REFERENCES

Agamuthu, P. Palm Oil Mill Effluent-Treatment and Utilization. in Waste Treatment Plants, Eds by Sastry, C.A., Hashim, M.A. and Agamuthu, P, john Wiley & Sons (Asia) Pte Ltd.: 338-360. 1995.

Ahmad, A.L., Ismail, S., Ibrahim, N. and Bhatia, S. Removal of Suspended Solids and Residual oil from Palm Oil Mill Effluent. J Chem Technol Biotechnol, 78 (2003) : 971-978.

Ahmad, A.L., Ismail, S., Ibrahim, N. and Bhatia, S. Water Recycling from Palm Oil Mill Effluent (POME) Using Membrane Technology. Desalination. 157 (2003) : 87-95.

Allenby, B.R. Industrial Ecology: Policy Framework and Implementation. New Jersy: Prentice Hall, 1999.

Allenby, B.R. and Graedel, T.E. Industrial Ecology, Prentice Hall, New Jersey, 1995.

Ayres, R.U. and Simonis, U.E. Industrial Metabolism: for Sustainable Development. United Nations : University Press, 1994.

Bass, L.W. and Boons, F.A. An IndustrialEcology Project in Practice: Exploring the Boundaries of Decision-making Levels in Regional Industrial Systems. J. of Cleaner Production. 12(8-10) (2004) : 1073-1085.

Barrantes, J. O. System of Innovation and Cleaner Technologies in the Palm Oil Sector, Costa Rica. *Available in* : http//www.business.auc.dk/druid/conferences/nw/paper1/barrantes.pdf [2001, October 24].

Biomass One-stop Claring House (BOSCH). Biogas Production from Palm Oil Mill Effluent using Completely Stirred Tank Reactor, J. of Energy Policy and Planing Office. 61 (2004) : 36-41.

Bishop, P.L. Pollution Prevention: Fundamentals and Practice. The McGraw-Hill Book Co., Singapore, 2000.

Borja, R., Charles, J.B. and Sanchez, E. Anaerobic Treatment of Palm Oil Mill Effluent in Two-stage up-flow anaerobic Sludge Blanket (UASB) System. Journal of Biotechnology. 45 (1996) : 125-135.

Buttel, F.H. Reflections on the Potentials of Ecological Modernisation as a Social Theory. NSS 8 (2000) : 5-12.

Brian, H.R. The Application of Industrial Ecology Principles and Planning Guidelines for the Development of Eco-industrial Parks: an Australian Case Study. J. of Cleaner Production 12 (2004) : 997-1010.

Bunyagidj, C. Promoting Cleaner Production in Thailand: integrating Cleaner production into ISO 14001 Environmental Management Systems. UNEP Industry and Environment; July-September.: 44-47, 1996.

Chin, K.K., Lee, S.W. and Mohammad, H.H. A Study of palm Oil Mill Effluent Treatment Using a Pond System. Water Science and Technology, 34 (1996) : 119-123.

Chiu, A.S.F. On the Industrial Ecology Potential in Asian Developing Countries. J. of Cleaner Production, 12 (2004) : 1037-1045.

Chiu, A.S.F.and Yong, G. On the Industrial Ecology Potential in Asian Developing Countries. J. of Cleaner Production, 12 (2004) : 1037-1045.

Choy, E.A. Environmental Management: The Drivers Toward Better Environmental Performances in the Palm oil Milling Sub-sector in Malaysia. Printed in *The 2nd Annual INREF and AGITS Working Conference:* Environmental governance in Asia: 'regional perspectives on Institutional and Industrial Transformation', November 26-28.2004, Kuala Lumpur, 2004.

Chu, K.H. and Hashim, M.A. Adsorption and Desorption Characteristics of Zinc on Ash Particles Derived from Oil Palm waste. J. Chem Technol Biotechnol. 77 (2002) : 685-693.

Daniere, A. and Takahashi, L.M. Rethinking Environmental Management in the Pacific Rim. Exploring Local Participation in Bangkok. Thailand: Ashgate Publishing Ltd. England, 2002.

Department of Agriculture Technology. Database of Agriculture: Oil Palm. Available in : http//www.doa.go.th/data-doa/palm/stat/st04.hym [2002, November 6]

Department of Industrial work, Ministry of Industry. Environmental Management guideline for the Palm Oil Industry, Bangkok: Thailand Environment Institute, 1997.

Department of Industrial work, Ministry of Industry. Project Impact Assessment: Palm Oil Industry. Bangkok: Thailand Environment Institute, 1999.

Department of Industrial work, Ministry of Industry. Imlementation of Economic Instruments for Industrial Environmental Management. Bangkok: Consultants of Technology Co.,Ltd., 2002.

Department of Energy, Ministry of Science, Technology and Environment. A Feasibility Study on Co-generation from Palm Oil Mill Bio-mass. Bangkok: Prince of Songkla University and consultants of Technology, 2002.

Department of Pollution Control, Ministry of Science, Technology and Environment. National Master Plan on Cleaner Production, Bangkok, Thailand, 2003.

Editorial. Ecological Modernization. Geoforum 31, Elsevier Science Ltd.: 1-8, 2000.

Eckersky, R. Markets, the State and the Environment: *Towards Integration*, London: Macllan, 1995.

Erkman, S. and Ramaswamy, R. Industrial Ecology: a new cleaner Production Strategy. Industry and Environment. 22 (2001) : 64-67.

Falbo, J.F. Developments in Environmental Law. Environmental Policy and law. 27 (1997) : 217-220.

Faisal, M. and Unno, H. Kinetic Analysis of Palm Oil Mill Wastewater Treatment by a Modification Anaerobic Baffled Reactor, Biochemical Engineering Journal, 9 (2001) : 25-31.

Fresner, J. Cleaner Production as a Means for Effective Environmental Management. J. of Cleaner Production. 6 (1998) : 171-179.

Frijns, J. and Vliet, B. van. Small-Scale Industry and Cleaner Production Strategies. World Development. 27 (1999) : 967-983.

Frosch, R.A. and Gallopoulos, N.E. Strategies for manufacturing. Managing Planet Earth, 1989.

Gombault, M. and Versteege, S. Cleaner Production in SMEs through a Partnership with (local) Authorities: Successes from the Netherlands. J. of Cleaner Production. 7 (1999) : 249-261.

Gibbs, D. Ecological Modernization, Refional Economic Development and Regional Development Agencies. Geoforum. 31 (2002) : 9-19.

Girovich, M.J. Biosolids Treatment and Management: Process for Beneficial Use. Marcel Dekker, Inc.,N.Y., 1996.

Gopal, J. The Development of Malaysia's Palm Oil Refining Industry: Obstacles, policy and performce. Ph.D. Thesis of the University of London and Diploma of Imperial College, England, 2001.

Graedel, T.E. and Allenby, B.R. Industrial Ecology. Englewood Cliffs, Newjersy 07632: Prentice Hall, 1995.

Gurbuz, S., Kiran-Ciliz and Yenigun, O. Cleaner Production Implementation Through Process Modifications for Selected SMEs in Turkish Olive Oil Production. J. of Cleaner Production. 12 (2004) : 613-621.

Hai, T.C. The Palm Oil in Malaysia; from Seed to Frying Pan. Paper prepared for WWF Switzerland, November 2002.

Hamed, M.M. and Mahgary, Y.E.I. Outline ofa National Strategy for Cleaner Production: the Case of Egypt. J. of Cleaner Prouction. 12 (2004) : 327-336.

Hengel, P. Why Producing Waste if It is thrown Away Anyway, Preventive of Waste and Emission of Small and Medium Scale Textile Dyeing Enterprises in Ho Chi Minh City in Vietnam, MSc. Thesis of Wageningen Agricultural University, The Netherlands, 1998.

Hiebert, M. Farm Hand: New Methods Bolster Rubber and Palm Oil Production. Far Eastern Economic Reviews. *Available in*: http//www.fur.com/1999/9907-22/P47tech.html, [2001, September 19].

Huber, J. The Rainbow Society: Ecology and Social Politics. Fisher Verlag, Frankfurt, 1985.

Husain, Z., Zainac, Z. and Abdullah, Z. Briquetting of Palm Fibre and Shell from the Processing of Palm Nuts to Palm Oil. Biomass and Bioenergy. 22 (2002) : 505-509.

Husain, Z., Zainac, Z. and Abdullah, Z. Analysis of Biomass-residue-based Cogeneration System in Palm oil mills. Biomass and Bioenergy. 24 (2003) : 117-124.

Husin,M., Ramli, R., Mokhtar, A., Hassan, W.H.W., Hassan, K. Mamat, R. and Aziz, A.A. Research and Development of Oil Palm Biomass Utilization in Wood Based Materials. Palm Oil Development, 36: 1-5, 2003.

Intarakumnerd, P., Chairatana,p. and Tangchitpiboon, T. National Innovation System in Less Successful Developping Countries; the Case of Thailand. Research Policy, 9 (2002) : 1445-1457.

Jackson, T. Clean Production Strategies: Developing Preventive Environmental Management in the Industry Economy. CRC Press Inc., Florida, 2000.

Industrial Estate authority of Thailand. Development of Eco-industrial Estate and Networks Project (DEE and Net Project), 2nd International Conference& Workshop for Eco-Industrial development, Thailand, [2004, March 7- 12].

Jarusombat, S. Policy Strategies on Public Participation in Environmental Management in Thailand. Proceeding of the 1st ASEM International Conference on Public Participation on "Toword Good Practices in Public Participation for Sustainable Development". Bangkok, Thailand, 1-10, [2002, June 1-10].

Jeswani, H. K. Environmental Improvements in Edible Oil and Ghee Mills through Cleaner Production Options. *Available in*: http//www.etpi.org/pdf/sep-00(EN)01.pdf. [2001, October 16].

Kangas, P.C. Ecological Engineering: Principle and Practice. Lewis Publishers, Florida, 2004.

Kautto, P. and Melanen, M. How does Industry Respond to Waste Policy Instruments-Finnish Experiences. J. of Cleaner Production. 12 (2004) : 1-11.

Keitsch, M.M. Towards an Interdisciplinary Research in Technologies and Humanities on the Concept of Industrial Ecology, *available in*: http//www.indecol.ntnv.no/ieforum/e2/keitsch1.htm [2001, October 1].

Khan, F. I., Natrajan, B.R., Revathi, P. Green Pro: a New Methodology for Cleaner and Greener Process Design and Development. Journal of Loss Prevention in the Process Industries. 14 (2001): 307-328

Khunkitti, S. Thailand Needs Better Clean Production Policy to Cut Costs and Improve Competitiveness. Kenan Institute Asia- Press Release. *Available in*: http//www.kiasia.org/archive/press/etech.htm [1999, October 1].

Kittikun, H., et al. Thai German Project on Palm Oil Industry, PN91.2070.0- 01.100, Prince of Songkhla University, Thailand, 1996.

Kochapansunthorn, S. Development of a simulation model for the Anaerobic Biochemical-Reactor for producing biogas from wastewater of Palm Oil Extraction Plant. Master's Thesis of the Chulalongkorn University, Thailand, 1998.

Korhonen, J., Huisingh, D. and Chiu, A.S.F. Applications of Industrial Ecology-an Overview of the Special Issue. J. of Cleaner Production. 12 (2004) : 803-807.

Langhelle, O. Why Ecological Modernization and Sustainable Development Should Not Be Conflated. Journal of Environmental Policy & Planing. 2(2000) : 303-322.

Lartey, R.B. and Acquah, F. Development National Capability for Manufacture of Activated Carbon from Agricultural wastes, The Ghana Engineer, Ghana, 1999.

Liang, J.B. Use of Agricultural Byproduct for Sustainable Livestack Production- The Malaysian experience, Proceeding of The Second Symposium on Sustainable utilization of Agricultural Byproduct for Animal Production, Bangkok, Thailand, 26-27 July 2001.

Lim, C.F., Muk, H., Ravoof, A. A. and Thavalingam, M. Utilization of Palm Oil By-product Utilization, Palm Oil Research Institute of Malaysia, 1981.

Lua, A.C. and Yang, T. Effects of Vacuum Pyrolysis Conditions on the Characteristics of Activated Carbons derived from Pistachio-nut Shells. J. Colloid and Interface Science. 276 (2004) : 364-372.

Luken, R.A., Stevenson, R.S. and Berkel, R.V. Introduction to the Special Issue on Building Institutional Capacity for Cleaner Production in Developing and Transition Economies. J. of Cleaner Production. 12 (2004) : 189-194.

Ma, A.N. Management of Palm Oil Mill Effluent. Paper Presented at Environmental Quality: 25 years of Endeavor in Malaysia, 1999.

Ma, A.N. Environmental Management for the Palm Oil Industry. Palm Oil developments, 30: pp. 1-10, 1999.

Malaysian Palm Oil Broad. MPOB in Brief. *Available in*: http//mpob.gov.my/mpobrief.html [2001, September 6].

Mol, A.P.J. The Refinement of Production: Ecological Modernization Theory and the Chemical Industry. Utrecht : Van Arkel/ International Books, 1995.

Mol, A.P.J. Ecological modernisation and institutional reflexivity. Environmental reform in the late modern age. Environmental Politics. 5 (1996) : 302-323.

Mol, A.P.J. and Spaargaren, G. Environment Modernity and the Risk Society: the Apocalyptic Horizon of Environmental Reform. International Sociology. 8 (1993) : 431-459.

Malaysian Palm Oil Board. Malaysian Oil palm statistics 2000. 20th Ed. MPOB: 132 pp, 2001.

Minsirinun, K. Depositionof Zinc in Activated carbon from Anthracite and Palm-Oil Shell Activated by Zinc Chloride. Ph.D. Thesis of the Chulalongkorn University, Thailand, 1999.

MPOB. MPOB Corporate Information. Available in http://www.mpob.gov.my/corporate/broc-establish.htm [2003, September 23].

Murphy, J. Toward Understanding of Environmental Policy in Advanced Industrial Countries. Ph.D. Thesis, University of Hull, 1999.

Murphy, J. and Gouldson, A. Environmental policy and Industrial Innovation: Integrating Environment and Economy through Ecological Modernisation. Geoforum. 31 (2000) : 33-44.

Mustapha, S., Ashhuby, B. Rashid, M. and Azni, I. Start-up Strategy of a Thermophilic Upflow Anaerobic Filter for Treating Palm Oil Mill Effluent, Trans IChem E. 81(part B) (2003) : 262-266.

Nemerow, N.L. Zero Pollution for Industry: Waste Minimization through Industrial Complexes. John Willy& Sons,Inc.,Canada, 1995.

OECD (Organization of Economic Cooperation and Development). Promoting Cleaner Production in Developing Countries: the Role of Development Co-operation, OECD documents, 1995.

Onlyia, C.O., Uyub, A.M., Akunna, J.C. Norulaini, N.A. and Omar, A.K.M. Increasing the Fertilizer Value of Value of Palm Oil Mill Sludge. Bioaumentation in Nitrification, 44 (2001) : 157-162.

Panyawathanakit, P. Production Activated carbon from Palm Oil Shell: Activated by superheated steam. Master's Thesis of Mahidol University, Thailand, 1997.

Phuong, P.T. Ecological Modernization of Industrial Estate in Vietnam. Ph.D.- Thesis, Wageningen University, 2002.

PORIM. Overview of the Malaysian Oil Palm Industry. *Available in*: http//161.142.157.2/home2/home/su_overview01.htm [2001, July 2].

Promotion of Renewable Sources in South East Asia. (2001). Thailand-Biomass: Prospects, *Available in*: http//www.ace.or.id/pressea/thailand/biomass/prospects.htm [2001, July 25].

Rao, P.P. Wastewater Management in Palm Oil Mill: A Case Study. Thesis of Master of Engineering. School of Environment, Resources and Development. AIT, Thailand, 1999.

Ramli, R., Sitaler, S. and Jamaludin, M.A. Properties of Medium Density Fibreboard from Oil Palm Empty Fruit Bunches Fiber. J. of Oil Palm Research. 14 (2002) : 34-40.

Remmen, A. and Smind, C.K. Reforming Environmental Regulation: New Way to Accomplish Industrial Application of Pollution Prevention. Paper Presented at 6 th. European Roundtable on Cleaner Production, Budapest. Hungary, 29 September- 1st. October 1999.

Research Department, Bangkok Bank Public Company limited. The palm oil industry. *Available in*: http://wwwbbl.co.th/mrevivw/200006_palm-oil1.htm [2001, November 2].

Roberts, B.H. The Application of Industrial Ecology Principles and Plannin Guidelines for the Development of Eco-industrial Parks: an Australian Study. J. of Cleaner Production. 12 (2004) : 997-1010.

Rock, M.T. Pollution Control in East Asia. Lessons from the Newly Industrializing Economies, An RFF Press Book, Washigton, DC: 119-139, 2001.

Salim, M.R., Othman, F., Petterson, J. and Hardy,T. Application of Locally Available Materials for the Yreatment of Organic Polluted Water. J Water Science and Technology. 46 (2002) : 339-346.

Setidi, T., Husaini and Djajadiningrat, A. Palm Oil Mill Effluent Treatment by Anaerobic Baffled Reactors: Recycle Effect and Biokinetic Parameter. Water Science and Technology. 34 : (1996).

Simeh, A. and Ahmad, T.M.A.T. The Case Study on Malaysian Palm Oil Industry, Prined in Proceeding of Regional Workshop on Commodity Export Diversification and Poverty Reduction in South and South-East Asean. April 3-5, 2001, Bangkok.

Simonis, U. Ecological Modernization of Industrial Society: Three strategic elements. International Social Science Journal.121 (1989) : 347-361.

Singhal, S. and Kapur, A. Industrial Estate Planing and Development in India-an Integrated Approach Towards Industrial Ecology. Journal of Environmental Management. 66(2002) : 19-29.

So, A.Y. and Lee, Y.F. Environmental Managements in Thailand in Asia's Environmental Movements: Comparative perspectives, Armonk, NY:MG sharpe:120-142, 1999.

Sricharoen, P. Impact of Emission Charge on Palm Oil Mill Industry with Special Reference to Economic Performance. MSc. Thesis, Inter-Departmental Program in Environmental Management, Chulalongkorn University, Thailand, 2002.

Sterr, t. and Ott, T. The Industrial Region as a Promosing Unit for eco-industrial Development- Reflections, Practical Experience and Establishment of Innovation Instruments to Support Industrial Ecology. J. of Cleaner Production. 12 (2004) : 947-965.

Stevenson, R.S. An Assessment of the Design and Effectiveness of the ASEAN Environmental Improvement Program. J. Cleaner Production. 12 (2004) : 725-736.

Suravattanasakul, T. Production of Activated Carbon from Palm-oil Shell by Pyrolysis and Stream Activation in a fixed Bed Reactor. Ph.D. Thesis, Inter-Departmental Program in Petrochemistry, Chulalongkorn University, Thailand, 1997.

Tran, T.M.D. Greening Food Processing Industry in Vietnam: Putting Industrial Ecology to Work. Ph.D.- Thesis, Wageningen University, 2003.

Tsai, W.T. and Chou, Y.H. Government Policies for Encouraging Industrial Waste Reuse and Pollution Prevention in Taiwan. J. Cleaner Production. 12 (2004) : 725-736.

Taiwo, K.A., et al. Technological Assessment of Palm Oil Production in Osum and Ondo in Nigeria, Technovation, (20), Elsevier Science Ltd., 2000.

The World Bank. Greening Industry: New roles for communities, markets, and governments. New York: Oxford University Press, 1999.

The Thai Research Fund. Final Report: Developing Environmental Performance Indicators for Increased Competitiveness for Thai Industry. Bangkok: Thailand Environment Institute. 2001.

UNEP/ IEO. Cleaner Production Worldwide. Nation Publication, 1993.

UNEP. Government Strategies and Policies for Cleaner Production. UNEP Publication, 1994.

UNEP. (2001a), Cleaner Production- Key Element, *Available in*: http//www.unepie.org/pc/cp/understanding_cp/home.htm [2001, October 1].

UNEP. (2001b), Country policy profiles. Policy Case Studies: Thailand, *Available in* : http//www.emcenter.com/unepweb/policy/thailand/constraints.htm [2001, September 14].

Unapumnuk, K.Solid Waste Management in Palm Oil Mills: A Case Study in Thailand. M.aster's Thesis of Asian Institute of Technology, Thailand, 1999.

Visvanathan, C. and Kumar,S. Issue for Better Implementation of CP in Asian Small and Medium Size Industries. J. of Cleaner Production. 7(1999) : 127-134.

Wang, L.K. and Wang, M.H.S. Handbook of In ustrial Waste treatment. Marcel Dekker, Inc.,N.Y., 1992.

Werner, J. The MILLJET System for Crude Palm Oil Purification. Proceeding of the 1999 PORIM International Palm Oil Congress, Kuala Lumpur, Malaysia, 1999.

White, S. Environmental Conservation in Asian Industry, TDRI Quarterly Review. 14 (2001): 21-28.

Yeoh, B.G. A Technical and Economic Analysis of Heat and Power Generation from Biomethanation of Palm Oil mill Effluent, *Available in* : http//www.cogen3.net/doc/countryinfo/Malaysia/TechnicalEconomicAnalysisCHPPalmE [2004, November 3].

Yusof, B. Palm Oil and Its Global Supply and Demand Prospect, Malaysia Palm Oil Broad :1-10, 2001.

Zuur, K. Sustainability through Environmental Technology: A Case Study on Malaysia/ Thai Palm Oil Industry. MSc. Thesis, Wageningen University, 2004.

APPENDIX A

APPENDIX A-1

FACTORY B

Introduction to the company

Factory B was established in 1993. Factory B is a medium sized CPO company with 70 employees. This factory is situated at the west of a city that far from community space of 160,000 square meters. Production capacity of the factory is 60 ton/hour. The maximum production capacity is 1,400 ton/day. The average production capacity is 960 ton/day. In 2002, the factory produced 42,500 tons crude palm oil and 8,000 tons palm kernel nut from 250,000 tons fresh fruit brunch.

Inputs

Almost all fresh fruit bunches, raw material, is purchased from palm fruit suppliers, only the rest 5% is from their own plantation area. The production process of factory B is not different from factory A. Raw water from Tapee river nearby the factory is treated by alum and polymer before supply to the production process. In 2002, they consumed 250,000 m^3 of raw water and an energy amount of 3,360,000 kW. The electricity used in this mill is obtained from 2 sources, from a turbine generator in the factory and purchase from government supplier. The electricity generated in the factory is about 80% of total electricity consumption.

Production Technology

Crude palm oil production process of factory B is briefly described in Figure A1.1. The factory employs a modified oil clarification process, consisted of a settling tank followed by a decanter (three-phase centrifuge) and then a separator (two-phase centrifuge) is used to separate oil and suspended solids from wastewater.

This factory has installed a water tube boiler with a capacity of 20 tons steam per hour. Steam from the boiler is send to turbine for electricity generation. Steam from the turbine generation is supplied to various units of the production process. Autoclaves for sterilizing fresh fruit bunch are manually operated at a control temperature of 120-130°C, pressure 3-3.5 bar and settling time for 75 minute. After oil extraction, raw crude oil flows to a vibrating screen to separate large particles from crude oil. Then sand is separated from raw crude oil by a sand cyclone before the raw crude oil flows to a buffer tank and a clarification tank used for the separation of sludge and wastewater from crude oil,

Factory B has implemented many clean technology options. During the last seven years the following measures has been taken in that respect.

- Installation of buffer tank to separate sludge from crude palm oil before this palm oil flows to the settling tank in order to enhance oil separation.
- Install 2 bunch stripper to enhance fruit separation from bunch stalk with the aim to reduce oil losses from empty fruit bunch.
- Recycling sterilized condensate to screw press and separator in order to reduce hot water use.

- Recycling sludge from vibrating screen to digestion tank.
- Recovery of oil from wastewater using a decanter and a separator. Recovered oil is pumped to settling tank.

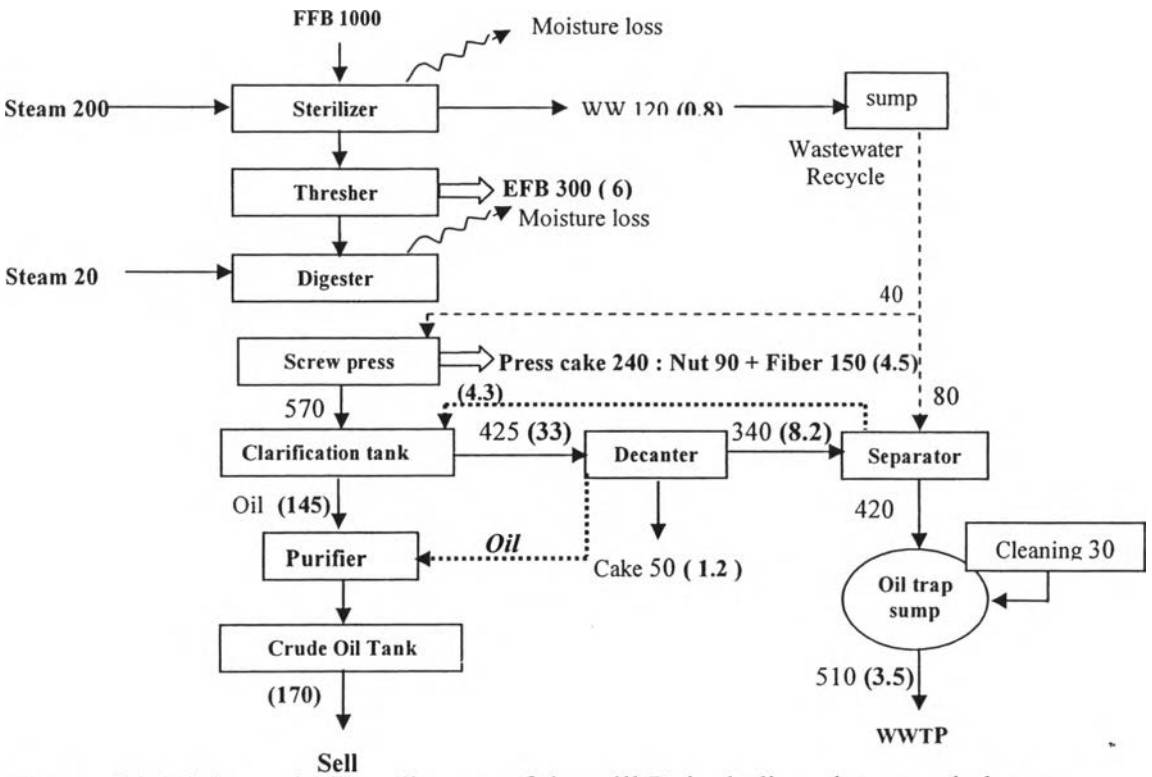


Figure A1.1 Schematic flow diagram of the mill B, including also mass balances.
( ) Oil content

Mass balances in term of dry weight based on 1 ton of fresh fruit bunch (wet weight) flows can be expressed in Figure A1.2.

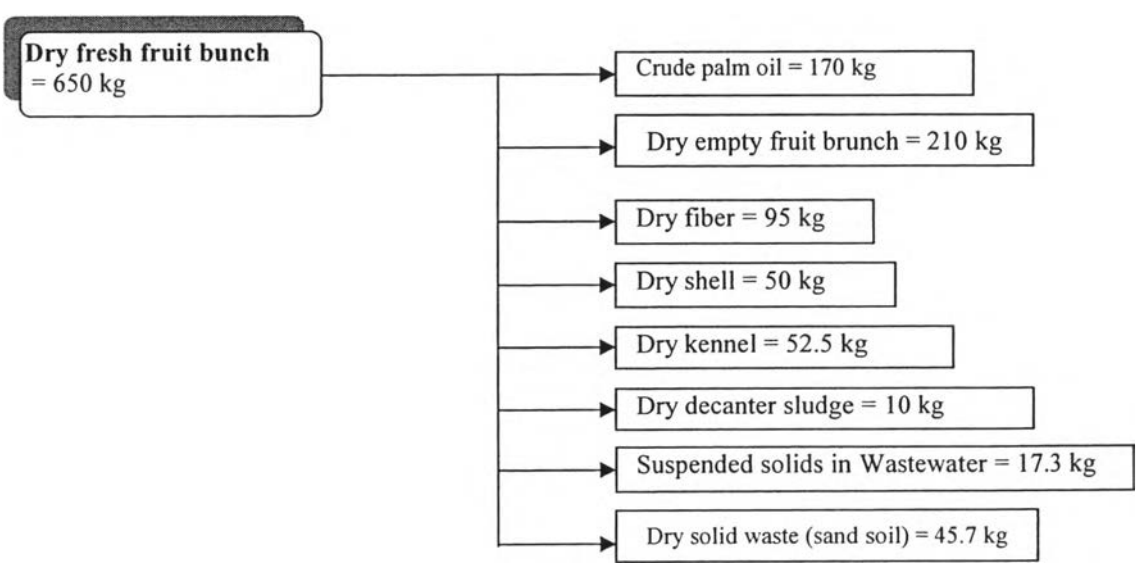


Figure A1.2 Mass balance in term of dry weight per ton FFB (factory B).

Liquid material and energy balance

Figure A1.3 shows the volume balance for liquid material flow of the palm oil production of factory B. In this balance all liquid material including supplied water and generated wastewater are considered. Water consumption of factory B is amount 1 m^3. About 50% of the supplied water becomes wastewater Wastewater from. Sterilizer which amounts to 0.12 m^3 (12% of water consumption), is recycled in the production process.

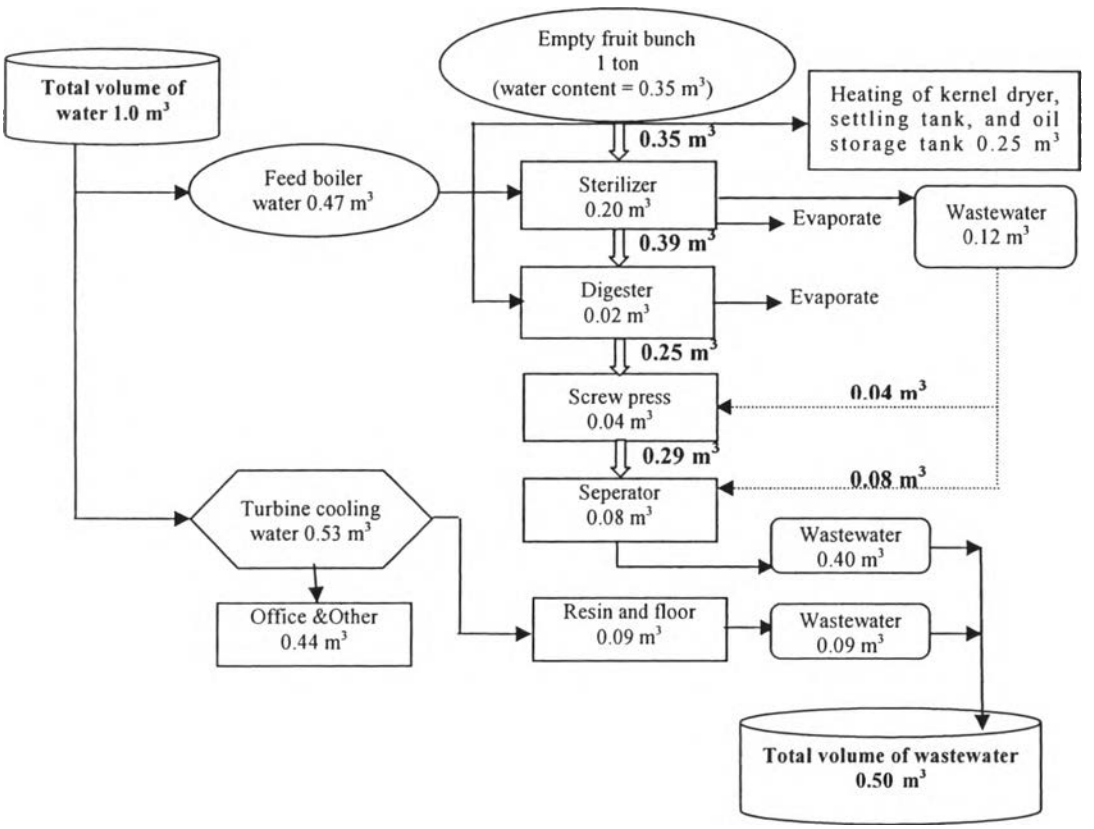


Figure A1.3 Liquid material balance of factory B.

The energy required for the process is produced by a caogeneration system produces heat (steam) an electrical power. The fiber and shell generated in the process have high calorific value, are used as fuel is the boiler. Fuel, composed of fiber and shell in the ratio of 3:1, is send to the boiler in an amount of 113 kg/ton of fresh fruit bunch. The electricity generated is sufficient for the plant operation and other uses. Factory B consumes electricity about 10.5 kWh /ton of fresh fruit brunch. During the shutdown and the start up of mill, they are using electricity from Electricity Generation Authority of Thailand (EGAT). It is estimated that 4.21 kWh/ton FFB is purchased from outside. This mill has installed boiler capacity of 20 ton/hr. That can produce 410 kg/ton FFB steam. The energy balance is presented in Figureure A1.4. All supplied electricity and steam is consumed, no other energy sources were generated from the current production process. The total energy loss occurred in production process are 60% of total energy production.

Cost benefit analysis

The cost structure of a large crude palm oil of large extraction plant shows that the fixed cost including fuel/energy cost, labor cost, maintenance, interest and others is 2.3 bath/kg CPO. The production cost per unit is 11.1 bath/kg CPO, higher than 10.1 Baht/kg CPO of factory A. This is due to production efficiency of factory A which is 0.5% higher than factory B. Factory A owns their oil palm plantation area and can get higher yield of FFB. The high-yield palm oil breed also increases a CPO production.

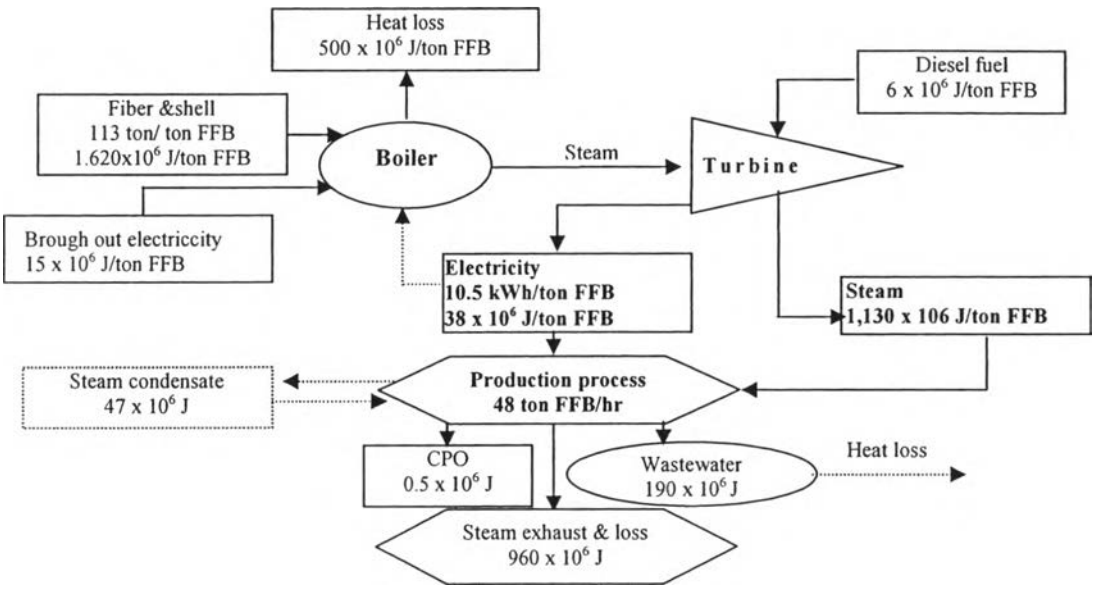


Figure A1.4 Energy balance in production process of factory B.

Wastewater treatment plant

Wastewater generated from production process is pumped to a wastewater treatment plant (WWTP) that is located in the factory area. Wastewater is cool down and oil is separated from wastewater in oil trap sumps before going to WWTP. WWTP consists of 6 ponds with a total surface area of 63,000 m^2. The first 3 ponds are anaerobic pond, pond 4 and pond 5 are oxidation ponds and the final pond is a maturation pond. Wastewater is kept in ponds without discharge. The characteristic of the wastewater in each pond is shown in table A1.1.

Table A1.1 Shows characteristics of wastewater from production process and WWTP.

Sampling point	pH	BOD_5 (mg/l)	COD (mg/l)	SS (mg/l)	TS (mg/l)	TKN (mg/l)	TP (mg/l)	O&G (mg/l)	Color (pt.Co unit)
Influent	4.83	59,650	74,304	39,033	60,440	126	13	6,860	18,000
Pond 3	8.12	3,650	6,192	5,000	14,680	479	32	222	9,800
Pond 4	8.52	288	3,578	1,120	12,510	126	13	44	9,100
Pond 5	8.42	172	2,890	527	11,225	176	12	6	4,900
Pond 6	8.34	36	605	89	1,917	25	6	ND	750

APPENDIX A-2

FACTORY C

Introduction to the company

Company C is a medium scale industry located at Krabi province, Southern Thailand. The mill was established in1984 and is located in an area of 82 rai (131,200 m^2). The total staff and workers, working in the company consist of 90 persons.

The mill is running with a capacity of 40 ton fresh fruit brunch / hr. The maximum production capacity is 1,000 ton fresh fruit bunch / day. Running hours of the mill is not constant throughout the year due to fluctuation in fruit availability. The mill is located very close to village (300m distance from the village). This mill does not own an oil palm plantation area, so they have to buy fresh fruit brunch from oil palm grower. The final product from this mill is crude palm oil and palm kernel. They sell this crude palm oil to refineries and palm kernel to other crude palm oil mill for produce palm kernel oil.

Input and products.

The raw materials need for the production process are fresh fruit bunch, alum, clay, coagulant aid, diesel oil, salt and electricity. An overview of raw material consumption and products are shown in table A2.1. The total energy consumption of all electric machine is about 11 kWh / ton fresh fruit brunch. About 93.1% of electricity used in production process is generated from turbine generator that reuses fiber as fuel in boiler. All fiber generated is feed to boiler (rate 10 ton / hr) to produce steam and generated electricity and also supply in factory.

Table A2.1 Raw materials, products and by-products of factory C

Item	Quantity (per year)	Quantity (per ton FFB)
Raw material		
1. Fresh fruit bunch	200,000 ton	-
2. Clay	210 ton	1.1 kg
3. Electricity demand	2,200,813 kWh	11.0 kWh
4. Diesel oil	108,800 L	0.5 L
Product		
1. Crude palm oil	34,000 ton	170 kg
2. Palm kernel	12,500 ton	62.5 kg
By-product		
1. Empty fruit brunch	46,000 ton	230 kg
2. Fiber	28,000 ton	140 kg
3. Shell	8,000 ton	40 kg

Production process

Production process of factory C is similar to factory A and B except the machine used for oil recovery from wastewater in the oil clarification step. This mill has installed an installs oil trap tank to remove oil from wastewater before it goes to the anaerobic

digestion tank to recover biogas. After the digestion tank it flows to anaerobic ponds. The shift to clean technology within 5 years can be illustrated as follows:

- Installation of 2° brunch stripper to enhance fruit separation from bunch stalk and increase oil yield.
- Installation 30-ton water tube boiler with cyclone for control particulate matter instead of using a wet scrubber.
- Construction of anaerobic digester tank to recover biogas from wastewater.

The flow diagram of the process with mass balances is shown in Figure A2.1

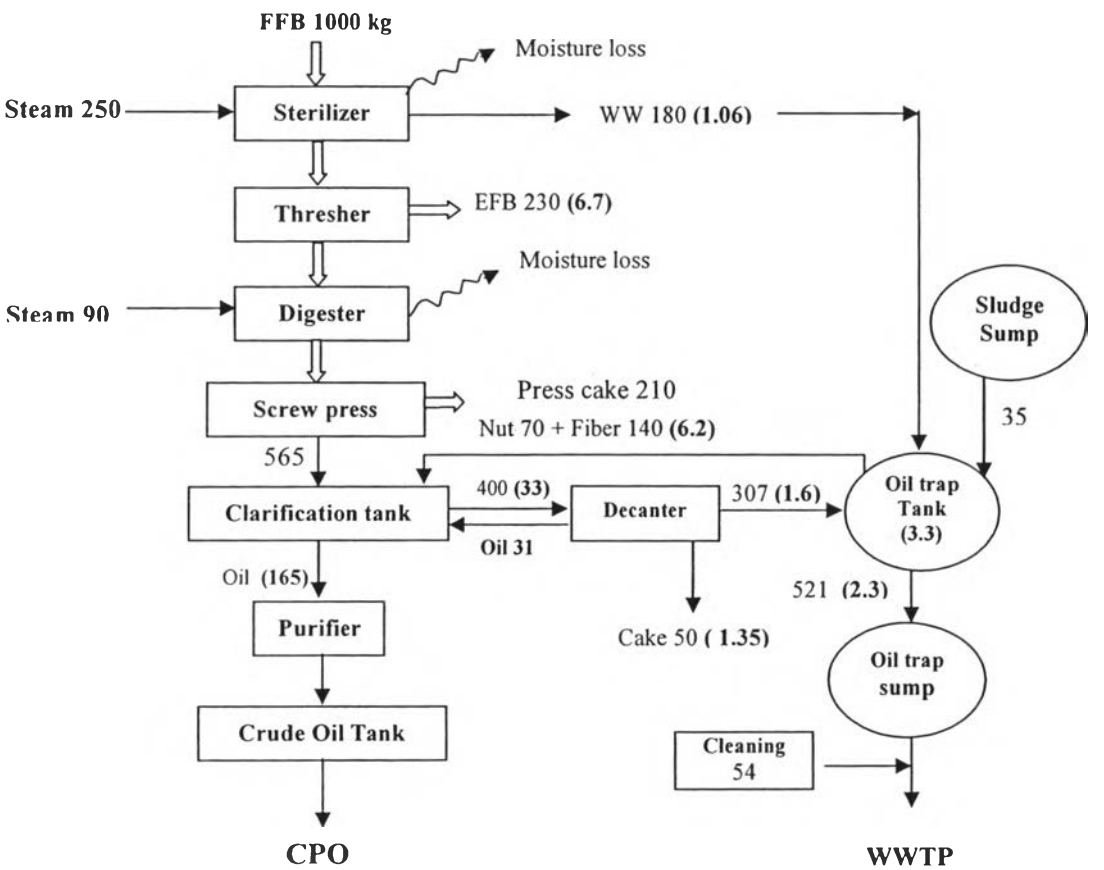


Figure A2.1 Schematic flow diagram of the mill C, including also mass balances.
( ) Oil content

Water usage and wastewater generation

Canal water is the source of process water. Clarification and filtration is necessary to use this water in the process. Alum and polymer are used as coagulation and flocculant in the clarifier. The water consumption of the mill is about 28 m^3 / hr. or 1.1 m^3 / ton fresh fruit bunch. Wastewater generation is amount to about 52.7% of water supply (0.58 m^3 / ton fresh fruit bunch). Table A2.2 shows the water usage in the production process of factory C. This mill has installed only a decanter to recover oil from wastewater, so the water consumption in the production process is lower compared to factory A and B. There is no wastewater reuse/recycle in production process. Wastewater is pumped to an oil trap tank (retention time of 3 days) in order to remove oil from wastewater before this

is sent to a treatment plant. Table A2.3 and A2.4 show the characteristics of the wastewater generated from production step and from wastewater treatment plant.

Table A2.2 Water demand for crude palm oil production process of factory C.

Process stream	Flow rate of water consumption	
	m^3/ton FFB	m^3/day
Water for boiler (steam)	**0.54**	**285**
• Sterilizer	0.25	132
• Digester	0.09	48
• Other (nut dryer,crude oil storage tank, hot water tank)	0.20	105
Water from cooling system in turbine is reused in	**0.56**	**306**
• Screw press	-	-
• Vibrating screen	0.004	2
• Factory cleaning, clay bath	0.07	54
• Other.	0.49	262
Water use in production process	**0.64**	**341**
Total water consumption	**1.10**	**614**

Note: Production capacity is 530 ton/day

Table A2.3 Characteristics of wastewater from production process and wastewater treatment plant of factory C.

Source of wastewater	pH	BOD_5 (mg/l)	COD (mg/l)	SS (mg/l)	TS (mg/l)	O&G (mg/l)	Color (pt.Co unit)
Sterilizer	5.26	46,350	66,048	20,067	55,300	5,910	7,400
Decanter	4.75	57,600	84,089	50,567	69,500	5,090	10,000
Sludge sump	4.85	8,262	30,270	5,840	119,890	16,270	3,500
Influent	4.76	52,300	79,808	38,833	63,930	3,600	8,500

Table A2.4 Characteristics of wastewater from wastewater treatment plant of factory C.

Sampling point	pH	BOD_5 (mg/l)	COD (mg/l)	SS (mg/l)	TS (mg/l)	TKN (mg/l)	TP (mg/l)	O&G (mg/l)	Color (pt.Co unit)
Influent	4.76	52,300	79,808	38,833	63,930	324	87	4,540	8,500
Pond 1	5.27	8,633	41,280	16,850	27,120	529	57	2,444	6,800
Pond 2	7.53	3,730	7,568	5,500	14,700	625	55	389	4,643
Pond 3	7.54	2,886	6,330	2,600	12,310	448	33	444	4,800
Pond 4	8.48	3,125	3,715	631	8,535	149	5	244	5,500
Pond 9	8.7	76	2,472	350	1,120	35	ND	101	890

Solid waste and by-product

One ton of fresh fruit bunch processing generates 230 kg empty fruit bunch, 140 kg fiber, 40 kg shell 30 kg palm kernel 57 kg decanter cake and 17 kg ash. All fibers

generated is used as fuel in boiler. The solid waste handling methods in this factory are shown in Figure A2.2

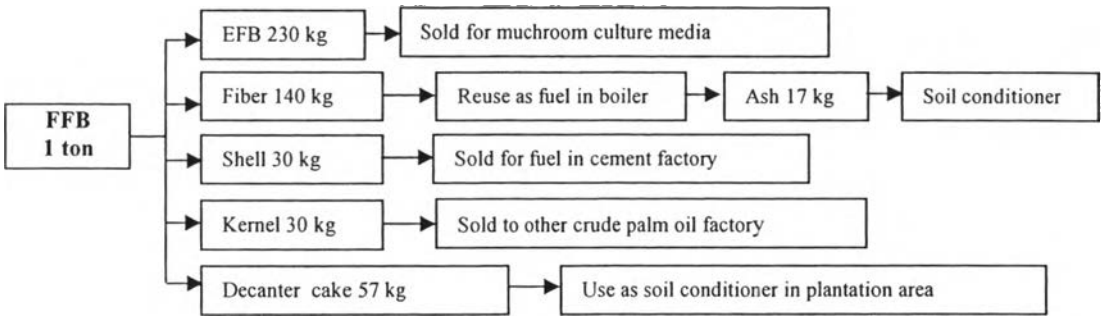


Figure A2.2 Solids waste management in mill C

Material and energy balances

Figure A2.3 and A2.4 show the water balance and energy balance in the production process of factory C. The mill dose not apply a wastewater recycle and energy conservation options. Fiber generated in production process (130 kg/ton fresh fruit bunch) is reused as fuel in boiler. For one ton of fresh fruit bunch processing, 540 kg feed water boiler is pumped to generated steam 450 kg (215 ^{o}C), then steam is apply to turbine to generate electricity 20 kWh. Electricity used in boiler and in production process is about 5.8 and 10.6 kWh /ton fresh fruit bunch, respectively. About 18% of the electrical electrical power generated from turbine is loss during production process.

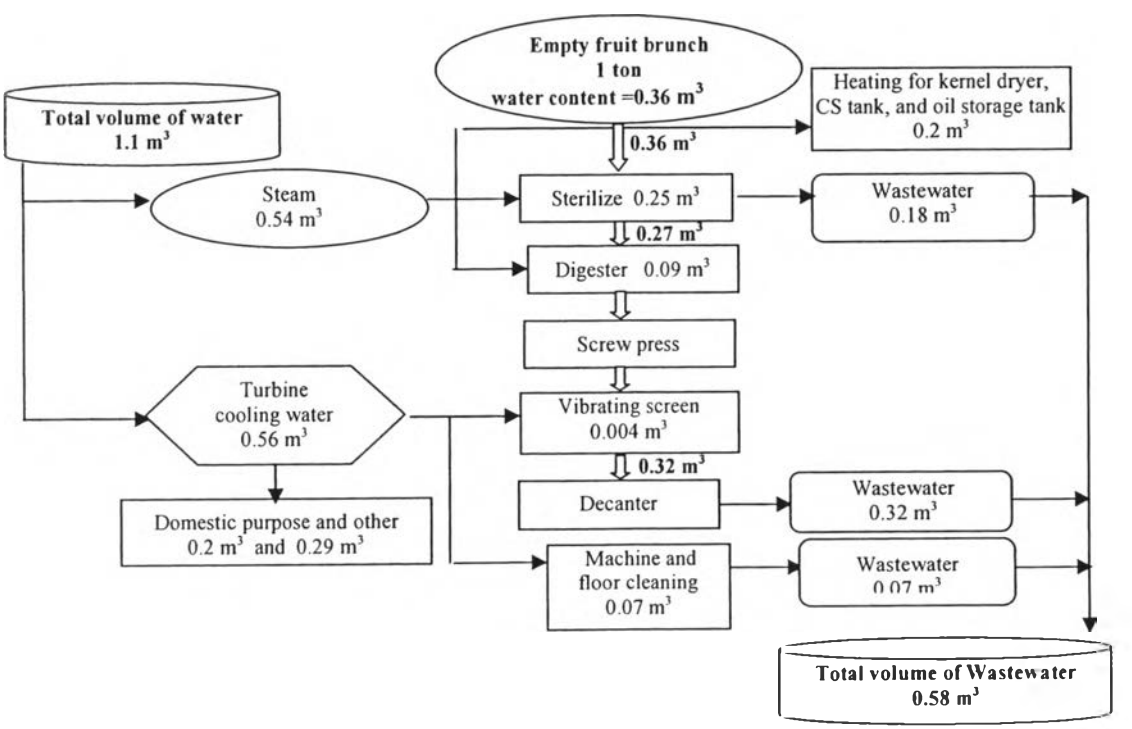


Figure A2.3 Water and wastewater balance of factory C.

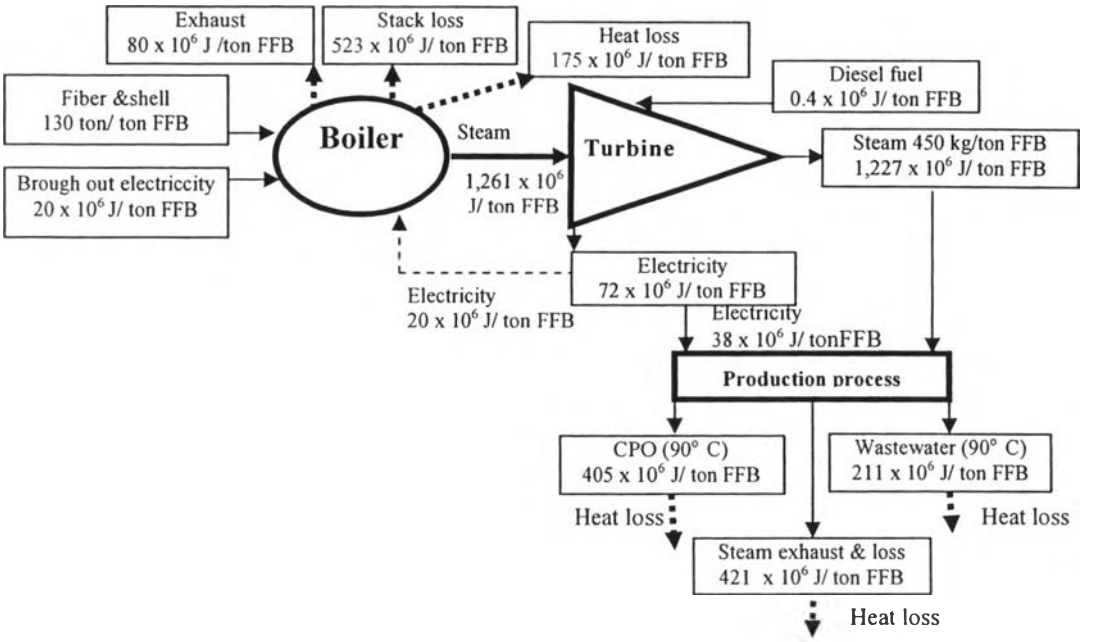


Figure A2.4 Energy balance in production process of factory C.

Economic performance

From the data obtained from the study of Sricharoen (2002), an estimation can be made of the average total production cost per kg crude palm oil from raw material consumption. The equations for estimating such Figure are as below:

TCp = Cp x Pcpo x 1000 (kg/ton)
= (1.8 + 8.8) x 34,000 x 1000 = 360 million Baht

Where:

TCp = Total production cost (Baht)
Cp = Production cost (Baht/ kg CPO)
= Fixed cost (Baht/ kgCPO) + Raw material cost (Baht/ kgCPO)
Pcpo = CPO production (ton)

Fixed cost = Transportation cost, fuel cost, labor cost, maintenance, overhead, interest and others. = 1.8 Baht

Raw material cost = Average FFB price x 100 / % CPO extraction

Actual sale = CPO production (ton) x CPO cost (Baht/ kg CPO) x 1,000
= 34,000 x 12 x 1,000
= 408 million Baht

APPENDIX A-3

FACTORY D

Introduction to the company

Factory D has one of the highest productions of CPO from the five cases studied. This mill is located in oil palm plantation area. The production process is operated continuously for 24 hours a day, 300 days per year. The average production capacity is about 41 tons of FFB per hour, the maximum production capacity is equal to 60 tons/hr. In 2002, the raw material (EFB) processed about 269,760 ton, while the CPO production was equal to 46,852 ton. The efficiency of production process was 17.4%.

Production activities of the company have not yet caused serious pollution to the environment because most wastes can be reused/ recycled in their plantation area, particularly wastewater is reused for irrigation. Factory D owns an oil palm plantation area of 25,000 rai and the mill is situated in the plantation area. About 40% of FFB processed is from their plantation. The rest of 60% is purchased from fresh fruit bunch suppliers.

Production Process

Factory D employs standard decanter process, consisting of a settling tank followed by a decanter to separate oil from wastewater. The production process is similar to factory C. Factory Dhas good housekeeping practice illustrated by :

- A separation of fresh fruit bunches into 3 categories: ripe fruit, unripe fruit and medium ripe fruit. They can control the optimum condition for sterilization of fresh fruit bunch. The optimum time to sterilize ripe fruit is shorter than those for unripe fruit. This approach saves energy and steam for sterilization step. However in plant survey of this factory take place in high production season of fresh fruit brunch, so fruit was almost ripen and trend to loss oil from fruit easily. So oil loss from sterilized wastewater is higher than other factories.
- Construction sewer to collect oil contaminated stormed water from loading ramp in order to recovery oil.

Clean technologies options applied in this mill are:

- Installation of decanter to recovery oil from wastewater.
- Installation of automatic controller to optimize operation for sterilizer (steam pressure, time).
- Collecting..... (manually) and resterilized unripe fresh fruit brunch
- Install buffer tank to separate sludge from crude oil before flow to settling tank.
- Recycling wastewater from sterilizer and sand cyclone to screw press in order to reduce hot water used and recover oil.
- Installation of oil recovery sump and oil trap tank (HRT1 day) to recover oil from wastewater before sent to WWTP.

The schematic flow diagram with mass balances of the standard decanter process of factory D is shown in Figure A3.1.

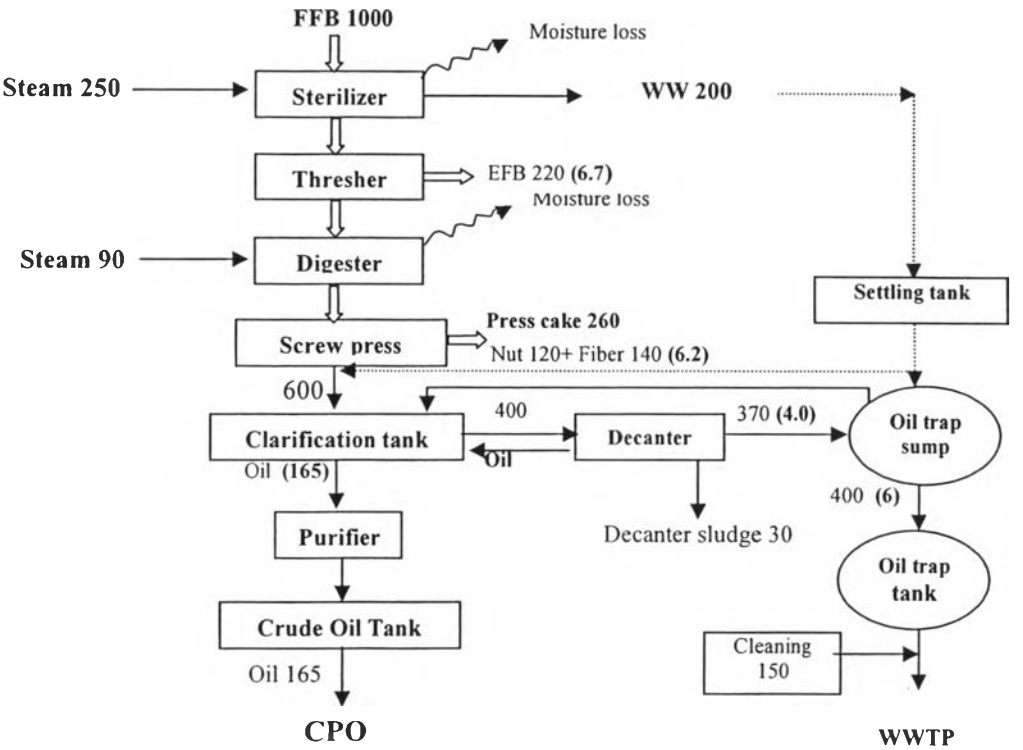


Figure A3.1 Schematic flow diagram of the mill D, including also mass balances.
( ) Oil content

Environmental aspects

The maximum production capacity of factory D is about 1,600 ton/day. The total water consumption is 341,080 m^3/year or equal to 1.26 m^3/ ton fresh fruit brunch. About 40% of the water consumption (0.51 m^3/ton fresh fruit bunch) is used for feed boiler water. Only feed boiler water is treated by coagulation with alum and followed by ion exchange. The cost of chemicals used for treating supply water is 1.45 Baht. Turbine cooling water of 0.4 m^3/ton fresh fruit bunch is pumped from reservoir without treating and drained back to the reservoir after it is used.

About 0.545 m^3 of wastewater is generated per ton of fresh fruit bunch production and stored in an pond system consisting of 6 anaerobic ponds, 2 aeration ponds, 3 facultative ponds and the final pond. Wastewater in final pond is aerated and allowed to be settled before discharged to the cannel. Since this mill owns an oil palm plantation area, the bottom sediment from treatment pond can reused as fertilizer in this plantation area. Also wastewater from clay bath can be recycled in this plantation area after patial evaporation in a sedimentation pond already mentions. Table A3.1 shows characteristic, of the wastewater in the WWTP of factory D.

Table A3.1 Characteristic of wastewater from wastewater treatment plant of factory D.

Sampling point	pH	BOD_5 (mg/l)	COD (mg/l)	SS (mg/l)	TKN (mg/l)	TP (mg/l)	O&G (mg/l)	Color (pt.Co unit)
Influent	5.10	38,650	99,840	35,510	1,090	-	14,980	10,000
Anaerobic pond (pond 1)	4.62	46,500	79,870	27,880	1,008	117	12,240	15,000
Aerated pond (pond 7-8)	8.15	3,466	19,470	12,720	1,040	76	110	19,000
Oxidation pond (pond 9)	7.95	1,973	8,990	7,200	560	110	ND	12,000
Final pond (pond 12)	8.36	268	1,520	580	81	9	ND	5,000

Note: ND= not detect

Material and energy balances

Mass balances for solid material (wet weight) flows are shown in Figure A3.2. It is clear that 1 ton of fresh fruit bunch processed produces 164 kg of crude palm oil and generates 220 kg of FFB, 140 kg of fiber, 60 kg of shell, 50 kg of nut and 30 kg of decanter cake wastewater.

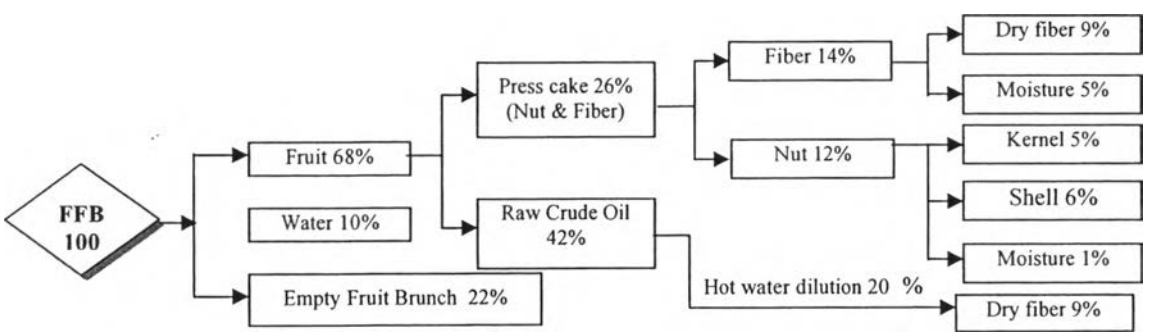


Figure A3.2 Material balance of palm oil mill D.

Liquid material balances

The water consumption in the mill is 1.26 m^3/ton fresh fruit bunch. Steam, 30 ton/hr is applied to a generator for generating electricity before supply to sterilizer, digester, kernel dryer tank, settling tank, and oil storage tank. About 50% of stream is supplied to the sterilizer. Wastewater generated from satirize condensate is sent to settling tank to remove settleable solids before recycling to a vibrating screen. The main source of wastewater in the process is generated from the decanter (0.4 m^3/ton fresh fruit bunch is produced). The other sources of wastewater are from resin regeneration and cleaning water. That is about 0.15 m^3/ton fresh fruit bunch (Figure A3.3).

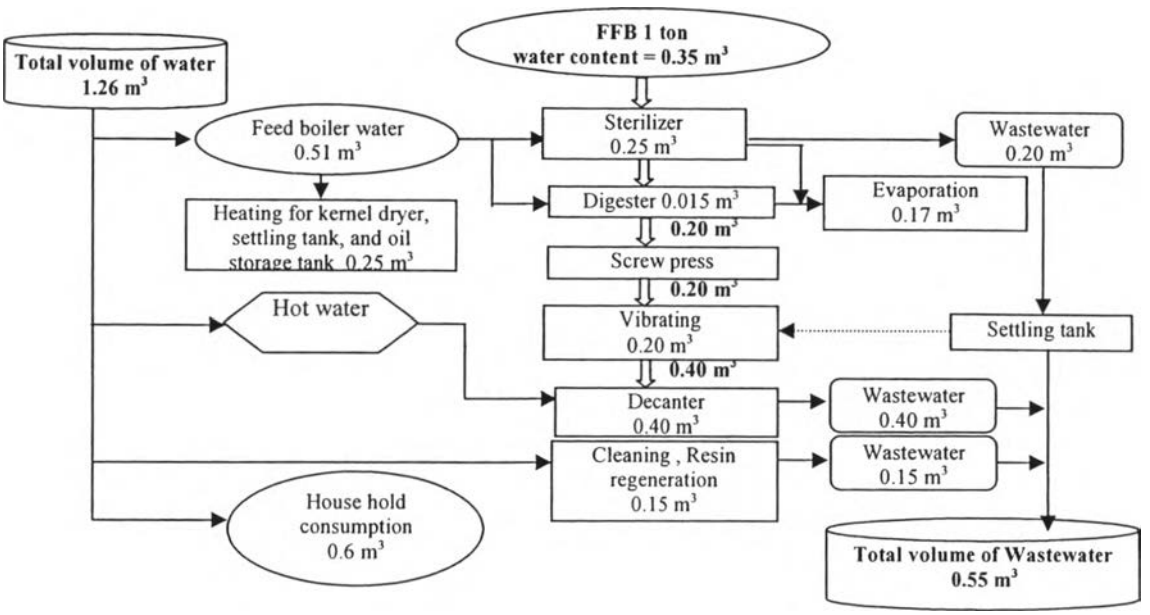


Figure A3.3 Water balance of 1 ton FFB in production process of factory D.

Energy balance

Factory D consumes electricity and diesel fuel at an amount of about 800 kW/d and 200 l/d respectively. The turbine generator can generated 1200 kWh/d that is used in both production process, office and households . Fiber and shell are fed to the boiler (4 ton/hr). The energy balance is presented in Figure A3.4.

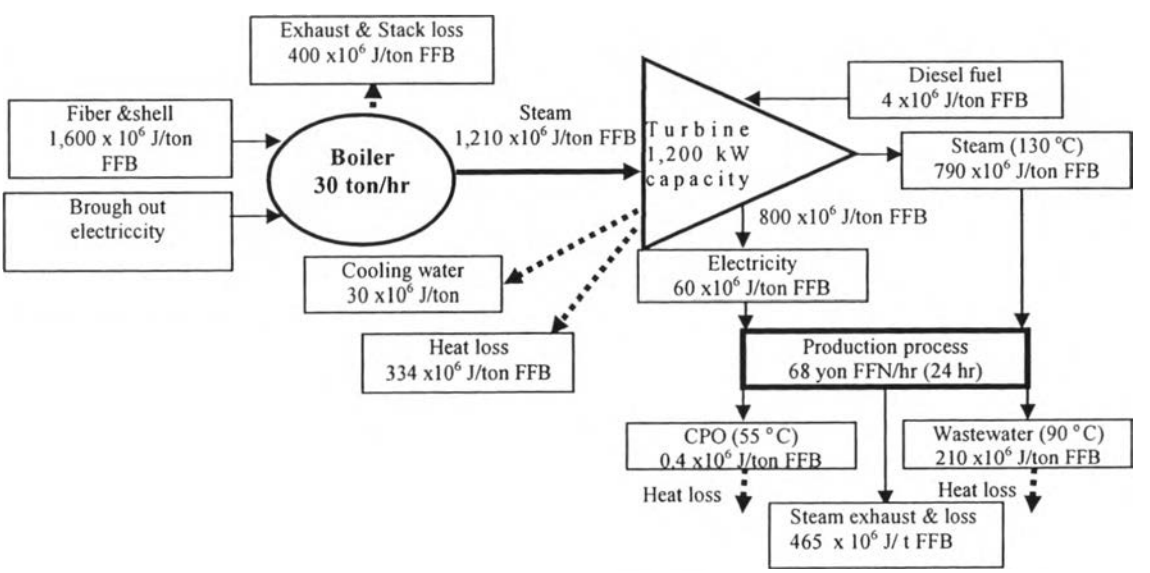


Figure A3.4 Energy balance in the production process of factory D.

APPENDIX A-4

FACTORY E

Introduction to the company

Factory E is one of the smallest companies involved in crude palm oil production. This factory is established in 1993 on an area of 160,000 m^2. It has approximately 50 employees. The production capacity is 30 ton FFB/hr the average production capacity is 400 ton FFB/day. Total production of the company is 10,000 ton CPO/year and 3,400 ton Palm kernel /year.

Input

The amount of FFB is 100,000 tons/year. Water consumption amount to the 156,000 m^3/ year from the deep well in the factory. Water is treated by adding coagulation aid to remove SS water. Factory E employs a standard wet process. A settling tank followed by a separator is used to extract palm oil. A schematic flow diagram of the standard wet process with mass balance is shown in Figure A4.1. This factory applies a few clean technology options. They also perform good are housekeeping, such as processing fresh fruit bunches in 24 hours after harvesting, reuse of the cooling water from turbine for cleaning and domestic purpose. Last 2 year they install 2 bunch stripper to enhance fruit separation from bunch stalk in order to reduce oil loss from FFB.

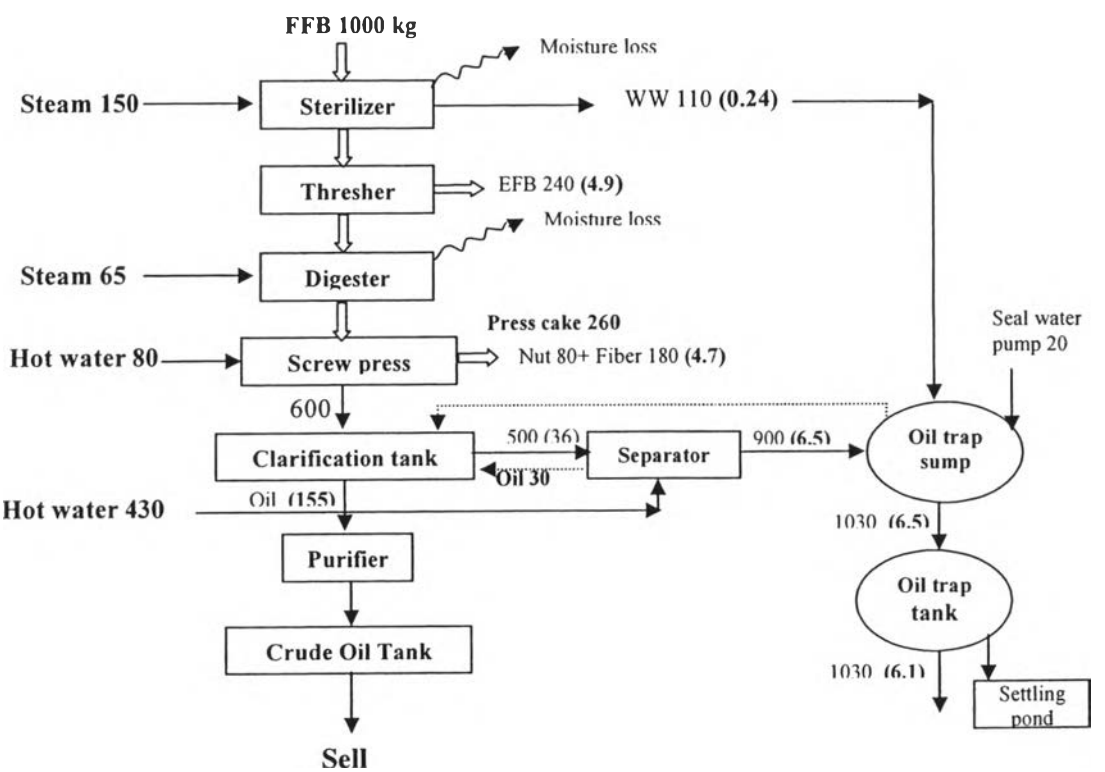


Figure A4.1 Schematic flow diagram of the mill E, including also mass balances.
( ) Oil content

Material and energy balance

a) Solid material balance

Factory E uses a separator for oil recover from wastewater in their production process. So there is no sludge from decanter generated in production process. All substances found in material flows are FFB, product (CPO and kernel), by-products such as empty fruit bunch, fiber, shell and solid waste such as solid contained in wastewater, sand etc. Mass balances based on ton of fresh fruit bunch (wet weight) are shown in Figure A4.2

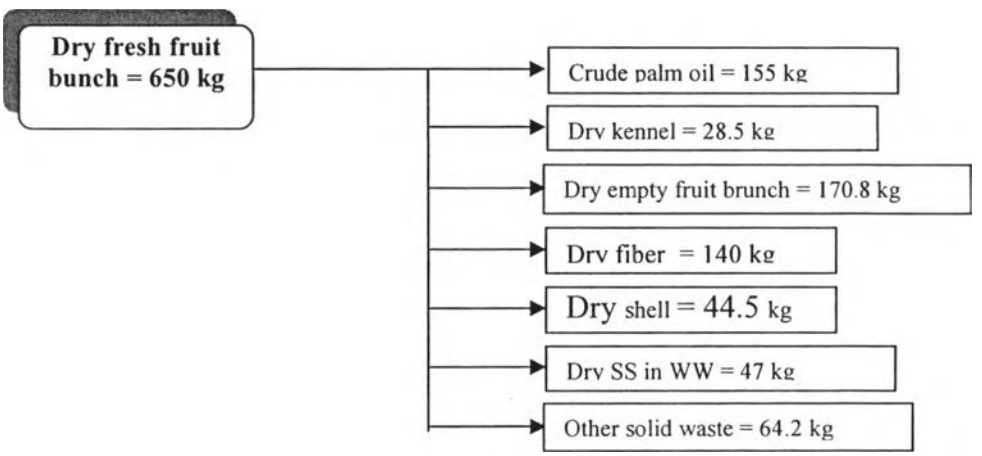


Figure A4.2 Mass balance for material flows in terms of dry weight.

b) Liquid material balance

The demand of water to process 223 ton of FFB is about 290 m^3. One ton of FFB consumes 1.3 m^3 of fresh water. The liquid materials including water consumed in each production step and wastewater generations are showed in Figure A4.3. This factory uses only a separator for recovery oil from wastewater and does use neither hot water nor wastewater in production process. Therefore all wastewater generated directly goes to the WWTP. The total wastewater for the production process is 1.0 m^3/ton FFB. That is the highest volume of wastewater per ton FFB from production process compared to other factories, which use all a decanter (factory A-D) in production process. Wastewater generated from separator is about 0.9 m^3/ ton FFB which is higher than wastewater generated from decanter. It is clear that wastewater generated from a factory that uses a decanter can reduce 43-54% of wastewater from production process. Because the concentration of SS-in the wastewater to be fed to the separator is not more than 4% so they have to dilute wastewater by hot waste before feeding to the separator.

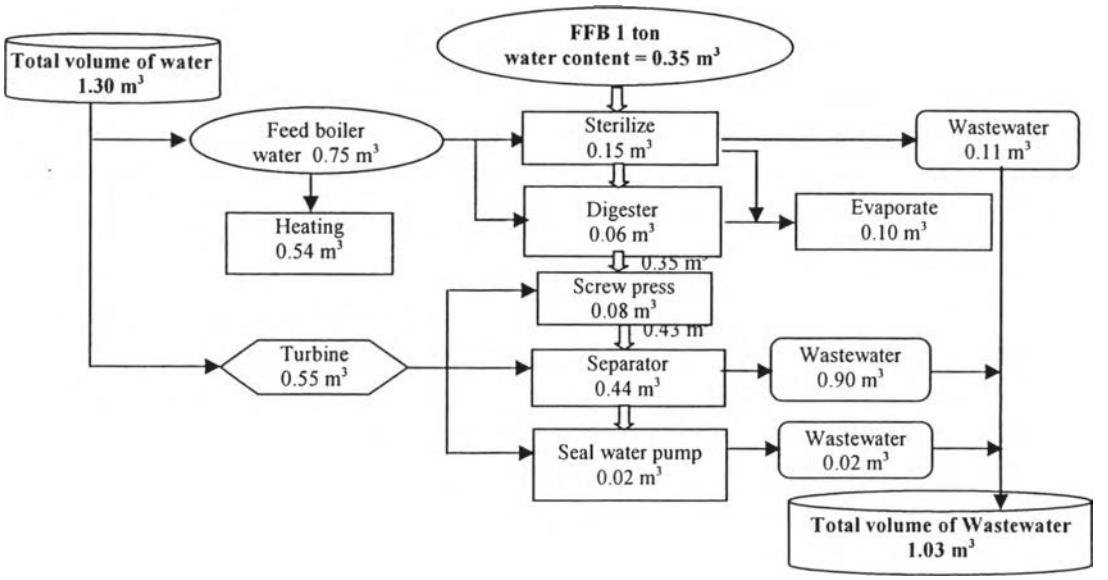
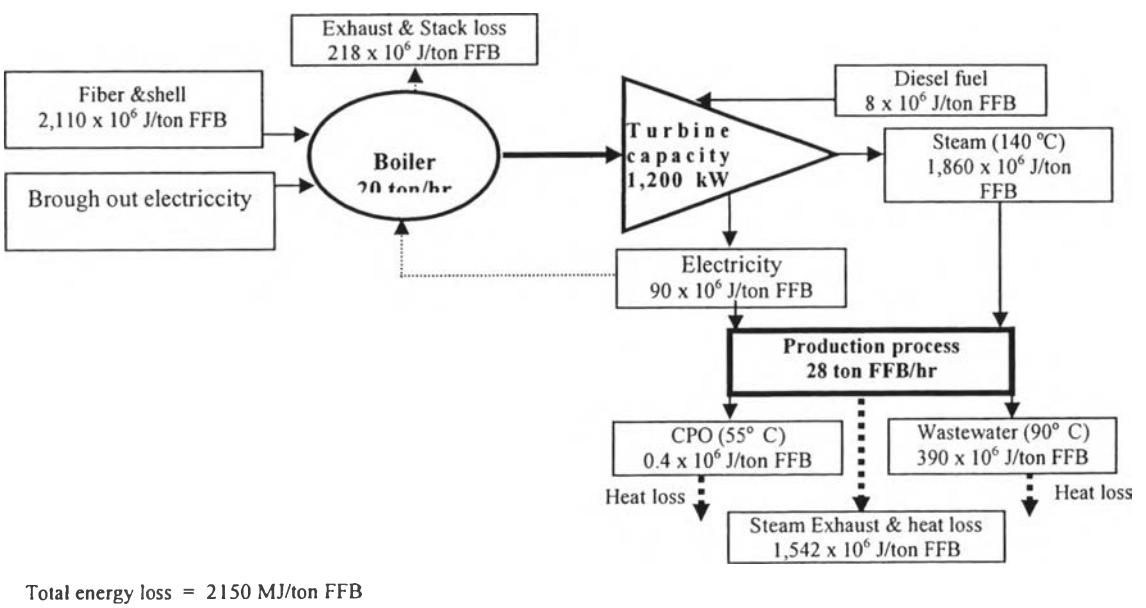


Figure A4.3 Volume balance for liquid material flow in factory E.

c) Energy balance

The energy balance of this mill is presented in Figure A4.4. Since capacity of turbine and boiler are higher than production capacity of this factory, a high energy loss is occurred. Electricity generated from turbine capacity of 900 kWh, but only 61% of the total power generated is used in the production process. Also steam exhaust and heat loss is very high. In the production process about 73% of energy loss in occurred in production process.



Total energy loss = 2150 MJ/ton FFB

Figure A4.4 Energy balance of the factory E.

Cost benefit analysis

Raw material cost is 9.7 Baht/kg CPO. Fixed production cost of this mill is equal to 0.9 Baht/kg CPO which is higher than other factories. This is due to the production efficiency of this mill, which is lowest (15.5%) compared to tht others. Total cost of production is 10.6 Baht/kg CPO. It is estimated that 91.5% of the production cost is for raw material purchasing. This mill get ...benefit from selling CPO equal to 1.4 Baht/kg CPO

APPENDIX B

APPENDIX B-1

General Survey: Palm Oil Industry

Part 1 General Data

Date ..... / ..... / .....

Factory Name ..... Registered Number .....

Location .....

.....

Telephone Number ..... Fax .....

Total employees ..... Male ..... Female .....

Working day per year .....

Year established ..... Investment cost .....

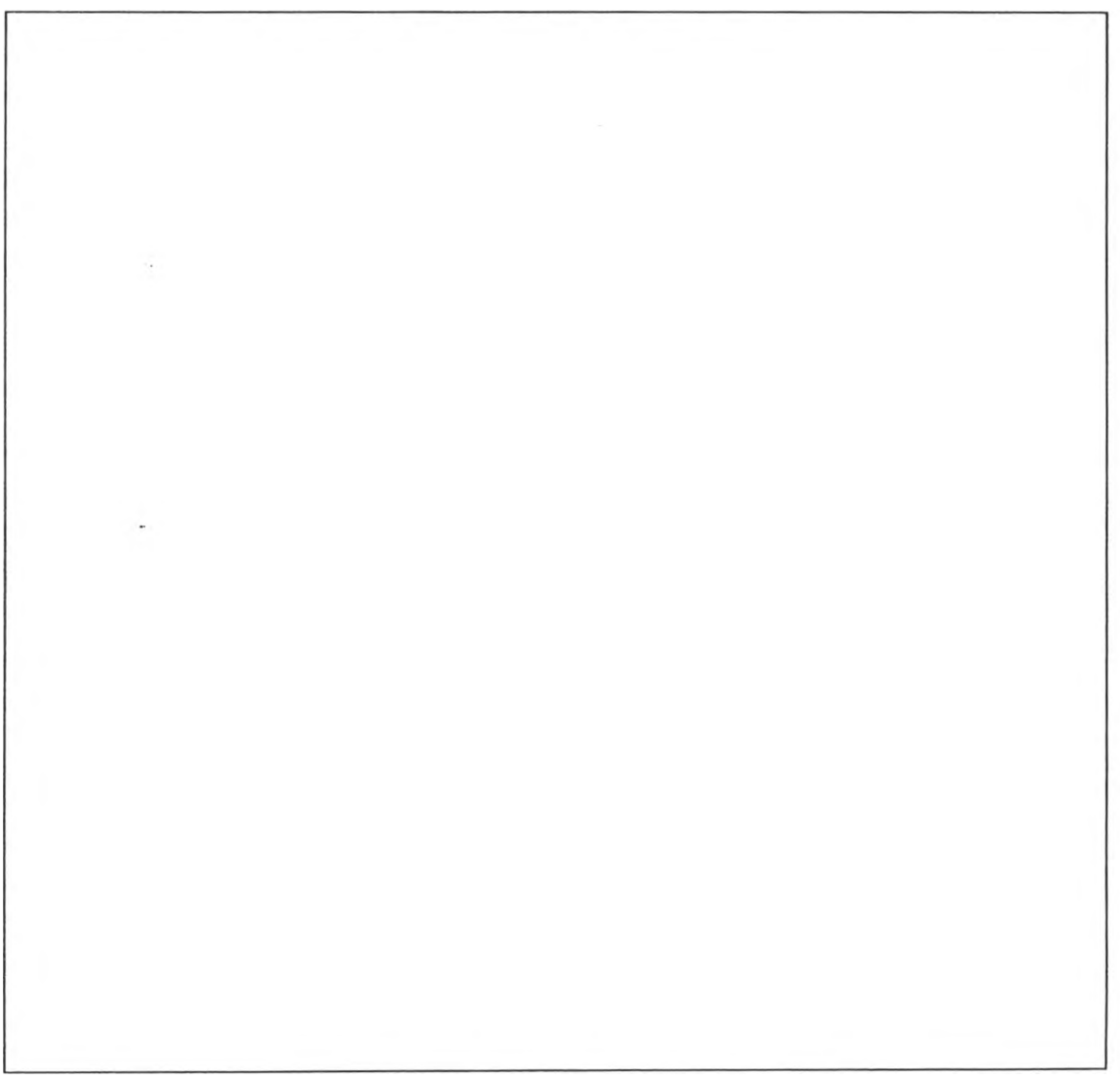
Baht

Owner .....

Customer .....

Palm supplier .....

Location Map of Factory



Part 2 Production Process Data

1. Raw Material

Material Type	Quantity (ton) / Year	Price / Unit (Baht)
For Production Process 1) Fresh Fruit Bunch 2)		
For Wastewater Treatment Plant 1) 2) 3)		

2. Product

Products	Quantity (ton) / Year
1) Palm Oil 2) Kernel Palm Oil	
By Product	**Quantity (ton) / Year**
1) Kernels 2) Fibers 3) Shell 4) Empty Fruit Bunches 5) Ash from Boiler 6) Waste Water	

3. Energy Use

Energy Use	Energy Use / Month		
	Production Process	Wastewater Treatment	Total
1) Electricity (Unit) 2) Diesel (Unit) 2) Fiber or shell (Unit)			

4. Water Use

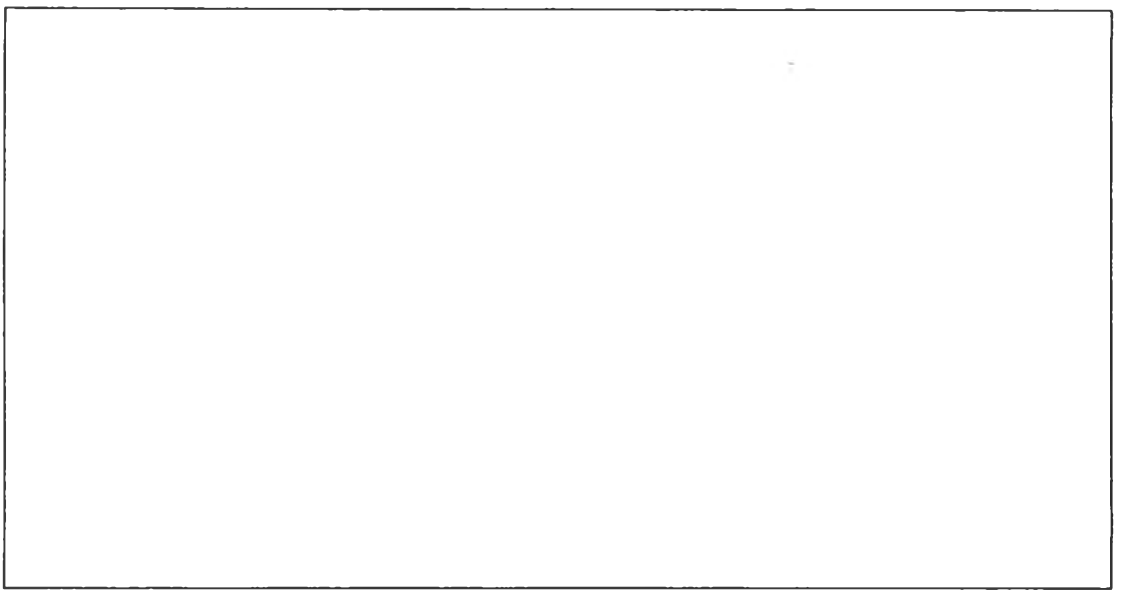
Production Process	Water Used (m^3/month)
1) Boiler 2) Cooling water 3) Sterilization 4) Oil Extraction • Digester • Screw Press • Separator • Vibrating screen • Sand cyclone 5) Cleaning machine 6) Clay bath 7) Domestic	
Total	

Schematic Diagram : Palm Oil Mill Process .....

Working Hour ..... per day, ... shifts / day
Average Production Capacity ..... (unit : ..... per month)
Maximum Production Capacity ..... (unit : ..... per month)

Part 4 Waste Management

1. Wastewater Treatment Schmatic Diagram



2. Wastewater Characteristic

Parameter	Influent	Effluent
1) pH 2) SS (mg/l) 3) BOD (mg/l) 4) COD (mg/l) 5) G & O (mg/l)		

3. Effluence management

O Agriculture O canal, river O Other .....

4. Solid Waste Management

Waste	In plant reuse/recycle	External reuse/recycle			Disposal
		Sell to	Price	Other	
1) Fiber 2) Shell 3) Empty Fruit Bunches 4) Sludge cake 5) Ash from Boiler					

5. Air Pollution Control

O Air pollution control equipment .....

O No

6. What is the environmental problem of the factory?

O Wastewater O Solid waste O Noise
O Air pollution O Smell from ..... O Dust from .....

7. What have been the biggest obstacles to improve the environmental performance?

O Technology
O Financial
O Knowledge
O Other .....

8. Do you think that industrial emission / effluent standard are appropriate?

O Yes.
O No. Reason .....

Part 5 Clean Technology
I. General

1. What is the conception of the word clean technology?

.....
.....
.....

2. Has the company adopted the Cleaner Production?

O Yes from when ..... O No

3. Why does the company apply cleaner production?

O Reduce oil loss
O Enhance product quality
O Increase competitiveness
O Increase production efficiency
O Reduce cost of production
O Comply with the effluent standard

4. What is the incentive for company to apply the clean technologies?

.....
.....

5. What have been the changes adopted in last 10 years?

O Clean technology
□ Good house-keeping .....
.....
.....
□ In-plant reuse/recycle.....
.....
.....
□ Process Modification .....
.....
.....

O Waste exchange

□ Reuse/ recycle of waste .....

.....

.....

□ Wastewater water treatment plant.....

.....

.....

6. Who have introduced clean technology to the factory?

O Government agency O Foreign organization
O NGO O University
O Other mills O Supplier

7. What are the major barriers of clean technology application within the mill?

O Lack of the personal resource O Lack of know-how
O Lack of information O Lack of incentive from government institute
O Lack of competitiveness O Lack of money
O Other .....

8. What the government agencies should do for better industrial environmental management?

.....

.....

.....

II. Clean Technology application

1. What kind of improvements have been done?

1.1 Wastewater

- Control system of sterilizer

O Automatic O Manual

- Management of wastewater from sterilization

O Go to Wastewater Treatment plant
O Separate and recycle to .....
O Other .....

- Oil-water separation equipment

O Separator O Decanter O Decanter & Separator
O Settling tank O buffer tank
O Other .....

- Management of steam condensate

O Drain to sewer
O Separate and recycle to .....

- Oil separation from wastewater before go to wastewater treatment

O Oil Trap tank O Oil skimmer O Other .....

1.2 Solid Waste management

- EFB disposal
  O Mushroom O Fertilizer O Landfill O Burning

- Fiber disposal
  O Fuel in factory O Sell to other factories O Other

- Shell disposal
  O Fuel in factory O Sell to other factories O Other

- Floating scum
  O Soap O Fuel O Other

2. After cleaner production application, Any change ?
   O Increase production yield O Enhance product quality
   O Reduce water consumption O Reduce waste water flow
   O Reduce oil loss in wastewater O Reduce energy consumption
   O Reduce operation cost O Other

3. What is done in order to introduce continuously improvement and how is this done?

.....

.....

.....

4. What will be done, in the future, related to improving the technology management in the company ?

.....

.....

.....

III. Knowledge

1. What is your source of knowledge in relation to improvement of the environmental performance ?
   O Consultancy O Supplier O University/Research institute
   O Government agency O NGO O Foreign organization
   O Other .....

2. What kind of knowledge do the company need in order to improve more ?
   O Technical assistance
   □ Consultancy □ Training □ Demonstration
   □ Manual □ Pilot plant □ Other .....

   O Financial assistance
   □ Low interest loan □ Grant □ Other .....

IV. Regulation

1. Which environmental laws must the company comply with ?

.....
.....
.....

2. Who enforces the law and how is this done?

O Control of emission
O Visual inspections
O Other .....
O Self – control
O Reaction when problem occur

3. What is the conception of the regulation authority?

O Enemy
O Co – operation
O Partner
O Control and enforcement

4. Do the company think that the regulation need to be improved ?

O Yes .....
O No

V. Market

1. Who is the competitive of palm oil ?

.....
.....
.....

2. What is the competitive advantages of the company today / in the future ?

.....
.....
.....

3. Does the company see opportunities in the market in the field of green products ?

.....
.....
.....

4. How big is the capacity to investigate the opportunities in new markets and create new market potentials ?

.....
.....
.....

5. What need to be done to improve this ?

.....
.....
.....

APPENDIX B-2

Questionaire for 5 selected factories (Clean Technology approach)

1. What is the conception of the world clean technology?

---

2. What are the environmental problems of the factory?

---

3. Project concern in environmental improvement of the factory (Actor involving , how, when and the outcome)

1) ---
---
2) ---
---
3) ---
---
4) ---
---
5) ---
---
6) ---
---
7) ---
---
8) ---
---
9) ---
---

4. What have been done in process to improve environmental performance or reduce environmental impact in company ?

1) ---
---
2) ---
---
3) ---
---
4) ---
---
5) ---
---

5. Detail of clean technology introduction within a mill.

Project	Motivation	Incentive	Information	From whom	Barrier	Problem

6. What relationship do you have with the following actors?

Actor	Relationship	Contact Frequency	Report	Report frequency	Type of resource	Type of exchange
Policy Actors • TOA/ POA • DIW/ PIA • PCD • PHPA • Municipality/ District • Others **Economic Actors** • Other millers • Other downstream factory • Suppliers • Customer/ consumer • Bank • Insurance companies • Oil palm planters • Other • University / research institute • Palm oil association • Other **Societal Actor** • Community • NGO • Mass media • Other						

7. Do you have to deal with any pressure from environmental agencies, the surrounding community, or other actors on environmental issues?

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8. What is the improvement of the business in the future?

- Hardware ----------

- Software ----------

BIOGRAPHY

Orathai Chavalparit was born on 3 January 1960 in Bangkok, Thailand. Since 1986, after received her M.Sc. Degree in Environmental Biology from Mahidol University, she worked in Office of Natinal Environmental Board. From 1987 till 1990 she worked as a lecturer at the Faculty of Science of Rangsit University. In 1990 she came to work with Faculty of Engineering, Chulalongkorn University. She was promoted to Associated Professor from 1997 up till now. She came to Chulalongkorn University at 2000 to start her PhD study.