PETROCHEMICALS OUTLOOK OF MALAYSIA IN 2010 AND ITS FUTURE TRENDS

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **PETROCHEMICAL OUTLOOK OF MALAYSIA IN 2010 AND ITS FUTURE TRENDS** was prepared by **CHOO EE LAINE** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Engineering (Hons.) Chemical Engineering at Universiti Tunku Abdul Rahman.

Approved by,

Signature : _______________

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Date : ________________

I dedicate this thesis to my parents. Without their understanding, support, and most of love, the completion of this work would not have been possible.

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PETROCHEMICALS OUTLOOK OF MALAYSIA IN 2010 AND ITS FUTURE TRENDS

ABSTRACT

Petrochemicals are chemicals made from petroleum (crude oil) and natural gas. In general, the largest production volume in petrochemical industry is other than methanol, ethylene, propylene, butadiene, benzene, toluene and xylenes. Fossil fuels—coal, crude oil or petroleum, natural gas liquids and natural gas—are the primary sources of basic petrochemicals. Nowadays, it is clearly proven that petrochemical industry still remains one of the most significant industry that stalwartly influenced by the globalization of the world economy circumstances. Besides, the growing demand for energy and the end products has rendered to declines in supply, skyrocketing costs, and swelling environmental apprehension. However, petrochemical industry still remnants as one of the strongest and fast-growing industry in Malaysia. This is mainly because the availability of resources in hydrocarbon feedstock from oil and gas reserves in our country assisted in the development of petrochemical industry. Moreover, Malaysia's government investment in the industry also made Malaysia become the leading industry in ASEAN where we are the major exporter of petrochemical products within the ASEAN region. However, in keeping pace with the instability of global economy downturn, petrochemical industry in Malaysia persists to fine-tune through divestitures, joint ventures and other forms of partnership with other countries, leading to lesser and larger manufacturers of commodity petrochemicals with broader geological reach.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Malaysia has attained momentous growth in developing the economy and recuperating the quality of life of its people, regardless of the complex and volatile external environment in recent years in the aspect of politics and economics. According to Department of Statistic Malaysia 2010, Malaysia has a total area of 329,845 km^2 (127,354 sq mi) and the estimated population in year 2010 is 28.25 million. In addition, the GDP (nominal) of Malaysia in year 2010 is total of $191.674 billion ($6,896 per capita) whereas GDP (PPP) in year 2009 is total of $382.257 billion ($13,551 per capita).

Petrochemicals are the crucial link in a chain that consents to crude oil or natural gas to be transform into a full bunch of sophisticated and refined chemicals and consumer products. Natural gas and crude oils are the basic raw materials for the manufacture of petrochemicals. Secondary raw materials, or intermediates, are obtained from natural gas and crude oils through different processing schemes. The intermediates may be light hydrocarbon compounds such as methane and ethane, or heavier hydrocarbon mixtures such as naphtha or gas oil. Both naphtha and gas oil are crude oil fractions with different boiling ranges. Two main petrochemical classes are olefins and aromatics. The primary petrochemical industry makes basic chemicals such as ethylene, usually from gas or oil. Secondary petrochemical industries convert basic petrochemicals into certain materials that can be used directly by other industries. The major raw materials (oil and natural gas) include primarily of hydrocarbons, and such petrochemicals contain carbon or hydrogen or both. Petrochemicals can be modified into variety of industrial and consumer products, which includes paint, plastic, rubber, detergents, dyes, fertilizers, textiles, and even solvents. Besides, many compounds now considered as petrochemicals were formerly made out from wood and coal. Petrochemicals are vital building blocks for most innovations, which permit industry to endow with solutions to society's challenges such as energy, food or health care. It is interesting to note that one third of the world chemical market is in the Asia Pacific region. The big demand for chemical products in this region is due to the massive infrastructure development and industrialization program going on in the region. The accessibility of hydrocarbon feedstock from indigenous oil and gas has led to the expansion of the petrochemical industry. According to MIDA (2009) "The petrochemical industry is an important sector in Malaysia with investments totalling RM 57.2 billion as at the end of 2008."

MIDA (2009) also stated that "The petrochemicals sector is a main contributor and pillar industry to overall manufacturing in Malaysia and also the pillar industry of national economy, which itself contribute about 30 percent of the gross domestic product. The petroleum and petrochemical industry covers natural gas, petroleum products and petrochemicals. The industry is an important sector in Malaysia with investments totalling RM57.2 billion as at 2008." The production of petrochemicals has been stimulated by the ease of use of natural gas as feedstock for the industry. Natural gas is primarily used for the production of liquefied natural gas (LNG) and power generation. Malaysia is currently the third largest producer of LNG in the world, after Algeria and Indonesia. As of January 2007, Malaysia held 75 trillion cubic feet (Tcf) of proven natural gas reserves as of. While much of the country's oil reserves are found off Peninsular Malaysia, much of the country's natural gas production comes from Eastern Malaysia, especially offshore Sarawak (EIA 2007).

According to the Malaysian Industrial Development Authority (MIDA) 2009 reports, Malaysia has the world's 24th largest crude oil reserves (inclusive condensates), which comes to 5.52 billion barrels. In 2008 the Petrochemical

Industry is one of the leading industrial sectors with total investments of RM 57.2 billion. Overall, Malaysian investments in the industry amounted to RM 35.6 billion (62%), with PETRONAS being the major investor. The largest source of foreign investments in the petrochemical industry is the USA (40%), followed by Germany (22.8%) and Japan (14%).

The production index of chemicals and chemical products expanded by 23% to 117.5 from year 2009 to 2010, sales value recorded a 25.2% increase from RM54.1 billion to RM67.7 billion for the January-May 2010 period. Exports of chemicals and chemical products, and petroleum products also recorded increases of 37.8% and 58.2% respectively compare to year 2009. At present, there are 42 companies with a collective capacity of 1.2 mln tpa and 20 companies producing various types of lubricating oils (Plastic News 2009). With an annual average of 20% export surplus, Malaysia is one of the 20 largest export nations worldwide and is ranked 28th out of 121 countries by the "Global Enabling Trade Report 2009", published by the World Economic Forum.

Malaysia's total exports to China have increased from US$1.29 billion in 1995 to US$18.06 billion in 2008. Even more remarkable is Malaysia's export of petrochemical to China which has swelled 26 times from US$43 million to US$1.15 billion within the same phase.

A wide range of petrochemicals are produced in Malaysia are displayed as below:

Manufactured Products	
Paraxylene, Benzene	Acrylic Acid
Ammonia	Polyester Copolymers
Acetic Acid	Purified Terephthalic Acid
Ethylene	Dispersion Polyvinyl Chloride
Ethoxylates	Methyl Methacrylates Copolymers
Propylene	MTBE
Ethanolamines	Polyacetals
Ethylene Oxide	Ethylene Glycol
Polyethylene & Low Density Polyethylene	Plasticizers

Vinyl Chloride Monomer	Butanediol
Ammonia, Urea	Tetrahydrofurane
Liquefied Natural Gas	BTX
Glycol Ethers	Butyl Acetate
Butanol	Polypropylene
Middle Distillates	Polystyrene
Esters	Ethylbenzene, Styrene Monomer
Syngas	Expandable Polystyrene
Oxo-alcohols	Ethylene Vinyl Acetate
Phthalic Anhydride	Gamma-butyrolactone
Polyvinyl Choride	

Table 1.1 List of petrochemical products produced in Malaysia

1.2 AIMS AND OBJECTIVES

Malaysia has significant known reserves of oil and natural gas. This paper discusses the position of Malaysia as one of the major petrochemical manufacturer in the world and the future development. This paper emphasise on any other potential feedstocks that we can create or make use of to substitute petrochemicals particularly when we are running out of petrochemical resources sooner or later and also to intend a new petrochemicals route based on the current market.

On other hand, by considering the academic aspect, this project able to provide students a thorough knowledge on the petrochemical activities in Malaysia. Besides, this project also make available the data and maps composed and collected throughout the research for future reference or purpose. Nevertheless, this project too can help students in Petrochemical Engineering (new course in UTAR) to attain more information in Petrochemical Outlook in Malaysia and its Future Trend for study intention. Furthermore, this project can contribute information or records to Malaysia petrochemical industries that is yet to be explored or done by others. Moreover, upon completion of the project, active petrochemical companies in Malaysia can be introduced and revealed in order to grant UTAR's Chemical

Engineering students a better understand in the Oil and Gas industry for future job hunting.

As we know, economic management remains exigent amidst an environment of constantly high crude oil prices, mounting global interest rates and rising competition from China, India and other emerging regional economies. On the external front, concern over high crude oil prices following strong demand and tight refining capacity as well as heightened geopolitical tensions in the Middle East are expected to stay. This could lead to an unremitting rise in global inflation and subsequent hikes in global interest rates, impacting both trade and growth. The current global imbalances can also have an uncontrollable consequence on the financial markets and hinder world trade as well as investment flows. However, rising inflation due to higher crude oil prices could pose a challenge to the financial stance.

Furthermore, we might need to consider one of the biggest predicaments in petrochemical industry: how long will it take for all the reserves in the earth to be depleted when the consumption in just the past few years had doubled. In addition, as the supply dwindles and demand increases, this will create considerable price pressure. The question is, are we going to stay dependent on the resources till it runs out or are we going to find alternatives to liberate ourselves from this reliance. Furthermore, in the post industrial era, the abundance of natural resources can no longer guarantee the prosperity of a nation. The key is to develop productive capacity to add economic value to the primary and intermediate products using environment-friendly and sustainable production technology. The challenge for the industry is, especially the chemical engineers in this country, to come up with innovative and economically viable product and process to consolidate this plan.

However, the long term reliability and security of gas supply assures the sustainable development of Malaysia’s petroleum industry. The Malaysian petrochemicals industry will exhibit strong growth in 2010 and beyond as the domestic market flourishes and exports recover, which will prompt a revival of projects shelved during the economic downturn.

CHAPTER 2

LITERATURE REVIEW

2.1 HISTORY OF WORLD PETROCHEMICAL

In 1872 the first chemical to be made from petroleum is identified as carbon black, was produced by the partial combustion of natural gas in air. Carbon black is then used mainly in the production of synthetic rubber. Cracking was introduced into crude oil refineries in 1913 where cracking is the name given to breaking up large hydrocarbon molecules into smaller and more useful bits. This is achieved by using high pressures and temperatures without a catalyst, or lower temperatures and pressures in the presence of a catalyst. Extensive production of petrochemicals grew out of efforts to recover and use the chemical by-products of the cracking process. The modern petrochemical industry started in 1920 with the opening of the Standard Oil Company plant in New Jersey. Propylene, the original petrochemical feedstock, is a by-product of refinery cracking of gasoline.

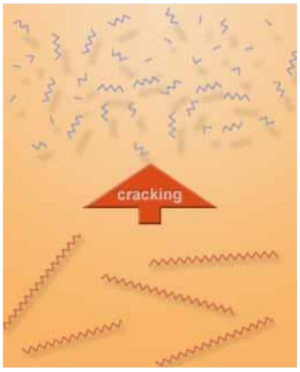


Figure 2.1 Cracking of Crude Oil

The first petrochemical use of ethylene occurred when Union Carbide opened a plant in 1923. The World War I era inspired the growth of the petrochemical industry, with the British extracting benzene and toluene from petroleum. During World War II the industry in the United States extended swiftly to meet up the increased demand for petrochemicals. Scientists in Western Europe began creating chemicals that could be other alternative for natural products in the 1950s and ‘60s. Because of the industry's dependence on crude oil and natural gas supplies, the 1970s oil crisis, during which oil supplies turned down and prices escalated, negatively affected the whole petrochemical industry.

The history of oil and gas in Malaysia started in the early 19th century with the first oil discovery in Miri, Sarawak, in 1910 (Bowie, 2001). However, it took almost half a century before several oil majors such as Shell, Esso and Conoco, started the exploration and commercial production of the oil and gas. Until the early 70s, the exploration and production activities were mainly by foreign concessionaires with royalty considerations to the Malaysian Government. However, the industry took a significant turn with the establishment of Petronas in 1974 under the Petroleum Development Act. Within half a decade, Petronas has already made significant contribution to the development of oil and gas in Malaysia, taking the leading role in upstream, refining and downstream activities, including petrochemical production.

2.2 GLOBAL PETROCHEMICAL INDUSTRY: AN OVERVIEW

The history of the development of the modern petroleum industry is a history of scientific invention and technological innovation. The over-100-year history of the petroleum industry fully proves that science and technology are the keys to the success of the petroleum industry. The petrochemical industry of today is a crucial part of the manufacturing and consuming sectors, whipping out products which include paint, plastic, rubber, detergents, dyes, fertilizers, textiles, and even solvents.

The petrochemical industry began to thrive in the 1920s, when petroleum producers and chemical manufacturers started to undertake research on how petroleum and natural gas might be used as a less expensive source of organic raw materials than coal.

During the 1960s and into the 1970s, world petrochemical production and trade were almost totally in the hands of producers in the US, Western Europe and Japan. These regions supplied their own needs, dealed with each other to some point, and supplied all other regions.

During the 1970s, numerous of developing countries come to the stage at which their domestic markets became huge enough to justify local production of integrated petrochemical facilities. Industrial and technical infrastructure was also adequately developed, and financing became promising from local and international sources. These projects in countries like Korea, Taiwan, Brazil and Mexico modified global trading patterns by reducing or stabilizing exports of some commodity products from the developed regions.

During the early 1980s, the first predominantly export-oriented petrochemical projects were developed, in Western Canada and in the Middle East, following the earlier trends in ammonia and methanol. Oil prices and hence feedstock costs in the industrialized regions were by this time at such high levels that inconsistent costs came to rule the economics of commodity petrochemical production. Feedstock position had become the main source of competitive advantage in petrochemicals, and the prospects of cheap feedstock in parts of the world with surplus gas led to the developments in the Middle East and elsewhere. These took trade share away from the main industrialized regions: Japan was eliminated as a significant net petrochemical exporter, and the US and Europe competed for what was left.

Declining real oil prices through the 1980s eroded this competitive advantage, so new export-oriented project approvals were few. The Saudi Arabian producer SABIC, however, continued to invest through the depths of the recession, despite the low oil/feedstock price environment, confident of its competitive advantage under any market conditions.

In the 1980s petrochemical costs rose with oil and gas prices and Middle Eastern countries began to develop their own petrochemical plants. During this period 5 percent of the crude oil and 3 percent of the natural gas produced were used to make petrochemicals. In the 1990s, despite relatively low oil prices, several major new export projects have been approved in the Middle East, which will further increase the region's impact on global trade. Until the early 1990s, Asian ethylene production capacity accounted for less than 20% of total world production, with the region depending on excess petrochemicals in US and Europe to satisfy its demand. Production capacities for ethylene in the Middle East will more than double in the next five years, rising from over 13 million metric tons in 2007 to over 29 million metric tons in 2012. This represents nearly half of global capacity growth.

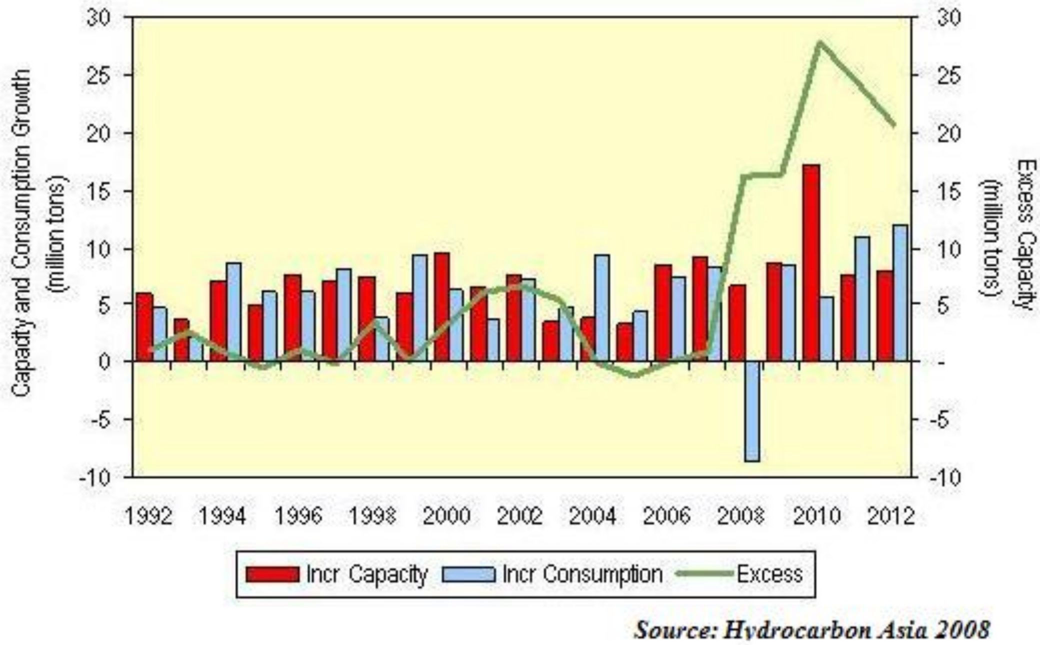


Figure 2.2 Global Ethylene and Propylene Balance

Figure 1 illustrates the global ethylene and propylene balance from year 1992 to year 2012. By observing the graph, we can see that when there is an increase capacity, increase consumption will plunge. This is because excess capacity of ethylene and propylene occurred and over supply of ethylene and propylene take place. On the other hand, when increase capacity reduces, increase consumption will soar. This come to pass because demand is greater than supply, therefore, there will be a shortage of ethylene and propylene. In year 2008 – 2009, economic downturn and causes the downbeat in increase consumption. On year 2010, the increase consumption of global ethylene and propylene arise because there is ample of newly built petrochemical plants and companies go on in Middle East and East.

Generally, two types of feedstock may be used – natural gas (eg. methane) or naphtha. Ethane’s high yields (more than 40% compared with 30% for naphtha) make it the cheapest feedstock. However, it is expensive to transport, limiting its use as a feedstock to countries with ready access to source. This gives countries with natural gas reserves a distinct feedstock advantage.

In view of its cleaner combustion, gas has been promoted as fuel substitutes to oil and coal, and has so far used widely for power generation and domestic heating worldwide. Apart from being energy source, gas played an important role as the main feedstock for petrochemical industry. In view of the significant economic growth of the developing countries, with China and India taking the lead, there was also significant demand growth for gas to provide the fuel for power and the petrochemical feedstock required. This has led to the steady increase in the gas price though not as drastic as for the crude oil.

2.3 PETROCHEMICAL INDUSTRY IN MALAYSIA: AN OVERVIEW

Malaysia is well endowed with both conventional (non-renewable) and non-conventional (renewable) sources of energy. The largest non-renewable energy resource found in Malaysia is petroleum (i.e. oil and gas) which is being actively exploited. Malaysia's domestic oil production occurs offshore and primarily near Peninsular Malaysia. Most of the country's oil fields contain low sulphur, high quality crude.

Year	Gross domestic product based on purchasing-power-parity (PPP) per capita GDP	Percent Change
2000	9083.4	7.33 %
2001	9135.399	0.57 %
2002	9578.898	4.85 %
2003	10158.502	6.05 %
2004	10902.125	7.32 %
2005	11610.472	6.50 %
2006	12477.738	7.47 %
2007	13400.566	7.40 %
2008	14081.496	5.08 %
2009	13551.394	-3.76 %
		Source: ***CIA World Factbook February 19, 2010***

Table 2.1 GDP per Purchasing-Power-Parity (PPP) per Capita in Malaysia

By referring the GDP (PPP) per capita at the table above, we can see that GDP in Malaysia increases constantly over the past 8 years and under the vision 2020 industrial program, the GDP is set to grow by about 7.5% per year up to the year 2020.

Malaysia is endowed with natural gas reserves that are three times larger than its oil reserves. Most of these gas reserves are located offshore Peninsular Malaysia, Sarawak and Sabah. These natural gas resources are carefully harnessed to serve as the main source of fuel for Malaysia's industrialization through the Industrial Master Plan, charting out the long-term energy utilization strategy for Malaysia. This saw Malaysia ushering in the gas era in the 1980s with the introduction of natural gas as a source of fuel for power generation and industrial development as well as the harnessing of the gas resources for foreign exchange earnings in the form of liquefied natural gas exports.

As energy prices soared, Malaysia's wealth of oil and natural gas for feedstock was a major attraction, helping to draw in foreign direct investment. Figures from the Malaysian Industrial Development Authority showed total investment in the petroleum products and petrochemicals industry rising steadily to 57.2 billion Malaysian ringgit, or $15.8 billion, at the end of last year from 56.9 billion ringgit at the end of 2007 and 55.5 billion ringgit a year earlier.

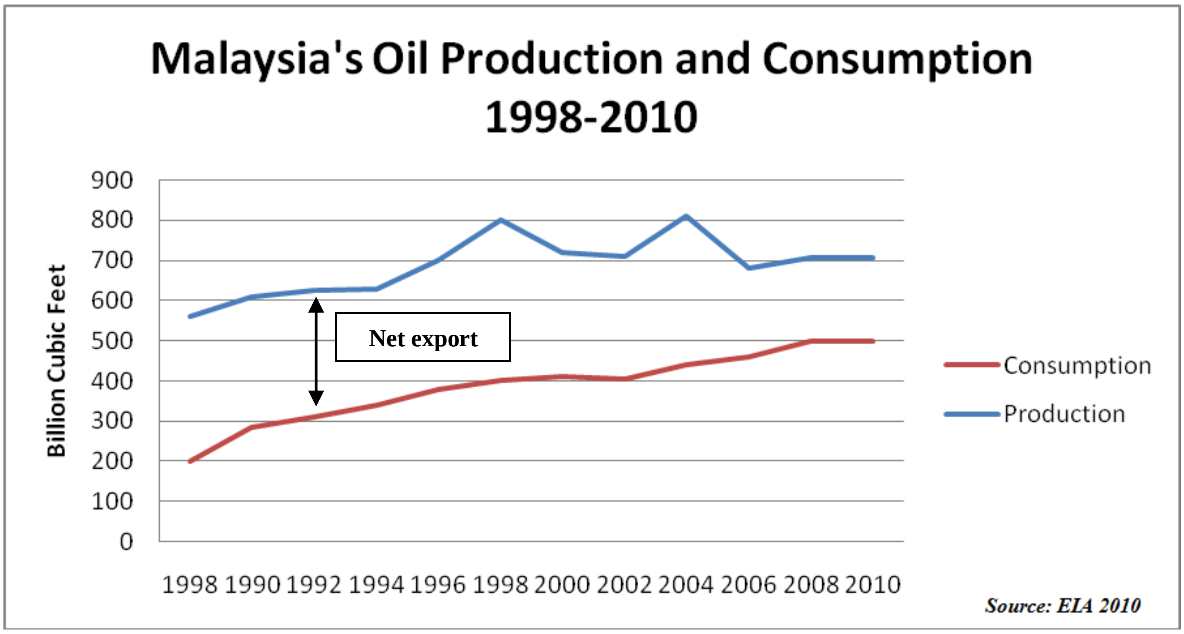


Figure 2.3 Malaysia's Oil and Consumption, 1998-2010

By referring to figure 2, Malaysia's oil production and consumption augment from year 1998 to year 2010 although there is some ups and downs in the oil production due to the closing down and opening up of new and existing petrochemical plants in Malaysia. Malaysia's oil production is always in excess of production.

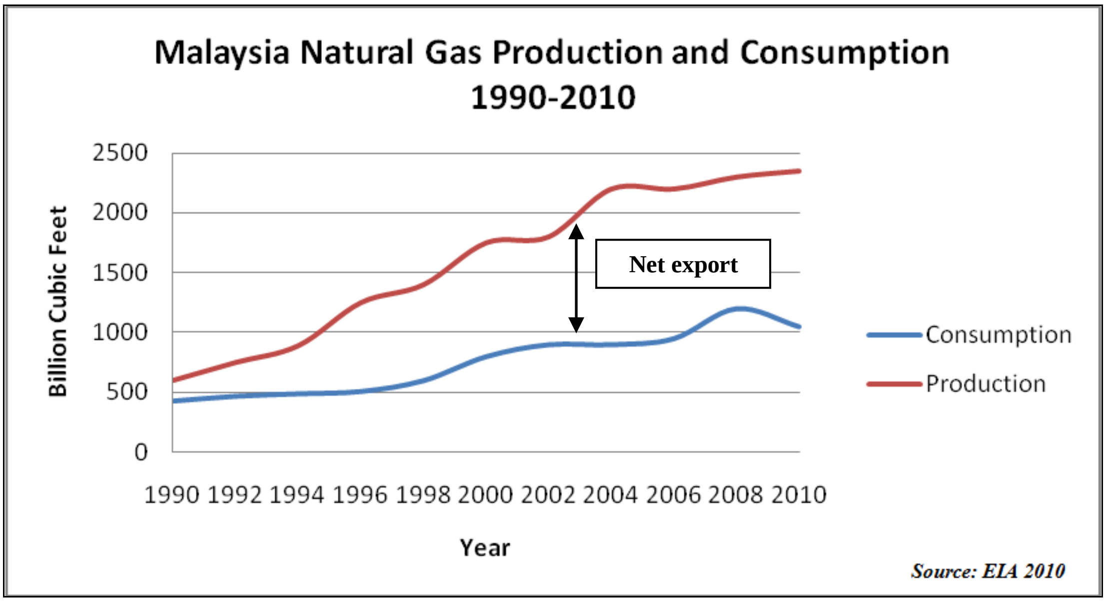


Figure 2.4 Malaysia's Oil and Consumption, 1998-2010

Conversely, natural gas production has been going up gradually, reaching 2.1 Tcf in 2009, while domestic natural gas consumption has also increased steadily, reaching 1.0 Tcf in 2009. There are quite a few important ongoing projects that are expanding natural gas production in Malaysia in the future. Exploration and expansion activities in Malaysia persist to focus on offshore Sarawak and Sabah.

The domestic investor in Malaysia's petrochemical industry is none other than PETRONAS. In addition, existence of significant players in petrochemical industry such as ExxonMobil and Shell for more than 100 years in our country strongly proved their confidence and reliance in the particular industry. The reason behind the rapid growth of this industry is contributed by several grounds which will be further discussed in Chapter 4. The presence of world renowned petrochemical companies, such as Dow Chemical, BP, Shell, BASF, Eastman Chemicals, Toray, Mitsubishi, Idemitsu, Polyplastics, Kaneka, Dairen and West Lake Chemical speaks clearly of Malaysia's potential as an investment location for petrochemical industries. Most of these companies are working in collaboration with Malaysia's national petroleum company, PETRONAS.

2.3.1 COMPARISON OF PETROCHEMICAL ACTIVITIES IN SINGAPORE AND MALASIA

The petrochemical industry in Singapore is undergoing a major expansion. Investment over the past decade has been in the region of $US 2 billion per year for several years, representing about a third of Singapore’s annual manufacturing investments. Much of this investment is in the form of joint ventures with Japanese petrochemical companies. These investments are set to establish Singapore as a major player in the export markets of the Far East and, because of the close proximity, a major competitor to Malaysian and Australian petrochemical industry.

On the islands are two large oil refineries (Esso Singapore Pte. Ltd. (227,000 bbl/d) and Singapore Refining Company (285,000 bbl/d). Petrochemical feedstock supply can be supplemented from other Singapore refineries (Shell Eastern Petroleum (405,000 bbl/d) on Pulau Bukom and Mobil Oil Singapore (255,000 bbl/d) on the mainland near Jurong. The Mobil refinery is integrated with a large aromatics complex producing para-xylene, benzene and cyclo-hexane for the production of polyester and polyamides elsewhere in the Far East. According to Plastic News (2008) Over 90% of Singapore’s petrochemical products are exported in the Asia-Pacific region.

Singapore petrochemical activities are more on concentrating naphtha as a feedstock and the cracking operations in Singapore are based on the cracking of naphtha. Naphtha steam cracking generates a very broad spectrum of primary products. The large ethylene production feeds downstream plants producing polyethylene, styrene, ethylene glycol, ethylene oxide and EO derivatives. On the other hand, petrochemical activities in Malaysia compromise of broader range of feedstock like naphtha, crude oil and also natural gas.

In sum, Singapore's petrochemical plants are currently fairly competitive compared with others in Asia especially Malaysia, given their large size and modern technology. Furthermore, they are also currently in a relatively stronger financial position measure up to Malaysia's financial status.

2.4 MAJOR PETROCHEMICAL ACTIVITIES IN MALAYSIA: AN OVERVIEW

There are numerous types of petrochemicals and petrochemical end products. Some have consumer uses and others are mainly for industrial use. The primary petrochemical industry produces substances such as methanol, ethylene, toluene, and propylene directly from feed stocks. Intermediate and derivative petrochemicals are generally produced when primary petrochemicals are converted to a more complicated form. Such products include vinyl acetate for paint, vinyl chloride for PVC, and styrene for rubber and plastic.

Since feed stocks and the resulting petrochemical products vary, there are a number of production methods. An ethylene producing petrochemical plant is likely use a method known as catalytic cracking, which utilizes high pressure and high temperatures to crack natural gas by repeated compression and distillation. In a methanol producing petrochemical plant, a reforming process is likely to be used. This method employs high temperature steam, medium pressure, and a catalyst to produce the product.

Differing factors, such as feed stocks, end products, production method, and location, result in numerous types and configurations of petrochemical plants. There are, however, characteristics of petrochemical plants that tend to be standard. For example, almost all petrochemical plants need extensive pipeline networks. Most use furnaces and rotating equipment. Although the sizes vary, every petrochemical plant needs an expanse of land to operate on.

Two petrochemical classes are olefins including ethylene and propylene, and aromatics including benzene, toluene and xylene isomers. Oil refineries produce olefins and aromatics by fluid catalytic cracking of petroleum fractions. Chemical plants produce olefins by steam cracking of natural gas liquids like ethane and propane. Aromatics are produced by catalytic reforming of naphtha. Olefins and aromatics are the building blocks for a wide range of materials such as solvents, detergents, and adhesives. Olefins are the basis for polymers and oligomers used in plastics, resins, fibers, elastomers, lubricants, and gels.

Methane, coal and biomass are being considered as alternatives to crude oil for the production of basic petrochemicals, such as light olefins.

Malaysia offers two great advantages to the petrochemical industry. Firstly, the raw materials for the petrochemical industry - oil and gas are present naturally in abundance off the shores of Malaysia. Secondly the Malaysian government has invested in petrochemical related infrastructure in specially designated zones to support such an industry.

Currently there are 27 petrochemicals plants throughout the country producing 38 different types of petrochemicals. Besides, there are 41 companies in operation with a capacity of 12.8 million tons of petrochemical products annually (The Asia Petrochemical Industry Reference 2009). The chemical industry in Malaysia is, however, broadly categorize into various sectors: oleochemicals, petroleum and petrochemicals, surface coatings, and the fine chemical sectors.

Basically, there are three types of operations in petrochemical industry which is divided into three major components: upstream, midstream and downstream. In general, midstream is always included in the downstream operation. The upstream oil sector is a term commonly used to refer to the searching for and the recovery and production of crude oil and natural gas. Upstream applies to the operation of exploration, drilling, hydrocarbon production, and transmission via truck, rail or ship or pipe line to the refinery intake valve. The upstream oil sector is also known as the exploration and production (E&P) sector. Downstream includes all work done at the refinery, distillation, cracking, reforming, blending storage, mixing and shipping.

Downstream in oil sector is a term regularly used to refer to the refining of crude oil, and the selling and distribution of natural gas and products derived from crude oil. Many of the downstream operations involve multinational corporations in a leading role.

There are two major ethylene plants that endorse in downstream operations in Malaysia. The main petrochemical zones are in Kerteh, Terengganu (Oil & Gas); Gebeng, Pahang(Gas); and Pasir Gudang/Tanjung Langsat, Johor (Naphtha). Each zone is an integrated complex with crackers, syngas and aromatics facilities to produce feedstocks for downstream products.

There are also other petrochemical plants in Malaysia such as the ammonia and urea plants in Bintulu, Sarawak and Gurun, Kedah; acrylonitrile butadiene styrene plant in Pulau Pinang; methanol plant in Labuan and the nitrile-butadiene rubber plant in Kluang, Johor.

Natural gas reserves discovered off the east coast of Peninsular Malaysia have been earmarked for domestic utilisation. These gas resources are harnessed via the Peninsular Gas Utilisation (PGU) System which was first developed in 1984. Under this system, offshore gas is landed via five offshore gas gathering pipelines and landed at Kertih in the state of Terengganu. The main consumer of the PGU gas is the power sector where the processed gas is used as fuel for electricity generation. Today, natural gas accounts for over 60% of the fuel mix in Malaysia's power sector.

The production of petrochemicals also uses naphtha obtained from petroleum refining. Naphtha is available from the existing petroleum refineries in Peninsular Malaysia, and the gas-based middle distillates syntheses (MDS) plant in Bintulu, Sarawak. To complement domestic requirements, a large proportion of naphtha is also imported. The naphtha cracker in Pasir Gudang-Tanjung Langsat, Johor, provides ethylene, propylene and butadiene as feedstocks for the production of polypropylene, polyethylene and aromatics. It also provides feedstock for the production of ethylene vinyl acetate (EVA). It is also used in the petrochemical industry for producing olefins in steam crackers and in the chemical industry for solvent (cleaning) applications.

Major products manufactured in the three petrochemical zones are:

Zone	Core Products	Derivatives and Products
Kerteh, Terengganu	**Ethylene, propylene, para-xylene, benzene and syngas**	**Ammonia, acetic acid, polyethylene (PE), ethanolamines, ethoxylates, glycol ethers, butanol, butyl acetate, ethylene oxide (EO), ethylene glycol (EG), vinyl chloride monomer and polyvinyl chloride (PVC)**
Gebeng, Pahang	**Propylene and syngas**	**Polypropylene (PP), acrylic acid and esters, butyl acetate, oxo-alcohols, pthalic anhydride and plasticisers, butanediol, tetrahydrofurane, gamma-butyrolactone, polyester copolymers, (PETG), purified terephthalic acid, dispersion PVC (DPVC), methyl metacrylate copolymers, methyl tertiary butyl ether (MTBE) and polyacetals**
Pasir Gudang-Tanjung Langsat, Johor	**Ethylene, propylene, benzene, toluene, xylene and butadiene**	**Polyethylene (PE), polypropylene (PP), ethylbenzene (EB), styrene monomer (SM), polystyrene (PS), expandable polystyrene (EPS) and ethylene vinyl acetate**
Source: Country Report from Malaysia, Malaysian Petrochemicals Association (MPA) Asia Petrochemical Industry Conference 2007		

Table 2.2 Major products manufactured in the three petrochemical zones

2.4.1 Naphtha

So far, naphtha remains the dominant feedstock. Ethane is used in several countries, where it is available from local natural gas developments. There has been a continued decline in the use of gas oil. LPG is a minor contributor to feedstock in the region, which is in contrast to the USA.

Petrochemical Complex in Pasir Gudang

PETRONAS has built two plants producing ethylbenzene and the styrene monomer, in partnership with Idemitsu. The plants commenced operations in 1997. Alongside PETRONAS, Titan Petrochemicals had earlier constructed larger facilities involving two naptha crackers, five polymer plants, a BTX unit and two cogeneration plants and their associated facilities. The development started in the 90s and to date Titan has earned the reputation of being the largest integrated olefins and polyolefins producer in Malaysia and the second largest polyolefins producer in south east Asia in terms of capacity.

The other major olefins plants are at Pasir Gudang in Johor operated by the Titan Group and these plants make use of naphtha or LPG as feedstock, which can be imported via the large Johor port. Pasir Gudang in Tanjung Langsat, located next to the port of Johor is an established industrial area. The other major olefins plants are at Pasir Gudang in Jahor operated by the Titan Group. These plants utilise naphtha or LPG as feedstock that can be imported via the large Jahor port. Initially built around providing feed to polyolefins plants, these facilities are expanding to produce aromatics. Titan Petrochemical is Malaysia's first and largest integrated producer of olefins and polyolefins, and one of the largest polyolefins producers in South-East Asia.

The main products are olefins (ethylene and propylene) and polyolefins (polyethylene and polypropylene). It has ten world-class manufacturing plants located on two integrated industrial sites in Pasir Gudang and Tanjung Langsat, Johor. Titan's integrated operation in Pasir Gudang-Tanjung Langsat, Johor includes a naphtha cracker which provides feedstock for its own production of polypropylene, polyethylene and aromatics. It also provides feedstock for the production of ethylene vinyl acetate (EVA). Naphtha is available from the petroleum refineries and Shell's middle distillates synthesis (MDS) plant in Bintulu Sarawak. To cope with the needs of the growing petrochemical industry, the adjacent Tanjung Langsat site has been developed to enhance manufacturing capacity.

Figure 2.5 Petrochemical Complex in Pasir Gudang

The 222 acre integrated complex consists of the following plants:

- 2 cracker plants that breakdown the raw materials (feedstock) such as naphta into intermediate products such as ethylene, propylene (both olefins) and pyrolysis gas.
- An aromatics plant that converts the pyrolisis gas into finished chemicals such as benzene and toluene (liquid form).
- 5 polyolefin plants that produce a wide range of polyethylene and polypropylene pellets (homopolymer polypropylene, copolymer polypropylene, linear low density polyethylene (LLDPE), low density polyethylene (LDPE), high density polyethylene (HDPE) and metallocene LLDPE (mLLDPE).
- A cogeneration plant that partly utilises some byproducts generated by the other plants to generate electricity and heat for the other plants.

2.4.2 Natural Gas and Oil

Crude oil is not a homogeneous material. Its physical appearance varies from a light, almost colourless liquid to a heavy viscous black/brown sludge whereas Natural gas is a mixture of light hydrocarbons, predominantly methane. Around three-quarters of the world’s natural gas is found in separate accumulations from crude oil (‘non-associated gas’); the remainder is found in combination with or in solution in crude oil (‘associated gas’). A typical barrel of NGLs contains natural gasoline, isobutane, propane, butane, and ethane.

Petrochemical Plants in Kerteh

The Kerteh site was designated to focus on ethylene based petrochemical products. Petrochemical plant incorporated in Kerteh, Terengganu is the oldest and biggest in Malaysia known as Kerteh Integrated Petrochemical Complex (KIPC) where the plant uses gas from the major oil and gas fields off the eastern coast of the Peninsula. Kerteh is the base of operations for Petronas in Terengganu, overseeing the oil platform operations off the state's coast as well as petrochemicals production and crude oil refining in nearby Paka. It houses the Petronas Petrochemical Integrated Complex (PPIC) that links the entire range of the oil and gas value chain – beginning from upstream exploration and production to the final stage of petrochemical manufacturing. The major downstream processes were essentially based on ethylene (polyethylene etc.).

Here, the gas is processed and separated at six gas processing plants before being transmitted through a more than 2,500 km cross country pipeline network to end users in the power, industrial and commercial sectors within the peninsula and for export to a power station in Singapore. The natural gas distribution network system consists of steel feeder lines and polyethylene pipelines to facilitate the delivery of an environment friendly fuel to end users in the industrial, commercial and transportation sectors.

The six gas processing plants located in Kerteh, Terengganu are built with a combined capacity of 2,000 million cubic feet (mmscf) of sales gas per day to ensure the industry an adequate supply of petrochemical feedstocks such as methane (sales gas), ethane, propane, butane and condensates. The two ethane crackers in Kerteh, Terengganu which use from the six GPPs in Kerteh and Tok Arun, Terengganu provide feedstock for the polyethylene plants, acetic acid plant and DOW PETRONAS ethylene derivatives complex. Condensates from the GPPs also provide feedstock to the aromatic plant in Kerteh, Terengganu for the production of paraxylene and benzene. KIPC channels some 400,000 barrels of crude oil (about 60% of Malaysia crude oil) and 2,200 million cubic feet of LPG (about 45% of Malaysian LPG) from off-shore rigs off Terengganu daily (Petronas Department of Media Relations and Information 2004).

With ready feedstock from Kerteh Integrated Petrochemical Complex and Gebeng Integrated Petrochemical Complex, the Kertih Plastics Park (KPP) is linked by road and rail to Kuantan, which is the region's export hub. The KPP is expected to be fully operational in 2015, attracting RM2 billion worth of investments and creating more than 7,000 jobs (East Coast Economic Region 2010).

Figure 2.6 Petrochemical Plant in Kerteh

<u>Petrochemical Complex in Gebeng</u>

Gebeng was designated for propane-based petrochemical productsThe Gebeng Integrated Petrochemical Complex (GIPC) concentrates on propylene-based products. Malaysia's Peninsular Gas Utilisation (PGU) trans-peninsular gas transmission pipeline channels delivers gas to industries around the country. The Peninsula Gas Utilization (PGU) pipeline project which delivers gas down the east coast to another integrated petrochemical project at Gebeng in Pahang State, is under development. Gebeng in Pahang is another petrochemical hub for multinational players like BASF, Amoco, Kaneka, Eastman and Polyplastics. The petrochemical zone provides an integrated environment that meets the specific needs of the petrochemical industry. This complex, in which BASF is a major player, produces acrylates, oxoproducts and derivatives. The PGU also delivers gas to a large fertilizer complex at Gurun in Kedah State on the west coast. Propane from the GPPs is the raw material for the propane dehydrogenation plant in Gebeng, Pahang. This provides feedstock to the polypropylene and MTBE plants and to the BASF PETRONAS integrated propylene derivatives complex for the production of acrylics, oxo alcohols, butanediol,butylacrylates, plasticisers and tetrahydrofurane.

Figure 2.7 Petrochemical Plant in Gebeng

The first of the two petrochemical plants built at the two sites were MTBE-propylene & polypropylene (1990 in Gebeng) and ethylene-polyethylene (1991 in Kertih). Other important facilities in Kertih and Gebeng are Aromatics Complex, Polyvinyl Chloride-Ammonia-Syngas Plant, Acetic Acid Plant, Ethylene Cracker, Propane Dehydrogenation Plant, Oxo-Alcohols Complex, Acrylic Acid-Acrylic Esters Plant and a Butandieol Plant.

Bintulu Petrochemical Plants

Malaysia's largest producer of liquefied natural gas (LNG) produced from the Central Luconia field, off the Bintulu coast, Sarawak. It covers a land area of 276 hectares and with a combined production capacity of about 23 million tons per annum (Mtpa), and was established in 1978 and Malaysia's national oil corporation, Petronas, is the major share holder. The natural gas is supplied to the plant from the gas fields located between 125 km and 275 km offshore of Bintulu. Japan, China and South Korea are the major buyers of LNG from the Bintulu plant.

Offshore gas feeds a large methanol plant (660,000 tpa) on Labuan Island and an ammonia plant at Bintulu. Also at Bintulu is the large Shell Gas to Liquids plant that produces high valued linear paraffins and wax as byproducts. There are three LNG plants with a combined capacity of 24 million tonnes a year. Furthermore is has an ammonia/urea fertiliser plant. The petroleum products sub-sector includes refinery products such as naphtha, liquefied petroleum gas, gasoline, kerosene, diesel, fuel oils, wax, bitumen and lubricating oils. Presently, five refineries and a gas-to-liquid plant are in operation, processing 714,300 barrels of crude oil per day.

Construction began on the Sabah Oil and Gas Terminal (SOGT) in February 2007 and is scheduled to be completed by January 2010 and start operating by end of 2010. It will have handling capacity of 300,000 barrels of crude and 1 billion cubic feet of natural gas per day and will primarily serve export markets. The Sabah-Sarawak Gas Pipeline project is part of this development. The SOGT will receive, store and export crude oil as well as receive, process, compress and transport the gas produced from the field’s offshore Sabah. Covering an area of about 250 acres, the SOGT will have the capacity to handle up to 300,000 barrels of crude oil per day and 1.0 billion standard cubic feet of gas per day. The crude oil and condensate received and stored at the terminal will be loaded into vessels for export through single point moorings located about 10km offshore Kimanis.

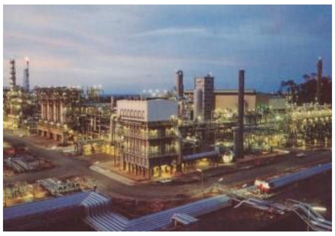


Figure 2.8 Petrochemical Plant in Bintulu

2.4.3 Coal

Coal has been identified as part of our fuel mix strategy and forms part of the long-term development of a sustainable energy supply for the country. Malaysia has a coal mining history dating back as far as 1851. The coal resource of Malaysia to date is estimated at about 1,050 million tons of various qualities ranging from lignite to anthracite; bituminous to sub-bituminous coal, however forms the bulk of this amount (Country Report from Malaysia, Malaysian Petrochemicals Association 2010).

The known resource may be classified into 231.85 million tons proven reserve; 171.38 million tons indicated reserve and 646.84 million tons inferred reserve. Of the total amount, about 69% are found in Sarawak, 29% in Sabah and 2% in Peninsular Malaysia (Country Report from Malaysia, Malaysian Petrochemicals Association 2010).

Most of these known coal areas are located inland where infrastructure is poor. The coal resource in Peninsular Malaysia is negligible. Coal is also another alternative feedstock options to produce large scale of chemical products by using gasification and liquefaction process.

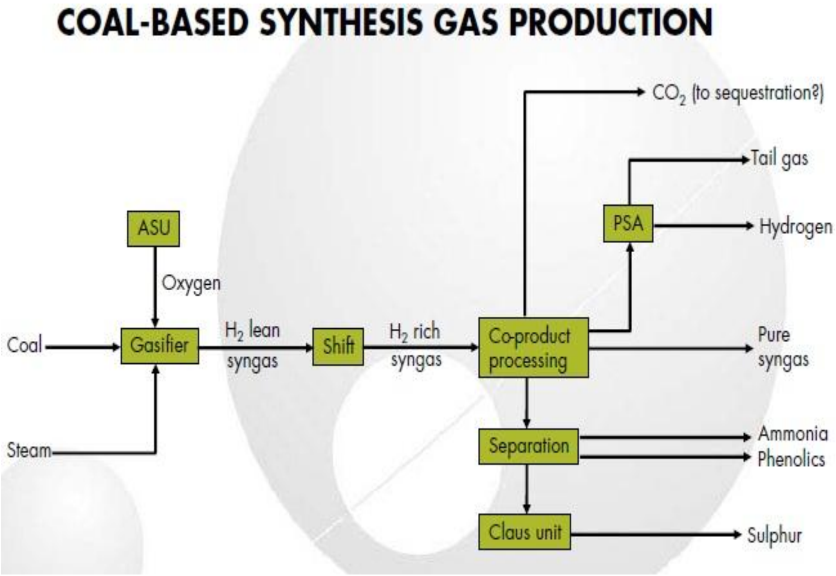


Figure 2.9 Coal-Based Synthesis Gas Production

By synthesizing coal, we can produce different types of gas according the diverse method of operation which are shown in figure above.

In particular, the strong demand and profitability experienced in the mid-1990s led to massive investment plans for capacity expansion, especially in Asia, in line with projections of strong growth in demand. In Southeast Asia, for instance, demand growth rates for base petrochemicals averaged 23% p.a. for 1993-1997, according to industry analyst Chemical Market Associates, Inc. By 2010, Malaysia’s demand for coal is expected to reach 19 million tonnes, according to the Malaysian Chamber of Mines, which champions the cause of the local mining sector.

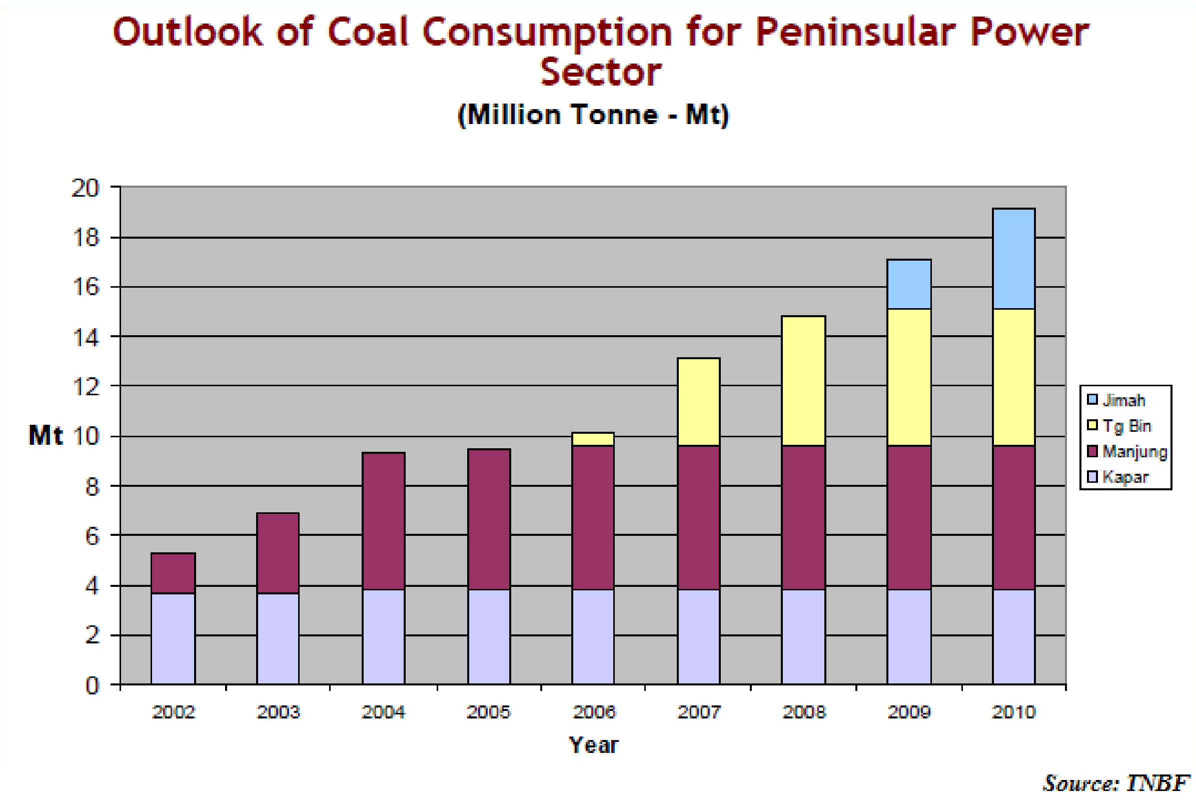


Figure 2.10 Outlook of Coal Consumption for Peninsular Power Sector

According to TNBF, coal consumption will swell continuously for peninsular power sector in the future. This owes to the increase in population in Malaysia where more power is required to generate in order to supply sufficient power to different places, houses and families in Peninsular Malaysia.

There are a few factors influencing the demand and supply of coals in Malaysia. One of the factor that manipulate the demand and supply is the Increasing coal imports from China, India and high demand growth in China, India, Indonesia and other developing nations. Besides, support challenges like Port problems and congestion, labor unrest, derailments and port allocation cut also affect the supply and demand chain. Moreover, logistic glitches like shortage of mining equipments, shortage of manpower, higher stripping ratio, lowering of coal quality and government intervention on price and supply also have an effect on the chain. Lastly, weather and major majeure like unpredictable rainy season resulting in mine flooding and storm causing vessels unable to berth also have impinge on the chain.

Table 10 shows the known coal resources in Malaysia where different types of coal exist in diverse location.

LOCATION	**RESERVED**			**COAL TYPE**
	Measured	**Indicated**	**Inferred**	
SARAWAK 1. Silantek 2. Merit-Pila 3. Bintulu 4. Mukah-Balingan	7.25 176.20 - 43.60	10.60 107.08 - 8.30	32.40 121.84 120.00 98.10	Coking coal semi-anthracite, anthracite Sub-bituminous
Sub-total	**227.05**	**125.98**	**372.34**	
SABAH 1. Silimpopon 2. Labuan 3. Maliau 4. Malibau 5. SW Malibau	4.80 - - - -	1.50 - - 17.90 26.00	7.70 8.90 215.90 25.00 -	Sub-bituminous Sub-bituminous Bituminous
	4.80	**45.40**	**257.5**	
PENINSULAR 1. Batu arang	-	-	17.00	Sub-bituminous
Sub-total	-	-	**17.00***	
Grand Total	**231.85**	**171.38**	**646.84**	
Source: Country Report from Malaysia, Malaysian Petrochemicals Association (MPA) 2010				

Table 2.3 Known Coal Resources in Malaysia

2.4.4 Agricultural

Before the rapid development of the petrochemical industry, many feedstocks for manufacturing paints, plastics, fibers, lubricants, adhesives, and a host of other products were derived from agriculture. Good examples are linseed, castor, tung, tall, and soybean oils; natural rubber, gums, starch and cellulose, and many sources of fiber from the plant kingdom, as well as hides, bones, and fats and oils from the animal kingdom. In addition to these traditional agricultural materials, several new plant sources have been developed through new crops research.

When we think of the problems associated with peak oil, our first thoughts may turn to transport, electricity, or plastics. The use that tends not to come to mind, yet could be the most devastating of them all, is agriculture. Also, new ways have been developed for converting existing agricultural products to better chemical intermediates. Availability of farm land, economics of crop production and competition with petroleum are such that agriculture should be considered seriously as a viable alternative for at least part of our chemical feedstock requirements. Considering that about 8% of our oil and natural gas is used for petrochemical feedstocks, this amount could be produced from agricultural crops rather easily.

The development path for this industry has been painted with various mix of strategy driven by goals which shifted according to the demand of time.Agriculture remains an important sector of Malaysia's economy, contributing 12 percent to the national GDP and providing employment for 16 percent of the population. The British established large-scale plantations and introduced new commercial crops (rubber in 1876, palm oil in 1917, and cocoa in the 1950s). The 3 main crops—rubber, palm oil, and cocoa—have dominated agricultural exports ever since, although the Malaysian share of the world's production of these crops declined steadily during the last 2 decades. The Malaysian Agriculture is characterized by two distinct sectors, namely, the plantation sector and the smallholders' sector. Major crops planted are oil palm, rubber, rice, mixed horticulture, coconut and orchard.

Department of Agricultural (2006) stated that "Agricultural area occupied total of 6.6 million ha in Malaysia which is about 20% of total area of 33 million in

Malaysia. At $2.07 billion in 1989, Malaysia's imports of agricultural products from all sources increased 20 percent from the previous year." This made the country the 23rd largest agricultural importer in the world. Polyolefins is one of the main feedstock produced in agricultural sector in Malaysia. Malaysia is a net exporter of polyolefin with export of 620KMT compared to import of 410KMT in 2006. Major exporting destinations were China (including Hong Kong), South East Asia and India Sub-Continent (Malaysia Country Report 2007 Asia Petrochemical Industry Conference).

Taking advantage of its proximity to the Kerteh's major palm oil producing areas and petrochemical feedstock, the Palm Oil Industry Park will be developed within the Kuantan Port for logistical and industry support benefits.

Table below demonstrate the agricultural commodity in Malaysia. In overview, there is an increase of area for assorted agricultural crops sowed in Malaysia.

Commodity	2000	2005	2010
Industrial Commodities			
Oil Palm FFB (metric tonnes/hectare/year)	19.1	22.5	25.0
Rubber (metric tonnes/hectare/year)	1.2	1.3	1.7
Pepper (metric tonnes/hectare/year)	2.1	1.5	1.8
Cocoa (metric tonnes/hectare/year)	0.9	1.2	1.6
Tobacco Grower-Curer System (metric tonnes/hectare/season)	1.1	1.4	1.5
Food Commodities **Paddy (metric tonnes/hectare/season)**			
Granary	3.8	4.5	6.5
Non-Granary	2.2	5.0	5.0
Aquaculture (metric tonnes/hectare/cycle)			
Freshwater	0.4	0.4	0.5
Brackish Water	1.0	1.1	1.1
Miscellaneous			

Pineapple (metric tonnes/hectare/cycle)	16.9	21.1	22.1
Flowers (thousand stalks/hectare/season)	155.6	162.9	190.4
Fruits (metric tonnes/hectare/season)	3.3	4.8	6.8
Vegetables (metric tonnes/hectare/cycle)	10.1	12.1	13.2
Coconut (metric tonnes/hectare/year)	3.0	3.3	3.7
			Source : Department of Agriculture 2006

Table 2.4 Agricultural Commodities in Malaysia

Table 12 shows the areas cultivated with commercial crops in Peninsular Malaysia where the major land use is for the plantation of oil palm and rubber where each of them allocated 1,858,448 and 1,854,744 hectares in Peninsular.

Areas Cultivated with Commercial Crops in Peninsular Malaysia		
Crop	**Hectares**	**% of Total Land Use**
Oil Palm	1,858,448	14.05
Rubber	1,854,744	14.02
Rice	425,080	3.21
Cocoa	46,564	0.35
Mixed Horticulture	289,080	2.19
Coconut	189,785	1.43
Orchard	103,261	0.78
Others	8,462,012	63.97
		Source: Department of Agriculture 2009

Table 2.5 Areas Cultivated with Commercial Crops in Peninsular Malaysia

CHAPTER 3

METHODOLOGY

3.1 EXTENDED SUMMARY

Most petrochemical industry plants today are located near oil-producing and oil refining areas around the world. Such petrochemical plants are costly, with some requiring at least more than $500 million to build. This industry became a hit after the war, with the increasing demand for synthetic consumer products.

The perfect storm on year 2009 causes all the undesirable forces to culminate into one – impact on the global petrochemical. Global economic slowdown, collapse of demand in China, and falling oil prices have significantly impacted the chemical industry. Many companies have announced operating rate cuts and capacity shutdowns to balance the supply in light of demand destruction. Polyolefins pricing in Asia has also declined significantly in the last two months. This trend of declining prices is now affecting other regions such as Western Europe and North America. Platts recently reported that shipments from the Middle East are now headed towards Western Europe due to lack of demand in Asia. Shipping costs have also decreased by almost 30% due to declining demand.

Overall it seems that declining demand has had more adverse effect on the chemical industry than the price declines; since the price declines are complemented with equal decline in raw material costs. The price of naphtha is now much closer to the price of cost advantaged ethane in the Middle East. Therefore, an improvement in demand at lower oil prices could be beneficial to the chemical industry. The largest impact has been on Asian countries due to the decline in demand and prices in China.

The impact will be largest in export-oriented countries such as Singapore, Malaysia, South Korea, and Thailand. Asian countries using naphtha as feedstock saw a decline in cost along with the decline in prices. Companies in Thailand that are based on ethane mainly saw a decline in price without a significant decline in cost. These countries in the short-term will focus on decreasing the operating rates via capacity shut-down. In the medium term the focus will be on shifting exports to countries other than China and increase participation in specialty polyolefins markets.

We can witness that there is a major decrease in global ethylene plants capacity in table below where most of the companies in Asia is operating at a slower pace whereas some of the companies are considering cutting rates or some even had shutdown due to the economy recession.

Company	Country	Ethylene Capacity	Comments
LG Chemical	South Korea	750,000	Considering rate cuts
LG Chemical	South Korea	860,000	Considering rate cuts
Lotte Daesan	South Korea	650,000	Operating at 90%
KPIC	South Korea	460,000	Considering rate cuts
SK Corp.	South Korea	190,000	Shutdown end of Oct 2008
YNCC 1	South Korea	857,000	Operating at 80%
YNCC 2	South Korea	555,000	Operating at 80%
YNCC 3	South Korea	400,000	Operating at 80%
Formosa 1	Taiwan	700,000	Operating at 85-90%
Formosa 2	Taiwan	900,000	Restarted to run at 85-90%
Formosa 3	Taiwan	1,200,000	Restarted to run at 85-90%
CPC 3	Taiwan	230,000	Operating at 65%
CPC 4	Taiwan	380,000	Shut for turnaround until end of Nov 2008
CPC 5	Taiwan	450,000	Operating at 70%
Maruzen	Japan	550,000	Operating at 85%
Mitsubishi	Japan	450,000	Shut down Oct 8 2008, Restarted Oct 23 2008
Mitsubishi	Japan	375,000	Operating at 80-85% until Dec 2008

Mitsubishi	Japan	476,000	Operating at 80-85% until Dec 2008
Mitsui Chem	Japan	600,000	Shut down for repaing in Oct 2008 for 10 days
Nippon Oil	Japan	404,000	Considering rate cuts
Sanyo	Japan	470,000	Operating at 95%
Sumitomo Chem	Japan	416,000	Operating at 96%
Titan Petchem	Malaysia	260,000	Operating at 80%
Titan Petchem	Malaysia	407,000	Operating at 80%
PCS	Singapore	475,000	Operating at 70%
PCS	Singapore	655,000	Operating at 70%
LyondellBasell	United States	770,000	All Capacity down from Oct. 1 to Early 2009
LyondellBasell	United States	300,000 (Propylene)	All Capacity down from Oct. 1 to Early 2009
LyondellBasell	Germany	290,000	Operating Rate cut - actual rate cut unknown
LyondellBasell	Germany	760,000	Operating Rate cut - actual rate cut unknown
LyondellBasell	France	530,000	Operating Rate cut - actual rate cut unknown
			Source: Chemical Market Resources Inc. 2009

Table 3.1 Partial List of Announced Cracker Closures

Despite of the fact that recession had intensely affected the global petrochemical industry, Malaysia is successful in drawing foreign investment constantly. Still, the industry is reassessing its competitive position within ASEAN and especially the ‘threat’ facade by China’s swift industrial expansion. Therefore, the petrochemical industry is facing tougher market conditions when added with deteriorating product prices, slow in demand growth and a massive increase in capacities in Asia and the Middle East.

Prospects for the Malaysian petrochemicals industry solely depend on its capability to promote and preserve competitive advantages over other competing nations in the face of extremely intensified competitiveness in the global market. In the short term, the main agendas at the forefront are likely overcoming feedstock shortages and mechanical hitches. The utilisation of the country’s considerable ethane reserves is vital in maintaining competitiveness with other nations. Moreover, this will be strengthened by the growth and development of our LNG sector.

The use of naphtha as feedstock has caused the unstable feedstock prices, and consequently affected petrochemical demand in the domestic market. This condition will carry on not considering of how enormous domestic reserves that Malaysia have until one day when the prices stabilise. The development of the petrochemical industry in Malaysia is driven intimately by the availability of hydrocarbon feedstock from the local oil and gas industry.

However, Malaysia's chemical and petrochemical industry is perched for recovery this year based on improved overall performance in the first five months of year 2010, as per International Trade and Industry Minister Datuk Seri Mustapa Mohamed. Malaysian petrochemicals industry is set to go ahead of the regional economic recovery in 2010 following the expansion in methanol, propylene and polypropylene (PP) capacities in 2008, however, it will countenance a harsh competitive situation seeing that China ramps up its own capacities. Plastic News (2010) said that "The production index of chemicals and chemical products expanded by 23% to 117.5, sales value recorded a 25.2% increase from RM54.1 billion to RM67.7 billion for the January-May period." Exports of chemicals and chemical products, and petroleum products also recorded increases of 37.8% and 58.2% respectively. Moreover, according to Datuk Mustapa, industry players agreed that this year would be better than 2009 in terms of sales and performance while the industry expected to see steady growth in year 2011.

3.2 RESEARCH METHODS

Basically, there are two types of researches method which are qualitative and quantitative research. In qualitative research, the types of data available are much more extensive than in quantitative research. Qualitative types of data might be categorized in terms of their sources: as open-ended interviews, open-ended observations, and documents (private and public), and audiovisual materials (e.g., videotapes, photographs, sounds). In quantitative research, the forms of data have been reasonably stable over the years. Moreover, structured interview also gathered and observational data in which the response categories are determined before the data collection in a closed-ended fashion. Factual information in the form of numbers from census data, attendance reports, and progress summaries are collected. Again, as with the forms of qualitative data, which options will best address their research questions, assumptions or hypotheses will need to be reviewed. The approach we take to data collection involves systematically gathering information and recording it in such a way that it can be preserved and analyzed by a single researcher or a team of researchers. In qualitative research, much discussion in the literature is directed toward reviewing and anticipating the types of issues likely to arise "in the field" that will yield less-than-adequate data.

3.3 DATA COLLECTION

Data are facts, figures, enumerations and other materials, past and present, serving as basis for study and analysis; they are also the raw material for analysis; provide basis for testing hypothesis, developing scales and tables. Moreover, data also help researches draw inferences on specific issues or problems. Quality of findings depends confidentially on relevance, adequacy and reliability of data. Types of data included secondary data and primary data.

There are few types of data used for completing this paper. Firstly we can collect and compile data by using existing data which already collected by someone else for different or general purpose for examples like retrospective panel study, library statistics, raw data and published directories or reports. On the other hand, we can also use secondary data like published or unpublished literate as supplementary data, for reference purpose, as bench marks or rarely as sole source. There are a few spots we need to take into account while collecting data which are reliability, suitability and adequacy.

The data collection procedure needs to fit the type of mixed methods design in the study of this title; which examines the petrochemical industry outlook in Malaysia and its future trend. This requires using procedures drawn from concurrent forms of data collection, in which both the quantitative and qualitative data are collected concurrently, or from the sequential forms of data collection, in which one type of data is collected and analyzed prior to a second data collection. Sources and data provided in the paper are acquired by collecting the information on the internet. There are some phases to the process of data collection that, in combination, comprise the data collection step in research. We need to consider the types of data that are possible and examine and weigh each option so they can determine what sources of data will best answer the research questions or assumptions.

3.4 ORGANIZING DATA

At the early stage of analysis, qualitative data, normally collected in large amounts and in various forms, including interview tapes, field notes, documents, photographs and other visual materials, need to be compiled into file folders, cards or computer files.

Data and findings are presented, typically in the form of:

(a) A comparison table;

(b) A hierarchical tree diagram representing the interconnection between themes;

(c) A chain diagram demonstrating the relationship between themes;

(d) A map depicting the physical layout of the setting; and

(e) A demographic table describing personal or demographic information or sites visited in the research.

3.5 INTERPRETING DATA

Qualitative research is interpretive research, where interpretation can be accomplished by comparing the present data with past studies.

Interpretation of the findings may include:

(a) A review of the major findings and how the research questions were answered;

(b) Consistency of the present data with past studies in order to assess whether the findings support or contradict;

(c) Personal reflections about the research findings. Qualitative research believes that personal views can never be separated from interpretation. Besides, the researcher may have been to the field and visited the subject studied personally and spent a great deal of time with the respondents. The researcher is therefore in a good position to reflect and remark on the larger meaning of the data;

(d) Limitations of the study; and

(e) Suggestions for future research.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 PETROCHEMICAL OUTLOOK OF MALAYSIA IN 2010

The 21st century is seeing a paradigm shift from West to East in the petrochemicals business, with the Middle East emerging as global production hub with natural advantages of low cost feedstock. Major consumption centres are shifting to Asia given the rapid growth in demand in China on account of chemical intensive and export driven industry & India emerging as global consumption centres. Asia is establishing itself as the biggest petrochemical industry and market worldwide, having overtaken North America and Western Europe. Challenges lie ahead, however. The region consumes mainly naphtha feedstock, which has been costly in recent years due to high crude oil prices. This has undermined profitability. Meanwhile, petrochemical markets worldwide are headed for oversupply in 2009-11 due to the huge amounts of new capacity due to come on-stream in the Mideast and Asia in the intervening period, analysts say. Industry leaders from around the world discussed the continuing shift of petrochemicals production from established bases in Europe and the U.S. to the Middle East, where 50% of planned global ethylene capacity will be built. Product is destined for fast-growing markets in China and Asia, where competition will be fierce in the coming years.

The accessibility of hydrocarbon feedstock from indigenous oil and gas has lead to the expansion of the petrochemical industry in our country, Malaysia. This is proven when Malaysia still top the chart of Asia-Pacific Proven Oil Reserve Holders after China and India where Malaysia held proven oil reserves of 4 billion barrels as of January 2010.

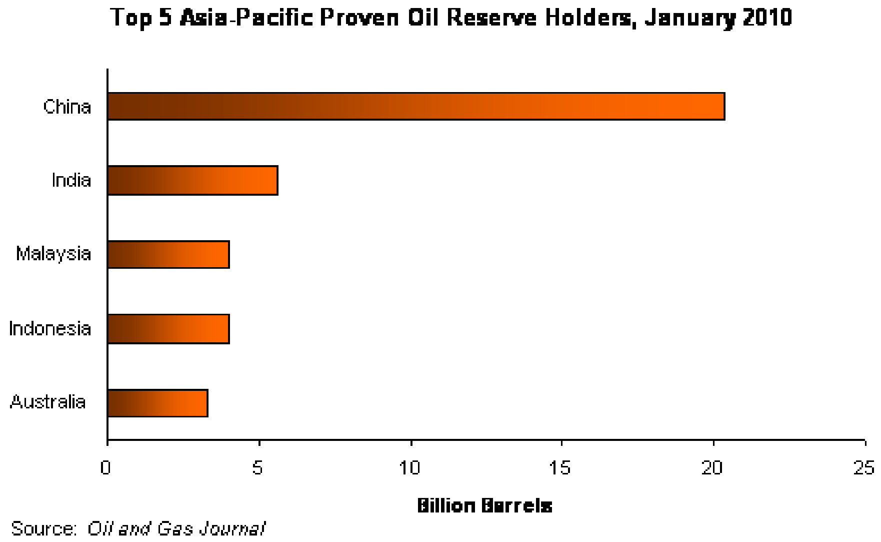


Figure 4.1 Top 5 Asia-Pacific Proven Oil Reserve Holders, January 2010

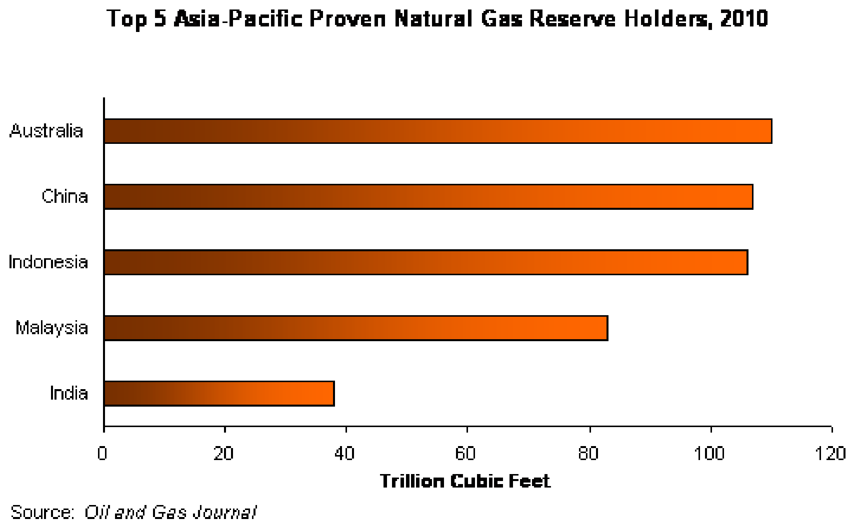


Figure 4.2 Top 5 Asia-Pacific Proven Natural Gas Reserve Holders 2010

On the other hand, Malaysia held 83 trillion cubic feet (Tcf) of proven natural gas reserves as of January 2010 after Australia, China and Indonesia based on Oil and Gas Journal. Most of the country's natural gas reserves are in its eastern areas, predominantly offshore Sarawak.

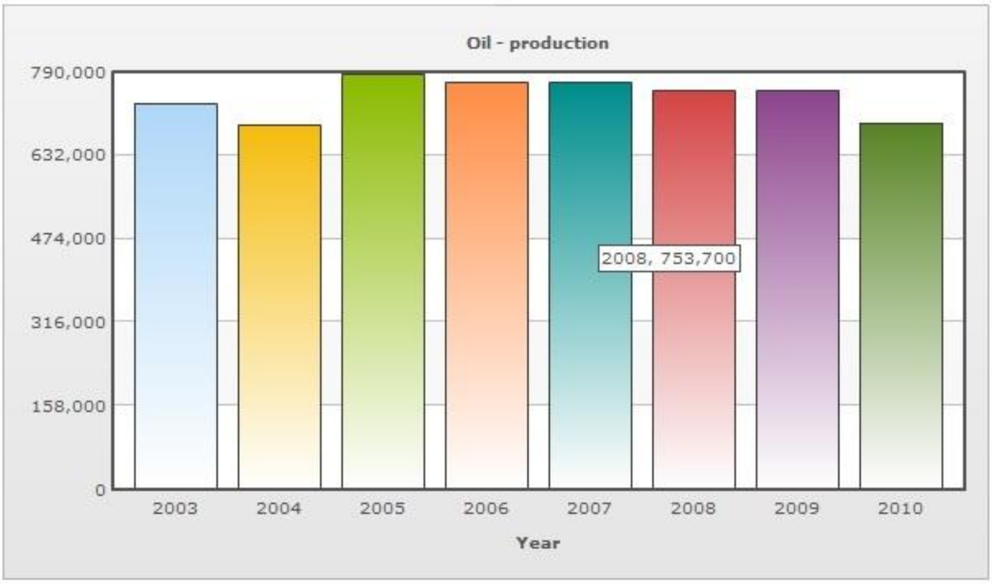
Following the expansion and increased productivity in petrochemical industry has result in the improved of export performance where we can see that as for total export in year 2010, liquefied natural gas (RM3.4 billion or 6.5% of total exports) is ranked the third highest products after electrical products and palm oil followed by chemicals and chemical products (RM3.17 billion or 6.1% of total exports); then crude petroleum (RM2.45 billion or 4.7% of total exports); and refined petroleum products (RM1.86 billion or 3.6% of total exports) based on Malaysia External Trade Statistic.

MALAYSIA EXTERNAL TRADE STATISTICS JANUARY 2010

TABLE 2: MAJOR EXPORT PRODUCTS

Products	January 2010[i]	December 2009[p]	January 2009[p]
	RM Million	RM Million	RM Million
Total Exports	**52,447.3**	**54,672.9**	**38,269.6**
Electrical & Electronic Products	21,372.3	22,679.6	13,732.8
Palm Oil	3,985.0	3,444.0	2,771.6
LNG	3,400.3	3,307.3	4,181.4
Chemicals & Chemical Products	3,173.9	3,144.0	2,116.2
Crude Petroleum	2,447.1	3,211.8	1,805.9
Refined Petroleum Products	1,862.1	2,289.5	1,161.2
Machinery, Appliances & Parts	1,650.3	1,935.2	1,356.1
Manufactures Of Metal	1,568.7	1,394.8	948.3
Optical & Scientific Equipment	1,429.4	1,254.5	894.1
Rubber Products	1,247.8	1,211.3	879.9

Table 4.1 Major Export Products in Malaysia



Year	Oil - production	Rank	Percent Change	Date of Information
2003	729,200	27		2001 est.
2004	690,000	27	-5.38 %	2003 est.
2005	785,000	22	13.77 %	2004 est.
2006	770,000	23	-1.91 %	2005 est.
2007	770,000	23	0.00 %	2005 est.
2008	753,700	25	-2.12 %	2008 est.
2009	753,700	26	0.00 %	2008 est.
2010	693,700	26	-7.96 %	2009 est.

Source: World CIA Factbook

Figure 4.3 Oil Production in Malaysia

By referring the graph and figure above, we can see that oil production in Malaysia decreases radically from year 2009 to year 2010. This is mainly because in year 2009, Malaysia petrochemical capacities remained unchanged from the previous year; there are no new projects announced despite staging recuperation in 2010 after the regional economic recovery in year 2010. Petrochemical industry in Malaysia is facing tougher market conditions with declining product prices, dawdling demand growth and an enormous raise in capacities in Asia and the Middle East.

According to International Trade and Industry Minister Datuk Seri Mustapa Mohamed, input of oil and gas industry is anticipated to experience an increase of

20% for the coming 5 years where it is believed to arrive at RM81.9 billion in year 2015 with the downstream activities contributing RM38.9 billion. The industry is positioned for advance development and expansion of the world class infrastructure across the value chain, for instance offshore rigs, the three integrated petrochemical zones explicitly in Pahang, Terengganu and Johor Baru as well as the liquefied natural gas production site in Sarawak as described in Chapter 2.

In general, tables below exhibit the main aspect and statistics in Petrochemical industries in Malaysia.

A) Production, Import, Export and Consumption of Raw Material in Malaysia

Product	Unit: KTPA	2007	2008	2009	2010	% Change +/-
Ethylene	Production	1,581	1,686	1,617	1,505	-0.04%
	Import	10	10	-	-	-100%
	Export	101	136	140	90	-32%
	Consumption	1,498	1,536	1,477	1,415	-3%
Propylene	Production	839	870	867	808	0.3%
	Import	33	40	25	8	0%
	Export	78	97	95	50	-2%
	Consumption	765	811	797	744	-5%

Source: Country Report from Malaysia, Malaysian Petrochemicals Association (MPA)

Table 4.2 Production, Import, Export and Consumption of Raw Material in Malaysia

Economic conditions deteriorated sternly in the last quarter of 2008 and continued unimproved into the middle of 2009 such that world year-over-year comparisons are negative for all but a few ethylene end uses. In 2009, production and consumption are anticipated to flow slower as the impact of the severe recession continues. Since ethylene is mainly used in consumable packaging markets with much stable food sales, therefore it is typically less affected by recession compared with other petrochemicals. However, the rigorous economic recession on year 2008-2009 features an unprecedented inventory decline in the supply chain and this has intensified ethylene sales weakness in packaging markets. We will be expecting to see a more dynamic growth of the ethylene demand starting year 2011. Among the most important buyers are producers of HDPE. They account for a third of ethylene demand. On the second place are producers of LLDPE and LDPE.

D) SUPPLY AND DEMAND FOR PVC (Unit: 1,000MT)

	2006	2007	2008	2009	2010E
Capacity	280	280	280	280	280
Production	240	250	245	250	250
Domestic Demand	160	160	160	150	160
Balance	80	90	85	100	90
Import	40	35	30	20	20
Net Inventory	120	125	115	120	110

Source: Country Report from Malaysia, Malaysian Petrochemicals Association (MPA)

Table 4.3 Supply and Demand for PVC

There are not much changes of the supply and demand for PVC in Malaysia because there is no any construction of PVC plant in Malaysia. Most of these plants had been idled ever since year 2008-2009 due to poor economics according to ICIS News (2010). A likelihood of oversupply problems and slow demand growth causes the amid high inventory levels. The PVC market is no longer driven by regional supply/demand and cost factors, but rather by global supply/demand and cost factor. PVC prices have increased as a result of a fundamental shift (increase) in raw-material costs according to SpecialChem (2010).

E) MALAYSIAN SM CAPACITY & DEMAND

Unit : KMts

YEAR	2006	2007	2008	2009	2010	2011	2012
Demand	334	322	300	302	325	330	350
Capacity	240	240	240	240	240	240	240
Balance	-94	-82	-62	-62	-85	-90	-110
Import	144	146	135	102	140	144	180
Export	40	34	32	37	37	34	37

Source: Country Report from Malaysia, Malaysian Petrochemicals Association (MPA)

Table 4.4 Malaysia SM Capacity and Demand

Malaysia's demand for Styrene Monomer (SM) has grown at a fast pace in the past decade. SM supply will be tight this year as downstream capacity has a large increase. The firmness in the SM market was expected to continue into the second-half of 2011 according to ICIS (2010).

4.2 PETROCHEMICAL FUTURE TRENDS OF MALAYSIA IN 2010

Since Malaysia is set on industrialization and is promoting vehicle manufacturing, electrical and computer hardware industries, we can expect similar expansions in the plastics manufacturing industries. In terms of volume, most of the petrochemical industry is linked to the production of plastics, which in turn is market driven. Hence the demand pattern of plastic products has significant bearing on the development of the petrochemical industry.

Malaysia's petrochemical sector has also put in to the development of local downstream plastic processing activities in year 2010. For example, supply and demand for polyolefin, a polymer produced from a simple olefin as a monomer that used in plastic industries increases persistently from year 2006 to year 2010 no matter in the number of production, import or export. In addition, there will be notable demand growth in Asia where, over the 2009-2013 period, on an annual average estimated basis, demand for ethylene derivatives will grow at 5.7% (equivalent to 10.37 million tons of ethylene) and at 5.4% for propylene derivatives according to Chemical Division, Manufacturing Industries Bureau.

As we know, petrochemical plants in Malaysia are export driven and our competitive advantages lie in the low priced gas feedstock and our large integrated complex with top-notch facilities based on naphtha. However, the industry is facing a sturdy market conditions with economic recession, falling product prices, slowing demand growth and massive increase in capacities in Asia and Middle East especially.

In addition, release of IPO (Initial Public Offering) as Malaysia's biggest petrochemical participant in the country lately according to PetChem News (2011) will definitely affect whole perspective of the industry. In that case, by merging all the petrochemical plants of Petronas in Kerteh, Gebeng and other areas, it is anticipated that the level of playing field will be towed up with increase in proficiency and cost cutting method. Malaysia petrochemicals industry began its recovery in year 2010 where the growth over the intermediate term will be sustained by the three integrated petrochemicals zones in Terengganu, Pahang and Johor Baharu as well as growth in the oil sector and the LNG production site at Sarawak.

It is expected that Malaysia will persists to catch the attention of foreign investment, but the key predicament the industry will have to achieve is to re-assess its aggressive and striving status within ASEAN and also to overcome the threat facade by other countries' rapid industrial expansion, especially China. What is more, producers in will have to restrain the feedstock costs with the aim to maintain production capacity as an enormous increase in capacities in Asia and the Middle East causes downward strain on product prices which then bring Malaysia in facing a sturdier market situation. On the other hand, crackers in Malaysia are likely to remain highly competitive due to favourable ethane prices.

Investments with the highest possible economic performance ought to be considered by petrochemical companies with long-term higher profitability objectives. For instance, investing in China, particularly in non-pure ethylene derivatives is one option. Invest in low-cost feedstock regions with stranded natural gas reserves or refinery product accessibility is another major alternative. In both cases, it is essential for us to come up with a strong technology and market position for meeting higher profit objectives.

Most ethylene demand is based on worldwide polyethylene growth, with regional ethylene demand shares changing with cracker feedstock slates and the growth of end-use markets. Regions with naphtha cracking capacity may have a bigger and broader ethylene market, since petrochemicals involving a combination of by-products-such as ethylene, benzene, and butadiene for acrylonitrile butadiene styrene resins-or special niche markets for example specialty ethylene oxide markets in developed regions.

Petronas is practising a policy of aggressive expansion. This especially involves attracting foreign investors for about half the money. The achievement of this plan is possible to be adversely affected if Malaysia's exchange rate controls were to become an undeviating feature, although their provisional imposition does not seem to have had a damaging effect.

Chemical Market Associate Inc (CMAI), said the next few years the global petrochemical demand is expected to average about 5% of the rate of growth, but can restrain the production of excess profitability of the petrochemical industry, this situation will carry on until 2012. From 2013 onwards, the profitability of the global petrochemical industry will begin to recover; year 2014 to year 2015 will reach a peak in this cycle.

We can foresee that Malaysia's petrochemical industry future with the manufacturer's products in the global market share rising, where their talent developed regions will be more attractive to the introduction of more advanced technology to strengthen the global position according to HC Plastic Mesh News (2011).

The eventuality of globalization and customer first is a main line of the global petrochemical industry. Malaysia and BRIC (Brazil, Russia, India and China) countries are leading the growth in global demand for petrochemical products, while increasing level of environmental awareness of consumers to make people demand environmentally friendly products is increasing.

Global mega trends majorly focus on health awareness and go green concept results in strong demand for specialty chemicals including superabsorbent polymers for personal hygiene application. Therefore, the new super-absorbent polymers plant in Malaysia under planning of BASF Petronas Chemicals should be thoroughly reviewed and studied. Super-absorbent polymers, which are made from partially neutralized, lightly cross-linked

Figure 4.4 Super-Absorbent Polymers (SAP)

poly acrylic acid, are materials with the ability to absorb and retain large volumes of water and aqueous solutions. (BASF Petronas 2011).

Moreover, ICIS, Asian Chemical Connections (2011) affirmed that there is a global trend moving towards cleaner and low-sulphur transportation fuels. Therefore, with the proposition of stricter fuel standards and policies, we will have refinery bottoms that we may consider to promote to cleaner fuels, or use as a feedstock for chemicals.

According to ICIS, LPG could also be used as a substitute feedstock to naphtha for crackers, on top of other industrial users. Consequently, it is significant for us to determine the feasibility of an LPG terminal. On behalf of that, biomass is certainly a new option that should be evaluated. Our strategic location positioned in the center of a region where we are abundant with plentiful of biomass, having strong logistic connectivity, integrated with plenty of opportunities to our chemical industry, we can actually discover present attractive new openings for companies. Illustration of biomass accessible in our country which can help in creating a more sustainable and environmentally friendly society comprise of palm-based materials are palm oil, palm kernel shells, palm kernel cake, mesocarp fibre, empty fruit bunches and ligno-cellulosic materials. Ahead of the existing down cycle, significant new capacities will be desired to meet rising market demand.

SWOT ANALYSIS FOR PETROCHEMICAL INDUSTRY IN MALAYSIA

4.2.1 Strength

Facilities

Malaysia can boast of having one of the well-developed infrastructures and world class integrated petrochemical facilities particularly petrochemical zones in Kerteh, Gebeng, and Tanjung Langsat among the newly industrializing countries of Asia which lead to the rapid growth of petrochemical industry. Moreover, Malaysia has the world’s largest production facility at a single location of liquefied natural gas with production of 23 million metric tonne per year and thus these strengthen

Malaysia's petrochemical activities. The development of petrochemical zones where petrochemical plants are clustered together has shaped a value chain which makes certain the progressive development of downstream petrochemicals activities.

Feedstock Reserves & Supply

The existence of a trans-peninsular gas transmission pipeline system and six gas processing plants has resulted in a ready supply of gas to the industry. World scale producers of LDPE, LLDPE, HDPE, PP, EPS, GPPS, HIPS, PVC, ABS, SAN and PET resins have established plants in Malaysia (MIDA 2010). In addition, wide range of petrochemicals are produced in Malaysia such as olefins, polyolefins, aromatics, ethylene oxides, glycols, oxo-alcohols, exthoxylates, acrylic acids, phthalic anhydride, acetic acid, styrene monomer, high impact polystyrene, ethyl benzene, vinyl chloride monomer and polyvinyl chloride and polybutylene terephthalate (CICM/MIDA 2010). Thus, these world scale plants have contributed drastically to the expansion of local downstream plastic processing activities and provide a steady supply of feedstock material for the plastic industry.

Supporting Service

The Peninsular Gas Utilization (PGU) project, finished in 1998, expanded the natural gas transmission infrastructure on Peninsular Malaysia and the long term reliability and security of gas supply ensure the sustainable development of the country's petrochemical industry. The PGU system spans more than 880 miles and has the capacity to transport 2 billion cubic feet per day (Bcf/d) of natural gas. Pipelines at the moment connect Malaysia with Singapore and Indonesia, and the Trans-Thailand-Malaysia Gas Pipeline System allows Malaysia to pipe natural gas from the Malaysia-Thailand JDA to its domestic pipeline system. This linkage marks a momentous pace toward the realization of the planned "Trans-ASEAN Gas Pipeline" (TAGP) system, a transnational pipeline network linking the major natural gas producers and consumers in Southeast Asia. Because of Malaysia's extensive natural gas infrastructure and its location, therefore we are considered as the natural candidate to serve as a hub in the proposed TAGP project. Moreover, the construction of the Gas Processing Plant (GPP) in Kerteh has lead to the opening of the Petrochemical Processing Complex in Kerteh and Gebeng. The implementation of a series of exchange controls and anti-import measures by government have granted the local economy some shield from the surrounding storm. As a result, our country has retained good GDP growth, which is swiftly outpaced by the development in chemicals industry investment. The Malaysian Industrial Development Agency (MIDA) gives further incentives to develop in the country. These include R&D grants, training grants and low rents (MIDA 2010).

Cost Competitiveness

Low priced gas feedstock and large integrated plants based on naphtha are some of the competitive advantages of petrochemical industry in Malaysia. Value incorporation through inter-plant synergies is also authorized to uphold the competitiveness of Malaysia petrochemical industry. Thus, this results in the ability of the complex in distributing chemical intermediates throughout the Far East including Australia. The development of world class centralized utility facilities present an absolute and reliable supply of vital utilities such as power, steam, demineralized and cooling water, as well as services such as primary waste water treatment, further improves the competency of the integrated petrochemical zone concept, making Malaysia competitive as similar sites in the region and the Asia Pacific. To emphasize the competitive position of Malaysian producers, the industrial development authority is offering import duty exemptions for raw materials and various investment incentives.

Strategic location

Malaysia is situated strategically in Southeast Asia, bordered by Thailand in the north, Indonesia in the south, and the Philippines in the east. The strategic importance of Malaysia is in its location along the Strait of Malacca, which is a major sea-route connecting the Far East to Asia, Europe, and the Middle East is expedient for petrochemical imports and exports activities.

4.2.2 Weakness

Slow demand due to economy downturn

Demand showed only weak growth based on poor performance of the global economy. Slump in global demand and the declining profitability of the pattern of change in the petrochemical industry, where the sharp decrease in demand as a result of the downturn has led to reduced utilization rates, temporary shutdowns and in many cases permanent closures. Petrochemical producers were forced to shut down equipment, spare capacity, optimize operations to improve production efficiency and reduce costs (Frbiz Tien 2010). The recession has slowed the progress of many petrochemical projects globally. Product prices and sales plunged drastically and this causes a serious impact on corporate earnings.

Limited resources due to depletion

Petroleum resources are the only major mineral commodities where many experts fear resource depletion will produce significant scarcities over the next several decades. Vision 2030, Planning Commission said that all or very nearly all of Malaysia's prolific petroleum basins are believed identified and most are partially to near-fully explored.

No extensive plan in further develop petrochemical activities

There is no extensive plan on further expand petrochemical activities besides trying to explore oil field at other countries in order to extend the oil depletion period. Extensive plan such as to expand, develop alternative petrochemical feedstocks or invest in any expansion of a particular refinery plant or to focus on a specific chemical compounds are not planned methodically.

4.2.3 Opportunity

<u>Partnership with other members of ASEAN for the supply of gas</u>

Malaysia has forged partnerships with other ASEAN members for the supply of gas such as Vietnam, Indonesia and the Malaysia-Thailand Joint Development Area (JDA) to complement the existing gas reserves and to make sure further security of gas supply. Additionally, gas supply will be further improved with the implementation of the ASEAN gas grid, an undertaking to make gas available to all the 10 ASEAN countries.

Figure 4.5 ASEAN Member

<u>ASEAN Free Trade Area (AFTA)</u>

By referring to Chemical Technology 2011, the article state that petrochemical manufacturers in Malaysia will gain from a single market with the full implementation of AFTA.

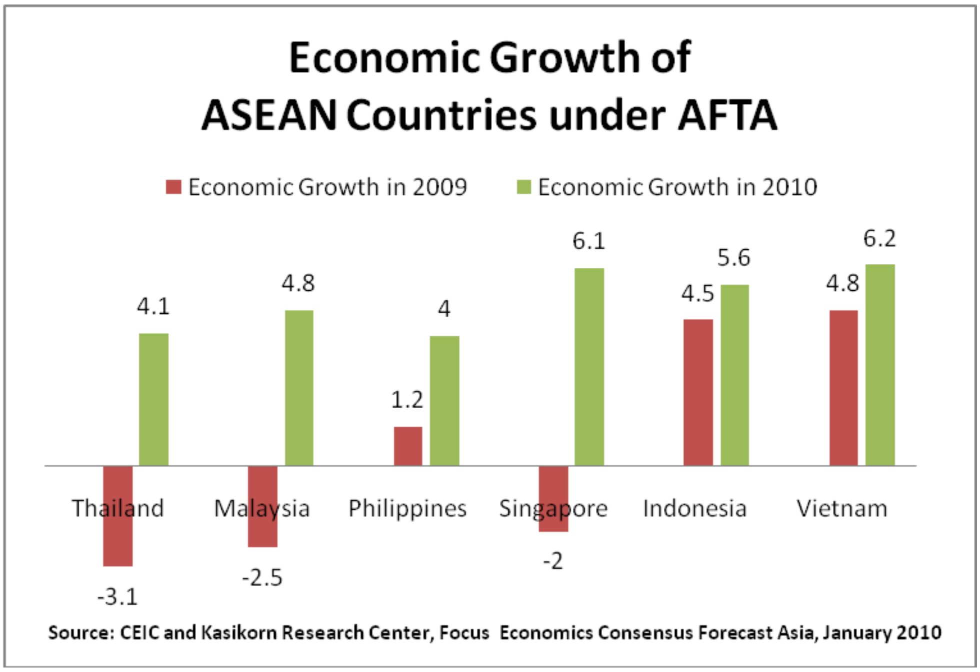


Figure 4.6 Economic Growth of ASEAN Countries under AFTA

Manufacturers based in Malaysia benefit from the access to a much larger Asia Pacific market. With China being a net importer of petrochemicals, Malaysia's 'early harvest' Free Trade Agreement with China will lay open new business opportunities and prospects for petrochemicals manufacturers in Malaysia.

<u>The development of petroleum products</u>

Globalization poses evenly challenges and opportunities simultaneously for Malaysian petrochemical industries. Therefore, it is very essential for Malaysian manufacturers to maintain their competitiveness through enhanced technologies, improved skills and penetrating new markets in developed and developing economies.

The discovery of new petrochemical feedstock (further explained in chapter 5)

A sustainable petrochemical source must soon be found to replace the imminent worldwide petroleum exhaustion. For instance, biomass can be developed and produce methane. Detailed explanation will be discussed in Chapter 5. The depletion of petrochemical, coupled with the increasing awareness of environmental protection, has led to intensive and escalating efforts in search for renewable and environmentally friendly alternative feedstocks.

4.2.4 Threat

Thailand's petrochemical activities

The Thai petrochemical industry owes its existence primarily to the discovery of natural gas and condensate offshore in the Gulf of Thailand in the 1980s (Peter H. Spitz 2003). Thai government decided to price feedstocks and ethylene on a cost-of service basis in order to guarantee the success of these ventures. It also established relatively high import duties to help the new industry. The government decided to focus its efforts mainly on developing the upstream sector, with the collaboration of the private sector, while leaving downstream development exclusively to the private sector in the early stages and these petrochemical industrial developments lasted from 1980 to 1989. The second phase, which last from 1989 to 1995, saw an increased in liberalization and private sector interest, and the development of olefins and aromatics that resulted in a extensive reduction of imports. The third stage of development from 20014 to 2018 focuses on competitiveness, asset integration and strategic coalitions for growth and added value. According to State of Israel, Ministry of Industry, Trade and Labor, the petrochemical plan anticipates considerable growth and opportunity for investors. With high projected gross domestic product growth, feedstocks, infrastructure and a population of 70 million people in the domestic market, Thailand was and remains a logical country to produce petrochemicals. Significant growth in sectors such as automotives, packaging, electrical and electronics, construction and agriculture in their country also have a say in the impressive expansion of petrochemical industries in Thailand.

Singapore's petrochemical activities

Generally, Singapore's petrochemical plants are somewhat viable compared with others in Asia, given their large size and modern technology. In addition, at present, they are in a stronger financial position compared to other ASEAN countries especially Malaysia. In the longer run, however, the lack of natural gas reserves would be a negative factor. Singapore maintains an edge over Malaysia in every aspect be it business environment, taxes, IPR regime, global competitiveness, bureaucracy, labor-force, openness to trade, extent of innovation, or living environment (BMI 2010).

Middle East's political influence

The other stiff competitor is the Middle East, due to its basic trade environment and abundant, low-cost hydrocarbon resources. Companies searching for an advantage are looking beyond provisional Middle East hostilities and planning to build capacity there. New capacity in the Middle East and Asia progressively invest in operation a large number of global petrochemical producers will bring tauter competition. Similar to Asia-Pacific countries like China and India are able to offer very low labour costs compared to North American and European countries; the Middle East major advantage is they have an incomparable feedstock advantage. The production volumes in the Middle East are set to ascend on account of the availability of low cost feedstock. The majority of the petrochemicals in the Middle East are made from ethane, which is a natural gas derivative. This gives an advantage to the Middle East as gas is traded throughout the world on a regional level, compared to crude oil which is traded on a global integrated level. According to Global Data 2010, the gas is sold at a discounted price to the Middle East producers, giving them an intrinsic competitive advantage above other global producers. This has resulted in a large amount of capacity additions in the region in the coming future, making it an epicentre of global petrochemical production. However, the rise of political parties with unfavourable commercial policies in many countries causes investment interest in Middle East declined.

<u>China's petrochemical activities</u>

In Asia, as China maintains low labour costs vs. rising labour costs in other Asian countries, investment interest therefore has shifted to China. Comparing India and China, although the two countries have similar economic latent, India poses political obstacles for investors. Downstream manufacturing industries have moved from other countries, including those in Asia, and into China. This makes China the largest growing petrochemical market in the world and, as such, an attraction pole for petrochemical investment. China is the biggest producers of many petrochemicals in the world. The rising use of coal feedstock in China is incessantly increasing the share of coal-based petrochemicals production worldwide. Simultaneously China, while still a net importer has itself developed into the largest petrochemical producer in Asia, adding to tough competition that the Malaysia industry encounter from producers in the Middle East, where naphtha feedstock is copious and capacity is rising.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 ISSUES WITH PETROCHEMICAL FEEDSTOCKS

In accordance with Malaysia Energy Sector 2010, our geological structure has matured over the years. All major discoveries of oilfields have already been developed and in production for more than 30 years. Physical nature of the fields which are relatively small in size, scattered and faraway from the existing production facilities lead to the difficulty in developing of these fields. Additionally, the remaining oil and gas fields are of lower quality due to high carbon dioxide content. Therefore, the cost of developing future resources will be much expensive and thus may not be economically viable.

The petrochemical industry (PCI) has undergone profound changes during the last decade and is continuing to adjust to changing world economic conditions. One of the most important of these is the price of crude oil.

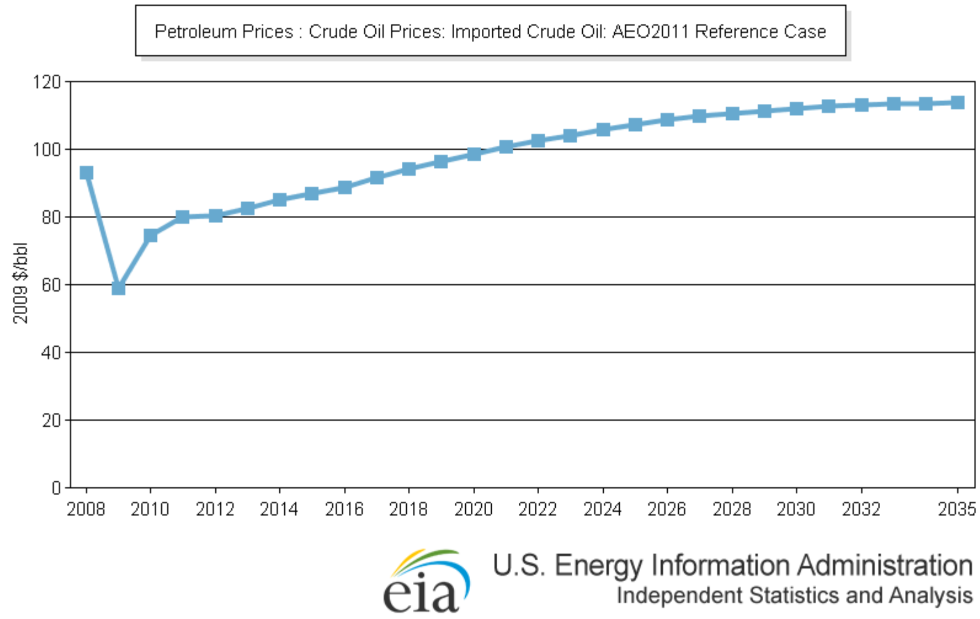


Figure 5.1 Crude Oil Price for Year 2008-2035

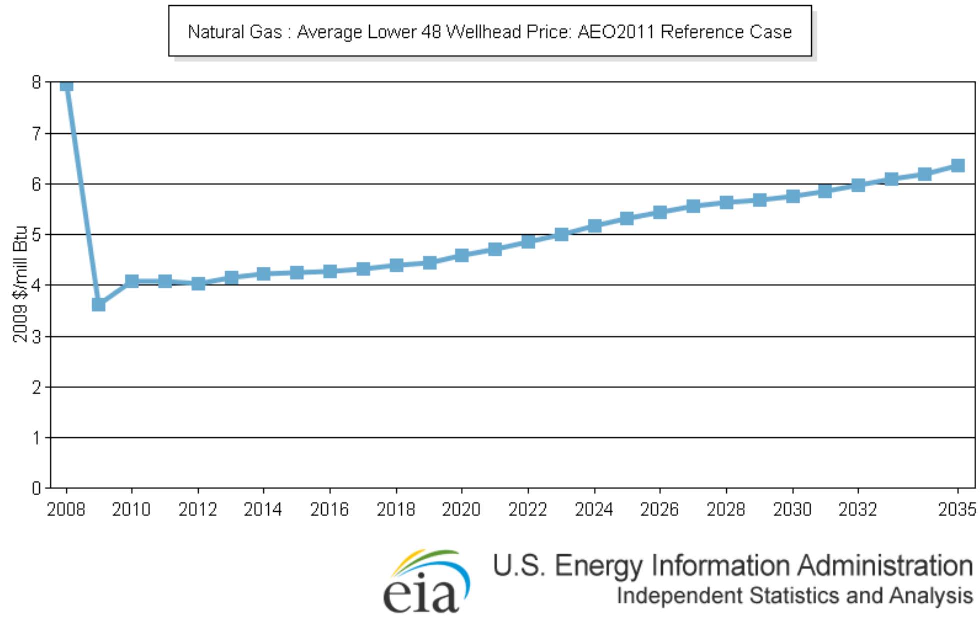


Figure 5.2 Natural Gas Prices for Year 2008-2035

The recent hiking price and supply volatility foretell a not-too-distant future when even more pronounced volatility will occur in all the regions. We all know that one day natural gas and petroleum production will "peak," plateau and then decline. Resembling the "peak" will be disruptive, and this might add considerably pressure to supply and prices and accelerate the industry's move from petroleum and natural gas to other less volatile alternative feedstocks such as coal or biomass.

Moving forward, the nation will be increasingly dependent on imported petroleum. In fact, about 25% of gas supplied to domestic market is now being imported according to Economic Planning Unit Malaysia 2010. The technology and know-how required to produce chemicals from alternative, renewable, and novel feedstocks is available and presently practiced at large scales in many parts of the world where we might need to become skilled at in order to face the depletion of crude oil and natural gas in the future.

5.2 ALTERNATE FEEDSTOCKS OPTIONS AND RELATED PROCESSES

In general, there are six alternative feedstock sources which are coal, biomass, petroleum coke, tar sands and oil shale, organic municipal solid waste, and unconventional natural gas, including methane from “stranded” or “remote” sources, coal bed methane and gas hydrates. On behalf of that, five technologies are identified because of their potential application in production of chemicals which included gasification, fermentation/extraction, pyrolysis, liquefaction, and coking. However, only 4 main alternative feedstocks will be discussed in this chapter: coal, biomass, unconventional natural gas and tar sands/heavy oil (Chemical Industry Vision 2020).

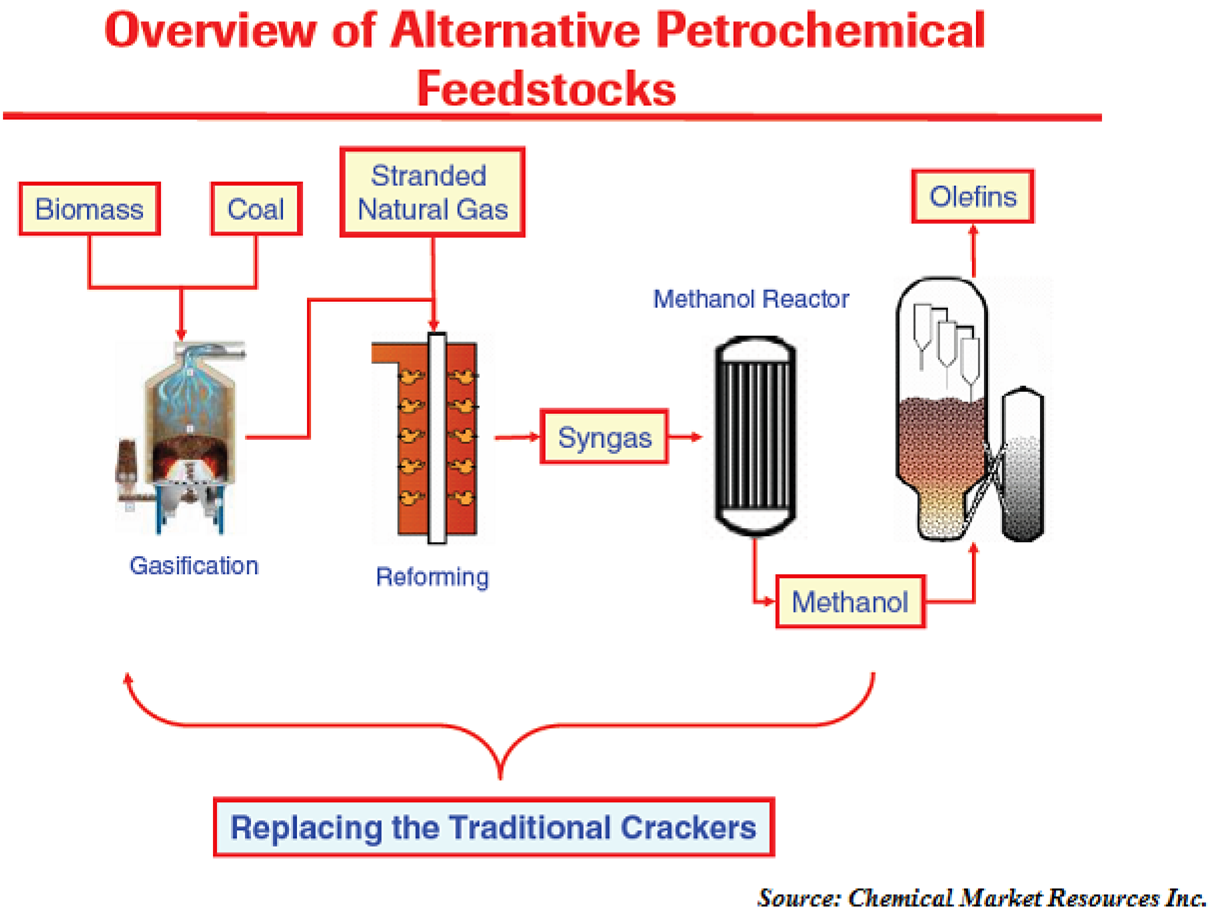


Figure 5.3 Overview of Alternative Petrochemical Feedstocks

5.2.1 COAL

Coal was always considered as a disruptive technology if we were to compare with crude oil and natural gas. This is because coal is not attainable and accessible by using conventional drilling technique and also transporting methods that we used for natural gas and oil. Coal has become less attractive alternative to oil and natural gas in the past mainly because of the major difficulties in coal mining, recovery, cleaning and transportation. “Clean coal” technologies that are lately developed by quite a few countries are making it economical in certain regions of the world. There has been several evaluation of the use of coal for generation of syngas and fuel liquids through Fischer-Tropsch process. The recent coal developments were driven by China, with the world’s second largest coal reserves, given that it has limited supplies of oil and natural gas (Chemical Market Resources Inc 2009). Most of the technologies developed worldwide had a chance to demonstrate their feasibility in China. This also provided motivations to a number of developing countries to explore their coal reserves. For example, Chemical Vision 2020 stated that syngas to fuels is being done by Sasol in South Africa, and China has invested in coal liquefaction to fuels.

Coal Gasification

Process of producing coal gas is called coal gasification, where it is a type of syngas – a mixture of carbon monoxide (CO) and hydrogen (H_2) gas – from coal. Further catalysis assists the reaction of CO to CO_2 in presence of water to generate H_2 (e.g., at Dakota Gasification Company). Consequently, ammonia can be produced, or methanol, alcohols, and aldehydes by oxosynthesis. Alternatively, the coal gas (also known as "town gas") can be converted into transportation fuels such as gasoline and diesel through additional treatment via the Fischer-Tropsch process. Integrated Gasification Combined Cycle systems used in coal gasification are extremely clean, and are much more efficient than traditional coal fire power plants (World Nuclear Association).

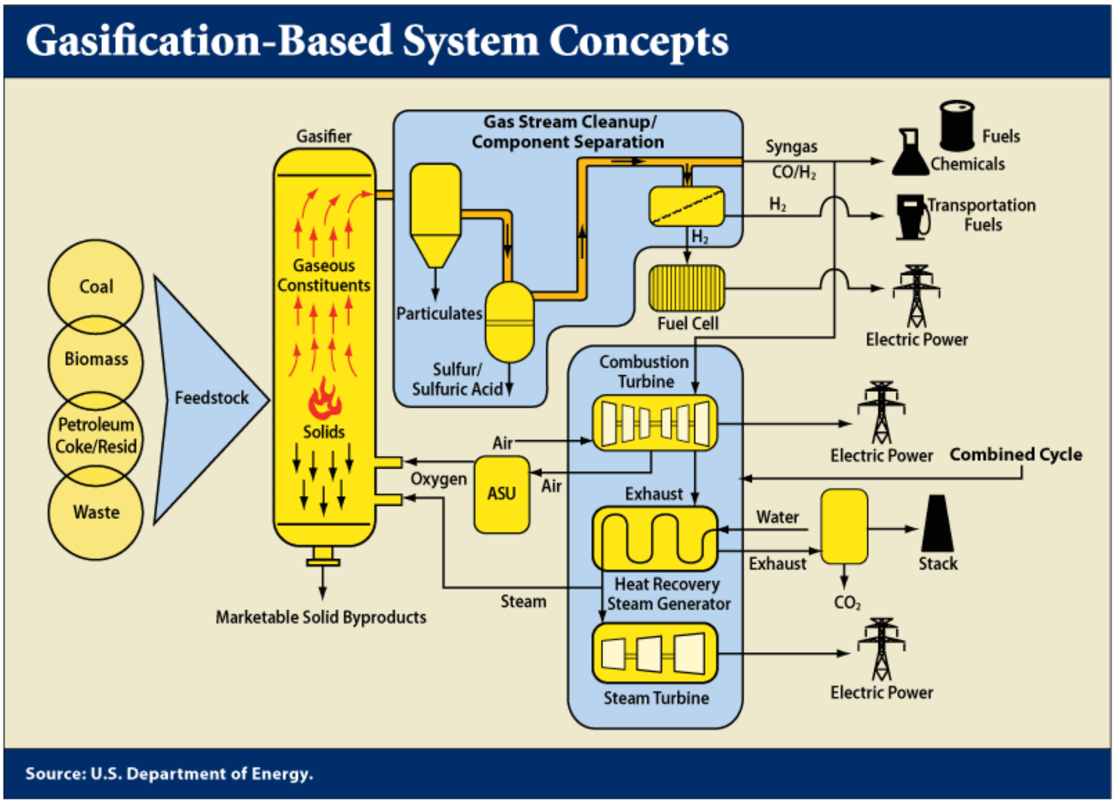


Figure 5.4 Gasification-Based System Concepts

The heart of a gasification-based system is the gasifier. A gasifier converts hydrocarbon feedstock into gaseous components by applying heat under pressure in the presence of steam.

A generic oxygen-blown gasification system is illustrated in figure above and comprises the following main steps (Europe's Energy Portal 2006):

(i) Reaction with oxygen or steam at 70 atm

(ii) Quenching with water to remove particles and cool syngas

(iii) Water-gas shift reaction (WGS) to produce H_2 and CO_2

(iv) Removing H_2S and CO_2 simultaneously, using physical solvents

Solvents are recovered by depressurization. H_2S is converted to sulfur in a two-step process by first heating in oxygen to produce SO_2, which then reacts further with H_2S to produce sulfur and steam. The by-products of coal gas manufacture included coke, coal tar, sulphur and ammonia; all useful products. There are a variety of organic compounds derived from coal gas, for instance, dyes, medicines, including sulpha drugs, saccharin and etc. The benefit of gasification-based energy systems is that carbon dioxide will be produced by the process when oxygen is used in the gasifier (rather than air) therefore making it easier and less expensive to separate and capture. Once the carbon dioxide is captured, it can be sequestered - that is, prevented from escaping to the atmosphere, where it could otherwise potentially contribute to the "greenhouse effect."

Coal Liquefaction

Coal liquefaction is the conversion of coal to manufacture synthetic fuels. A process has been developed to convert coal to synthetic fuels where it requires the coal to be in contact with a hydrogen environment at high temperatures and pressures. It is a marvelous piece of technology because 1) it is well developed and thus could be executed fairly rapidly and 2) there are relatively large quantities of coal reserves in Malaysia.

The major purpose of coal liquefaction is to produce synthetic oil to supplement the natural sources of petroleum. The usage of liquid and solid products from coal is extensive where it can be used for fueling transportation vehicles, providing fuels for power generation, and yielding raw materials for chemicals. Although coal liquefaction plants might be a little too pricey to build and maintain, but their products should be very competitive when world oil production turns down. According to The Energy Blog (2005), coal liquefaction has historically been used in countries without a secure supply of crude oil, such as Germany and South Africa. The technology used in coal liquefaction is quite old, and was first implemented during the 19th century to provide gas for indoor lighting.

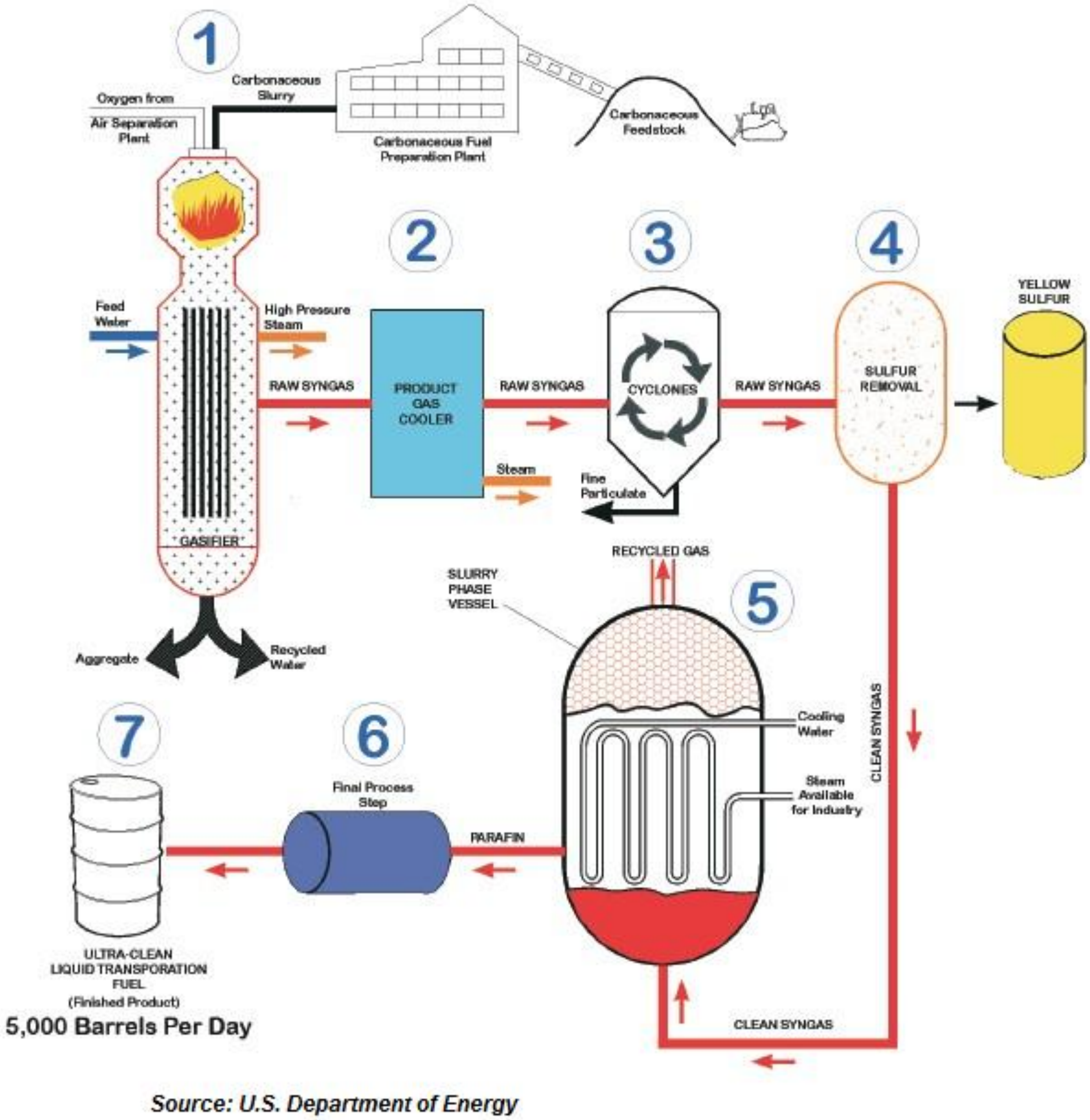


Figure 5.5 Coal Liquefaction Process

Two ways of producing liquid fuels are direct coal liquefaction (DCL) and indirect coal liquefaction (ICL). In DCL the coal is directly contacted with a catalyst at elevated temperatures in the presence of added hydrogen. On the other hand, the ICL process consists to two major steps: 1) gasification to produce a synthesis gas and 2) conversion of the gas to a liquid by synthesis over a catalyst in a Fischer-Tropsch process. Removal of the sulfur from the coal before passing the gas over the catalyst is necessary to prevent "poisoning" of the catalyst. Removal of the CO_2 is also desirable to perk up synthesis efficiency. Without mitigation, coal liquefaction released 7-10 times the CO_2 of oil production. DCL processes are more efficient than ICL processes, 67% vs. 55% (The Energy Blog 2005). However, DCL require higher quality coal and a more complex process.

5.2.2 BIOMASS

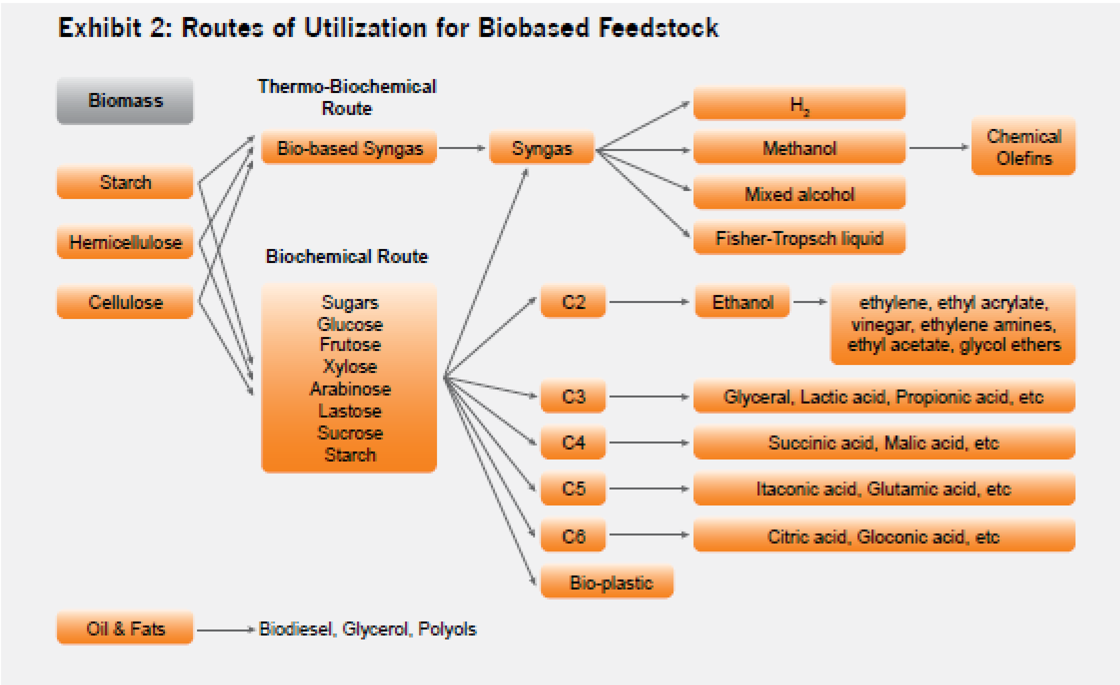
Nowadays, potential of biomass to be converted into carbon-neutral biofuels is drawing wide public attention. Moreover, there is also a great possibility and potential for it to be transformed into chemical feedstocks. Biomass.net (2010) stated that biomass is defined as regenerative (renewable) organic material that can be used to create energy. Biomass included aquatic or terrestrial vegetation, residues from forestry or agriculture, animal waste and municipal waste. Biomass can be manufactured from crops, wood, manure, land fill gasses and alcohol fuels.

Primary example of biomass alcohol fuel is ethanol. It is a rather complicated procedure to produce fuel and energy from biomass but the main theory behind it corresponds directly to photosynthesis. Photosynthesis is s the process by which plants, some bacteria, and some protistans use the energy from sunlight to produce sugar, and oxygen gas in which cellular respiration converts into adenosine triphosphate (ATP), the "fuel" used by all living things (M.J.Farabee 2007). It is amazing since plants become autotrophs because they use glucose as a source of energy rather than fossil fuels.

For instance, sugar beet pulp, which has low value to sugar beet growers and processors, may possibly become an important source of renewable methanol.

Biomass can first be converted to syngas by a process called partial oxidation, and later converted to methanol. Berkeley Lab and UC Berkeley researchers have discovered a mild and relatively low-cost method of removing oxygen from biomass. If this procedure can be effectively industrialized, could allow many of today's petrochemical products, including plastics, to instead be made from biomass.

Currently, research is being conducted to explore bench-scale and pilot-scale processes of biomass gasification, fermentation of sugars, decomposition of cellulose, and separation of lignin and other plant components, high-temperature pyrolysis, and biorefining of wood and waste materials. The main concerns restraining the replacement of petroleum with biomass feedstocks includes impurities, feedstock composition variability, distributed supply, scalability and pathways for breakdown of cellulose (Chemical Vision 2020).



Source: Chemical Market Resources Inc.

Figure 5.6 Routes of Utilization for Biobased Feedstock

A biorefinery is an integrated facility that incorporates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass. The concept of a biorefinery is equivalent and somewhat similar to today's petroleum refineries, which manufacture multiple fuels and products from petroleum. Industrial biorefineries have been recognized as the most potential route to be utilized for the formation of a new domestic biobased industry. A biorefinery can take advantage of the differences in biomass components and intermediates by producing multiple products and make best use of the value derived from the biomass feedstock. Biorefining feedstocks include crops, waste plant or animal material, and recycled fibers. Biorefining becomes more cost effective when coupled with production of food, feed, power, and industrial and consumer products, and also help in reducing waste.

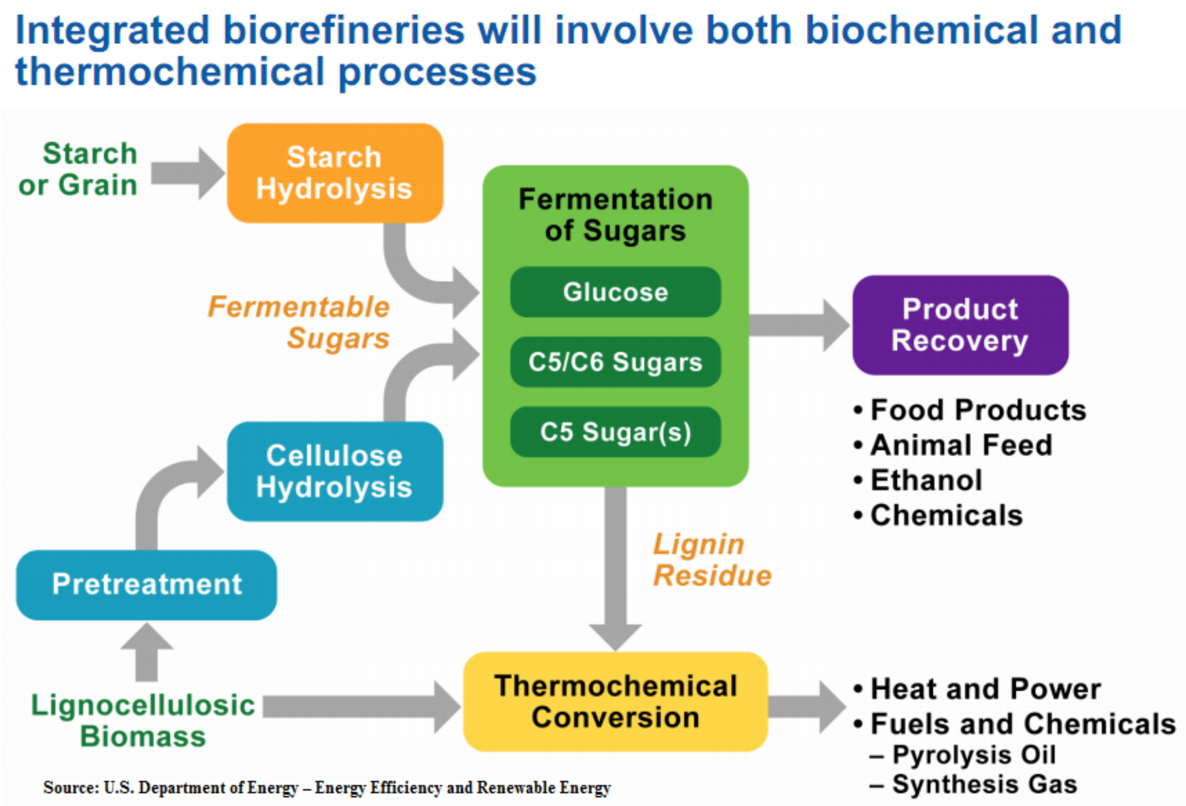


Figure 5.7 Integrated Biorefineries Process

Biomass Thermochemical Gasification

Syngas for commodity chemical production can be derived from biomass. Syngas is a mixture of hydrogen and carbon monoxide and can be converted into fuels such as hydrogen, natural gas or ethanol. Biomass gasification is the process in which synthesis gas is formed in the biomass gasification process using organic wastes such as agricultural waste and urban wood waste. Biomass gasification is a high temperature process where it uses 600 to 1000℃ to decompose the complex hydrocarbons of biomass into simpler gaseous molecules, mainly hydrogen, carbon monoxide, and carbon dioxide (Renewable Energy Institute 2007). In most cases, some char and tars are also formed, along with methane, water, and other constituents. Hydrogen and carbon monoxide are the desired product gases, because they can be directly fired into a gas turbine for power generation or used in chemical synthesis, unlike other combustion gases. A prime benefit of biomass gasification over biomass combustion is that the power generation efficiency of a gas turbine combined cycle system can be twice as much the efficiency of biomass combustion processes, which uses a steam cycle alone. Syngas can be used as a fuel to generate electricity and steam or as a chemical building block for the petrochemical and refining industries.

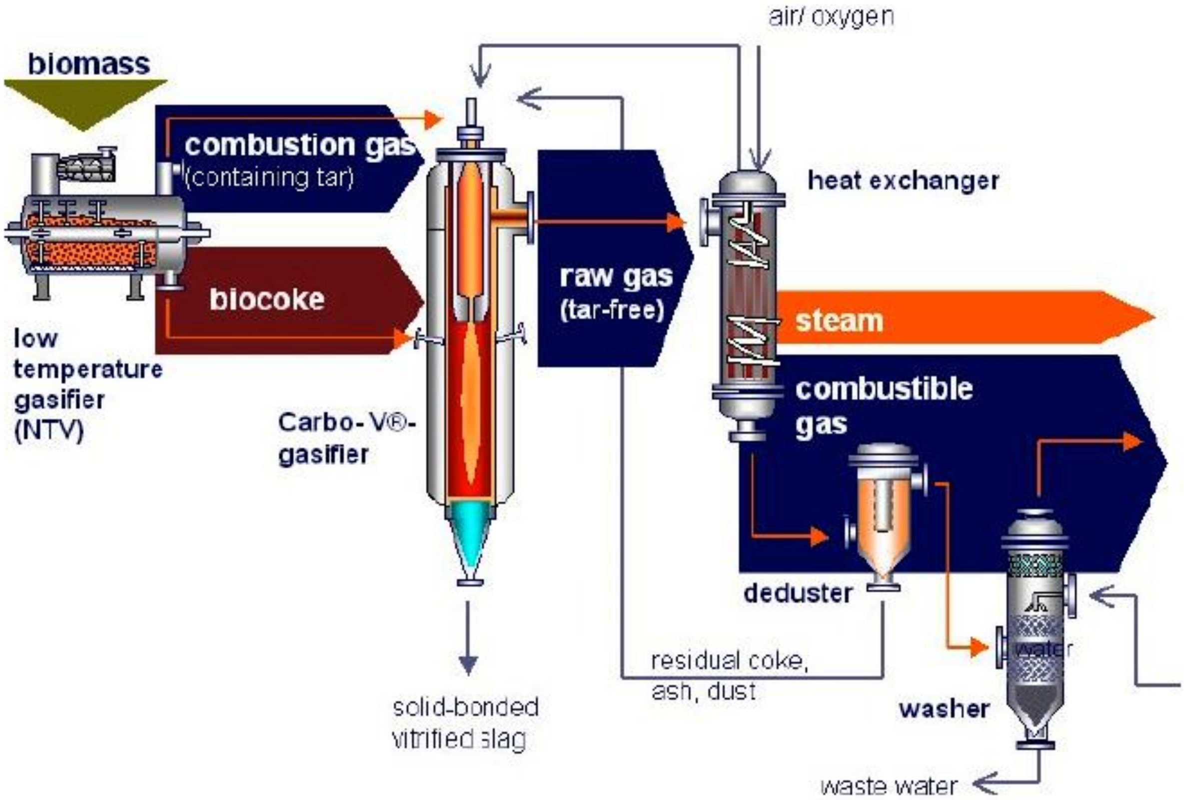


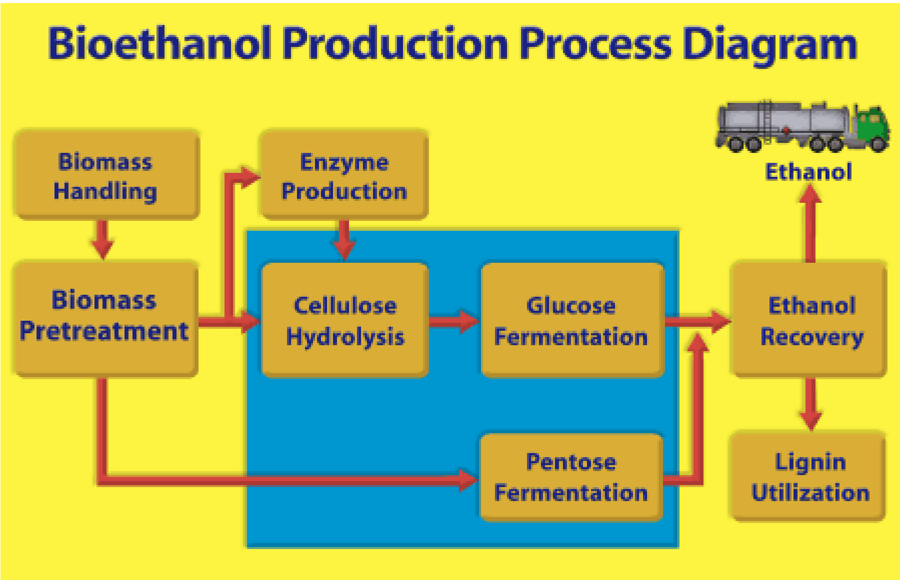
Exhibit 5: Syngas Biomass Gasification Scheme
Source: www.choren.de

Figure 5.8 Syngas Biomass Gasification Scheme

Since biomass has large water content, there is a need where excessive water content to be removed before gasification since the Choren process requires that starting material contain less than 35% water. In addition, innovative methods, such as feedstock densification or onsite drying prior to shipping, will assist with achieving economies of scale because production of biomass requires a large land base, feedstocks are spread wide, and manufacturing is distributed (e.g., forest pulp mills).

Biomass Fermentation

Fermentation is the process of transformation of sugars into alcohols and it is a common practice among farmers. Fermentation of sugars using bacteria, yeast or fungi is often aerobic. Ethyl alcohol produced, commonly known as alcohol is one of the most significant and popular industrial fermented products. It is a liquid fuel, and can also be used as an alternative to automobile fuels.



Source: U.S. Department of Energy – Energy Efficiency and Renewable Energy

Figure 5.9 Bioethanol Production Process Diagram

The sugar enriched materials like beet sugar, cane sugar, fruit sugar, potato, rice or any other crop of high sugar contents can be used as substrates mainly, along with starchy and ligno-cellulosic materials (World Agriculture Group 2010). A team of experts from the Pacific Northwest National Laboratory (PNNL), the National Renewable Energy Laboratory (NREL), and EERE chosen the top 12 target products from sugar fermentation using biomass for the most feasible building blocks for manufacturing high-value products.

Building Blocks
1,4 succinic, fumaric and malic acids
2,5 furan dicarboxylic acid
3 hydroxy propionic acid
aspartic acid
glucaric acid
glutamic acid
itaconic acid
levulinic acid
3-hydroxybutyrolactone
glycerol
sorbitol
xylitol/arabinitol

Source: ***National Renewable Energy Laboratory (NREL)***

Figure 5.10 Twelve Top Products from Sugar Fermentation Using Biomass for the Most Viable Building Blocks

Chemical transformation of sugars can take place by oxidation (e.g., of starch), oxidative dehydration (of C_6 sugars), hydrogenation (sometimes acid-catalyzed) of cellulosics and sugars, acid amination, and esterification of oils (Joanna McFarlane 2006). Products produce by the processes above can be further transformed to derivatives by chemical reactions like oxidation, hydrogenation and dehydration bond cleavage and direct polymerization.

Then again, lignocellulosic biomass is biomass that is comprised of cellulose, hemicelluloses, and lignon. The fermentation of lignocellulosic biomass to ethanol is an attractive route to fuels that supplements the fossil fuels. We all are aware that biomass is a carbon-neutral source of energy and in view of the fact that it comes from plants, the combustion of lignocellulosic ethanol generates no net carbon dioxide into the earth's atmosphere. Aside from ethanol, many other lignocellulose-derived fuels are of potential interest, as well as butanol, dimethylfuran and gamma-Valerolactone.

Pyrolysis

Pyrolysis of biomass is a form of incineration that chemically decomposes organic materials by using heat in the absence of oxygen. Pyrolysis units cannot operate alone without an external supply of heat. The liquid fraction of pyrolisised biomass consists of an insoluble viscous tar, and pyroligneous acids which consist of of acetic acid, methanol, acetone, esters, aldehydes, and furfural (Jenö Kovács 2001). The provision of pyrolysis products differs depending on a few factors: the feedstock composition, heating rate, temperature, and pressure.

Why biomass pyrolysis is so attractive? This is because solid biomass and wastes which are very hard and costly to handle can be readily and easily converted into liquid products. These liquids, as crude bio-oil or slurry of charcoal of water or oil, have advantages in transport, storage, combustion, retrofitting and flexibility in production and marketing (Food and Agriculture Organizations of the United Nations 1996).

Up to now, numerous types of processes are available which rely upon the reaction parameters such as conventional, flash or fast. Yet, the typical pyrolysis process can be illustrated in this manner: Firstly, the biomass are cut to size and dried to get hold of a fully control of the process. Then, they are feed into the reactor with just sufficient air to burn that fraction of biomass by using heat carrier (sand or others) to supply the heat required to the process. A series of cyclones and condensers system is then used to allow the recovery of the products. In general, the biomass pyrolysis system deals with several aspects which included biomass planting, pre-treatment, pyrolysis process, products utilization and upgrading, cost and economic evaluation (Food and Agriculture Organizations of the United Nations 1996).

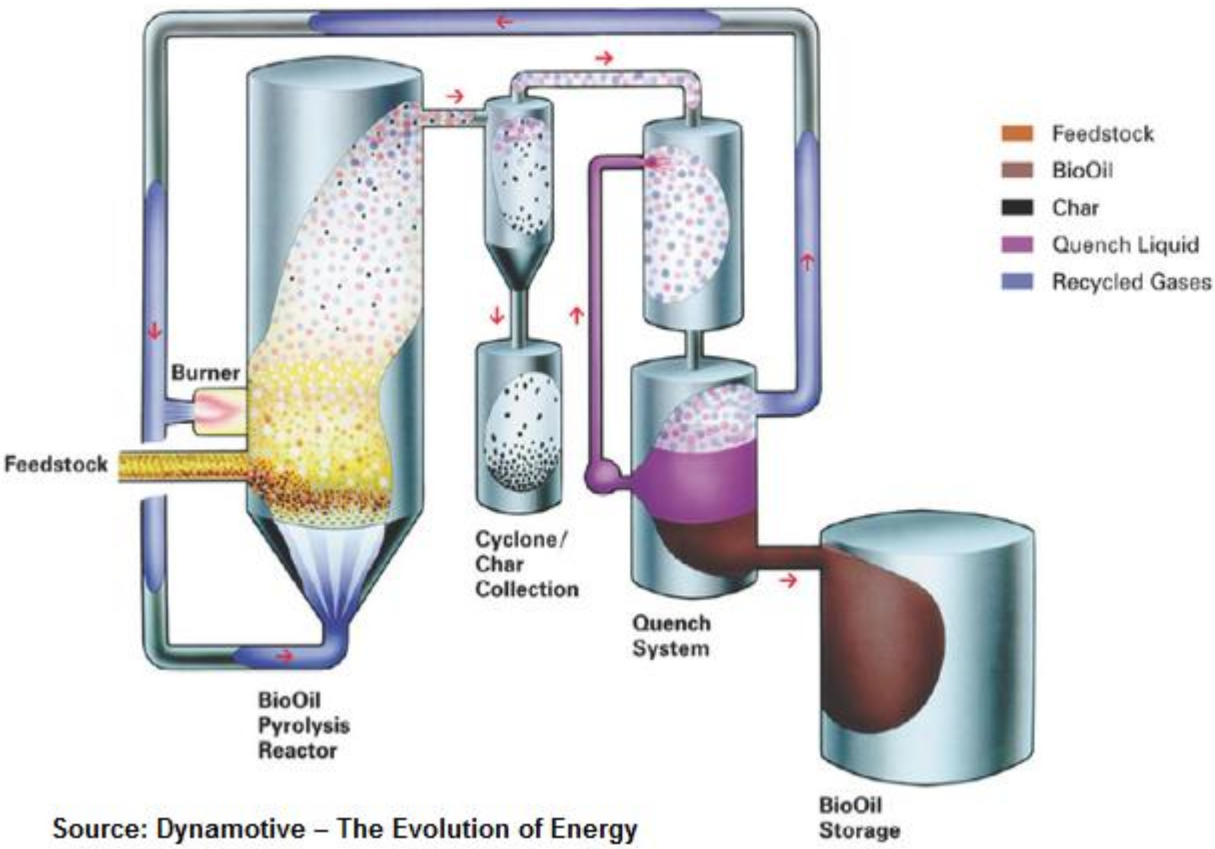


Figure 5.11 Pyrolysis Process

There are two types of pyrolysis processes: slow pyrolysis or fast pyrolysis. Fast pyrolysis is currently the majority widely used pyrolysis system. In slow pyrolysis, biochar is the core product formed and usually this process employed several hours to complete. Conversely fast pyrolysis yields 60% bio-oil and takes seconds for complete pyrolysis. In addition, it gives 20% biochar and 20% syngas (Alternative Energy Emag 2007). Fast pyrolysis processes consist of open-core fixed bed pyrolysis, ablative fast pyrolysis, cyclonic fast pyrolysis, and rotating core fast pyrolysis systems (Alternative Energy Emag 2007). The important features of a fast pyrolysis process are:

- Very high heating and heat transfer rates, which involve a finely ground feed.
- Vigilantly controlled reaction temperature at around 500℃ in the vapour phase

- Residence time of pyrolysis vapours in the reactor is less than 1 sec
- Quenching of the pyrolysis vapours to give the bio-oil product.

5.2.3 UNCONVENTIONAL NATURAL GAS

Unconventional natural gas is gas that is more difficult and complicated or less economical to extract, typically because the technology and skill to reach it has not been developed entirely or it is too expensive or that is not economically viable to transport by pipeline or tanker: remote, coal bed methane, hydrates, anaerobic fermentation. These resources have several characteristics that require special attention for successful exploration and production, thus separating them from conventional gas resources.

List of unconventional natural gas sources are (Dave Cohen 2006):

- Coal Bed Methane
- Deep Gas (onshore or offshore in the GOM)
- Tight Gas Sands
- Shale Gas (from Devonian or Carboniferous sediments)
- Geopressurized Zones
- Methane Hydrates

Gas from unconventional sources must be controlled, concentrated, or converted to a liquid form or stabilized in some manner before being transported to the manufacturer, power plant, or end user. An alternative to transfer the gas is to build up modular plants that can be scaled down so that the trapped methane gas may perhaps be used in situ. These modular plants can be small scale with microturbines, fuel cells, or distributed systems that could be incorporated into farms, mills, or remote settings. By converting methane to liquid product such as methanol, this will consent to easier transportation of resources from remote sites. One example of gas to liquids is the Fischer-Tropsch production of liquid fuels such as done by Sasol, or methanol to gasoline (MTG) done by Mobil.

Besides, we can combine a new methanol process technology with a marine vessel which allows the conversion of huge quantities of remote or stranded gas to a liquid. Then, we can transport the liquid to markets for use as fuel for power generation or feedstock for the petrochemical industry in the conversion of methanol to olefins. In the case of methanol to olefins (MTO), technologies are under development by UOP/Norsk Hydro and Exxon Mobil.

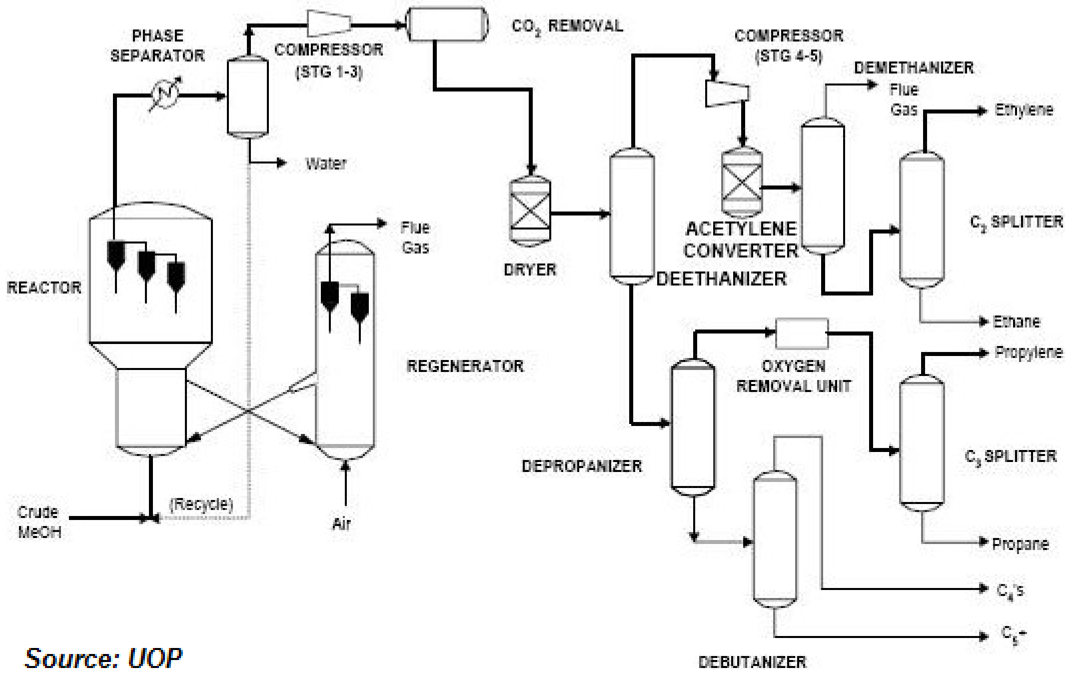


Figure 5.12 Simplified Process Flow Diagram for UOP/Hydro MTO Process

5.2.4 TAR SANDS/HEAVY OIL

Unconventional oil—which includes tar sands, heavy oil, bitumen, or shale oil—refers to any type of crude-like resource that cannot and does not flow easily and is thus difficult to produce. The sands usually contain naturally occurring mixtures of sand, clay, water, and a dense and tremendously viscous form of petroleum theoretically referred to as bitumen (Bob Weber, 2010). In the past, major detriment to the use of heavy oil is caused by the relatively high cost of extraction of these hydrocarbons. Oil sands reserves have only recently been considered to be part of the world's oil reserves, these feedstocks are now more competitive owing to the hiking and high prices of conventional resources.

There are several steps in the extraction of bitumen-derived crude (BDC). Firstly, heavy oil is extracted from the rock. Tar sands (7% bitumen by weight from the tar sands) and oil shale be composed of rather low concentrations of hydrocarbons. Some loss (<10% of bitumen) happens in the primary extraction process. Increased mechanical breakup or froth treatment can add to the yield (Chemical Vision 2020).

By using surface mining, we can recover the bitumen in tar sands. Open-pit mining methods can be employed where thick deposits occur near the surface. Earth-moving equipment is used to strip and stockpile the topsoil, remove and dispose of the overburden, and excavate the tar sand. The recovery efficiency of surface mining tar sands is estimated at roughly 90 percent (Brittanica Encyclopaedia 2011). A mill is necessary to detach the bitumen from the sand in order to improve it to commercial quality. What happened in this process is where the tar sand is crushed and the bitumen is separated by mixing the crushed ore with steam and hot water. The bitumen is concentrated by floating and is then treated with a solvent for final separation from the sand and water. The cleaned crude bitumen is upgraded in a delayed coking unit, which produces a blend of lighter hydrocarbon fractions that yield synthetic crude oil, naphtha, kerosene, and gas oil.

Is it a fact that heavy oil is much more expensive to extort from the natural reservoir, to process, and to distribute. The crucial cost addition take places in the refining process, much of which must be done in close proximity to the source. Hydrogen required is one of the major cost components. It is essential both for hydrocracking and for sulfur removal. The recovery of heavy crude oils is hindered by a viscous resistance to flow at reservoir temperatures. Therefore we need to heat the heavy crudes in order to improve their mobility and promotes their recovery. Heat may be initiated by burning some of the heavy oil in the reservoir (a process referred to as in situ combustion or fire flooding) or by injecting a hot fluid into the reservoir, such as steam or hot water. Many of the methods developed to extract hydrocarbons from the heavy gas oil (HGO) derived from bitumen are also suitable for petrochemical manufacture. These include hydrocracking, fluidic carbon cracking (FCC), PetroFCC from UOP, deep catalytic cracking (DCC), and the catalytic pyrolysis process (CPP).

5.3 OVERVIEW

Bio-based feedstock is the most suitable platform for Malaysia due to: (1) enormous feedstock advantage and available arable land; (2) High potential to add value to agricultural products, (3) Strong support from government, for alternative feedstock, renewable energy, fuel (i.e. ethanol and bio-diesel) and bio-plastics.

5.4 CONCLUSION

Throughout this project, I have better and thorough understanding of the petrochemicals market and the most important and relevant process chemistry that is integral to this industry. Petrochemical activities in Malaysia then are identified and I am capable to classify the petrochemical plants according to the feedstock. Last but not least, I am taught on how to research, assemble and compile the data, graphs, figures and statistics related to petrochemical activities and industries in Malaysia with supported documents.

In conclusion, Malaysia petrochemical industry will have to depend on its capacity to develop and sustain competitive advantages over other nations by developing new sets of strategy especially when the market competition is too rigid. Malaysia has the infrastructure and system in place for petrochemical manufacturers to compete favourably with regional players. The Malaysian government will execute the need to take substantial measures to further enhance the business environment, infrastructure development.

The technologies required for commercialization include: the infrastructure for extracting/harvesting, transporting and storing feedstock; the process equipment for converting feedstock into intermediate chemicals; the ancillary process equipment (e.g., air separation unit (ASU), carbon capture and sequestering units, etc.); and the final conversion chemical process equipment. Feedstock conversion technologies may be technologically ready, but not commercially competitive. The science and engineering of the technology may be demonstrated, but implementation will be delayed until the economics of the technology are viable. The ability to rapidly commercialize alternative, renewable and novel feedstock is highly desirable.

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