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Palm Oil Processing Recommendations to Support the New Life Project for Underprivileged Children

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PALM OIL PROCESSING RECOMMENDATIONS TO SUPPORT THE NEW LIFE PROJECT FOR UNDERPRIVILEGED CHILDREN

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ABSTRACT

The Duang Prateep Foundation established the New Life Project in Kanchanaburi, Thailand to help underprivileged children escape slum life and learn skills to succeed in society. The goal of our project was to help the New Life Project advance toward self-sustainability by presenting viable options for generating profit from its oil palm plantation. Our analysis showed that both selling the palm fruit and establishing a palm oil production facility would be profitable, but with varying risk levels and social impacts.

ACKNOWLEDGEMENTS

Our project would not have been possible without the efforts of several individuals outside our project group. We would like to take time to thank everybody who made our research possible.

We would like to begin by thanking the Duang Prateep Foundation for the extensive time and effort they committed to sponsoring our project. We would like to thank Khru Prateep Ungsongtham Hata, the founder and chairperson of the Duang Prateep Foundation, for taking time from her busy schedule to provide us with information about the New Life Project and for sharing Thai food and culture with us. We would also like to thank the Foundation's head of secretariat, Dr. Supphawut Manochantr, for the critical role he played in providing us with information regarding the New Life Project. Furthermore, we would like to thank the staff at the New Life Project, especially Khun Rotchaya Ittirattana, the manager of the oil palm plantation, for their hospitability in hosting us and providing a tour of the plantation in Kanchanaburi.

We would not have been able to begin the investigation within our project without the hospitality offered by local palm oil processing plants. At Suk Sombun Palm Oil in Chon Buri, we would like to thank Khun Chana Chintarattanawong, the managing director, for providing us with an information session; Khun Sura Tanwiset, the palm farm coordinator, for touring us through the facility; and Khun Nipaporn Chintaratanawong, the account manager, for touring us through the facility. At Sasdee Palm Oil in Kanchanaburi, we would like to thank Khun Sutida Sendee, the factory manager, for the information she provided us during our tour.

The collaboration between MTEC and Great Agro provided us with a foundation from which to base our analysis. We would like to thank Khun Ascha Chandsongsang for touring us through Great Agro's prototype system and Khun Bundit Jumras for providing additional information regarding Great Agro's system and purpose.

Our project and overall experience in Thailand would not have been possible without the CU and WPI faculty members that helped us get here. We would like to thank Dr. Supawan Tantayanon of CU for her assistance in advising our project along with her continuing efforts in working with the WPI IGSD office to make the Bangkok project site possible. Finally, special thanks are due to our advisors, Chrys Demetry and Rick Vaz, for their constant efforts and input to improve our project. They provided direction in our dead-ends and helped to make our project so much more than just a paper.

EXECUTIVE SUMMARY

In the Klong Toey slum of Bangkok, Thailand, young boys and girls often fall victim to neglect, malnutrition, unsafe living conditions, and emotional stresses, such as isolation and depression. This can often lead to greater societal issues such as prostitution and drug addiction. In an effort to address these problems, the Duang Prateep Foundation (DPF) established the New Life Project 200 kilometers outside of Bangkok in the rural province of Kanchanaburi. The New Life Project gives children from the slums an opportunity to learn basic life skills in a safe environment through education, farming, and maintaining responsibilities around the plantation.

The DPF currently relies on fundraising and other donations in order to pay for the operation of the New Life Project in Kanchanaburi, about 1.5-2 million baht annually. However, it would like the New Life Project to become self-sustaining, and it established an oil palm plantation at the site in 2003 in order to raise income. The plantation contains 8600 trees; currently, only the oldest six-year-old trees are harvested and the fruit is sold to a local palm oil facility, but the rest of the trees will be ready for harvest within the next two or three years. The DPF would like to investigate the possibility of an on-site palm oil processing facility in hopes that it would be more profitable than simply selling the fruit. The goal of our project was to help the New Life Project advance toward self-sustainability by presenting viable options for generating profit from its oil palm plantation.

Investigation of Small-Scale Palm Oil Production Systems

To collect information about different options for palm oil processing, we visited three local facilities of different scales: a small-scale factory in Kanchanaburi called Sasdee Palm Oil; a large-scale facility in Chon Buri called Suk Sombun Palm Oil; and a small-scale prototype system in Pathum Thani. The prototype system was the result of collaboration between the National Metal and Materials Technology Center (MTEC) and Great Agro, an agricultural engineering company. We decided to analyze Great Agro's system more thoroughly as it was applicable to the scale of the DPF's plantation and provided a machinery manufacturer contact.

We believe that the Great Agro system is a good choice for the DPF as it processes one tonne of fruit hourly, which is an appropriate scale for the fruit produced by the New Life Project

plantation. It enables the sale of the nut and fiber of the palm fruit as well as grade A crude palm oil. Furthermore, it produces neither wastewater nor emissions, making it environmentally friendly. The initial cost of Great Agro's system is 7.5 million baht and includes the machinery and its installation, a building to house the machinery, and training of the operator.

Financial Analysis

We analyzed the following three revenue-generating scenarios with respect to their projected profitability, payback periods, and social implications:

1. *Continuing to sell fruit*. The DPF would continue to sell the fresh fruit bunches from its mature plantation to a nearby processing facility.
2. *Purchasing and installing Great Agro's system to process New Life Project's fruit*. The DPF would use Great Agro's system to process the fruit bunches produced by its mature plantation, which would require two days of operation per week, eight hours per day.
3. *Purchasing and installing Great Agro's system to process New Life Project's fruit along with supplemental fruit.* The DPF would use Great Agro's system and would supplement its own fresh fruit bunches with fresh fruit bunches that it would buy from surrounding plantations in order to run the facility six days a week, eight hours a day.

To estimate profit for each scenario, we subtracted the estimated costs from the expected revenue. The revenue sources and operating costs that we analyzed include:

Sources of Revenue

- *Fresh fruit bunches*. This applies to the first scenario only.
- *Crude palm oil*. This applies to the second and third scenarios.
- *Byproducts of processing, including nut and palm press fiber of the fruit*. These apply to the second and third scenarios.

Operating Costs

- *Plantation maintenance*. This cost is the same for all three scenarios. We accounted for the annual cost of irrigation, fertilization, and labor for harvesting fruit.

- *Transportation of fresh fruit bunches*. This applies to the first scenario only and is the price for transporting the bunches to a processing facility. We used the current price that the DPF pays to transport its fresh fruit bunches.
- *Oil processing labor*. This cost applies to scenarios 2 and 3. We estimated labor costs assuming two workers at minimum wage and a more skilled operator at a higher wage. The costs are determined from hours of operation.
- *Electricity*. This cost applies to scenarios 2 and 3. We obtained power consumption of the machinery from Great Agro and the average 2009 Thailand electricity rates for a small business. The electricity costs are determined from power consumption and hours of operation. Our estimate does not consider possible increases in power consumption as the equipment ages. We did consider the power that would be required to heat up the dryer for one hour in advance of production.
- *Fuel*. This cost applies to scenarios 2 and 3. The engineering manager at Great Agro told us the annual cost of the LPG (liquefied petroleum gas) used for two facility components when running for an average workweek, so we used this fuel cost estimate for scenario 3. He told us that fuel cost is directly proportional to number of operating days, so we divided his estimate by three in order to estimate the fuel cost used for scenario 2.
- *Machinery maintenance*. This cost applies to scenarios 2 and 3. The engineering manager at Great Agro advised us to estimate annual maintenance costs as 3% of the startup cost of the system. We assumed that the maintenance costs would be less for scenario 2 compared to scenario 3 as machinery maintenance is based upon the time that the machine is used (Fogiel & Keller, 1998). For simplicity, we assumed that the equipment maintenance cost for each scenario would be constant over the lifetime of the equipment. We did not consider extra machinery downtime for larger machinery repairs.
- *Machine replacement*. This cost applies to scenarios 2 and 3. The engineering manager at Great Agro informed us that Great Agro believes the machinery to have a lifetime of approximately ten to twenty years, operating in eight-hour shifts daily. We included a cost for scenario 3 to replace the entire system every ten years, to be conservative. We assumed that this cost would be one-third of the amount for scenario 2 compared to scenario 3 because the lifetime of the machinery is based upon the time that the machine *is used*, not on the time the machine exists (Fogiel & Keller, 1998).

- *Raw materials*. This applies to the third scenario only and included the cost of the supplemental fresh fruit bunches that the DPF would need to buy from local farmers to run their facility for an average workweek.

For scenarios 2 and 3, we also estimated the payback period, or the amount of time that it would take the DPF to earn back their investment. We divided the initial investment for Great Agro's system, approximately 7.5 million baht, by the profit *beyond* what they would be making if they chose to sell the fruit. This is because the DPF is *already* selling their fruit and the payback period represents the time it takes the revenue, beyond what they are already making, to exceed the operating and initial costs.

Conclusions

Table 1 shows the range of projected annual profits and payback periods for the scenarios. The wide range in these projections is due to price volatility for fresh fruit bunches and crude palm oil. For purposes of illustration, we used price data from 2008.

Table 1: Range of projected annual profits and payback periods for scenarios.

Scenario	Annual Profit (in Millions of Baht)	Payback Period (in Years)
1	1.3 – 4.6	–
2	2.7 – 6.1	2.7 – 5.6
3	4.9 – 11.1	0.9 – 2.0

*Price ranges in Thailand in 2008 for fresh fruit bunches and crude palm oil were 2.82–5.98 baht/kg and 17.02–36.26 baht/kg, respectively (*Department of Internal Trade*, 2009).

We predict that continuing to sell fruit would generate enough profit to finance the operating costs of the New Life Project site in Kanchanaburi. We expect that by 2012 when all the trees at the New Life Project reach maturity, selling the fruit would yield an annual profit of *1.3–4.6 million baht.* Assuming the average price of fresh fruit bunches for 2008, we project an annual profit of *3.3 million baht*. This option has very little risk because there is no initial investment.

Purchasing and installing Great Agro's System to process only the fruit grown at the New Life Project plantation should generate more revenue than simply selling the fruit, but with more uncertainties. Given the range of fresh fruit bunch and crude palm oil prices, we estimate that by 2012, the DPF would yield an annual profit of *2.7-6.1 million baht*, or *4.9 million baht* using average bunch and oil prices, by processing its own fruit. This exceeds the operating cost of the New Life Project site in Kanchanaburi. These profits will pay back the initial investment of 7.5 million baht in *2.7–5.6 years*. Although this option is more profitable than simply selling fruit, it introduces more uncertainty.

We predict that purchasing and installing Great Agro's system to process the fruit from the New Life Project and that of local farmers would be the most profitable option for the DPF; however, the DPF should be aware of the associated complications. Assuming the average prices from 2008, our calculations show that this scenario would generate an annual profit of *7.9 million baht*, or a range of *4.9–11.1 million baht*. We predict that the profits from this scenario would recoup an initial investment of 7.5 million baht in *0.9-2 years*.

We conclude that scenarios 2 and 3 have social benefits for the community and the environment. Great Agro's palm oil production facility would:

- *Provide jobs*. The facility could provide jobs young men who are too old to stay at DPF's New Life Project site in Chumporn. Because it operates for a full workweek, the third option provides more labor, but both scenarios would require workers to operate the machinery.
- *Benefit the local economy*. Creating more oil production capacity in Kanchanaburi could encourage more local farmers to begin growing oil palm trees.
- *Benefit the environment*. The facility that currently processes the DPF's fruit emits air pollution, but the Great Agro system utilizes clean-burning liquid petroleum gas and does not produce wastewater.

Whichever option the DPF chooses, we believe that its oil palm plantation will be a substantial source of revenue in the years to come. We hope that our work will help the New Life Project advance towards a state of self-sustainability so that the DPF can, without constant fundraising, give the young children living in poverty in Klong Toey a new life.

AUTHORSHIP AND CONTRIBUTIONS

Information Gathering

- Gift communicated with many of our Thai-speaking contacts.
- Kevin obtained many statistics from our English-speaking contacts.
- Nan provided summaries and translations for several web pages posted in Thai.
- Both Nan and Gift actively translated during interviews and translated Thai documents.
- Nan conducted additional research into marketing and manufacturers.
- Gift conducted additional research from the Thai Department of Internal Trade.
- All five members documented information received in interviews and tours.
- Anne played an active role in compiling and organizing our notes.

Analysis

- Kevin wrote the initial spreadsheet used for many of our calculations.
- Joe devised the projection equations, which accounted for variation in pricing.
- Anne wrote a revised spreadsheet that was more concise and reader-friendly.

Miscellaneous Contributions

- All five members participated in the writing and organization of presentations.
- Anne acted as a group secretary and maintained organization within our documents, presentations, and drafts.
- Kevin created many of the visual aids used in the presentations and the paper.
- Joe monitored time management and set approximate deadlines to pace the project.

Writing Contributions

Abstract: Joe and Anne collaborated to write the abstract.

Acknowledgements: Joe wrote the acknowledgments and Anne proofread this section to check for spelling, grammar, and completeness.

Executive Summary: Anne wrote the executive summary and Joe conducted final editing.

Introduction: Joe wrote the introduction and Anne provided major editing both before and after receiving advisor feedback.

Literature Review: Joe, Anne, and Kevin all wrote large sections of the background chapter during PQP. After arrival in Thailand, Joe and Anne worked together on major editing of this section.

Methodology: Anne generated an outline for this section and Joe wrote the section, based on that outline. Anne edited this section and conducted a final proofread before submission. After receiving advisor feedback, Joe conducted major editing and Anne contributed minor editing and proofreading.

Findings: Anne wrote the majority of the findings section and Joe proofread this section before initial submission. After receiving advisor feedback, Kevin added additional material during his editing. Joe and Anne also contributed major editing to this section.

Conclusions and Recommendations: Anne and Joe worked together to write this section; however, after advisor feedback, most of this section was deleted. Joe re-wrote the section and Anne provided feedback while Joe wrote and conducted editing afterwards.

Appendices: Joe edited Anne's compiled notes and formatted them into complete sentences for Appendices A and B. Anne compiled pictures in Appendix C. Using Kevin's graphs and Joe's equations, Anne compiled Appendices D and E.

*Anne provided major editing in the formatting of the paper and Joe conducted minor editing in the format to ensure consistency.

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1. INTRODUCTION

In the Klong Toey slum of Bangkok, Thailand, young boys and girls often fall victim to neglect, malnutrition, unsafe living conditions, and emotional stresses, such as isolation and depression. This can often lead to greater societal issues such as prostitution and addiction to hard drugs, including amphetamines and heroin. In an effort to address these problems, the Duang Prateep Foundation (DPF) established the New Life Project 200 kilometers outside of Bangkok in the rural province of Kanchanaburi. The New Life Project gives children from the slums an opportunity to learn basic life skills in a safe environment through education, farming, and maintaining responsibilities around the plantation.

The DPF currently relies on fundraising and other donations in order to pay the expenses of maintaining the New Life Project site in Kanchanaburi. Ultimately, the DPF would like the New Life Project in Kanchanaburi to reach a point of self-sustenance. The Foundation established an oil palm plantation at the site in 2003 in order to raise income to support the operation. Currently, only the oldest six-year-old trees are harvested, but the rest of the trees will be ready for harvest within the next two or three years. The fruit is sold to a local palm oil production facility that also buys most of the palm fruit produced by the 20,000 oil palm trees in Kanchanaburi. The DPF would like to investigate an on-site palm oil processing facility in hopes that it would be more profitable than simply selling the fruit. Rather than relying on fundraising, the DPF would like the sale of palm oil or palm fruit to generate enough revenue to alleviate the cost of providing food and shelter to the children living at the New Life Project.

The goal of our project was to help the Foundation's New Life Project advance toward self-sustainability by presenting viable options for generating profit from its oil palm plantation. We met this goal by addressing each of the following objectives:

1. Determining the priorities and needs of the DPF regarding the design of a palm oil processing facility, and assessing the current conditions of the New Life Project oil palm plantation in Kanchanaburi.
2. Gathering information about local palm oil production facilities.

3. Analyzing several suitable revenue-generating palm fruit scenarios, taking into account the possibility of processing the fruit of surrounding farmers.

The outcome of our project was revenue and cost projections for each scenario, along with an analysis of the social and environmental considerations of each. We worked closely with the DPF in order to provide the organization with profitable possibilities that met their needs in order to help the New Life Project move towards self-sustainability.

2. BACKGROUND

In this chapter, we begin with an overview of the societal dangers that often arise from slum life, specifically from the Klong Toey slum of Bangkok. Khru Prateep Ungsongtham Hata founded the Duang Prateep Foundation in order to help the young children living in Klong Toey. One of her many outreach endeavors, the New Life Project, recently started an oil palm plantation to generate revenue. Although the Foundation currently sells its palm fruit, it would like to investigate whether processing its own palm oil would be more profitable. In this chapter, we discuss the palm oil industry as well as its common standards and production methods. We then close by discussing the status of the New Life Project plantation in Kanchanaburi.

2.1 Duang Prateep Foundation's New Life Project

Poverty within a community often leads to further social complications. Children in particular often fall victim to neglect and social injustice. In the Klong Toey slum of Bangkok (Figure 1), thousands of children live with parents or grandparents who do not have the economic resources to support them, and many are forced to work in the streets from an early age. Because of these social pressures, children often feel hopeless and incapable of rising above poverty. It is common for children of the Klong Toey slum to fall victim to sexual abuse or addiction to hard drugs including amphetamines and heroin.

Prateep Ungsongtham Hata grew up in the Klong Toey slum of Bangkok and suffered the same financial struggles in her childhood as the children she now helps. At the age of twelve, after receiving a minimal education, she became a street worker in order to pay for secondary schooling. She took classes at night while working all day and eventually managed

Figure 1: Klong Toey slum in Bangkok.

to complete her higher education. In 1968, Prateep and her sister began a school out of their home in the slum. At first, the city government deemed the school illegal, but she fought for ten persistent years and finally legitimized the school (Khru Prateep, personal communication, January 12, 2009). In 1978, she won the Ramon Magsaysay Award for Public Service and used the prize money to begin the Duang Prateep Foundation (DPF). In 2004, Prateep received the World's Children Prize and the Global Friends' Award "for her 35-year-long struggle for the rights of Thailand's most vulnerable children" (DPF, 2009).

One way that the DPF provides hope for the children of the Klong Toey slum is through the New Life Project. The DPF founded the first New Life Project (for boys) in the province of Chumporn (Figure 2), where the boys learn interpersonal skills and responsibility through agricultural work, caring for farm animals, and trading their crops. A rural location for the New Life Project, 200 kilometers south of Bangkok, ensured that the boys would not be able to obtain drugs. The DPF hopes that the boys leave the New Life Project not only drug-free but also with the skills and confidence to build a better life.

The success of the New Life Project in Chumporn led to the founding of a second New Life Project in 1998 in the rural province of Kanchanaburi, 200 kilometers northwest of Bangkok on the border of Myanmar (Figure 2). The DPF does a great deal of fundraising to finance the New Life Projects and began an oil palm plantation at the Kanchanaburi site in 2003 in order to raise additional revenue for the operation. The oil palm plantation in Kanchanaburi contains about 8600 trees, approximately 200-300 of which are mature. The DPF currently sells the harvested fruit to a palm oil production facility thirteen km away, but it is considering producing crude (unprocessed) palm oil on-site in order to increase its earnings. The DPF would like to learn more about palm oil processing and its revenue-generating options in order to continue to support the children of the Klong Toey slum (Khru Prateep, personal communication, January 12, 2009).

Figure 2: Map of Thailand showing locations of DPF and New Life Projects. Modified from http://upload.wikimedia.org/wikipedia/commons/2/28/BlankMap_Thailand.png.

2.2 The Palm Oil Industry

With refining, crude palm oil has many uses ranging from food applications to the fuel that runs our cars. Both worldwide and in Thailand, the palm oil industry has increased very rapidly in recent years. In this section, we will discuss the applications of palm oil and the growing industry before moving into the growing and harvesting of the oil palm tree.

There is a variety of uses for palm oil. About 90% of palm oil produced is used in food-related applications. After refining, palm oil contains only about 50% saturated fat, is free of cholesterol, is odorless and tasteless, and contains many antioxidants. It lacks trans fat and can be a healthier substitute for other seed oils like soybean and canola oil. There are many products fried in palm oil, including potato chips, French fries, doughnuts, ramen noodles, and nuts. Palm oil can also be separated into a solid part called the stearin, which is used in shortening and margarine, and a liquid part called the olein, which is used as frying oil. Non-food applications for palm oil can be divided into two categories, products that use the oils themselves and products that use oleochemicals, which are chemicals derived from the oil. Some products made with the oil itself include soaps, plastics, drilling mud, and biofuel. Products made with oleochemicals derived from palm oil include candles, lotions, body oils, shampoos, skincare products, rubber, and cleaning products (American Palm Oil Council, 2008).

Palm oil production has increased worldwide during the past three decades. It doubled from 5 million tonnes in 1980 to 11 million tonnes in 1990 and doubled again to 21.8 million tons in 2000. By 2005, that number had increased to 34.4 million tonnes (Fromm, 2007). As shown in Figure 3, more palm oil was produced worldwide in 2007 than any other vegetable oils or fats (*Malaysian Palm Oil Council*, 2008). Currently, Indonesia and Malaysia produce 87% of the world's palm oil (Figure 4), and Thailand, the third-largest producer, lags behind with 3% of the world's production (Butler, 2008).

The oil palm was first brought to Thailand in 1968 after it successfully replaced the native rubber trees in Malaysia (Prasertsan, 1996). Small-scale farmers own about 70% of Thailand's oil palm plantations, and the remaining plantations are run by the private sector and cooperatives (Yangdee, 2007). Following the worldwide trend, palm oil production has also increased in Thailand. As shown in Figure 5, the annual palm oil production in Thailand has climbed steadily over the last decade from 2.5 million tonnes in 1998 to 6.5 million tonnes in 2006. In the province of Kanchanaburi, where the New Life Project is located, palm oil production reached 859 tonnes in 2006 (Office of Agricultural Economics, 2008).

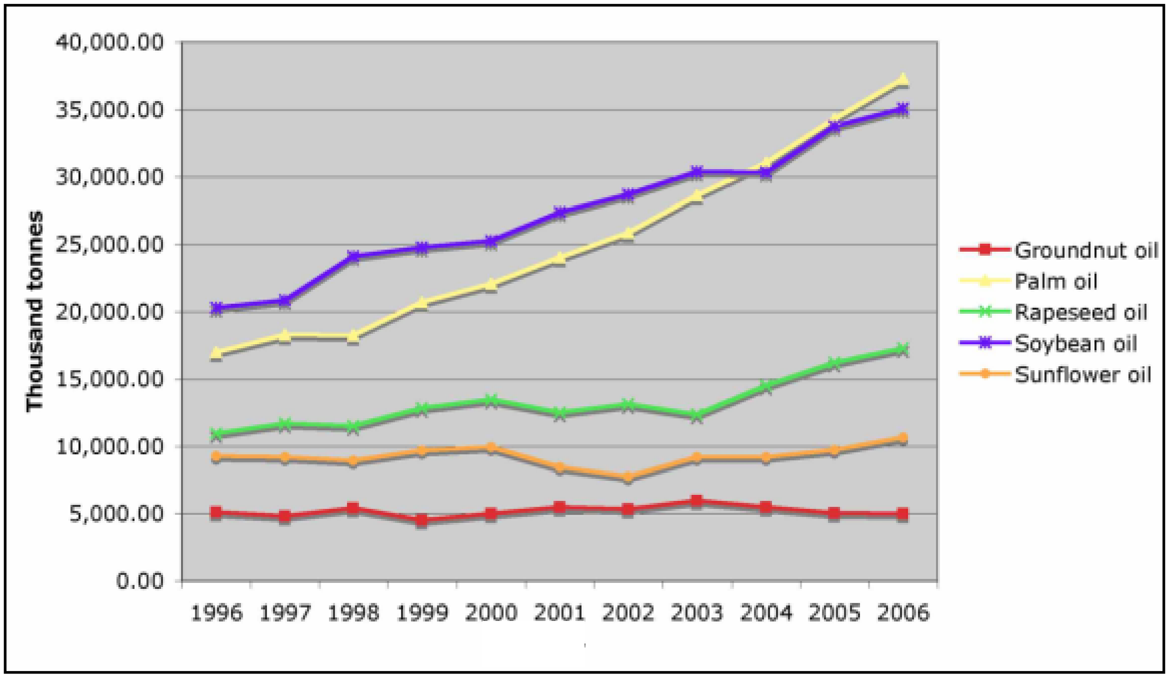

Figure 3: 1996-2006 World production of dominant vegetable oil. Source: http://www.sustainablefoodlab.org.

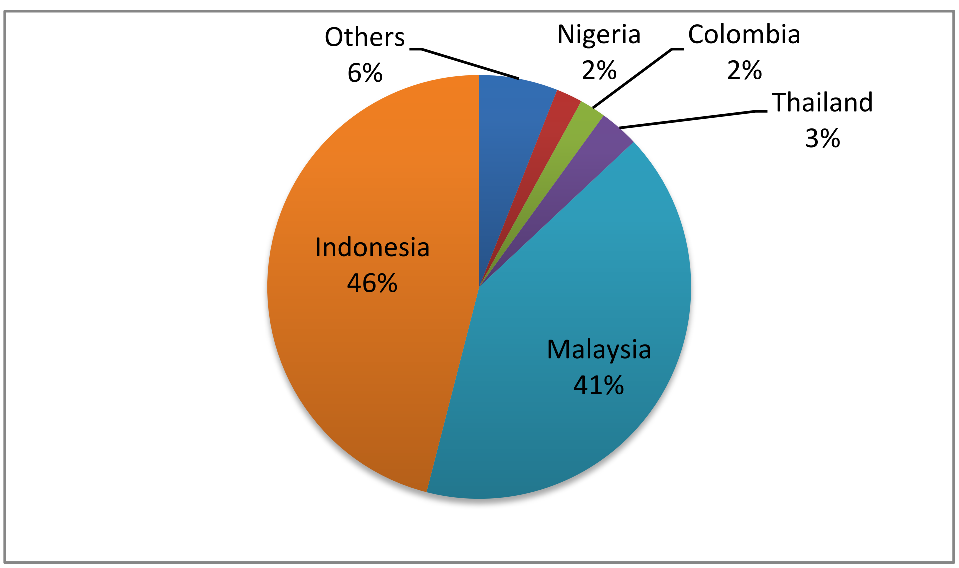

Figure 4: 2008 World production of palm oil by country. Modified from http://news.mongabay.com/2008/0709-amazon_palm_oil.html.

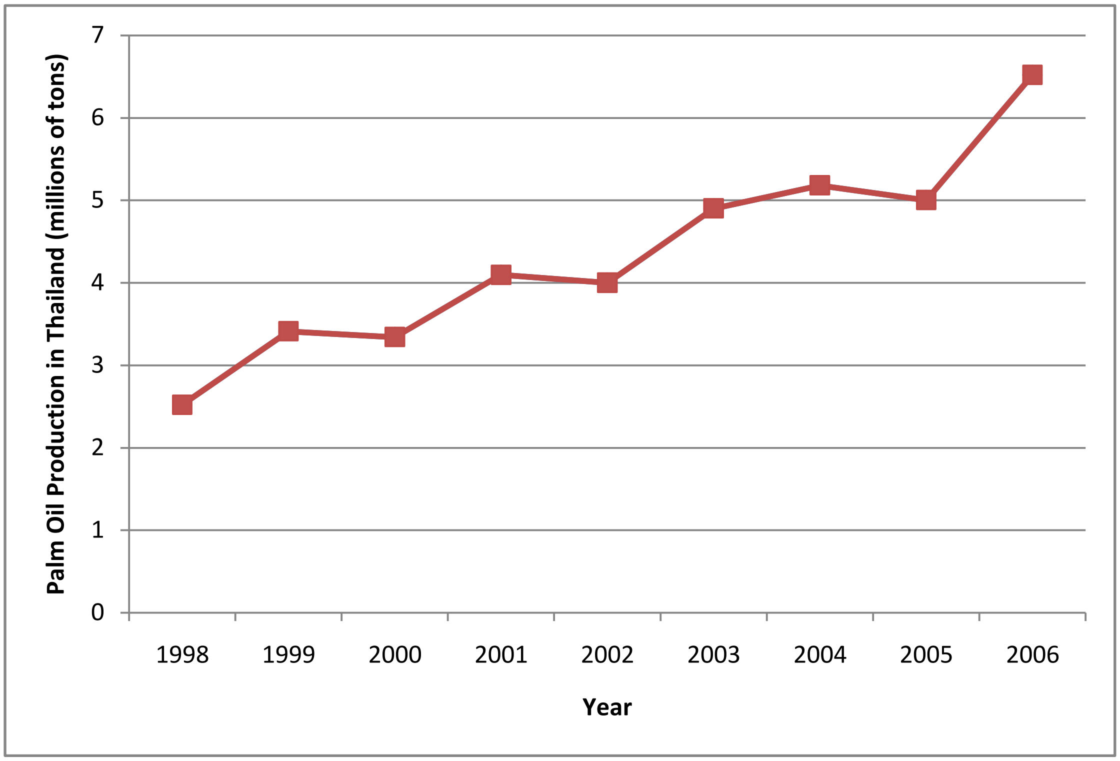

Figure 5: 1998-2006 Annual palm oil production in Thailand. Modified from http://www.dede.go.th/dede/fileadmin/upload/pdf/Oil_Palm_Production.pdf

Palm oil comes from the fruit of the oil palm, *Elaeis guineensis*, which is most commonly found in one of the following three varieties: *Dura*, *Pisifera*, and *Tenera*, a hybrid cross of *Dura* and *Pisifera* that is the most commonly planted today (Vanichseni, 2002). The trees reach a height of about 60 feet and produce fruit bunches that weigh between 10 and 25 kg and contain several hundred fruitlets (Figure 6). The round fruitlets are o0range-red and ripen to dark purple (*Malaysian Palm Oil Council*, 2008). On average, two or three bunches are harvested from each tree. The trees produce fruit for thirty years, although it is more difficult to harvest the trees as they grow.

Figure 6: Fresh palm fruit bunch.

As shown in Figure 7, the fruit is composed of an outer skin called the exocarp; the fleshy mesocarp from which the palm fruit oil is squeezed; an inner nut called the endocarp; and a kernel inside the nut from which palm kernel oil is squeezed (Kwaski, 2002). Crude palm fruit oil is bright orange-red in color and is semi-solid at room temperature. Each palm fruitlet is composed of about 61% crude oil by weight, and a fruit bunch contains about 17-20% oil by weight. The oil palm produces about 2.7-2.8 tonnes of fresh fruit bunches per rai (one rai = 0.16 hectares) annually (Khun Bundit Jumras, personal communication, February 6, 2009).

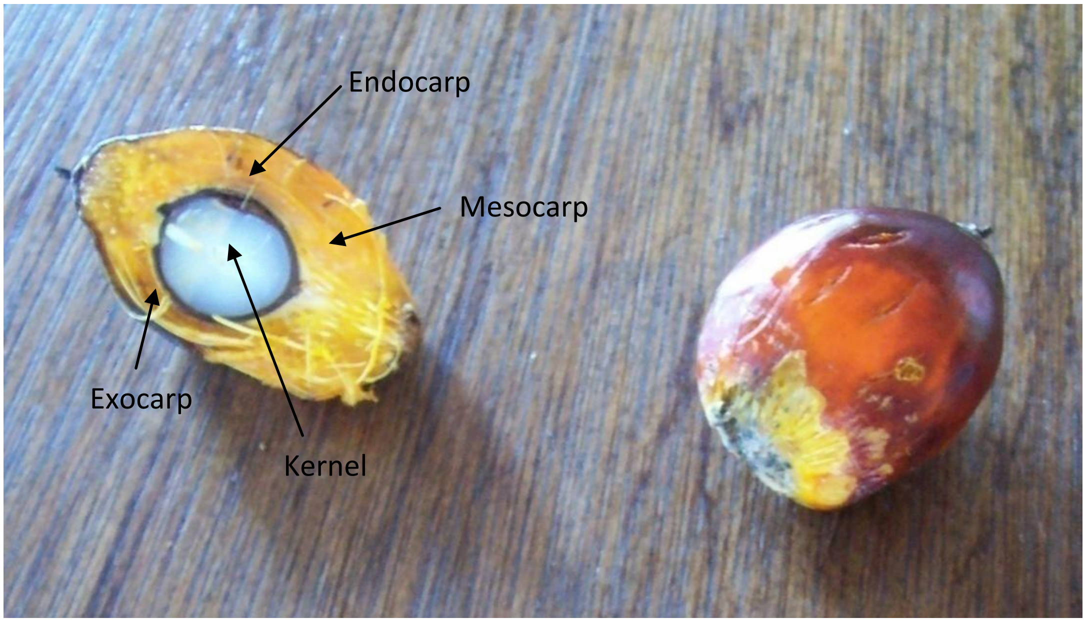

Figure 7: Parts of the oil palm fruit.

2.3 Production of Palm Oil

The production of crude palm oil includes a series of phases beginning with harvesting the fruit and ending with storing the oil, each using different methods and machines. In this section, we will describe the processing methods of palm oil production and address the associated environmental concerns.

Oil palm fruit can be processed in batch, continuous, or semi-continuous systems. A batch system extracts oil from consecutive batches of fruit, while in a continuous system, each step in the oil extraction process feeds into the next. In a semi-continuous system, there may be pauses if some steps take longer than others do. The Food and Agriculture Organization (FAO) of the United Nations compiled a bulletin describing methods of palm oil processing. According to the bulletin, often small-scale facilities, which process two or less tonnes of fresh fruit bunches per hour, employ batch processes that utilize manual labor and have low operating costs. Large-scale facilities typically use continuous systems and require skilled laborers and greater management. Large-scale plants process more than ten, and often up to sixty tonnes of fresh fruit bunches per hour (Kwaski, 2002).

The two kinds of crude palm oil that can be made by processing palm fruit are grade A crude palm oil and grade B crude palm oil. Grade B oil is made when the mesocarp is pressed with the nut still intact to produce oil. Grade A palm oil is made by pressing only the mesocarp of the palm fruit, after removing the nut. Records from the Department of Internal Trade in Thailand show that grade A oil is sold for approximately one baht more per kilogram of oil than grade B (2009).

Typically, grade A oil is produced in a large-scale facility, employing a “wet” process, where the fruit absorbs additional water through boiling or steaming. Grade B oil is usually produced in a small-scale facility using a “dry” process. The dry process cooks the fruit before extraction using dry heat. Although the wet and dry processes occur at different scales and produce different grades of oil, both procedures share a similar production process.

Oil Production Steps

The crude palm oil production process requires a large set of equipment, which can range from crude, manual mechanisms to advanced, automated machinery. Regardless of the types of machines used to produce crude palm oil, there are still a set of basic steps needed to produce palm oil. The following processing steps are common to all facilities and the products of each step are summarized in Figure 8.

The first step in palm oil production is harvesting the palm fruit bunches. A harvester cuts the fresh fruit bunches from trees and allows them to fall to the ground. The fruit may be allowed to ferment, or fully ripen, in order to loosen the base of the fruitlets from the bunches and to make their removal easier.

The fruitlets are removed from the bunch during the threshing process. Threshing can either be done by hand or with a mechanical thresher, which rotates or vibrates to separate the fruit from the bunch (Figure 9).

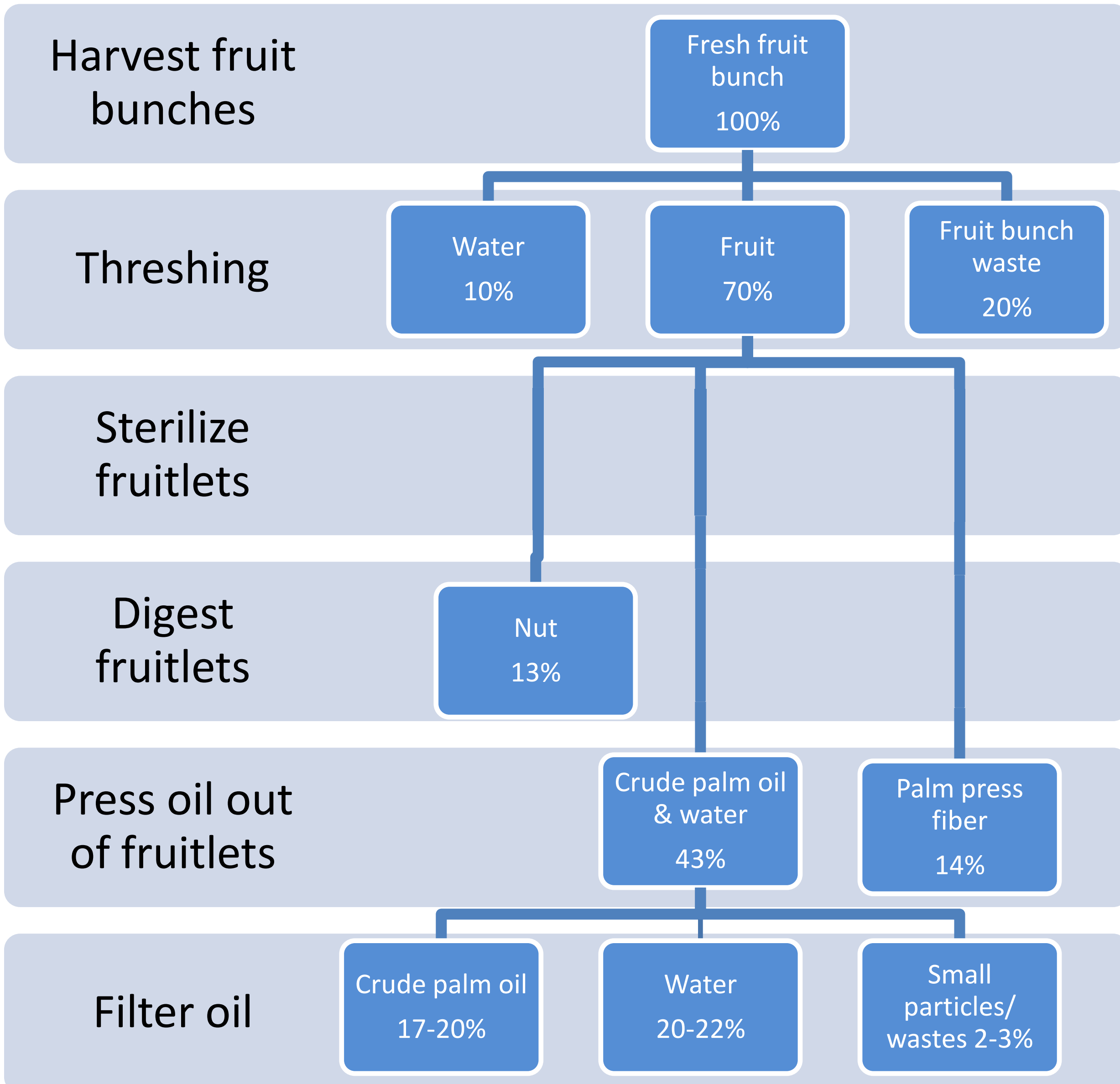

Figure 8: Palm oil processing unit operations with products and byproducts.[1]

[1] Adapted from Khun Chana, Suk Sombun Palm Oil, Chonburi, Thailand.

Figure 9: Thresher at Sasdee.

The sterilization process uses heat to partially cook the fruit. This process also stops enzymatic reactions that lead to oxidation and disrupts the cells in the mesocarp, allowing for easier oil extraction (Kwaski, 2002). Wet processes use water to sterilize the fruit by either steaming or boiling the fruit, producing wastewater as a byproduct, while dry processes sterilize the fruit by smoking or roasting it, as seen in Figure 10. When implementing a wet process, the fruit is sterilized *before* the threshing process. In a dry process, the fruit is sterilized using dry heat *after* the threshing process.

Figure 10: Sterilizer at Sasdee.

The digestion process crushes the fruit before extraction and warms the pulp to maximize oil yield. Facilities that use the wet process remove the nut from the pulp before pressing to yield grade A oil.

The pulp is then pressed, which bursts the oil-containing cells, releasing the palm oil. There are several types of presses that may be used to press the fruit pulp, including manual presses, hydraulic presses, and screw presses. The screw press (Figure 11) is the most commonly used press because it yields the most oil when pressing the mesocarp (Baryeh, 2001). Next, the oil is heated and filtered to remove impurities.

Figure 11: Motorized screw press at Sasdee.

In the wet process, additional steps must be taken to ensure that water moisture in the mixture is removed. This is usually done in a clarifying tank, which drives excess moisture out of the oil through heating to reduce the moisture content from 0.25% to 0.15% (Kwaski, 2002). Once the oil has been checked for appropriate moisture and fat content, it is ready to be stored and sold.

Environmental Considerations

The DPF wishes to minimize environmental impact of any production facility it might consider. The DPF planted their oil palm plantation on wasteland without cutting down any mature trees (DPF, 2009). Palm oil production is a relatively clean procedure with minimal CO_2 emissions – the only greenhouse gases emitted are from the burning of fuel for heating during the sterilization, digestion, and filtering procedures (Rosenthal, 2007). However, at the end of the palm oil extraction process, there is a substantial amount of waste material. Table 2 lists major waste products from the processing procedure, including empty fruit bunches, palm kernel shells, palm press fiber, and wastewater. Although a great deal of waste is produced, much of this waste can be used for other applications.

Table 2: Production waste products for the processing of crude palm oil (adapted from Chavalparit, 1999)

Production step	Waste product
Harvest fruit bunches	--
Remove fruitlets from bunches	Empty fruit bunch
Sterilize fruitlets	Wastewater*
Digest fruitlets	Nut
Press oil out of fruitlets	Palm press fiber, wastewater*
Filter oil	Wastewater*

*These waste products are from the wet process only.

The empty fruit bunches can be compressed into blocks used for fertilizer, mushroom cultivation, or animal feed (Prasertsan, 1996). Using the empty fruit bunches and shells as a fuel source often results in higher smoke emissions due to incomplete combustion. The smoke emitted often exceeds the maximum of 400 mg/m^3 set by National Quality Standards. Facilities can burn the empty bunches to heat the sterilization process, or they can incinerate the empty bunches and use the ash, which contains a great deal of potassium, to fertilize the palm trees (Kwaski, 2002). Palm press fiber can also be used as fertilizer for plants. The fiber is combustible, making it useful as a secondary, although inferior, fuel source. Its ash contains phosphorous, potassium, and calcium, making it a good source of fertilizer. The wastewater produced from palm oil processing contains high levels of nitrogen, phosphorous, potassium, and magnesium, all of which are essential nutrients to the growth of oil palm trees. Thus, it is also ideal as a fertilizer for oil palm trees (Chavalparit, 1999).

After the kernels are used in the production of palm kernel oil, the empty shells can be processed to manufacture active carbon, which is useful for water filtration. They can also be used in the production of concrete and bricks (Chavalparit, 1999).

In the wet process, the overall water intake can be reduced through the reusing of wastewater and the collection and reuse of water condensate. Many processing facilities practice a form of co-generation, where electricity is generated to run their own machinery using waste press fiber as fuel (Figure 12). Simply collecting and reusing boiler water can save 30 m^3 of water for every tonne (1000 kg) of fruit bunches processed (Chavalparit, 1999).

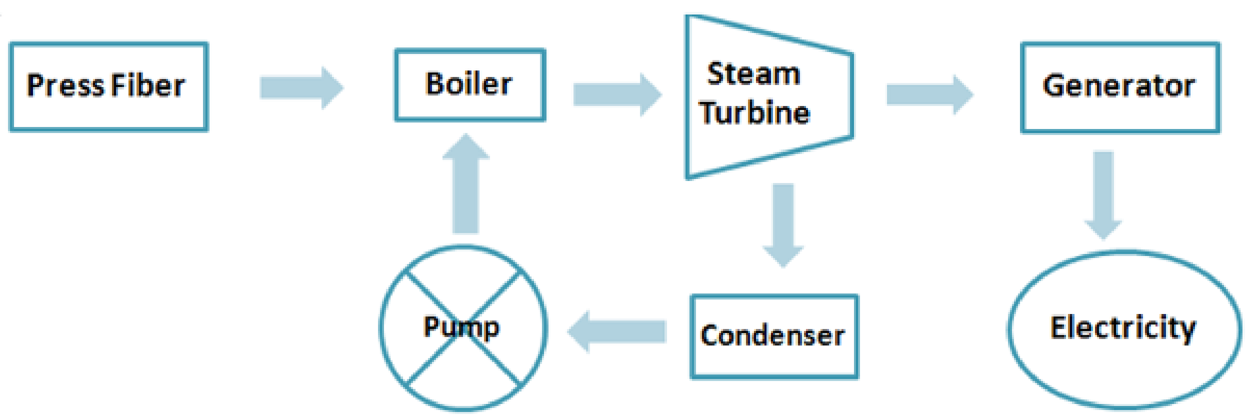

Figure 12: Recycling of condensate water within the co-generation system (Modified from Chavalparit, 1999).

2.4 Current Status of New Life Project's Oil Palm Plantation

The New Life Project in Kanchanaburi began an oil palm plantation in 2003 in order to raise additional revenue to support the operation. The plantation contains about 8600 trees: approximately 200-300 are six years old, slightly more than 4000 are four years old, and approximately 4,400 trees are two years old (Figure 13). Currently, only the six-year-old trees are harvested, but the rest of the trees will be ready for harvest within the next two or three years.

Figure 13: Two-year-old oil palm trees at the New Life Project plantation.

The DPF sells its fruit to a local palm oil production facility that also buys most of the palm fruit produced by the 20,000 oil palm trees in Kanchanaburi. The DPF would like to investigate whether an on-site palm oil processing facility might be more profitable than simply selling the fruit and would like our recommendations for constructing such a facility.

Ultimately, the Duang Prateep Foundation would like the New Life Project in Kanchanaburi to advance towards a state of self-sustenance. Rather than relying on fundraising to alleviate the cost of providing food and shelter to the children living at the New Life Project, the DPF wants the sale of palm oil or palm fruit to generate enough revenue to pay for these costs.

3. METHODOLOGY

The goal of our project was to help the Foundation's New Life Project advance toward self-sustainability by presenting viable options for generating profit from its oil palm plantation. We met this goal by addressing each of the following objectives:

1. Determining the priorities and needs of the DPF regarding the design of a palm oil processing facility, and assessing the current conditions of the New Life Project oil palm plantation in Kanchanaburi.
2. Gathering information about several local palm oil production facilities.
3. Analyzing several suitable revenue-generating palm fruit scenarios, taking into account the possibility of processing the fruit of surrounding farmers.

The outcome of the project was revenue and cost projections for each scenario, along with an analysis of the social and environmental considerations of each. In this chapter, we will describe the methods we used to meet each of these objectives.

3.1 Determine Priorities of DPF and Assess Current Conditions

The starting point of our project was to clarify our sponsor's desired outcomes. The information we sought from our initial meetings with the DPF included:

- *The final palm product that the DPF was looking to manufacture.* We sought to determine the level of refinement required. Khru Prateep verified that she wanted to produce crude palm oil, which, although very basic information, helped to plan the rest of the project and determine some of the necessary processing machinery.
- *The current rate of fruit production*. We wanted to know the New Life Project plantation's statistics, such as the number of trees of each variety, the level of maturation of the trees, and any future possibilities of expanding the oil palm plantation. This information allowed us to understand the production scale required for processing as well as provided a means to estimate the quantity of oil that the New Life Project plantation was capable of producing.

- *The revenue from the DPF's current fruit sales.* We sought to determine the revenue that the oil palm plantation was already making in order to compare better the profitability of installing an on-site palm oil facility.
- *The environmental concerns of the DPF*. Palm oil processing can be harmful to the environment if good practices are not followed. We sought to find the extent to which the DPF would like to limit their impact on the environment.
- *The number of workers at the New Life Project available to work at a potential facility*. This helped us decide whether or not the New Life Project had sufficient labor or if the potential processing plant would require the DPF to hire external workers.
- *The DPF's budget and revenue requirements for this project*. We sought to find out the amount of earnings that the DPF wanted to bring in from its oil palm plantation and how much it was willing to spend on the purchase and installation a palm oil processing system.
- *The total cost of running the New Life Project*. The DPF hopes to use the revenue from their oil palm plantation in Kanchanaburi to pay for the operating costs at the New Life Project.

In order to gather this information, we performed several semi-structured interviews with Khru Prateep Ungsongtham Hata, the founder and chairperson of the DPF, and Dr. Supphawut Manochantr, the head of the secretariat office at the DPF who was assigned to our palm oil production project by Khru Prateep. Although the primary purpose of these interviews was to collect information, through casual conversation in addition to interviews, we hoped to build good relations with the DPF and gain mutual trust. In order to gain a better sense of the poverty to which the children were exposed, we toured the Klong Toey slum surrounding the Duang Prateep Foundation buildings. With the purpose of building relations, we visited the Duang Prateep Foundation in Bangkok and met its staff and the children who attended the school.

We also visited the New Life Project site in Kanchanaburi with Khru Prateep and Dr. Supphawut. We met the New Life Project's staff as well as the girls and boys that our project affected. In addition, the manager of the oil palm plantation, Khun Rotchaya Ittirattana, gave us a tour of the plantation to help us conceptualize the project (Figure 12: Recycling of condensate water within the co-generation system (Modified from Chavalparit, 1999).Figure 14). We conducted a second interview with the DPF in order to clarify some questions we still had about the DPF's priorities and the current conditions at the New Life Project.

We conducted our communication with the DPF primarily in English, so a translator was not necessary. Two of our team members, Khun Erika Kubota and Khun Kemjira Watthanakornchai, are fluent in Thai and clarified some of our questions with interviewees. Some of the communication was conducted in Thai and later translated to our entire group in English. We documented the interviews and the New Life Project visit by taking notes, which we later compiled as a group.

Figure 14: Documenting information at the New Life Project plantation.

3.2 Gather Information about Existing Palm Oil Production Facilities

A key outcome from our information gathering at the New Life Project was an estimate of its palm fruit yield. With this knowledge, we began to collect information from existing palm oil production facilities regarding processing options. We sought to learn about the range of equipment and procedures, regarding:

- *Processing methods*. We used this information to gain a better understanding of the various stages necessary for palm oil production of varying scales and to determine the processing steps suitable for a facility for the New Life Project.
- *Machinery used, their prices and sources, and the parts of the system that could use improvement*. We sought to determine the necessary machinery for the DPF's needs and to gain manufacturer contacts as well.
- *Labor requirements*. We sought to learn the workday length and frequency of running the systems in order to estimate the labor required for various production scenarios.

- *Production rate of the system and market pricing of fresh fruit bunches, crude oil, and byproducts*. We used these as a starting point for the economic analysis for various production scenarios, including the cost of raw materials and revenue.
- *Waste management options*. Several waste products of the palm oil process can be re-used or sold for use in other products. We searched for options that we could incorporate into various production scenarios for the New Life Project.
- *Initial and operating costs*. The operating costs we searched for included the costs of maintaining the machinery, paying workers at the facility, and energy. We used these to approximate the costs associated with varying scales of production, which in turn allowed us to estimate the costs of a facility at the New Life Project.

We gathered information about the designs of several palm oil production facilities throughout Thailand, including Sasdee Palm Oil, Suk Sombun Palm Oil, and a prototype system in Pathum Thani (See Appendix B for detailed notes). Prior to each visit, we prepared an interview protocol during a group brainstorming session. We toured the production process at each facility, asking questions as they arose, and performed semi-structured interviews with workers. All discussion was conducted in Thai and translated into English by Khun Erika and Khun Kemjira. With permission, we took pictures of the equipment to document every step of production and compiled detailed notes of our visits.

We toured Sasdee Palm Oil, a small-scale facility in the province of Kanchanaburi, 13 km away from the New Life Project site, to which the DPF currently sells its palm fruit. Although the visit provided a great deal of information, we were unable to conduct it exactly as planned. The tour of Sasdee was somewhat disorganized and conducted in Thai by several workers, making documentation difficult. We prepared interview questions and anticipated that a fully structured interview would not be sufficient, as discussion was likely to arise; however, our interview with Khun Sutida Sendee, the factory manager at Sasdee, became somewhat confusing. Workers were eager to describe how their machinery worked and several of them talked to us simultaneously, which hindered us from maintaining a semi-structured interview. Workers shared information with Khru Prateep, Khun Erika, and Khun Kemjira simultaneously, which made documentation difficult and somewhat hectic.

We also visited Suk Sombun Palm Oil, a large-scale facility in Chon Buri. A semi-structured format was maintained throughout the interviews with Khun Chana Chintarattanawong, the managing director, and Khun Sura Tanwiset, the palm farm coordinator, which allowed us to record detailed notes in an organized manner. Khun Sura guided us through a facility tour, and we were able to ask questions as they arose and thoroughly document the production process through notes and photographs.

Although our visits to Sasdee and Suk Sombun yielded much of the information we sought regarding processing techniques, neither facility was able to provide useful information about machinery costs or availability. At the suggestion of Dr. Supphawut, we researched and visited a prototype system in Pathum Thani. The National Metal and Materials Technology Center (MTEC) collaborated with Great Agro, an agricultural engineering company, to construct a prototype palm oil processing system that could produce grade A oil in a small-scale facility. MTEC and Great Agro were working together to create a palm oil processing system aimed to encourage oil palm farmers to implement better agricultural methods by involving them more directly in the production of palm oil.

At the prototype processing facility, Khun Ascha Chandsongsang, one of MTEC's researchers, gave us a tour of the compact facility, explaining the machinery step-by-step and allowing us to ask questions. We decided to analyze this prototype more thoroughly, as it was applicable to the scale of the DPF's palm oil plantation and provided a contact for machine manufacturing, offering the DPF an option to purchase palm oil processing machinery from a single manufacturer. Thus, we scheduled a follow-up meeting with Khun Bundit Jumras, a senior engineer from Great Agro, to learn more about the prototype system. Because the DPF is a potential client for Great Agro, we were able to obtain detailed information regarding the pricing and manufacturing of their palm oil production system.

Besides Great Agro, we sought additional processing machinery manufacturing contacts. We contacted the Agricultural Ministry of Thailand and talked with Khun Suksit, a palm oil expert. He referred us to Khun Yungyong, the manager of Kranchanakit Palm, a small-scale palm oil processing company in Surattani province in southern Thailand. Khun Yungyong told us over the phone that the facility imported its machines from Malaysia. However, Khru Prateep had told us that she would like processing machinery for a potential facility at the DPF to be available locally, so we did not pursue this manufacturing contact further.

We also called the Thai Machinery Organization and spoke with Khun Manop, who referred us to Nammansabudum Company, a palm oil machinery manufacturing company in Pathum Thani. We spoke over the phone to Khun Orrachun, the owner of the company, about a screw press that the company sells. Unfortunately, its scale was too small for the DPF's needs and the company did not offer machinery for any other processing steps, so we did not pursue this manufacturing contact further.

We received most of the information that we sought via our fieldwork but wanted to resolve some discrepancies in market prices of palm fruit and crude palm oil, so we researched trends in the market pricing through Thailand's Department of Internal Trade website. Once we obtained this information, we organized and compiled it to complete the data collection phase of our project. We utilized the information gathered from our first two objectives to begin analyzing projected revenues and costs as well as payback periods for possible sources of income from the oil palm plantation at the New Life Project.

3.3 Analyze Scenarios

Once we gathered all of the required data from our first two objectives, we devised several viable scenarios for the DPF and analyzed each of them with respect to their revenue-generating capabilities, their costs, and their social implications. We considered three possible revenue-generating scenarios:

1. *Continuing to sell fruit*. The DPF would continue to sell the fresh fruit bunches from its mature plantation to a nearby processing facility.
2. *Processing New Life Project's fruit*. The DPF would process on-site only the fresh fruit bunches produced by its mature plantation.
3. *Processing New Life Project's fruit along with supplemental fruit.* The DPF would supplement its own fresh fruit bunches with fresh fruit bunches that it would buy from surrounding plantations in order to run a facility for an average workweek.

Before we could begin any analysis of the revenue-generating scenarios for the DPF, we performed a series of calculations that led to projections for total revenue, total costs, and eventually total profit for each scenario. We also estimated the payback periods for each scenario. D details the complete calculations.

Preliminary Estimates

We sought to estimate how much fruit the New Life Project plantation would produce assuming that all of the existing trees would be mature. We projected this quantity two different ways but unfortunately arrived at two dissimilar estimates. Khru Prateep provided us with an exact number of trees at the New Life Project; approximate ranges for fruit harvested from each tree; and the weight of an average fruit bunch. We approximated the fruit production based on the conservative ends of Khru Prateep's ranges. We also estimated the annual fruit production based on typical oil palm fruit production rates in Thailand per rai, given to us by Khun Bundit (Great Agro's senior engineer), and the number of rai at the New Life Project. When the two fruit production estimates were dissimilar, we chose to use the second one, as it was more conservative.

Once we projected the fruit production at the mature New Life Project plantation, we were able to search for palm oil processing equipment suitable for the DPF. After our visit to Great Agro's prototype facility, the remainder of our project focused on scenarios based off the Great Agro prototype. This was because their system was appropriately scaled for the needs of the DPF and because we were unable to find any additional manufacturers who sold machinery sized for the New Life Project plantation's scale. The values Great Agro gave us for the hourly palm oil production capabilities appeared to be appropriate for the calculated fruit production of the palm oil plantation at the New Life Project.

Next we sought to determine the tonnage of fresh fruit bunches that Great Agro's system could process annually. We assumed an eight-hour workday and a six-day workweek because Khru Prateep said that this was a typical Thai work schedule and that it is what she would like for a facility at the New Life Project. We used the hourly fruit processing capacity of Great Agro's system given to us by Khun Ascha, an MTEC researcher, and the percentage of the fruit contained in a fruit bunch to calculate the maximum tonnage of fresh fruit bunches that could be processed annually by Great Agro's system. We used this estimate to provide analysis for processing only the fruit from the New Life Project and an approximation of the amount of fresh fruit bunches that the DPF could purchase to operate the machinery at an average workweek of six days, eight hours per day.

Profit Projections

With the preliminary estimates completed, we began more extensive calculations to project the profitability of each option. The results of these calculations became the basis for our presentation to the DPF of revenue-generating options for the existing New Life Project oil palm plantation. For every scenario, we used the following basic profitability equation:

$$Profit = \{Revenue\} - \{Costs\}$$

We expanded this simple equation to more specific equations for each option. Revenue is the income that each option would bring to DPF through the sale of fresh fruit bunches, crude oil, or byproducts of the oil production process. The costs considered for the profit projection included annual expenses and initial costs. We gathered estimates for our revenue sources and costs used in our profit equations in our first two objectives. Although many of the quantities that we gathered from our contacts were approximations, we did not round any quantities until we obtained final profit projections. To convey that our projections are approximations, we presented them with only two significant digits. Chapter 4 contains a detailed analysis of the limitations and assumptions that we made for the costs and income of each scenario, and Appendix D contains detailed profit calculations.

Payback Period Projections

After estimating the profit of each scenario, we calculated the payback period for the second and third scenarios, which required an initial investment of 7.5 million baht to purchase and install Great Agro's system. The payback period is the amount of time that that the DPF would take to recover its initial investment. We used the following equation to calculate the payback period:

$$Payback\ period = \frac{Initial\ investment}{Annual\ profit}$$

The annual profit used to calculate the payback period was the annual profit was the profit *beyond* the profit that would be generated by scenario 1. This is because the first option represents profit that the DPF would already be making, considering that their plantation has already been implemented and they would be generating profit from the fruit sales without installing a facility.

There are several major limitations to a payback period analysis. The first is that it does not account for monetary inflation. Secondly, it does not consider changes in profitability after the payback period. It also assumes annual revenues and costs remain consistent, which is often not the case (*Payback period explained*, 2008).

After estimating profitability and payback period for each scenario, we considered other factors that affect profitability as well that we did not include in our projections. We also considered the social effects of each scenario for a more complete analysis. We were interested in their employment opportunities, benefits on the local economy, and their environmental considerations.

4. FINDINGS

In this chapter, we begin with an analysis of Great Agro's prototype palm oil production system and why we believe that it is a good choice for the DPF. Then we present the results of our financial analysis, which indicate that while all of the revenue-generating options can be expected to be profitable, they vary in the amount of profit that can be made and risk that is involved. We discuss some factors that may affect the profitability of the scenarios we present. Because the DPF is a charitable organization and not strictly a business, the most suitable scenario may not necessarily be the most profitable. Thus, we finally consider the social effects of the scenarios.

4.1 Analysis of Great Agro's System

In this section, we explain why we believe the Great Agro prototype palm oil production system is a good choice for the DPF. We analyzed its scale relative to the fruit bunch production at the New Life Project as well as its benefits over existing palm oil production systems, and the startup costs of the system.

After visiting the three palm oil production systems, we decided to analyze Great Agro's system more closely as we determined that it could accommodate the needs of the DPF (Figure 15). Khun Ascha, the MTEC researcher, informed us that the processing facility is capable of processing one tonne of fruitlets per hour and was designed to operate in shifts, warming up and shutting down the machinery daily. Assuming that Great Agro's system is run for an average

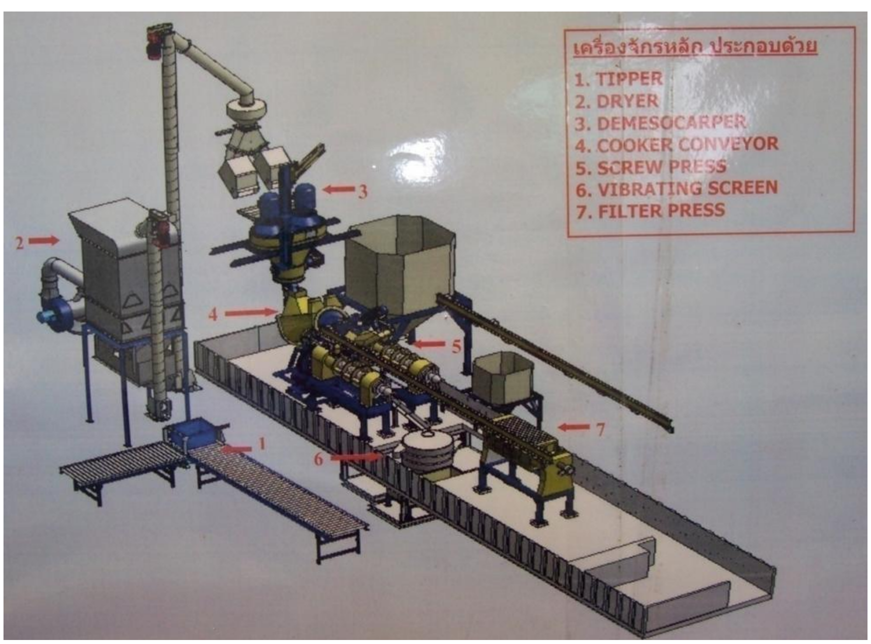

Figure 15: Diagram of Great Agro's prototype palm oil production facility.

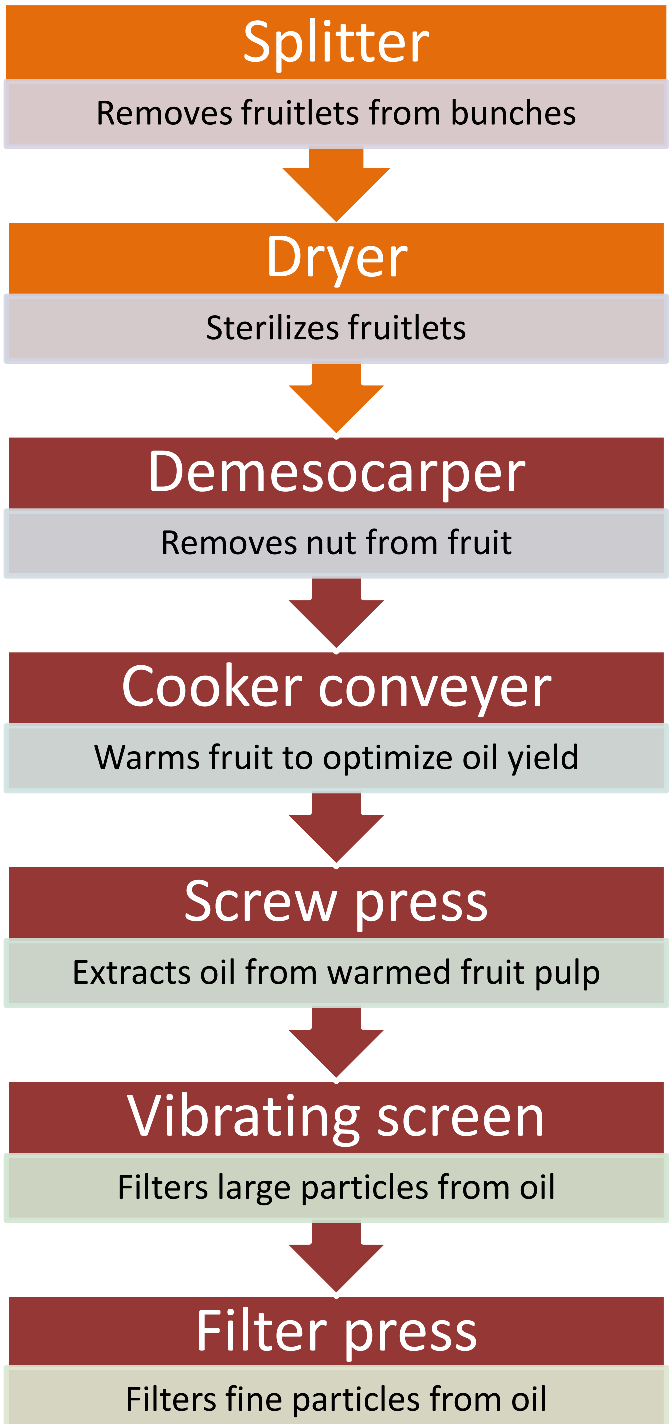

Figure 16: Components and steps of Great Agro's prototype palm oil processing system; the last five machines comprise the Modular Palm Oil Extraction Plant.

workweek in Thailand for six days a week for eight hours per day, it would process approximately 3566 tonnes of fresh fruit bunches each year, which is well above the 1053 tonnes of fruit bunches that we estimate will be produced annually by the New Life Project in Kanchanaburi.

Great Agro's prototype system consists of seven major components within the unit (Figure 16), some seen in other processing facilities and some new technology that garners the benefits of the wet and dry processes. Appendix C contains pictures of the system. The input to the processing facility is already removed fruitlets, rather than fresh fruit bunches; however, Great Agro sells a splitting unit to remove the fruit from the bunch. The prototype facility uses a *tipper* to move a batch of pre-measured fruitlets into a collector. The pricing information for the system does not include the *tipper*, so we did not factor it into our cost analysis. The collector carries the fruit to the *dryer*, which acts as a sterilizer for the system. Rather than a long roasting process or a wet steaming or boiling process, the *dryer* heats the fruit using LPG (liquefied petroleum gas) to 80ºC for thirty minutes, quickly cooking the fruit while preserving vitamins and avoiding adding further moisture. The *demesocarper* is another machine unique to Great Agro's prototype. It removes the nut from the fruit and sends the un-pressed pulp through the *cooker conveyor*, which warms the fruit to optimize oil extraction. The warm fruit is immediately sent to the *screw press*, the *vibrating screen*, and the *filter press*, all of which are found in existing processing plants. The *screw press* extracts the oil, the *vibrating screen* acts as a coarse filter, and the *filter press* is a final, fine filter, which drains the ready-to-package, grade A palm oil directly into a storage tank.

Prior to Great Agro's prototype facility, there were two existing palm oil processing techniques, wet and dry methods. The wet method separates the nut from the fruit, yielding grade A oil, which sells at a higher price, while the dry method presses the fruit with the nut still intact, yielding grade B oil. The wet process results in a large amount of wastewater from steaming or boiling the fruit, also requiring drying of the oil after extraction. The dry process does not have any wastewater, as the fruit is roasted. The wet process generally involves burning palm press fiber to generate electricity for self-sufficiency, while the dry process sells the press fiber as animal feed (Chavalparit, 1999). One attractive aspect of Great Agro's prototype is that, in a small-scale processing facility, it combines the best aspects of the existing wet and dry palm oil processing techniques (Figure 17). Some of its key advantages include:

- Production of grade A oil, which is beneficial because of:
  - Greater revenue. Grade A oil sells at approximately one baht higher per kilogram than does grade B oil. Producing grade A oil also means that the nut can be sold separately to other processing plants. Khun Bundit, the senior engineer from Great Agro, informed us that the nut itself can be sold for 7-8 baht per kilogram to produce palm kernel oil from the kernel and cement or active carbon from the shell.
  - Decreased energy consumption. Pressing the fruit with the nut in the dry process causes unnecessary friction and mechanical wear within the screw press. Khun Ascha informed us that this friction results in the screw press consuming more electricity, as the screw press draws in additional current when processing fruit with the nut intact, as opposed to pressing just the mesocarp of the fruit.
- No wastewater production, so it is more environmentally friendly.

- Selling the palm press as animal feed rather than burning the palm press fiber to generate electricity. This is beneficial because it:
  - Avoids of harmful pollution caused by burning of the palm press fiber, which produces black smoke.
  - Generates greater revenue. Khun Bundit approximated that the palm press fiber used for animal feed sold for 3-4 baht/kg, whereas the palm press fiber used for generating electricity sold for only 0.12 baht/kg.

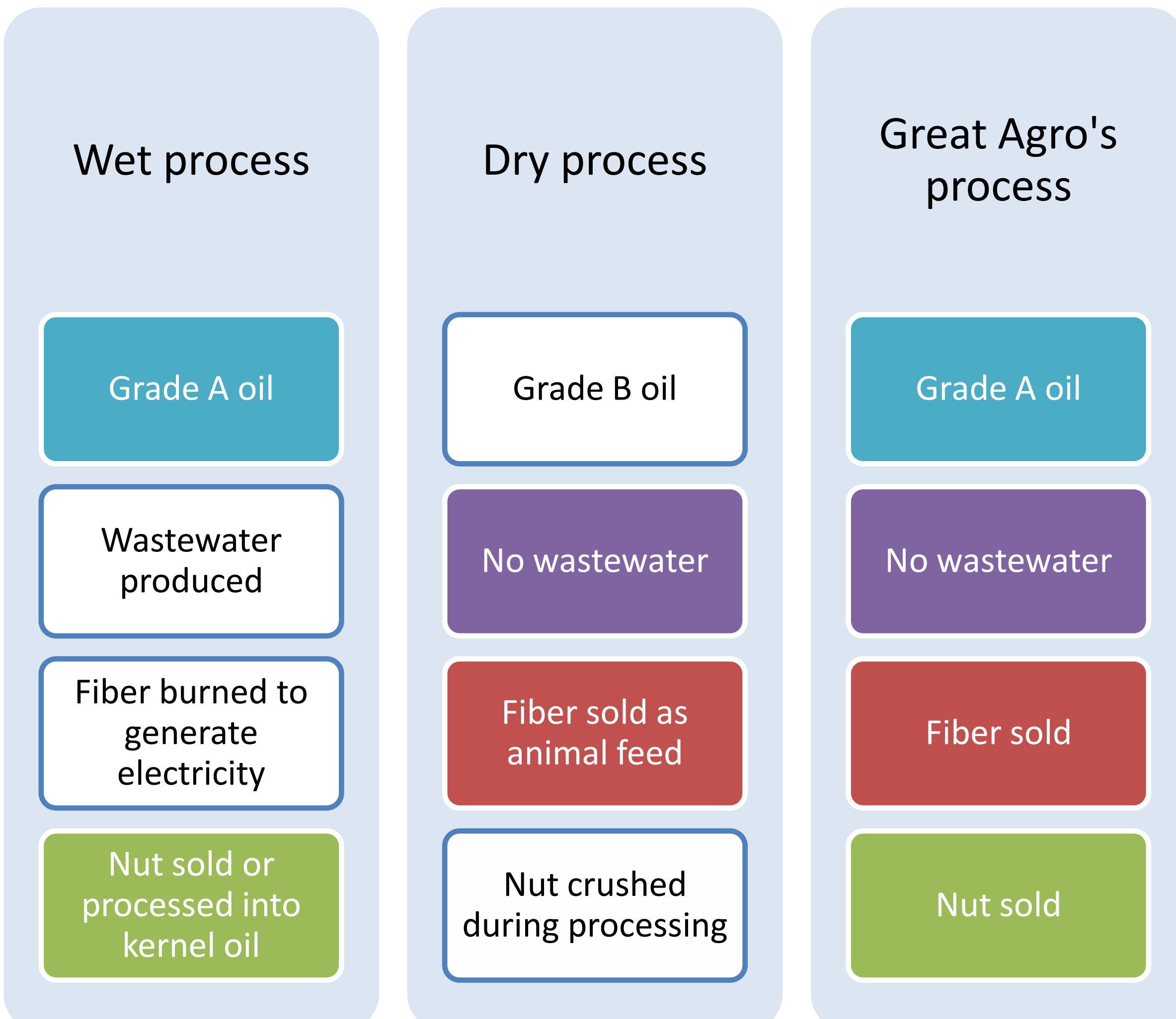

Figure 17: Comparison of wet and dry processes with Great Agro's process.

Great Agro sells the processing machines from the demesocarper to the filter press as a package, called the *"modular palm oil extraction plant,"* but a complete facility requires several other components. Khun Bundit told us that the DPF can buy these components from other companies, but he gave us a list of the estimated prices for each, shown in Table 3. The *modular palm oil extraction plant* requires housing, listed as the *container* in Table 3. When fresh fruit bunches are delivered to a facility, they are weighed at a *weigh station*. The bunches also require a *reception station*, often a concrete slab covered by a roof, where they are stored until they are about to be processed. Another piece of equipment necessary for a facility is a *transformer*, which increases or decreases voltage for the system's machinery. After production, the crude oil is stored in tanks. The nuts are stored in a *silo*, which dries with LPG (liquefied petroleum gas) and stores up to ten tonnes of nuts until they are sold. If the DPF were to purchase fruit from local farmers, they would need the *weigh station* in order to pay for the fruit they purchase by weight.

Table 3: Prices of Great Agro's system and components.

Machinery and components	Description	Price (in baht)
Splitting unit	Removes the fruitlets from the fresh fruit bunches	400,000
Dryer	Sterilizes the raw fruit with dry heat	600,000
Modular palm oil extraction plant	Digests, warms, presses, and filters the sterilized fruit to produce crude palm oil	4,200,000
Container	Houses the *modular palm oil extraction plant*	300,000
Reception station	Temporarily stores fruitlets until processing	200,000
Transformer	Steps voltage up or down to meet the needs of the machinery	500,000
Tank farm and silo	The tank farm stores crude palm oil The silo dries and stores the nut	600,000
Weigh station	Weighs fruit purchased from local farmers	500,000
Other equipment	Includes additional equipment that may need to be purchased	200,000
Total		**7,500,000**

4.2 Analysis Assumptions and Limitations

Due to the broad range of data and many possible situations that the DPF may encounter, we made several assumptions before beginning our profit projection calculations (See Appendix D for complete calculations). We would like to point out some limitations and assumptions within our research that may alter the accuracy of our projections.

Initial Costs

We analyzed the initial cost of Great Agro's system. We would like to first note that the system is a prototype, and thus it is likely more expensive than a similar mass-produced system. Great Agro provided us with a list of initial costs for their system, totaling 7.5 million baht. In addition to the machinery listed in Table 33, Khun Bundit, Great Agro's senior engineer, informed us that the following expenses are included with the purchase of the system:

- *Site preparation*. Great Agro includes any land preparation in its initial cost, along with the installation of concrete and supporting foundations for the machinery.
- *Operational training*. Great Agro includes a training program that teaches workers how to operate the facility.
- *Preventative maintenance*. Great Agro would provide training to the workers to teach them how to perform routine maintenance on the machinery and how to troubleshoot machine problems. Additional support is available via telephone if needed.
- *Installation labor*. The initial investment of 7.5 million baht includes the wages of workers installing the facility.

Several factors that the DPF may want to consider that we did not include in our initial cost estimation include:

- *Costs of possible ISO certification.* If the DPF chooses to comply with the International Organization of Standards (ISO) 9000 series standards, they would have to invest approximately 200,000-300,000 baht into laboratory equipment to check the oil for impurities and monitor the free fatty acid content, the adobe (ripeness), and the moisture content of the oil (Khun Bundit, personal communication). There would also be fees associated with obtaining ISO acceptance and audits. Achieving and operating at the ISO 9002 standard would allow the DPF to find easily a secure buyer, as many palm oil refineries seek ISO-certified sources for crude palm oil. However, studies suggest that compliance with the ISO 9000 series standards has only small and short-term effects on financial performance (Kirche, Khumawala, & Wayhan, 2002).
- *Replacing the splitter with manual labor*. Although we assumed two workers and one operator throughout our financial analysis, the DPF could create additional employment

opportunities by hiring workers to remove manually the ripened fruit from the fresh fruit bunch and eliminate the splitting unit from the system. This option would also save the DPF 400,000 baht in their initial investment, although it would add the expense of paying workers (150 baht per day for each worker).

- *Replacing the tipper with manual labor*. Although the tipper has negligible electricity usage, it is not necessary and the DPF could use manual labor to move the fruit into the dryer.

Operating Costs

We analyzed the following operating costs for our cost projections:

- *Plantation maintenance*. This cost is the same for all three scenarios. We accounted for the annual cost of irrigation, fertilization, and labor for harvesting fruit.
- *Transportation of fresh fruit bunches*. This applies to the first scenario only and is the price for transporting the bunches to a processing facility. We used the current price that the DPF pays to transport its fresh fruit bunches.
- *Oil processing labor*. This cost applies to scenarios 2 and 3. We estimated labor costs assuming two workers at minimum wage and a more skilled operator at a higher wage. The costs are determined from hours of operation.
- *Electricity*. This cost applies to scenarios 2 and 3. We obtained power consumption of the machinery from Great Agro and the average 2009 Thailand electricity rates for a small business. The electricity costs are determined from power consumption and hours of operation. Our estimate does not consider possible increases in power consumption as the equipment ages. We did consider the power that would be required to heat up several machine components prior to production.
- *Fuel*. This cost applies to scenarios 2 and 3. Khun Bundit told us the cost of the LPG (liquefied petroleum gas) used for both the dryer and silo when running for an average workweek, so we used this fuel cost estimate for scenario 3. He told us that fuel cost is directly proportional to number of operating days, so we divided the estimate by three in order to estimate the fuel cost used for scenario 2.

- *Machinery maintenance*. This cost applies to scenarios 2 and 3. The senior engineer at Great Agro, Khun Bundit, advised us to estimate annual maintenance costs as 3% of the startup cost of the system. We assumed that the maintenance costs would be less for scenario 2 compared to scenario 3 as machinery maintenance is based upon the time that the machine is used, as in machine replacement. For simplicity, we assumed that the equipment maintenance cost for each scenario would be constant over the lifetime of the equipment. Our analysis does not consider extra machinery downtime for larger machinery repairs.
- *Machine replacement*. This cost applies to scenarios 2 and 3. The engineering manager at Great Agro informed us that Great Agro believes the machinery to have a lifetime of approximately ten to twenty years, operating in eight-hour shifts daily. We included a cost for scenario 3 to replace the entire system every ten years, to be conservative. We assumed that this cost would be one-third of the amount for scenario 2 compared to scenario 3 because the lifetime of the machinery is based upon the time that the machine *is used*, not on the time the machine exists (Fogiel & Keller, 1998).
- *Raw materials*. This applies to the third scenario only and included the cost of the supplemental fresh fruit bunches that the DPF would need to buy from local farmers to run their facility for an average workweek.

Although our analysis includes most major considerations that the DPF will need to account for, there are several factors that we were unable to consider in our projected estimates:

- *Insurance*. We do not know if the DPF would be required to purchase business or building insurance, so we did not include it in our cost estimates.
- *Fluctuations in prices beyond those of fresh fruit bunches and crude palm oil*. Our equations use variables for prices and thus will allow the DPF to determine revenue and operating costs as those variables change. However, the projections we present are based only on fresh fruit bunch and crude palm oil prices for Thailand in 2008 and do not take variation of the following into account:
  - The price of electricity or LPG gas in Kanchanaburi.
  - The minimum wage in Kanchanaburi.
  - The cost of irrigation and fertilizer at the New Life Project Plantation.

- Transportation costs of fresh fruit bunches.
- The market price of palm oil processing byproducts.

Revenue Sources

We considered the following sources of income for our revenue projection:

- *Fresh fruit bunches*. This applies to the first scenario only.
- *Crude palm oil*. This applies to the second and third scenarios.
- *Byproducts of processing, including nut and palm press fiber of the fruit*. These apply to the second and third scenarios.

Several factors that could also affect our revenue projection include:

- *The fluctuation of prices of fresh fruit bunches and crude palm oil*. These prices have a rough positive correlation, and Appendix E shows their trends over six years. In 2008, crude palm oil ranged from 17.02-36.36 baht/kg, and fresh fruit bunches ranged from 2.78-5.98 baht/kg (*Department of Internal Trade*, 2009).
- *Waste buildup in the machinery*. The DPF would be using Great Agro's system for one shift per day, turning the entire system on and off daily. This could lead to palm fruit pulp or oil building up in the equipment, wasting a small quantity of fruit and oil daily. Khun Bundit informed us that Great Agro's system works as a "first in, first out" system, where fruit or pulp left in the machine is the first to leave the machine the next time it operates; however, this buildup may oxidize, yielding lower quality oil.
- *The quality of fruit*. The fruit contains its highest percentage of oil between 21 and 22 weeks after the palm tree flowers. Khun Bundit informed us that within this harvesting timeframe, fresh fruit bunches can yield up to 24% crude palm oil by weight. To be conservative, we assumed in our projections that fresh fruit bunches yield 17% crude palm oil by weight. However, if fruit quality is optimal, greater revenue is possible.
- *The variability of fruit production*. Oil palm trees increase their fruit production until they reach about fifteen years of age, at which point their fruit production decreases until about age thirty when they become economically unfavorable. The DPF will need to harvest the trees more often as they reach their peak fruit production, which will require

more workers. This *appears* to have a negative impact on profitability; however, the workers harvesting the fresh fruit bunches are paid by the amount of fruit they harvest (0.4 baht per kilogram of fresh fruit bunches). As the trees produce larger fruit bunches, more frequently, the DPF will generate revenue proportionally to this labor cost, as fruit and oil are sold by weight.

4.3 Profit Projections

One of the major concerns of the DPF was whether a palm oil processing plant would provide enough profit to make the venture worthwhile. In this section, we review the projected profits of each scenario and analyzed the major differences between the scenarios regarding revenue and costs.

Using information gathered from our background materials and through our fieldwork, we calculated revenue, cost, and profitability projections for each of the scenarios, summarized in Table 4. We took fresh bunch and crude palm oil prices to be variables in our equations, given their ranges. For purposes of illustration in this chapter, we used average values from 2008 in our calculations. We believe that using the Thailand 2008 market prices for our projections is reasonable as fresh fruit bunches were 3.00 baht/kg for December 2008 (*Department of Internal Trade*, 2009), and Khru Prateep told us that the DPF was selling their fruit for 3 baht/kg in December 2008.

The DPF should be aware that it would likely not get a steady profit from any of the scenarios due to constantly changing markets for fresh fruit bunches and crude palm oil. We illustrated this by graphing the projected annual profits of each scenario using the 2008 monthly average fresh fruit bunch and crude palm oil market prices in Thailand (Figure 18). See Appendix E for the fluctuations in fresh fruit bunch and crude palm oil market prices over six years.

Continuing to Sell Fruit

We first considered the scenario in which the New Life Project plantation sold the fruit from its mature trees. Our calculations show that the DPF would produce about 1100 tonnes of

Table 4: Annual costs, revenue, and profit projections and payback periods for scenarios.

All cost, revenue, and profit projections are in thousands of baht.

Annual Revenue	**Scenario 1**	**Scenario 2**	**Scenario 3**
Fresh fruit bunches*	4910	0	0
Crude palm oil*	0	5300	18000
Nuts	0	958	3240
Palm press fiber	0	442	1500
Total	4910	6700	22740

Annual Costs	**Scenario 1**	**Scenario 2**	**Scenario 3**
Plantation maintenance	1130	1130	1130
Transportation of FFB	527	0	0
Oil processing labor	0	62	187
Electricity	0	170	510
Fuel	0	88	264
Machinery maintenance	0	75	225
Machinery replacement	0	250	750
Raw materials	0	0	11700
Total	1657	1775	14766

Annual Profit	**Scenario 1**	**Scenario 2**	**Scenario 3**
Profit	3253	4925	7974
Compared to Scenario 1	-	1672	4721
Payback period range (in years)	-	2.7 – 5.6	0.9 – 2.0

*The average fresh fruit bunch and crude palm oil prices for Thailand in 2008 were 4.66 baht/kg and 17.81 baht/kg, respectively (*Department of Internal Trade*, 2009).

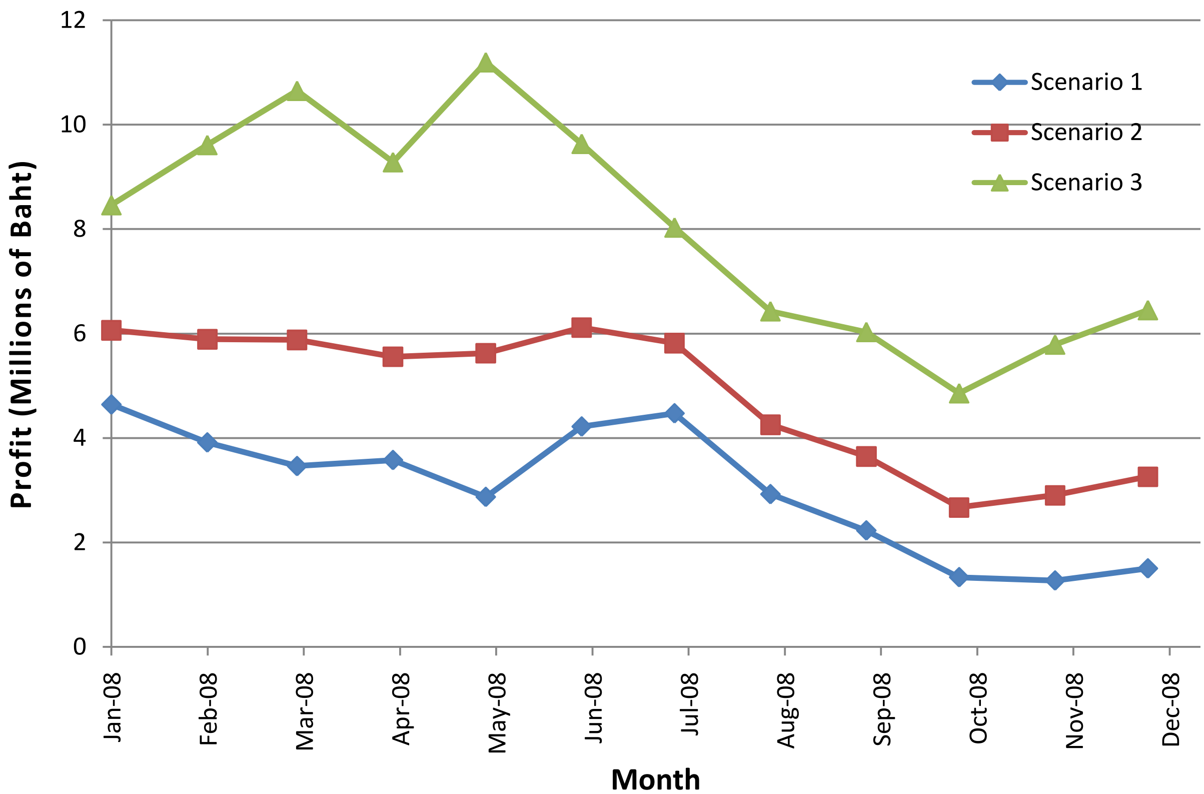

Figure 18: Projected annual profits based on 2008 monthly crude palm oil and fresh fruit bunch Thailand market prices.

fruit annually at a total cost of about 1.13 million baht. Our projections show that the DPF could be generating an annual profit ranging from 1.3 million baht to 4.6 million baht, depending on the market price of palm fruit. Assuming a selling price of 4.66 baht/kg, the average price of palm fruit bunches in Thailand in 2008, the DPF would generate a profit of approximately 3.3 million baht per year. Khru Prateep stated that the costs of the New Life Project are up to two million baht. Therefore, we estimate that this scenario would provide enough profit for the DPF to cover the costs of maintaining the New Life Project.

Although this scenario would not generate as much profit as would the other options, it does have several benefits. It is a low-risk option and the DPF would avoid the complications associated with installing a palm oil production system. Another major benefit would be that there are no startup costs, so money raised by the DPF could be used for other philanthropic projects.

Installing a Factory to Process New Life Project's Fruit.

We considered the scenario in which the DPF built an on-site palm oil processing facility using Great Agro's machinery. The facility would need to run for two eight-hour shifts weekly to process the fruit produced by the DPF, once all of the trees at the New Life Project plantation reach maturity in 2012.

This scenario requires a large initial investment of 7.5 million baht, introducing a greater risk than scenario 1; however, the potential profit is greater. In addition to generating revenue from the sale of palm oil, this scenario generates additional revenue from the sale of palm press fiber for use as animal feed and from the sale of the nut to be processed into palm kernel oil. The total projected annual profit for this option ranges between 2.7 million baht and 6.1 million baht, varying with the market price of crude palm oil.

Although the DPF plans on raising funds for the 7.5 million baht required to install Great Agro's system, we calculated the payback period of this investment. Our calculations show that the DPF would be generating profit from this investment in about 2.7 years if the crude palm oil is sold at a high price, but no longer than 6.1 years in the event of low market prices of palm oil (Appendix E). Assuming the average crude palm oil price from 2008 of 29.64 baht per kilogram, our calculations show that the DPF would generate a profit of 4.9 million baht annually with a payback period of 4.5 years, as shown in Figure 19.

Installing a Factory to Process New Life Project's Fruit Along With Supplemental Fruit

Our third scenario entails the DPF purchasing enough supplemental fresh fruit bunches from surrounding oil palm plantations to run Great Agro's system for an average workweek, assumed to be eight hours a day, six days a week. This scenario entails the same initial investment of 7.5 million baht as option 2, but introduces an additional risk associated with finding farmers to fill the capacity of Great Agro's system. With this increased risk comes a greater potential for increased profit.

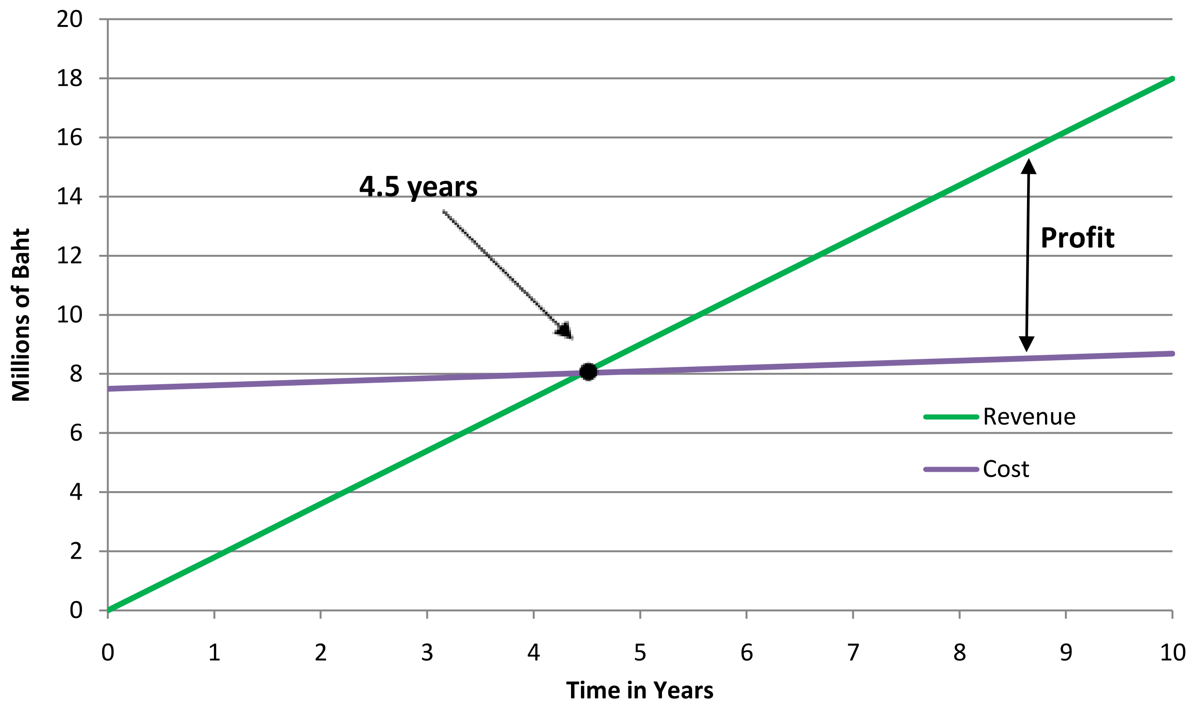

Figure 19: Projected payback period for scenario 2.

Our calculations demonstrate that this facility could generate a profit ranging between 4.9 million baht and 11.1 million baht annually, depending on the market prices of fresh fruit bunches and crude palm oil (Appendix E). Using this range of profit projections, we calculated the payback period to be between 0.9 and 2.0 years.

Using the average market prices of crude palm oil and fresh fruit bunches from 2008, respectively 29.64 baht per kilogram and 4.66 baht per kilogram, to provide a more tangible estimation, we calculated the annual profit for this option to be 7.9 million baht. The estimated break-even point using these averages is approximately 1.5 years (Figure 20).

4.4 Social Impacts of a Palm Oil Production Facility

Although the profitability of the scenarios is very important to the New Life Project, the DPF is a charitable organization, not strictly a business. Thus, the most suitable scenario is not necessarily simply the most profitable and we considered their social aspects to better compare to one another.

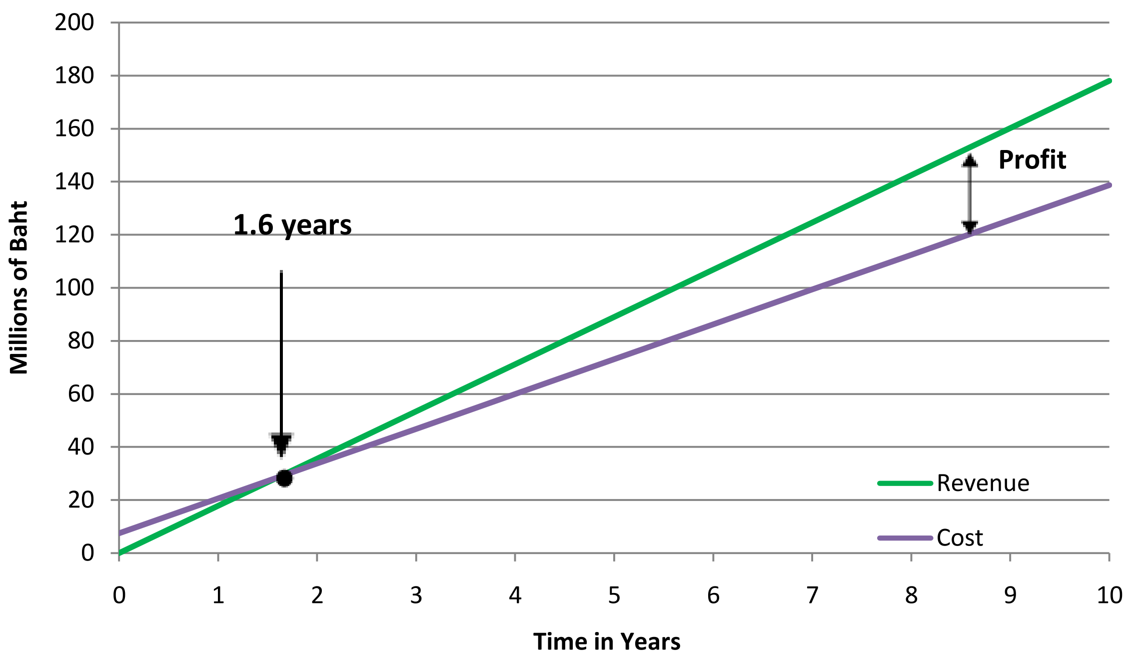

Figure 20: Projected payback period for scenario 3.

Through our meetings with Khru Prateep and the DPF staff members (Appendix A), we determined that the two important social aspects of the palm oil processing facility were its impacts on the community and environment. The DPF aims to build a better community for children in the Klong Toey slum as well as for the people living near the New Life Project locations. Khru Prateep also stressed the New Life Project's commitment to environmental awareness. Great Agro's palm oil production facility would:

- *Provide jobs*. Khru Prateep told us that the potential palm oil production facility would provide labor for the boys who were too old to stay at the New Life Project sites, especially the site in Chumporn. Because it operates for a full workweek, the third option provides the most labor; however, both scenarios 2 and 3 would require workers to operate the machinery.
- *Stimulate the local economy*. Khru Prateep believed that buying fruit from surrounding plantations could encourage more local farmers to begin growing oil palm trees, so scenario 3 may facilitate growth within the local economy.
- *Benefit the environment*. The facility that currently processes the DPF's fruit generates air pollution, but the Great Agro system does not. Khru Prateep stressed in our meetings with

her that she wanted the potential facility to produce as little waste as possible. The Great Agro system is environmentally friendly as the system produces no wastewater and emits no harmful pollution. Conversely, the facility that current processes the DPF's fruit generates air pollution.

The need for additional fruit in scenario 3 is both a challenge and an opportunity. Already a local palm oil processing facility buys fruit from most farmers in Kanchanaburi, and we believe that it would be worthwhile to consider creating a cooperative or incentive program to encourage them to sell their fruit to the DPF. A cooperative would also provide social benefits to local farmers.

One cooperative model for the DPF to consider would be working together with farmers as a joint firm that shares responsibilities and risks. According to John M. Staatz, an agricultural economics professor at Michigan State University, the fruit price that the DPF would pay farmers depends on the earnings of the cooperative firm. Instead of the DPF paying farmers for their fruit as they bring it to the facility, Staatz claims that it is common for fruit and vegetable processing firms to set up a payment plan in order to maintain revenue that is more consistent. In this case, the DPF would pay farmers for their fruit as well as give them a share of the oil sale profits at even intervals throughout the year (Staatz, 1987). In this cooperative, the farmers would be more committed to and have a voice in major decisions of the firm. Establishing a cooperative would allow the DPF to establish a relationship with local farmers to promote a stronger and more reliable customer base.

The benefit of this cooperative model is that the ability to pool together resources, expenses and revenue would allow the DPF greater market flexibility, as the cooperative would reduce variability in revenue. This idea of pooling, as described by Staatz, is helpful to farmers because they would not need to take out loans, for which they may need to pay a high rate due to uncertainties in agricultural production and market prices. The downside to this model is that the cooperative would need more managerial power to oversee all of the concerns regarding the farmers and the processing facility. This would include regulating the buying and selling decisions of pooling (Staatz, 1987).

Another way for the DPF to encourage farmers to sell their fruit to the New Life Project facility is through an incentive program. One idea for an incentive is for the DPF to offer the farmers a fruit bunch price lower than market price, but give them a percentage of the oil sale profits. In total, the farmers' revenue is higher than the average market price of fresh fruit bunches. This would decrease the DPF's projected profits for scenario 3.

Another incentive option is for the DPF to offer farmers a higher price than the market price for their fruit. This option offers the DPF a solution to the problem of competition without the complications of a cooperative. However, it would also decrease the DPF's projected profits for scenario 3.

5. CONCLUSIONS AND RECOMMENDATIONS

The Duang Prateep Foundation would like the New Life Project in Kanchanaburi to move toward self-sustainability by generating additional income from its oil palm plantation to pay for its annual operating costs of two million baht. The DPF currently sells its palm fruit to a local crude palm oil processing facility and would like to investigate the possibility of installing an on-site processing facility. We analyzed three potential revenue-generating oil palm scenarios, focusing on the profit projections and societal and environmental impacts of each. In this chapter, we will describe our conclusions for each scenario as well as provide recommendations to the DPF.

5.1 Conclusions

In this section, we have summarized the conclusions that emerged from our analysis of Great Agro's palm oil processing system and three revenue-generating plantation scenarios:

1. Continuing to sell the palm fruit grown at the New Life Project.
2. Purchasing and installing Great Agro's system to process the New Life Project's fruit.
3. Purchasing and installing Great Agro's system to process the New Life Project's fruit along with supplemental fruit.

We predict that continuing to sell fruit would generate enough profit to finance the operating costs of the New Life Project site in Kanchanaburi. Given the range of fresh fruit bunch and crude palm oil prices, we expect that by 2012 when all the trees at the New Life Project reach maturity, selling the fruit will yield an annual profit of *1.3–4.6 million baht.* This projection accounts for the cost of maintaining the plantation (which includes irrigation, fertilization, and harvesting of the fruit bunches) as well as for transportation of the fresh fruit bunches to the processing facility. Appendix E shows further analysis of the effect on profit of variance within fruit bunch pricing. Assuming the average price of fresh fruit bunches in Thailand in 2008, 4.66 baht per kilogram, we project an annual profit of *3.3 million baht*.

This option has little risk associated with it because there is no initial investment. The DPF would likely meet the annual operating cost of the New Life Project by selling the fruit for as low as 3.48 baht per kilogram. Although this option is profitable and safe, options two and three provide opportunities for a larger profit; however, greater risks are associated.

Purchasing and installing Great Agro's System to process only the fruit grown at the New Life Project plantation should generate more revenue than simply selling the fruit, but there are more uncertainties. In this scenario, the facility would operate for two days per week. Given the range of fresh fruit bunch and crude palm oil prices, we predict that by 2012, the DPF would make *2.7-6.1 million baht* per year by processing fruit from its plantation. Using the average price of crude palm oil from 2008 (29.64 baht per kilogram), we estimate that by 2012, processing fruit from its plantation should yield an annual profit of *4.9 million baht*. This exceeds the operating cost of the New Life Project site in Kanchanaburi, providing the DPF with additional money to invest in other charitable projects throughout Thailand.

If the DPF chooses to install a palm oil processing system, they would raise funds in order to cover the initial costs. This would be a challenging and time-consuming task, so to ensure that this large investment of 7.5 million baht would be worthwhile, we calculated the payback period. Given the range of fresh fruit bunch and crude palm oil prices, our projections show that the DPF would be generating profit after approximately 2.7 to 5.6 years. Using the average price of crude palm oil from 2008, the payback period would be about 4.5 years. It is worth noting that the Great Agro system is a prototype. This means that the lifetime of the machinery has not been tested, and it is likely more expensive than a mass-produced system.

We predict that purchasing and installing Great Agro's system to process the fruit from the New Life Project and that of local farmers would be the most profitable option for the DPF; however, the DPF should be aware of the risks and complications associated. Our analysis showed that this option can generate between 4.9 million and 11.1 million baht annually. We predict that the DPF will be able to make back their initial investment in 0.9 to 2.0 years. Assuming the previously mentioned average prices from 2008, 4.66 baht per kilogram of fresh fruit bunches and 29.64 baht per kilogram of crude palm oil, our calculations show that this scenario would generate a profit of *7.9 million baht*. Appendix E further explains our analysis of this system and the effects of changing variables on profit.

We would like to note a key factor that may alter the profitability of the New Life Project plantation's revenue-generating options. In general, the market prices of fresh fruit bunch and crude palm oil increase together; thus, we expect the profit for all three scenarios would increase as crude palm oil and fresh fruit bunch prices increase.

We conclude that scenarios 2 and 3 provide social benefits for the community and the environment. Great Agro's palm oil production facility would:

- *Provide jobs*. Khru Prateep would like some of the boys who are too old to stay at the other New Life Project site in Chumporn to work at the facility. Because it operates for a full workweek, the third option provides the most labor; however, both scenarios would require workers to operate the machinery.
- *Stimulate the local economy*. Khru Prateep believed that buying fruit from surrounding plantations could encourage more local farmers to begin growing oil palm trees, so scenario 3 may facilitate growth within the local economy.
- *Benefit the environment*. The facility that currently processes the DPF's fruit generates air pollution, but the Great Agro system utilizes clean-burning LPG.

5.2 Recommendations for Palm Oil Production at the New Life Project

While gathering our data, we determined that there were several topics into which further research would be valuable. These include the ISO Standard and the feasibility of beginning a cooperative between the DPF and local Kanchanaburi farmers.

If the DPF chooses to install Great Agro's system, we recommend that it investigate the advantages and disadvantages of complying with the quality standards set by the International Organization of Standards (ISO). The ISO 9002:2000 standard is used to check the free fatty acid (FFA) and moisture content of crude palm oil, the adobe (ripeness) of the oil, and impurities within the oil. According to Khun Bundit, Great Agro's senior engineer, the FFA and moisture contents can be checked on-site, but the adobe and impurities must be checked at a laboratory off-site.

Although compliance with these standards would increase the likeliness of finding a secure buyer, the certification process is expensive and tedious. Furthermore, studies show that compliance with the ISO 9000 standards does not guarantee increased profitability (Kirche et al., 2002).

If the DPF chooses the third option, we recommend that they consider a cooperative or incentive program for local Kanchanaburi farmers in order to compete with other local processing facilities. One model for the DPF to consider is a cooperative in which farmers and the DPF work together as a joint firm that shares responsibilities and risk. The DPF would pay farmers for their fruit as well as give them a share of the oil sale profits at even intervals throughout the year; however, the farmers would be expected to pay a membership fee.

Another model in which the farmers are less involved in the processing plant is for the DPF to pay them more for their fruit than would other processing plants. One option for this model is for the DPF to offer farmers a fruit bunch price lower than market price but give them a percentage of oil sale profits for a total revenue higher than the average market price of fresh fruit bunches. The second option is for the DPF to offer farmers a higher price than market price for their fruit.

The overarching cause behind our goal was to help the New Life Project of the DPF provide a safe environment for children of the Klong Toey slum who have faced neglect, sexual abuse, and drug addiction. We analyzed the profitability of three options to increase profit from the oil palm plantation at the New Life Project site in Kanchanaburi. We determined that all three scenarios are viable options for the DPF, yet each has varying levels of profitability and risk. Our hope is that our research and recommendations will help the New Life Project advance towards a state of self-sustainability so that the DPF can, without constant fundraising, give the young children living in poverty in Klong Toey a new life.

REFERENCES

American Palm Oil Council. (2004). *Palm Oil Food Products.* Retrieved November 12, 2008, from http://www.americanpalmoil.com/foodproducts.html#1

Baryeh, E. (2001). Effects of palm oil processing parameters on yield. *Journal of Food Engineering*, *48*(1-6).

Butler, R. (2008). Amazon Palm Oil: Palm Oil Industry Moves into the Amazon Rainforest. Retrieved from http://mongabay.com

Chavalparit, O. (2003). Industrial ecosystems in the crude palm oil industry in Thailand. *Proceeding of Environmental Governance in Asia*, 9-11.

Department of Internal Trade. (2009). Retrieved February 2, 2009, from http://dit.go.th

Duang Prateep Foundation. (2009). Retrieved February 26, 2009, from http://en.dpf.or.th

Fogiel, M., & Keller, W. D. (1998). *Business, accounting, and finance problem solver*. Piscataway, NJ: Research and Education Association.

Fromm, I. (2007). Integrating small-scale producers in agrifood chains: The case of the palm oil industry in Honduras.

Kirche, E.T., Khumawala, B. M., & Wayhan, V. B. (2002). ISO 9000 certification: The financial performance implications. *Total Quality Management*, *13*(2), 217.

Kwaski, P. (2002). Small-scale palm oil processing in Africa. *FAO Agricultural Services Bulletin*, *148*(3).

Malaysian Palm Oil Council. (2008). Retrieved November 18, 2008, from http://www.mpoc.org.my

Office of Agricultural Economics. *Thailand Oil Palm Production : 1998 - 2006.* Retrieved December 1, 2008, from http://www.dede.go.th

Prasertsan, S., & Prasertsan, P. (1996). Biomass residues from palm oil mills in Thailand: An overview on quantity and potential usage. *Biomass and Bioenergy, 11*(5), 387-395.

Rosenthal, E. (2007, January 31). Once a dream fuel, palm oil may be an eco-nightmare. *New York Times*, pp. 1-2.

Staatz, J. M. (1987). Farmers' incentives to take collective action via cooperatives: A transaction cost approach. *Cooperative Theory: New Approaches. USDA, Agricultural Cooperative Service (Service Report 18),* 87-107.

Payback period explained. Value Based Management.Net. (2008). Retrieved February 25, 2009, from http://valuebasedmanagement.net

Vanichseni, T., Intaravichai, S., Saitthiti, B., & Kiatiwat, T. (2002). Potential biodiesel production from palm oil for Thailand. *Kasetsart Journal, Natural Sciences, 36*(1), 83-97.

Yangdee, B. (2007). Ten million rai of oil palm plantation: A catastrophe for the Thai people. Project for Ecological Awareness Building (EAB).

APPENDIX A: TRANSCRIPT OF INTERVIEW WITH DUANG PRATEEP FOUNDATION AND VISIT TO NEW LIFE PROJECT IN KANCHANABURI

Notes from Initial Meeting with Duang Prateep Foundation

Interview with Khru Prateep Ungsongtham Hata, Founder and Chairperson of the DPF, and Dr. Supphawut Manochantr, DPF's Head of Secretariat

- The primary purpose of the palm oil processing facility is to attain self-sufficiency at the New Life Project center in Kanchanaburi.
- The factory will produce unrefined crude palm oil.
- The factory should not be harmful to the environment.
- If possible, the factory could be owned as a cooperative, providing job opportunities for local farmers and workers at the New Life Project.
- We should clearly communicate the processes involved as well as explain the machinery involved in palm oil processing.
- The DPF currently has 2 million baht set aside for this project, but is willing to fundraise up to 10 million baht to install the facility.
- The DPF would like to encourage local villagers to begin growing oil palm.

Notes from Visit to New Life Project in Kanchanaburi

Interview with Khun Rotchaya Ittirattana, Manager of the Oil Palm Plantation

- The New Life Project center in Kanchanaburi currently owns 8,578 oil palm trees at various levels of maturity; however, all trees will be mature within the next four years.
- The fruit bunches are harvested 2-3 at a time when the fruit color begins to darken and the fruitlets begin to fall off.
- The oil palm trees produce fruit for 30 years.
- The trees are harvested approximately twice per month; however, less fruit is produced during the very hot months and the cooler months.
- The DPF currently sells their fruit to Sasdee, a processing facility in Kanchanaburi.
- The younger trees are grown with banana trees interspersed to provide partial shade. The banana trees are cut down as the trees mature.
- Three types of fertilizer are used at the oil palm plantation, including composted banana leaves.

APPENDIX B: TRANSCRIPT OF VISITS TO PALM OIL PRODUCTION FACILITIES

Interview Topics/Questions

1. What parts of your system's processes and machines work well? What parts do not work well?

2. Where did you obtain the equipment and machinery for producing palm oil? Can you refer us to any specific machine manufacturers?

3. How much oil does your system produce per day / per fruit bunch?

4. We would like to determine your system's profitability. What are the energy costs of your system? What are the labor costs? What are the machine and start-up costs? What extra materials (such as the fruit bunches and lubricants for machines) besides the machines does your system use, and what are their costs?

5. How does your system manage waste? Do you change the waste to make a new product?

6. How often is your processing cycle run? From whom do you regularly buy fruit, and do you have any non-regular customers? What are the selling prices/market prices for your crude oil? How often do you sell your crude oil?

7. Does the quality of oil matter – for example, what are the quality standards for selling crude oil and do you vary the oil quality based on the buyer? How do you package and store the oil, and does this affect its quality?

8. How do seasons and economy affect how much fruit is sold to you and how much oil is produced?

9. Are there building codes and standards for constructing a palm oil processing facility? Could we get more information regarding this from any specific government agencies, such as the FAO?

Notes from Sasdee Palm Oil in Kanchanaburi Province

Interview with Khun Sutida Sendee, Factory Manger

Processing Notes

- Harvest the fruit bunches.
- FFB broken down into smaller bunches by hand. The workers used hatchets and large knives.
- A rotating drum was used to separate the fruit from the plant matter
- Approximately 25% of the "separated" fruit was larger bunches of plant matter (75% fruitlets).
- The thresher was approximately 8 feet long and 1.5 feet in diameter.
- The extra plant matter is manually separated with a rake.
- Roast the fruit bunches.
- A screw mechanism lifts the fruit into the roaster.
- To slow the roasting process and prevent burning, water is thrown into the roaster at the first signs of black or dark smoke.
- The roaster was approximately 10 feet wide, 30 feet long, and five feet tall.
- Roaster is heated by wood-burning stove and the hot smoke is transferred to the roaster by a fan.
- The smoke was not evenly distributed. Parts of the roaster were hot to the touch, while others were cool to the touch through the concrete walls.
- Each batch is roasted for 48 hours, but preserves the palm fruit for up to one year.
- Roasting eliminates wastewater.
- The fruit is roasted quickly after harvest because it minimizes the acid content of the oil.
- Mash fruitlets and extract oil.
- Screw mechanism is used again to lift roasted fruit into the hopper in order to mash the fruitlets.
- The kernel is not separated from the fruit before pressing, resulting in grade B oil.
- The facility wants to expands and add more presses.

- After the fruitlets are mashed, the substance is thick and yellow and the pressed fiber has not been separated yet.
- After the oil is squeezed out, the fiber waste is made into fertilizer or animal feed and sold for 3 baht/kilogram.
- Three weight units of fruit produce one weight unit of oil.
- Press uses 75 HP.
- Filter oil.
- Oil is heated to liquefy it and then it goes through a cloth filter.
- Filtering cloth is handmade.

Other Notes

- It took approximately one year to make all the machines.
- The ex-monk designed the machines, and a person from southern Thailand created them.
- He built his own machines because he could not find small-scale machines in Thailand and did not realize that they were available in China.
- He is learning as he goes (trial and error), which is why facility has had to remake several machines.
- So far, the ex-monk has invested over 6 million baht in the facility.
- At the ex-monk's request, some of the facility's profit goes towards the creation of a Buddhist meditation center.
- There are 15 full-time workers at the facility.
- The facility is waiting to get a machine to turn the field waste into fertilizer or to cultivate mushrooms.
- A company buys fruit from local farmers and sends it to facility.
- There are 20,000 rai palm plantations in Kanchanaburi province, and almost all of that palm fruit is brought to Sasdee. In addition, fruit from two neighboring provinces, Petchburi and Ratchburi, is brought to Sasdee.

Notes from Suk Sombun Palm Oil in Chon Buri Province

Interview with Khun Chana Chintarattanawong, Managing Director

- So far, the factory has invested 300 million baht.
- They have been planting palms for 20 years.
- When it was just a plantation, they sent their fruit to Southern Thailand to produce oil.
- When they wanted to open their own, they visited plantations and factories in Southern Thailand for ideas.
- At first, they produced oil every 3-4 days because they did not have enough raw material, but now they produce oil every day.
- At first, the factory processed 30 tons of fruit/hr; it currently processes 75 tons of fruit/hr; and by the end of the year, the factory plans to process 135 tons of fruit/hr.
- The factory produces oil for eight hrs/day in two shifts.
- Currently use the machines for only eight hrs/day so that they do not break, but plan to begin overtime of 4 hours.
- Factory separates kernel before crushing the fruit, resulting in grade A oil.
- The plant refines crude oil here to get cooking oil.
- After the crude oil, there are three products: stearins, fatty acids, and vegetable oil.
- Stearins are used to make butter, margarine, and candles
- Fatty acids are used to make soap and dish detergent
- Mixture of stearin and cooking oil was used to make condensed milk
- Kernel oil was sent to food companies for use in the food industry.
- Free fatty acids should not exceed five wt% in the crude oil.
- Moisture should not exceed 0.5 wt% in the crude oil.
- Machines are imported from Malaysia.
- There are 20 workers per shift, one shift is 12 hours: 8 hrs of machines running, 4 hrs of maintenance.
- Initially invested 50-60 million baht into the factory, and it always separated nut and fruit.
- Kernel can be stored for a relatively long time before spoilage.

- CPO and kernel oil have similar prices – currently CPO is 23 baht/kg and kernel oil is 18 baht/kg.

Interview with Khun Sura Tanwiset, Palm Farm Coordinator

- The DPF owns 200 rai of land in Chon Buri near factory.
- The facility exports cooking oil to Laos and Burma.
- A 5 L bottle of cooking oil is sold for 170 baht.
- The sooner the oil is produced, the better the quality.
- The fruit should be processed within two days.
- Some farmers from E-sarn (Northeast) also send fruit to this factory.
- The farmers pay for fruit transportation.
- 1000 tonnes of raw material are sent to factory per day, which is less than capacity.
- The hours worked daily depends on the amount of raw materials.
- The palm oil is 17% by weight of the fruit.
- Some machines were bought used from factories that were closing.
- The factory buys large FFB (over 5 kg) for 3.5 baht – 0.5 baht is for transportation to help farmers. The factory buys small FFB (under 5 kg) for 2.85 baht.

Notes from Great Agro's Prototype Palm Oil Processing Facility in Pathum Thani Province

Interview with Khun Ascha Chandsongsang, MTEC Researcher

- The kernel is separated from the fruit, resulting in grade A oil.
- No steam is used, so no wastewater is produced (dry process).
- The total machine costs are 4.5 million baht.
- Grade B oil is 1 baht cheaper/L than grade A.
- The facility plans to sell the kernels for 12,000 – 13,000 baht/tonne.
- Solid waste is sold to a company that makes it into animal feed for 3000 – 4000 baht/tonne.
- Steaming kills nutrients in waste, making it less useful as animal feed.
- The palm oil contains Vitamin A and Beta Carotene, which are especially important in palm oil because it helps prevent malnutrition in Thai children.
- One tonne of fruit yields 20% oil.
- Whole process is completed in only one day, which differs from the ex-monk's facility because he roasted for two days.
- The facility consisted of seven major steps:
- The tipper utilizes a hydraulic arm to lift fruit into a collecting bin, which transports the fruit to a roaster via screw lift.
- The roaster heats the fruitlets for 30 minutes at 80°C and then transports the fruit to the demesocarper using a second screw lift.
- The demesocarper threshes the fruit, removing the kernels from the fruitlets.
- The cooker conveyor transports the fruit pulp to the screw press.
- The screw press extracts the oil from the fruit pulp.
- The vibrating screen acts as a coarse filter for the pressed oil.
- Finally, the filter press pumps the oil through cloth filters, resulting in crude palm oil.

APPENDIX C: DETAILS OF GREAT AGRO'S PALM OIL PRODUCTION PROTOTYPE SYSTEM

The contact for the Great Agro System is Mr. Bundit Jumras, the Senior Project Engineer at Great Agro Co., LTD, a division of the CP Group Company. His email address is bundit.jumras@gmail.com and his phone numbers are 081-5146499 and 089-1399835. Great Agro Co.'s address is 171/6 M. 5, Salaya-Bangpasee Rd., T. Salaya, A. Buddha-Monthol, Nakornpathom 73170.

Figure 21: Reception station (left) and container for processing equipment (right).

Figure 22: Control panel for processing system.

Figure 23: Reception station for fresh fruit bunches.

Figure 24: Dryer to sterilize fruitlets.

Figure 25: Demesocarper to remove nut from fruit (yellow machine in back) and cooker conveyer to warm fruit.

Figure 26: Cooker conveyer to warm fruit, screw press to extract oil, and vibrating screen to filter coarse material.

Figure 27: Vibrating screen to filter coarse material.

Figure 28: Filter press to filter fine material.

APPENDIX D: PROFIT PROJECTION CALCULATIONS

Profit = {Revenue} – {Costs}

We define the variables used in our profit equations and their values for each scenario in Table 5.

Table 5: Variables and values used in profit projections.

Symbol	Variable	Sell DPF fruit	Process DPF fruit	Process for average workweek
Q	Quantity of fruit bunches produced annually, in kg	1,052,755	1,052,755	1,052,755
Q_{LF}	Quantity of fruit bunches purchased from local farmers, in kg	0	0	2,512,960
P_{FFB}	Price at which fruit bunches are sold per kg	4.66	0	0
P_{CPO}	Price at which crude palm oil is sold per kg	0	29.64	29.64
P_{PPF}	Price at which palm press fiber is sold per kg	0	3	3
P_N	Price at which the nut is sold per kg	0	7	7
M_P	Annual plantation maintenance cost	1,129,000	1,129,000	1,129,000
T	Transportation cost for fruit bunches per kg	0.5	0	0
D	Number of days per week that the facility operates	0	2	6
N	Number of workers at the facility (excluding the operator)	0	2	2
W_W	Wage paid daily to workers (excluding the operator)	0	150	150
W_O	Wage paid daily to the operator	0	300	300
P	Power used by machinery, in kW	0	75	75
E	Electricity cost per kW-h	0	2.42	2.42
F	Annual fuel cost	0	88,000	264,000
M_F	Annual maintenance cost of equipment	0	75,000	225,000
M_D	Annual machinery replacement (depreciation) fund	0	250,000	750,000
C_{FFB}	Cost per kilogram of fruit bunches purchased	0	0	4.66
	ANNUAL PROFIT PROJECTION (MILLIONS OF BAHT)	**3.3**	**4.9**	**7.9**

Annual Projected Profit Equations

Continuing to sell fruit

Annual Profit = $\{Q\,(P_{FFB} - T)\} - \{M_P\}$ = 3.3 million baht

Utilizing Great Agro's System to Produce Only Fruit at New Life Project

Annual Profit = $\{Q\ (0.17*P_{CPO} + 0.14*P_{PPF} + 0.13*P_N)\} – \{(D\ (n*W_W + W_O + 8P*E) + F + M_P + M_F + M_D)\}$ = 4.9 million baht

Utilizing Great Agro's System For An Average Workweek

Annual Profit = $\{(Q + Q_{LF})\ (0.17*P_{CPO} + 0.14*P_{PPF} + 0.13*P_N)\} – \{(D\ (n*W_W + W_O + 8P*E) + F + M_P + M_F + M_D + Q_{LF}*C_{FFB})\}$ = 7.9 million baht

Profit Projection Assumptions

Here we have described how we estimated the values in

Table 5: Variables and values used in profit projectionsTable 5.

Preliminary Calculations

<u>Quantity of fruit bunches produced annually</u>

Khru Prateep gave us a document about the New Life Project that stated that its plantation contained 8578 oil palm trees, and she informed us that the DPF did not have plans to expand the plantation. Khun Sura (the palm farm coordinator at Suk Sombun), Khun Ascha (the MTEC researcher), and Khun Bundit (Great Agro's senior engineer) told us that on average, 22 trees are planted per rai. We used these two numbers to calculate that the New Life Project plantation contained 389.91 rai:

$$8578\ trees * \frac{rai}{22\ trees} = 389.91\ rai$$

Bundit told us that from his research in Thailand, oil palm plantations produce 2.7-2.8 tonnes of fresh fruit bunches annually/rai, so we used 2.7 to be conservative in our calculations. We used the number of rai at the New Life Project and the annual fresh fruit bunch production per rai to calculate the projected annual fresh fruit bunch production at the mature New Life Project plantation as 1053 tonnes of fresh fruit bunches:

$$390\, rai * 2.7 \frac{\frac{tonnes\ FFB}{year}}{rai} = 1053 \frac{tonnes\ FFB}{year}$$

We checked this annual production rate using information that we received from Khru Prateep when she showed us the New Life Project plantation. She told us that the DPF currently harvested two or three fresh fruit bunches, each weighing about 20 to 25 kg, from each tree once or twice per month. We calculated the conservative annual fresh fruit bunch production rates for this data to be 4118 tonnes:

$$8578\ trees * \frac{2\ FFB}{month} * \frac{20\ kg\ FFB}{FFB} * \frac{1\ tonne\ FFB}{1000\ kg\ FFB} * \frac{12\ months}{year} = 4118 \frac{tonnes\ FFB}{year}$$

The ranges for this data varied greatly, which made the calculations using that data less reliable. Conversely, three of our sources (the manager of the Chon Buri processing facility, Khun Bundit, and Khun Ascha) told us that typically, 22 oil palm trees are planted on one rai, which is a more reliable statistic that we used in our first calculation of annual fresh fruit bunch production. For these reasons, we determined that our first calculation of annual fresh fruit bunch production, 1053 tonnes, was more accurate and more conservative, so we used this rate in our subsequent calculations.

Quantity of fruit bunches purchased from local farmers

Next, we determined the quantity of fresh fruit bunches that the DPF would need to purchase from local farmers for one shift of eight hours, six days a week. In order to do this, we calculated the Great Agro system's processing capacity. Khun Ascha told us that the system could process one tonne of fruit per hour. The handout from Khun Chana, managing director of Suk Sombun, told us that the fruit is 70% by weight of a fresh fruit bunch. Thus, the fresh fruit bunch capacity of Great Agro's system was 1.43 tonnes of fresh fruit bunches per hour:

$$\frac{1\ tonne\ fruit}{hour} * \frac{1 tonne\ fresh\ fruit\ bunch}{0.7\ tonnes\ fruit} = 1.43 \frac{tonnes\ fresh\ fruit\ bunch}{hour}$$

Thus, we calculated that the facility could process 3566 tonnes of fresh fruit bunches annually running for eight hours a day, six days a week:

$$\frac{1.43\ tonnes\ FFB}{hour} * \frac{8\ hrs}{day} * \frac{6\ days}{week} * \frac{52\ weeks}{year} = 3566 \frac{tonnes\ FFB}{year}$$

Since the New Life Project plantation produced 1053 tonnes of fresh fruit bunches annually, the proposed facility would accommodate 2513 additional tonnes of fresh fruit bunches annually:

$$3568 \frac{tonnes\ FFB}{year} - 1053 \frac{tonnes\ FFB}{year} = 2513\ additional\ tonnes \frac{FFB}{year}$$

Revenue Sources

In the profit equations, the coefficients in front of the prices for crude palm oil, palm press fiber, and nuts refer to the composition of the fresh fruit bunch:

- $0.17*P_{CPO}$: This quantity is the revenue generated from the sale of crude palm oil per kg of fresh fruit bunch. Khun Chana gave us a handout that said that crude palm oil was 17-20% by weight of a fresh fruit bunch. Khun Bundit told us that crude oil was 18% by weight of a fruit bunch, which confirmed this range. To be conservative, we used 17% in our calculations.
- $0.14*P_{PPF}$: This quantity is the revenue generated from the sale of palm press fiber per kg of fresh fruit bunch, assuming that the average fresh fruit bunch contains 14% by weight fiber. The value of 14% was also from Khun Chana's handout.
- $0.13*P_{N}$: This quantity is the revenue generated from the sale of the nut per kg of fresh fruit bunch, assuming that the average fresh fruit bunch contains 13% by weight nut. The value of 13% was also from Khun Chana's handout.

Price at which fruit bunches are sold

For purposes of illustration in our Findings chapter, we used average values from 2008 in our calculations. We believe that using the Thailand 2008 market prices for our projections is reasonable as fresh fruit bunches were 3.00 baht/kg for December 2008 (*Department of Internal Trade*, 2009), and Khru Prateep told us that the DPF was selling their fruit for 3 baht/kg in December 2008. In our calculations, we assumed that the DPF would sell its fruit at the average price in Thailand in 2008 through November, 4.66 baht/kg of fresh fruit bunch (*Department of Internal Trade*, 2009).

Price at which crude palm oil is sold

Because we believed that using the Thailand 2008 market price for fresh fruit bunches was reasonable, we also assumed that the DPF would sell its crude oil at market price as well. The proposed Great Agro system would produce grade A crude palm oil, which sold for an average of 29.64 baht/kg in Thailand in 2008 through the month of November (*Department of Internal Trade*, 2009).

Price at which palm press fiber is sold

Khun Bundit told us that the Great Agro prototype sold its palm press fiber for 3-4 baht/kg. Khun Sutida, the factory manager at Sasdee, told us that her facility sold its fiber for 3 baht/kg, so we used 3 baht/kg in our calculations to be conservative.

Price at which the nut is sold

Khun Bundit told us that the price of the nut was about 7-8 baht/kg, so we used the most conservative number in these ranges, 7 baht/kg, for our calculation.

Operating Costs

Annual plantation maintenance cost

In order to help us determine the annual operating cost of the plantation, Dr. Supphawut called Khun Ming Phon Ungsongtham, director of the New Life Project, and Khun Kanokwan Suttirak, agricultural section head. Their information included that the current annual cost of fertilizer for the plantation is 435,000 baht. Since the DPF does not have any plans to expand the plantation, we assumed that this figure would remain approximately the same when the plantation is mature. Khun Ming and Khun Kanokwan estimated that irrigation of the plantation would cost about 7,000 baht/rai over ten years, which is about 700 baht/rai annually. As the New Life Project plantation contains about 390 rai, its annual irrigation cost is 273,000 baht:

$$\frac{\frac{(700\ baht)}{rai}}{year} * 390\ rai = 273{,}000 \frac{baht}{year}$$

Dr. Supphawut gave us an approximate annual labor cost of harvesting fresh fruit bunches, 0.4 baht/kg. As the mature New Life Project plantation would produce 1053 tonnes of fresh fruit bunches annually, the annual labor cost of harvesting the fruit is 421,200 baht:

$$1053\ tonnes\ FFB * \frac{1000\ kg}{tonne} * \frac{0.4\ baht}{kg} = 421{,}200 \frac{baht}{year}$$

Accounting for fertilizer, irrigation, and labor to harvest the fresh fruit bunches, the total annual operating cost of the New Life Project plantation is 1,129,000 baht/year:

$$435{,}000 + 273{,}000 + 421{,}000 = 1{,}129{,}000 \frac{baht}{year}$$

Transportation cost for fruit bunches per kg

The scenario in which the DPF sells its fresh fruit bunches has a cost for transporting the bunches to a processing facility. Dr. Supphawut told us that the DPF pays 0.5 baht/kg to transport its fresh fruit bunches now, so we assumed that this price would remain the same in our scenario. In the facility scenarios, there are no transportation costs for the sale of crude palm oil. There is an initial cost for buying the tank, but the oil is picked up from the tank at the facility and its transportation cost is included in the selling price of the oil.

Number of days per week that the facility operates

Scenario 3 assumed an average workweek, which Khru Prateep said was about eight hours per day, six days per week in Thailand. For scenario 2, we used the annual fresh fruit bunches produced by the New Life Project plantation and the processing rate of the proposed facility to determine that the factory would need to run for 14.2 hours each week:

$$\frac{1053\ tonnes\ FFB}{year} * \frac{1\ year}{52\ weeks} * \frac{1\ hr}{1.43\ FFB} = 14.2 \frac{hrs}{week}$$

As Khru Prateep had told us that she would like the employees at the proposed facility to work for eight hours a day, we determined that the facility would need to run for approximately two days per week in order to process just the New Life Project plantation

Number of workers at the facility (excluding the operator)

Khun Bundit told us that Great Agro's prototype system used two workers plus an operator. He also said that someone would need to check the crude oil quality but that this would require an on-site lab. He said that another alternative was to send the oil to a lab off-site, and we assumed that the DPF would do this, as building an on-site lab was costly. Thus, we determined that the proposed DPF system would require three total workers.

Wage paid daily to workers (excluding the operator)

Khru Prateep told us that she would like to pay any facility workers minimum wage, which she said was 150 baht a day for a 7-8 hour shift.

Wage paid daily to the operator

The operator would require more training that the other two facility workers. Khun Bundit said that the operator's wage would be at least 5000 baht/month, or at least 208 baht/day. To be conservative, we estimated a wage of 300 baht per day for a 7-8 hour shift.

Power used by machinery, in kW

Khun Bundit told us that Great Agro's system, including all machinery in the container and the dryer, used 75 kW.

Electricity cost per kW-h

We used the 2009 average price of electricity for a small business in Thailand, 2.42 baht/kW-hr (*Department of Internal Trade,* 2009). Khun Bundit told us that the screw press and dryer required 15-20 minutes to warm up and that the dryer took no longer than thirty minutes to heat up. We rounded these estimates up to one hour to be conservative, so we assumed that the equipment would run for nine hours every day.

Annual fuel cost

Khun Bundit told us the LPG (liquefied petroleum gas) used for both the dryer and silo costs 264,000 baht/year when running for an average workweek, so we used this fuel cost estimate for scenario 3. Khun Bundit told us that fuel cost is directly proportional to number of operating days, so we divided 264,000 baht/year by three in order to estimate the fuel cost used for scenario 2 (88,000 baht/year):

$$\frac{264{,}000\,\frac{baht}{year}}{3} = 88{,}000\ baht/year$$

Annual maintenance cost of equipment

For simplicity, we assumed that the equipment maintenance cost for each scenario would be constant over the lifetime of the equipment. We did not consider extra machinery downtime for larger machinery repairs. At the recommendation of Khun Bundit, we assumed the annual maintenance costs to be 3% of the initial system price when running the system for an average workweek. Machinery maintenance costs are based upon the amount of time that the machine is used (Fogiel & Keller, 1998). The total cost of this machinery was 7.5 million baht. Thus, we calculated the annual facility maintenance costs to be 225,000 baht/year for the average workweek scenario:

$$0.03 * \frac{7.5\ million\ baht}{year} = 225{,}000\ baht/year$$

The system would need to run two days a week if the DPF processed only its own fruit. Because this running time is one-third of the running time for the average workweek scenario, we assumed that this maintenance cost would be one-third of the facility maintenance costs of that scenario, or 75,000 baht/year:

$$\frac{225{,}000\ baht/year}{3} = 75{,}000\ baht/year$$

Annual machinery replacement (depreciation) fund

The engineering manager at Great Agro informed us that Great Agro believes the machinery to have a lifetime of approximately ten to twenty years, operating in eight-hour shifts daily. We included a cost to replace the entire system every ten years, to be conservative. The lifetime of the machinery is based upon the time that the machine *is used*, not on the time the machine exists (Fogiel & Keller, 1998). We divided the initial cost of the system by the lifetime of the machinery to get an annual machinery replacement of 750,000 baht:

$$\frac{7{,}500{,}000\ baht}{10\ \text{years}} = 750{,}000\ baht/year$$

The system would need to run two days a week if the DPF processed only its own fruit. Because this running time is one-third of the running time for the average workweek scenario, we assumed that this maintenance cost would be one-third of the facility maintenance costs of that scenario, or 250,000 baht/year:

$$\frac{750{,}000\ baht/year}{3} = 250{,}000\ baht/year$$

Cost per kilogram of fruit bunches purchased

For the scenario in which the DPF would run Great Agro's system for an average workweek, we assumed that the DPF would buy supplemental fruit at around the average price in Thailand in 2008 through November, 4.66 baht/kg of fresh fruit bunch (*Department of Internal Trade*, 2009). See Appendix E to analyze further the fluctuations of fresh fruit bunch market prices from 2003-2008.

APPENDIX E: FLUCTUATION OF FRESH FRUIT BUNCH AND CRUDE PALM OIL PRICES

We generated Figures 29 and 30 using statistics from Thailand's Department of Internal Trade website.

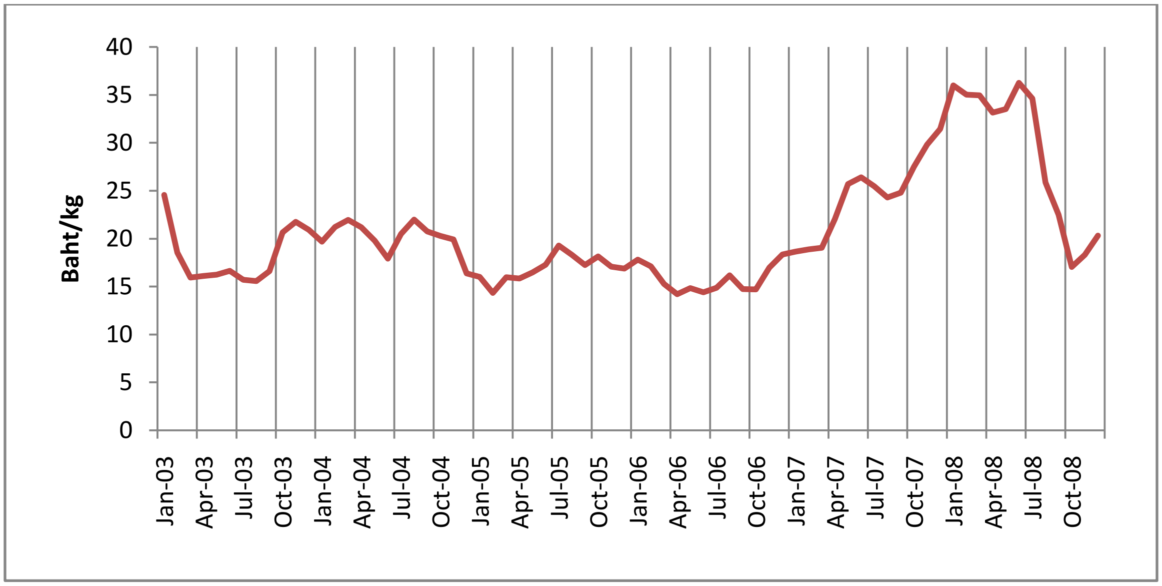

Figure 29: Crude palm oil market prices in Thailand from 2003-2008.

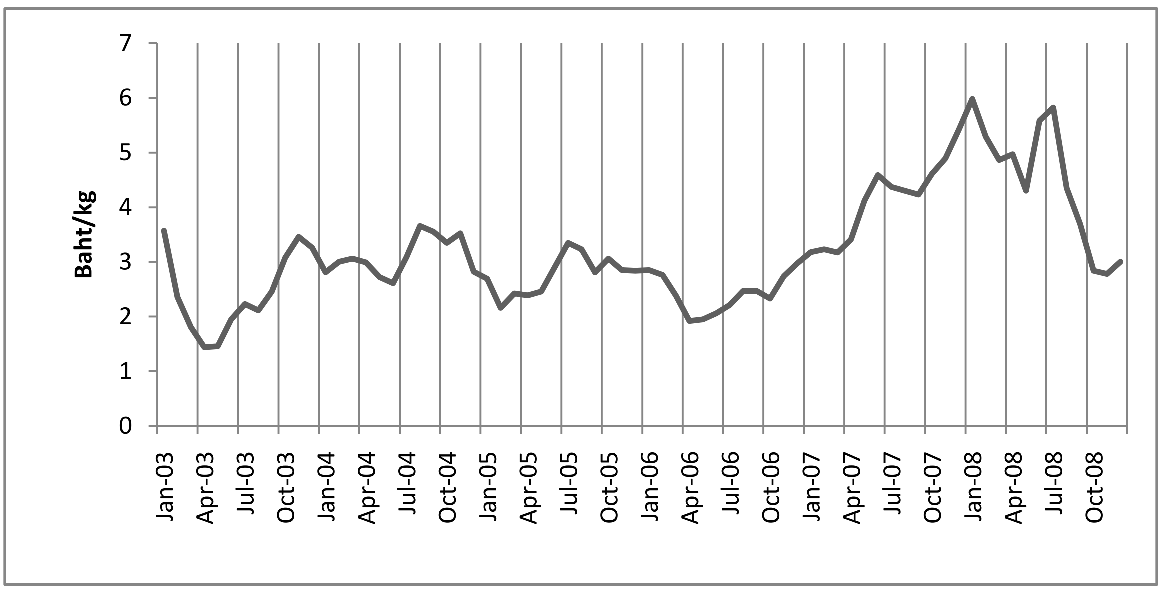

Figure 30: Fresh fruit bunch market prices in Thailand from 2003-2008.

APPENDIX F: TEAMWORK SELF-ASSESSMENTS

The past three teamwork assessments were effective in improving the productivity of our team. We have decided to format the final teamwork assessment in a similar structure, with emphasis on a summative component for the whole group. Each group member wrote up a "self" assessment that was meant to be critical and constructive. This assessment addresses each of our strengths as a team member, while analyzing how we have improved.

Reflection on the Previous Teamwork Assessments

During the first teamwork assessment, we believed it would help to begin by brainstorming attributes that describe a productive group member. We then had every group member write about how effective he or she believed that every other group member was for each attribute. This system was time-consuming and the assessments lacked critical, constructive thought. Other than some self-assessments, it contained mostly praise.

With this in mind, we decided to take a different approach to the subsequent teamwork assessments by having a group discussion. We felt that a discussion was an easier way for everyone to voice his or her opinions, and the group was patient in making sure that everyone said everything they wanted. We talked about group areas for improvement and possible solutions. We also discussed areas of improvement for each group member, and we respectfully shared solutions. After our discussions, we wrote a summary of how we agreed to improve as a group and as individuals.

Group Assessment

After we received our midterm evaluation, we realized that we needed to work together more effectively in order to improve our performances during adviser meetings and to increase productivity. In general, we increased our preparation for meetings as well as delegated tasks more often.

The Difficulties and Solutions with the Collaboration between WPI and Chula Students

The collaboration between WPI students and Chula students posed many challenges, but we believe that we made significant progress in addressing them. We believe that many complications that arose regarding this collaboration resulted from the varying time commitments between the WPI students and the Chula students. Joe, Kevin, and Anne spent seven weeks prior to coming to Thailand researching background information of the project. Furthermore, Nan and Gift had classes during the week and were each expected to spend half as much time on the project as Joe, Kevin, and Anne.

Early in the project, Nan and Gift were generally passive during meetings. About halfway through the term, during a team assessment, Joe, Kevin, and Anne addressed the passive nature of the Chula students. Nan and Gift expressed that they were afraid of sounding uninformed during discussions. Because of our varying time commitments, many decisions regarding the project were made without Nan or Gift because they needed to be made as they arose.

After we addressed Nan and Gift's quietness during meetings, Nan and Gift's participation during both group meetings and adviser meetings increased. Nan and Gift were able to better understand the nature of Joe, Kevin, and Anne regarding the project work, and became comfortable adjusting their working methods. Similarly, Joe, Kevin, and Anne were better able to understand Gift and Nan's comfort zones and were able to help improve their performance in the group. Anne, Joe and Kevin helped Nan and Gift during adviser discussions by asking them introduce new topics. Anne, Joe and Kevin then would try to be more patient with Nan and Gift to give them more time to think about topics.

Discussions and Meetings

Initially our discussions within our advisers lacked initiative, planning, and productive dialogue. The advisers made many recommendations without enough input from the group. After the midterm evaluation, we adopted a "coach-like" perspective of the advisers where we used their input as helpful suggestions rather than as strict directive. We used discussions to help rally ideas between the group members and the advisers to come up with the best approaches to our project. We also prepared for adviser meetings beforehand by having group discussions in which we decided which topics to bring to the adviser meetings and made sure that everyone understood all the topics.

Presentations

We believe that our presentations developed stronger content each week that portrayed more clearly the most necessary information. This was the result of thinking carefully about the advisers' previous comments and an increase in practice and prior preparation for the presentations. We helped improve the presentation skills of all group members. For instance, Nan looked at the slides often at the beginning of the term. By the end, she glanced at the slides only occasionally during the presentation. Kevin often forgot the content of slides during presentations at the beginning of the project, but by the end, he was able to remember most of the content in the correct order. Anne initially lacked confidence in her public speaking and often used "filler" words. She now has more confidence in her public speaking ability and has avoided most of the words she used to use.

Financial Analysis

We believe that better organization would have made our financial analysis more efficient. Our original spreadsheet was confusing and incomplete, and we rushed towards the end of the term to ensure that we made all of our assumptions and limitations clear. We also realize that we should have defined all of our equation variables earlier in the project.

Drafts

Anne usually wrote the first drafts, and Joe elaborated on the ideas and provided topic sentences and transitions between topics. Kevin helped with the overall organization of paper and made the group aware of inconsistencies. He also provided critical thinking about the statistical analysis. We realized after adviser comments on our rough drafts that we needed to word our ideas more carefully. The advisers' comments also helped us edit our papers with better efficiency and think about the topics more critically.

Contributions

Nan

Nan translated most of the personal interviews and some of the phone interviews. She also translated many documents and websites. She researched market prices and machinery manufacturers as well as providing major contacts for information.

Joe

Joe contributed major writing and editing of the paper. He generated the profit projection equations and the graphs used in the paper and presentations. He edited the spreadsheets to include variation in pricing and payback periods. He also edited the poster. Finally, Joe served as a time-management coordinator by setting deadlines.

Anne

Anne contributed major writing, editing, and formatting of the paper. She organized and compiled information given to the group as well as delegated tasks within the group to increase team efficiency. She devised the final spreadsheet used to calculate profit projections and generated many of the tables and other visuals used in the paper. She also edited the presentations.

Kevin

Kevin served as the primary contact for all our liaisons and informants. He acted as a leader during group discussions. He devised the initial profit projections spreadsheet. Along with minor writing and editing of the paper, he designed the final presentation and poster.

Gift

Gift translated most of the phone interviews and some of the personal interviews. She provided major contacts for information. She researched market prices and rates as well as machinery manufacturers.

Self-Assessments

Nan

During this project, I think that I was reliable and delivered solid effort, but I was sometimes lack of activeness. I was comfortable when my partners gave me constructive critics and when I gave comments to my partners. I always opened to their suggestions and tried to improve the issue promptly. For my weakness, I was fully aware that I had difficulty in participating in the advisor meeting. However, I overcame it in the later meetings which were also the results from the better communication within the team and the helps from my partners. When I was working with my team, I was comfortable and regularly shared my feelings and ideas.

Kevin

My partners would say that I am reliable and give my best effort. I was motivated to work on writing sections of the paper because I have intended on improving my writing skills for several years. After writing and editing some sections, my group members approached me about my writing skills. They believed that I took too long with my writing, and that editing my writing would often take longer for them than if they were to write it instead. It had been clear to me that some group members were much more skilled at writing than I; however, it is still difficult news to hear. I was eager to write but it was not sufficient use of our time for other group members to edit my writing for long periods of time that could be better spent with work better suited for me. I was understanding and did not try to argue against them, and we discussed possible options. I was delegated to work on quantitative analyses for our project, producing equations, charts, tables and graphs for profit projections. I was able to keep myself occupied with work relevant to the project that I could deliver to the best of my ability that was of acceptable quality as well. After the discussion about the roles in the group, I felt much more confident in the work I created and I was glad that the issue was addressed.

My implications when speaking to the group were often unclear or misinterpreted. When I think out loud during group discussions, much of what I say sounds poorly thought out. I believe this process I have adopted inspires more unique “out of the box” thinking from my project members and from myself. This approach to discussions has lead to many arguments over the ideas that I bring up. One example of this is when I offered an idea about how to graph the profit projects and some of the group members became frustrated because it contradicted a decision that the group already discussed and decided on, and felt that I was wasting the group's time with my ideas. I viewed these "brainstorming" discussions as productive. However, it also seemed to frustrate some of my other group members who interpreted what I said to be my personal opinion on the topic and would argue strongly against the opinion. This aspect to my personality was pointed out to me by my group members, who helped me better understand how I solve problems and who inspired me to think about how I can best benefit the group.

I often make assumptions that unintentionally lead to complications with the group. This has been something I have known about myself since Middle School and have been trying to correct since. An example of this was when I made an assumption that the average prices from last year that we used in our calculations was from all over Thailand, when instead it was just from the Krabi province in Thailand. I look at topics by using several perspectives and approaches. I am able to solve problems because of my simplification methods. A downfall to this is that specific information tends to escape me from time to time as seen in the example mentioned. I hope to keep these strengths and weaknesses in mind as I am working in future groups, and I hope on continuing to work on my weaknesses to improve my character.

I hope that the feedback I gave my partners helped them to think about their actions and their implications and motivated them to improve. During presentations, I tried to help people think about a way to improve their presentation skills by offering one thing they should improve such as speaking more slowly, watching their "uhm"s and looking at the audience when they speak. Being able to help improve some of the group members' English speaking skills was also a challenge because when in group discussions I had to make sure I was speaking slowly and clearly so that they could better understand me. This helped them feel more comfortable contributing to the group as they were eager to improve their English. Group discussions were a big challenge for the group. I tried to make sure the whole group participated by ensuring that most everyone would start discussion on a new topic so that we could hear new ideas from every group member.

Joe

I feel that I was very reliable throughout the project and always delivered my best effort. I thought of my work as “deliverables” to the rest of the group, and wanted to ensure that my work was already reviewed and polished before giving it to my teammates for their reviews. I tried to set small, achievable goals for the project within the larger ones and stressed organization and effective use of time. This was received as rushing the project by the more laid-back members of the team; however, in several situations where I was dissatisfied with the pace of the project, I worked earlier in the morning, before our group meetings began to keep the project on track.

Coming into the project, I was aware of my stubborn tendencies, and I feel that I have done a very good job fighting the urge to argue my opinions. When someone offered criticism of my work, I was willing to listen to their reasoning and carefully consider their thoughts. I was willing to discuss changes to my work and only suggested keeping my work the way it was if I could justify a specific reason as to why it was written the way it was. After a few weeks of forcing myself through this routine, it became a natural process for me and helped me to work through one of my largest downfalls as a team member. I believe that this helped our team as a whole and will continue to help me in future team projects.

When learning about Thai culture, I was concerned about being too straightforward with the Chulalongkorn students in my group, but I feel that I was able to offer constructive criticism to my entire team delicately, but effectively.

Anne

I believe that I was very reliable and consistently delivered my best effort through the duration of this project. I realize that I am a perfectionist and hold high standards for the project’s quality. I was also aware that my teammates might perceive my attention to detail as intense or nit-picky. I often take longer to think and write than others, and I realized that teammates might get impatient with my slow, methodical working style, especially when writing the paper. I feel that I did a good job being reasonable about how our team should use our time effectively to balance all parts of the project. I did my best to be accommodating by spending time at night writing, editing, and formatting the paper so that we could focus more on preparing for presentations and meetings while we met as a group.

I tried to keep my disposition optimistic by consistently encouraging and giving positive feedback to my teammates. I wanted my teammates to know that I genuinely valued their creativity and ideas, and I believe that I was open and receptive to their feedback on my contributions. I had difficulty directly addressing issues that I had with my teammates, or I sometimes addressed them later than I should have. I also could have avoided some of these issues by making my priorities or expectations for the project clearer from the beginning. As our team became more comfortable with one another and better understood each other's working styles, I improved with this, but I believe that I could still use more improvement in this area. I hope that the teamwork skills that I learned during this project will serve me well in future endeavors.

Gift

When I start this project, my enormous problem is language. Because I am not excellent to speak and listen English so I can't connect with other WPI members not well. However my members always try to listen and understand me and try to speak slowly for me. Now, I can more connect with other member better.

Other problems are I scare to give the opinion between working and discussion and also scare presentation too. But I must do everything in this project. But my team member would like to listen my opinion, thus I feel that I have more improve about propose opinion. Because this project has presentation every week, thus this project also improves me for better presentation too. About discussion, I have just little improvement although my group members try to support me for more discussion.

APPENDIX G: CULTURAL ESSAYS

The WPI-Bangkok Project Center provides students with a special opportunity to advance their intercultural awareness and competence. During the preparation period and on-site, students learn about general categories of cultural difference, specific aspects of Thai culture, and how to distinguish cultural stereotypes from appropriate generalizations. The essays in this Appendix use the Describe-Interpret-Evaluate (D-I-E) process for debriefing and analyzing cultural encounters in constructive ways. Recommended by intercultural learning and study abroad experts, this model guides learners to separate observable facts from interpretation, and to delay judgment until multiple perspectives of the same events or behaviors have been identified and considered. By doing so they are more likely to be empathic and less likely to make incorrect interpretations and negative judgments that will limit their effectiveness when working internationally or domestically with people of different origins. Using this process can also help people manage the stress and frustration often felt in cross-cultural situations.

Kevin – "Large and in Charge in Thailand"

At a night market within Chula Soi in Bangkok Thailand, I sit down to dinner with some of my friends. We sat down to eat at a place that has a delicious reputation for their noodles. The seats there small plastic stools that wobbled slightly when I sat down on them. An employee came over to take our order, and then walked away. Moments later the same employee came over with a smile on her face as she glanced at me and pointed down at what I thought was my pants. She immediately proceeded to walk over to a group of Thai customers and spoke to them for a moment. Moments later the entire table looked in my direction as several of them giggled. After about half a minute of talking amongst themselves, one of them walked over who I believed was the best English speaking person at the table. He came over and asked in simple English that I sit in two chairs instead of one because I may break the one I was sitting on.

One perspective to view this situation with would be modeled after North American culture. In this situation, there was a very forward reference to my weight, which is uncommon, particularly coming from a stranger. In the States, it would usually be considered very offensive to point and laugh at someone because of their physical characteristics. This is especially so concerning weight. Obesity is considered a common problem in America, and many people do not like being reminded of this fact.

This same situation could also be interpreted two different ways as I see it from the Thai culture perspective. The first way would be a more utilitarian view. In this situation, the employee was concerned about the safety of her customer (me) as well as the condition of her equipment (the chair). Seeing that the chair was buckling underneath me, she felt that it was necessary to insist that I sit in two chairs instead of one. These people may be using laughter as a social tool to avoid situations of an awkward nature, especially when the need to confront someone arises. These people could have been pointing and laughing to make it seem like a friendly suggestion rather than a strict order.

Another way this could be viewed still looking at it from a Thai point of view would be from an entertainment perspective. In this perspective, the employee and the customers at the other table found my situation humorous and were merely pointing out the situation while being friendly. From my personal experience, Thai people seem to comment on the “socially” negative aspects of their friend in a light yet humorous manner. In one situation where I was taken out to dinner with a group of Thai students from Kasedsart University, an outgoing male Thai seemed to be consistently making fun of his Thai friends by pointing out the negative aspects of their live. He was always commenting on his friend’s dark skin or on their poor English speaking skills. During a trip to Kanchanaburi, I befriended a group of Thais who comfortably nicknamed me phuung yay which means “big belly” in Thai. There is also a Thai girl at the dorms I stay at who commonly approaches me and immediately grabs my arms commenting on the amount of fat I have.

Initially I was taken aback by this blatant exposure of my physical weight. I believe I felt this way initially because I was brought up in an environment that shared the social view that obesity is an unmentionable. After living in Thailand for about two months, I noticed how Thais commonly acted around each other. Thai friends enjoy discovering certain unusual characteristics about each other. This, as I have been told by a Thai person, is considered to be playful and often helps to individualize the person by noting specific characteristics unique to them. From my perspective, Thais believe strongly in embracing individuality. It is because of this that I believe they point out uncommon aspects in people. Obesity is extremely uncommon in Thailand and so I tend to stand out more to them. This is likely the contributing factor to the common comments on my weight. Other physical characteristics such as beauty, height, and nationality are also common topics used to help initiate friendly dialogue.

If I were a member of the Thai culture, I probably would have reacted much differently to this situation. I would not have been stunned by such a comment. These comments would be common to me, and so I may have anticipated this situation. Though, when confronted with the pointing and laughing, as a Thai I believe I may have joined in on the laughter and offered a friendly comment about how skinny they are in jest. If I were a less outgoing Thai, I probably would have just laughed and thought very little of it. It is better to try and fully understand situations before drawing conclusions about them, because they are often based on our own values and beliefs which often differ between cultures.

Joe – "To Sanuk or Not To Sanuk?"

I was receiving a foot and leg massage at a Thai massage parlor that I had been to several times. Entranced, it took me a few seconds to realize that a girl was tapping me. As I jolted up, I recognized the girl as another masseuse who had given me a massage a few weeks earlier. She greeted me very energetically in Thai and I responded "Sawatdii Khrap. Sabay dii mai khrap?" – Hello, Are you doing well?

She responded, "Sabay dii" – I am well, and continued in broken English, "I give you massage before." I smiled and nodded. She asked me if I enjoyed the massage and I told her that I did. She then told me, "You have very beautiful hair." Smiling and blushing, I responded, "Thank you."

At this point, my massage had finished and I was standing at the counter to pay. She then continued to tell me, "Suay… You are very handsome." Bashfully, I continued to smile and thanked her. She then pinched my side and exclaimed, "Fat!" and began giggling as she ran to the back room of the massage parlor. She ran back out as I was about to leave and told me to come back again.

I had several initial ideas of what this could have meant, but consulted one of my Thai project partners, Nan, for her insight. One possible interpretation of this encounter is that the girl was joking with me. In Thai culture, people generally do not criticize one another's personalities; however, it is not uncommon for young Thais to poke fun at physical appearances. The girl may have been playfully teasing me because my build was larger than a typical Thai person. Another possible interpretation is that the girl was playfully flirting. Nan suggested that the girl may have thought that my physical difference was "cute". A third possible interpretation of this scenario is that the language barrier between us may have limited the connotations implied by her words. Much of our communication was conducted in Thai, but when we spoke English to one another, her English was very broken. It is possible that she did not know a more delicate way to communicate my size difference in English and may have been unaware that many Western cultures consider it offensive to call someone "fat".

Although initially offended by the masseuse's abrupt comment, I was able to recognize that it was not meant to be malicious. She invited me back to the massage parlor and complimented me several times, but I felt that the situation required further reflection to fully understand. From the standpoint of a typical Thai person, I would perceive this as *sanuk*, or fun, which is held with high importance in Thai society. Thais are generally very playful and jovial, especially among peers. If I had been raised in a culture where *sanuk* was very important, I would likely not have been offended by the girl's comment. Somewhat contradictory to Western culture, I would have likely perceived this as a friendly gesture. Understanding the differences in fundamental values held by differing cultures is an important part of gaining deeper cultural meaning. Whether vacationing in a foreign country, or residing there for a long period of time, understanding these key differences can help to avoid potential conflict and gain true cultural experiences.

Anne

Now that I have spent two months in Thailand, I have accumulated a number of interesting cultural experiences in my interactions with others. In this essay, I will describe one such occurrence regarding communication difficulties at my dormitory, give possible interpretations of why it took place in light of Thai culture, and explain my personal opinion of the event.

After several weeks of staying at the Suksitnives dormitory, my roommate Stacey and I noticed a large number of red bites on our legs and arms. Several of our other WPI friends mentioned similar symptoms, and some began to research bedbugs, suspecting that they were the cause. Those of us who thought that we might have bedbugs spoke with our WPI project advisers, Aacaans Rick and Chrys. They told us that they would contact our Thai adviser, Dr. Supawan, to ask her to speak with the facilities crew at our dorm.

A few weeks later, I was working downstairs in the courtyard of our dorm one morning with my project group. A woman, who I assume is the facilities director at our dorm, asked if she could speak with me about the bedbugs. She had spoken with Stacey and me a few days prior and had told us that the mattresses in our rooms were only six years old but had asked us if she and several other maids could search our room for bedbugs or anything else that could be the cause of the bites on our skin. We agreed, and they immediately after all came into our room and asked us to leave. Later that week, I explained to her that I was working with my friends and asked her if I could meet with her later. With an impassive look on her face, she slowly asked where were the other WPI students who suspected that they had bedbugs. I told her that they were all away from the dorm doing group work as well, and when she suggested that we all meet at 2:00 pm or 4:00 pm, I told her that we would still be working. I suggested that we all meet after dinner, and we agreed on 8:00 pm.

We did not actually get back to the dorm after dinner until about 8:30, and sometime around 9:00, the facilities director came up to Stacey and me when we were on our computers in the courtyard and we had a conversation. With the same look on her face as earlier that day, she explained that the maids had found bug eggs in our room and that they would spray our room and luggage with insecticide. She told us that we would need to move into another room for at least a few days, as the smell of the insecticide was strong. She did not offer any additional information about the procedure, so we asked her several questions about it, including when this spraying would take place, and she replied that it would be by the end of the week. Stacey asked her to give us a warning about the spraying so that we could prepare and move into another room, and she agreed. It is almost the end of the week, and we did not hear about the room spraying for three more weeks.

There are several ways that one can interpret the director's facial expressions and communication. I have learned a great deal about Thai culture through speaking with my Chula teammates, Nan and Gift, and through reading a collection of essays entitled *Reflections on Thai Culture* by William J. Klausner, who lived in Thailand for thirty years and is an expert on its culture. I employed use of this Thai cultural knowledge in explaining these interpretations:

- The facilities manager may have been hesitant to speak with us because she feels uncomfortable speaking with foreigners or because she is not confident in her ability to speak English. Gift has told me that she sometimes hesitates to speak at group meetings because she is concerned about her English speaking aptitude.
- The facilities manager may have been embarrassed that there were bugs in several rooms. Thais usually do not want to be told directly if someone is upset by their behavior, as they typically prefer a more indirect style of communication (Klausner, 254), and my straightforward discontent with the bedbug situation may have embarrassed her.
- Maybe she did not want to deal with or was frustrated by the situation or me but did not show her feelings through her facial expression. Klausner considers the influence of Buddhist teaching, which puts a positive religious emphasis on avoiding emotional extremes and confrontation, to be one reason for the typical Thai way of communication. Thais are usually expected to hide their emotions, especially negative emotions, in order to preserve harmony in the community (253-254).
- Maybe she was upset that Stacey and I were late in meeting with her that evening. However, Klausner explains that Thais do not generally adhere strictly to exact times and deadlines (334).

My opinion about this scenario is that the facilities director and I were both uncomfortable around one another. She spoke slowly and seriously, with an expression on her face that seemed void to me, and this led me to feel that she did not believe our room had bedbugs at all. Even after the dorm staff found the bug eggs, I did not feel that she considered the bedbugs in our room to be an urgent issue. It is likely that she noticed my subsequent frustration, although I tried to maintain my composure and politeness, and this led us to feel even more awkward around each other. This is probably the reason that she did not offer much information about the spraying procedure to Stacey and me. If I were a Thai person, I likely would have remained calmer in the situation by better avoiding letting frustration show on my face and in my tone of voice.

Despite my discomfort during my communication with the facilities manager, I learned about the importance of examining the facts of a situation and thinking about a variety of possible interpretations. This tool is a valuable way of approaching cultural experiences, and I will continue to use it in Thailand and in other areas of the world that I visit in the future.