CHAPTER IV

RESULTS AND DISCUSSIONS

Before the discussions, it must be noted that during this research the factories discussed will be designated by a letter, using the letters A-O (Factory A, Factory B, and so forth), based on commercial confidentiality.

4.1 Palm Oil Industrial Survey Results

4.1.1 General Information

Most palm oil mill factories are located in the southern region of Thailand because raw materials, fresh fruit basket (FFB), are promoted in that area. The oldest wet process palm oil mill was established 28 years ago. This factory also has conducted researches and developments on oil palm breed and plantation. The newest one, factory F, was established 2 years ago. There were no significant differences of know-how between the factories which variation on the operation periods due to a well inter-exchange of production process information. The operation day per year depends on the availability of fresh fruit bunch (FFB). The average operation time is 300 days per year, 2 shifts/day and 8 hours/shift.

The factory owners or executives were graduated at 33% of bachelor degree, 60 % of master degree, and 7% of doctoral degree. Over 50% of them enrolled on engineering fields.

4.1.2 Palm Oil Production Capacity

According to the surveys of 15 factories, the information of production capacity, raw material consumption, percentage of crude palm oil (CPO) extraction efficiency and CPO production are shown in ***Table 4.1***.

Table 4.1 Palm Oil Production Capacity of Surveyed Palm Oil Mill Factories

No.	Factory	Rated Production Capacity (ton/hr)	Actual Raw Material Consumption* (tonFFB/year)	CPO Production* (ton/yr)	CPO Extraction* (%)
1	Factory A	30	153,300	26,506	17.3
2	Factory B	60	186,900	33,642	18.0
3	Factory C	45	216,000	36,720	17.0
4	Factory D	50	315,800	56,844	18.0
5	Factory E	45	193,100	31,862	16.5
6	Factory F	45	168,000	28,560	17.0
7	Factory G	45	270,000	45,900	17.0
8	Factory H	60	288,000	48,960	17.0
9	Factory I	45	216,000	36,720	17.0
10	Factory J	45	216,000	34,560	16.0
11	Factory K	30	91,400	15,995	17.5
12	Factory L	45	201,200	34,204	17.0
13	Factory M	30	162,000	26,730	16.5
14	Factory N	30	148,800	23,808	16.0
15	Factory O	15	29,100	4,802	16.5
Total		**620**	**2,855,600**	**485,811**	**N/C**
Average		**N/C**	**N/C**	**N/C**	**17.0**
Standard Deviation		**N/C**	**N/C**	**N/C**	**0.6**
Minimum		**15**	**29,100**	**4,802**	**16.0**
Maximum		**60**	**315,800**	**56,844**	**18.0**

Note: * based on year 2001 factory data, surveyed on May 9, 2002 to June 29, 2002.

Generally, Thailand's palm oil supply cannot meet the domestic demand. From factory surveys, over 90% of crude palm oil (CPO), product from palm oil mill industry, was supplied to the domestic market. The export proportion depended on the world market price and government policy. CPO is practically sent to refineries located in Bangkok and vicinity.

Table 4.1 presents that the existing cumulative production capacity of all palm oil mills is more than the FFB productivity. In 2001, the FFB production is approximately 3.88 million tonFFB/year, but maximum production capacity of overall 20 wet-process factories is approximately 834 tonFFB/hr (refer to ***chapter 2***, ***Table 2.2***) or 6 million tonFFB/year (with 300 operation days/year and 24 hours/day). Therefore, factories currently operate at only 60-70% of their maximum capacity. Since, the government through the Ministry of Agriculture and Cooperatives aims to increase oil palm production by providing a promotion for oil palm plantation, the budget of 2,400 million Baht is planning to be arranged in the 9^{th} National Economic and Social Development Plan (B.E. 2545-2549).

The CPO extraction efficiency of Thai mills is in a typical range of 16-19%. The factors influencing to the extraction efficiency are raw material source ratio, sterilization conditions, oil loss control and oil recovery efficiency, quantity and quality of oil extraction machines.

The raw material source ratio is a portion of FFB from the factory's own plantation and FFB from purchasing. The factories, which have their own plantation, can control FFB quality by controlling the appropriate harvest time, palm breed, fertilizer addition, and plantation management.

In production process, the conditions for sterilization such as temperature, pressure, and sterilized time are the import factors on CPO extraction capacity which may differ on each factory.

Oil loss control and oil recovery also influence the oil extraction capacity. The factories, which have labs for oil and grease analysis, will have higher CPO extraction capacity because they can monitor their performance and control oil loss and oil recovery. Although each factory has the same oil extraction machine, the capacity and sequence of machines still affect on oil extraction capacity.

When comparing the efficiency of CPO extraction to the biggest palm oil producer, Malaysia, Thai still have lower oil extraction efficiency. About 18-20 % oil extraction is a typical range of Malaysia mills when 16-19% stands for Thai mills.

4.1.3 Thai Palm Oil Production Cost Structure

From factory surveys, palm oil production cost is of 10.6 bath/kgCPO. Over 84% of main cost is from raw material, FFB. The production cost from raw material is depended on the FFB price which varied year-by-year basis. The rest 16% is a fixed cost including transportation cost, fuel/energy cost, labor cost, overhead, marketing, maintenance, interest and others. It represents that FFB price significantly influence to economic performance of palm oil industry. An improvement on palm oil breeds and FFB production per plantation area will reduce FFB production cost because the farmer could get the higher yield of FFB with the same amount of production cost. The high-yield palm oil breed also increase on CPO production. The material cost and fixed cost of 15 surveyed factories are illustrated in ***Table 4.2***.

From ***Table 4.2***, the production costs of 15 surveyed factories are varied from 9.6-11.6 Baht/kgCPO. There are many reasons why the production cost of palm oil mill tend to differ from each other, including differences in proportion of their owned oil palm plantation, plant location, size, production technology. Proportion of owned palm oil plantation, for example, can affect oil extraction efficiency due to differences in the quality and price of inputs. Factories, which have their owned oil palm plantation, could control FFB breed and quality, control appropriate harvested time and have less potential of lacking raw materials. Moreover, the capital cost of FFB is lower than of the factories that purchased all inputs from farmers. The other reasons of such variation are transportation, fuel/energy, labors, interest, maintenance cost, machine depreciation cost, office and marketing expenses of each factory.

Table 4.2 Production Cost Structure of Palm Oil Industry

Average FFB Pric 1.50 Baht/kg

(average value of year 2001, calculated from palm oil factory records)

No.	Factory	CPO Extraction (%)	Fixed Cost *		Raw Material Cost **		Production Cost***
			(Bath/kgCPO)	%	(Bath/kgCPO)	%	(Bath/kgCPO)
1	Factory A	17.3	1.3	13	8.7	87	9.9
2	Factory B	18.0	1.3	13	8.3	87	9.6
3	Factory C	17.0	1.8	17	8.8	83	10.6
4	Factory D	18.0	1.8	18	8.3	82	10.1
5	Factory E	16.5	2.0	18	9.1	82	11.1
6	Factory F	17.0	1.6	15	8.8	85	10.4
7	Factory G	17.0	2.5	22	8.8	78	11.3
8	Factory H	17.0	2.3	20	8.8	80	11.1
9	Factory I	17.0	1.8	17	8.8	83	10.6
10	Factory J	16.0	2.0	18	9.4	82	11.4
11	Factory K	17.5	1.9	18	8.6	82	10.5
12	Factory L	17.0	1.2	12	8.8	88	10.0
13	Factory M	16.5	1.7	16	9.1	84	10.8
14	Factory N	16.0	0.7	7	9.4	93	10.1
15	Factory O	16.5	2.5	22	9.1	78	11.6
Average		**17.0**	**1.7**	**16**	**8.9**	**84**	**10.6**
STD.		**0.6**	**0.5**	**4**	**0.3**	**4**	**0.6**
Minimum		**16.0**	**0.7**	**7**	**8.3**	**78**	**9.6**
Maximum		**18.0**	**2.5**	**22**	**9.4**	**93**	**11.6**

Note: * Fixed cost = transportation cost, fuel/energy cost, labor cost, overhead, marketing, maintenance, interest and others

** Raw material cost = $\frac{\text{Average FFB Price x 100}}{\text{\% CPO Extraction}}$

*** Production cost = fixed cost + raw material cost

Source: Factory data, surveyed on May 9, 2002 to June 29, 2002.

When compared to previous study (DIW, 1997) on palm oil mill production cost structure (***see Table 4.3***), there are the differences on both material cost and fixed cost. The raw material cost of year 1990 is higher than of year 2001. It is because the average FFB price is of 1.89 Baht/kgFFB in year 1990 and 1.50 Baht/kgFFB in year 2001. When convert those costs into per unit of CPO, the raw material costs are about 11.1 Baht/kgCPO, 8.9 Baht/kgCPO, respectively. The raw material cost is a major proportion of production cost, therefore, the variation of FFB price significantly influences to the production cost.

For the fixed cost, there is some decrease. The fixed cost of year 2001 is lower than of year 1990. The fixed cost had reduced from 2.9 Baht/kgCPO to 1.7 Baht/kgCPO. The reduction is a result of Thai palm oil industry has modified and developed their production process to abate production cost according to several government assistant projects. Cleaner technology/pollution prevention is commonly applied in palm oil factories. The effectiveness of that application represents more utilizing by-products, applying preventive maintenance, reducing water and energy consumption, etc. The increasing the application of waste minimization of palm oil mill industry was reported in the project impact assessment of DIW in 1999. It concluded that there were significant improvements in palm oil mill industry due to the implementation of "Environmental Advisory Advice for Industry" project conducted by DIW and GTZ.

Table 4.3 Production Cost Structure of Thai Palm Oil Industry

Items	Production Cost			
	DIW study**		This study***	
	Bath/kgCPO	%	Baht/kgCPO	%
Fixed Cost*	2.9	23	1.7	16
Raw Material Cost	10.0	77	8.9	84
Total	12.9	100	10.6	100

Note: * Fixed cost = transportation cost, fuel/energy cost, labor cost, overhead, marketing, maintenance, interest and others.

** Refer to ***Chapter 2***, ***Table 2.7***, large factories (based on average domestic FFB price = 1.89 Baht/kgFFB).

*** This study analyzes based on average domestic FFB price = 1.5 Baht/kgFFB from factory surveys, year 2001.

4.1.4 Water Consumption

Most palm oil mill factories use surface water as a water resource for production process. Only 14 % of them use groundwater as a water resource because their locations are far away from surface water resource. Water consumption rate of surveyed factories is typically 0.56-1.5 m^3/tonFFB. However, the above data was not exactly measured and recorded, but, factories estimated from relevant data such as pump capacity, water treatment system capacity, boiler capacity, and from previous studies that were conducted by several organizations. The difference on water consumption rate are the results of boiler capacity, oil extraction equipment (settling tank requires more water to separate oil when compared to decanter), and the level of cleaner technology or waste minimization application, such as recycle of condensed steam, recover of oil loss in oil and grease trap, and reuse the cooling water from boiler.

4.1.5 Wastewater Characteristics and Wastewater Management

Average wastewater generation rate is of 0.4 m^3/tonFFB. From the factories' wastewater analysis reports, the raw BOD concentration is typically of 20,000-50,000 mg/l, with 36,000 mg/l on average. The BOD concentration of final pond are typically of 60-300 mg/l.

All surveyed factories have installed wastewater treatment system. The well-accepted type is pond system because of lower cost and uncomplicated construction, operation and maintenance. Hence, the wastewater treatment operators are always the workers or foremen of each shift and supervised by factory engineers or factory managers. There are no assigned full-time personnel to handle wastewater treatment system. The investment cost of wastewater treatment is never recorded.

The important problem of factories concerning wastewater treatment system is malodor. 100% of palm oil mills is unable to solve bad odor problem due to anaerobic condition in the earlier ponds. Over 50% of them claim that the effluent standard is too stringent and hard to comply. They recommend that the standards should be set up based on practical treatment level.

Factory L declared that its existing treatment level could treat wastewater beyond compliance with the effluent standards. The poly aluminum chloride (PAC) addition following with filtration system is the option that the factory applies before recycle their wastewater in the plant. The effluent BOD is lower than 20 mg/l (about 8 mg/l, measured on October 15, 2001) with cost of 0.46 Baht/m^3. If EC is implemented, this alternative would be worth for factory when compared to the EC rate. The existing wastewater management of surveyed factories is shown in ***Table 4.4***.

From ***Table 4.4***, about 60% of all factories employed oxidation ponds, 33% employed oxidation ponds together with aerated lagoons, but, generally not run the aerator, and 7% employed biogas plus oxidation ponds. The wastewater qualities from final ponds of palm oil mill factories mostly not comply with effluent standards especially for BOD and color. It is because of the existing treatment systems are the anaerobic treatment systems that can not treat the residue BOD concentration met the standard. Besides, palm oil mill industry is prohibited to discharge wastewater to environment, excepted for irrigation. All factories have to reserve large area to storage their wastewater.

By 73% of all factories apply their wastewater for oil palm and rubber plantation irrigation. Wastewater from treatment system is pumped or discharged by gravity to those areas surrounded factories. For the factories located among community and no palm oil plantation area, they have held their wastewater in large-volume pond systems. The overflow of wastewater into environment during monsoon is commonly occurred. The spillover wastewater may cause effects to the aquatic life, surface water quality, and environmental deterioration due to high loading of BOD, grease and oil.

Table 4.4 Palm Oil Wastewater Management (Treatment and Disposal)

No.	Factory	Wastewater Treatment System	Effluent BOD Concentration (mg/l)	Wastewater Discharge Management	Wastewater Treatment Problem
1	Factory A	Oxidation Pond + Aerated Lagoon	10	Irrigation for Oil Palm	Odor + Colour
2	Factory B	Oxidation Pond	160	Irrigation for Oil Palm	Odor
3	Factory C	Bio Gas+Anaerobic Pond+Polishing Pond	60	Irrigation for Oil Palm	Odor + Hardly to Compliance with the eff. std.
4	Factory D	Grease Trap+Oxidation Pond+Stabilization Pond	300	Irrigation for Oil Palm	Odor+High O&M cost+Hardly to Compliance with the eff. std.+Lack of professional staffs+Overflow of WW
5	Factory E	Grease Trap+Oxidation Pond+Aerated Lagoon+Stabilization Pond	150	Irrigation for Oil Palm	Odor
6	Factory F	Oxidation Pond + Aerated Lagoon	120	Irrigation for Oil Palm	Odor
7	Factory G	Oxidation Pond	60	Storage in holding pond	Odor+Hardly to compliance with the eff. std.+Overflow of storage wastewater
8	Factory H	Oxidation Pond	300	Storage in holding pond	Odor+Hardly to compliance with the eff. std.
9	Factory I	Oxidation Pond+Aerated Lagoon	150	Irrigation for oil palm	Odor+Hardly to compliance with the eff. std.
10	Factory J	Oxidation Pond+Aerated Lagoon+Stabilization Pond	90	Irrigation for oil palm	Odor+Hardly to compliance with the eff. std.
11	Factory K	Oxidation Pond	200	Irrigation for oil palm	Odor
12	Factory L	Oxidation Pond + Filtration System	150	Reuse & Recycle in plant	Odor
13	Factory M	Oxidation Pond	200	Irrigation for oil plam	Odor+Hardly to compliance with the eff. std.
14	Factory N	Oxidation Pond	6*	Irrigation for rubber tree	Odor
15	Factory O	Oxidation Pond	86	Storage in Holding Pond	Odor+High O&M cost+Hardly to Compliance with the eff. std.

Note: * Not expressed in the statistical analysis due to diluted with rain.

Source: Factory data, surveyed on May 9, 2002 to June 29, 2002.

4.1.6 BOD Load Estimation for Emission Charge Calculation

According to the existing condition of palm oil wastewater characteristics and existing wastewater treatment system, the BOD load in final pond does not represent the overall effluent BOD load from palm oil mill industry. Over 70% of wastewater is utilized for land application. Most BOD loads discharge into oil palm or rubber plantation areas. Moreover, the land application normally does not uses the wastewater in final pond, but regularly employ it from the high BOD concentration pond. From Malaysia research, it indicated that when the BOD level is brought down to below 5,000 mg/l, the digested palm oil mill effluent is allowed for land application (Malaysia Palm Oil Board, 2000). The BOD concentration of wastewater treated by facultative or anaerobic pond of surveyed factories when assigned 90% BOD removal are typically below 5,000 mg/l. Thus, the BOD load estimation is based on an assumption that the factories that applying their wastewater for land application use wastewater from the facultative or anaerobic pond, not from final ponds. Studies by various groups have demonstrated that such an application was beneficial to oil palm, besides the tremendous saving on fertilizer cost. Moreover, long term studies have also established that water quality of the applied area was not affected (Malaysia Palm Oil Board, 2000). From NSW-EPA guidelines, it recommended that the maximum organic load for most soils should below 40 kgBOD/ha/day (New South Wales-Environment Protection Authority. 1995). Accordingly, it can be calculated the minimum area requirement for land application based on each factory BOD load. Those figures guide that if factories apply their wastewater for irrigation, the minimum required area should not less that those figures. From factory surveys, palm or rubber plantations that applying wastewater for irrigation always exist with larger areas than that required by the minimum area criteria. It confirmed that land application of palm oil mill wastewater could be possible and acceptable.

The effluent BOD load for EC calculation was estimated from the actual removal efficiency of wastewater treatment system. The removal efficiency of anaerobic or facultative system, such as anaerobic pond, oxidation pond, polishing pond, and stabilization pond, normally not exceeds 90%. Thus, the calculation is based on the maximum removal efficiency of 90% because all palm oil mill factories employed many series of ponds that the summation of removal efficiency could be up to the maximum capacity. For the factories that employed the aerobic system such as aerated lagoon, the removal efficiency was assigned at 95% following to the actual removal efficiency of aerated lagoon.

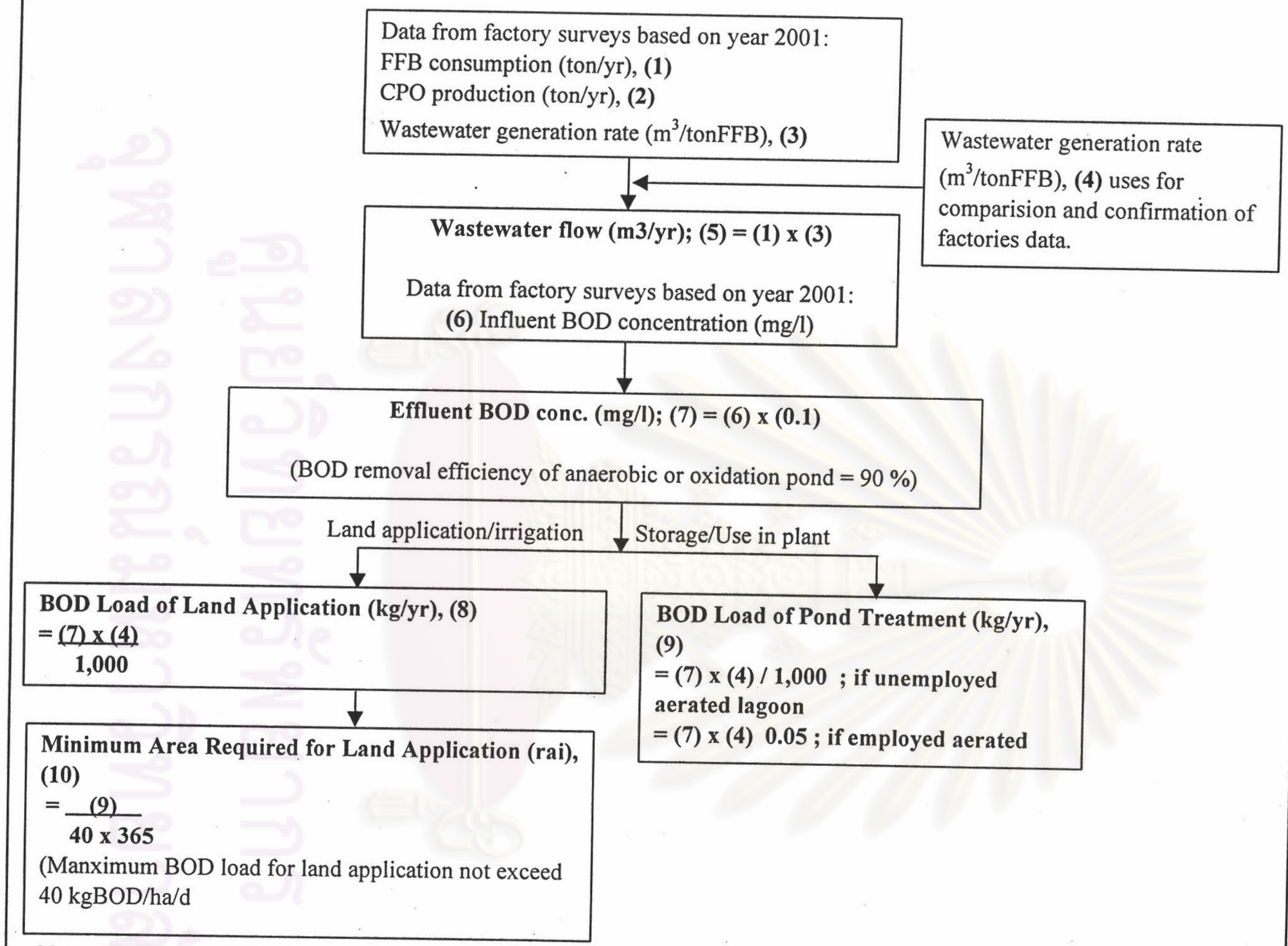
Wastewater from anaerobic or facultative system is applied in palm or rubber plantation by factories that informed that their wastewater is irrigated. Out of this, the factories which informed that their wastewater was stored in wastewater treatment ponds, all BOD load is calculated under EC scheme. This solution based on an assumption that it is impossible to storage all wastewater in ponds without overflow. It is because palm oil mill factories located in southern region where high intensity of rain is well known (normally exceed 1,000 mm/yr). The abatement of BOD load from anaerobic treatment system is also provided for the factories that employed the aerobic treatment system such as aerated lagoon (by 95% removal efficiency). It is recommended that this assumption should be applicable for EC implementation. The factories that not accepted the estimation can appeal for an approval by third party monitor. The calculation method for BOD load is shown in ***figure 4.1*** and the result from the calculation is shown in ***Table 4.5***. This BOD load calculation will be applied for EC calculation in ***Section 4.3***.

4.1.7 Abatement Cost

To evaluate the level of emissions that the palm oil mill factories would emit under the emission charge scheme, it is necessary to know the function of abatement costs of the factories. However, the factories cannot provide the actual costs of abatement. Thus, this study would estimate the abatement costs based on the existing conditions of each factory. The abatement costs are comprised of several parts as below:

- Capital Cost, including:

  - Construction cost: The treatment system of palm oil mill factories mainly employed the pond system, thus, the construction costs for palm oil mill factories are from the excavation cost of treatment ponds. The estimations are calculated from the volume of ponds and the unit cost of excavation (Baht/cu.m.).



Note: **(1)**, **(2)**, ..., **(10)** refer to columne numbers of ***Table 4.5***.

Figure 4.1 BOD Load Calculation Method for Emission Charge Calculation

Table 4.5 BOD Load Estimation of Emission Charge Calculation

No.	Factory	FFB Consumption (tonFFB/yr)	CPO Production (tonCPO/yr)	Wastewater Generation Rate (m3/tonFFB)	Wastewater Generation Rate (COT,1999) (m3/tonFFB)	Wastewater Flow (m3/yr)	Influent BOD Concentration (mg/l)	Effluent BOD Concentration (at 90% removal) (mg/l)	BOD Load for Land Application (kg/yr)	BOD Load of Pond Treatment (kg/yr)	Minimum Area Required for Land Application (rai)
Column		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	Factory A	153,300	26,506	0.5	N/A	76,650	36,000	3,600	275,940	-	118
2	Factory B	186,900	33,642	0.5	0.4	93,450	50,000	5,000	467,250	-	200
3	Factory C	216,000	36,720	0.4	0.1	86,400	20,000	2,000	172,800	-	74
4	Factory D	315,800	56,844	1.0	0.3	315,800	36,000	3,600	1,136,880	-	487
5	Factory E	193,100	31,862	0.3	0.5	57,930	30,000	3,000	173,790	-	74
6	Factory F	168,000	28,560	0.3	N/A	50,400	44,000	4,400	-	11,088	5
7	Factory G	270,000	45,900	0.5	0.2	135,000	25,000	2,500	-	337,500	144
8	Factory H	288,000	48,960	0.5	0.9	144,000	50,000	5,000	-	720,000	308
9	Factory I	216,000	36,720	0.3	N/A	64,800	35,000	3,500	226,800	-	97
10	Factory J	216,000	34,560	0.3	N/A	64,800	36,000	3,600	233,280	-	100
11	Factory K	91,400	15,995	0.3	N/A	27,420	36,000	3,600	98,712	-	42
12	Factory L	201,200	34,204	0.3	N/A	60,360	30,000	3,000	-	181,080	78
13	Factory M	162,000	26,730	0.6	N/A	97,200	40,000	4,000	388,800	-	166
14	Factory N	148,800	23,808	0.5	N/A	74,400	36,000	3,600	267,840	-	115
15	Factory O	29,100	4,802	0.4	N/A	11,640	36,000	3,600	-	41,904	18
Total		**2,855,600**	**485,811**			**1,360,250**			**3,442,092**	**1,291,572**	**2,026**
Average				**0.5**			**36,000**	**3,600**			
Standard Deviation				**0.2**			**8,115**	**812**			
Minimum		**29,100**	**4,802**	**0.3**		**11,640**	**20,000**	**2,000**	**-**	**-**	**5**
Maximum		**315,800**	**56,844**	**1.0**		**315,800**	**50,000**	**5,000**	**1,136,880**	**720,000**	**487**

Note: (1), (2), (3) and (6) from factory surveys, based on year 2001 data

(4) = from DIW, 1999. (Actual survey by Consultants of Technology Co.,Ltd)

(5) = (1) x (3)

(7) = (6) x 0.1

(8) = (7) x (4)/1,000, if factories apply wastewater for irrigation

(9) = (7) x (4) /1000, if factories not apply ww for irrigation and not employed aerobic treatment system such as areated lagoon.

(9) = (7) x (4) x 0.05 /1000, if factories not apply ww for irrigation but employed aerobic treatment system such as aerated lagoon.

(10) = (7) / 40 / 365 x 10,000 / 1,600 , the maximum BOD load for land application not exceed 40 kgBOD/ha/day

The factories which employed additional treatment system such as biogas, and filtration systems are assigned by the actual abatement cost that informed by the factories.

- Equipment and machine cost: Aerators and pumps are the major equipment/machines that used in the wastewater treatment system of the palm oil mill industry. The estimations are based on the wastewater generation rate of each factory and the application of wastewater (land application or storage in ponds).

- Land cost: The costs of land for wastewater treatment system are estimated in term of land rental or opportunity cost.

- Operation and Maintenance Cost, including:

- Labor cost: The labor costs are estimated from the worker (s) that factories employ for operation and maintenance purposes.

- Electricity cost: The electricity costs are estimated from the power of pumps and aerators.

- Chemicals cost: The costs of chemicals are assigned if factory used chemicals for wastewater treatment.

- Maintenance cost: The maintenance costs are estimated from the cost of annual dredging of treatment ponds. The factories which using decanter for oil extraction have lower maintenance cost than the factories which using separator. It is because decanter can remove more sludge and reduces more impurity in wastewater. Thus, the ponds have not much sludge to remove annually.

- Land application cost: The factories which applying their wastewater for irrigation are assigned the electricity cost of wastewater pumping and the soil loosening cost.

The abatement cost of palm oil mill factories are estimated according to the above assumption and shown in ***Table 4.6***. The details of abatement cost estimation of each factory are shown in ***Appendix C***.

Table 4.6 Estimation of Wastewater Abatement Cost of Palm Oil Mill Industry

Assumption

1 Interest Rate (i) 0.095 (Bank of Thailand, 2002)

2 Annual Recovery Cost factor 0.1017 $= \frac{i(1+i)^n}{(1+i)^n - 1}$

3 Working Life (Years) = 30

4 Capital cost of land for wastewater treatment is assigned based on rental rate

5 Land Application

- included cost of pump, and piping system (as shown in capital cost)
- included cost of electricity for wastewater pumping, of soil loosening for 1 time/year
- (as shown in operation and maintenance cost)
- excluded cost of land due to wastewater is applied for oil palm or rubber plantation area
- wastewater application rate is of 40 kg/ha/day (NSW-EPA, 1995)

1) Land Application

Factory	BOD Generation (tonBOD/yr)	BOD Removal (tonBOD/yr)	Emission (tonBOD/yr)	Construction Cost (Baht)	Machine Cost (Baht)	Land Rental Cost (Baht/yr)	Total Annual Cost (Baht/yr)	O&M Cost (Baht/yr)	Total Abatement Cost (Baht/yr)	Average Abatement Cost (Baht/tonBOD)
A	2,759	2,483	276	7,650,000	1,550,000	250,000	1,185,461	2,414,594	3,600,055	13,047
B	4,673	4,205	467	8,000,000	350,000	300,000	1,149,033	3,628,936	4,777,969	10,226
C	1,728	1,555	173	8,600,000	350,000	175,000	1,085,041	1,792,156	2,877,197	16,650
D	11,369	10,232	1,137	6,462,500	500,000	2,433,390	3,141,341	8,224,129	11,365,471	9,997
E	1,738	1,564	174	7,383,750	1,050,000	189,492	1,047,041	1,522,931	2,569,972	14,788
F	2,218	1,996	222	7,581,950	1,050,000	236,936	1,114,638	1,745,455	2,860,093	12,897
I	2,268	2,041	227	7,200,000	1,150,000	225,000	1,074,033	1,846,819	2,920,851	12,879
J	2,333	2,100	233	4,275,000	1,150,000	133,594	685,211	1,762,562	2,447,773	10,493
K	987	888	99	2,400,000	200,000	75,000	339,370	897,262	1,236,631	12,528
M	3,888	3,499	389	6,500,000	350,000	39,447	735,959	2,935,608	3,671,567	9,443
N	2,678	2,411	268	12,858,350	350,000	250,000	1,593,033	2,123,114	3,716,147	13,875

2) Treatment by Pond System

Factory	BOD Generation (tonBOD/yr)	BOD Removal (tonBOD/yr)	Emission (tonBOD/yr)	Construction Cost (Baht)	Machine Cost (Baht)	Land Rental Cost (Baht/yr)	Total Annual Cost (TAC) (Baht/yr)	O&M Cost (Baht/yr)	Total Abatement Cost (Baht/yr)	Average Abatement Cost (Baht/tonBOD)
G	3,375	3,038	337	6,400,000	270,000	200,000	878,209	450,048	1,328,257	3,941
H	7,200	6,480	720	8,147,856	270,000	250,000	1,105,933	106,048	1,211,981	1,683
L	1,811	1,810	1	3,561,400	120,000	17,544	391,871	394,756	786,627	786,627
O	419	377	42	1,000,000	90,000	50,000	160,832	504,213	665,045	15,834

Table 4.6 indicates that the abatement cost of land application is higher than the abatement cost of pond treatment. The average abatement costs of both cases are illustrated in ***Figure 4.2*** and ***Figure 4.3***. These results will be integrated with the EC rate to find out the emission level of palm oil mill factories under EC scheme as shown in ***Section 4.4***.

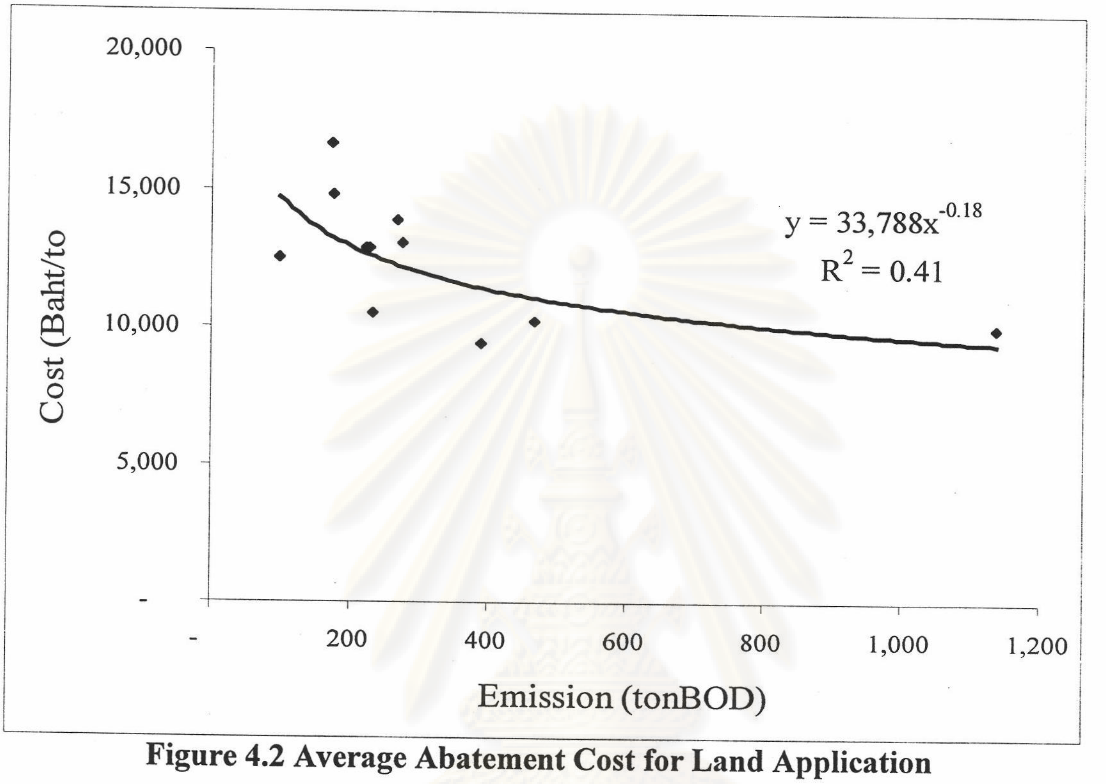


Figure 4.2 Average Abatement Cost for Land Application

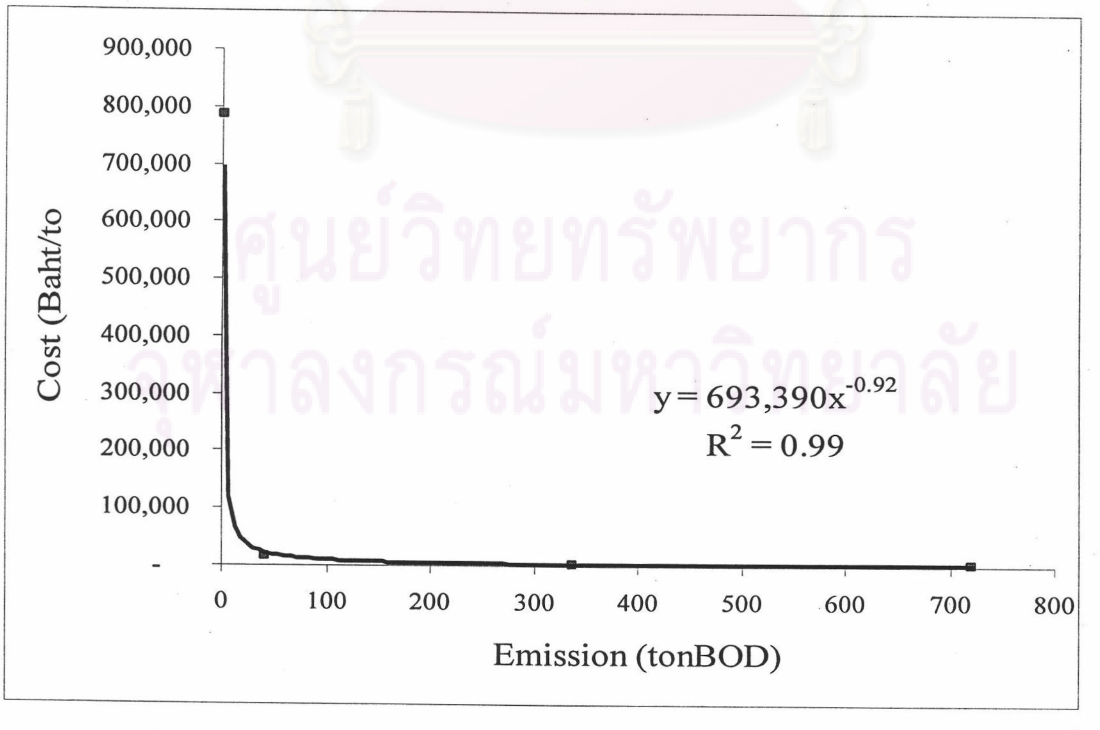


Figure 4.3 Average Abatement Cost for Pond Treatment

4.1.8 Existing Environmental Management Policy

The existing environmental management policy of factories is performed by level of participation in government and academic institute projects. 53% of all factories applied CT/PP, EMS, or benchmarking project assisted by DIW or TEI.

From the factory surveys, 27% of all factories have a good environmental management. 33% are ranked in fair environmental management level and 40% are ranked in poor environmental management. It was weighed by the level of participation in the environmental projects of governments or academic institutes, benchmark ranking of factories, environmental investment, availability of environmental management resources and from factory surveys.

The important factor influencing to environmental management policy of factories are community and regulation by 53% and 40%, respectively. It reflects the power of public on the level of environmental management. The willingness to reclaim environment of factories is not from internal factor, but is enforced by the external factors. The factories surrounded with community always have an acceptable environmental management level. The relationships between factory and community are expressed by, for example, establishing co-committee to solve the environmental problems, donation of utilities for publics or government offices, welcoming for factory visits, employing workers from community. The detailed of environmental management of the surveyed factories are shown in ***Table 4.7***.

4.1.9 Awareness Level of the Palm Oil Factories on EC Implementation

73% of 15 surveyed factories have been informed on polluter-pays principle and emissions charge implementation policy of DIW. Over 80% of 15 surveyed factories agree to the implementation plan. 20% of 15 surveyed factories disagree to the policy and are unwilling to pay EC by the reason of high charge rate and effect on their production cost.

Table 4.7 Existing Environmental Management Policy of the Surveyed Factories

No.	Factory	Existing Environmental Management Policy									Important Factors on Environmental Management Policy
		Conclusion	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	
1	Factory A	Good	X			X		X	X		Communities, Regulations, Shareholders
2	Factory B	Fair						X	X		Production Cost
3	Factory C	Good	X	X		X	X		X		Communities, Incentive of support/subsidy
4	Factory D	Poor			X						Investment cost on pollution abatement, Communities
5	Factory E	Poor								X	The production cost (decrease % oil loss)
6	Factory F	Poor								X	Shareholders, Communities
7	Factory G	Fair		X				X			Communities, Incentives of support/subsidy
8	Factory H	Fair	X	X							Incentives of support/subsidy
9	Factory I	Fair	X	X		X					Regulations, Communities
10	Factory J	Fair	X						X		Investment cost on env. conservation, Regulations
11	Factory K	Poor								X	-
12	Factory L	Good	X	X	X	X	X	X	X		Clients, Shareholders,Regulation
13	Factory M	Good	X				X	X	X		Employees, NGOs, Communities, Regulations, Investment cost on env. conservation, Liability
14	Factory N	Poor								X	-
15	Factory O	Poor								X	Communities, Regulations
Conclusion		Good = 27% , Fair = 33%, Poor = 40%									

Note: option 1 = Apply CT/PP; option 2 = Apply EMS/ISO14000; option 3 = Apply ISO 9000; option 4 = Participate in TRF's projects, i.e. bench marking, biomass; option 5 = Investment for environment issues, i.e. ww treatment construction, o&m; option 6 = Engage environmental management staffs for pollution control; option 7 = Good house keeping; option 8 = None

Source: Factory data, surveyed on May 9, 2002 to June 29, 2002.

The main reason of the agreement of such factories associates to the existing restriction of palm oil wastewater discharge to environment. The permission of palm oil mill discharge is only for irrigation. Accordingly, the factories with no irrigation application and facing with overflow problem are willing to pay EC.

It has to note that initial EC implementation will be dually enforced with the command and control approach. DIW regulation states that the discharge of pollutant concentration threefold above the standards will be shutdown. Consequently, the factories under EC scheme have to pay EC based on BOD load and treat their wastewater to comply with standards at the same time. This condition prevent the factories from discharging high load pollutants to environment due to the charge rate is not high enough to encourage factories treat their pollution load. It has to be weighted between the effect on industrial sectors and environmental deterioration. The final solution will be expressed in term of the ***"f coefficient"*** in the EC equation. The study on impact of EC on other main industrial sectors should be done for an effective implementation plan, especially for the appropriate charge rates.

Even if they agree to the EC implementation, the factories still criticized on the effectiveness of government enforcement and worried about the competitive ability in world market. Hence, DIW has to educate factories if EC is enforced. Moreover, monitoring mechanism should be ensured factories on monitoring strengthening. The researches and developments on the appropriate quantity and quality of palm oil wastewater application should be done as it could be effected to environment. The authorized organization should be established for approvals of land application, irrigation, reuse and recycle alternatives.

The details of awareness level of surveyed palm oil factories are shown in ***Table 4.8***.

Table 4.8 Awareness Level of Palm Oil Factories on EC Implementation

No.	Factory	Polluter-pays-principle Awareness of Factories		Emission Charge Implementation Awareness of Factories		Agreement on EC Implementation	
		Informed	Never Informed	Informed	Never Informed	Agree	Disagree
1	Factory A	x		x		x	
2.	Factory B	x		x		x	
3	Factory C	x		x		x	
4	Factory D	x		x		x	
5	Factory E	x		x			x
6	Factory F		x	x		x	
7	Factory G	x		x		x	
8	Factory H	x		x		x	
9	Factory I	x			x	x	
10	Factory J	x			x	x	
11	Factory K	x		x		x	
12	Factory L	x		x		x	
13	Factory M		x	x			x
14	Factory N		x		x	No Comment	
15	Factory O		x		x	No Comment	
Conclusion		**11**	**4**	**11**	**4**	**11**	**2**

Note: Information sources of palm oil factories which have been informed about polluter-pays-principal and EC implementation are from DIW, TEI, newspaper, television, and inter-communication with factories.

Source: Factory data, surveyed on May 9, 2002 to June 29, 2002.

4.2 Economic Performance of Palm Oil Mill Factories

4.2.1 Profit/Loss Calculation

The profit/loss calculation of the palm oil mill factories was established to find out their economic performances. The profit/loss also provide the information for the EC implementation policy that would not burden to factories under EC scheme. It has to note that the profit calculation of this study may not precisely reflect the realized costs, because they were abstracted from several dimensions of each factory information which may differ from each other. Moreover, the production costs was hard to be provided by factories due to the commercial confidence. The completed data could be obtained from few factories.

From the data obtained from the surveyed factories, over year 2001, it could be estimated the average FFB price and CPO cost. The average cost of FFB and CPO were 1.5 Baht/kgFFB and 12 Baht/kgCPO, respectively. Both figures were higher than the average domestic costs referring to Bangkok market, 1.19 Baht/kgFFB and 10.86 Baht/kgCPO, respectively (refer to ***Table 2.6*** in ***Chapter 2***). It is because, year 2001, Thai had a large stock of crude palm oil during world market CPO cost was increased higher than domestic market cost. For example of some period, world market cost was of 15.51 Baht when domestic cost was of 14.50 Baht (http://www.dailynews.co.th/agriculture/ 11199.html, 2001). Thus, Thai crude palm oil was exported a lot in such period. From annual record, it is increased by 160,810 tonCPO compared with year 2000 export. Furthermore, the CPO is often sale with higher volume in high-cost period. The average CPO cost has to weight with the volume of actual sale. This circumstance induced over the year 2001 average surveyed CPO cost higher than the average domestic CPO cost.

For FFB price, the actual cost purchased by factories always higher than that declared. Palm oil mill factories have provided extra rate for a large quantity of FFB supplied. Moreover, the FFB price is depended on the CPO cost. If CPO cost increase, the FFB price will also increase consistently. Similar to the CPO cost, the average FFB price has to weight with the actual purchased volume.

As described above for year 2001 situation, the calculations for profit/loss of palm oil mill factories are determined with 2 cases of CPO costs:

A. With CPO cost equal to the actual average cost from factories surveys, 12 Baht/kgCPO, and

B. With CPO cost equal to the average domestic market cost, 10.89 Baht/kgCPO.

The calculation of case B is simulated for the study on impacts of EC on palm oil mill factories, if year 2001 Thai palm oil mill factories have to trade their CPO in domestic market.

Since the economic performances of factories regarding to profit/loss are not available from all factories, the estimation from related data have to be done for the study of impact of EC to palm oil industry with special reference to the economic performance. By the interviews with palm oil owners or executives, the year 2001 data included raw material consumption, percent of oil extraction, CPO production, and production cost per kgCPO are used as the input data for estimating the actual sale (AS), total production cost (TC) and profit (P) of each factory. The study is analyzed based on year 2001 data. The equations for estimating such figures are as below:

$$AS = P \times C \times 1{,}000 \quad \text{.......... (4.1)}$$

When AS = Actual Sale (Baht)

P_{CPO} = CPO production (ton)

C_{CPO} = Average CPO cost (Baht/kgCPO)

$$TC_P = C_P \times P_{CPO} \times 1000 \text{ (kg/ton)} \quad \text{.......... (4.2)}$$

When TC_P = Total Production Cost (Baht)

C_P = Production Cost (Baht/kgCPO)

= Fixed Cost (Baht/kgCPO) + Raw Material Cost (Baht/kgCPO)

P_{CPO} = CPO production (ton)

Fixed Cost = Transportation cost, fuel/energy cost, labor cost, overhead, marketing, maintenance, interest and others (refer to ***Table 4.3***)

$$\text{Raw Material Cost} = \frac{\text{Average FFB price (Baht/kgFFB)} \times 100}{\text{\% Oil Extraction}}$$

$$P = AS - TC_P \quad \text{...} \quad (4.3)$$

When P = Profit (Baht)

AS = Actual Sale (Baht)

TC_P = Total Production Cost (Baht)

As to the above equations, the economic performances of surveyed factories are shown in ***Table 4.9***. For case A, CPO cost equal to the actual average cost from factory surveys, 12 Baht/kgCPO. From cross checking with the actual profits received from available factory data (factory D, I and N), it confirmed that the estimations from related data provided the reliable data because the estimated profits match with the actual profits.

Total actual sale of the surveyed factories is of 5,825 million Baht per year while the total production cost is of 5,122 million Baht/year. Therefore, the profit of surveyed palm oil factories is of 703 million Baht/year.

As per kgCPO unit, palm oil factories have production cost of 9.6-11.6 Baht/kgCPO and gain profit of 0.41-2.42 Baht/kgCPO typically.

The difference of profits under plant operations is the production cost as discussed in ***section 4.1.3***, Thai palm oil production cost structure.

For case B; with CPO cost is equal to the average domestic market cost, 10.89 Baht/kgCPO, the economic performance estimation is shown in ***Table 4.10***.

Table 4.9 Economic Performance Analysis of Surveyed Palm Oil Mill Factories

CASE A: FFB Cost = **1.5** Baht/kgFFB (average value of year 2001, estimated from palm oil factory records)

CPO Cost = **12.0** Baht/kgCPO (average value of year 2001, estimated from palm oil factory records)

No.	Factory	Raw Material Consumption (tonFFB)	CPO Extraction Efficiency (%)	CPO Production (ton)	Actual Sale (Bath)	Production Cost (Bath/kgCPO)			Total Productio Cost (Bath)	Profit (Baht)	Actual Profit (Baht)	Profit per CP (Baht/kgCPO)	Profit per CPO Cost (%)
						Fixed Cost	Raw Material	Total					
Column		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	Factory A	153,300	17.3	26,506	318,066,840	1.3	8.7	10.0	265,055,700	53,011,140	-	2.00	16.67
2	Factory B	186,900	18.0	33,642	403,704,000	1.3	8.3	9.6	322,963,200	80,740,800	-	2.40	20.00
3	Factory C	216,000	17.0	36,720	440,640,000	1.8	8.8	10.6	389,232,000	51,408,000	-	1.40	11.67
4	Factory D	315,800	18.0	56,844	682,128,000	1.8	8.3	10.1	574,124,400	108,003,600	~ 104,000,000	1.90	15.83
5	Factory E	193,100	16.5	31,862	382,338,000	2.0	9.1	11.1	353,662,650	28,675,350	-	0.90	7.50
6	Factory F	168,000	17.0	28,560	342,720,000	1.6	8.8	10.4	297,024,000	45,696,000	-	1.60	13.33
7	Factory G	270,000	17.0	45,900	550,800,000	2.0	8.8	10.8	495,720,000	55,080,000	-	1.20	10.00
8	Factory H	288,000	17.0	48,960	587,520,000	2.3	8.8	11.1	543,456,000	44,064,000	-	0.90	7.50
9	Factory I	216,000	17.0	36,720	440,640,000	1.8	8.8	10.6	389,232,000	51,408,000	~ 50,000,000	1.40	11.67
10	Factory J	216,000	16.0	34,560	414,720,000	2.0	9.4	11.4	393,984,000	20,736,000	-	0.60	5.00
11	Factory K	91,400	17.5	15,995	191,937,001	1.9	8.6	10.5	167,944,876	23,992,125	-	1.50	12.50
12	Factory L	201,200	17.0	34,204	410,448,000	1.2	8.8	10.0	342,040,000	68,408,000	-	2.00	16.67
13	Factory M	162,000	16.5	26,730	320,760,000	1.7	9.1	10.8	288,684,000	32,076,000	-	1.20	10.00
14	Factory N	148,800	15.8	23,436	281,232,000	0.9	9.5	10.4	243,734,400	37,497,600	36,627,000	1.60	13.33
15	Factory O	29,100	16.5	4,802	57,618,000	2.5	9.1	11.6	55,697,400	1,920,600	Lost	0.40	3.33
Total		**2,855,600**		**485,439**	**5,825,271,841**				**5,122,554,626**	**702,717,215**			
Average			**16.9**			**1.7**	**8.9**	**10.6**	**341,503,642**	**46,847,814**		**1.40**	**11.67**
Standard Deviation			**0.6**			**0.4**	**0.3**	**0.6**	**135,873,164**	**25,868,574**		**0.55**	**4.61**
Minimum		**29,100**	**15.8**	**4,802**	**57,618,000**	**0.9**	**8.3**	**9.6**	**55,697,400**	**1,920,600**		**0.40**	**3.33**
Maximum		**315,800**	**18.0**	**56,844**	**682,128,000**	**2.5**	**9.5**	**11.6**	**574,124,400**	**108,003,600**		**2.40**	**20.00**

Note: (3) = (1) x (2) / 10

(4) = (3) x Average CPO Cost (refer to *eq.4.1*)

(5) = Transportation + Feul/Energy + Labors + Others (refer to *table 4.3*)

(6) = Average FFB Cost x 100 / (2)

(7) = (5) + (6)

(8) = (7) x (3) x 1000 (refer to *eq. 4.2*)

(9) = (4) - (8) (refer to *eq. 4.3*)

(10) = actual data from the factory interviews and stock market.

(11) = (3) / (9) / 1000

(12) = (11) / Average CPO Cost x 100

Table 4.10 Economic Preformance Analysis of Surveyed Palm Oil Mill Factories

CASE B: FFB Cost = **1.50** Baht/kgFFB (average value of year 2001, estimated from palm oil factory records)

CPO Cost = **10.89** Baht/kgCPO (average domestic market cost of year 2001,)

No.	Factory	Raw Material Consumption (tonFFB)	CPO Extraction Efficiency (%)	CPO Production (ton)	Actual Sale (Bath)	Production Cost (Bath/kgCPO)			Total Production Cost (Bath)	Profit (Baht)	Actual Profit (Baht)	Profit per CPO (Baht/kgCPO)	Profit per CPO Cost (%)
						Fixed Cost	Raw Material	Total					
Column		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	Factory A	153,300	17.3	26,506	288,645,657	1.3	8.7	10.0	264,407,241	24,238,416	-	0.91	8.40
2	Factory B	186,900	18.0	33,642	366,361,380	1.3	8.3	9.6	324,084,600	42,276,780	-	1.26	11.54
3	Factory C	216,000	17.0	36,720	399,880,800	1.8	8.8	10.6	390,096,000	9,784,800	-	0.27	2.45
4	Factory D	315,800	18.0	56,844	619,031,160	1.8	8.3	10.1	576,019,200	43,011,960	~ 104,000,000	0.76	6.95
5	Factory E	193,100	16.5	31,862	346,971,735	2.0	9.1	11.1	353,373,000	- 6,401,265	-	- 0.20	- 1.84
6	Factory F	168,000	17.0	28,560	311,018,400	1.6	8.8	10.4	297,696,000	13,322,400	-	0.47	4.28
7	Factory G	270,000	17.0	45,900	499,851,000	2.0	8.8	10.8	496,800,000	3,051,000	-	0.07	0.61
8	Factory H	288,000	17.0	48,960	533,174,400	2.3	8.8	11.1	- 544,608,000	- 11,433,600	-	- 0.23	- 2.14
9	Factory I	216,000	17.0	36,720	399,880,800	1.8	8.8	10.6	390,096,000	9,784,800	~ 50,000,000	0.27	2.45
10	Factory J	216,000	16.0	34,560	376,358,400	2.0	9.4	11.4	393,120,000	- 16,761,600	-	- 0.49	- 4.45
11	Factory K	91,400	17.5	15,995	174,182,828	1.9	8.6	10.5	167,490,025	6,692,803	-	0.42	3.84
12	Factory L	201,200	17.0	34,204	372,481,560	1.2	8.8	10.0	342,844,800	29,636,760	-	0.87	7.96
13	Factory M	162,000	16.5	26,730	291,089,700	1.7	9.1	10.8	288,441,000	2,648,700	-	0.10	0.91
14	Factory N	148,800	15.8	23,436	255,218,040	0.9	9.5	10.4	244,292,400	10,925,640	36,627,000	0.47	4.28
15	Factory O	29,100	16.5	4,802	52,288,335	2.5	9.1	11.6	55,653,750	- 3,365,415	Lost	- 0.70	- 6.44
Total		**2,855,600**		**485,439**	**5,286,434,196**				**5,129,022,016**	**157,412,180**			
Average			**16.9**			**1.7**	**8.9**	**10.6**	**341,934,801**	**10,494,145**		**0.28**	**2.59**
Standard Deviation			**0.6**			**0.4**	**0.3**	**0.5**	**136,359,666**	**17,858,023**		**0.54**	**4.99**
Minimum		**29,100**	**15.8**	**4,802**	**52,288,335**	**0.9**	**8.3**	**9.6**	**55,653,750**	**- 16,761,600**		**- 0.70**	**- 6.44**
Maximum		**315,800**	**18.0**	**56,844**	**619,031,160**	**2.5**	**9.5**	**11.6**	**576,019,200**	**43,011,960**		**1.26**	**11.54**

Note: (3) = (1) x (2) / 1

(4) = (3) x Average CPO Cost (refer to *eq.4.1*)

(5) = Transportation + Feul/Energy + Labors + Others (refer to *table 4.3*)

(6) = Average FFB Cost x 100 / (2)

(7) = (5) + (6)

(8) = (7) x (3) x 1000 (refer to *eq. 4.2*)

(9) = (4) - (8) (refer to *eq. 4.3*)

(10) = actual data from the factory interviews and stock market.

(11) = (3) / (9) / 1000

(12) = (11) / Average CPO Cost x 100

Total actual sale of the surveyed factories is of 5,286 million Baht per year while the total production cost is of 5,122 million Baht/year. Therefore, the total profit of surveyed palm oil factories is of 164 million Baht/year. However, there are 4 factories that take a loss if CPO cost is of 10.89 Baht/kgCPO. As per kgCPO unit, palm oil factories have production cost of 9.6-11.6 Baht/kgCPO and gain profit/loss of -0.70 - 1.31 Baht/kgCPO typically.

However, this condition hardly occurred due to the FFB price is depended on CPO cost. If in year 2001 all CPO product was sold in the domestic market with average cost of 10.89 Baht/kgCPO, the FFB price also equals to the average domestic market cost, 1.19 Baht/kgFFB, as reported by Office of Agricultural Economy, Ministry of Agriculture and Cooperatives, 2001. The economic performance calculation of case B by substituting FFB price = 1.19 Baht/kgFFB and CPO cost = 10.89 Baht/kgCPO is shown in ***Table 4.11***.

From ***Table 4.11***, total actual sale of the surveyed factories is of 5,286 million Baht per year while the total production cost is of 4,244 million Baht/year. Therefore, the total profit of surveyed palm oil factories is of 1,043 million Baht/year. This performance indicated that the palm oil mill factories are not affected from the variation of CPO cost. The palm oil mill often keeps profit by setting the FFB price according to the CPO cost. As per kgCPO unit, palm oil factories have production cost of 7.9-9.7 Baht/kgCPO and gain profit of 1.18-2.98 Baht/kgCPO typically. Thus, case B is not a worst case for the study on impacts of EC on the palm oil mill factories.

4.2.2 Relationship between CPO Cost and FFB price

Prior to an analysis of impacts of EC on palm oil mill industry, the FFB and CPO cost relationships should be determined to anticipate the economic performance due to the movements of market FFB and CPO costs and the impacts of EC on profit/loss.

Table 4.11 Economic Preformance Analysis of Surveyed Palm Oil Mill Factories

CASE B: FFB Cost = *1.19* Baht/kgFFB (average domestic market cost of year 2001,)

CPO Cost = *10.89* Baht/kgCPO (average domestic market cost of year 2001,)

No.	Factory	Raw Material Consumption (tonFFB)	CPO Extraction Efficiency (%)	CPO Production (ton)	Actual Sale (Bath)	Production Cost (Bath/kgCPO)			Total Production Cos (Bath)	Profit (Baht)	Actual Profit (Baht)	Profit per CPO (Baht/kgCPO)	Profit per CPO Cost (%)
						Fixed Cost	Raw Material	Total					
Column		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1.	Factory	153,300	17.3	26,506	288,645,657	1.3	6.9	8.2	216,884,241	71,761,416	-	2.71	24.86
2	Factory	186,900	18.0	33,642	366,361,380	1.3	6.6	7.9	266,145,600	100,215,780	-	2.98	27.35
3	Factory	216,000	17.0	36,720	399,880,800	1.8	7.0	8.8	323,136,000	76,744,800	-	2.09	19.19
4	Factory	315,800	18.0	56,844	619,031,160	1.8	6.6	8.4	478,121,200	140,909,960	~ 104,000,000	2.48	22.76
5	Factory	193,100	16.5	31,862	346,971,735	2.0	7.2	9.2	293,512,000	53,459,735	-	1.68	15.41
6	Factory	168,000	17.0	28,560	311,018,400	1.6	7.0	8.6	245,616,000	65,402,400	-	2.29	21.03
7	Factory	270,000	17.0	45,900	499,851,000	2.0	7.0	9.0	413,100,000	86,751,000	-	1.89	17.36
8	Factory	288,000	17.0	48,960	533,174,400	2.3	7.0	9.3	455,328,000	77,846,400	-	1.59	14.60
9	Factory I	216,000	17.0	36,720	399,880,800	1.8	7.0	8.8	323,136,000	76,744,800	~ 50,000,000	2.09	19.19
10	Factory J	216,000	16.0	34,560	376,358,400	2.0	7.4	9.4	326,160,000	50,198,400	-	1.45	13.34
11	Factory	91,400	17.5	15,995	174,182,828	1.9	6.8	8.7	139,156,025	35,026,803	-	2.19	20.11
12	Factory	201,200	17.0	34,204	372,481,560	1.2	7.0	8.2	280,472,800	92,008,760	-	2.69	24.70
13	Factory	162,000	16.5	26,730	291,089,700	1.7	7.2	8.9	238,221,000	52,868,700	-	1.98	18.16
14	Factory	148,800	15.8	23,436	255,218,040	0.9	7.6	8.5	198,164,400	57,053,640	36,627,000	2.43	22.35
15	Factory	29,100	16.5	4,802	52,288,335	2.5	7.2	9.7	46,632,750	5,655,585	Lost	1.18	10.82
Total		**2,855,600**		**485,439**	**5,286,434,196**				**4,243,786,016**	**1,042,648,180**			
Average			**16.9**			**1.7**	**7.0**	**8.8**	**282,919,068**	**69,509,879**		**2.11**	**19.42**
Standard Deviation			**0.6**			**0.4**	**0.3**	**0.5**	**113,927,401**	**30,902,481**		**0.50**	**4.63**
Minimum		**29,100**	**15.8**	**4,802**	**52,288,335**	**0.9**	**6.6**	**7.9**	**46,632,750**	**5,655,585**		**1.18**	**10.82**
Maximum		**315,800**	**18.0**	**56,844**	**619,031,160**	**2.5**	**7.6**	**9.7**	**478,121,200**	**140,909,960**		**2.98**	**27.35**

Note: (3) = (1) x (2) / 100

(4) = (3) x Average CPO Cost (refer to *eq.4.1*)

(5) = Transportation + Feul/Energy + Labors + Others (refer to *table 4.3*)

(6) = Average FFB Cost x 100 / (2)

(7) = (5) + (6)

(8) = (7) x (3) x 1000 (refer to *eq. 4.2*)

(9) = (4) - (8) (refer to *eq. 4.3*)

(10) = actual data from the factory interviews and stock market.

(11) = (3) / (9) / 1000

(12) = (11) / Average CPO Cost x 100

The relationships between CPO costs and FFB prices are analyzed according to the production cost (CP) and actual sale (AS) of each factory by using the ***Equation 4.1***, ***Equation 4.2*** and ***Equation 4.3*** as defined in ***section 4.2.1*** and calculation sheet is shown in ***Table 4.9***. By varying FFB price between 1.5 - 3.5 Baht/kgFFB and CPO cost between 10 - 25 Baht/kgCPO (as a historical market cost of FFB and CPO shown in ***Table 2.6*** in ***Chapter 2)*** The relationships between FFB price, CPO cost and profit could be calculated as shown in ***Table 4.12***.

From ***Table 4.12***, the values of estimated FFB price, CPO Cost, and profit could be expressed as shown in ***Figure 4.4.***

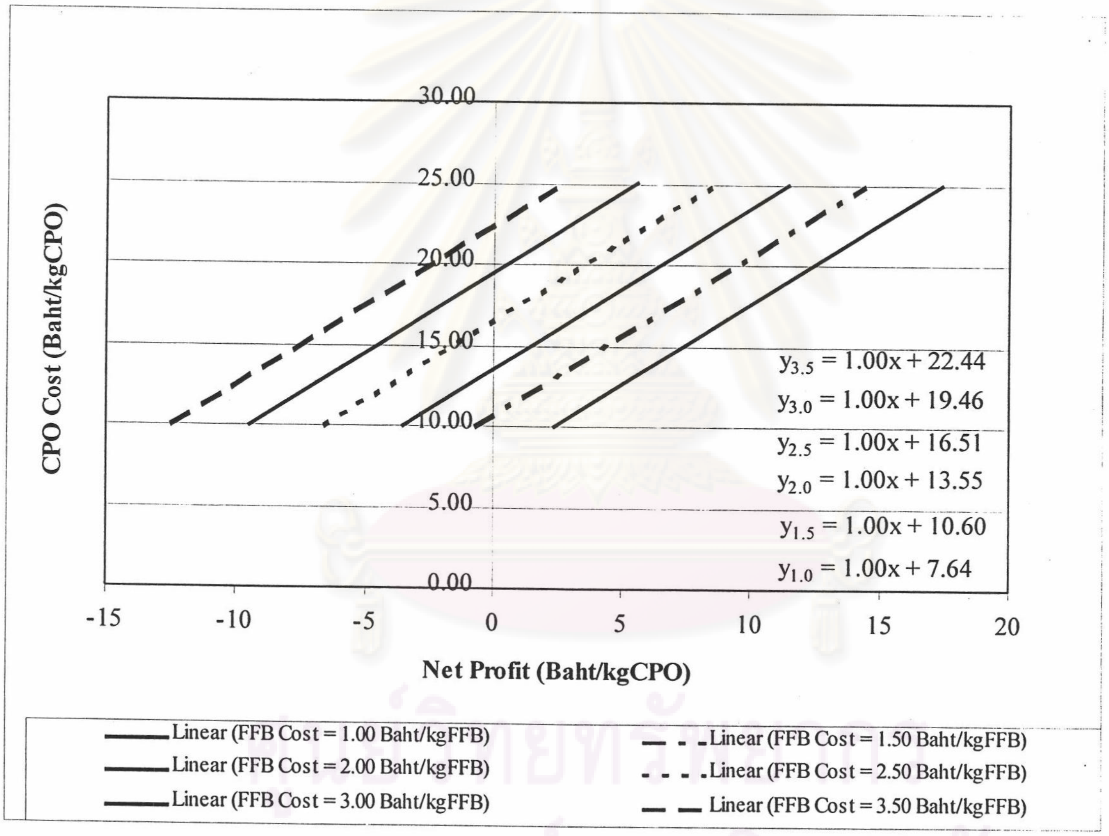


Figure 4.4 Relationships between FFB price, CPO cost and Profit

Table 4.12 Estimation of Average FFB Cost, CPO cost, and Profit

FFB $Cost_{avg}$ (Baht/kgFFB)	CPO $Cost_{avg}$ (Baht/kgCPO)	Net $Profit_{avg}$ (Baht/kgCPO)	FFB $Cost_{avg}$ (Baht/kgFFB)	CPO $Cost_{avg}$ (Baht/kgCPO)	Net $Profit_{avg}$ (Baht/kgCPO)
1.00	10.00	2.36	1.50	10.00	-0.60
1.00	15.00	7.36	1.50	15.00	4.40
1.00	20.00	12.36	1.50	20.00	9.40
1.00	25.00	17.36	1.50	25.00	14.40
2.00	10.00	-3.55	2.50	10.00	-6.51
2.00	15.00	1.45	2.50	15.00	-1.51
2.00	20.00	6.45	2.50	20.00	3.49
2.00	25.00	11.45	2.50	25.00	8.49
3.00	10.00	-9.46	3.50	10.00	-12.42
3.00	15.00	-4.46	3.50	15.00	-7.42
3.00	20.00	0.54	3.50	20.00	-2.42
3.00	25.00	5.54	3.50	25.00	2.54

The equations of FFB price, CPO cost and profit from ***Figure 4.4*** are as below:

Y_1 = $X_1 + 22.40$, when FFB price = 3.5 Baht/kgFBB .... (4.4)

Y_2 = $X_2 + 19.46$, when FFB price = 3.0 Baht/kgFBB .... (4.5)

Y_3 = $X_3 + 16.51$, when FFB price = 2.5 Baht/kgFBB .... (4.6)

Y_4 = $X_4 + 13.55$, when FFB price = 2.0 Baht/kgFBB .... (4.7)

Y_5 = $X_5 + 10.60$, when FFB price = 1.5 Baht/kgFBB .... (4.8)

Y_6 = $X_6 + 7.64$, when FFB price = 1.0 Baht/kgFBB .... (4.9)

When Y_n = CPO cost (Baht/kgCPO)

X_n = Profit (Baht/kgCPO)

The interception values at profit = 0, are determined from ***Figure 4.4*** which represent the minimum CPO cost (Y) or minimum market price. ***Table 4.13*** shows the values of minimum CPO costs at variation of FFB prices in the range of 1.0 - 3.5 Baht/kgFFB, by substituting profit, X = 0 in ***Equation 4.4 - Equation 4.9***, the FFB prices and minimum CPO costs at profit = 0.

Table 4.13 Minimum CPO Cost (Y) for profit = 0

FFB price (Baht/kgFFB)	Minimum CPO Cost (Baht/kgCPO)
3.5	22.40
3.0	19.46
2.5	16.51
2.0	13.55
1.5	10.60
1.0	7.64

From above relationships (***Table 4.13***), it could be developed a linear equation of FFB price and minimum CPO cost at profit = 0, as shown in ***Figure 4.5***.

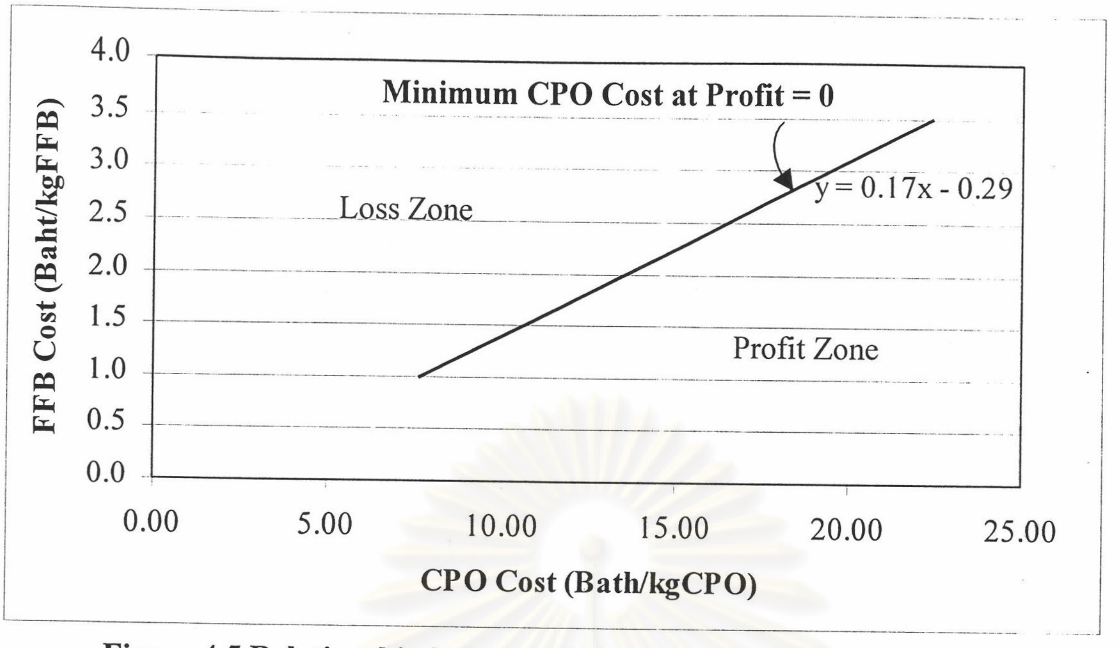


Figure 4.5 Relationship between CPO cost and FFB price at Profit = 0

4.3 Impacts of EC Scheme

Thailand is a member of Asian Free Trade Area (AFTA). Following to the AFTA agreement, Thai has to transfer palm oil items from the Temporary Exclusion List (TIL) to a Fast Track class of the Inclusion List (IL) and reducing import tax to 20% within year 2000. Within year 2003, Thailand has to reduce import tax to 0-5% following to AFTA agreement. Nevertheless, Malaysia excuses itself from including CKD-CKB cars in the IL. Thus, Thailand decides to delay entering palm oil in to the IL on grounds that the industry is not ready. However, Thai palm oil industry has to develop the production efficiency for competitive ability in world market due to higher production cost compared to Malaysia and Indonesia. The government also has to issue urgent measures to minimize the effects of a steady downturn of palm oil price, as well as to plan long-term measures for production restructuring. From the Siam Commercial Bank (SCB) Research Institute report, 2000, it identified that the impact of the production restructuring could cause some unadjustable planters and palm oil millers to close their plantations and mills. The government ought to make preparations for their rehabilitation.

Accordingly, the study on impacts of EC scheme has to consider separately into 2 cases: with AFTA obligation and without AFTA obligation implementation due to the international trade policy has a significant effect to the performance of palm oil mill industry. The analysis will be presented in the later section.

The impacts of emission charge system are analyzed based on DIW proposed ***Equation 4.10***:

$$EC = f \times c \times B \quad \text{.......... 4.10}$$

When f = Arbitrary coefficient for policy rate adjustment, this study assigns $f = 1$.

c = coefficient of charge per BOD load (Baht/kgBOD), which is set at 35 Baht/kgBOD, reflects the 90 percent level of pollution abatement cost.

B = effluent BOD load (kg/year), in case of palm oil industry, the effluent equal to the final pond wastewater.

4.3.1 Without AFTA Obligation Implementation

Without AFTA obligation implementation, the study analysis is based on the economic performance of palm oil mill factories in year 2001. The EC calculations using ***Equation 4.10*** are based on 2 types of wastewater applications: BOD load of pond storage and BOD load of land application.

BOD load of pond storage is calculated with $f = 1$ following to assumption described in ***Section 4.1.6*** that overall BOD load of pond storage is charged under EC. If factories do not agree to that calculation, they have to prove for their storage capacity by third party monitor.

According to proposed EC notification, land applications are not under EC scheme, if it is approved by the responsible governments. By this study, however, the land application is included in EC scheme but with the variation of coefficient f. It is because the appropriate BOD load limits of land application still are not set up by the responsible government. In the earlier stage of EC implementation, land application still can not approved by any government. The study on the appropriate level of coefficient *f* for land application has to be identified. Such level should not effect to the economic performance of factories and they are willing to pay.

At *f* = 1, it indicates that EC strongly effect to palm oil mill factories. Over 90 % (14 factories out of 15 surveyed factories) will burden with EC per profit more than 10% (10.2–323%). Such level of EC is not accepted by factories. From the interviews with palm oil mill factories for their willingness to pay, it indicated that most factories prefer to pay for EC without impacts on their economic performance at *f* = 0.1

At *f* = 0.1, Over 70% (11 factories out of 15 surveyed factories) will be levied for EC per profit of less than 10% (0.9 – 4.4%). There are only 4 factories that burden with EC per profit of more than 10% (10.2-323%). Those 4 factories have stored their wastewater in pond system and have not employed aerobic treatment system to abate the residue BOD load from anaerobic treatment system.

From the factory interviews, the level of EC that the palm oil mill factories agree and not burden to their economic performance is of 5% of their profits.

The impact analysis of EC on palm oil mill factories with *f* = 1.0 and *f* = 0.1 for land application and *f* =1.0 for pond storage are shown in ***Table 4.14***.

For the responses of palm oil factories to EC implementation, they plan for the improvements as below:

- 87% of palm oil factories will apply wastewater for irrigation and recycling to reduce wastewater discharge.

Table 4.14 Impact Analysis of Emission Charge on Palm Oil Mill Industry (Without AFTA Obligation Implementation)

No.	Factory	CPO Production (tonCPO/yr)	Profit (Baht)	Profit per CP (Baht/kgCPO)	BOD Load for Land Applicatio (kg/yr)	BOD Load in Final Pond (kg/yr)	EC of Land Application (Baht/yr)		EC of Final Pond (Baht/yr	Total EC (Baht/yr)		Profit (Baht/yr)		EC per Profit (%)	
							f = 1.0	f = 0.1		f = 1.0	f = 0.1	f = 1.0	f = 0.1	f = 1.0	f = 0.1
Column		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	Factory A	26,506	53,011,140	2.0	275,940	-	9,657,900	965,790	-	9,657,900	965,790	43,353,240	52,045,350	22.3	1.9
2	Factory B	33,642	80,740,800	2.4	467,250	-	16,353,750	1,635,375	-	16,353,750	1,635,375	64,387,050	79,105,425	25.4	2.1
3	Factory C	36,720	51,408,000	1.4	172,800	-	6,048,000	604,800	-	6,048,000	604,800	45,360,000	50,803,200	13.3	1.2
4	Factory D	56,844	108,003,600	1.9	1,136,880	-	39,790,800	3,979,080	-	39,790,800	3,979,080	68,212,800	104,024,520	58.3	3.8
5	Factory E	31,862	28,675,350	0.9	173,790	-	6,082,650	608,265	-	6,082,650	608,265	22,592,700	28,067,085	26.9	2.2
6	Factory F	28,560	45,696,000	1.6	-	11,088	-	-	388,080	388,080	388,080	45,307,920	45,307,920	0.9	0.9
7	Factory G	45,900	55,080,000	1.2	-	337,500	-	-	11,812,500	11,812,500	11,812,500	43,267,500	43,267,500	27.3	27.3
8	Factory H	48,960	44,064,000	0.9	-	720,000	-	-	25,200,000	25,200,000	25,200,000	18,864,000	18,864,000	133.6	133.6
9	Factory I	36,720	51,408,000	1.4	226,800	-	7,938,000	793,800	-	7,938,000	793,800	43,470,000	50,614,200	18.3	1.6
10	Factory J	34,560	20,736,000	0.6	233,280	-	8,164,800	816,480	-	8,164,800	816,480	12,571,200	19,919,520	64.9	4.1
11	Factory K	15,995	23,992,125	1.5	98,712	-	3,454,920	345,492	-	3,454,920	345,492	20,537,205	23,646,633	16.8	1.5
12	Factory L	34,204	68,408,000	2.0	-	181,080	-	-	6,337,800	6,337,800	6,337,800	62,070,200	62,070,200	10.2	10.2
13	Factory M	26,730	32,076,000	1.2	388,800	-	13,608,000	1,360,800	-	13,608,000	1,360,800	18,468,000	30,715,200	73.7	4.4
14	Factory N	23,436	37,497,600	1.6	267,840	-	9,374,400	937,440	-	9,374,400	937,440	28,123,200	36,560,160	33.3	2.6
15	Factory O	4,802	1,920,600	0.4	-	41,904	-	-	1,466,640	1,466,640	1,466,640	453,960	453,960	323.1	323.1
Total		485,439	702,717,215		3,442,092	1,291,572	120,473,220	12,047,322	45,205,020	165,678,240	57,252,342	537,038,975	645,464,873		
Average			46,847,814	1.4	229,473	86,105	8,031,548	803,155	3,013,668	11,045,216	3,816,823	35,802,598	43,030,992	56.6	34.7
Std.			25,868,574	0.6	292,241	199,242	10,228,419	1,022,842	6,973,478	10,068,929	6,670,003	20,272,845	25,791,316	81.0	86.6
Minimum		4,802	1,920,600	0.4	-	-	-	-	-	388,080	345,492	453,960	453,960	0.9	0.9
Maximum		56,844	108,003,600	2.4	1,136,880	720,000	39,790,800	3,979,080	25,200,000	39,790,800	25,200,000	68,212,800	104,024,520	323.1	323.1

Note: (1), (2), and (3) = from *table 4.9*

(4), and (5) = from *table 4.5*

(6) = (4) x 35 , from ***eq.4.10*** and substitued ***f = 1***

(7) = (4) x 35 , from ***eq.4.10*** and substitued ***f = 0.1***

(8) = (5) x 35, from ***eq.4.10*** and substitued ***f = 1***

(10) = (7) + (8)

(11) = (2)-(9)

(12) = (2)-(10)

(13) = (9) / (11) x 100

(14) = (10) / (12) x 100

- 67% of the factories plan to improve and modify production process to reduce BOD load.
- 40% of the factories plan to improve and/or increase wastewater treatment capacity to abate BOD concentration.
- 20% of the factories plan to install new equipment to reduce BOD load.

Following to the options that factories expect to do, they avoid to invest on high cost options but select to apply cleaner technology, pollution prevention options.

With the options that factories expect to do, it can believe that EC application would achieve on decreasing overall BOD load from palm oil factories. The important circumstances that responsible government agencies have to research and develop prior to an implementation of EC. The appropriate dosage and characteristic of wastewater applied for irrigation have to be identified due to palm oil industry have been prohibited to discharge wastewater out of factory, but given permission for irrigation. Land applications can significantly reduce EC that factories would pay. As shown in ***Table 4.14*** with $f = 0.1$, the factories that utilized their wastewater for land application will be levied by EC much lower than that stored wastewater in ponds.

4.3.2 With AFTA Obligation Implementation

With AFTA obligation implementation, the domestic CPO cost and world CPO cost will has no difference. Thai palm oil mill factories have to sell CPO at the world CPO cost. Therefore, the implementation of AFTA obligation analyses will present the CPO cost by world market cost.

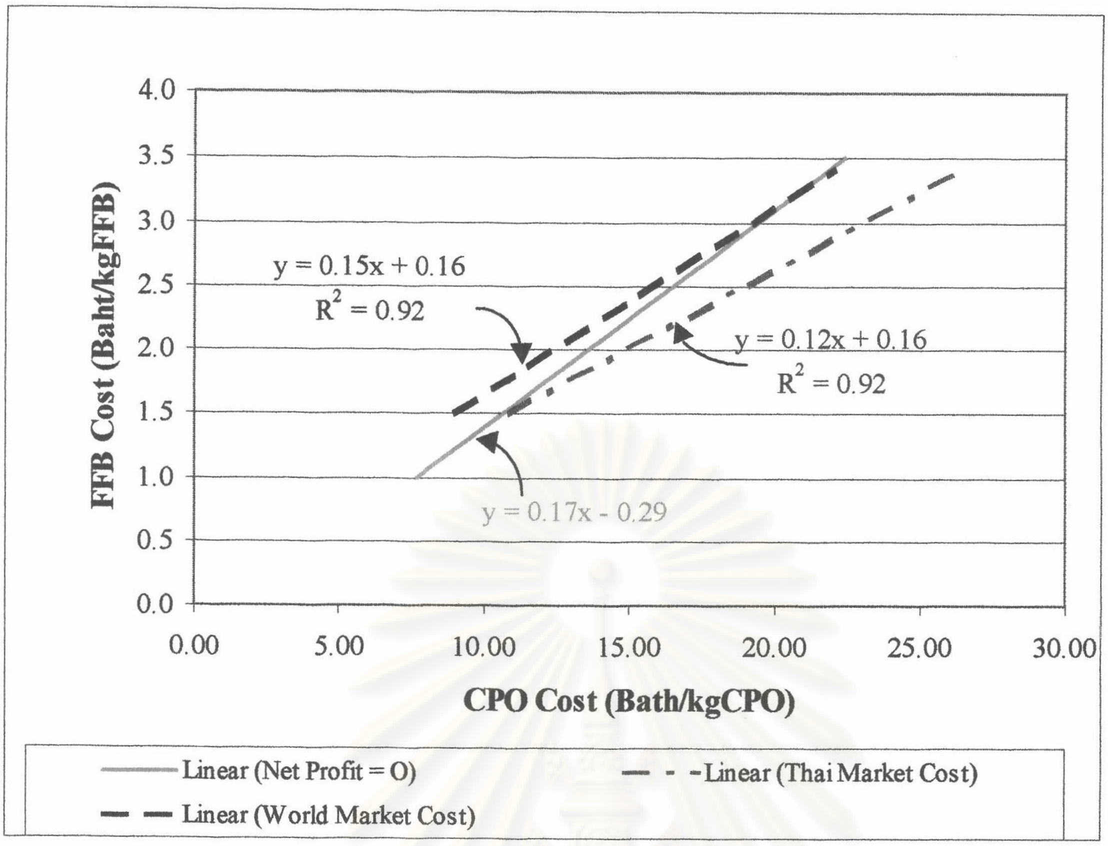


Figure 4.6 FFB price and CPO Cost of Thai and World Market Cost

From ***Figure 4.6***, the solid line represents the FFB and CPO cost with profit = 0 based on the equation synthesized from surveyed information (from ***Figure 4.5***). As existing condition have unemployed AFTA obligation, the FFB and CPO costs relationships in Thai or domestic market is under the solid line. It is expressed that current palm oil mill industry gain profits. However, the existing Thai market cost of CPO is higher than world market cost (refer to Malaysia market). If there is no tax barrier, according to AFTA agreement, Thai palm oil market will be expressed by the upper dotted line. At that situation, the industry could be run at loss because of the FFB and CPO cost relationships are stated closely to the line which the profit = 0.

Thai has rose CPO cost that imported from other countries by a 20% tax. From this policy, the difference of domestic CPO cost and world CPO cost is of 20% on average. To fine out the relationships of the world CPO cost and FFB price, the 20% incremental has to be deleted from domestic CPO cost. The equation of world CPO cost and FFB price from ***Figure 4.6*** is as below:

$$Y = 0.15\,X + 0.16 \quad \dots\dots \quad 4.11$$

When Y = FFB price (Bath/kgFFB)

X = CPO Cost (Baht/kgCPO)

The analysis of palm oil mill economic performance is based on the average FFB price of 1.5 Baht/kgFFB, according to factory surveyed data. By substituting Y = 1.5 in ***Equation 4.11***, then the average CPO cost of the world market cost, X, is of 8.9 Baht/kgCPO. Accordingly, the impact of EC on palm oil mill industry with AFTA obligation case analysis is shown in ***Table 4.15***.

From ***Table 4.15***, if Thai palm oil mill industry has to sell the CPO at world market cost, all factories will be burdened with loss condition. It can be concluded that if AFTA obligation is applied, the Thai palm oil mill industry will be severely affected from EC implementation. With AFTA obligation, EC scheme is not feasible to be implemented on palm oil mill industry. The responsible governments have to plan for the support on palm oil farmers, palm oil mills and palm oil refineries to protect those large valuable industries from shutting down their processes.

The governments also have to consider on the incentives for factories to abate their pollution without burden to their economic performance and their competitive ability in word market. The subsidy for research and development on such as palm oil breed, oil extraction capacity, waste reduction/waste minimization/cleaner technology, wastewater application for irrigation and wastewater treatment technology should be engaged to improve overall productivity and environment.

Table 4.15 Impact Analysis of Emission Charge on Palm Oil Mill Industry (With AFTA Obligation Implementation)

FFB Cost = 1.50 (average value of year 2001, estimated from palm oil factory accounts)

CPO Cost = 8.90 (CPO cost with AFTA obligation implementation)

No.	Factory	CPO Production (tonCPO/yr)	Profit (Baht)	Profit per CPO (Baht/kgCPO)	BOD Load for Land Application (kg/yr)	BOD Load in Final Pond (kg/yr	EC of Land Application (Baht/yr)		EC of Final Pond (Baht/yr)	Total EC (Baht/yr)		Profit (Baht/yr)		EC per Profit (%)	
							f = 1.0	f = 0.1		f = 1.0	f = 0.1	f = 1.0	f = 0.1	f = 1.0	f = 0.1
Column		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	Factory A	26,506	-29,156,127	-1.1	275,940	-	9,657,900	965,790	-	9,657,900	965,790	-38,814,027	-30,121,917	-24.9	-3.2
2	Factory B	33,642	-23,549,400	-0.7	467,250	-	16,353,750	1,635,375	-	16,353,750	1,635,375	-39,903,150	-25,184,775	-41.0	-6.5
3	Factory C	36,720	-62,424,000	-1.7	172,800	-	6,048,000	604,800	-	6,048,000	604,800	-68,472,000	-63,028,800	-8.8	-1.0
4	Factory D	56,844	-68,212,800	-1.2	1,136,880	-	39,790,800	3,979,080	-	39,790,800	3,979,080	-108,003,600	-72,191,880	-36.8	-5.5
5	Factory E	31,862	-70,095,300	-2.2	173,790	-	6,082,650	608,265	-	6,082,650	608,265	-76,177,950	-70,703,565	-8.0	-0.9
6	Factory F	28,560	-42,840,000	-1.5	-	11,088	-	-	388,080	388,080	388,080	-43,228,080	-43,228,080	-0.9	-0.9
7	Factory G	45,900	-87,210,000	-1.9	-	337,500	-	-	11,812,500	11,812,500	11,812,500	-99,022,500	-99,022,500	-11.9	-11.9
8	Factory H	48,960	-107,712,000	-2.2	-	720,000	-	-	25,200,000	25,200,000	25,200,000	-132,912,000	-132,912,000	-19.0	-19.0
9	Factory I	36,720	-62,424,000	-1.7	226,800	-	7,938,000	793,800	-	7,938,000	793,800	-70,362,000	-63,217,800	-11.3	-1.3
10	Factory J	34,560	-86,400,000	-2.5	233,280	-	8,164,800	816,480	-	8,164,800	816,480	-94,564,800	-87,216,480	-8.6	-0.9
11	Factory K	15,995	-25,591,600	-1.6	98,712	-	3,454,920	345,492	-	3,454,920	345,492	-29,046,520	-25,937,092	-11.9	-1.3
12	Factory L	34,204	-37,624,400	-1.1	-	181,080	-	-	6,337,800	6,337,800	6,337,800	-43,962,200	-43,962,200	-14.4	-14.4
13	Factory M	26,730	-50,787,000	-1.9	388,800	-	13,608,000	1,360,800	-	13,608,000	1,360,800	-64,395,000	-52,147,800	-21.1	-2.6
14	Factory N	23,436	-35,154,000	-1.5	267,840	-	9,374,400	937,440	-	9,374,400	937,440	-44,528,400	-36,091,440	-21.1	-2.6
15	Factory O	4,802	-12,964,050	-2.7	-	41,904	-	-	1,466,640	1,466,640	1,466,640	-14,430,690	-14,430,690	-10.2	-10.2
Overall		485,439	-802,144,677		3,442,092	1,291,572	120,473,220	12,047,322	45,205,020	165,678,240	57,252,342	-967,822,917	-859,397,019		
Average			-53,476,312	-1.7	229,473	86,105	8,031,548	803,155	3,013,668	11,045,216	3,816,823	-64,521,528	-57,293,135	-16.7	-5.5
Std.			27,294,902	0.6	292,241	199,242	10,228,419	1,022,842	6,973,478	10,068,929	6,670,003	32,903,320	31,921,678	11.0	5.8
Minimum		4,802	-107,712,000	-2.7	-	-	-	-	-	388,080	345,492	-132,912,000	-132,912,000	-41.0	-19.0
Maximum		56,844	-12,964,050	-0.7	1,136,880	720,000	39,790,800	3,979,080	25,200,000	39,790,800	25,200,000	-14,430,690	-14,430,690	-0.9	-0.9

Note: (1), (2), and (3) = from *table 4.9*

(4), and (5) = from *table 4.5*

(6) = (4) x 35 , from ***eq.4.10*** and substitued $f = 1$

(7) = (4) x 35 , from ***eq.4.10*** and substitued $f = 0.1$

(8) = (5) x 35, from ***eq.4.10*** and substitued $f = 1$

(10) = (7) + (8)

(11) = (2)-(9)

(12) = (2)-(10)

(13) = (9) / (11) x 100

(14) = (10) / (12) x 100

4.4 Emission Level of Palm Oil Mill Industry under EC Scheme

The emission level of palm oil mill industry under EC scheme could be determined from the marginal abatement cost and the EC rate as described in ***Chapter 2, Section 2.1.4***. Factories will reduce emissions until the marginal abatement costs are equal to the emission charge rate.

By input the EC line of 35 Baht/kgBOD or 35,000 Baht/tonBOD into the marginal abatement cost curve, the emission level of palm oil mill industry can be determined from the intersection of MAC and EC.

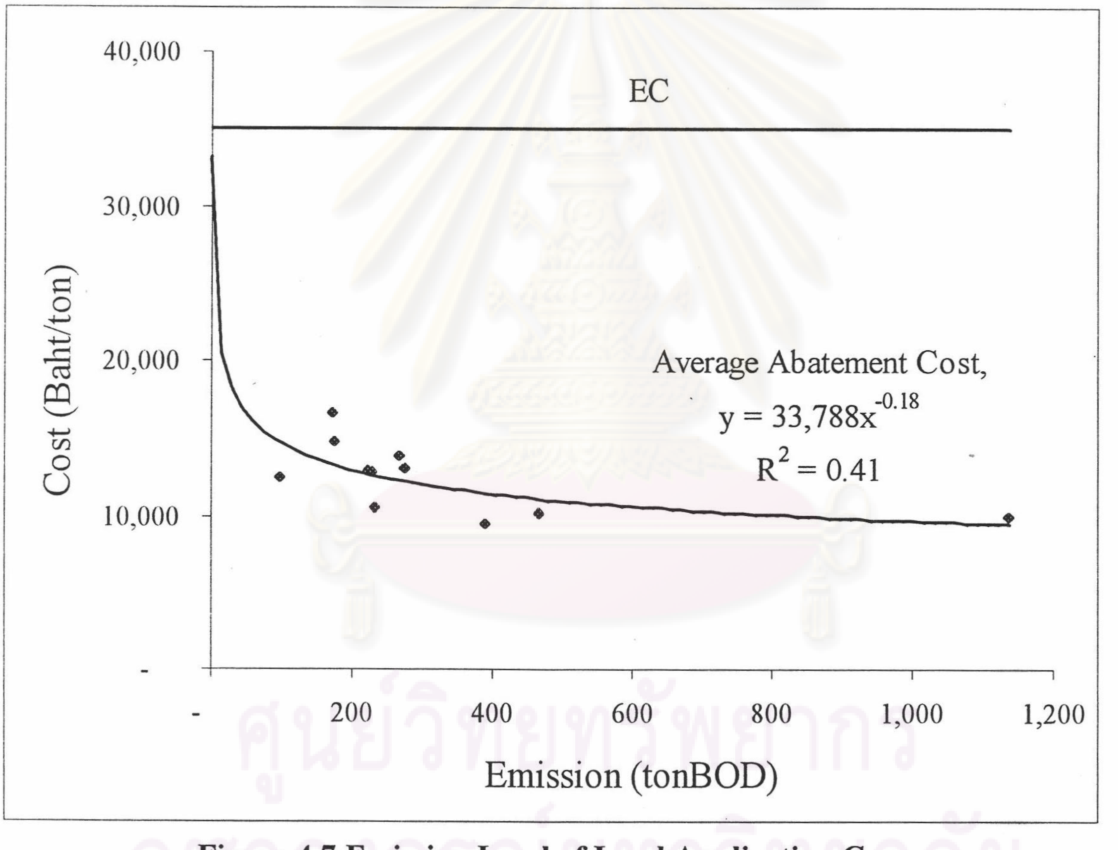


Figure 4.7 Emission Level of Land Application Case

The marginal abatement cost could be determined from the average abatement cost equation (***Figure 4.7***). The emission level of land application case can be analyzed by substituting marginal abatement cost, MAC, with EC rate. The determination of emission level of land application case can be calculated as follows:

$$Y = 33{,}788\ X^{-0.18} \quad \text{.. 4.12}$$

$$\frac{Y'}{X} = 33,788\ X^{-0.18} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 4.13$$

$$Y' = 33,788\ X^{0.82}$$

$$MAC = \frac{dY'}{dX} = \frac{d(33,788X^{0.82})}{dX}$$

$$= (0.82 \times 33,788)X^{(0.82-1)}$$

$$= 27,706X^{(-0.18)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 4.14$$

When Y = Average Abatement Cost (Bath/tonBOD)

Y' = Abatement Cost, MAC (Baht)

X = Emission (tonBOD)

If MAC = 35,000 Bath/tonBOD

$$X = \left(\frac{35,000}{27,706}\right)^{(-1/0.18)}$$

$$= 0.27 \text{ tonBOD}$$

From above calculation, it could be concluded that factories, which use their wastewater for land application, would choose to apply their wastewater for land application until the BOD load is equal to 0.27 tonBOD and would pay the EC for the residue BOD load. Also, the factories which have BOD load less than 0.27 tonBOD would choose to pay the EC instead of applying their wastewater for land application.

From ***Table 4.5***, total BOD load of land application is approximately 3,442 tonBOD/year. It indicated that the factories that apply their wastewater for land application would emit total BOD load equal to 3,442 tonBOD/year, if EC is not implemented. When EC is imposed, the total BOD load of 11 land-application factories is equal to 2.97 tonBOD/year (= 0.27 tonBOD/yeat x 11 factories). The EC provides the factories an incentive to abate their pollution load closely to 100 % reduction (abatement level = [3,442-2.97]/3,442 ≈ 100%).

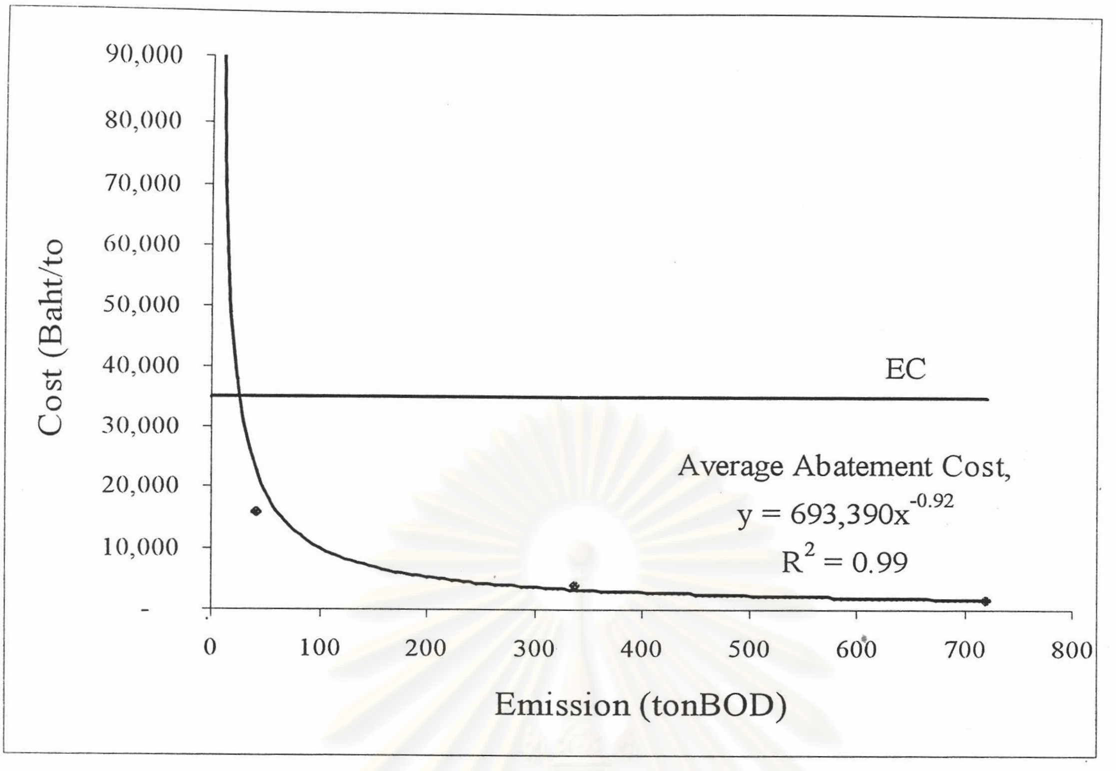


Figure 4.8 Emission Level of Pond Treatment Case

The emission level of pond treatment case can be analyzed by substituting marginal abatement cost, MAC, with the EC rate. The determination of emission level of pond treatment case can be calculated as follows:

$$Y = 693{,}390\ X^{-0.92} \quad \text{.......... } 4.15$$

$$\frac{Y'}{X} = 693{,}390\ X^{-0.92} \quad \text{.......... } 4.16$$

$$Y' = 693{,}390\ X^{0.08}$$

$$MAC = \frac{dY'}{dX} = \frac{d(693{,}390X^{0.08})}{dX}$$

$$= (0.08 \times 693{,}390)X^{(0.08-1)}$$

$$= 55{,}471X^{(-0.92)} \quad \text{.......... } 4.17$$

When Y = Average Abatement Cost (Bath/tonBOD)

Y' = Abatement Cost, (Baht)

X = Emission (tonBOD)

If MAC = 35,000 Bath/tonBOD

$$X = \left(\frac{35{,}000}{55{,}471}\right)^{-(1/0.92)}$$

= 1.65 tonBOD

From above calculation, it could be concluded that factories would choose to treat their wastewater by their own treatment system until the BOD load is equal to 1.65 tonBOD and would pay the EC for the residue BOD load. Also, the factories which have BOD load less that 1.65 tonBOD would choose to pay the EC instead of installing more wastewater treatment system.

From ***Table 4.5***, total BOD load from pond treatment case is approximately 1,292 tonBOD/year. It indicated that the factories that treat their wastewater by their own treatment system would emit total BOD load equal to 1,292 tonBOD/year if EC is not imposed. When EC is imposed, the total BOD load of 4 own-treatment factories is equal to 6.6 tonBOD/year (= 1.65 tonBOD/yeat x 4 factories). The EC provides the factories an incentive to abate their pollution load to 99.5 % reduction.

4.5 Relationships between the Willingness to Pay for EC and other Factors

The willingness to pay for EC of palm oil industry are varied on each factory and cannot be accounted on what level each factory prefer to pay. Factories get use to the system that they have not paid for their emissions. Thus, it is difficult for factories to identify the level of their willingness to pay. However, the factories replied their agreement for the calculated EC in term of agreement or disagreement. By integrating all data from factory surveys, interviews and theirs commends on EC implementation, it could be concluded that the profit, production capacity, the policy maker's education, and existing environmental policy of palm oil mill factories are not significantly influenced to their willingness to pay for emission charge.

The profit levels of each factory are varied by reason of the differences on their production cost. Raw materials, CPO extraction efficiency, and operation cost are the major factors influencing their production cost and profit. Among the well-economic-performance factories, they have differences on agreement in EC payment. Some factories comment that the EC is high, even though they have made a large profit.

According to the existing production capacity of palm oil mills industry is higher than the availability of raw material input, thus, the higher capacity factories are still challenged with lacking of FFB like the lower ones. They can not utilize their maximum capacities, correspondingly, the production capacity of palm oil mill factories has no significant reflection on the their willingness to pay for EC.

In term of policy makers' education, there is no relationship between the willingness to pay and the education. Even if the policy maker has earlier been informed about the polluter-pays-principle and EC implementation, it is not expressed on the influence of policy makers' education to the willingness to pay for EC. It is interesting to note that the factories with no idea on EC payment never have been informed about the polluter-pays-principle and emission charge implementation. It indicated that the government has to educate and promulgate factories before any policy implementation. Acknowledgement on government policy will help factories to design their responses and plan for their management, even though it not encourage their willingness to pay.

The existing environmental policy of palm oil factory is not influenced to the willingness to pay for EC. It may be because the palm oil factories have prohibited for wastewater discharge to environment, even if they have a good environmental policy or not. Well participation in government environmental assistance projects or high investment on environmental concerns not relate to the willingness to pay for EC due to the fact that they may have been settled for the marketing purpose, reducing their production cost or preventing from petitions of communities and inspections of government officers. Moreover, the prohibition for wastewater discharge may influence them to preferably pay EC instead of wastewater storage or irrigation. Wastewater storage and irrigation eventually challenge with community petitions on effects of their overflow, especially in rainy season and concentration on inspection from government officers.

The treatment level or treatment ability of existing treatment system influence to the willingness to pay for EC. The factories that agreed to EC payment often have low effluent BOD concentration, although, they cannot treat to comply with effluent standards. It is interesting that one factory has demonstrated that it can treat wastewater beyond compliance with the effluent standards. Nevertheless, such level will be conducted only for special purpose, such as, reuse or recycle in the plant. With current condition, there is no incentive to treat all wastewater to such a level. However, the cost per removal load is lower than the EC rate. If the EC is implemented, the factory extremely prefers to treat their wastewater for a lower EC payment. This case can illustrate that if factories have efficiency or availability of treatment technology with acceptable cost, they also prefer to treat their waste instead of pay EC. This result replies the economic instrument goal in abatement of pollutants with lowest cost.

Moreover, the factories, which are troubled with wastewater overflows, express their agreement to the EC scheme. It indicated that the government has to consider on the other measures to prevent the high-load discharge from factories that chose to pay EC instead of treating their wastewater complying with standards. The command and control approach still need to enforce in the transition periods to prevent on high-load emission from factories under EC. It also indicates that the purposed charge rate may be not high enough to encourage all factories treating their wastewater.

Most factories complain on the difficulty of wastewater treatment to compliance with effluent standards. This outcome suggested that the researches and developments on wastewater application, such as for irrigation, land application, recycle and reuse options, have to be conducted to support the industry on utilizing their wastewater and reducing their burden from EC scheme.

The treated wastewater application is influenced to the willingness to pay of palm oil mill factories. The factories that not surrounded with palm plantation areas and storage wastewater in ponds, or have applied for in-plant utilization express their agreement on EC scheme. Those factories prefer to pay EC, instead of reserving a large piece of land for storage wastewater. It indicated that the government has to consider on the other measures to prevent the high-load discharge from factories that choosing to pay EC, instead of treating their wastewater complied with standards. The command and control approach still need to enforce in the transition periods to prevent on high-load emission from factories under EC.