AN APPROACH TO MARKET BIOFUEL FROM WASTE CASTOR BEAN SHELL

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Thesis submitted in partial fulfillment of the requirements for the award of the degree of Master of Chemical Engineering with Entrepreneurship

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ABSTRACT

The objectives of this study are to utilize the waste of castor bean shell as biofuel source, to investigate market demand of biofuel, and to perform economic analysis on production of biofuel. The main concerns in this study are to reduce the carbon emission which contributes to the Green House Effect, to solve the problems of depletion of fossil fuel because biofuel can be used as gasoline additive and as replacement for gasoline itself. Besides, this study can solve the waste shell problem and prevent the environmental pollution. This approach is an alternative way to avoid from using food crops as feedstock such as corn, sugar baggasse because we want to control the food price in the future. Thus, producing bioethanol using non edible source is seen as a good fuel alternative because the source crops can be grown renewably and in most climates around the world especially in Malaysia. Economic analysis has been performed in this study where the projected bioethanol price has been calculated and the result shows that by using waste castor been shell as raw material, the estimated price of bioethanol is RM 2.04/liter. In order to lowering the selling price of bioethanol, blending with gasoline is preferred. Overall, this feasibility study shows that the plant will be a profitable plant and it is considered to be a very promising industrial opportunity. Thus, biofuel is highly renewable resources and has highly potential to be penetrated in the market area.

ABSTRAK

Objektif kajian ini adalah untuk menggunakan sisa kulit kacang kastor sebagai sumber untuk menghasilkan bahan bakar, untuk menyiasat permintaan pasaran bahan bakar, dan untuk melaksanakan analisis ekonomi terhadap pengeluaran bahan bakar. Kajian ini memberi sumbangan yang sangat bernilai terhadap alam iaitu mengurangkan pelepasan karbon yang menyumbang kepada Kesan Rumah Hijau, menyelesaikan masalah kekurangan bahan api fosil kerana bahan bakar ini boleh digunakan sebagai bahan tambah petrol dan sebagai gantian untuk petrol itu sendiri. Selain itu, kajian ini dapat menyelesaikan masalah pembuangan sisa kulit kacang kastor kerana ia dapat digunakan semula dan dapat mencegah pencemaran alam sekitar. Pendekatan ini adalah satu cara alternatif untuk mengelakkan daripada menggunakan tanaman makanan sebagai bahan mentah bahan bakar seperti jagung, dan gula tebu untuk pengawalan harga makanan di masa hadapan. Oleh itu, menghasilkan bahan bakar dari tumbuhan yang tidak boleh dimakan sebagai bahan api alternatif adalah jalan terbaik kerana tanaman sumber boleh dihasilkan dengan mudah dan sesuai ditanam di kebanyakan iklim di seluruh dunia terutamanya di Malaysia. Analisis ekonomi telah dilakukan dalam kajian ini di mana harga bahan bakar semulajadi ini telah dikira dan hasilnya menunjukkan bahawa dengan menggunakan harga anggaran bahan api alternatif adalah RM 2.04/liter. Dalam usaha untuk mengurangkan harga jualan bahan api alternatif, mengadun dengan petrol adalah pilihan yang baik. Secara keseluruhan, kajian ini berkemungkinan dapat menunjukkan bahawa dengan menggunakan sisa tumbuhan untuk menghasilkan bahan bakar juga boleh menghasilkan keuntungan. Oleh itu, bahan bakar alternatif dengan menggunakan sumber-sumber yang boleh diperbaharui mempunyai potensi untuk menembusi pasaran dunia.

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW OF BIOFUEL

In recent years, largely in response to uncertain fuel supply and efforts to reduce carbon dioxide emissions, bioethanol (along with biodiesel) has become one of the most promising biofuels today and is considered as the only feasible short to medium alternative to fossil transport fuels in Europe and in the wider world. Biofuels refers to renewable fuels such as ethanol (an alcohol fermented from plant materials) and biodiesel (fuels made from vegetable oils and animal fats) that can substitute for petroleum-based fuels. Although specially modified vehicles can operate on pure versions of these fuels, most biofuels are sold mixed with conventional gasoline or diesel for use in standard production vehicles. Mixes are usually indicated by the percent biofuel, such as B5 (5 percent biodiesel) and E85 (85 percent ethanol) blends (Kutas et al., 2007).

Bioethanol is seen as a good fuel alternative because the source crops can be grown renewably and in most climates around the world. In addition the use of bioethanol is generally carbon dioxide (CO_2) neutral. This is achieved because in the growing phase of the source crop, CO_2 is absorbed by the plant and oxygen is released in the same volume that CO_2 is produced in the combustion of the fuel. This creates an obvious advantage over fossil fuels which only emit CO_2 as well as other poisonous emissions. In the 1970s, Brazil and the USA started mass production of bioethanol grown from sugarcane and corn respectively. Smaller scale production started more recently in Spain, France and Sweden mostly from wheat and sugar beet (RESTMAC, European Renewable Energy Council, 2006).

Product proposed in this thesis is producing biofuel using waste castor bean shell as raw material. Castor shell is a source of lignocellulosic biomass which can be converted to biofuel via several process steps. It is an innovative line of producing biofuel from waste castor bean shell because of confronted with rocketing oil prices, and in the name of environmental protection, it is necessary implementing policies encouraging biofuel production for developed and emerging countries. At this time, the majority of production is based on technologies that using agricultural food to produce green fuel. By contrast, this production of biofuel is using non-edible food which castor is non-edible that is not disturbing the food circle.

1.2 PROBLEM STATEMENT

Bioethanol has taken precedence as Prime Biofuel after lot of controversy erupted on international food shortages and spiralling food prices. In spite of all the controversy shrouding biofuels, there has been understanding that it is important to continually look at alternate sources of fuels and feedstock's which are non-food and this has seen visible interest for sugarcane based bioethanol to wheat, maize and other food crops. Producing biofuel using waste castor shell will be an alternative way to overcome this problem. In addition, the problem arise from waste castor shell are it is also labelled as agriculture waste which is 30-35% by weight become a burden to farmers as it would cause an environmental pollution due to their fast growth. So, it is clearly show that castor is a non-edible source which is not disturbing food circle and can solve the problem arise nowadays which is depleting on source of energy. Thus, producing biofuel by using non edible waste source is an alternative way to replace the fossil fuel in the future.

1.3 OBJECTIVES

- To utilize the waste of castor shell as biofuel source.
- To investigate market demand of biofuel.
- To perform economic analysis on production of biofuel.

1.4 SCOPE OF RESEARCH

In order to achieve objectives in this study, some investigations and understanding regarding biofuel production process using lignocellulosic biomass must be studied. The process starts with biomass handling where castor shell goes through a grinding process, biomass preparation, cellulose hydrolysis, glucose fermentation and ethanol recovery. Besides, we also have to concentrate about biofuel applications especially on transportation fuel which applied to vehicles. Some reviews about biofuel market demand are studied, determine target customers, create marketing strategy, and perform economic analysis on estimation cost for production of biofuel.

1.5 SIGNIFICANT OF RESEARCH

- Solving the problems in fuel industry because biofuel is highly renewable resources and has highly potential to be penetrated in the market area.
- Solve the waste shell problem.
- Prevent the environmental pollution.

CHAPTER 2

LITERATURE REVIEW

2.1 HISTORY OF BIOFUEL PRODUCTION

Biofuel production was researched and developed after 1970 oil crisis to decrease the dependence on fossil fuels as a source for energy. Current trends indicate that a number of countries are committing to reduce dependence on fossil fuels and increase alternate supplies of energy as a result of the impending shortage of oil and increasing oil prices, as well as the damaging effect fossil fuels have on the environment. Conn, 2006, Executive Director of British Petroleum, in an address to the Harvard University Centre for the Environment, stated that the feasibility of biofuels as a sustainable alternate source of energy could meet four needs which it can meet demand, offer security of supply, address climate change and support agricultural activity (Conn, 2006).

Many environmental problems such as greenhouse gases and pollution of air, water, and soil were originated from fossil fuels. Fossil fuels release greenhouse gases like carbon dioxide that contribute to global warming. Carbon dioxide from fossil fuel combustion accounted for nearly 80% of global warming in the 1990s (Hileman, 1999). However, renewable energy sources such as lingo-cellulosic biomass are environmentally friendly because they emit less pollution without contributing net carbon dioxide to the atmosphere.

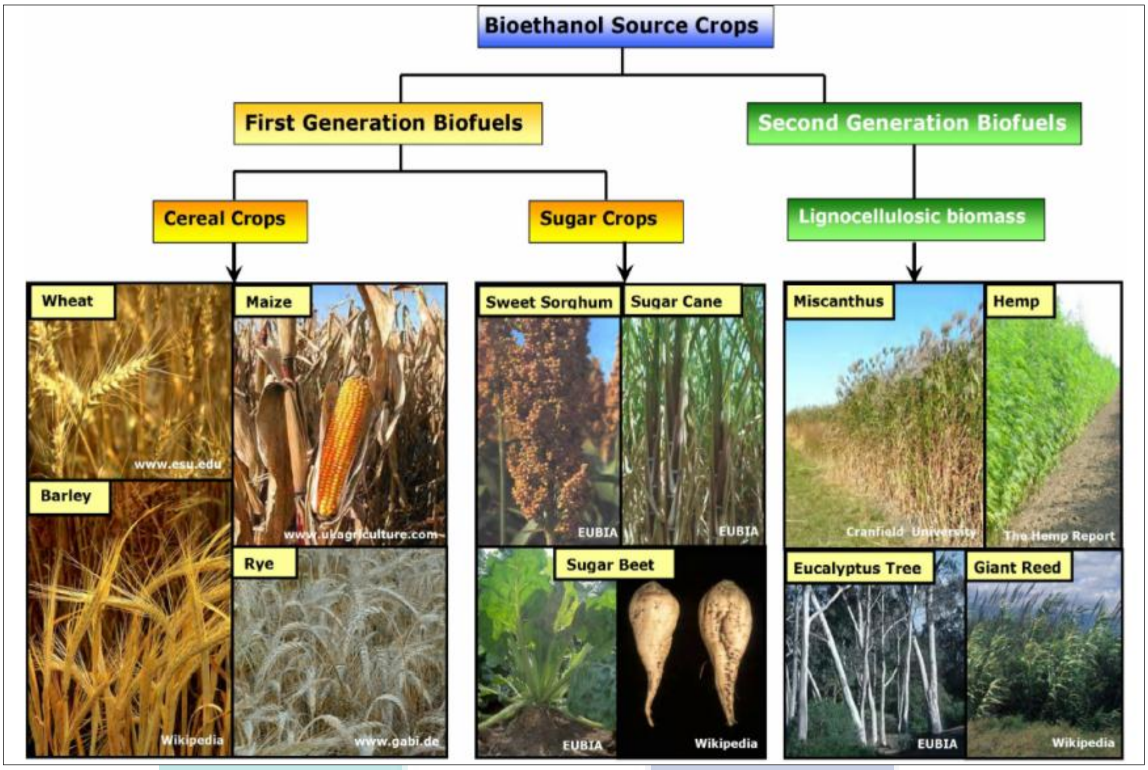

Figure 2.1: Bioethanol Source Crops (Source: European Renewable Energy Council)

From Figure 2.1, bioethanol source crops is divided into two generations which first and second generation biofuels. The production of bioethanol from traditional means, or First Generation Biofuels is based upon starch crops like corn and wheat and from sugar crops like sugar cane and sugar beet. In addition to this, the development of lignocellulosic technology has meant that not only high energy content starch and sugar crops can be used but also woody biomass or waste residues from forestry. This development is seen as the Second Generation of Biofuels. This process is still expensive by comparison to traditional bioethanol production. Bioethanol, or rather ethanol, itself belongs to the chemical family of alcohols and has a structure of C_2H_5OH. It is a colourless liquid and has a strong odour.

2.2 DESCRIPTION OF BIOFUEL PRODUCT

2.2.1 General Description of Biofuel Product

Castor is a species of flowering plant which can live in tropical area. Castor bean is a source of castor oil which each capsule or shell contains 3 seeds. The seed can produce biofuel as well as its waste shell. In this project, the waste shells which comprise 20% to 30% from the product are used which contains cellulose that can be converted to produce biofuel via several process steps. This plant is non-edible and the oil produce from this plant is renewable oil. It is widely used for aerospace, electronics, medicine, agriculture and many more.

There are many source of cellulosic biomass that can be converted to bioethanol such as rice husk (Simone et al., 2011), apple pomace (Alexander et al., 2009), rice straw (Roslan et al., 2011), wood chip (Xuejingwang et al., 2011), sugarcane bagasse (Teixeira et al., 2011), wheat straw (Zabihi et al., 2010), and corn straw (Kim, 2004). Recent researcher found that waste castor shell can be a source of cellulosic biomass and the main value of the waste castor shell is this plant is non-edible and will not disturb the food circle.

(Shih and Smith, 2009) used basic steps to convert cellulosic biomass to ethanol. Firstly, cellulosic biomass will undergo pre-treatment. After pre-treatment, the cellulose is enzymatically hydrolysed to glucose using commercial enzyme mixture and then fermented to ethanol. The fermentation of simple sugars, a multi-step reaction is employed to hydrolyse cellulose to glucose, and then ferment this to ethanol. The same steps will be used in the production of bioethanol using waste castor shell and the steps are shown in the figure as follow:

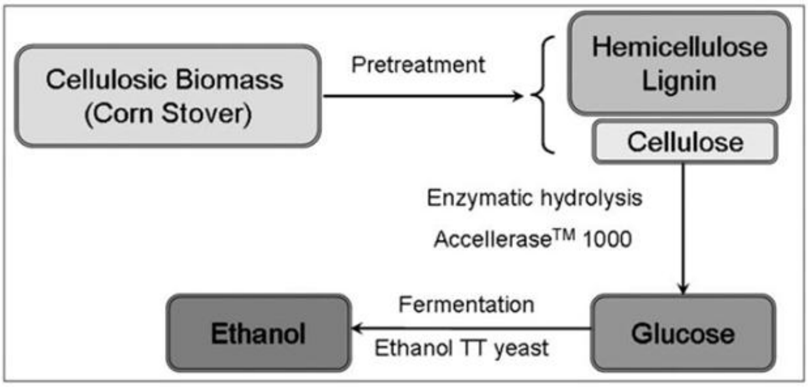

Figure 2.2: Steps to convert cellulosic biomass to ethanol (Shih and Smith, 2009)

2.2.2 Value of the Product

Fossil fuel is depreciating nowadays. Thus, it is a good opportunity for trying to find solution of replacing the conventional oil with the new, green energy and sustainable energy for future. People now are using palm oil, corn oil to produce biofuel. This edible oil will disturb the food cycle. Decreasing production of food will increase its price in the market place. Recently, people find non-edible resources to produce biofuel such as soya bean and jatropha and now, it is found that by using waste shell of castor bean also can produce biofuel as well. Some advantages of castor plant are it has high economic potential, alternative to petroleum based derivative, environmental friendly, high oil concentration, low cultivation cost, and also fast return.

Biofuel is widely used in the transportation, pharmaceutical and solvent in the industry. Not only that, biofuel is used as an intermediate chemical and also used as a fuel and more. There are many advantages of biofuel which are reducing the amount of greenhouse gases emitted, much cleaner source of energy than conventional sources, increased energy security for the country producing it, as they will not have to rely on imports or foreign volatile markets, creating a brand new job infrastructure and will help support local economies, reduction in fossil fuel use, used in vehicle which it reduces the number of vibrations, smoke and noise produced. In addition, biofuel is a biodegradable, non-toxic, renewable source and has a high flash point which is making it safer and less likely to burn after an accident.

2.3 THE IMPORTANCE OF USING BIOFUEL AS GREEN FUEL

Biofuel is also known as agro fuel where these fuels are mainly derived from biomass or bio waste. These fuels can be used for any purposes, but the main use for which they have to be brought is in the transportation sector. Most of the vehicles require fuels which provide high power and are dense so that storage is easier. These engines require fuels that are clean and are in the liquid form. The most important advantage of using liquid as fuel is that they can be easily pumped and can also be handled easily. This is the main reason why almost all the vehicles use liquid form of fuels for combustion purpose. For other forms of non-transportation applications there are other alternative solid biomass fuel like wood. These non-transportation applications can bring into use these solid biomass fuels as they can easily bear the low power density of external combustion. Wood has been brought into use since a very long period and is one of the major contributors of global warming.

Biofuels are the best way of reducing the emission of the greenhouse gases. They can also be looked upon as a way of energy security which stands as an alternative of fossil fuels that are limited in availability. Today, the use of biofuels has expanded throughout the globe. Some of the major producers and users of biogases are Asia, Europe and America. Theoretically, biofuel can be easily produced through any carbon source such as making the photosynthetic plants the most commonly used material for production. Almost all types of materials derived from the plants are used for manufacturing biogas. One of the greatest problems that is being faced by the researchers in the field is how to covert the biomass energy into the liquid fuel.

There are two methods currently brought into use to solve the above problem. In the first one, sugar crops or starch are grown and through the process of fermentation, ethanol is produced. In the second method, plants are grown that naturally produce oil like jatropha, algae and castor plant. These oils are heated to reduce their viscosity after which they are directly used as fuel. This oil can be further treated to produce biofuel which can be used for various purposes. Most of the biofuels are derived from biomass or bio waste. Biomass can be termed as material which is derived from recently living organism. Most of the biomass is obtained from plants and animals and also include their by-products.

The most important feature of biomass is that they are renewable sources of energy unlike other natural resources like coal, petroleum and even nuclear fuel. Some of the agricultural products that are specially grown for the production of biofuels are switch grass, soybeans and corn in United States. Brazil produces sugar cane, Europe produces sugar beet and wheat while, China produces cassava and sorghum, south-east Asia produces miscanthus and palm oil while India produces jatropha.

The main problem we are facing today is the disappearance of the fossil fuel as our energy source. Thus, we must find an alternative solution to replace the conventional oil with the new, green energy and sustainable energy for future. People now are using palm oil, corn oil to produce biofuel. This edible oil will disturb the food circle. Decreasing production of food will increase its price in the market place. Recently, it is found that by using waste shell of castor bean also can produce biofuel as well. Some advantages of castor plant are it is non-edible plant, has high economic potential, alternative to petroleum based derivative, environmental friendly, high oil concentration, low cultivation cost, and also fast return.

2.3.1 Advantages of Biofuel

There are many advantages of biofuel. Using biofuels can reduce the amount of greenhouse gases emitted. They are a much cleaner source of energy than conventional sources. As more and more biofuel is created there will be increased energy security for the country producing it, as they will not have to rely on imports or foreign volatile markets. Besides, first generation biofuels can save up to 60% carbon emissions and second-generation biofuels can save up to 80%. Biofuels will create a brand new job infrastructure and will help support local economies. This is especially true in third world countries. In addition, there can be a reduction in fossil fuel use and biofuel operations will help rural development. Biofuel can be used in vehicle which it reduces the number of vibrations, smoke and noise produced. Biofuel is a biodegradable, non-toxic, renewable source and has a high flash point which is making it safer and less likely to burn after an accident.

2.4 BIOFUEL APPLICATIONS

2.4.1 Chemical

A number of chemicals are produced in the ethanol industry and potentially even more in the 2nd generation bioethanol industry, serving a wide range of uses in the pharmaceuticals, cosmetics, beverages and medical sectors as well as for industrial uses. The market potential for bioethanol is therefore not just limited to transport fuel or energy production but has potential to supply the existing chemicals industry.

2.4.2 Transport Fuel

Bioethanol has mostly been used as a biofuel for transport, especially in Brazil. Indeed it was in Brazil where the first bioethanol fuelled cars emerged on a large-scale. Although generally unknown to the average consumer, a large volume of bioethanol is already used in Europe as it is blended with petrol at 5%. It is used as a substitute for lead as an oxygenating additive and has a high octane rating, which improves performance. Although the eventual target is the private consumer, few are aware of bioethanol's potential to, at least, partly replace petrol as a transport fuel in Europe. Stakeholders in the Bioethanol Fuel Market:

- bioethanol producers
- fuel suppliers
- car manufacturers
- the government - support is also extremely important as was the case in Brazil in the late 1970s and in the USA today bioethanol has been endorsed by the President and helped by subsidies and tax breaks
- transport users

In addition supermarkets who provide petrol stations to customers are seeing the opportunity to provide petrol/ethanol blends from 5-85% (E5 –E85). Even though most experts agree that up to a 10% mix will not damage modern car engines, the manufacturer warranty for standard cars is set at 5%. Above this level to maintain the warranty, the car engines need to be modified or one has to buy a fuel flexible vehicle (FFV).

2.5 MARKET SURVEY OF BIOFUEL

In developed countries, they are using bioethanol as renewable energy to be their source of fuel as demand is increasing day by day.

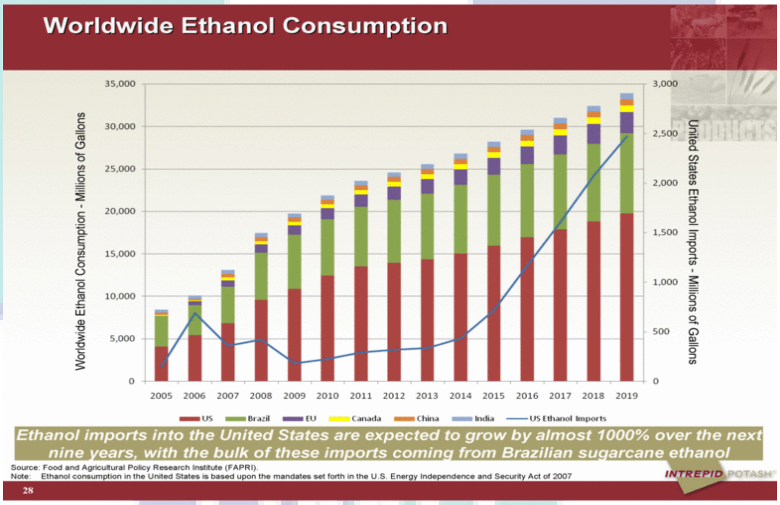

Figure 2.3: Worldwide fuel ethanol consumption (Intrepid Potash, 2010)

Figure 3 shows worldwide ethanol consumption up to 2012 are gradually increasing and it is estimated that the use of ethanol through the year will exceed the volume. In 2019, fuel ethanol consumption is estimated to be 28 billion of gallons. From the graph, United State is the largest country which import the fuel ethanol because they are widely use ethanol as transportation fuel source as their fossil fuel is decreasing nowadays.

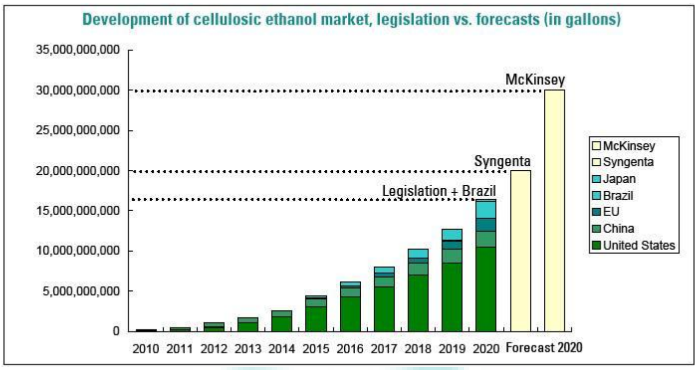

Figure 2.4: Worldwide cellulosic ethanol production (Energy and Environment, 2008)

Based on the worldwide cellulosic ethanol production forecast in year 2020, the production of ethanol will be at least 16.5 billion of gallons. Thus, we need to meet the demand of 28 billion of gallon where the required amount of bioethanol that must be produced is estimated 11.5 billion of gallons. From the model of cellulosic ethanol production proposed in this research, it is estimated to produce 0.02 billion of gallon per year. Thus, we are contributing 0.17% of the production of bioethanol worldwide.

From figures below, the price for ethanol in April 2012 is USD 2.225/ gallon and tend to increase up to USD 2.37 / gallon or much more higher than that. The trend of the price of ethanol is increasing starting from 2010 until 2012. The projected bioethanol production cost calculated in this research is estimated to be USD 2.27/gallon.

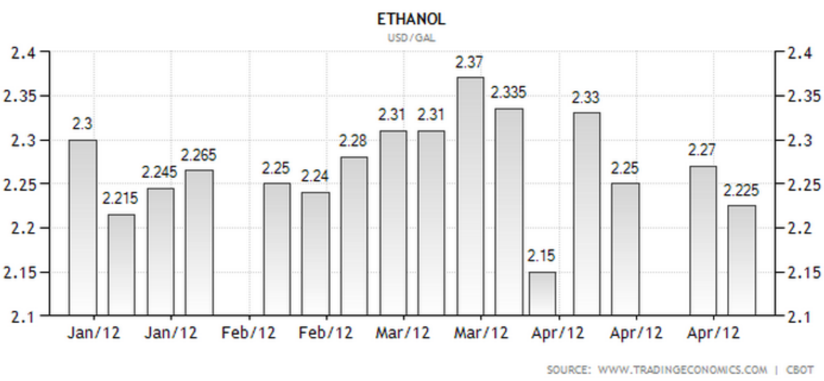

Figure 2.5: Ethanol price in 2012

2.5.1 Biofuel Production and Its Demand

2.5.1.1 Thailand

Ethanol production in Thailand was 192.8 million litres in 2007. There are nine operating plants with a total capacity of 435 million litres per year, and nine plants are under construction (440 ML per year). Almost 90% of ethanol produced in Thailand is from cane molasses. The remaining 10% is from cassava. The proportion is expected to shift over time in favour of cassava. Molasses supplies are expected to increase to 3 million tonnes, half of which will be used in food industries (mostly for liquor production), and the balance will be for exports and fuel ethanol production (USDA 2007). Cassava production was 22.5 million tonnes in 2006, and it is expected to grow as the planned cassava-based ethanol production plants start operating.

Thailand currently sells gasohol (E10), which accounts for about 20% of total petroleum sales, through its service stations. The state-owned companies PTT and Bangchak started supplying E20 in January 2008. Bangchak plans to introduce E85 at its stations in the near future. B2 is available nationwide; PTT and Bangchak started selling B5 in 2007. There were 3,822 gasohol service stations in Thailand as of December 2007. Currently, 40 stations in Greater Bangkok sell E20 (February 2008). B2 is available at all stations throughout Thailand; 976 stations offer B5 in Greater Bangkok. E20 compatible vehicles are available in Thailand from Ford, Toyota, Honda, and Nissan. Most ethanol producers plan to supply ethanol domestically (particularly those who do not have sugar mill businesses), due to concerns regarding sourcing of raw materials (USDA 2007). However, fuel ethanol export is expected to grow as the production increases in Thailand. About 14.4 million liters of fuel ethanol was exported in 2007 to Singapore, the Philippines, Chinese Taipei, Australia, and Europe (DEDE, 2008).

2.5.1.2 Philippines

In the Philippines, sugarcane is considered a primary source for ethanol production. The government sees it as the most reliable feedstock due to its well-established farming technologies and the highest yield per hectare compared to other feedstock (corn, cassava, and sweet sorghum). Sugarcane production in the Philippines is expected to increase to meet the requirements of the Biofuels Act. At present, the sugar industry can only supply 79% of the needs of the 5% ethanol blend, which is between 200 and 400 million litres per year. The Philippines, therefore, needs to expand its current 167,300 sugarcane farms covering a total area of 344,700 hectares to meet the ethanol demand. The Sugar Regulatory Administration (SRA) already identified 237,748 hectares of new sugar fields, mostly in Mindanao, that can be tapped to produce fuel ethanol (Bulatlat 2007). Additional ethanol feedstock considered by the government are sweet sorghum and cassava (Oroullo and Salle, 2007). E10 (10% ethanol and 90% gasoline) are available nationwide. E10 is currently offered by all Sea oil stations nationwide. It is expected that in 2008 more gas stations will be offering E10 (Biofuels Philippines 2007).

2.5.1.3 Malaysia

In Malaysia, an opportunity for cellulosic ethanol production exists from the oil palm biomass (part of it left unutilized), but this technology is yet to be commercialized. Meanwhile, the economy is focused on creating a successful industry with what exists, which is palm biodiesel. The main concern for expanding biodiesel production in Malaysia is land availability and associated sustainability and biodiversity issues (Koizumi and Ohga, 2007). Ethanol production is commercially insignificant in Malaysia. There is an opportunity for ethanol production from oil palm biomass but the technology is yet to be commercialized. Ethanol consumption is unlikely as retail gasoline prices are subsidized. Therefore, the ethanol production will be a starting point for Malaysia to be one of the producers of bioethanol as we can produce by using waste castor bean shell as raw material. The castor plant will be planted in Malaysia and the seeds will be used to produce biodiesel while the waste shell will be used to produce bioethanol. The usage of blended bioethanol with gasoline in Malaysia is not commercialized yet but we can still export the bioethanol to the other country.

2.5.1.4 Japan

Japanese fuel ethanol production is in an experimental stage, and the current production level is 30,000 litres in April 2006. Sugarcane molasses in Okinawa, wheat and corn unsuitable for food in Hokkaido, sorghum in Yamagata, and wood residues in Okayama and Osaka are the raw materials used for ethanol production. To further promote domestic ethanol production, the government hopes to use abandoned arable land (Koizumi and Ohga 2007). It also will rely on technological breakthroughs in lignocellulosic ethanol in the near future, which would allow the use of waste material such as crop and wood residues.

Japan began testing E3 (3% ethanol and 97% gasoline) and ETBE (ethyl tertiary butyl ether) in 2007. Japan started to offer E3 at two gasoline stations, one in Sakai City and the other in Daito City, in October 2007. E3 is also offered in Osaka but is limited to about 100 cars registered in advance with the local government. Japan is gradually increasing the number of E3-supplying gas stations to sell the product to the general public in 2008. There are about 50 stations in the Tokyo metropolitan area offering ETBE blended gasoline. Their number is expected to reach 100 during 2008, increasing to 1,000 nationwide in 2009 (Asia Times 2007). Japan imports ethanol mostly from Brazil and China to supply its beverage, chemical, and pharmaceutical industries.

2.5.1.5 China

China is the world's third-largest producer of ethanol, but most of it is consumed by the pharmaceutical and beverage industries. In 2006, there were four operating ethanol bio refinery running at maximum capacity, about 1.02 million tonnes. Though Beijing has stopped approving new fuel ethanol projects since December 2006, four more plants in the provinces of Guangxi (110,000 tonnes), Hebei (300,000 tonnes), Liaoning (300,000 tonnes), and Hubei (200,000 tonnes) were scheduled to be completed in 2007. Nearly 80% of the fuel ethanol in China is made from corn. Three of the existing facilities (Heilongjiang, Jilin, and Anhui) use the grain as feedstock. The bio refinery in Henan uses wheat. Concerns about food supply and high prices led the industry to look at other, non-grain feedstock, such as cassava, sweet sorghum, and sweet potato, viewed as transitional feedstock in the long term.

The crops could be grown on China's 116 million hectares of marginal land unsuitable for producing grains. Ultimately, China plans to transition to ethanol production from cellulosic biomass, particularly crop residue, which is of sufficient supply. Estimates show that the member economy generates approximately 1,500 million tonnes/year of agricultural and forest residues, which is sufficient to produce 370 million tons of ethanol. Currently, there are several pilot plants producing ethanol from lignocellulosic biomass via biochemical conversion process.

2.6 COMMON ETHANOL FUEL MIXTURES

There are several common ethanol fuel mixtures in use around the world. The use of pure hydrous or anhydrous ethanol in internal combustion engines (ICE) is only possible if the engine is designed or modified for that purpose. Anhydrous ethanol can be blended with gasoline (petrol) in various ratios for use in unmodified gasoline engines, and with minor modifications can also be used with a higher content of ethanol. Low ethanol blends, from E5 to E25, are also known as gasohol, though internationally the most common use of the term gasohol refers to the E10 blend. Blends of E10 or less are used in more than twenty countries around the world, led by the United States, where ethanol represented 10% of the U.S. gasoline fuel supply in 2011 (Renewable Fuel Association, 2012). Blends from E20 to E25 have been used in Brazil since the late 1970s. E85 is commonly used in the U.S. and Europe for flexible-fuel vehicles. Hydrous ethanol or E100 is used in Brazilian neat ethanol vehicles and flex-fuel light vehicles and in hydrous E15 called hE15 for modern petrol cars in Netherlands (BEST, 2009).

2.6.1 E10 or Less

E10, sometimes called gasohol, is a fuel mixture of 10% anhydrous ethanol and 90% gasoline that can be used in the internal combustion engines of most modern automobiles and light without need for any modification on the engine or fuel system. E10 blends are typically rated as 2 to 3 octane higher than regular gasoline and are approved for use in all new US automobiles, and are mandated in some areas for emissions and other reasons. The E10 blend and lower ethanol content mixtures have been used in several countries, and its use has been primarily driven by the several world energy crises that have taken place since the 1973 oil crisis.

2.6.2 E15

E15 contains 15% ethanol and 85% gasoline. This is generally the highest ratio of ethanol to gasoline that is possible to use in vehicles recommended by auto manufacturers to run on E10 in the U.S. As a result of the Energy Independence and Security Act of 2007, which mandates an increase in renewable fuels for the transport sector, the U.S. Department of Energy began assessments for the feasibility of using intermediate ethanol blends in the existing vehicle fleet as a way to allow higher consumption of ethanol fuel (West et al., 2008).

2.6.3 E20 and E25

E20 contains 20% ethanol and 80% gasoline, while E25 contains 25% ethanol. These blends have been widely used in Brazil since the late seventies. As a response to the 1973 oil crisis, the Brazilian government made mandatory the blend of ethanol fuel with gasoline, fluctuating between 10% to 22% from 1976 until 1992 (Rico, 2008).

2.6.4 E70 and E75

E70 contains 70% ethanol and 30% gasoline, while E75 contains 75% ethanol. These are the winter blends used in the United States and Sweden for E85 flexible-fuel vehicles during the cold weather, but still sold at the pump labelled as E85. The seasonal reduction of the ethanol content to an E85 winter blend is mandated to avoid cold starting problems at low temperatures (EPIC, 2007).

2.6.5 E85

E85 is a mixture of 85% ethanol and 15% gasoline, and is generally the highest ethanol fuel mixture found in the United States and several European countries, particularly in Sweden, as this blend is the standard fuel for flexible-fuel vehicles. This mixture has an octane rating of about 105, which is significantly lower than pure ethanol but still higher than normal gasoline (87-95 octanes, depending on country). The 85% limit in the ethanol content was set to reduce ethanol emissions at low temperatures and to avoid cold starting problems during cold weather, at temperatures lower than 11 °C(52 °F) (Davis et al., 2002).

2.6.6 E100

E100 is pure ethanol fuel. Straight hydrous ethanol as an automotive fuel has been widely used in Brazil since the late seventies for neat ethanol vehicles and more recently for flexible-fuel vehicles (Lashinsky and Schwartz, 2006). E100 imposes a limitation on normal vehicle operation as ethanol's lower evaporative pressure (as compared to gasoline) causes problems when cold starting the engine at temperatures below 15 °C (59 °F). For this reason both pure ethanol and E100 fuel vehicles are built with an additional small gasoline reservoir inside the engine compartment to help in starting the engine when cold by initially injecting gasoline. Once started, the engine is then switched back to ethanol (Kotrba, 2008).

2.6.7 Ethanol Blend Mandate in Asia Pacific

Table 2.1 below shows the bioethanol blending mandate in Asia Pacific. Different countries have their own mandates which are due to the vehicle's specification/modification. In Asia, only Malaysia, New Zealand, South Korea, Taiwan, and Thailand are still not using bioethanol as their vehicle fuel source because of low market demand and vehicles in these country does not suitable with the blending fuel.

Table 2.1: Bioethanol Blending Mandate in Asia (Source: www.biofueldigest.com)

Country	Bioethanol Blending Mandate
Australia	E5
China	E10
Fiji	E10
India	E5
Indonesia	E3
Malaysia	-
New Zealand	-
The Philippines	E5
South Korea	-
Taiwan	-
Thailand	-
Vietnam	E5

2.6.8 Bioethanol Use Limitation

The use of ethanol blends in conventional gasoline vehicles is restricted to low mixtures, as ethanol is corrosive and can degrade some of the materials in the engine and fuel system. Also, the engine has to be adjusted for a higher compression ratio as compared to a pure gasoline engine in order to take advantage of ethanol's higher oxygen content, thus allowing an improvement in fuel efficiency and a reduction of tailpipe emissions (The Royal Society, 2008). The following table shows the required modifications to gasoline engines to run smoothly and without degrading any materials.

Table 2.2: Required adjustment to gasoline engines to cope with different blends of ethanol fuel (The Royal Society, 2008)

<table>
<tr><th colspan="15">Required adjustment to gasoline engines to cope with different blends of ethanol fuel</th></tr>
<tr><th>Ethanol blend</th><th>Carburettor</th><th>Fuel Injection</th><th>Fuel Pump</th><th>Fuel Pressure Device</th><th>Fuel Filter</th><th>Ignition System</th><th>Evaporative System</th><th>Fuel Tank</th><th>Catalytic Converter</th><th>Basic Engine</th><th>Motor Oil</th><th>Intake Manifold</th><th>Exhaust System</th><th>Cold Start System</th></tr>
<tr><td>≤ 5%</td><td colspan="14">Any Vehicle</td></tr>
<tr><td>E5-E10</td><td></td><td colspan="13">Vehicles up to 15-20 years old</td></tr>
<tr><td>E10-E25</td><td colspan="9">Specially designed vehicles</td><td colspan="5">Vehicles up to 15-20 years old</td></tr>
<tr><td>E25-E85</td><td colspan="13">Specially designed vehicles</td><td></td></tr>
<tr><td>E85-E100</td><td colspan="14">Specially designed vehicles</td></tr>
<tr><td colspan="2"></td><td colspan="5">Modification not necessary</td><td></td><td colspan="5">Modification probably necessary</td><td colspan="2"></td></tr>
</table>

2.7 MAIN TARGET MARKET

Our main competitor is bioethanol producer. Up to date, there is still no bioethanol producer in Malaysia but there will be some future competitors which are expecting to build bio-refinery plant in Malaysia to produce biofuel from second generation bioethanol. Table below shows list of future competitors of bioethanol producer and expected year of operation.

Table 2.3: List of potential competitors

Name of Competitor	Future Plant Location	Production Capacity	Expected operation
Lestari Pasifik Bhd joint venture with Russian Arter Group (received project financing from Chinese government)	3 plants: Johor, Sabah and Sarawak	Not stated	2016
Sime Darby Plantation collaborate with Mitsui Engineering and Shipbuilding of Japan	Next to Sime Darby's Tennamaram palm oil mill, Selangor	1.25 metric ton EFB per day	2015
Toyo Engineering & Construction Sdn Bhd has awarded contract by joint venture between GlycosBio Asia Sdn Bhd and Malaysian Bio-Xchell Sdn Bhd	Johor Bharu	10,000 ton per year	2013

Focus groups of customer for this production are listed as below:

- Fuel suppliers: (Shell, PETRONAS, British Petroleum, Exxon Mobil, Caltex)
- Car manufacturers
- Transport users
- Chemical industry: cosmetic, pharmaceuticals, cosmetics, beverages and medical sectors

2.8 STRENGTH, WEAKNESS, OPPORTUNITY, THREAT (SWOT) ANALYSIS

In order to get an overview of advantages and disadvantages of bio-fuels, a SWOT analysis was conducted in the framework of the project biofuel marketplace.

2.8.1 Strengths

- Feedstock costs are relatively low as the material used is from waste shell of castor bean which contain 35% amount of cellulose and it is non-edible which not disturbing food chain.
- Only low input of fertilizer and pesticide are required for feedstock production.
- Continuous feedstock as castor tree's harvesting season is 3 times per year.
- Bio-ethanol can be blended with gasoline at any ratio which can reduce gasoline demand.
- Bio-ethanol has high octane number which is good for combustion properties.
- Bio-ethanol contains 35% oxygen which reduces particulate and NOx, CO and sulfur dioxide emissions from combustion when compared to the combustion of petrol.
- Flexible flue vehicle which can be used for transportation.
- Bio-ethanol reduces pollution and greenhouse gas emissions.
- Bio-ethanol is a renewable fuel.
- Ease of production.

2.8.2 Weaknesses

- Corrosive is nature
- There are no experiences for large scale production of bio-ethanol from cellulose.

2.8.3 Opportunities

- Demand for bio-ethanol by using non edible source is increasing.

- Oil price rises.
- Research is carried out to optimize ethanol processing from cellulose.
- Due to the use of the whole plant, high yields of wastes per hectare are expected.
- Tax exemptions and mandatory blending obligations could largely increase use of ethanol.
- Malaysian fuel standard for ethanol is under development.

2.8.4 Threats

- Energy input for ethanol processing from cellulose is higher than ethanol processing from sugar or starch.
- Loss of key supplier which would result in higher price of products.
- In Malaysia country, the use of bio-ethanol is not yet established and thus limited infrastructure for ethanol distribution exists.

2.9 MARKETING STRATEGY

It is important to determine the effective marketing strategy to penetrate the product easily in the market sectors. Some strategies can be used to market biofuel which are listed below:

- Producing bioethanol blending according to mandates each of customers' country.
- Blending of bioethanol with gasoline is available upon request according to country bioethanol blending mandate all around the world.
- Bioethanol will be transported via tankers or drums and will be delivered to customer as soon as possible.
- Minimum accepted order is 2000 gallon / 7570.82 litre
- Product delivery in 15-20 days after purchase order accepted.
- Give discount to loyal customers.

2.10 SITE SELECTION AND PLANT LAYOUT

The characteristics of the land at a proposed plant site should be examined carefully. The geography of land and the soil structure must be considered, since either or both may have a pronounced effect on construction costs. The cost of the land is important, as well as local building costs and living conditions. Future changes may make it desirable or necessary to expand the plant facilities. Therefore, even though no immediate expansion is planned, a new plant should be constructed at a location where additional space is available.

2.10.1 Site Selection

Cellulosic bioethanol plant will be constructed near the plantation of castor plant in Lundu, Sarawak due to raw material availability, transportation, utilities supplies and site characteristics.

2.10.2 Raw Material Availability

In this research, waste castor bean shells were used as raw material to produce biofuel as final product. CASA KINABALU SDN BHD will supply the raw material with a certain price and the price of the raw material is expected will be much more lower compare to the price of the corn because they are food source.

Castor plant project, 7000 acres in Lundu, Sarawak, 30 acres in Gua Musang, Kelantan 10 acres Lukut, Negeri Sembilan, 5 acres in Muar, Johor 10 acres in Kulai, Johor and 20 acres in Kedah. CASA KINABALU SDN BHD is targeting to expand to 20,000 acres of crops throughout Malaysia. Thus, the biggest plantation of castor is in Lundu Sarawak and the waste shell will be expected highest there.

There will be no problem in getting these raw material continuously as castor plant plantation in Malaysia are grown fast which the harvesting season for this plant is 3 times per year. Figure below shows the castor tree, seeds and waste of castor shells. In this project, the waste will be collected to be lingo-cellulosic source to be used in the production of biofuel.

Figure 2.6: Castor tree (Source: CASA KINABALU SDN BHD)

Figure 2.7: Castor seeds and waste castor shells (Source: CASA KINABALU SDN BHD)

2.10.3 Transportation

As the castor plant is situated in Lundu, Sarawak, the waste will be supplied to our plant via trucks.

2.10.4 Utilities Supplies

The continuous and sufficient supply of electricity and water supply to the plant ensures the smooth day to day operation. Most chemical plants require large quantities of water for cooling and general usage. Thus the avaibility of nearby resources must be ensured. The chemical plant also needs electricity to operate the plant. In this plant, the important utilities required are boilers, combustor, turbo generator, cooling water and installation air system.

2.10.5 Plant Layout

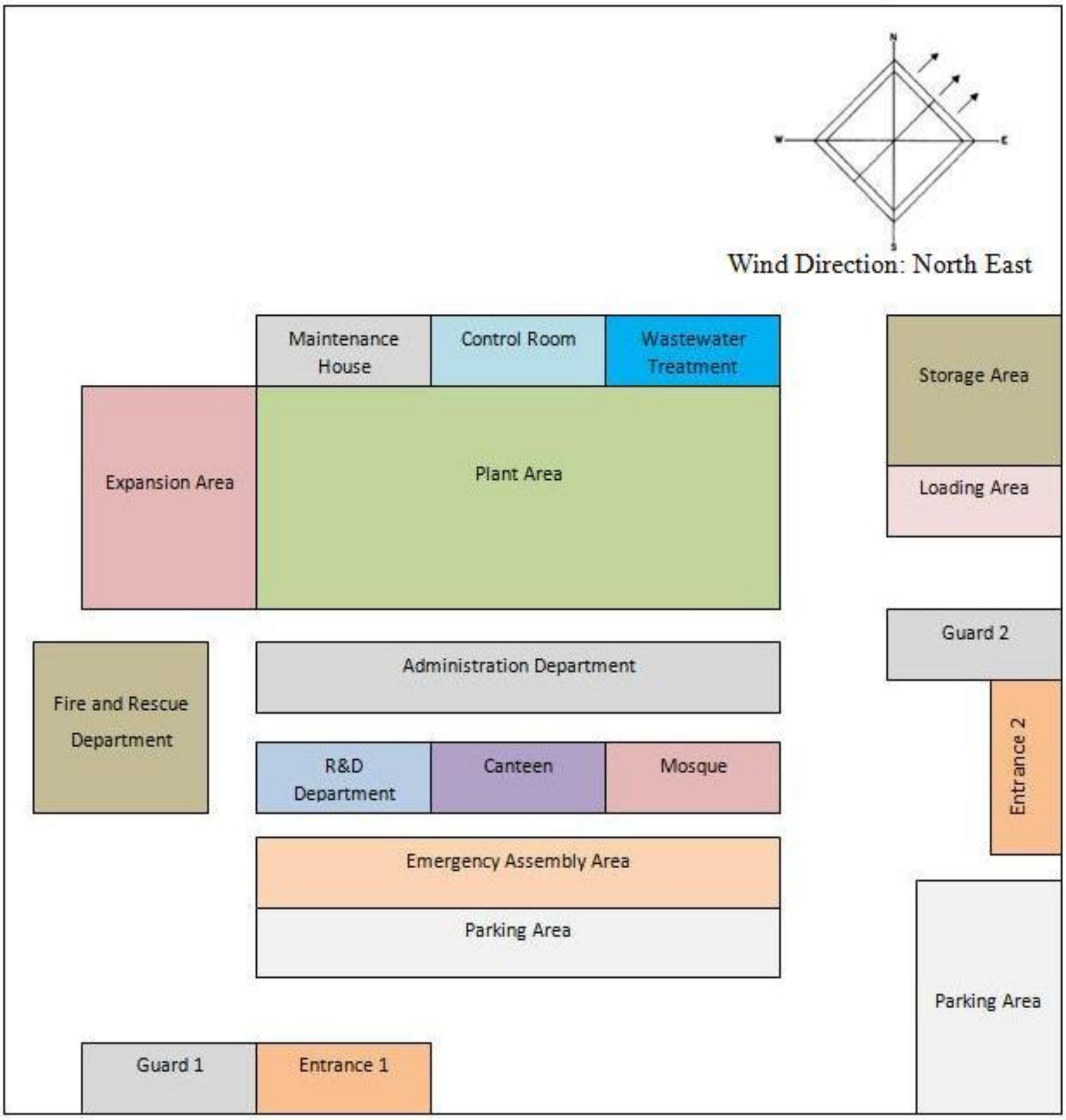

Figure 2.8: Plant Layout

CHAPTER 3

METHADOLOGY/OPERATION SECTION

3.1 TECHNICAL PROCESS AND RESEARCH DESIGN OF BIOFUEL

Basically, there are two steps in the methodology to perform this production as well as to market the biofuel. The first process step is to produce bioethanol from raw material until end product and the second steps is performing research design to market the product. Flow diagrams below show all the steps required to produce and market the bioethanol.

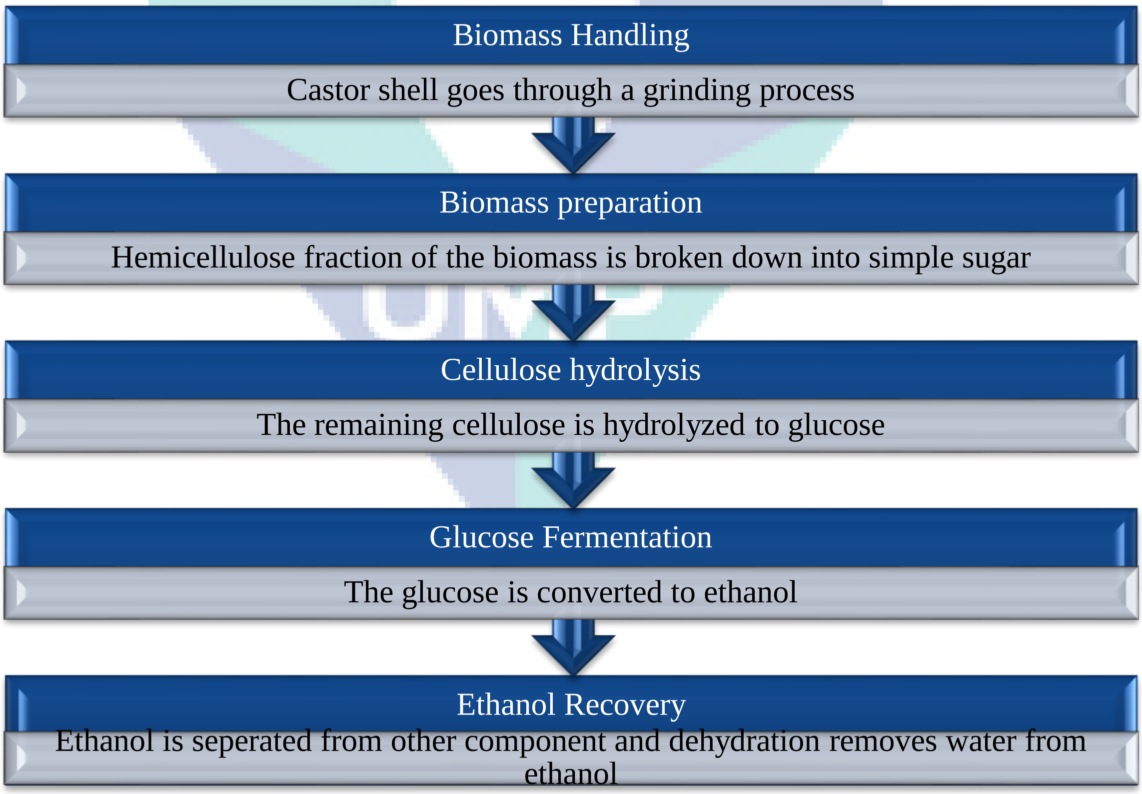

Figure 3.1: Technical process step is to produce bioethanol

Figure 3.2: Research design to market the product

3.2 STAGE OF DEVELOPMENT

In this stage of development section, general process of producing biofuel, simplified block diagram of production process, inline steps to market the product, risk assessment and risk management, and quality control of the product are reviewed.

3.2.1 Block Diagram for Bioethanol Production

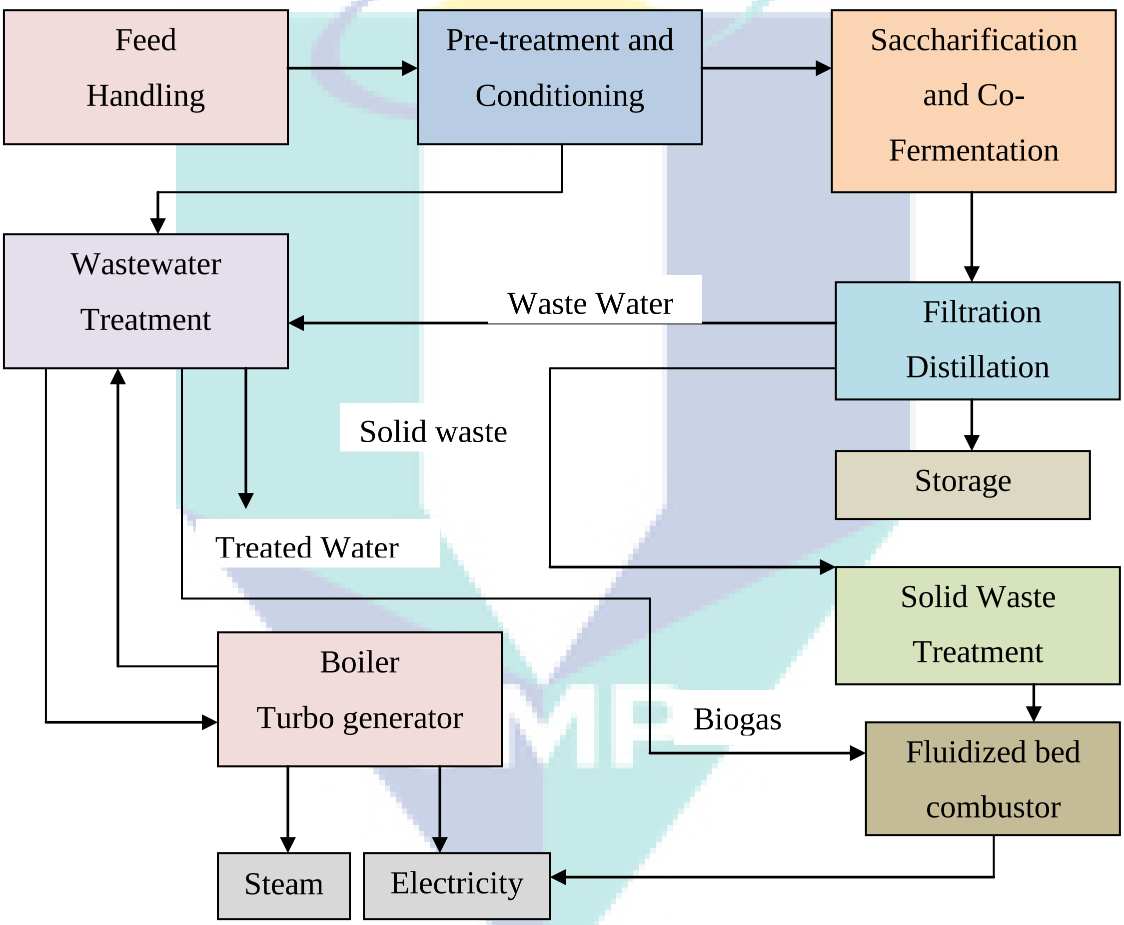

Figure 3.3: Overall process block diagram

3.2.2 General Process to Produce Biofuel

The process being analysed here can be described as using co-current dilute acid pre-hydrolysis of the lignocellulosic biomass with enzymatic saccharification of the remaining cellulose and co-fermentation of the resulting glucose and xylose to ethanol. The process design also includes feedstock handling and storage, product purification, wastewater treatment, solid waste treatment, product storage, and all other required utilities.

The feedstock, in this case waste castor bean shell is delivered to the feed handling area for storage and size reduction. From there the biomass is conveyed to pre-treatment and detoxification. In this area, the biomass is treated with dilute sulphuric acid catalyst at a high temperature for a short time, liberating the hemicelluloses sugars and other compounds. Separation with washing removes the acid from the solids for neutralization. Over liming is required to remove compounds liberated in the pre-treatment that are toxic to the fermenting organism. Detoxification is applied only to the liquid portion of the hydrolysis stream.

Enzymatic hydrolysis (or saccharification) coupled with co-fermentation of the detoxified hydrolyzate slurry is carried out in continuous hydrolysis tanks and anaerobic fermentation tanks in series. A purchased cellulase enzyme preparation is added to the hydrolyzate in the hydrolysis tanks that are maintained at an optimum temperature to optimize the enzyme’s activity. The fermenting organism Zymomonas mobilis is first grown in a series of progressively larger batch anaerobic fermentations to make enough cells to inoculate the main fermenters. The inoculum, along with other nutrients, is added to the first ethanol fermenter along with the partially saccharified slurry at a reduced temperature. The cellulose will continue to be hydrolysed, although at a slower rate, at the lower temperature. After several days of separate and combined saccharification and co-fermentation, most of the cellulose and xylose will have been converted to ethanol.

Product recovery involves filtering and distilling process to separate the ethanol from the water and residual solids. Solids from the distillation bottoms will be sent to solid waste treatment. Waste water from distillation process will be sent to waste water treatment where they will be treated by anaerobic and aerobic digestion. The biogas (high in methane) from anaerobic digestion is sent to the combustor for energy recovery. The treated water is suitable for recycling and is returned to the process.

The solids from distillation and biogas from anaerobic digestion are combusted in a fluidized bed combustor to produce high-pressure steam for electricity production and process heat. The majority of the process steam demand is in the pre-treatment reactor and distillation areas. Generally, the process produces excess steam that is converted to electricity for use in the plant and for sale to the grid.

Figure 3.4 shows the conversion routes for sugar or starch feed stocks to ethanol and co-products. Figure 3.5 shows the ethanol production from lignocelluloses via the biochemical route. From figure below, second generation biofuel production undergo more complicated process in hydrolysis where the lignin, cellulose and hemicelluloses must be separated and they must go for separation process to separate solid-lignin and liquid-glucose before go for fermentation process. Thus, the operation and production cost for second generation biofuel is higher than first generation biofuel.

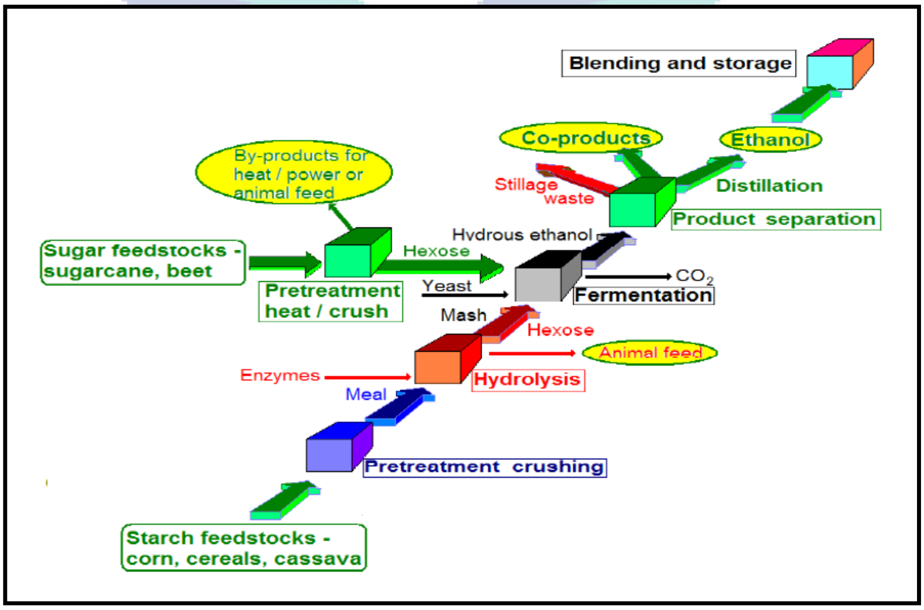

Figure 3.4: Conversion routes for sugar or starch feed stocks to ethanol and co-products (IEA Bioenergy, 2008)

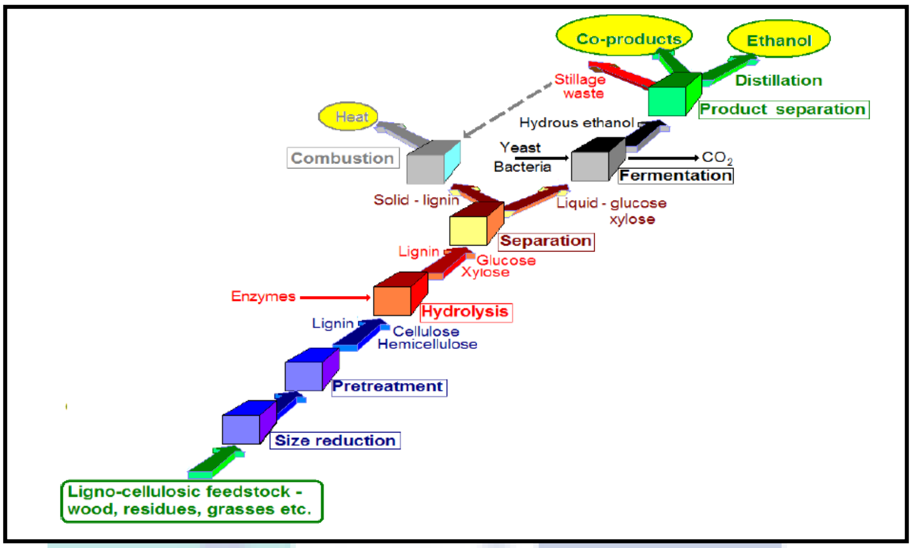

Figure 3.5: Ethanol production from lignocelluloses via the biochemical route (IEA Bioenergy, 2008)

3.2.3 Process Flow Diagram

Process flow diagram in Figure 3.6 described detailed flow process throughout streams and equipment. Basically, the raw materials are waste castor shell and water. Waste shells are converted into glucose before go through the fermentation process with yeast as a catalyst. There are five major equipment, which are steam explosion vessel, Simultaneous Saccharification and Fermentation vessel, centrifuge, distillation column, cross flow filter and storage tank.

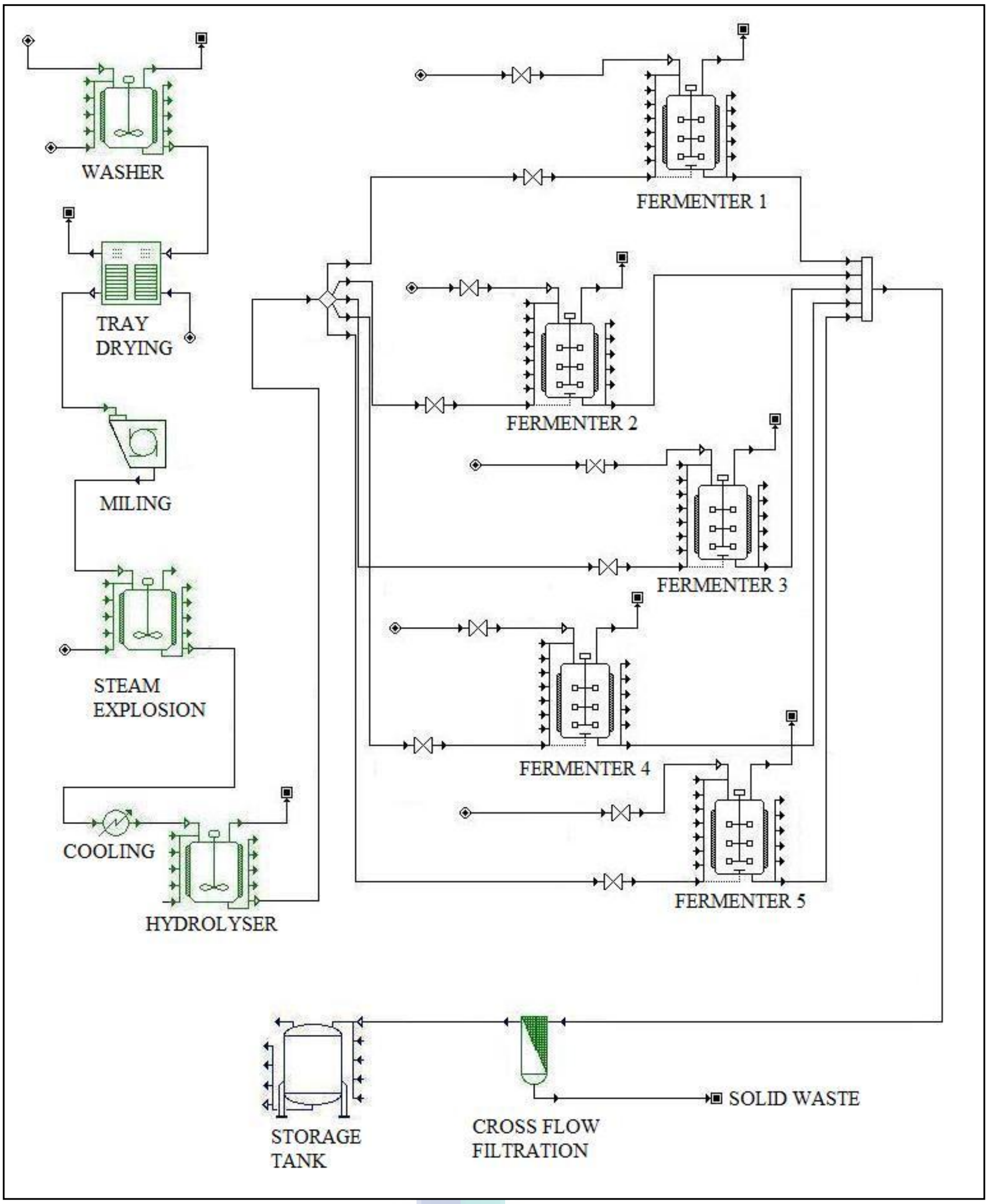

Figure 3.6: Process Flow Diagram

3.3 HAZARD AND OPERABILITY ANALYSIS

The following risks can cause problems to the production and distribution of product. We want to overcome these problems by having risk management to make sure that our company can withstand in any condition of problems.

Table 3.1: Risk Assessment and Risk Management

RISK ASSESSMENT	RISK MANAGEMENT
• Corrosive is nature	• Remove water up to 90% in final product
• There are no experiences for large scale production of bio- ethanol from cellulose	• Increase research and development investment to scale up production plan
• Energy input for ethanol processing from cellulose is higher than ethanol processing from sugar or starch.	• Operate plant at optimum temperature and optimum pressure to minimize the using of energy
• Loss of key supplier which would result in higher price of products	• Use bank loan as back-up plan operation as we have to import our raw material from international suppliers
• In Malaysia country, the use of bio-ethanol is not yet established and thus limited infrastructure for ethanol distribution exists.	• Increase in marketing and promotional plan

3.4 QUALITY CONTROL

Quality Control and Assurance Department which handled by QC/QA engineers will control product quality. They have to make sure that the final products are following the standard before release them to market. Some laboratory test must be performed to check whether the product is out of spec or not. Bioethanol standard specifications follow The American Society for Testing and Materials (ASTM) standards which have been established a standard D4806-98 for “Denatured fuel ethanol for blending with gasoline, for use as automotive spark-ignition engine fuel which is generally accepted throughout the industry. The standard ASTM fuel ethanol specifications are as follows:

Table 3.2: ASTM Fuel Ethanol Specification

Property	Units	Limits
Ethanol	% v/v	92.1 min.
Methanol	% v/v	0.5 max. (5,000 ppm)
Water	% v/v	1.0 max. (10,000 ppm)
Solvent-washed gum	mg / 100ml	5 max. (50 ppm)
Chloride ion	mg / L	40 max. (40 ppm)
Copper content	mg / kg	0.1 max. (0.1 ppm)
Acidity, as acetic acid	mg / kg	0.007 max. (70 ppm)
Appearance	Visibly free of suspended or precipitated contaminants (clear and bright).	
Denaturant	A minimum of 1.96% v/v, and a maximum of 4.76% v/v of natural gasoline, gasoline components or unleaded gasoline.	

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

The goal of any manufacturing industry is to gain as higher profit as they can. This is realized by producing products with high market value from raw materials with a low market value. The chemical process industry produces high values chemicals from low value raw materials. Estimation of operating costs and capital costs were provided for the production of 20,000,000 litre/year of bioethanol. From this material an economic evaluation can be carried out to determine if the process generate money and to evaluate whether the process is attractive compared to other processes.

4.2 MANUFACTURING COST AND TOTAL PRODUCTION COST

Total production cost for a chemical plant consists of manufacturing cost and general expenses. Manufacturing cost consists of direct and indirect production cost where the cost associated with the day-today operation of plant. This is another equally important part is the estimation of costs for operating the plant and selling the products.

4.2.1 Factors which Affect the Manufacturing Cost in a Chemical Plant

Many elements influence the cost of manufacturing chemicals. The cost information provided is divided into three categories:

i. Direct manufacturing costs

These costs represent operating expenses that vary with production rate. When product demand drops, production rate is reduced below the design capacity. At this lower rate we would expect a reduction in the factors making up the direct manufacturing costs. These reductions may be directly proportional to the production rate.

ii. Fixed Manufacturing Costs

These costs are independent of changes in production rate. They include management, and depreciation that are charged at constant rates even when the plant is not in the operation.

iii. General Expenses

These costs represent an overhead burden that is necessary to carry out business functions. They include management, sales, financing and research functions. General expenses seldom vary with production level. However, item such as research and development and distribution and selling costs may decrease if extended periods of low production levels occur. Table 4.1 below shows the factor that may affect the cost of manufacturing for a chemical product.

Table 4.1: Factors Affecting the Cost of Manufacturing (COM) for a Chemical Product

Factor	Description of Factor
1. Direct Cost	**Factors that vary with the rate of production**
A. Raw Material	Cost of chemical feed stocks required by the process
B. Waste Treatment	Cost of waste treatment to protect environment
C. Utilities	Cost of utility streams required by process such as: • Fuel diesel, oil and/or coal • Electric power

	• Steam (all pressure) • Cooling water • Process water • Boiler feed water • Instrument air • Inert gas (nitrogen) • Refrigeration
D. Operating Labor	Cost of personnel required for plant operations
E. Direct Supervisory and Clerical Labor	Cost of administrative/engineering and support personnel
F. Maintenance and Repairs	Cost of labor and materials associated with equipment maintenance
G. Operating Supplies	Cost of miscellaneous supplies that support daily operation not considered to be raw materials. Examples: Chart paper, lubricants, miscellaneous chemicals, respirators and protective clothing for operators, etc.
H. Laboratory Charges	Cost of routine and special laboratory tests required for product quality control and troubleshooting.
I. Patents and Royalties	Cost of using patented or licensed technology
2. Fixed Cost	**Factors not affected by the level of production**
A. Depreciation	Cost associated with the physical plant (buildings, equipment, etc). Legal operating expenses for tax purposes.
B. Local Taxes and Insurance	Cost associated with property taxes and liabilities insurance. Based on plant location and severity of the process.
C. Plant Overhead Costs • Administrative Costs • Distribution and Selling Costs • Research and Development	Catch all costs associated with the operation of auxiliary facilities supporting the manufacturing process, payroll and accounting services, fire protection and safety services, medical services, cafeteria, payroll overhead, sales and marketing, and research activities

4.3 PROCESS DESIGN AND COST ESTIMATING

Table 1 (Appendix A1) shows the product yield and energy consumptions used to operate this production process (refer to Appendix A). To be noted, this biofuel plant production is producing 20,000,000 litre/year bioethanol in 320 working days where one month is reserved for periodical maintenance. The account payable, receivable and inventories of this production are shown in Table 2 (Appendix A2). The estimation of balance sheet and income statements for this production was calculated which are shown in Table 3 (Appendix A3) and Table 4 (Appendix A4) respectively. Year of operations that has been weighed up in the balance sheet and income statements are for 5 years where in the balance sheets, the assets and liabilities and equities were analysed precisely.

For the income statements, the total revenue, total production costs, gross profit, and total administration and operating expenses were computed. The 5 year average return on investment (ROI) in this project is 30.29%. Table 5 (Appendix A5) shows projected biofuel production cost for average 5 years of operations. The cost of feed stocks, direct labour, chemicals/enzymes used, operation/maintenance, electricity, denaturant, makeup water, wastewater disposal, administrative and pre-tax income were considered to estimate the price per litre for this biofuel production. Lastly, in Table 6 (Appendix A6) shows the cost summary for this whole plant where the production cost is estimated around RM2.04/litre and the selling price is RM2.45/litre to gain 20% profit from this production.

4.3.1 Cash Flow Analysis

The final step in this profitability analysis is to determine the payback period (PBP). The total operating period is 20 years, excluding the 18 month for start-up operation. Since this is a new plant, we may meet many problems in production flow in the beginning of start-up. Hence the production cannot achieve the target as desired. The sales income for the first year after start-up was assumed to be 80% of the targeted value. The plant achieves its target at 5.33 years of production.

In order to determine the value of the payback period of this plant, a cash flow analysis is needed where the annual capital investment, sales income, depreciation, total expenses, cash income, net profit, federal income tax, net profit after taxes, net cash income, and accumulated net cash income must be calculated first. Table 7 (Appendix

A7) summarizes the cash flow analysis and a graph for accumulated net cash flow versus year of completion was obtained.

4.6 BIOETHANOL PRICING

According to the final report of Asia-Pacific Economic Cooperation, 2010, the summary of the cost production using 1st generation and 2nd generation way to produce biofuel are shown as in Table 4.2 below:

Table 4.2: Production Cost to produce biofuel via 1st generation and 2nd generation biofuel

Name of generation	Feedstock	Production Cost
1st generation	Corn	RM 1.421/ litre
1st generation	Sugarcane	RM 0.556/ litre
2nd generation	Cellulosic (woody biomass)	RM 1.85/ litre

By referring to the production cost above, production cost for second generation is higher that first generation biofuel. Second generation biofuel is expensive by comparison to traditional bioethanol production because process synthesis route to produce bioethanol is more complicated than the first generation biofuel route. This study's projected biofuel production cost using cellulose from castor shell as feedstock cost RM 2.04/litre which price is higher compared to production cost stated in Table 4.2 above because it includes additional step of hydrolysis process before fermentation process. Although the selling price is quite high but it is worth because we use very cheap material and supporting environment.

Due to high production cost for second generation biofuel which is using lignocellulosic biomass, we can reduce the selling price of biofuel by blending biofuel with gasoline. Thus, the percentage usage of biofuel in fuel is decreasing and the price will reduce. In order to sell the blending biofuel for vehicle, we must follow the mandates of each country because different country using different percentage of blending biofuel. It is because the usage of biofuel is different to different type of engine (refer mandate in Table 2.1) and required adjustment to gasoline engines to cope with different blends of ethanol fuel (refer to Table 2.2). With many interest, many optimization can be made to increase the quality of biofuel.

4.7 WASTE MANAGEMENT

Many by products are formed during the production of ethanol. These by products can be very harmful to the environment as well as to human health. Because of this, these by products must be either eliminated or reduced. It is unreasonable to think that all the by products can be totally eliminated. These by products can only be reduced into other compounds. In order to reduce these by products, a waste treatment method has been implemented. Techniques of waste management are:

- Dilution and dispersion
- Discharge to foul water sewer (with agreement)
- Physical treatment: scrubbing, settling, absorption and adsorption
- Chemical treatment: precipitation, neutralization
- Biological treatment: activated sludge
- Incineration on land or sea
- Landfill at controlled sites
- Sea dumping

By relation to this study, we have two type of waste which are waste water and solid waste. Thus, suitable techniques of waste management for waste water are discharge of foul water sewer with agreement, physical treatment which include scrubbing and settling and chemical treatment using precipitation while for solid waste can be dumped to landfill at controlled sites.

4.7.1 WASTE TREATMENT

When waste is produced, processes must be incorporated for its treatment and safe disposal. The waste that produces during the production of ethanol is carbon dioxide. Carbon dioxide is a by-product of production of ethanol. As a by-product from the ethanol production, carbon dioxide can be another income to the company beside of ethanol selling. Carbon dioxide produced is in a vapour condition or can be compressed into liquid by using a carbon dioxide compressor. To reduce the cost, carbon dioxide in a vapour condition sells to Schlumberger Limited Corporation.

There are many particles that include in the wastewater of any industries. The wastewater must be treated to reduce and possibly remove the contaminant particles and hazardous material. The wastewater treatment process treats large objects, small or light particles and also treat sludge which are coming from the waste during the process of the industries not only for production of ethanol but for others production.

In this process, the feed used are water and waste castor bean shell. While using water as a feed and also made a medium transfer, the water used must be remove as a wastewater. The material in wastewater not only water, but also other material such as ash, lignin, hemicelluloses, glucose, lactic acid, and many more. These materials should be removed properly because they are hazard and toxic. The equipment consist of grit chamber, primary settling tank, aeration tank, secondary settling tank, disinfection and the last is boiler that boil the clean water before it is ready to used. These equipment are arranged for large particle until light particle removal.

4.8 STORAGE AND HANDLING OF ETHANOL

While handling a volatile chemical, there are many rules that must be consider. It is to ensure and avoid any risk which can make an explosion and damage. The chemical must be store in a tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances or any area where the fire hazard may be acute. Keep away from heat, sparks, and flame and sources of ignition protect against physical damage. Outside or detached storage is preferred. Separate from incompatibles. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be ‘No Smoking’ areas. Use non-sparking type tools and equipment, including explosion proof ventilation. Containers of this material may be hazardous when empty since they retain product residues (vapours, liquid), observe all warnings and precautions listed for the product. Do not attempt to clean empty containers since residue is difficult to remove. Do not pressurize, cut, weld, braze, solder, drill, grind or expose such containers to heat, sparks, flame, static electricity or other sources of ignition: they may explode and cause injury or death.

4.9 POTENTIAL HEALTH EFFECT

4.9.1 Eye Contact: Contact with ethanol can produce irritation, characterized by a burning sensation, redness, tearing, inflammation, and possible corneal injury. It vapours may cause eye irritation and also a painful sensitization to light.

4.9.2 Skin: The contact of ethanol may cause skin irritation and make a skin dry.

4.9.3 Ingestion: Ingestion of the solution may be fatal or cause blindness if swallowed. It is also may cause irritation of the digestive tract, kidney damage and systemic toxicity with acidosis. This chemical substance also can cause central nervous system depression which characterized by excitement, followed by headache, dizziness, drowsiness, and nausea.

4.9.4 Inhalation: A harmful contamination of the air will be reached rather slowly on evaporation of this substance at 20°C. When ethanol is inhale, it will cause not just respiratory tract irritation but also visual impairment and possible permanent blindness.

4.9.5 Chronic: For chronic (long-term) health effects can occur at some time after exposure to ethanol and can last for months or years. Prolonged or repeated skin contact may cause dermatitis. Chronic inhalation and ingestion may cause effects similar to those of acute inhalation and ingestion.

4.9.6 Brain: Exposure to chemical substances can cause adverse effects on the nervous system (Neurotoxicity). Chemicals toxic to the central nervous system can induce confusion, fatigue, irritability, and other behavioural changes.

CHAPTER 5

CONCLUSIONS

5.1 CONCLUSIONS

The possibility of obtaining a renewable, available, safe and effective source of energy is one of the challenges that humanity should face. The biofuels, particularly the bioethanol, are an environmentally clean source of energy. However, production costs of fuel ethanol are higher than production costs of gasoline in some cases, although there is a strong influence of factors as the prices of oil and feedstock for ethanol production. Nevertheless, many groups and research centres in different countries are continuously carrying out studies aimed at reducing ethanol production costs for a profitable industrial operation. Bioethanol fetches a price of RM2.67/ litre for the industrial grade of ethanol. For the low grade, the prices are RM1.50/litre. A huge amount of profit can be made from this selling price when compared to the total cost investment. In this study, the projected biofuel price was calculated which it costs RM 2.04/ litre. Although it seems quite expensive, we can reduce the price by blending the bioethanol with the gasoline because if the percentage usage of biofuel in fuel is decreasing, the fuel price will also reduce. Several mandates must be followed according to each country because different blending percentage of biofuel will only be compatible to different types of vehicle engines.

Thus, plant for the production 20,000,000 litre/year of biofuel by using waste castor bean shell in Malaysia will be the first made biofuel plant and is considered to be a very promising industrial opportunity. This is due to the fact that there is no existing ethanol plant in Malaysia. As a result, the proposed plan to set up an ethanol plant in Malaysia, Lundu, Sarawak to be precise, is indeed an advantageous venture.

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APPENDIX A1

Table 1: Product Yield and Energy Consumptions

Product Yield and Energy Consumption	1st Year Operation	2nd Year Operation	3rd Year Operation	4th Year Operation	5th Year Operation
Ethanol Production Increase Over Previous Year	0.00	0.00	0.00	0.00	0.00
Denatured Ethanol Sold (litre/year)	17,042,857.00	20,000,000.00	20,000,000.00	20,000,000.00	20,000,000.00
Ethanol Price (RM/litre)	2.46	2.46	2.46	2.46	2.46
Ethanol Sales Commission (% of Ethanol Price)	0.01	0.01	0.01	0.01	0.01
Ethanol Transportation (RM/litre)	0.00	0.00	0.00	0.00	0.00
Feedstock Usage (kg/year)	214,087.00	244,671.00	244,671.00	244,671.00	244,671.00
Feedstock Moisture Content (%)	0.10	0.10	0.10	0.10	0.10
Feedstock Usage (dry kg/year)	192,678.00	220,204.00	220,204.00	220,204.00	220,204.00
Feedstock Price (RM/kg)	0.17	0.17	0.17	0.17	0.17
Feedstock Price (RM/dry kg)	0.19	0.19	0.19	0.19	0.19
Electricity Use (kWh/kg)	-0.62	-0.54	-0.54	-0.54	-0.54
Annual Electricity Use (million KWh/year)	-132.36	-132.36	-132.36	-132.36	-132.36
Electricity Price (RM/kWh)	0.22	0.22	0.22	0.22	0.22
Fresh Water Use (1000liter/kg)	0.54	0.54	0.54	0.54	0.54
Annual Fresh Water Use (1000liter/year)	104,895.00	119,880.00	119,880.00	119,880.00	119,880.00
Fresh Water Price (RM/1000liter)	0.41	0.41	0.41	0.41	0.41
Effluent Water Disposal (1000liter/kg)	0.05	0.05	0.05	0.05	0.05
Annual Effluent Water Disposal (1000liter/year)	10,490.00	11,988.00	11,988.00	11,988.00	11,988.00
Effluent Water Disposal Price (RM/1000liter)	0.82	0.82	0.82	0.82	0.82

Denaturant Use (% of alcohol sold)	0.05	0.05	0.05	0.05	0.05
Annual Denaturant Use (litre/year)	925,926.00	1,058,201.00	1,058,201.00	1,058,201.00	1,058,201.00
Denaturant Price (RM/liter)	1.23	1.23	1.23	1.23	1.23
Chemical & Enzyme Cost (RM/litre ethanol)	0.66	0.66	0.66	0.66	0.66
Number of Employees	33.00	33.00	33.00	33.00	33.00
Average Salary Including Benefits(RM)	55,833.00	55,833.00	55,833.00	55,833.00	55,833.00
Maintenance Materials & Services (%)	0.02	0.02	0.02	0.02	0.02
Property Tax & Insurance (%)	0.01	0.01	0.01	0.01	0.01

APPENDIX A2

Table 2: Account Payable, Receivable and Inventories

Accounts Payable, Receivable & Inventories	Receivable	Payable	Inventories
Fuel Ethanol	14 days		8 days
Co-products	14 days		8 days
Denaturants		10 days	15 days
Chemical & Enzymes		15 days	20 days
Feedstock		10 days	10 days
Utilities		15 days	

APPENDIX A3

Table 3: Balance Sheet

BALANCE SHEET	Construction (Year 0)	1st Year Operation	2nd Year Operation	3rd Year Operation	4th Year Operation	5th Year Operation
ASSETS						
Current Assets						
Cash	0.00	18,531,312.00	37,839,751.00	57,329,350.00	76,917,874.00	96,604,275.00
Account Receivable	0.00	2,310,000.00	2,376,000.00	2,376,000.00	2,376,000.00	2,376,000.00
Inventories						
Feedstock	0.00	330,061.00	377,212.00	377,212.00	377,212.00	377,212.00
Chemical, Enzymes &Yeast	0.00	914,000.00	870,748.00	870,748.00	870,748.00	870,748.00
Denaturant	0.00	61,224.00	61,224.00	61,224.00	61,224.00	61,224.00
Finished Product Inventory	0.00	410,053.00	496,586.00	496,586.00	496,586.00	496,586.00
Spare Parts	0.00	300,000.00	300,000.00	300,000.00	300,000.00	300,000.00
Total Inventories	**0.00**	**2,015,338.00**	**2,105,770.00**	**2,105,770.00**	**2,105,770.00**	**2,105,770.00**
Prepaid Expenses	0.00	0.00	0.00	0.00	0.00	0.00
Other Current Assets	0.00	0.00	0.00	0.00	0.00	0.00
Total Current Assets	**0.00**	**22,856,650.00**	**42,321,521.00**	**61,811,120.00**	**81,399,644.00**	**101,086,045.00**
Land	300,000.00	300,000.00	300,000.00	300,000.00	300,000.00	300,000.00
Property, Plant & Equipment	116,837,482.00	130,632,758.00	131,105,414.00	131,578,069.00	132,050,725.00	132,523,381.00
Less Accumulated Depreciation & Amortization	0.00	8,594,931.00	16,785,224.00	24,867,474.00	32,869,081.00	40,808,921.00
Total Net Property, Plant & Equipment	**116,837,482.00**	**122,037,827.00**	**114,320,190.00**	**106,710,595.00**	**99,181,644.00**	**91,714,460.00**
Capitalized Fees & Interest	2,117,193.00	3,120,410.00	2,808,369.00	2,496,329.00	2,184,287.00	1,872,246.00
Total Assets	**119,254,675.00**	**148,314,887.00**	**159,750,080.00**	**171,318,044.00**	**183,065,575.00**	**194,972,751.00**

LIABILITIES & EQUITIES						
Current Liabilities						
Account Payable	0.00	604,105.00	679,707.00	679,707.00	679,707.00	679,707.00
Notes Payable	0.00	0.00	0.00	0.00	0.00	0.00
Current Maturities of Senior Debt (including sweeps)	0.00	6,347,437.00	6,870,670.00	7,437,034.00	8,050,085.00	8,713,671.00
Current Maturities of Working Capital	0.00	0.00	0.00	0.00	0.00	0.00
Total Current Liabilities	**0.00**	**6,951,542.00**	**7,550,377.00**	**8,116,741.00**	**8,729,792.00**	**9,393,378.00**

Senior Debt (excluding current maturities)	64,121,841.00	73,725,919.00	66,855,248.00	59,418,214.00	51,368,128.00	42,654,457.00
Working Capital (excluding current maturities)	0.00	0.00	0.00	0.00	0.00	0.00
Deferred Income Tax	0.00	0.00	0.00	0.00	0.00	0.00
Total Liabilities	**64,121,841.00**	**80,677,461.00**	**74,405,625.00**	**67,534,955.00**	**60,097,920.00**	**52,047,835.00**

Capital Units & Equities						
Common Equity	57,291,604.00	57,291,604.00	57,291,604.00	57,291,604.00	57,291,604.00	57,291,604.00
Preferred Equity	0.00	0.00	0.00	0.00	0.00	0.00
Grants (capital improvements)	0.00	0.00	0.00	0.00	0.00	0.00
Distribution to shareholders	0.00	0.00	0.00	0.00	0.00	0.00
Retained earnings	-2,158,770.00	10,345,822.00	28,052,851.00	46,491,485.00	65,676,051.00	85,633,312.00
Total Capital Shares & Equities	**55,132,834.00**	**67,637,426.00**	**85,344,455.00**	**103,783,089.00**	**122,967,655.00**	**142,924,916.00**

Total Liabilities & Equities	**119,254,675.00**	**148,314,887.00**	**159,750,080.00**	**171,318,044.00**	**183,065,575.00**	**194,972,751.00**

APPENDIX A4

Table 4: Income Statement

INCOME STATEMENT	Construction (Year 0)	1st Year Operation	2nd Year Operation	3rd Year Operation	4th Year Operation	5th Year Operation
Revenue						
Ethanol	0.00	50,617,286.00	59,400,000.00	59,400,000.00	59,400,000.00	59,400,000.00
Gypsum	0.00	0.00	0.00	0.00	0.00	0.00
Carbon dioxide	0.00	0.00	0.00	0.00	0.00	0.00
Cellulosic Producer Tax Credit	0.00	0.00	0.00	0.00	0.00	0.00
Total Revenue	**0.00**	**50,617,286.00**	**59,400,000.00**	**59,400,000.00**	**59,400,000.00**	**59,400,000.00**
Production and Operating Expenses						
Feedstock	0.00	11,552,130.00	13,202,434.00	13,202,434.00	13,202,434.00	13,202,434.00
Chemicals, Enzymes & Yeast	0.00	13,333,333.00	15,238,095.00	15,238,095.00	15,238,095.00	15,238,095.00
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00
Electricity	0.00	-9,251,805.00	-9,251,805.00	-9,251,805.00	-9,251,805.00	-9,251,805.00
Denaturants	0.00	1,278,214.00	1,500,000.00	1,500,000.00	1,500,000.00	1,500,000.00
Makeup Water	0.00	52,448.00	59,940.00	59,940.00	59,940.00	59,940.00
Wastewater Disposal	0.00	10,490.00	11,988.00	11,988.00	11,988.00	11,988.00
Direct Labour &Benefits	160,833.00	965,000.00	965,000.00	965,000.00	965,000.00	965,000.00
Total Production Costs	**160,833.00**	**17,939,810.00**	**21,725,652.00**	**21,725,652.00**	**21,725,652.00**	**21,725,652.00**
Gross Profit	**-160,833.00**	**32,677,476.00**	**37,674,348.00**	**37,674,348.00**	**37,674,348.00**	**37,674,348.00**
Administrative&Operating Expenses						
Maintenance Materials & Services	0.00	2,119,692.00	2,422,505.00	2,422,505.00	2,422,505.00	2,422,505.00
Repairs & Maintenance	43,104.00	320,500.00	320,500.00	320,500.00	320,500.00	320,500.00

Consulting, Management and Bank Fees	0.00	150,000.00	150,000.00	150,000.00	150,000.00	150,000.00
Property Taxes & Insurance	304,557.00	1,522,787.00	1,590,392.00	1,490,062.00	1,391,138.00	1,293,261.00
Admin, Salaries, Wages & Benefits	290,875.00	557,000.00	557,000.00	557,000.00	557,000.00	557,000.00
Legal & Accounting/Community Affairs	1,109,000.00	84,000.00	84,000.00	84,000.00	84,000.00	84,000.00
Office/Lab Supplies & Expenses	50,400.00	72,000.00	72,000.00	72,000.00	72,000.00	72,000.00
Travel, Training & Miscellaneous	200,000.00	50,000.00	50,000.00	50,000.00	50,000.00	50,000.00
Total Administrative & Operating Expenses	**1,997,936.00**	**4,875,979.00**	**5,246,397.00**	**5,146,067.00**	**5,047,143.00**	**4,949,266.00**

EBITDA	**-2,158,769.00**	**27,801,497.00**	**32,427,951.00**	**32,528,281.00**	**32,627,205.00**	**32,725,082.00**
Less:						
Interest-Operating Line of Credit	0.00	0.00	0.00	0.00	0.00	0.00
Interest-Senior Debt	0.00	6,701,974.00	6,218,587.00	5,695,354.00	5,128,990.00	4,515,939.00
Interest-Working Capital	0.00	0.00	0.00	0.00	0.00	0.00
Depreciation & Amortization	0.00	8,594,931.00	8,502,334.00	8,394,291.00	8,313,648.00	8,251,880.00

Pre-Tax Income	-2,158,769.00	12,504,592.00	17,707,030.00	18,438,636.00	19,184,567.00	19,957,263.00
Current Income Taxes	0.00	0.00	0.00	0.00	0.00	0.00

Net Earnings (Loss) for the Year	**-2,158,769.00**	**12,504,592.00**	**17,707,030.00**	**18,438,636.00**	**19,184,567.00**	**19,957,263.00**

Pre-Tax Return on Investment (ROI) (%)	0.00	24.70	29.81	31.04	32.30	33.60
5 year average annual pre-tax ROI (%)	30.29					

APPENDIX A5 Table 5: Projected Biofuel Production Cost for Average 5 years of Operation

Projected Biofuel Production Cost (Average 5 years)								
COST OF PRODUCTION	Production cost for 20,000,000 litre							Cost for 1 litre (RM/litre)
	Construction (Year 0)	1st Year Operation	2nd Year Operation	3rd Year Operation	4th Year Operation	5th Year Operation	Average 5 years	
Feedstock	0.00	11,552,130.00	13,202,434.00	13,202,434.00	13,202,434.00	13,202,434.00	10,726,977.67	0.536348883
Direct Labour/Benefits	160,833.00	965,000.00	965,000.00	965,000.00	965,000.00	965,000.00	830,972.17	0.041548608
Chemicals/Enzymes	0.00	13,333,333.00	15,238,095.00	15,238,095.00	15,238,095.00	15,238,095.00	12,380,952.17	0.619047608
Operations/Maintenance	1,997,936.00	4,875,979.00	5,246,397.00	5,146,067.00	5,047,143.00	4,949,266.00	4,543,798.00	0.2271899
Electricity	0.00	-9,251,805.00	-9,251,805.00	-9,251,805.00	-9,251,805.00	-9,251,805.00	-7,709,837.50	-0.385491875
Denaturant	0.00	1,278,214.00	1,500,000.00	1,500,000.00	1,500,000.00	1,500,000.00	1,213,035.67	0.060651783
Makeup water	0.00	52,448.00	59,940.00	59,940.00	59,940.00	59,940.00	48,701.33	0.002435067
Wastewater disposal	0.00	10,490.00	11,988.00	11,988.00	11,988.00	11,988.00	9,740.33	0.000487017
Administrative/Operating	1,997,936.00	4,875,979.00	5,246,397.00	5,146,067.00	5,047,143.00	4,949,266.00	4,543,798.00	0.2271899
Pre-Tax Income	-2,158,769.00	12,504,592.00	17,707,030.00	18,438,636.00	19,184,567.00	19,957,263.00	14,272,219.83	0.713610992
							Total Cost (RM/liter)	**2.043017883**

APPENDIX A6

Table 6: Costing Summary

Current world biofuel price (RM/litre)	2.46
Projected biofuel price (RM/litre)	2.04
Gain 20% profit from production cost	2.45
Profit per litre (RM)	0.41
Profit for 20,000,000 litre of production/year (RM)	8,172,071.53
% production profit per year	20.00

APPENDIX A7 Table 7: Cash Flow Analysis

Year of Completion	Annual Capital Investment A(I)	Sales Income A(S)	Depreciation A(BD)	Total Expenses A(TE)-A(BD)	Cash Income A(CI)=A(S)-A(TE)+A(BD)	Net Profit ANP=A(CI)-A(BD)	Federal Income Taxes (28%) A(IT)	Net Profit After Taxes,ANNP=ANPA(IT)	Net Cash Income, A(NCI)	Accumulation of ANNP
1	RM (10,846,703.30)	RM 49,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 33,965,174.17	RM 26,955,660.17	RM 7,547,584.85	RM 19,408,075.32	RM 8,561,372.02	RM (10,846,703.30)
2	RM (27,116,758.25)	RM 49,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 33,965,174.17	RM 26,955,660.17	RM 7,547,584.85	RM 19,408,075.32	RM (7,708,682.93)	RM (18,555,386.23)
3	RM (70,503,571.45)	RM 49,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 33,965,174.17	RM 26,955,660.17	RM 7,547,584.85	RM 19,408,075.32	RM (51,095,496.13)	RM (69,650,882.36)
4		RM 49,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 33,965,174.17	RM 26,955,660.17	RM 7,547,584.85	RM 19,408,075.32	RM 19,408,075.32	RM (50,242,807.04)
5		RM 49,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 33,965,174.17	RM 26,955,660.17	RM 7,547,584.85	RM 19,408,075.32	RM 19,408,075.32	RM (30,834,731.72)
6		RM 150,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 134,965,174.17	RM 127,955,660.17	RM 35,827,584.85	RM 92,128,075.32	RM 92,128,075.32	RM 61,293,343.60
7		RM 150,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 134,965,174.17	RM 127,955,660.17	RM 35,827,584.85	RM 92,128,075.32	RM 92,128,075.32	RM 153,421,418.92
8		RM 150,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 134,965,174.17	RM 127,955,660.17	RM 35,827,584.85	RM 92,128,075.32	RM 92,128,075.32	RM 245,549,494.24
9		RM 150,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 134,965,174.17	RM 127,955,660.17	RM 35,827,584.85	RM 92,128,075.32	RM 92,128,075.32	RM 337,677,569.56
10		RM 150,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 134,965,174.17	RM 127,955,660.17	RM 35,827,584.85	RM 92,128,075.32	RM 92,128,075.32	RM 429,805,644.88
11		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 557,933,720.20
12		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 686,061,795.52
13		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 814,189,870.84
14		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 942,317,946.16
15		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 1,070,446,021.48
16		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 1,198,574,096.80
17		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 1,326,702,172.12
18		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 1,454,830,247.44
19		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 1,582,958,322.76
20		RM 200,000,000.00	RM 7,009,514.00	RM 15,034,825.83	RM 184,965,174.17	RM 177,955,660.17	RM 49,827,584.85	RM 128,128,075.32	RM 128,128,075.32	RM 1,711,086,398.08

APPENDIX A8

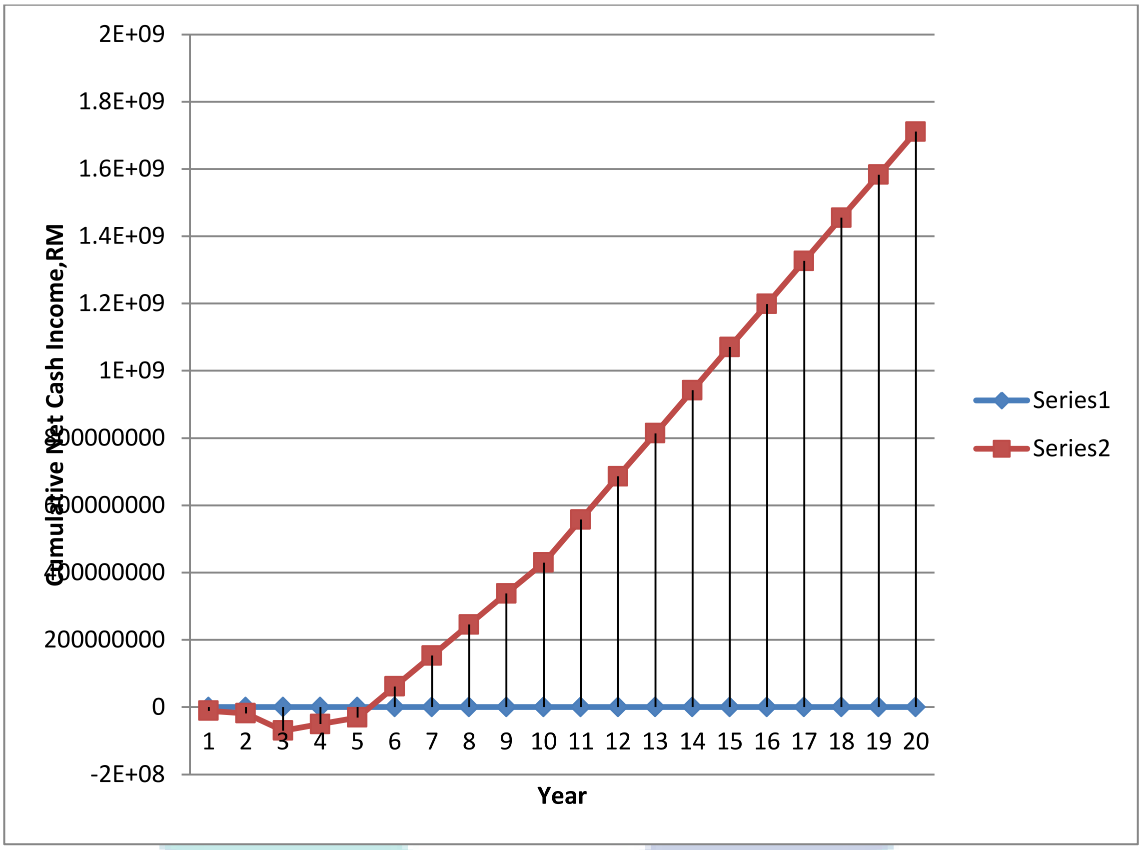

Figure 1: Cumulative net cash income versus year (Payback period=5.33years)