Overview of Petrochemical Based Industries in Malaysia

Mohamad Roji Sarmidi
Chemical Engineering Pilot Plant, UTM, Johor
Ramlan Aziz
Chemical Engineering Pilot Plant, UTM, Johor
Mohammed Azlan Hussain
Department of Chemical Engineering, Universiti Malaya, Kuala Lumpur
Wan Ramli Wan Daud
Department of Chemical Engineering, UKM, Bangi, Malaysia

This paper describes the current status of the petrochemical industry in Malaysia. The industry is broadly categorized into various sectōr that include the agrochemical and agroprocessing, basic chemicals, industrial gases, oleochemical, petrochemical, surface coatings, and the fine chemicals sector. With regard to industrial development, Malaysia has adopted the Manufacturing strategy and clustering concept for the manufacturing based industry. The main idea is to develop the chemical industry in the form of an industrial cluster where industrial symbiosis could flourish and achieve the national objectives within the next ten years or so. The focus of the paper is, however, on the resource based processing and petrochemical industry in particular.

Introduction

The chemical industry is a large and complex industry. The current world chemical market is in excess of USD 1,500 billion per year. The industry produces more than 70,000 products ranging from primary chemicals to finished consumer products such as pharmaceutical, cosmetics and food ingredients. However, these finished products are seldom seen by the public as being associated with the chemical industry. 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. Chemical industry is an enabling industry; it is a supplier for almost every other industry. Thus, the chemical industry has the potential to generate more wealth by creating forward, backward, and vertical integration with other industries. Despite the vast amount of natural resources in the region, Asia Pacific remains a net importer for chemical products and services. 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 global nature of the industry, the widespread use of the information superhighway, the ongoing consolidation of chemical companies, the interdependence of worldwide chemical industries, and their responsibilities require the industry to address these macro issues. The challenge to any country is to succeed in this world order of macro changes. With regard to the challenges of this important issue, Malaysia adopted the Manufacturing strategy and clustering concept for the manufacturing based industry. The main idea is to develop the chemical industry in the form of industrial cluster where industrial symbiosis could flourish. Within the industrial web, chemical plants, supporting services, industrial infrastructure, and related institutions are interlinked and interdependent. This requires the industries and

related institutions to adopt a new management and operating strategy that will foster collaboration, interfirm corporation, strategic alliances, and smart partnership. 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 strategy.

The Chemical Industry in Malaysia has been growing steadily over the past few years. The Second Industrial Plan (1996-2005) has specifically emphasized the development of the Chemical Industry to tag along with other manufacturing groups. The integration of chemical industry with manufacturing and other operations aims to strengthen industrial linkages and increase productivity and competitiveness of industries in Malaysia. The chemical industry in Malaysia is, however, broadly categorize into various sectors: oleochemicals, petroleum and petrochemicals, surface coatings, and the fine chemical sectors. In this paper, we will focus on the study of the petroleum and petrochemical industries, beginning from the next section onwards.

Status and Outlook of Hydrocarbon Industry in Malaysia

The factors that influenced the development of hydrocarbon industries in Malaysia were the Petroleum Act 1972, and the construction of the Peninsular Gas Utilization projects (PGU). Petroleum and petrochemical activities in Malaysia entered a new phase when the 'Petroleum Development Act' was passed by the Parliament known as the 'Petroleum Act 1972'. Petronas was then established to develop the nation's oil and gas reserves. Since then, Petronas has embarked on Production Sharing Contracts (PCS) with various multinational petroleum corporations. At present, a total of 60 PCS has been signed with over 40 multinational petroleum corporations operating in the country. Since then, Petronas has been actively involved in the development of this industry in Malaysia starting from the production, processing and right up to the operations of petrochemical industries.

Petroleum and Natural Gas Production

Malaysia has abundant reserves of hyrocarbon in the form of crude oil and natural gas. The 1997 recoverable reserves for crude oil is estimated at 3.9 billion barrel and ranked as the 24th largest. Natural gas reserve is 79.8 trillion standard cubic feet and ranked as the 11th largest. In 1997, Malaysia produced 767,000 barrels per day of crude oil, 4,336 million standard cubic feet of gas per day, and 19,000,000 metric per annum of liquefied natural gas (LNG)[1]. Almost all of Malaysia's oil and gas exploration and production occur offshore and primarily on the continental shelf. The main company involved in oil and gas production is actually the local company (i.e., CARIGALI, in conjunction with multinationals such as EXXON-MOBIL and SHELL). Despite falling reserve, Malaysia's total oil production has been steadily increasing. In 1997, the total oil production reached 767,000 barrels per day (bbl/d), up from 716,000 bbl/d in 1996, 703,000 bbl/d in 1995, and 663,000 bbl/d in 1994(1).

The major gas fields are the Duyong Gas Field and Jerneh Gas Field offshore Terengganu, and in many fields offshore Sarawak in East Malaysia. One of the most active areas in Malaysia for gas exploration and future production is the Malaysia-Thailand Joint Development Area (JDA), located in the lower part of the Gulf of Thailand and governed by the Malaysia-Thailand Joint Authority (MTJA). The MTJA was established by the two governments for joint exploration of the once disputed JDA with estimated reserves of 10 trillion cubic feet (tcf). Malaysia natural gas production has been steadily rising, reaching 1.30 tcf in 1996, up from 1.02 tcf in 1995, and 0.92 tcf in 1994.

Refining, and Downstream Processing

At present, 11 companies have been given approval to operate petroleum refineries in the country of which six are in operation. The six petroleum refineries have a combined capacity of 465,000 bbl/d. These refineries are Petronas Refinery in Kerteh, Trengganu (40,000 bbl/d), Esso Refinery in Port Dickson, Negeri Sembilan (75,000 bbl/d), Shell Refinery in Port Dickson (105,000 bbl/d), MRC (Petronas) Refinery in Melaka (200,000 bbl/d) and Shell Refinery in Lutong, Sarawak (45,000 bbl/d). The 100,000 bbl/d second phase of the MRC refinery is a joint venture of Petronas (45%), Conoco (40%), and Statoil (15%). This second refinery contains a 62,000 bbl/d vacuum distillation unit, 26,000 bbl/d catalytic cracker, 28,500 bbl/d hydrocracker, 35,000-bbl/d desulfurization unit, and 21,000 bbl/d coker. One of the main purposes of this refinery is to supply

gasoline to Conoco's service stations in Thailand and new line of stations planned for Malaysia. Since it is the biggest refinery in Malaysia at present, we will describe its operation in more detail in the next section.

Another important milestone for Malaysia's gas industries is the completion of Peninsular Gas Utilization (PGU) project linking the source of natural gas in the east coast of Malaysia to the consumer under PGU I and PGU II projects to the west and southern part of Peninsular Malaysia. They are receiving natural gas supply through pipelines, while PGU III links natural gas to the northern states.

Six Gas Processing Plant (GPP) namely GPP1, GPP2, GPP3, GPP4, GPP5 and GPP6, with combined capacity of 200 million standard cubic feet per day (mmscfd), have been developed in various parts of Peninsular Malaysia. Two Liquefied Natural Gas (LNG I, LNG II) with an annual capacity of 16 metrictonnes per annum (mtpa) have been constructed in Sarawak. These LNGs produced are exported to Japan, Korea, and Taiwan under long term contracts.

Petroleum Refinery of Melaka

The Petronas petroleum refinery located outside Melaka town processes both sweet and sour crude oil. With a combined capacity of 200,000 bbl/d, it is the largest refinery complex in Malaysia. The sweet and sour trains (both have capacity of 100,000 bbl/d) are two separate projects capable of independent and stand alone operations. The first phase (sweet train) is wholly owned by a subsidiary of Petronas, (i.e., Petronas Penapisan Sdn Bhd (PPMSB)), and the second phase (sour train) is owned by a joint venture of Petronas, Conoco, and Statoil which is named Malaysian Refining Company Sdn Bhd (MRC). However, both refineries are managed and operated by PPMSB.

The PPMSB refinery is designed to process light sweet crudes and condensates. It is a hydroskimming refinery with complete backup utility and offsite systems. The MRC refinery is a state-of-the-art conversion refinery designed to process a mix of imported heavy sour crudes and sweet crudes. The crude oil and condensate feedstocks for the sweet train come from the local Trengganu and Sarawak oil fields.

The sweet refinery basically contains the crude distillation unit (CDU) and the catalytic reformer unit (CRU). The CDU is designed to process 100,000 bbl/d of crude oil and condensates while the CRU is designed to process 200,000 bbl/d of treated naphtha. The various refined products from the sweet train can be seen on **Figure 1** and they are targeted primarily for the local market.

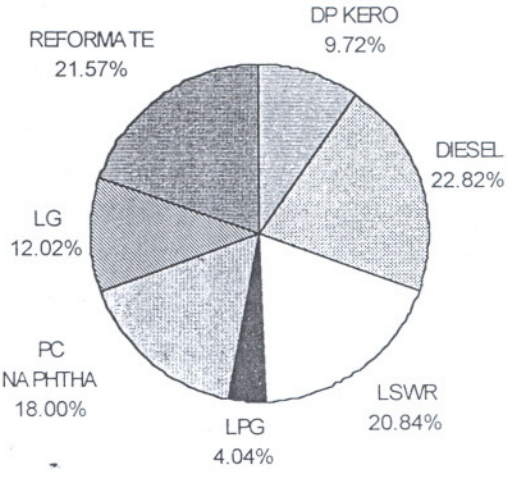

Figure 1. Refined products from sweet train

The MRC sour refinery on the other hand, incorporates major process units such as the CDU, Vacuum Distillation Unit, Catalytic Reformer, Isomerization, LPG/Naphtha Kero Treaters, Distillate Hydrotreater, Delayed Coker, Sulphur Recovery, and Gas Oil Hydrocracker.

These two refineries have their own dedicated crude storage tanks and intermediate feedstock tanks. However, the finished product tanks and blending facilities will be shared. Other shared facilities are the utility systems, marine jetty, and offsites like effluent treatment. This refinery also incorporates a lube blending plant, with a capacity of 35,000 kiloliters per year of lubricant products of various types and grades. For emission, a flare is installed with scrubber to minimize particulate and hazardous gas emission to the atmosphere. Air quality is monitored on a quarterly basis. A sludge farm with four plots to process sludge from the effluent treatment systems is also available.

The many state-of-the-art independent and common facilities at the Melaka refinery will enable both PPMSB and MRC to achieve manufacturing and marketing synergies. More importantly, the refinery will provide Malaysia with additional refining capacity to ensure a secured supply of petroleum products, as well as an increase net inflow of foreign exchange, by reducing imports and increasing exports of refined products.

Petrochemical Industry in Malaysia

The world demand for petrochemical products is projected in the next ten years to increase at an average rate of about 4% per year. However, there are variations in the regional demand according to the prevailing economic growth rate. The projected demand in the next 10 years for petrochemical products is expected to be 6% per year in Asia. At present, the United States, Western Europe and Japan account for 65% of the world production and 35% from the rest of the world. It is expected that the trend will be reversed in the near future[3]. More production facilities will be located in the developing countries to take advantage of economic growth and the availability of petrochemical feedstock. One of the issues that need to be addressed by Malaysia is how to increase the benefit of the nation from the projected growth in the exploitation of petroleum raw materials. In Malaysia, the petrochemical industry is being developed along an industrial cluster based approach. The global nature of the petrochemical industry warrants greater linkages and cooperation amongst the neighboring countries. A region of economic prosperity cannot exist in isolation.

The progress of petrochemical industry in Malaysia is no different from other countries although the industry is established only recently. Petrochemical industries in Malaysia started only in the early seventies and have been showing significant growth especially in the last decade. The petrochemical industry contributed significantly to the total national income generated under the chemical industry in Malaysia. In 1995, petrochemical investment in Malaysia reached up to RM 15 billion and production was estimated at RM 13.8 billion. However, despite the high growth and the abundant availability of oil and gas reserves, Malaysia is still a net importer of chemical products as well as other petrochemicals. In fact, chemical and its products account for only 3.5% of the country's total export value in 1998 (*see* **Table 1**).

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. For example, the successful venture in the domestic car manufacturing industry has created enormous demand for the car part components, a large number of which are made from plastics. Similarly, the proliferation of electronics and electrical goods manufacturing facilities also has been a boost to the demand for plastics.

The increasing consumption and production of petrochemical intermediate and plastic products have been the consequence of an expanding

Table 1. Malaysia's Export by Products

	Value (RM Million)	Share (%)
MANUFACTURING PRODUCTS	232,144.4	81.0
Electrical and electronics products	161,754.0	56.4
Textiles and clothing	13,464.5	4.7
Chemical and chemical products	9,974.8	3.5
Transport equipment	8,059.9	2.8
Wood products	5,981.6	2.1
Other manufactures	32,918.6	11.5
AGRICULTURES	33,288.8	11.6
Palm oil	17,881.6	6.2
Saw logs and sawn timber	5,258.3	1.8
Animal oil and fats	3,489.4	1.2
Others	6,659.5	2.3
MINING	18,733.1	6.5
Crude petroleum	8,105.4	2.8
LNG	6,893.3	2.4
Refined petroleum	2,650.0	0.9
Others	1,084.4	0.4
OTHERS	2,583.8	0.9
Total exports	286,750.1	100.0

Malaysian economy in which the GDP has been growing between 8-9% per annum for almost a decade, although the country is somewhat smaller in population size (1997: 21 million) compared with that of the larger Asian countries. The country is likely to maintain this growth rate for sometime in the future buoyed by abundant natural resources and increasing contribution of the manufacturing sector in line with the national commitment to achieve a highly industrialized status.

Major industries that are indispensable for the country in its development towards achieving the industrialized status are poised for rapid growth. This includes the petrochemical industry as described above. As Malaysia is strategic in the geographical context, and the fact that the country is an oil and gas producing country to some significance, the future seems conducive for the development of the petrochemical industry.

Petrochemical Plants in Malaysia

Malaysia's vision to be a fully industrialized country by 2020 can no longer depend on traditional industries. Instead, the country has to shift from a low value-added type of industry into a high value-added manufacturing facilities that emphasize on high technology, as well as a capital intensive industry, which would be of world scale capability in order to be globally competitive. The petrochemical industry is one such industry that meets this requirement. Under the Second Industrial Master Plan, the chemical industry, in which the petrochemical is a major segment, has been one of the most promoted industrial groups.

The petrochemical industry is relatively new in Malaysia and first made its appearance in the early seventies with the set up of the first poly vinyl chloride (PVC) and poly styrene (PS) resins manufacturing facilities, but it was only in the late eighties that the pace of the industry suddenly quickened. The earliest petrochemical plant in Malaysia using imported monomers were the PVC and PS plants in Tampoi, Johor, and the PVC plant in Prai, Penang. These plants were comparatively small in present day market environment. Since then, there was virtually no significant investment in the petrochemical sector until the Titan Group set up the first integrated petrochemical complex in Pasir Gudang in the early nineties.

Today, the petrochemical industry is developing rapidly in three main locations, (i.e., Kerteh in Terengganu, the Gebeng Industrial Area near Kuantan, and the areas around Pasir Gudang in Johor), although there are other industrial sites that have plants which are also classified as petrochemicals. These will be described in detail in the following sections below.

The Pasir Gudang Petrochemical Complex

The most important of the petrochemical investment in this area to date is the investment made by the Titan Group. The Group set up the first integrated petrochemical complex in the country in Pasir Gudang, Johor, when the first naphtha cracker, the first polypropylene plant, and the first polyethlene plant in Malaysia went into operations in the early nineties. Incidentally, the first petrochemical plants in Malaysia were also located in an area near Pasir Gudang, (i.e., in Tampoi, Johor, which is about 20 km away from Pasir Gudang), where the plants producing PVC and PS resins using imported monomers were built.

Titan invested in these multimillion-dollar projects to meet Malaysian demand for the widely consumed plastic resins polypropylene and polyethylene, as well as the overseas markets. Under the current phase of its operations, the petrochemical plants of the Titan Group are:

1. Polypropylene plant through Titan PP Polymers (M) Sdn. Bhd.
2. Polyethylene plant through Titan Polyethylene (Malaysia) Sdn. Bhd.
3. Naphtha cracker through Titan Petrochemicals (M) Sdn. Bhd.

The initiative behind the setting up of the Titan petrochemical complex in Malaysia is the Chao Group, which has long experience in the petrochemical industry. The Chao Group has successfully established petrochemical operation in Taiwan and is active in the U.S.A. through the Westlake Group of Companies. The other most significant partner in the Titan projects in Malaysia is Permodalan Nasional Berhad (PNB) through its wholly owned subsidiary PNB Equity Resource Corporation Sdn. Bhd. The other current partner in the Titan projects is Sinochem (China National Chemicals Import and Export Corporation) that holds a minor shareholding in TPE, which is its first investment in Malaysia.

Titan PP Polymers (M) Sdn. Bhd. (TPP)

formerly known as Titan Himont Polymers (M) Sdn. Bhd. (THP) was the first of the Titan companies to go into operations in December 1991. Originally, the shareholders of the joint ventures were the Chao Group, Permodalan Nasional Berhad, and Himont (later Montell). However, in early 1996, Montell sold its shareholding to the Chao Group, and PNB. Using the Montell Spheripol Process, TPP produces polypropylene homopolymers and copolymers for the domestic and export markets. Polypropylene resins from TPP are widely used in the making of products such as woven sacks, film, carpet yarn, specialty fabric, and containers. The potential for various other applications is rapidly being realized as more uses continue to be found every year.

Titan Polypropylene (Malaysia) Sdn. Bhd. (TPE) which went into operation in 1993 was the second of the manufacturing facilities to be commissioned, and its shareholders are the Chao Group, PNB and Sinochem. Originally BTR-Nylex was also a shareholder of the joint venture but it has divested its shareholding to the Chao Group, and PNB. TPE produces linear low-density polyethylene (LLDPE), and high density pohyethylene (HDPE) using the low pressure, gas phase Union Carbide Unipol process in a fluidized bed reactor with proprietary solid catalyst. The Unipol process is reported to be the most widely used (estimated around 70% of the world), and is a versatile process for a wide range of products, and is also a user-friendly process.

The Titan Petrochemical (M) Sdn. Bhd. (TPC) is the third manufacturing facility of the Titan Group and it began operations in 1994. The shareholders of the TPC are the Chao Group and PNB. Previously BTR-Nylex also held equity in TPC but it has since divested its shareholding to PNB and the Chao Group. The Petrochemical Plant (ethylene plant) consists of a naphtha cracker designed to produce 230,000 tonnes per year of ethylene, and 115,000 tonnes per year of propylene. These olefin compounds are the building blocks for the manufacture of two highly versatile and useful polymers of polyethylene and polypropylene. The plant utilizes the Stone & Webster Engineering Corporation's process, with state-of-the-art technology, and a proprietary energy recovery system known as Advanced Recovery System (ARS). It is estimated that conventional ethylene plants would consume 10% more energy than plants that employ the ARS technology.

Titan is currently undergoing an expansion plan to expand existing capacities, as well as adding new products. The construction work on a second naphtha cracker has already started. This plant has a bigger capacity than the first cracker. Titan would also invest in additional downstream activities by constructing another polypropylene manufacturing facility and a new line of HDPE manufacturing facility. It would also construct the first plant in Malaysia to produce LLDPE. Further downstream activities include PVC and PVM plants, as well as BTX and polyisobutylene plants.

A number of Titan's new projects would be located in Tanjung Langsat that is the new site promoted by the Johor Government for the setting of heavy industries that are located 10 km away from Pasir Gudang. The intermediate raw materials, mainly ethylene produced by the Titan crackers, needed for the projects at Tanjung Langsat would be transported via pipelines. There are also other internationally known petrochemical companies that have shown interest to invest in manufacturing operations at Tanjung Langsat. In the next decade, it is likely that the Pasir Gudang-Tanjung Langsat corridor would become an important petrochemical site in the region.

The Pasir Gudang-Tanjung Langsat site has several advantages and is strategic to the development of the petrochemical industries. The industries are located near the Johor Port. They have bulk cargo and jetty facilities that are close to the international shipping routes. They are also able to operate all the year round, as they are sheltered from the seasonal monsoons. Furthermore, the southern part of Johor is also one of the most concentrated industrial sites of the country that provides sizeable market outlets for the products.

Apart from the Titan project's, other petrochemical projects in Pasir Gudang include the manufacturing of ethyl benzene (EB), and styrene monomer (SM), in addition to the polystyrene plants. These plants were set up by the Idemitsu Group, which in the case of EB and SM, is a joint venture with Petronas, the state owned national oil company. A well-known international company, BASF, also has a manufacturing facility to produce expanded polystyrene (EPS) in Pasir Gudang.

Petrochemical Plants in Kerteh

The Kerteh and Kampung Tok Arun industrial area located in the oil and gas rich state of

Terengganu is an important petrochemical site in the country since the national petroleum company, Petronas, embarked on a number of petrochemical projects. The choice of site makes sense since it is close to the hydrocarbon feedstock. Terengganu has four gas processing plants with another two under construction. A refinery in Kerteh belonging to Petronas has been in operation since the early eighties and two more refineries are being planned in the state, and will provide feedstock for petrochemical plants.

Petronas has set up the first gas cracker plant, Ethylene Malaysia, which went into operation in 1995. This is a joint venture between Petronas and BP. In this plant, ethane is cracked to produce ethylene, and later on, this process has formed the feedstock of another Petronas joint venture project with BP to produce polyethylene resins. The cracker has an initial capacity to produce 320 kta of ethylene but has been upgraded to produce 400 kta of ethylene in 1997. Another gas cracker is also being planned to produce 600 kta of ethylene. This is a joint venture between Petronas and Union Carbide. This project is expected to be in operation by 2001.

New projects are expected in Kerteh. They are VCM and PVC, a joint venture between Petronas, Land and General Company, and Mitsui VCM Holdings of Japan. These plants have the capacity to produce 400 kta of VCM, and 150 kta of PVC. Thirumalai Chemicals has also built plants to produce maleic anhydride and phthalic anhydride which has been in operation since 1998. Other projects in Kerteh include an aromatic plant for the production of benzene and paraxylene from condensates.

Gebeng Petrochemical Complex

The Gebeng Industrial Estate in Pahang located near the Kuantan Port is another site. It has been embarked on large petrochemical projects. Petronas has set up a plant producing MTBE, and propylene for its polypropylene project. MTBE plant was originally a joint venture with Idemitsu Petrochemical and Nestle's subsidiary Borealis. The plant produces 300 kta of MTBE and 80 kta of propylene. It is a gas phase reactor using Unipol's technology. Amoco Chemical has also set up a plant producing 500 kta of purified terepthalic acid (PTA) which started operation in 1997 and has plans for further expansions. Other petrochemical plants slated to be built in this area include facilities to manufacture acrylics resins, methylenethacrylate and monoethylene glycol (MEG). Petronas has also agreed to set up, in joint venture with BASF, an acrylic and esters complex and oxy alcohols facility at Gebeng.

Table 2. First Major Petrochemical Plant in Malaysia

Product	Company	Location	Capacity (kta)	Date on Stream
Ethylene	Titan Petrochemical (Naphtha Cracker)	Pasir Gudang	230	1994
	Ethylene Malaysia (Gas Cracker)	Kerteh	320	1995
			80	1997
Propylene	Titan Petrochemical	Pasir Gudang	115	1994
	MTBE Malaysia	Kuantan	80	1992
Polyethylene (LLDPE/HDPE)	Titan Petrochemical	Pasir Gudang	200	1994
	Polyethylene Malaysia	Kerteh	200	1995
Polypropylene	Titan PP Polymers	Pasir Gudang	130	1991
	Polypropylene Malaysia	Kuantan	80	1993
Polystyrene (EPS)	BASF Sdn. Bhd	Pasir Gudang	50	1992
(HIPS)	Petrochemical Sdn.Bhd	Pasir Gudang	92	1994
Ethyl Benzene	Idemitsu Styrene Monomer	Pasir Gudang	215	1997
Styrene Monomer	Idemitsu Styrene Monomer	Pasir Gudang	200	1997
ABS	Toray Plastics	Prai	160	1991
MTBE	MTBE Malaysia	Kuantan	300	1992
PTA	Amoco Chemical	Kuantan	500	1997
MBS	Kaneka Malaysia	Kuantan	15	1997
Carbon Black	Cabot	Port Dickson	100	1970
PET Fibre and Resin	MPI Polyester	Shah Alam	20	1996
	Eastmant Chemical	Kuantan	30	1997
	Hualon Corp	Nilai	400	1996

Table 3. Petrochemical Plant in Malaysia: Major New and Future Projects

Product	Company	Location	Capacity (kta)	Date on Stream
Ethylene	Titan Petrochemical (Naphtha Cracker)	Pasir Gudang	330	1999
Propylene	Titan Petrochemical	Pasir Gudang	165	1999
	Shell Refining Co.	Port Dickson	80	1999
	MTBE Malaysia	Kuantan	195	2000
Polyethylene (LLDPE/HDPE)	Titan Polyethylene	Tanjung Langsat	200	2000
	Titan Polyethylene	Tanjung Langsat	100	2000
Polypropylene	Titan PP Polymers	Pasir Gudang	200	1999
Vinyl Chloride	VCM Malaysia	Kerteh	400	1998
Polyvinyl Chloride	VCM Malaysia	Kerteh	150	1998
	Malaysian Electrochemical Industries	Prai	50	1998
Polystyrene (HIPS)	Petrochemical	Pasir Gudang	30	1998
Ammonia	Petronas Fertilizer	Gurun	400	2000
Urea	Petronas Fertilizer	Gurun	600	2000
Methanol	Petronas Fertilizer	Gurun	70	2000
Maleic Anhydride	Thirumalai Chemicals	Kerteh	35	1998
Phthalic Anhydride	Thirumalai Chemicals	Kerteh	20	1998
Plyacetal	Polyplastics Co.	Kuantan	30	1999
Polyurethane	BASF Polyurethane	Bukit Jelutong	10	1998
Ethylene	Petronas/Union Carbide	Kerteh	600	2001
Propyene	Petronas/Union Carbide	Kerteh	160	2001
	Petronas/BASF	Kerteh	300	2000
Benzene	Aromatics Malaysia	Kerteh	150	2000
Paraxylene	Aromatics Malaysia	Kerteh	420	2000
Monoethylene Glycol	Petronas/BASF	Kuantan	400	2001
	Titan Group	Tanjung Langsat	300	2002
Vinyl Chloride	Titan Group	Tanjung Langsat	200	2002
Styrene Monomer	Titan Group	Tanjung Langsat	300	2002

Other Petrochemical Sites

There are other areas where petrochemical plants are located. However, these sites are smaller downstream petrochemical projects and are not integrated with upstream or other petrochemical operations. These plants are not supported by having nearby upstream petrochemical plants producing basic raw materials monomers such as ethylene and propylene. The plants are situated in these locations due to market conditions, facilities and other incentives. For example, PET films and resins are produced in Nilai, Seremban by the Hualon Industries, and in Prai, Penang by Penfibre.

Also, a plant producing PVC resins was set up in Prai in 1973 and was among the earliest petrochemical plants in Malaysia. The country's only ABS plant is also located in Prai and started operation in 1991. There is even a suggestion for petrochemical complex to be set up in the state of Kelantan by 2003 that includes a propane dehydrogenation plant and aromatics facility. Table 2 shows the existing petrochemical plants in Malaysia and **Table 3** shows the recent and future projects respectively.

A strategic direction for Malaysia is to focus its petrochemical cluster on the high value-added downstream activities. The cluster should also seek to foster synergy with other petrochemical cluster in the country and in the region.

A clear option for the future expansion of Malaysia's petrochemical is in the development of petrochemical industrial cluster based on C3, C4, and C5 chemistry and selected aromatic based products. Further downstream activities include petrochemical intermediates that can be used for the production of polymer resins, surface coatings, specialty solvents, adhesives, sealants, and new

material for the automobile, electronic, building and construction and packaging industries.

Sustainable Development

The exploitation of the petrochemical subsector is a good example in highlighting the dilemma facing governments and policy makers, and that is how to strike an optimal balance between extracting sufficient revenue for economic growth and maintaining "sky." The interdependence between economic growth and development and environment sustainability is not mutually exclusive. To ensure sustainable economic development, we have to pursue economic efficiency, maintain environmental integrity, and safeguard equity to incorporate the needs of not only the present generation but also the future generations taking into consideration the cultural and social dimensions.

In the case of nonrenewable natural resources such as the oil and gas sector, the rate of utilization and exhaustion of these valuable energy resource should be complemented with a development of other renewable resource of energy such as harnessing the solar energy, fuel cell and energy from biomass. Oil rich nations should invest more in Science and Technology in various alternatives to regenerate energy resources. It is the responsibility of each hydrocarbon producing nation to improve the contribution of this sector to the well-being of present and future generation by ensuring that the hydrocarbon resource is managed in an economically, environmentally, and socially sustainable manner. If the finite resources are to be used in a sustainable manner, they should be used at a rate of efficiency which could be equal or greater than the rate of extraction of the resource deposits. In the case of Malaysia, the current rate of production for the remaining oil reserves will last for the next 13-14 years, and the gas is estimated to last for another 88 years.

Conclusion

The petroleum and petrochemical based industries in Malaysia have contributed tremendously to the continual development of the country. The current and future challenge for Malaysia is on the issue of optimizing the use of the natural resources for the benefit of the nation in a sustainable manner. The way forward for the chemical industry is value adding through innovative product development and production technology.

Furthermore, there has also been a tremendous increase in the production capacity of these petrochemical products in the ASEAN region, however, interregional trading among ASEAN countries is not widespread. Nevertheless, once the tariff barriers are brought down to the fixture, restructuring of the petrochemical industries in Malaysia and the ASEAN region is inevitable.

Nomenclature:

ABS	acrylonitrile-butadiene styrene
EB	ethyl benzene
EPS	expanded polystryrene
HDPE	high density PE
LDPE	low density PE
LLDPE	linear low density PE
LSWR	low sulphur waxy residue
MTBE	methyl tertiary butyl ether
PA	polyamides
PC	polycarbonate
PE	polyethylene
PET	polyethylene tetraphthalate
PP	polypropilene
PS	polystryrene
PTE	purified teraphthalic acid
PVC	polyvinyl chloride
SM	stryrene monomer
VCM	vinylchloride monomer

References

1 http://www.jaring.my/petronas/economic/genstat.html#crudeoil

2 Petrochemical Industry Master Plan for Gebeng Phase III Report. 1997. UTM Skudai.

3 Proceeding Chemical Systems' Thirteenth Annual Southeast Asian Seminar, Singapore, 1996.

4 UNIDO. 1984-1990. Industry and Development Global Report, United Nations Industrial Development Organization, Vienna.

5 Buku Tahunan Perangkaan Malaysia (Statistic Department Malaysia), 1997.

6 Malaysia International Trade and Industrial Report, 1997, Ministry of International Trade and Industry, Malaysia.

7 Petrochemical Industry Briefs, May 1997 , Malaysian Industrial Development Authority.

8 Melaka Refinery. April 1997. IEM Bulletin.

ABOUT THE AUTHORS

Associate Professor ***Mohamed Romji Sarmidi*** is the R&D manager for the Chemical Engineering pilot plant division in the Faculty of Chemical Engineering, Universiti Teknology Malaysia, Skudai, Johore. He is also the council member of the Institute of Chemical Engineers Malaysia (IJKM). He has been actively involved in teaching and research in the area of Bioproceesing engineering for the last 15 years or so and has been publishing papers in the area in Conferences and Journals.

Professor ***Ramlan Abdul Aziz*** is the Director of the Chemical Engineering pilot plant division in the Faculty of Chemical Engineering, Universiti Teknology Malaysia, Skudai, Johore. He has been instrumental in the setting up of the Pilot plant facilities. He is also the deputy President of the Institute of Chemical Engineers Malaysia (IJKM). He has been actively involved in teaching and research in various areas of Chemical engineering for the last 20 years or so with many published papers in Conferences and Journals.

Associate Professor ***Mohamed Azlan Hussain*** is existing Head of the Department of Chemical Engineering, University of Malaya. He is a professional member of the American Institute of Chemical Engineers and the Institution of Engineers Malaysia. He has been actively involved in teaching and research in the area of Process Controls and Nonlinear controls for the last 15 years or so and has published more than 100 papers in these areas in Books, International Conferences and Journals.

Professor ***Wan Ramli Wan Daud*** teacher with the Chemical Engineering Department of Chemical & Process Engineering, Faculty of Engineering, Universiti Kebangsaan Malaysia since 1996. He was appointed the Deputy Dean of the Faculty of Engineering twice in 1990 to 1993 and 1995-1998 during which time he was involved in the planning and implementation of the four year and the three year undergraduate engineering programs, the administration of research and development of the faculty and the acquisition of research funding from the Malaysian Ministry of Science, Technology and Environment. He has been actively involved in teaching and research in various areas of Chemical Engineering for the last 20 years or so and has published more than 200 papers in these areas in reports, International Conferences and Journals.