMIZATION

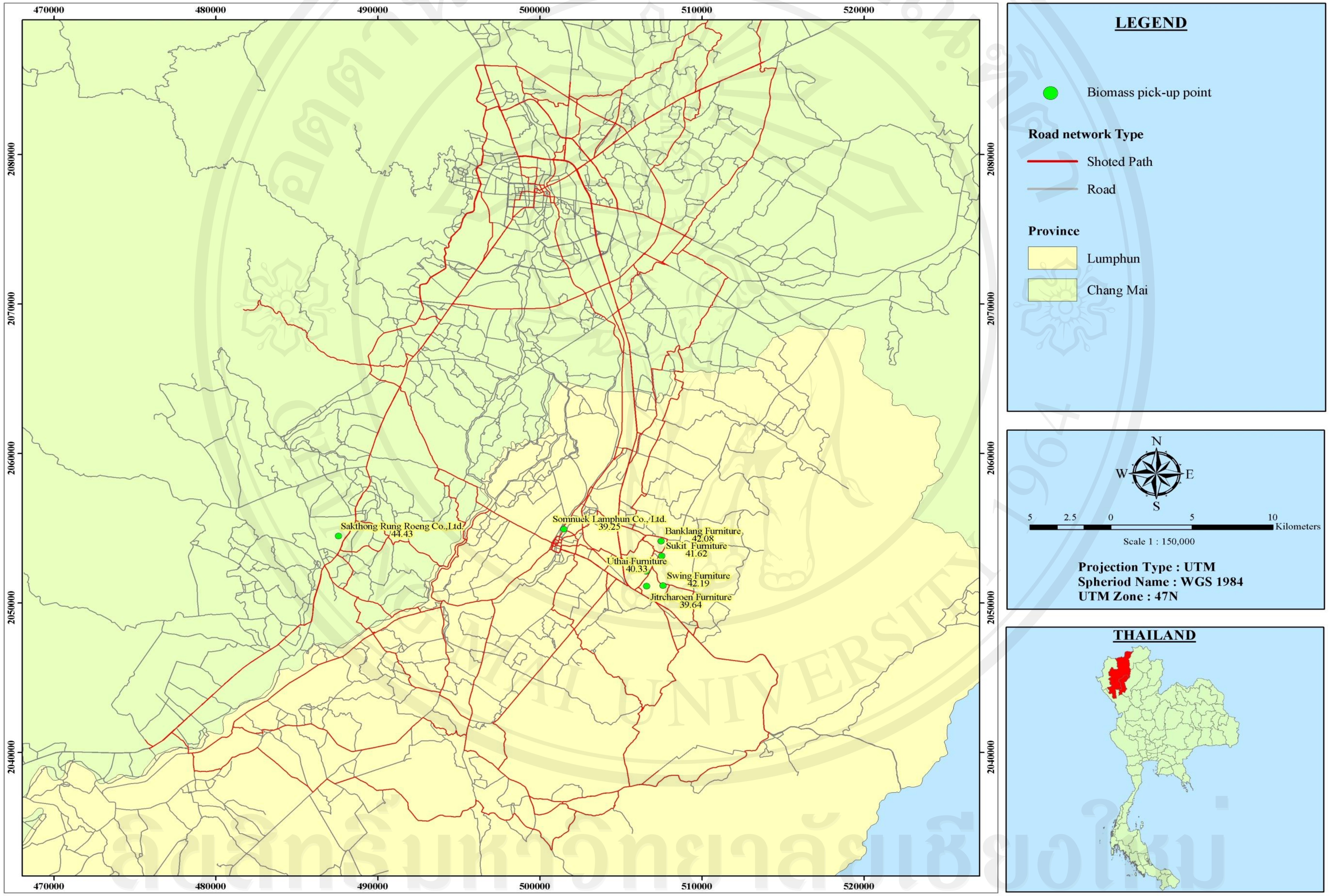


Figure E.4 The shorted route for collect wood fuel at Chiang Mai-Lamphun province

APPENDIX F

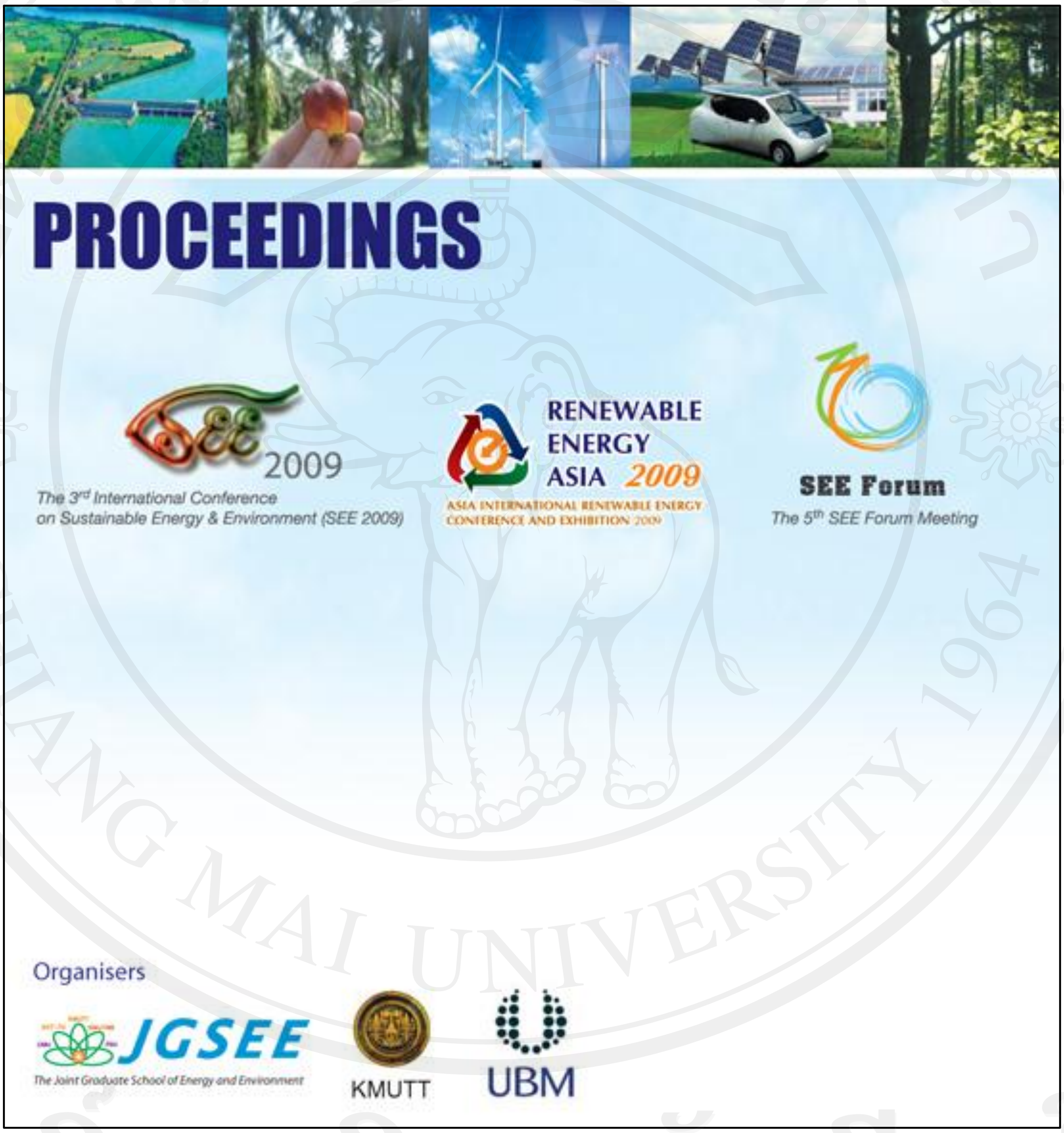
Publication

This thesis results in the following paper:

1. Jenjira Piamdee, Natanee Vorayos, Tanongkiat Kiatsiriroat, Weerachai Arjharn and Nat Vorayos (2009) "Comparison Study on Life Cycle Assessment of Small-Scale Dendrothermal Power Generation in Thailand including Economic Feasibility Analysis: a Case Study" World Renewable Energy Congress 2009 - Asia The 3rd International Conference on "Sustainable Energy and Environment (SEE 2009)" 19-22 May 2009, Bangkok, Thailand.
2. Jenjira Piamdee, Natanee Vorayos, Weerachai Arjharn and Nat Vorayos (2010) "Potentialities and Environmental Burdens of an Electricity Generation from Dendrothermal Power Plant" International Symposium on Low Carbon & Renewable Energy Technology 2010 (ISLCT2010) 15-18 November, 2010. Lotte Hotel, Juju, Korea.
3. Jenjira Piamdee, Weerachai Arjharn, Natanee Vorayos and Nat Vorayos (2013) "Feasibility of community-based power plant using fast-rotation woods as feedstock" *International Journal of Environmental Engineering and Management*, 4(1), 49-60.

World Renewable Energy Congress 2009 - Asia The 3rd International Conference on "Sustainable Energy and Environment (SEE 2009)"

19-22 May 2009, Bangkok, Thailand.



World Renewable Energy Congress 2009 - Asia
The 3rd International Conference on "Sustainable Energy and Environment (SEE 2009)"
A4-019 19-22 May 2009, Bangkok, Thailand

Comparison Study on Life Cycle Assessment of Small-Scale Dendrothermal Power Generation for in Thailand including Economic Feasibility Analysis: A Case Study

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Abstract: *Most of fast-rotation woods can grow rapidly within 3-5 years in plantation area and some of the species give large amount of yield. Their high-heating values are preferable for the use as fuel for electricification and potentially dependable as community-based biomass powerplant with zero net carbon. Two technologies; downdraft gasification and rankine steam power within 100kW scale which can sufficiently serve the demand of the small village with less than 100 households in Thailand are focused in this investigation based on studied cases in Nakorn Rachasrima and Chiang Mai. Since environmental concern has extensively become crucial factor for sustainable development, the consideration based on both economic feasibility and the life cycle assessment (LCA) of the electricity generated from a pilot dendrothermal power plants fueled by proposed fast-rotation woods is carried out. The analyses compare the economic feasibility and environmental impacts between dendrothermal technologies with the conventional electricity generation system in the country. The result from LCA shows that the environmental impact of the electricity generated from the pilot plant is mainly caused by the greenhouse gas emission related to the fossil fuel and chemical substance consumption during fuel-wood plantation, transportation and proposed technology following. However, if the greenhouse gas emission is ignored due to the fact that carbon dioxide is absorbed back due to the photosynthesis process of fuel wood, the impact of the pilot plant is then relatively low. In Additional to environmental quality, the results from the cost analysis during the life cycle also confirm that the dendrothermal power plant has high potential to be considered as one of the most suitable technologies for the sustainable development in small community especially when the fuel-wood plantation and the transportation management have been taken into account.*

Keywords: Dendrothermal Powerplant, Life Cycle Assessment, Economic Feasibility, Fast-Rotation Woods

1. INTRODUCTION

One of the importance measures to cope with the problem of energy shortage is to promote and support the use of renewable energy in electricity power generation. Thailand has targeted the utilization of renewable sources at 8% of the national consumption by 2011[1] and suggested the potential use of biomass in national energy policy. Biomass from fast-growth wood from energy plantation becomes one of the promising choices in terms of alternative sources of power generation due to number of reasons, one of which arises from the fact that it does not deliver heavy element which eventually contribute to the increase of pollutants from the energy conversion processes. Additionally, rotation of woodfuel plantation does not only help to cope with carbondioxide in the earth atmosphere but also helps to generate extra income to agricultural communities. There are number of investigations on the use of species of fast-growth wood and some offer studies on technologies for electricity generating from biomass [2,3], there are still needs for informations and feasibility studies for the whole systems are very much required especially for the community-sized system which would be applied well with the small agricultural village in Thailand. These communities with the need of reliable energy sources are found throughout the country.

The fast rotation woods that are normally planted in Thailand include Acacia, Cassia, Leucaena, Azadirachta and Eucalyptus along with vast variety of some other species [4]. It is reported that *Leucaena Leucocephala* is one of the most appropriate plants for the use as fuel for electricification [2-6], average growth of *Leucaena Leucocephala* is shown in Table 1. Its lower heating value is confirmed to be in the range of 15.91 – 20.10 MJ/kg while its yield is at 15.84 to 17.92 tonne/ Rai (1 Rai is approximately 0.3954 acres) for a 3-year rotation period [4]. Additionally, *Leucaena Leucocephala* can be adoped into most of area of the country with simple plantation and does not need much attention. Its turnips and leaves can be used for animal stock [4-6]. Main objective of this study is to carry out the comparison study of Life Cycle Assessment between two technologies; downdraft gasification in Nakorn Rachasrima and rankine steam power in Chiang Mai using *Leucaena Leucocephala* as feedstock. Downdraft gasification is a process that converts carbonaceous materials, including biomass, into carbon monoxide and hydrogen in which through the reaction of the raw material at high temperatures and a controlled amount of oxygen. Rankine steam power is a thermodynamic cycle shown in fig. 1 which converts heat into work. The heat is supplied externally to the process where water is usually used as working fluid Operating parameters of Dendrothermal powerplant in both sites are shown in Table 2

Table 1 Average growth of *Leucaena Leucocephala* [3,4]

Species	HV (MJ/kg)	yield (tonne/ Rai)	spacing(m)	years
Leucaena Leucocephala	15.91	15.84	1 x 1	3
		17.92	0.6 x 0.6	4

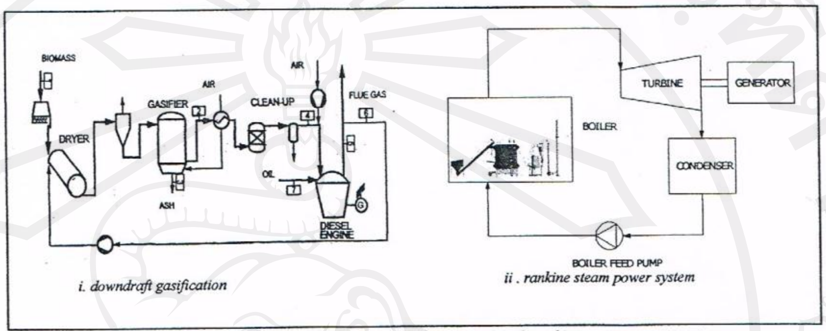

Fig. 1 Flow diagram of downdraft gasification system and *rankine steam power* system

Table 2 Operating parameter of Dendrothermal Power Generation

System	Down draft Gasifier[3]	Rankine steam power[6]
Installed capacity	100 kW	50 kW
Gas Flow	176.26 m^3/hr	-
Gasification Efficiency	80.50%	-
Engine-generator Efficiency	22.07%	38.6%
Electrical Efficiency	17.72%	7.2%
Specific Biomass Consumption	1.98 kg/kWh	4.78 kg/kWh
Operation Hour (80%)	7,008 hour/year	7,008 hour/year
life time of the system is	10 years	10 years
Power generation	7,008,000 kWh	3,504,000 kWh

2. METHODOLOGY

2.1 Life cycle assessment (LCA) methodology

Life cycle assessment (LCA) is a technique for assessing various aspects associated with development of a product and its potential impact throughout a product life starting from raw material acquisition, processing, manufacturing, utilization and finally its disposal. LCA studies, therefore, systematically and adequately address the environmental aspects of products and the correspondingsystems. Hence, it becomes an analysis tool to decide if the small-scale electrification system using wood from plantation is worth engaging both in terms of its economic and environmental advatages, especially for the small villages in the developing country. The depth of the details and time frame of an LCA investigation of the product; in this case: the electricity might be varied depending on the definition of goal and scope. The scope, assumptions, description of data quality, methodologies and output of LCA studies should be well planned. LCA methodology should be amenable enough to include new scientific findings and improvements in the corresponding technology. LCA can be used to study in a holistic manner for the whole product/system and accordingly enables us to avoid the sub- optimization that may be the result of only a few processes which possibly create misled information. The LCA methodology used in this study follows the stages outlined by International Organization for Standards (ISO) 14040[7]. The four major stages of the LCA applied in this study include; determination of the assessment scope and boundaries; selection of inventory of outputs and inputs; assessment of environmental impact data compiled in the inventory; and interpretation of results and suggestions for improvement as shown in Fig. 2

The goal of the study is emphasized on the determination of the environmental impacts, specifically global warming pot ential, from the production of electricity 1 kWh from two community-based biomass powerplants with different technol ogies; downdraft gasification and rankine steam power based on studied cases in Nakorn Rachasrima and Chiang Mai.

The lifecycle of dendrothermal eletectricity generation from *Leucaena Leucocephala* is divided into 5 processes as show in fig. 3 Scenario is assumed that *Leucaena Leucocephala* is cultivated in community-owned land and harvested

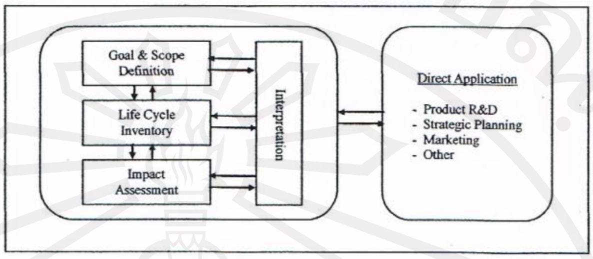

Fig. 2 Life cycle assessment framework [7]

after 3 years of cultivation. To continuously supply the fuelwood, cultivation land is suggested to be seperated into 12 plots each of which should be cultivated within 3 months in such a way that the first plot can be harvested within 3 years. Harvesting is carried out on all 12 plots in 36 months after which it can be repeated on the first plot once again. The reason for the 36-month rotation is to limit the size of the feedstock within 4-5 in diameter. Fuelwood is then easily chopped off at 10-cm length as wood logs using inexpensive basic equipments and tools or it can be alternatively shredded into pieces by low-cost machines. Most of the chopped wood is left for sundried at 40% of moisture content and some of them can be dried by heat recovery from the powerplant system itself. Strict schedule has to be maintained to store sufficient dried small wood log, especially in the autumn season. This study focuses on the inventory data of all process in the product system, including plantation process, material, fertilizer and energy used in process are necessary for calculate GHGs emission. Data can date back to the origin of the process, for example, it is known that electricity consumption of pumps for plantation water supply causes high emission of GHGs because it comes from the fossil-fired power plants and the number of corresponding emission can be calculated. Also in transportation process, the estimation of vehicles needed to carry the feedstock from plantation location to the power plant can be reports along with thier emissions. In this fashion, all related activities are studied in detail.

The results of the inventory analysis are translated into scores on a number of environmental issues or themes (e.g., climate change, acidification). The scores indicate the potential environmental harm of the interventions determined in the previous step. Examples are the global warming equivalents based on Global Warming Potentials (GWP's) and acidification equivalents based on acidification potentials. One of the results of the impact assessment step is the environmental profile (i.e., the list of impact scores) [8]. The environmental impacts of each alternative are estimated and studied by the LCA techique using the computer software tool SimaPro 7.1 EDIP/UMIP 97 complying EDIP method (Environmental Design of Industrial Products). In the improvement analysis, potential bottlenecks of the life-cycle and possibly improvements to overcome these difficulties are then identified.

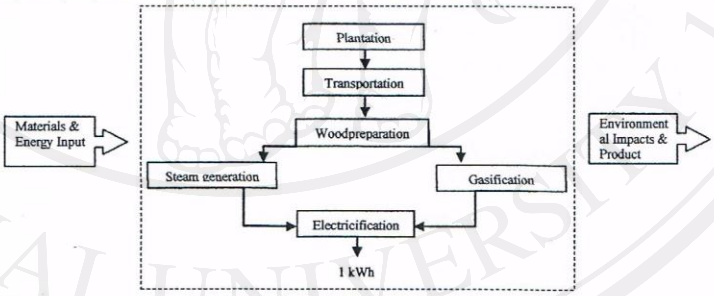

Fig. 3 System boundary of the study

2.2 Life Cycle Cost Analysis Methed

The life cycle cost (LCC) analysis is an economic assessment of desing altennative that considers all of the significant costs of ownership over an economic life and expresses them in an equivalent cost in order to compare the overall costs of each option. The equivalent cost is carried out by first establishing a base-line time reference and then using the

proper economic procedures to bring all relevant monies back to the base line. In this study, it finds out the product of electricity system, all cost are converted to present value by present worth tecniques.
The life cycle cost (LCC) is usually associated with capital costs, operating costs, maintenance cost, fuel costs, replacement costs and salvage value. The correlation between each trem can be represented as [10]:

$$LCC = C_{pw} + M_{pw} + F_{pw} + R_{pw} - S_{pw}, \qquad (1)$$

Where C = capital costs (baht)
M = operating and miantenance costs (baht)
F = fuel costs (baht)
R = replacement costs (baht)
S = salvage value (baht)
Subscript pw = present worth (baht)

The capital cost usually includes an initial cost expense for equipments, system engineer, and instalation. Costs of main equipments are shown in Table 3. It is considered as a single payment as well as the replacement cost. The corresponding salvage value of the systems is approximated at 10% of capital cost. The escalation rate of fuel cost and annal routine maintenance are 5% and 3%, respectively. For the recurring cost, this is normally constant such as routine maintenance cost, fuel cost, fertilizer cost, truck rent cost and plantation treatment. The unit cost of electricity each system is estimated under the assumtion as in Table 4. Each cost is converted to present value. The formula for finding the present value is

$$P = A\left(\frac{1+e}{d-e}\right)\left(1-\left(\frac{1+e}{1+d}\right)^{n}\right), \qquad (2)$$

Where e = escalation rate (excluding inflation rate)
i = inflation rate
A = annually uniform cost (baht)
n = time preiod (year)
d = discount rate

Table 3 Initial cost expense for equipment of electricity each system.

Equipment	Capacity	Cost of Unit (baht)
Water pump	0.6 - 2.4 m^3 / h	8,500
Chopping machines	700 kg/hr	16,000
Steam generation system	1,000 kg/hr, 22 bar g,	2,800,000
Turbine generation system	45±5% kW out power, 0.278 kg_{steam}/s	170,000
Dowdraft gasification system	100 kW out power	6,500,000
- Reactor		
-Gas cleaning system		
- Engine-generator set		
Connection gid-line equipment		700,000

Table 4 the unit cost of electricity each system is estimated under the assumtion as follows.

Parameter	Value
Interest rate and inflation rate	6.00% (data source: bank of Thailand at April 2009)
Operation Hour (80%)	7,008 hour/year
Survival rate of fuelwood	85%
Electricity Cost	3.17 baht/kWh [1 $US = 36 baht]
Annual routine maintenance cost	5% of capital
Salvue of the system is	10% of capital cost
Escalation rates of fuel cost are	5%
Escalation rates of maintenance cost	3%
Economic life time of the system	10 years.
Low Heating Value of Wood (40% db)	12.30 MJ/kg
Yield	14 ton/ 3 year
Diesel fuel Cost	22.69 baht/liter (data source: PTT, April 2009)
Benzine fuel Cost	28.84 baht/liter (data source: PTT, April 2009)

3. RESULTS AND DISCUSSION

Greenhouse gases or GHGs are gases in the Earth's atmosphere that allow sunlight through but absorb or capture infrared radiation and increase the temperature of the earth's surface. There are six GHGs listed in the Kyoto Protocol; Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (NO_2), Hydroflurocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur Hexafluoride (SF_6). These gases absorb terrestrial radiation and contribute to the greenhouse effect. According to the Environmental Protection Agency, earth's atmosphere contains both naturally occurring and man-made GHGs. Due to the fact that most important GHGs is CO_2, CO_2 emission will be mainly reported in unit of kg-CO_2 /kWh. Environmental impact are shown in Table 5

Table 5 Comparison of the life cycle emissions (g-CO_2/kWh)

The result it was show environmental impact in SimaPro 7.1 EDIP/UMTP 97.

System	downdraft gasification	rankine steam power
Plantation (g-CO_2/kWh)	-0.10	-0.25
Transport (g-CO_2/kWh)	5.78	13.96
Wood preparation (g-CO_2/kWh)	11.42	27.57
Gasification / Steam generation to Electricification (g-CO_2/kWh)	97.60	388.13
Total of life cycle CO_2emissions (g-CO_2/kWh)	114.70	429.41

This research, EDIP/UMIP 97 method in SimaPro 7.1 was used to calculate each impact estimation. The CO_2 emission result is shown in Table 5. This result shown that CO_2 emission from downdraft gasification and rankine steam power technique to use for electricity generation is 114.70 g-CO_2/kWh and 429.41 g-CO_2/kWh, respectively. While the CO_2 emission of electricity from country grid-mixed database from EGAT in 2008 is reported at 550 g-CO_2/kWh [11], the results from this study suggest the better alternatives in terms of lower environmental impacts. Their impacts are lass than net generation electricity from Thailand's grid. This is due to the fact that the large number of generation electricity of Thailand uses fossil fuel fired power plants. One more important aspect from the use of biomass from platation is that the CO_2 emission was absorbed back to the plantation through the photosynthesis process.

It is noticed that total of life cycle CO_2 emission of downdraft gasification is 4-time less than that of rankine steam power. This results from the higher efficiency of the downdraft gasification.

The CO_2 emissions from downdraft gasification and rankine steam power system for plantation is -0.10 g-CO_2/kWh and -0.25 g-CO2/kWh, respectively. This is to the fact that the fertilizers used for the plantation are biowastes from the animal farm in the designated community.

CO_2 emission from transportation and wood preparation processes of downdraft gasification system is lower than that of steam power system due to its higher efficiency. Wood preparation involves machines and equipments where electricity from the grid is utilized; therefore, it caused environmental impact which is even higher in comparison with transportation process. The electricity produced from the system is sold entirely back to the grid because of the high rate of governmental subsidy, as shown in Table 6.

Table 6 Fixed Adder of PEA's Power Purchase Plan for VSPP (Very-Small Power Producer) [1]

Fuel	Adder (baht/kWh)
Biomass (including biogas)	0.3
Hydropower less than 50 kW	0.8
Hydropower greater than 50 kW but less than 200 kW	0.4
Wind & municipal waste	2.5
Solar	8

Results from economic analysis are shown in Table 7. It is shown that the cost of electricity produced from downdraft gasification and rankine steam power systems are 3.59 baht/kWh and 4.45 baht/kWh, respectively. The economic of both powerplants is not well met as PEA (Provincial Electricity Authority) is bounded by law to buy the electricity back to national grid from such very-small power producer (VSPP) with lower rate; approximately 3.27 baht/kWh; adder already included. This is primarily due to their small sizes and low efficiencies. However, from the environmental standpoint, the impact of the electricity generated in terms of CO_2 emission is suggestively low. Additionally, there are still co-product and by-product of the systems left to be explored. Heat recovery from both systems is high potential heat source for agriculture product drying which is much needed in the regions around the country. The use of the systems as combined heat and power source might eventually bring the cost of electricity producing from the system down below the rate offered by PEA and thus suggests its high potential.

Table 7 Breakdown of economic for Small-Scale Dendrothermal Power Generation during system's lifetime

Capital item	downdraft gasification	rankine steam power
Installed capacity (kW)	100	50
Plant net efficiency (%)	17.72	7.20
Cultivation area (rai)	297	359
spacing(m)	1x1	1x1
seedling	546,480	660,560
Fuel wood (tonne/year)	1,388	1,676
Process		
Plantation (Baht)	2,237,908.93	2,692,441.19
Transport (Baht)	1,855,282.07	2,034,163.13
Wood preparation (Baht)	521,635.21	614,003.85
Steam generation (Baht)	-	4,843,469.89
Electricification (Baht)	20,553,259.97	5,398,488.59
Total	25,168,086.17	15,582,566.64
Electricity breakeven price (baht/kWh)	3.59	4.45

4. CONCLUSION

The environmental impacts of small-scale downdraft gasification and rankine steampower systems for community are studied using the LCA techique by SimaPro 7.1 EDIP/UMIP 97 EDIP method. The result shows that the environmental impact in terms of CO_2 of the electricity from country grid-mixed is higher than that of both suggested dendrothermal powerplant. The reported environmental impact is mainly caused by the greenhouse gas emission related to the fossil fuel and chemical substance consumption mainly from proposed technology, wood preparation, and wood transportation, respectively. However, if the greenhouse gas emission is ignored due to the carbon dioxide absorbed by the photosynthesis of fuel-wood, the impact of the pilot plant is then relatively low. Besides the advantage of environmental quality, the results from the cost analysis during the life cycle also confirm that the dendrothermal power plant has high potential if the utiliazation of the systems as combined heat and power source is achieved.

5. ACKNOWLEDGMENTS

This project has financial support from Energy National Research Council of Thailand (NRCT), Thailand.

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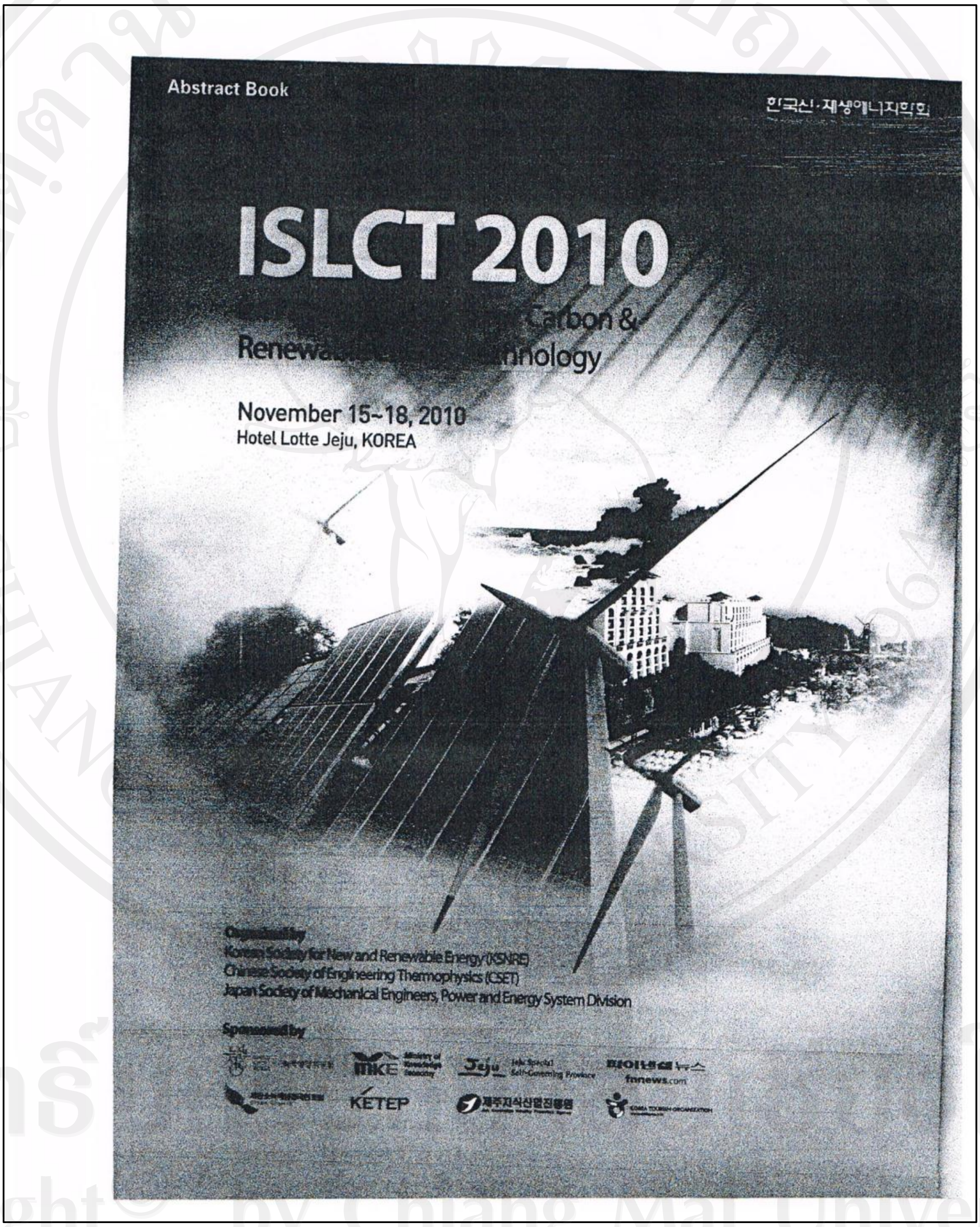

POTENTIALITIES AND ENVIRONMENTAL BURDENS OF AN ELECTRICITY GENERATED FROM DENDROTHERMAL POWER PLANT

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Fast-rotation woods are regarded as the possible substitutes for the conventional fossil fuels consumed in the power plant. They could offer not only the advantages of being renewable energy and indigenous but also improving the CO_2 balance. The CO_2 emitted by the combustion of fuel-wood is taken as neutral for the reason that it could be considered as being absorbed during the photosynthesis. However, since there are other emissions generated during the production (wood cultivation, harvesting and processing), storage, transportation and fuel transformation in the power plant, it is necessary to take all emissions into an account to ensure that these emissions would not significantly reduce or even completely cancel out the advantages. In this study, a life cycle assessment (LCA) technique has been applied for evaluating the environmental impacts of the electricity generated from the pilot 100 kW_e - dendrothermal power plant located in Lamphun province, Thailand. It is a small-scale cogeneration plant which could sufficiently serve the electricity demand of the small village with less than 100 households, typical size found throughout Thailand. The power plant is fired with coarse and small fuel woods, i.e. eucalyptus and acacia, which are planted in the studied area (inthe radius of 20 km. from the power plant). The results demonstrate that different environmental burdens become significant depending on the process, for example, N_2O emission resulting from the use of nitrogen-containing fertilizers during cultivation, CO_2 and CO emissions from fossil fuel combustion during transportation and particulate matters (PM) emission from biomass combustion during the fuel-wood transformation in the power plant. These emissions results to various categories of environmental impacts such as global warming, eutrophication, and smog. In terms of global warming, the net greenhouse gas emitted during the life cycle of electricity produced from dendrothermal power plant is found to be 0.18 $kg_{CO2\text{-}eq}$/kWh. In terms of the eutrophication, smog and acidification, the results are 0.73 $g_{PO4\text{-}eq}$, 2.5 $g_{SPM\text{-}eq}$ and 3.32 $g_{SO2\text{-}eq}$, respectively. However, these impacts could be reduced as much as 10 – 20% depending on the management criteria.

ISLCT2010

Best Paper Award

The Program Committee and The Award Committee of ISLCT2010 have selected the following paper as the best paper for its outstanding contribution to the symposium.

POTENTIALITIES AND ENVIRONMENTAL BURDENS OF AN ELECTRICITY GENERATED FROM DENDROTHERMAL POWER PLANT

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November 17, 2010

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Feasibility of Community-Based Power Plant Using Fast-Rotation Woods as Feedstock

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Abstract

The usage of biomass as a fuel to produce electricity is one of important energy strategies promoted in Thailand as Thai communities is small, agricultural-based, and suitable for producing biomass fuels in different ways. Still, there are a few practices and study of their impacts on the environment especially for the community-scaled system. This research aims to provide a feasibility study for a small decentralized and community-based biomass power plant to produce electricity. Fast-growth wood grown as plantation around the power plant facility is designated to be primary source of fuel. It is proposed that woody biomass is in three-year rotation and there are three batches of plantation for the continuity of plant operation. The unit and externality costs are suggested along with their environment impacts. The systems of 50-kW Rankine steam-turbine and 100-kW gasification with gas engine are in comparison based on the previous studies carried out at Chiang Mai University and Suranaree University of Technology. As the efficiency of 50-kWe steam system is as low as 7.2%, woodchips at 4.78 kg/kWh is required from 57 ha of plantation. At higher efficiency at17.72%, the 100-kWe gasification system consumes less woodchips at 2.27 kg/kWh on required area of 55 ha. In spite of the fact that the unit cost of electricity generated from steam system and gasification system is reported as 0.193 US$/kWh and 0.140 US$/kWh which his higher from the cost of electricity available from national grid, their environmental impacts are less than those of the national grid. Therefore, the externality cost does not affect much on the cost of the system. However, the systems are suggested to be more profitable when direct heat is utilized

Keywords: Small community-based biomass power plant, Economic feasibility, Life cycle assessment, Externality cost, Fast growth woods

Introduction

One of Thailand's energy strategies is to promote the utilization of renewable energy from the present 7.8% to 20.3% of the national energy consumption by the year 2022 [1]. The mid-term plan focuses on the introduction of renewable energy for its communities whose power consumption is not so large and usually based on diesel and electricity power from national grid[2-3].Most of Thai community, especially in the rural areas, are agricultural-based where a huge amount of agricultural products are produced and yields relatively large amount of by-products and residues. Nevertheless, raw agriculture materials strongly are seasonal and sensitive to market value which contradicts to the idea of the establishment of sustainable energy/electricity generation in community unless the community can secure the feedstock. When electrical power produced from renewable source is sold to national grid, additional incentive, "adder", is offered [4],i.e. 0.3 baths more for power generated by biomass but continuous generation has to be guaranteed otherwise predetermined fee is applied. Cellulose–based biomass has to be carefully selected as its properties and yields become crucial. There are a number of previous work that shown the technical feasibility to convert community biomass into electricity. Demirbas (2005) suggests the use of direct combustion in steam boiler to generate heat to be use in electricity production. There has been suggestion that fast-growing wood might be one of the effective biomass source to produce the electricity for the community including those from Jayasinghe et al. (2006),Viriyabancha et al. (2007), Kopetz (2007), Dwivedi and Alavalapati (2009),Arjharn et al. (2009) and Saidura et al. (2011)

The main objective of this research is to explore the potential of community electricity generation from plantation of fast-growing trees in terms of cost effectiveness and environmental impacts.

Assumptions and Scenario setups

a. Biomass Properties

Examples of potential fast - growth plants are *Eucalyptus camaldulensis* Dehn., *Acacia mangium* Wild., and *LeucaenaLeucocephala.* This research will refer to *Leucaena Leucocephala's*properties based on data obtained from variety of sources in Thailand such that its yield is approximately 87.5 tons/ha on three-year rotation with the spacing area of 2x2 m. The lower heating value (LHV) is approximately 12.50 MJ/kg [6-10].

b. Plantation management

Plantation of fuel wood should be in rotation and well managed. It is assumed that the whole facility is owned by the community itself such that there is not much expenses on land, wage and fuel feedstock. The plantation has to be operated systematically, the local people should participate and, perhaps, voluntarily. The power plant should be supported by the community budget or funding (at least partial if not full) and managed by the local community. Asfuel feedstock is assumed to be grown by the locals, income is generated back to the community as the lateral benefit. The main key operations in community power plant which consists of four managerial aspects as show in the Figure.1

The fast-growing plants are grown as a plantation in rotation. All feedstock is assumed to be ready for power generation; therefore, biomass preparation has to be done 3 years prior to the generation such that, at the end of third year of cultivation, the first batch should be ready for harvesting. In each batch if cutting period can be done in every three months, there should be 4 plots, i.e. there will be cutting four times a year. For 3-year rotation, the plantation should at least comprise of 12 plots.

c. Fuel transportation

In this research, it is assumed that the area of plantation is clustered around the power plant in the radius within 20 km. Raw materials are transported by the light truck from the plantation area to the power plant. The diesel light truck load is with 11-ton capacity. There are additional cost from community's labor force for the harvesting and loading which is approximated as31.25 US$/ha. The fuel consumption of light truck with no load and full load is 0.1775 liter of diesel/kilometer and 0.2272 liter of diesel/ton of load/kilometer, respectively [12].

d .Material preparation

As 3-year-biomass is approximated 3 inch in diameter and does not required large machineries to process it, transported feedstock will be cut to 5-6 inch-long to increase its energy density and suitable for conversion equipment. The heating value of the fuel should also be maximized through simple drying. Solar drying is possible in Thailand but it cannot be accomplished during autumn; therefore, simple drier heated by flue gas is needed as an auxiliary system. These processes should be centralized and close to the vicinity of the power plant.

e. Electricification

Technologies for generating electricity should not be too complex for the local community. Downdraft gasifier and rankine steam power are simple and viable options available in the local market. Downdraft gasification is a process that converts carbonaceous materials, including biomass, into carbon monoxide and hydrogen in which through the reaction of the raw material at high temperatures and a controlled amount of oxygen. Rankine steam power is a thermodynamic cycle which converts heat into work. The heat is supplied externally to the process where water is usually used as working fluid. The feasibility depends on the performance of a 50-kW rankine steam system constructed and installed at Chiang Mai University (Sri Buaban Campus) and the 100-kW downdraft gasifier locating at Suranaree Technology University both of which are designated for community use. Operating parameters are shown in Table 1. The total efficiency and the wood consumption of the gasification system are reported to be 17.7 % and 1.98 kg/kWh, respectively. In case of the steam power system, it consumes fuel wood at 4.78 kg/kWh while the efficiency is lower at 7.2 %. Annual working hour is 80% or 7,008 hours per year as void duration will be spent on total maintenance. Lifetime of both systems is expected to be 30 years.

Table 1 Performances of rankine steam power and downdraft gasification

Capital item	Unit	Rankine steam power[13]	Downdraft gasification[10]
Installed capacity	kW	50	100
Plant net efficiency	%	7.2	17.72
Fuel consumption rates	kg/kWh	4.78	2.27
Plant Factor	%	80	80
Electricity generation of life cycle	kWh/Y	350,400.00	700,800.00
Power generation system	US$/set	99,000.00	216,666.67

2.2 Methodology

a. Economic analysis

The assessment of life cycle cost of electricity reflects all resources and materials needed for operations. Initial investment, operation cost, maintenance costs, fuel costs, replacement costs, and costs of depreciation of equipment are included to determine the unit cost of electricity and externality, accordingly. Calculation is based on 8.7% interest rate and inflation rate, 0.11 US$ per kWh of electricity available from national grid, 5% escalation rates of fuel cost, and 3% escalation rates of maintenance cost. Annual routine maintenance cost and salvage value is approximately 5% and 10% of capital cost, respectively. Cost of diesel fuel is at 0.99 US$/liter. The life cycle costing will be in reference with current value and is based on the following equation [14]:

$$LCC = C_{pw} + M_{pw} + F_{pw} + R_{pw} - S_{pw} + (X_{pw}) \quad (1)$$

where C is capital costs (US$), M is operating and maintenance costs (US$), F isfuel costs (US$), R is replacement costs (US$), $S$is salvage value (US$), X_{pw} is externalities cost and subscript $_{pw}$ is present worth. The externalities are accounted from the environment impact from harmful emission. It can be estimated from the quantity of emissions and their monetization as:

$$X_{pw} = \sum (C_i x VED_i) \quad (2)$$

when C is amount of emission (kg) and $VED$is Value of Environmental Damage of substance i (US$/ton). As the externality cost is accessed from Value of Environmental Damage (VED) which is generated from consumer satisfaction and acceptance to pay (willingness to pay, WTP), it is the cost to solve for social and environmental impacts that occur from the projects[15].

b. Life Cycle Assessment.

In spite of the fact that the community-based biomass power plant might be economically feasible but the concerns on environmental issues has to be evaluated since it directly affects the quality of living of the community. Life cycle assessment is a method to assess the environmental effects related with the product or service during life cycle. The analyzed data includes the quantity of energy, raw material, all related wastes which are released to the environment[16]. These discharges are classified and categorized as the environmental impact in the form of indicators based on equivalent or characterization factors. The equivalent unit is set from ability to cause environmental impacts of substances on the basis of reference. For example, global warming is measured in the form of $CO_{2\text{-eq.}}$ LCA according to ISO14040 standard consists of 4 steps: defining goal & scope, developing life cycle inventory, assessing impact, and interpreting the results.

- ***Goal and Scope Definition***

Goal of this study is to determine the environmental impacts from the production of 1 kWh electricity from community-based biomass power plants. Two different technologies, i.e. 100 kW downdraft gasification and 50 kW rankine steam power are studied and in comparison. The environmental impacts in terms of Greenhouse (GHGs; $CO_{2\text{-eq}}$) are to be determined from all processes carried out in a biomass plantation to electrification (from cradle to gate). As stated earlier, wooden fuel is in three-year rotation and prepared in the vicinity of the power plant. Transportation of wood stems from plantation to the storage near power plant location is preferred where size and moisture reduction is then achieved. Waste heat recovery system is utilized to dry the woodchips. All materials and energy input into entire processes along with corresponding gas emission are analyzed. Environmental impacts from infrastructure assumingly yield less impact as electricity generation is far more affecting the environment [17]. All environmental impacts are based on 1 kWh of electrification and to be referenced to those generated from national grid. GHGs emission of electricity from country grid-mixed database from EGAT (Electricity Generating Authority of Thailand) in 2010 is reported at 574 g-CO2-eq/kWh[19].

- ***Life Cycle Inventory (LCI)***

Life cycle assessment depends on the items in inventory which consists all relevant data: raw materials, energy, waste and pollution from the all processes from the cycle of project. Inputs substance is raw material and energy requirements of system. Discharge substance is air emission and other releases for the entire life of all process. The details of energy, raw material, chemical substances and natural resources consumed for the production along with the resulting pollutants and wastes from each process are shown in Figure 1

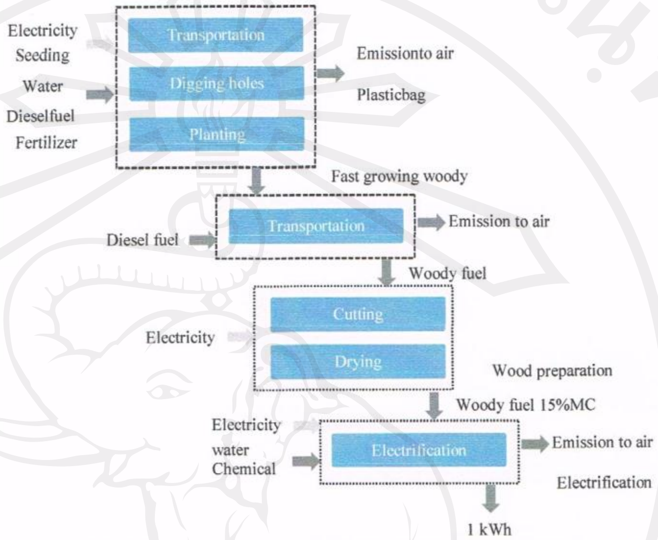

Figure 1 LCI and Operation of community-scaled electricity power plant

- ***Impact Assessment***

The environment impact is assessed for the net pollutants emission to environment from the production of electricity 1 kWh based on IPCC 2007 method using SimaPro software. IPCC 2007 method contains the climate change factors of IPCC (Intergovernmental Panel on Climate Change) with 100 year time frame.

- ***Interpretation***

Interpretation of the environmental impacts reveals the severity of the impacts on the environment and also their potential sources. This will open the opportunity to plan ahead to improve environmental conditions in the most efficient and effective way.

Result and Discussion

Life Cycle Cost

In general, LCC unit cost comparison in US$/kWh for rankine and downdraft gasification system are analyzed and compared for a small community-scaled power plant. The results are found that the unit cost from 50 kW rankine system is 0.193US$/kWh which is 38.88% higher than that of the Downdraft gasification which is at 0.140US$/kWh. The production processes of the both systems are divided in the same fashion into 4 main phases which are plantation phase, transportation phase, preparation phase and electrification phase. Costing ratio of all phases is similar for both systems, i.e. electrification is at the highest cost and it is followed by plantation phase, preparation phase and transportation phase, respectively. Cost of the rankine steam technology is 2.2 times less expensive than that of the downdraft gasification technology as it is only half in size. Furthermore, the rankine system shows the overall efficiency only 7.2% while the Downdraft system is at 17.72%. This is why the fuel consumption of the downdraft gasification is half of what rankine has to consume. Thus it leads less cost as shown in Figure 2.

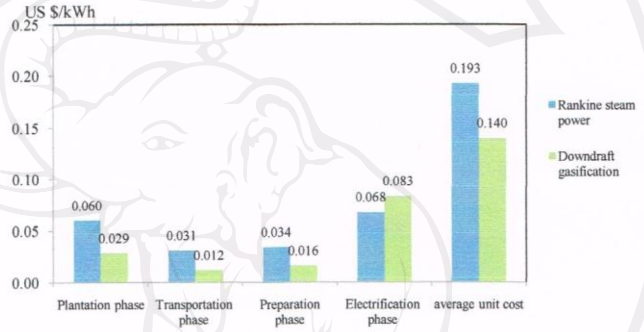

Figure 2 Cost analysis of the electricity generation phase.

It is clear that costs of energy from biomass are lower than those of other alternative energy sources, such as photovoltaic[20]. Figure 3 shows the price comparison among the electricity generation technologies reported in previous investigation. The current estimation is comparable with the others. Both unit costs are higher than that of national grid where it is reported as 0.127 US$/kWh due to its small size and efficiency. It is also shown that the unit costs are also higher than the price that Provincial Electricity Authority (PAE) can purchase back to the grid according to its adder regulation. Cost analysis of electrification by Downdraft gasification with a capacity of 100 kW studied by Mahapatra and Dasappa (2012), reveals the value of 0.099US$/kWh due to lower system's fixed cost and higher efficiency. The capital (fixed) cost of the afore-mentioned biomass gasification system is reported to be 1480-1720US$/kW while biomass consumption is reported at 1.4 kg/kWh which is lower than our current 2.27 kg/kWh. Additional, Cost analysis of electrification by Downdraft gasification with a capacity of 100 kW from fast-growing wood also studied by Dwivedi and Alavalapati(2009), shows the value of 0.153 US$/kWh, which was greater than the price of electricity supplied from their grid at 0.08US$/kWh.

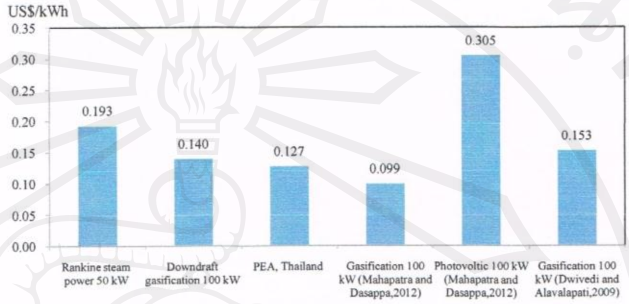

Figure 3 LCC comparisons of others alternative technologies

In the future, the price of electricity from the grid might increase according to lower fossil reserve and growing demands. At that time, the community-scaled power plant might catch national attention as the price might become more economical and project might become more feasible. However, other possibility is also left to be explored. Diesel fuel and liquid petroleum gas (LPG) are annually consumed for crop drying for the preservation and commercial proposes. As there are waste heat rejected from the steam condenser, crop drier should be constructed and exploit the available heat. Drying service can be provided to the community with acceptable fees which will ease the economics of the system. Additional analysis shows that the unit cost drops when heat rejected from the steam condenser is utilized. As 23% of heat retrieved, the unit cost of electricity produced is in comparison with the electricity from the national grid. This is shown in Figure 4.

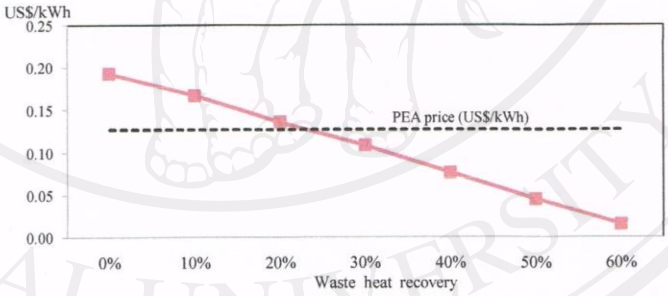

Figure 4 The relation between the ratio of waste heat recovery with unit cost from the rankine system

Life Cycle Assessment

Both technologies, the steam power system and the gasification system, are based on fast-growth wood. The environmental impacts of relating processes are reported in relating to all four processes: plantation, transportation, wood preparation, and electrification, are shown in Table 3. Analysis by SimaPro shows the advantage of community-based steam power system and gasification System. Impact from plantation process is reported between 0.137-0.290g-CO_{2-eq}/kWh for both systems. This results from the utilization of fertilizer material, i.e. N, P_2O_5, K_2O, Polyvinyl/chloride and relevant energy consumed, i.e. diesel fuel and electricity from nation grid. Fuel transportation contributes environmental impact less than any other processes. The GHGs impact from transportation is between 0.008 - 0.016g-CO_{2-eq}/kWh. This is due to the size of the truck used and the power plant and processing center is surrounded by the plantation, thus, reduce the need for diesel fuel.

As the size of wood stem from three year rotation is not so large, small chipping machine is needed but it needs to be operated much often or in daily basis. Drier is operated when it is needed, most of the time, in autumn. It also uses waste heat from flue gas; there is no additional fossil fuel required. GHGs is reported from 0.027-0.057 g-CO_{2-eq}/kWh for this preparation phase. The largest impact is from the electrification phase where GHGs is generated from all material used to fabricate both systems and also emission during their operations. The higher efficiency of the gasification system yields less environmental impact as it consumes fewer resources. There is also fewer use of the chemical substance energy for the relevant phases especially in providing wood fuel. The environmental impact of national grid line is reported as 574 g-CO_{2-eq}/kWh[19]. It is found to be lower than 0.672 g-CO_{2-eq}/kWh of steam-powered system but higher than 0.418 g-CO_{2-eq}/kWh of the gasification system. This is due to more chemicals needed for plantation in steam-powered system. However, the using organic or fermented fertilizer instead of chemical fertilizer is still viable. Additionally, the exploitation of sophisticating technologies into community-based system such as low No_x Burner, Electrostatic Precitator (ESP), and Flue Gas Desulfurization (FGD) is viable option but, for the sake of simplicity to the community to operate, it is not incorporated into this work. The externality cost of the rankine steam-powered system is 2.08E-03 US$/kWh. It could be emphasized that the main costs are electrification phase. Similarly, the externality cost of the gasification system is 1.30E-03US$/kWh which is lower than that of steam system due to its higher efficiency. The externality does not affect much on the cost so that the decision to select the system out of these cases will depend on the economic analysis only. More subtle aspects remains to be incorporated such that plantation also absorbs carbon dioxide for their photosynthesis activity, i.e. carbon dioxide generated from all four processes is, in fact, recycled. However, carbon recycling is not included in this work.

Table. 3 Life cycle cost analytical results of the community-based power plant.

Process	Rankine steam power	Downdraft gasification	Unit
Plantation area requirement	57	55	ha/project
Plantation phase	0.290	0.137	kg $CO_{2\ eq}$/kWh
Transportation phase	0.016	0.008	kg $CO_{2\ eq}$/kWh
Preparation phase	0.057	0.027	kg $CO_{2\ eq}$/kWh
Electrification phase	0.309	0.246	kg $CO_{2\ eq}$/kWh
Total	0.672	0.418	kg $CO_{2\ eq}$/kWh
1. LCA	0.672	0.418	kg $CO_{2\ eq}$/kWh
2. Externality cost	2.08E-03	1.30E-03	US$/kWh
3. Life cycle cost (Excluding Externality)	1.93E-01	1.40E-01	US$/kWh
4. Life cycle cost (Including Externality)	1.95E-01	1.41E-01	US$/kWh

Conclusions and Recommendations

The feasibility study of small community-based biomass power plant is reported in this study. Powered by biomass from plantation, economic and environment analyses of systems powered by two different technologies: 50 kW rankine steam-powered system and 100 kW gasification system are compared. Operation of the power plant is designed to be simple to avoid complexity so that the plantation and power plant can be community-owned which is much appropriate for small and agriculture-based communities around Thailand.

Corresponding life cycle costing for both systems is calculated and reported as 1.93E-01 US$/kWh for rankine steam-powered system and 1.40E-01 US$/kWh for gasification system due to its lower efficiency at such small scale. It is reported that profit from electrification alone is not feasible, even with nation's adder incentive policy, biomass-based power price is not competitive enough unless additional profit, for examples, co-products, by-products, and waste-heat recovery system is exploited.

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