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AN INTRODUCTION TO THE PETROCHEMICAL INDUSTRY IN SYRIA.

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INTRODUCTION.

Petrochemicals are usually thought of as products made from crude oil. However, the name covers a much wider group of products derived from a hydrocarbon or hydrogen raw material commonly referreo to as feedstock. The hydrocarbon or hydrogen feedstock may be produced from crude oil or natural gas. Some hydrocarbons can also be produced from coal during the calcining process to make coke. Products made from coke oven hydrocarbons have chemical compositions similar to those derived from crude oil. Therefore, in this study they will be classified as petrochemicals.

Petrochemicals satisfy an essential need in modern society. However, the public is exposed only to a number of chemicals and mostly in a finished form. In most other instances the use of petrochemicals is transparent. The origin of the product is not obvious to the user. These uses scan the full spectrum from essential products such as pharmaceuticals and food, to the necessary products such as clothing, detergents, and paints, to disposable packaging components.

Because of the large number of products, it is useful to classify petrochemicals into groups. In this study, the classification will be based on the degree of upgrading to which the product is exposed. Accordingly petrochemicals can be divided into three groups :

1. Primary products.
2. Intermediates.
3. Finished products.

1. Primary products are simple molecules which can be used as building blocks to produce intermediates and finished products. They include ethylene, propylene, the butylenes, benzene, toluene, xylene, methanol, and ammonia.

2. Intermediates include all products which have received one or more upgrading steps. By definition, they all fall one step short of the finished products.

3. Finished products are petrochemicals upgraded to a level which makes them useable by the public with minimum or no further processing. They include commodities such as detergents, paints, inks, textiles, plastics, housewares, fertilizers, pesticides, and components of capital goods.

RAW MATERIALS.

Hydrogen.

Hydrogen is a primary raw material for the production of petrochemicals. It is not available free in nature. It is prepared commercially by the steam reforming of methane, the major constituent of natural gas, or naphtha, a refinery stream produced from crude oil. It can also be produced by the electrolytic hydrolysis of water. However, it is included in this study because it is mostly produced from crude oil or natural gas.

Hydrogen is used to saturate olefinic functions in intermediates and finished products. However, its major use is in the production of ammonia and methanol.

Natural Gas.

Natural gas is found in nature associated with crude oil deposits. It is also found in geologic formations alone. It is a non-renuable resource containing mostly methane. It can also contain minor quantities of the following components :

- Ethane.
- Propane.
- Butane.
- higher molecular weight liquids.

Depending on the deposit, it can also contain other contaminants. Associated gas usually contains relatively high concentrations of liquids.

In addition to its use as a clean burning fuel, it is used as a petrochemical feedstock. Its use for the production of hydrogen was described in a previous section of this report. While producing hydrogen, carbon monoxide is also produced. The two products react to give methanol.

When hydrogen is allowed to react with nitrogen under specific conditions, ammonia is produced.

Ethane is used as cracker feedstock for the production of ethylene.

Propane and butane are usually sold as liquified petroleum gas (LPG). They could also be used as cracker feedstocks to produce ethylene, propylene, and butylenes.

The higher molecular weight hydrocarbons are used as gasoline blending components.

Crude Oil.

Crude oil complements natural gas as a feedstock for the petrochemical industry. In most cases, a refinery processes the crude and produces certain streams which can be used by petrochemical operations.

The main crude oil components used by petrochemical operations are naphtha, reformate, and gas oil. These components contain higher molecular weight hydrocarbons, essential for the production of some petrochemicals, and not available in natural gas.

THE REFINERY PETROCHEMICAL INTERFACE.

The primary objective of a refinery is to produce fuels to satisfy the demand of a specific market. These fuels include gasoline, kerosene, distillates, and residual fuel oil. When the market demand for the various fuels does not match the product slate obtained from the crude oil available to the refinery, additional process units are added to alter the product slate. These units produce products of value to the refinery and to any associated petrochemical facility.

Vacuum Tower And Cracker.

A vacuum tower is added to increase the white products obtained from the atmospheric tower bottoms. These additional distillates have a relatively high molecular weight. Therefore they are processed in a cracker to produce fuels of the desired boiling range. In this process olefinic by-products such as off-gases, propylene , and butylenes are obtained. The major use of the off-gases is as refinery fuel. If a chemical facility is available, the off-gases can be cracked further to produce ethylene.

The propylene and butylenes can be sent to an alkylation or polygas unit to produce additional high octane gasoline blending components. They could also be separated, purified and used to produce petrochemicals. The refiner determines the ultimate use of these olefinic by-products as a result of his need for clear octane barrels to match the market demand. The alternate use of these products as petrochemicals is considered viable when they can give higher netbacks to the refiner. As such they increase the profitability of the refinery as a whole.

Reformer.

The naphtha stream obtained in the refinery can be treated in a reformer to increase its octane value. This is accomplished by converting straight chain hydrocarbons into naphthenes and dehydrogenating the naphthene rings to produce aromatics. The most important components of the reformate stream are benzene, toluene, and xylene.

The reformate can be blended into the gasoline poole or can be separated into its components. The aromatic components are primary petrochemicals which can be used to produce a variety of derivatives. When the aromatics are extracted from the reformate, a stream composed mainly of paraffinic naphtha is obtained. This stream has a low octane value. However it can be upgraded into regular gasoline by the addition of lead alkyls. As the amounts of lead in gasoline are reduced, for environmental and health reasons, this stream looses some of its value as a gasoline component. It remains, however, a valuable feed for crackers to produce basic petrochemicals.

Naphtha.

A significant side stream from a refinery operation is straight run naphtha. It is a gasoline blending component. It is also an essential feedstock for petrochemical plants. Western Europe and Japan have, over the years, relied heavily on naphtha as the basic raw material for their petrochemical industries. The petrochemical industry in the United States used natural gas liquids as the basic raw material and relied on naphtha to complement the quantities and the product slate obtained from both raw materials.

The demand for aromatics, butylenes, and propylene make naphtha an indispensable raw material for basic petrochemicals.

Other Refinery Streams.

Refineries produce other side streams which can be processed further to produce various fuels and chemicals. These include atmospheric and vacuum gasoil, propane, and butane. These products can be used by both industries and the decision as to who uses them depends on economic and supply and demand considerations.

The Interface.

Refineries and petrochemical plants can be operated in a way that makes both operations more profitable. The petrochemical operation can start with low value by-product streams from the refinery and produces high value added products. At the same time these products are used to improve the quality of life in modern society.

PETROCHEMICAL PRODUCTS.

The primary petrochemicals were listed in an earlier section of this report. Also the intermediates and finished products were defined. This section will follow the sequence of upgrading of primary petrochemicals and describe the markets of the finished products.

ETHYLENE.

Ethylene is produced by cracking ethane, LPG, naphtha, or vacuum gas oil. It is the simplest and most widely used petrochemical building block. When naphtha or vacuum gas oil are used as cracker feedstocks, other primary petrochemicals are produced as by-products; these include propylene, butylenes, and aromatics. This close production linkage dictates the pricing structure for all of these products.

Ethylene is used to produce a wide range of intermediates and finished products. A listing of the most important ethylene derivatives is shown in chart 1. They include the following :

Polyethylene.

When ethylene is treated under selected temperatures and pressures in the presence of catalysts, it polymerizes to give polyethylene. If other monomers are included in the reaction mixture, polyethylenes having different properties will be formed. These polymers are long carbon backbones which may have different numbers of side chains with varying length. Polyethylenes are divided into three classifications :

1. Low density polyethylene (LDPE).
2. Linear Low Density Polyethylene (LLDPE).
3. High Density Polyethylene (HDPE).

Polyethylene is used to produce consumer goods such as film and sheet, injection and blow molded products, wire and cable, and pipe and conduit. These end products are used in packaging, households, and as components of capital goods.

Ethylene Oxide.

The addition of an oxygen atom to the ethylene molecule gives ethylene oxide. The oxide can be converted to ethylene glycol which is most commonly known for its use in antifreeze preparations. However, it is also used for the production of polyester fiber and film.

Ethylene oxide is also used to produce polyethylene glycols. These products are used as brake fluids as well as solvents. They can also react with isocyanates to produce polyurethanes.

Another derivative of ethylene oxide is the polyethers. These are nonionic surface active agents which are used in detergent formulations.

Ethylene oxide can also react with ammonia to produce ethanolamines and morpholine. These products are used in rubber formulations, adhesives, polishes , and corrosion inhibitors.

Ethylbenzene

Ethylene can react with benzene to produce ethylbenzene which is converted to styrene. The uses of styrene will be discussed under benzene derivatives.

Ethylene Dichloride.

Ethylene can be treated with chlorine under appropriate conditions to produce ethylene dichloride (EDC). Aside from its use as a solvent, EDC is converted to vinyl chloride monomer. The monomer is polymerized to produce polyvinyl chloride (PVC).

PVC is used extensively in the manufacture of plastic pipe. It is also used for the production of film and sheet, floor tiles, wire and cable coatings, and automotive and home furnishings.

Acetaldehyde.

Ethylene can be oxidized to produce acetaldehyde which is converted to acetic acid. Aside from its use as the active ingredient in vinegar, acetic acid is used in the production of vinyl acetate. Derivatives of vinyl acetate include polyvinyl acetate and polyvinyl alcohol. Both products are used as components of adhesives and other industrial compounds.

Acetic acid can also be converted to acetic anhydride which is used in the production of cellulose acetate film and fiber.

The esters of acetic acid are used as components of industrial solvents.

Ethanol.

Historically ethanol was produced by the fermentation of sugars. However, with the advent of inexpensive ethylene, the production of ethanol by the hydration of ethylene became economically viable. Absolute ethyl alcohol can be used as a solvent or can be reacted with acrylic acids to produce acrylates.

Alpha Olefins.

Ethylene can be polymerized to produce alpha olefins with carbon chains ranging from 4 to 18 carbons. The C-4 to C-10 can be used as comonomers in the production of polyethylene. They can also be converted to alcohols which can react with phthalic acids to produce plasticizers for use in PVC formulations.

The C-12 to C-18 olefins can be converted to linear alkyl sulfonates which are used in synthetic detergents. They can also be used to produce alkyl benzene which is sulfonated to produce linear alkyl benzene sulfonate.

The C-12 to C-18 can also be converted to alcohols which can be used as solvents or treated with ethylene oxide to produce nonionic surface active agents. The most important application of the C-12 to C-18 olefins is in the production of detergents. They surpass previous generations of detergents in that they are more biodegradeable.

Other Ethylene Derivatives.

Ethylene is also used to produce smaller volumes of other derivatives such as ethyl halides and ethylene propylene elastomers. The halides are used to produce more complex petrochemicals. The elastomers are used as rubber components.

ETHYLENE END USES IN THE USA, WESTERN EUROPE, AND JAPAN.

The United States, Western Europe, and Japan constitute the largest world markets for ethylene derivatives. Chart 2 shows the 1983 demand for these products in each of the three markets. The demand is broken by end use.

The USA consumed about 13 million tons of ethylene in 1983. Polyethylene accounted for 49% of that demand. Ethylene oxide accounted for 17% and EDC and styrene accounted for 14 and 7% respectively.

Western Europe consumed about 12 million tons of ethylene in 1983. Polyethylene accounted for 55% of that demand. Ethylene oxide, EDC, and styrene accounted for 11, 18, and 7% respectively.

Japan consumed about 3.7 million tons of ethylene in 1983. Half of the consumption went into polyethylene production. Ethylene oxide, EDC, and styrene accounted for 11, , and 9% respectively.

ETHYLENE AND ITS DERIVATIVES IN SYRIA.

Ethylene and its derivatives, at the intermediate and finished product level, are not presently produced in Syria. Some of the finished products are used. However, these are imported. The market size is small and the country does not presently have inherent advantages to enable Syria to enter the world markets.

PROPYLENE.

Propylene is obtained as a by-product while cracking naphtha or heavier liquids to produce ethylene. It is also produced in cat crackers in refineries. A listing of the intermediates and the final propylene derivatives of commercial importance is shown in chart 3. The following is a description of the end uses of these derivatives.

Polypropylene.

When propylene is polymerized under appropriate conditions polypropylene is produced. It is a versatile polymer with a variety of end uses. It is used to produce fibers for carpets and textile. These fibers have properties which make them superior to natural fibers in some applications such as carpet backing. It is also used to produce non woven fabrics used in diapers and packaging.

Polypropylene is also used to produce film and sheet. Also, a variety of consumer goods can be produced by injection molding polypropylene.

Some properties of polypropylene make it superior to polyethylene in certain applications.

Acrylonitrile.

Under proper conditions propylene reacts with ammonia to form acrylonitrile which is used to produce acrylic fibers and nitrile rubbers. It can also react with styrene to produce styrene acrylonitrile resins (SAN) and with butadiene and styrene to produce acrylonitrile butadiene styrene (ABS) polymers.

Acrylonitrile is also used in the manufacture of some nylons.

Propylene Oxide.

Propylene reacts with oxygen under specified conditions to produce propylene oxide. The oxide can be converted to glycols or polyether polyols. The glycols are used in the manufacture of unsaturated polyesters which are in turn used for the production of fiber glass backed equipment such as boats and automotive parts.

The polyether polyols react with isocyanates to produce polyurethanes. These products find application as foams for seating in furniture and transportation equipment. They are also used as engineering plastics because of their strength and resistance to corrosion.

Acetone.

Propylene can be hydrated to isopropyl alcohol (IPA) which is used as a solvent and a component of rubbing alcohol formulations.

Isopropyl alcohol can also be dehydrogenated to produce acetone.

Another commercial source of acetone is cumene which is obtained by alkylating benzene with propylene. The cumene is converted to cumene hydroperoxide which is then decomposed to acetone and phenol. The phenol applications will be discussed under benzene derivatives.

Aside from its use as solvent, acetone is used in the manufacture of methyl methacrylate, butyraldehyde, and bis-phenol A. Methyl methacrylate is used to produce acrylics. Butyraldehyde is converted to butyl alcohol and 2-ethyl hexanol. Both products are used as solvents and as plasticizer alcohols. Bis-phenol A is used in the manufacture of polycarbonates and epoxy resins. The products are important engineering plastics.

Epoxy resins are obtained from the reaction of bis-phenol A and epichlorohydrin, another propylene derivative.

Acrylic Acid.

Propylene is also used in the manufacture of acrylic acid which can be converted to acrylates. These products are used in paints, emulsifiers, adhesives, and polishes.

Other Propylene Derivatives.

Other derivatives of propylene include higher olefins such as heptene, nonene, and dodecene. These products are alkylating agents for phenol and benzene. The alkylates are used to produce anionic and nonionic surfactants.

PROPYLENE MAJOR END USES IN THE USA, WESTERN EUROPE, AND JAPAN.

The united States, Western Europe, and Japan have the worlds largest domestic markets for propylene derivatives. Chart 4 shows the demand for propylene in 1983 in these markets by end use.

The United States consumed about 6.4 million tons of propylene in 1983. The largest end use was polypropylene accounting for about 33% of total demand. Acrylonitrile was second using about one million tons of propylene equivalent to 17% of demand. The other derivatives consumed between 450 and 670 KT each.

Western Europe consumed about 6.5 million tons of propylene, slightly exceeding the american consumption. Polypropylene was the largest consumer of propylene in Western Europe accounting for about 2.1 million tons equivalent to 33% of the demand. Acrylonitrile and cumene accounted for 17 and 8% respectively of the propylene demand.

Japan consumed about 2.6 million tons of propylene in 1983. 43% of the demand was converted into polypropylene and 21% into acrylonitrile. The other major derivatives were isopropyl alcohol, cumene, and propylene oxide.

PROPYLENE AND ITS DERIVATIVES IN SYRIA

Propylene and its derivatives are not presently produced in Syria. However finished propylene derivatives are imported into the country. These include polypropylene, polyurethanes, epoxy resins, alkylates, acrylates, and nylons. The domestic market has been too small to justify production of these derivatives.

BUTYLENES.

The butylene stream contains butadiene, butene-1, butene-2, and isobutylene.

Chart 5 shows the derivatives of butadiene. most of them are polymers generically classified as rubbers. They include styrene butadiene rubber (SBR) which is used extensively in the manufacture of automobile tires.

Polybutadiene, neoprene, and nitrile rubbers are also made from butadiene and are used by the automotive industry.

Butadiene is also used in the manufacture of ABS and nylons. Both of these polymers are used as engineering plastics.

Another derivative of butadiene is styrene butadiene latex. This class of compounds is best known for its use in water based paints.

Butene-1, Butene-2, and isobutylene are raw materials for the production of polybutenes. They are also used in the manufacture of alcohols for solvent applications.

THE BUTYLENES AND THEIR DERIVATIVES IN SYRIA.

Butadiene, the butylenes, and their derivatives are not produced in Syria. However, the finished rubbers and latex are imported into the country. SBR is imported for the manufacture of automotive tires. The latex is imported for use in paint formulations.

The Syrian domestic market has been too small to justify the manufacture of these products in the country.

BENZENE

Benzene is the simplest aromatic nucleus. As such it has charecteristics which make it a useful building block. Chart 6 contains a listing of the most important benzene derivatives. The following is a description of these derivatives and their markets.

Styrene.

The largest benzene end use is in the manufacture of styrene. Benzene is alkylated with ethylene to produce ethylbenzene which is dehydrogenated to give styrene.

Styrene is used in the manufacture of polystyrenes which fall into three classes:

1. General Purpose.
2. High Impact.
3. Expandable beads.

The general purpose and high impact polymers are used for making cabinets for electronic equipment. They are also used for making film and sheet. They are used in packaging and housewares.

The expandable beads are used in insulation. They are also used in foamed to shape packaging to protect equipment during transportation. Another use of the expandable beads is for making cups.

The technology is available to use all three polystyrenes in insulation.

Styrene is also used for making ABS and SAN. Both products are used as components of capital equipment.

Styrene butadiene rubber and latex were described under butadiene derivatives because both raw materials are needed to produce these polymers.

Phenol.

Benzene is alkylated with propylene to produce cumene which is then treated with a peroxide to produce cumene hydroperoxide. The peroxide is decomposed to give phenol and acetone. The end uses of acetone were described under propylene derivatives.

The largest end use of phenol is in the production of phenolic resins. These resins are used in plywood, adhesives, glass fiber insulation, moulding compounds, and laminates.

Phenol is also used in the production of bis-phenol A which is a raw material for polycarbonates and epoxy resins. The polycarbonates are used in appliances, signs, sports and recreation, and transportation equipment. They are superior to metals in certain applications.

The epoxy resins are used in surface coatings, adhesives, laminates, encapsulating electrical parts, flooring, and pipes.

Cyclohexane.

Benzene can be reacted with hydrogen to produce cyclohexane which can be used as a solvent. It can also be used to produce caprolactam, adipic acid, and hexamethylene diamine. All of these products are raw materials for the manufacture of nylons.

The nylons can be used to produce fiber for textiles as well as film and sheet. They can also be used to produce molded parts for capital equipment.

Other Benzene Derivatives.

Other derivatives of benzene include aniline which is used to produce polyurethanes and chlorobenzenes which are used in the production of pesticides. Another benzene derivative is alkyl benzene which is sulfonated to produce alkyl benzene sulfonates, an essential component in detergent formulations.

BENZENE MAJOR END USES IN THE USA, WESTERN EUROPE, AND JAPAN.

The United States, Western Europe, and Japan have the worlds largest markets for benzene derivatives. Chart 7 shows the benzene demand by end use in each of the three markets for 1983.

The United States consumed about 4.8 million tons of benzene in 1983. 51% of the domestic demand went into the production of ethylbenzene/styrene. Cumene and cyclohexane consumed 21 and 15% of the demand respectively.

Western Europe was the second largest word market consuming almost 4.8 million tons. Ethylbenzene/styrene accounted for 48% of the demand. Cumene and cyclohexane accounted for 20 and 14% respectively.

Japan was the third largest market consuming about 1.8 million tons. 51% went into the production of ethylbenzene/styrene. Cyclohexane was the second largest benzene outlet in japan accounting for about 23% of the demand. Cumene/phenol were third accounting for 14% of the demand.

BENZENE AND ITS DERIVATIVES IN SYRIA.

Benzene and its derivatives are not presently produced in Syria. However, finished benzene derivatives are imported into the country. Alkyl benzene sulfonates are imported for the production of detergents and styrene derivatives are imported for production of packaging components.

The Syrian market is presently too small to justify domestic production of benzene derivatives.

TOLUENE.

Toluene is produced in ethylene crackers which use naphtha or gas oil as feedstocks. It is also produced in refinery reformers. In both cases it is part of an aromatic stream which requires seperation and purification before it can be used in chemical applications.

A small fraction of the toluene produced in refineries is isolated for chemical use. The balance is kept in the reformate and blended in the gasoline pool as an octane booster. Most of the isolated toluene finds a market in the following chemical areas.

Benzene.

The largest chemical market for toluene is in the production of benzene. The toluene is treated in a hydrodealkylation unit (HDA) under specified conditions to loose a methyl group and produce benzene. There is a yield loss of about 20% basis feed in this reaction. Therefore the benzene produced by HDA is more expensive than the benzene produced in the reformer.

Polyurethanes.

Toluene is converted in a series of reactions to produce dinitrotoluene, toluene diamine, and toluene di-isocyanate. When the di-isocyanate is reacted with polyols, polyurethanes are formed.

Other Toluene Derivatives.

Toluene is used as a solvent in paints and lacquers because of its relatively low toxicity.

Another market for toluene is in the production of benzoic acid which is used as a preservative in health and beauty aids as well as in some prepared foods and beverages. Benzoic acid can be oxidized further to produce phenol which is used in the production of adhesives.

The side chain in toluene can react with chlorine to produce benzyl chloride which can be easily converted to benzyl alcohol. The alcohol is used in industrial perfumes and other fine chemical preparations.

TOLUENE IN SYRIA.

Toluene is produced in the Syrian refineries. However it is not isolated. Therefore any toluene used domestically has to be imported. No toluene derivatives are produced in Syria. The domestic market for these derivatives has been too small to justify local production.

XYLENES.

Most of the xylenes produced in refineries is not isolated. The aromatic stream containing the product is blended into the gasoline pool as an octane booster. However some xylenes are used in chemical markets. Aside from the solvent applications, these markets require the seperation of the three xylene isomers : ortho xylene, meta xylene, and para xylene.

Chart 9 contains a listing of the chemical applications of the three xylene isomers.

Ortho Xylene.

The most important market for ortho xylene is in the production of phthalic anhydride. The anhydride is reacted with alcohols, such as 2-ethylhexyl alcohol, to produce di-octyl phthalate, a well known plasticizer for PVC and unsaturated polyester formulations.

Ortho xylene is also used as a solvent in paints, pesticide and herbicide formulations.

Meta Xylene.

Meta xylene is converted to isophthalic acid which is used for making unsaturated polyesters. It is also used as a raw material for the production of fine chemicals which end in pharmaceutical preparations and perfumes.

Para Xylene.

The most important market for para xylene is in the production of terephthalic acid and dimethyl terephthalate. Both products react with polyethylene glycols to produce polyesters. The three major applications of polyesters are fiber, film, and bottles.

THE XYLENES IN SYRIA.

Xylene mixtures are produced in the Syrian refineries. However the isomers are not separated. The small quantities needed by the domestic market are imported.

None of the xylene derivatives are produced in Syria. The domestic market has been too small to justify the production of these derivatives. Market demand has been satisfied by imports.

METHANOL.

Methanol is produced by reacting hydrogen and carbon monoxide under appropriate conditions. Both raw materials are obtained by steam reforming of methane, from natural gas, or naphtha. Historically, the use of methane and naphtha was evenly split. More recently, the trend has been changing in favor of natural gas. The new methanol plants are being built close to large natural gas fields. Several of these plants have been built in the Middle East and North Africa.

A listing of chemical uses of methanol is shown in chart 10.

Formaldehyde.

Historically, formaldehyde has been the major chemical derivative of methanol. It is still the major end use of the alcohol, however, its share of the market is declining as new applications are commercialized.

Formaldehyde is used to produce phenolic resins which constitute an essential part of adhesive formulations. The major market for adhesives is in forestry and lumber products.

Formaldehyde is also used to produce urea formaldehyde and melamine formaldehyde resins. Urea formaldehyde's major end use was in the production of foam insulation for homes. Recently, it was discovered that the foam decomposes with time emitting formaldehyde, which is a carcinogen, and exposing the residents to the vapors. As a result the use of urea formaldehyde in home insulation has been banned in a number of countries.

Acetic Acid.

Methanol can react with carbon monoxide under specific conditions to produce acetic acid. The acid can be converted to acetic anhydride which is used to produce cellulose acetate fiber an film. Acetic anhydride can also react with alcohols to produce acetates which are widely used in solvent applications.

Acetic acid can also be used to produce vinyl acetate, a monomer, which can be converted to polyvinyl acetate, polyvinyl alcohol or ethylene vinyl acetate. All of these derivatives are used in textiles and adhesives.

Dimethyl Terephthalate.

Methanol reacts with terephthalic acid to produce dimethyl terephthalate (DMT) which is used in the production of polyesters. The reaction between methanol and terephthalic acid takes place in situ while para xylene is converted to DMT. New technology makes it possible to produce free terephthalic acid, without having to produce the ester. The acid is then converted to the polyesters.

Methyl Tertiary Butyl Ether (MTBE).

Commercial production of MTBE in world scale plants started about 10 years ago. During this period the number of MTBE plants has increased significantly and the product has become an important octane booster in the gasoline poole.

Future MTBE plants are expected to be limited because of availability of isobutylene.

Other Methanol Derivatives.

Other methanol derivatives include methyl acrylates, chloromethanes, methanolamines, and glycol methyl ethers. The chloromethanes are used as refrigerants after the addition of other halogen atoms to the molecule. The other derivatives are used in the production of fine chemicals.

METHANOL IN SYRIA.

Methanol and its derivatives are not presently produced in Syria. The small quantities needed by the domestic market are imported.

PETROCHEMICAL MANUFACTURING ECONOMICS.

Ammonia is the only basic petrochemical produced in Syria. It is made in a 300 kilo ton/year plant in Homs. The ammonia plant is part of a fertilizer complex which includes a 560 kt/year sulfuric acid plant, a 450 kt/year superphosphate plant, a 315 kt/year urea plant, and a 50 kt/year ammonium nitrate plant.

The fertilizer complex is operated as a fully integrated facility with common management, maintenance shops, water treating facilities, and labour force. Because the complex is fully integrated, problems affecting any one of the units will impact on all the others. Also, no financial assessment of the performance of any of the units can be performed without having access to the books of the total complex. In the absence of such access to the books, only limited estimates can be made concerning the financial performance of the separate units.

The size of the fertilizer complex, the number of jobs it creates in the community, the quantity and value of its production, its impact on the agricultural sector in syria, its impact on the economy of the province and the country dictate that a detailed analysis of the complex should be performed. The analysis should quantify the contribution of the complex to all the above segments of society, and should recommend options for optimizing the complex's contribution to the Syrian economy.

For the present report we have developed the computer programs which can be used to determine the economics of producing ammonia and urea in stand alone plants located in Syria, Saudi Arabia, and the U. S. Gulf Coast. These programs were used to conduct analyses based on hypothetical plants completed (overnight) in the middle of 1983. The values of raw materials, utilities, labour, and other cost components reflect fair market value, of these commodities, in the respective locations as best as we were able to determine them. Maintenance labour and control laboratory staff costs were estimated using relationships to operating labour developed for a U. S. Gulf Coast plant. The cost of operating supplies was also related to operating labour. Plant overhead was equated to 80% of operating labour. Taxes and insurance were assumed to be equal to 2% of fixed capital. And capital was depreciated over a ten year period.

The results of the analysis are described in the following sections.

AMMONIA ECONOMICS.

U. S. Gulf Coast.

The plant was assumed to cost about 205 million U.S. dollars and uses natural gas as the feedstock. The detailed breakdown of the cost components is shown in chart 11. The plant gate cost, without depreciation, was 7.24 c/lb. The product cost was 9.81 c/lb, and the product value was 15.0 c/lb.

Saudi Arabia.

The plant was assumed to cost $ 328 million and uses natural gas as the feedstock. Natural gas was assigned a value of $0.5 per thousand standard cubic feet. The detailed breakdown of the cost components is shown in chart 12. The plant gate cost, without depreciation was 4.78 c/lb. The product cost was 8.53 c/lb, and the product value was 16.85 c/lb.

syria.

The plant was assumed to cost $ 328 million and uses natural gas as the feedstock. Natural gas was assigned a value of $ 1.5 per thousand standard cubic feet. The detailed breakdown of the cost components is shown in chart 13. The plant gate cost, without depreciation, was 5.15 c/lb. The product cost was 8.92 c/lb, and the product value was 17.24 c/lb.

These results indicate that the cash cost, ie. plant gate cost less depreciation, of ammonia produced in Syria is lower than that in the U.S. under the assumptions used in this study. The cash cost of the product in Saudi Arabia is lower than Syria, because the Saudis assign a lower value to natural gas.

UREA ECONOMICS.

U. S. Gulf Coast.

The plant was assumed to cost $ 72 million. Chart 14 shows the detailed breakdown of the cost components. The plant gate cost less depreciation was 5.3 c/lb. The product cost was 6.35 c/lb, and the product value was 8.17 c/lb.

Saudi Arabia.

The plant was assumed to cost $ 115 million. Chart 15 shows the detailed breakdown of the cost components. The plant gate cost less depreciation was 4.94 c/lb. The product cost was 6.43 c/lb, and the product value was 9.33 c/lb.

Syria.

The plant was assumed to cost $ 115 million. Chart 16 shows the detailed breakdown of the cost components. The plant gate cost less depreciation was 5.52 c/lb. The product cost was 7.03 c/lb, and the product value was 9.94 c/lb.

In the urea economic analysis, it was assumed that the plants in Syria, Saudi Arabia, and the U. S. Gulf paid the same price for the ammonia feedstock. Under this condition and the assumptions used in the analysis, the cash cost of producing urea in Syria is the highest of the three locations. However, the difference is relatively small.

SYRIAN DEMAND FOR SELECTED PETROCHEMICALS.

The Syrian domestic market for most petrochemicals is relatively small. Invariably, the products are imported to satisfy the market demand. We were unable to find Syrian import statistics to determine domestic consumption. In the absence of such statistics we probed the export statistics for the major exporting countries for these petrochemicals and identified the volumes they destined to the Syrian market. The results are shown in chart 17.

Most of the imports came from western europe, japan, and the United States. Some of these products are presently, or will, in the near future, be produced in neighboring Arab countries. Arranging supplies of these products from other Arab producers might prove beneficial to all concerned.

CHART 1

ETHYLENE
Major End Uses

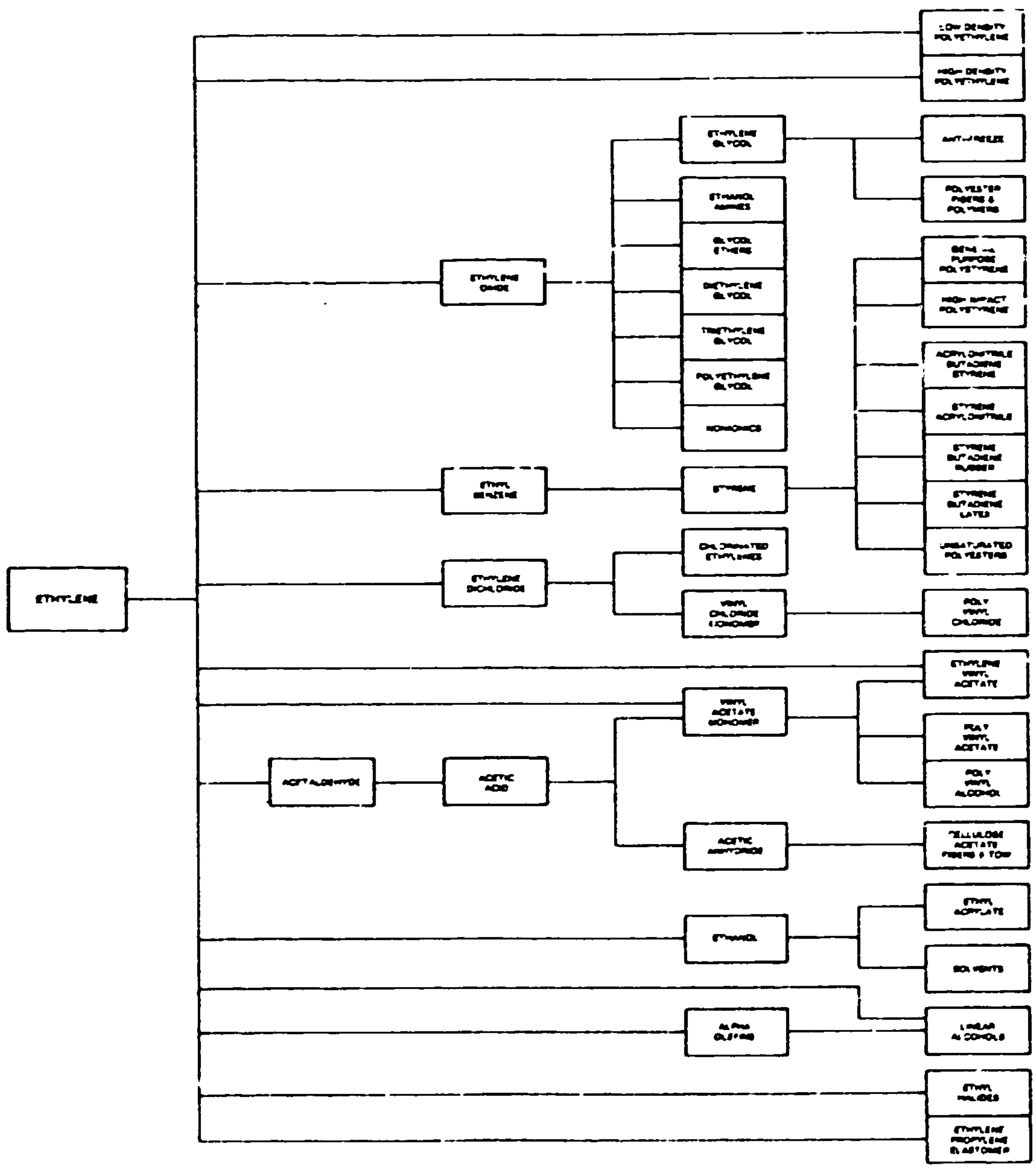

CHART 2

1983 Ethylene Demand By end Use In The USA, Europe, and japan
KT

End Use	USA	Europe	Japan
LDPE/LLDPE	3756	4638	1095
Ethylene oxide	2234	1263	412
HDPE	2684	1912	729
Ethylene Dichloride	1821	2192	671
Ethylbenzene	907	839	336
Oligomers	653		
Ethanol	274	603	
Vinyl Acetate	323		114
Acetaloehyde	195		173
Other	292	474	149
Totals	13139	11921	3679

CHART 3

PROPYLENE
Major End Uses

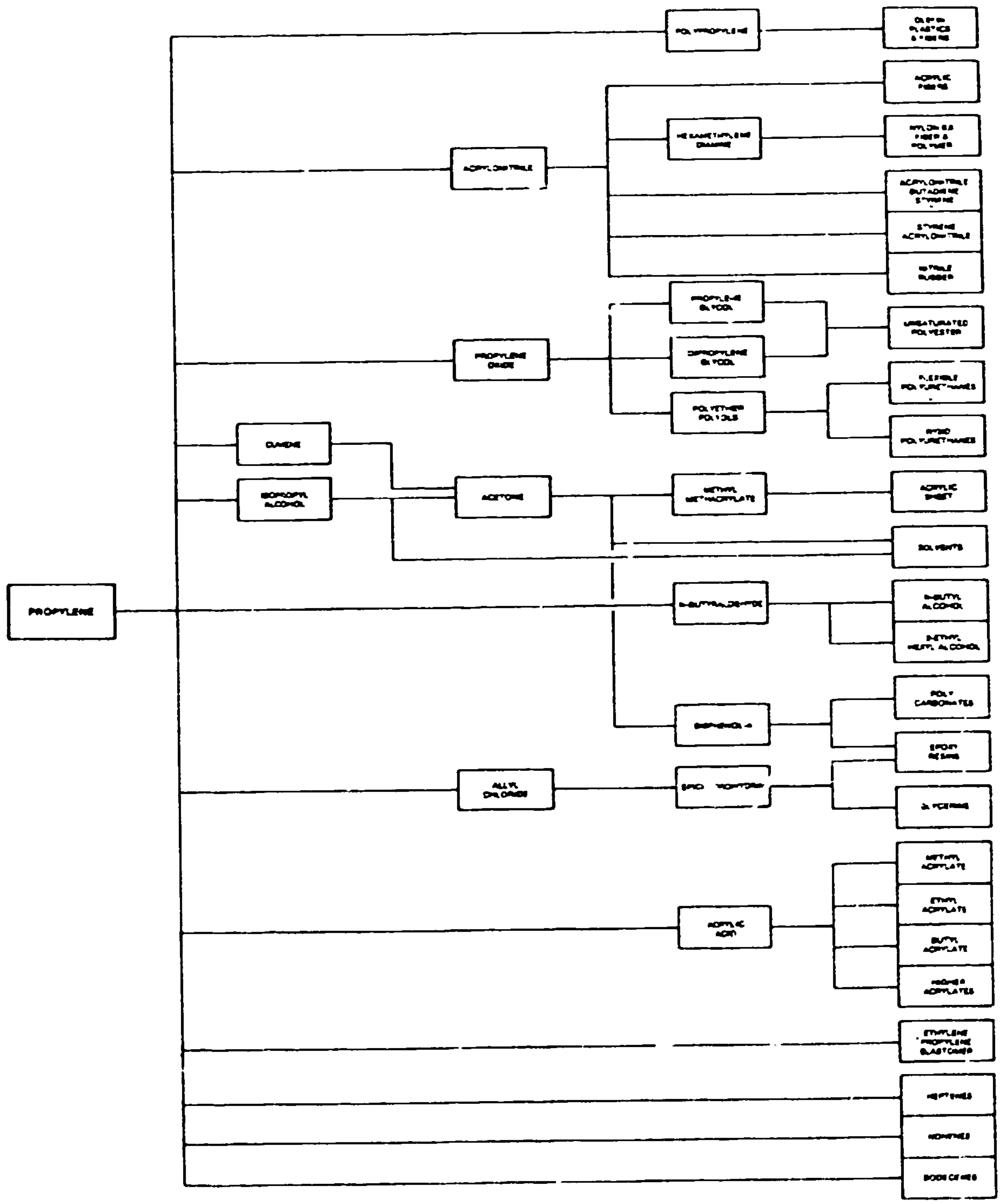

CHART 4

19 83 Prooylene Demand By End Use In The USA, Europe, And Japan
KT

End Use	USA	Europe	Japan
Polypropylene	2112	2126	1136
Acrylonitrile	1090	1100	542
Propylene Oxide	665	733	171
Isopropyl alcohol	458	412	
Cumene	599	540	300
Oxo Alcohols	543	908	290
Oligomers	495	289	
other	450	412	198
Totals	6412	6520	2637

CHART 5

BUTADIENE
Major End Uses

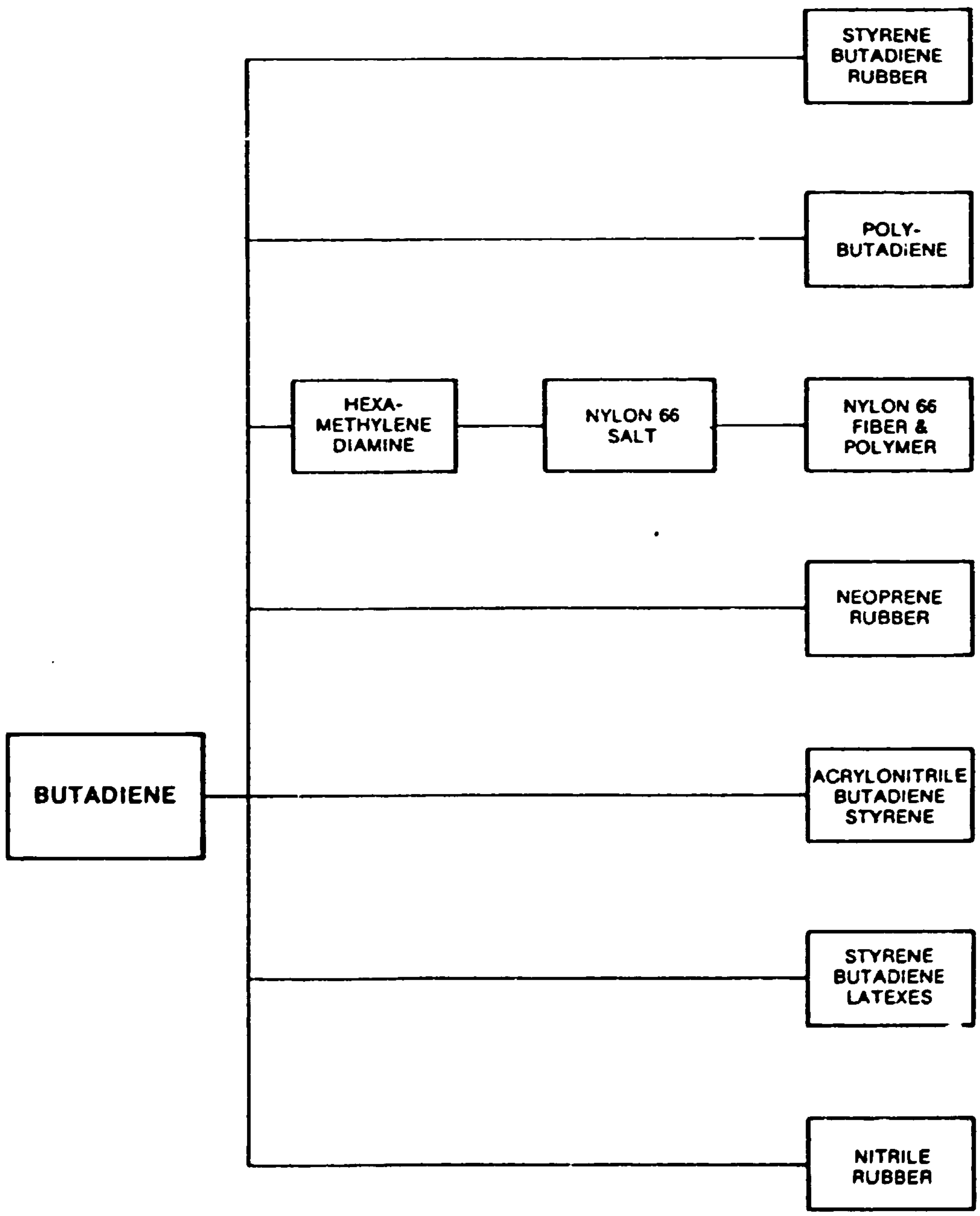

CHART 6

BENZENE
Major End Uses

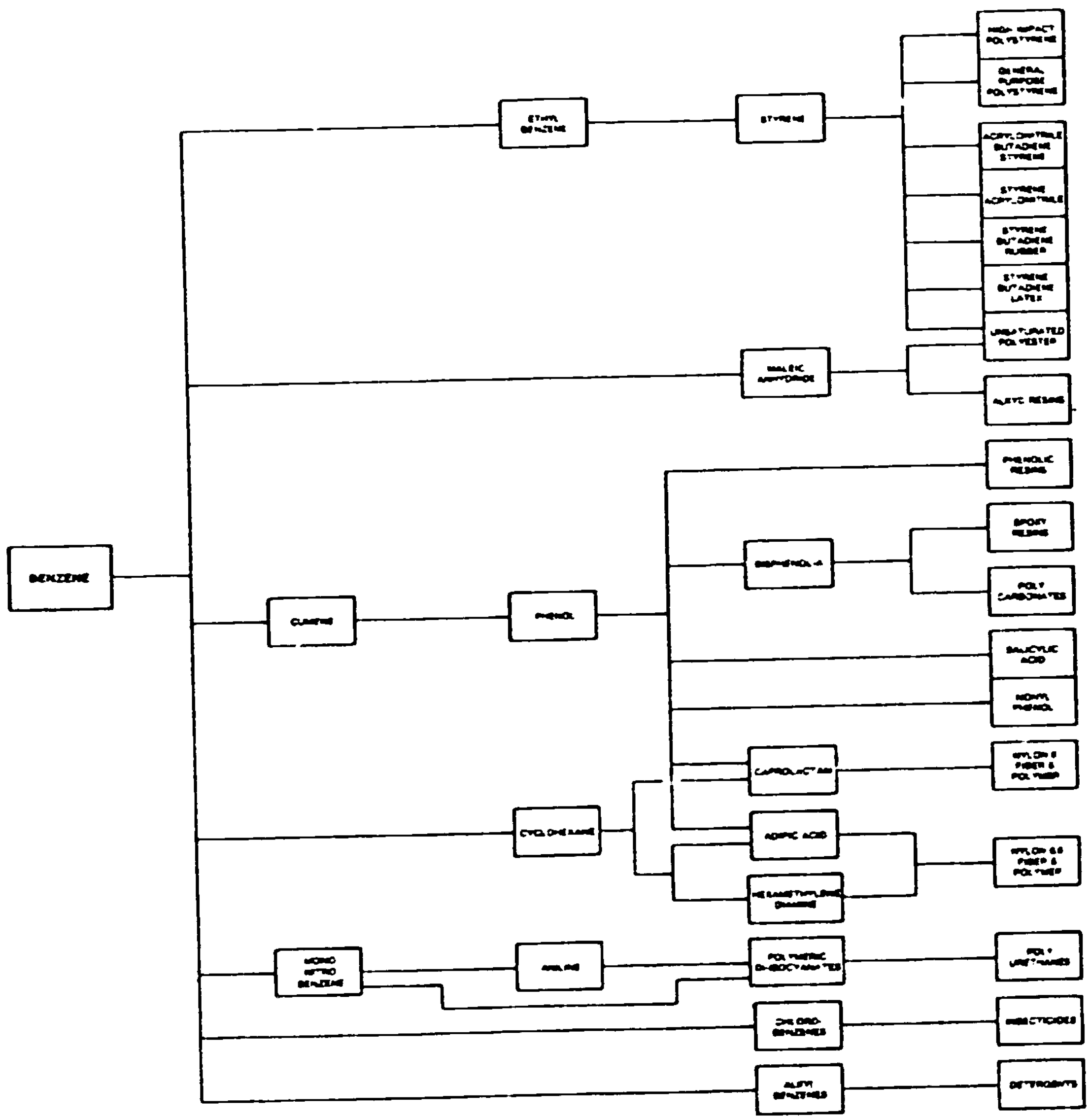

CHART 7

1983 Benzene Demand By End Use in The USA, Europe, and japan
KT

End Use	USA	Europe	Japan
Ethylbenzene	2462	2305	947
Cumene	1032	964	262
Cyclohexane	712	670	422
Aniline	251	317	
Maleic anhydride	38	144	40
Chlorobenzenes	126	89	
Dodecylbenzene	144	233	69
Other	42	66	113
Other	4807	4788	1853

CHART 8

TOLUENE
Major End Uses

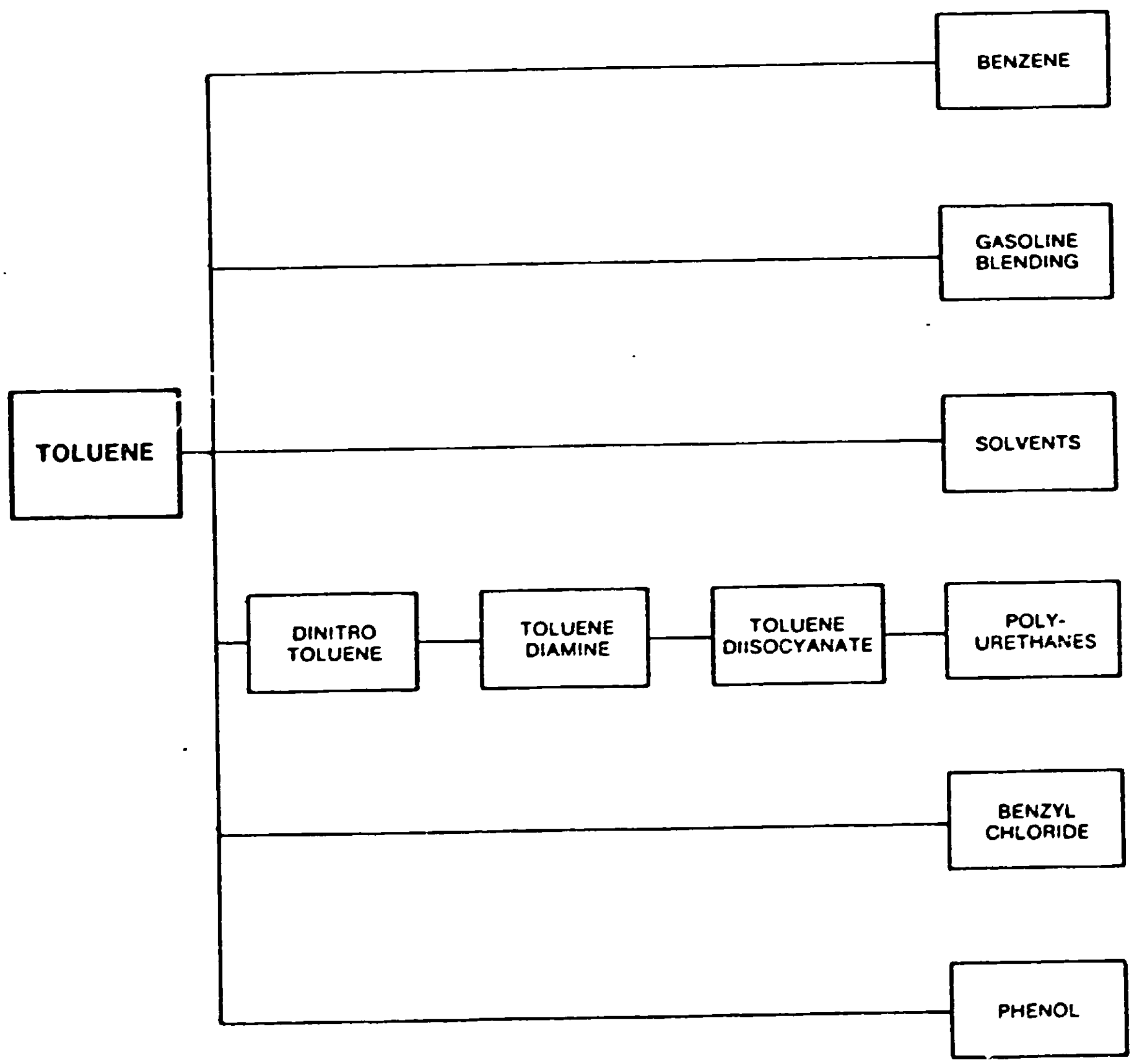

CHART 9

XYLENES
Major End Uses

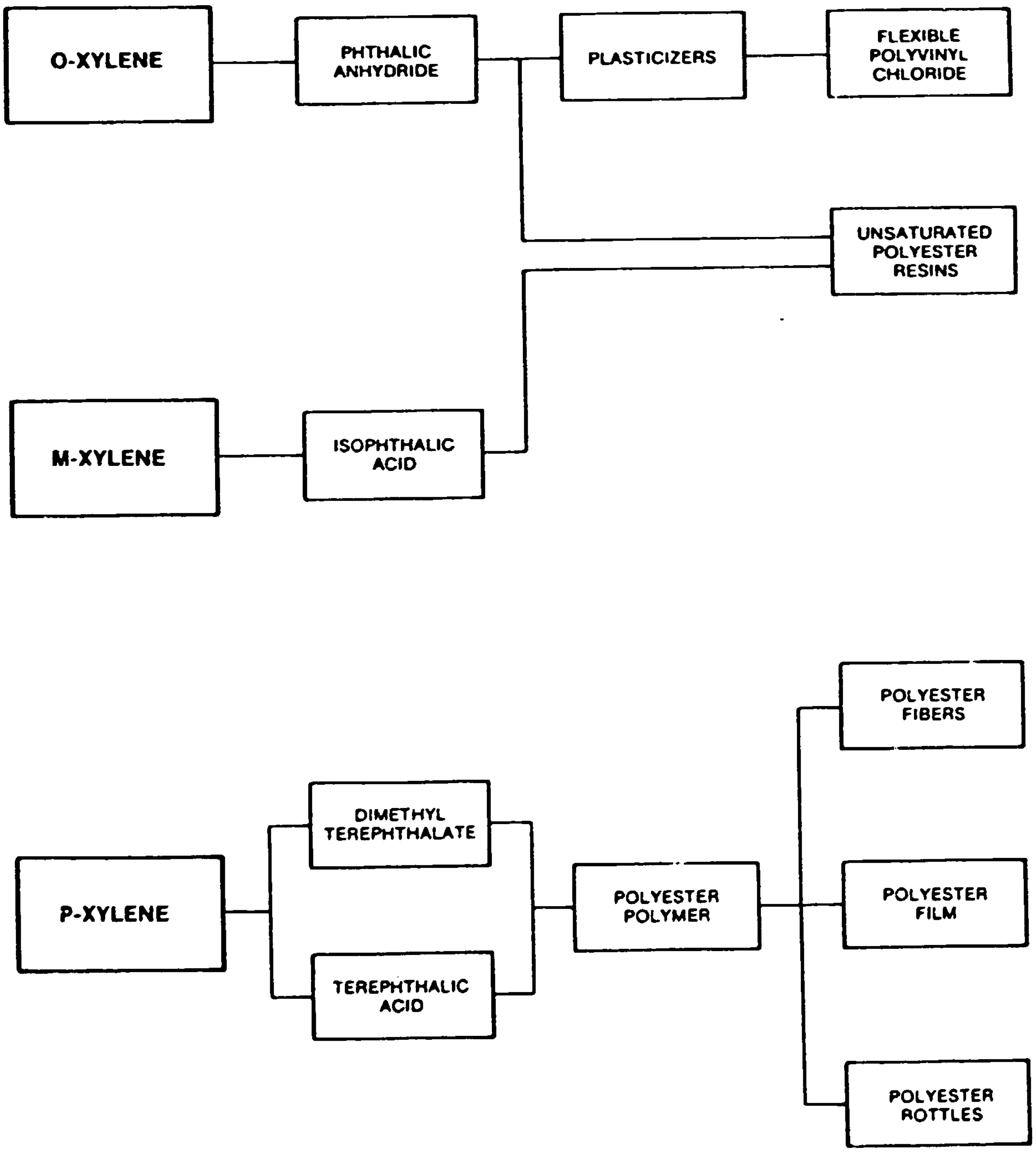

CHART 10

METHANOL
Major End Uses

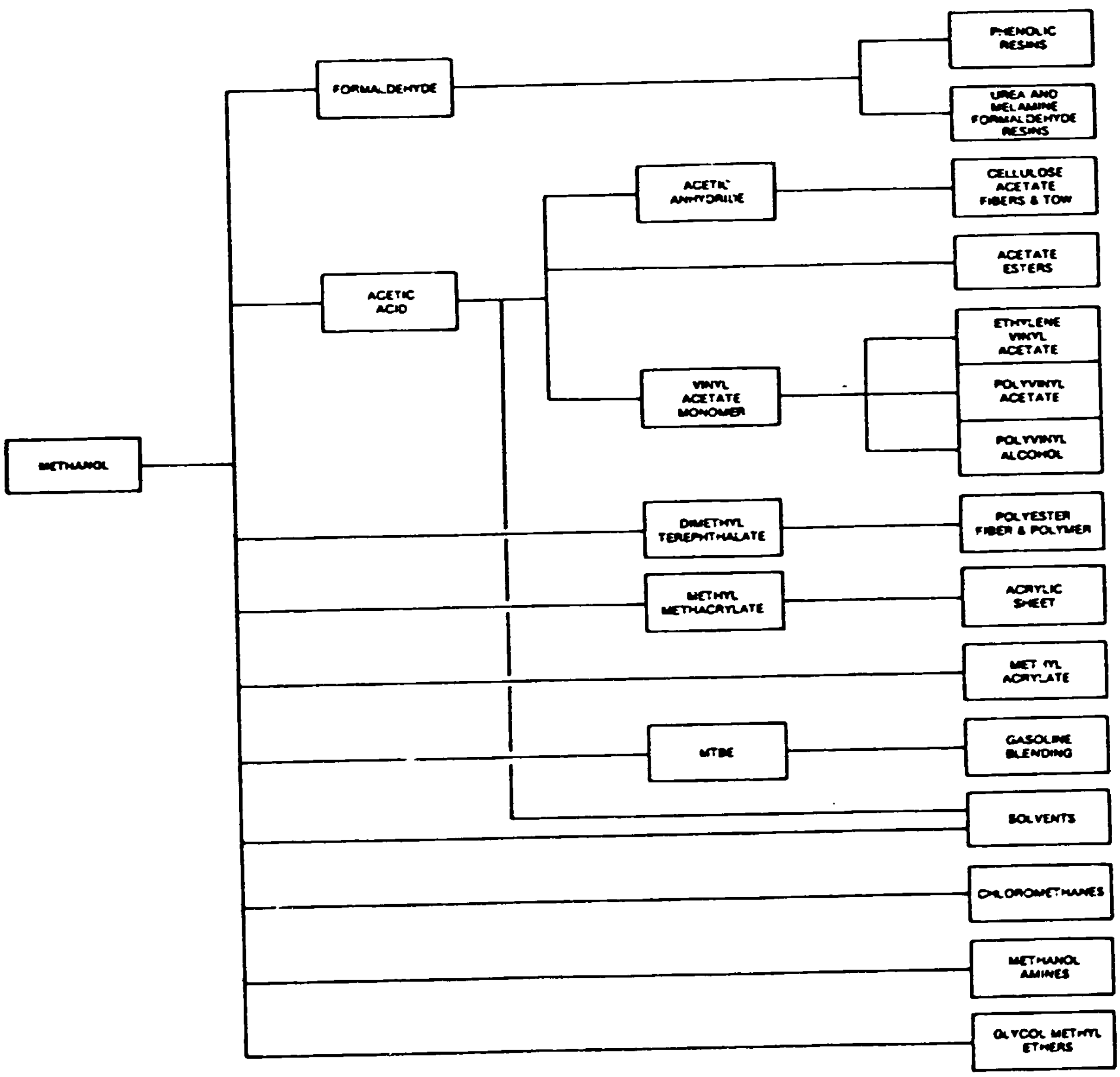

CHART 11

ammonia economics	us gulf coast			july 1983
plant capacity	m lbs/y			986.00
annual production	m lbs			986.00
capital costs				
battery limits	m $			145.70
off-sites	m $			59.20
working capital	m $			0.00
total capital	m $			204.90
variable costs				
raw materials				
methane c/scf		0.37		3.95
chemicals & catalyst				0.08
raw materials sub total	c/lb			4.03
utilities				
cooling water	usg/lb		23.40	0.16
process water	usg/lb		0.13	0.01
electricity	kwh/lb		0.02	0.13
natural gas	scf/lb		0.00	1.11
utilities sub total	c/lb			1.41
fixed costs				
labour (op+main+con)	c/lb			0.52
maintenance mat & sup	c/lb			0.45
plant overhead	c/lb			0.42
taxes & insurance	c/lb			0.42
depreciation	c/lb			2.08
plant gate cost	c/lb			9.32
sales admin & r&d	c/lb		5%of price	0.49
product cost	c/lb			9.81
product value	c/lb		25% roi bt	15.00

CHART 12

ammonia economics	saudi arabia			july 1983
plant capacity	m lbs/y			986.00
annual production	m lbs			986.00
capital costs				
battery limits	m $			233.00
off-sites	m $			95.00
working capital	m $			0.00
total capital	m $			328.00
variable costs				
raw materials				
methane c/scf		0.05		0.53
chemicals & catalyst				0.08
raw materials sub total	c/lb			0.61
utilities				
cooling water	usg/lb		23.40	0.16
process water	usg/lb		0.13	0.01
electricity	kwh/lb		0.02	0.13
natural gas	scf/lb		0.00	1.11
utilities sub total	c/lb			1.41
fixed costs				
labour (op+main+con)	c/lb			0.77
maintenance mat & sup	c/lb			0.71
plant overhead	c/lb			0.61
taxes & insurance	c/lb			0.67
depreciation	c/lb			3.33
plant gate cost	c/lb			8.11
sales admin & r&d	c/lb	5%of price		0.43
product cost	c/lb			8.53
product value	c/lb	25% roi bt		16.85

CHART 13

ammonia economics	syria			july 1983
plant capacity	m lbs/y			986.00
annual production	m lbs			986.00
capital costs				
battery limits	m $			233.00
off-sites	m $			95.00
working capital	m $			0.00
total capital	m $			328.00
variable costs				
raw materials				
methane c/scf		0.15		1.60
chemicals & catalyst				0.08
raw materials sub total	c/lb			1.68
utilities				
cooling water	usg/lb		23.40	0.16
process water	usg/lb		0.13	0.01
electricity	kwh/lb		0.02	0.13
natural gas	scf/lb		0.00	0.45
utilities sub total	c/lb			0.75
fixed costs				
labour (op+main+con)	c/lb			0.75
maintenance mat & sup	c/lb			0.71
plant overhead	c/lb			0.60
taxes & insurance	c/lb			0.67
depreciation	c/lb			3.33
plant gate cost	c/lb			8.48
sales admin & r&d	c/lb	5%of price		0.45
product cost	c/lb			8.92
product value	c/lb	25% roi bt		17.24

CHART 14

urea economics	us gulf coast			july 1983
plant capacity	m lbs/y			986.00
annual production	m lbs			990.00
capital costs				
battery limits	m $			40.20
off-sites	m $			31.80
working capital	m $			0.00
total capital	m $			72.00
variable costs				
raw materials				
ammonia c/ib		6.75		3.95
chemicals & catalyst				0.00
raw materials sub total	c/lb			3.85
utilities				
cooling water	usg/lb		9.30	0.06
process water	usg/lb		0.01	0.00
electricity	kwh/lb		0.01	0.05
utilities sub total	c/lb			0.83
fixed costs				
labour (op+main+con)	c/lb			0.20
maintenance mat & sup	c/lb			0.13
plant overhead	c/lb			0.16
taxes & insurance	c/lb			0.15
depreciation	c/lb			0.73
plant gate cost	c/lb			6.03
sales admin & r&d	c/lb	5%of price		0.32
product cost	c/lb			6.35
product value	c/lb	25% roi bt		8.17

CHART 15

urea economics	saudi arabia			july 1983
plant capacity	m lbs/y			986.00
annual production	m lbs			990.00
capital costs				
battery limits	m $			64.00
off-sites	m $			51.00
working capital	m $			0.00
total capital	m $			115.00
variable costs				
raw materials				
ammonia c/lb		6.75		3.85
chemicals & catalyst				0.00
raw materials sub total	c/lb			3.85
utilities				
cooling water	usg/lb		9.30	0.06
process water	usg/lb		0.01	0.00
electricity	kwh/lb		0.01	0.05
utilities sub total	c/lb			0.21
fixed costs				
labour (op+main+con)	c/lb			0.25
maintenance mat & sup	c/lb			0.20
plant overhead	c/lb			0.20
taxes & insurance	c/lb			0.23
depreciation	c/lb			1.16
plant gate cost	c/lb			6.10
sales admin & r&d	c/lb	5%of price		0.32
product cost	c/lb			6.43
product value	c/lb	25% roi bt		9.33

CHART 10

urea economics	syria			july 1983
plant capacity	m lbs/y			990.00
annual production	m lbs			990.00
capital costs				
battery limits	m $			64.00
off-sites	m $			51.00
working capital	m $			0.00
total capital	m $			115.00
variable costs				
raw materials				
ammonia c/lb		6.75		3.85
chemicals & catalyst				0.00
raw materials sub total	c/lb			3.85
utilities				
cooling water	usg/lb		9.30	0.06
process water	usg/lb		0.01	0.00
electricity	kwh/lb		0.01	0.05
utilities sub total	c/lb			0.83
fixed costs				
labour (op+main+con)	c/lb			0.23
maintenance mat & sup	c/lb			0.20
plant overhead	c/lb			0.19
taxes & insurance	c/lb			0.23
depreciation	c/lb			1.16
plant gate cost	c/lb			6.68
sales admin & r&d	c/lb	5%of price		0.35
product cost	c/lb			7.03
product value	c/lb	25% roi bt		9.94