EPCA

THE EUROPEAN PETROCHEMICAL ASSOCIATION

50 YEARS CHEMISTRY FOR YOU

PETROCHEMICALS & EPCA

A PASSIONATE JOURNEY

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THE STORY OF AN INDUSTRY THAT SHAPED OUR PAST, IMPROVES OUR PRESENT AND BUILDS OUR FUTURE

PUBLISHED ON THE OCCASION
OF THE 50TH ANNIVERSARY ANNUAL MEETING
OF THE EUROPEAN PETROCHEMICAL ASSOCIATION

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FOREWORD

Dear reader,

This year marks EPCA's 50th anniversary. In order to celebrate this milestone in our history, we have chosen "50 Years of Global Chemical Industry Evolution: What's Next?" as the theme of the EPCA Anniversary Annual Meeting. Implied in this theme is the assumption that the future builds on the foundation of the past. There are many quotes from people of all walks of life that underline this correlation. Eric Micha'el Leventhal, a literary consultant and holistic educator on the island of Maui, Hawai'i, put it this way: **"You invoke a new future when you envision your past in the light of your present."** This also holds true for our industry.

In order to reflect our past, EPCA has published this History Book that you are holding in your hands. On the following pages you will read about milestones reached by the chemical industry over the past 50 years aligned with the history of EPCA. It is a story of achievements and challenges, of progress and setbacks, and of inventors, leaders and visionaries. The History Book looks back on the beginnings of the petrochemical industry and its evolution during the past 50 years. But it also takes an opportunity to look ahead and outline our way into the future.

The petrochemical industry has come a long way, it has navigated stormy waters and fought its battles, but at the same time it has created ground-breaking materials and enabled **sustainable solutions for mankind.**

Moreover our industry is here to stay because the global challenges we are facing to maintain life on our planet – conquering climate change, providing health care, and ensuring energy and water supply – can only be resolved with innovative chemical solutions and efficient (as well as effective and innovative) supply chains. All over the world, EPCA member companies and their visionary leaders and **ingenious researchers are working to make our future a bright one.**

EPCA – with its more than 700 member companies – has been actively supporting these efforts by stimulating collaboration and knowledge transfer to enable progress and by advocating framework conditions to facilitate trade and business. And EPCA is committed to helping the industry be a responsible corporate citizen, good workplace, and enabler of sustainable solutions in the future.

Enjoy reading,

Tom Crotty, President, EPCA

"THE GLOBAL CHALLENGES CAN ONLY BE RESOLVED WITH INNOVATIVE CHEMICAL SOLUTIONS AND EFFICIENT SUPPLY CHAINS."

Tom Crotty,
President, EPCA.

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INTRODUCTION

AN INDUSTRY DESTINED TO BECOME A GLOBAL SECTOR

Petrochemicals are currently the biggest of the industrial chemicals sectors, accounting in 2016 for 40 percent of the global chemicals market of around €2.65 trillion. Petrochemicals represent the majority of all chemicals shipped between the continents of the world.
They are organic chemicals derived from petroleum but can also be defined as chemicals produced, usually in bulk, from carbon and hydrocarbon raw materials, including coal, natural gas and renewable alcohols. They have a history — stretching back in parts to the 19th century — that has been beset by many economic, commercial, technological and logistical changes, which the industry has shown extraordinary resilience in adapting to. However, from the beginning there have also been underlying trends which have remained constant and still shape the industry today.

Almost from the start it was an industry destined to become a global sector because of the contribution it makes to **raising the standards of living** of much of the world's population.
Since the early days, the same influences have been at work and would shape the rate and nature of its expansion, its structure and organisation of production, management systems, types of technologies, production locations and logistics, up to today.
These influences are:

- Economic and Social Factors — Economic growth rates, consumer demand, life style changes, and the spread of the middle classes that aspire to a better life with financial affluence.
- Science & Technology — Combined with economic factors, technology, particularly production processes, was the major driving force behind the expansion of the petrochemical sector.
- Industrial Trends — Oil prices and raw material (feedstock) costs, feedstock availability, demand for petrochemicals as raw materials, sales prices, investment levels, capacity utilisation in petrochemical plants.
- Production Structures — Many production locations were dictated by the need for integration of petrochemical and refinery production. Others were stand-alone petrochemical sites. Gradually, petrochemical complexes and clusters emerged, leading to geographical agglomeration with inter-regional and international production and supply-chain links between feedstocks, intermediates and raw materials for downstream converters.
- Corporate Structures — The big oil companies pushed petrochemical businesses, because of the added value of integration with refineries.

"PETROCHEMICALS HAVE MADE A MASSIVE CONTRIBUTION TO RAISING THE STANDARD OF LIVING OF THE WORLD'S POPULATION."

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Nonetheless there were variations in sizes of business units, different managerial systems and a persistent tendency towards concentration through mergers and acquisitions (M&A).

- Supply Chain and Logistics — From the earliest days of petrochemicals production, the sector has been subject to repeated initiatives to streamline and optimise logistics. There was a constant struggle to eliminate fragmentation and a need for greater integration of road, rail, waterways and marine shipping.
- Health, Safety and Environment — HSE focus topics were prevalent from the beginning of the industry with health and safety matters looming large initially. But environmental questions gradually became predominant with, in recent years, CO_2 and greenhouse gas emissions becoming the leading issue in the fight against climate change.

In all of these seven areas, there have been continuous challenges. The history of petrochemicals has been meeting those challenges and successfully overcoming them. It is **a story of achievement,** and the future will be the same.

The overall result of this tale of achievement has been a massive contribution to raising the standard of living of the world's population. Petrochemicals, particularly synthetic polymers, have been providing the means for making materials and equipment which have substantially improved levels of nutrition, access to drinkable water, quality of clothing, buildings and transportation, whilst also contributing to the reduction of energy use and emissions.

Founded in 1967, the European Petrochemical Association (EPCA) has been actively accompanying the remarkable journey of achievements — and challenges — of the petrochemical industry for the past 50 years. Looking back over the decades, the vision of the EPCA founders who drafted the initial Articles of Association can only be applauded, in that they set objectives which remain as valuable today as in 1969.

EPCA has strived over the decades to adapt to the changing needs of the petrochemical business community and their stakeholders — i.e. people such as investors, employees, customers, suppliers and authorities that have an interest in the industry — and challenge "business as usual" approaches for the long term sustainability of the industry.

This book provides a first-hand insight into the evolution of the petrochemical industry during the last 50 years and EPCA's alignment with business and stakeholders' requirements.

"PETROCHEMICALS REPRESENT THE MAJORITY OF ALL CHEMICALS SHIPPED BETWEEN THE CONTINENTS OF THE WORLD."

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EPCA has been actively accompanying the remarkable journey of achievements — and challenges — of the petrochemical industry for the past 50 years.

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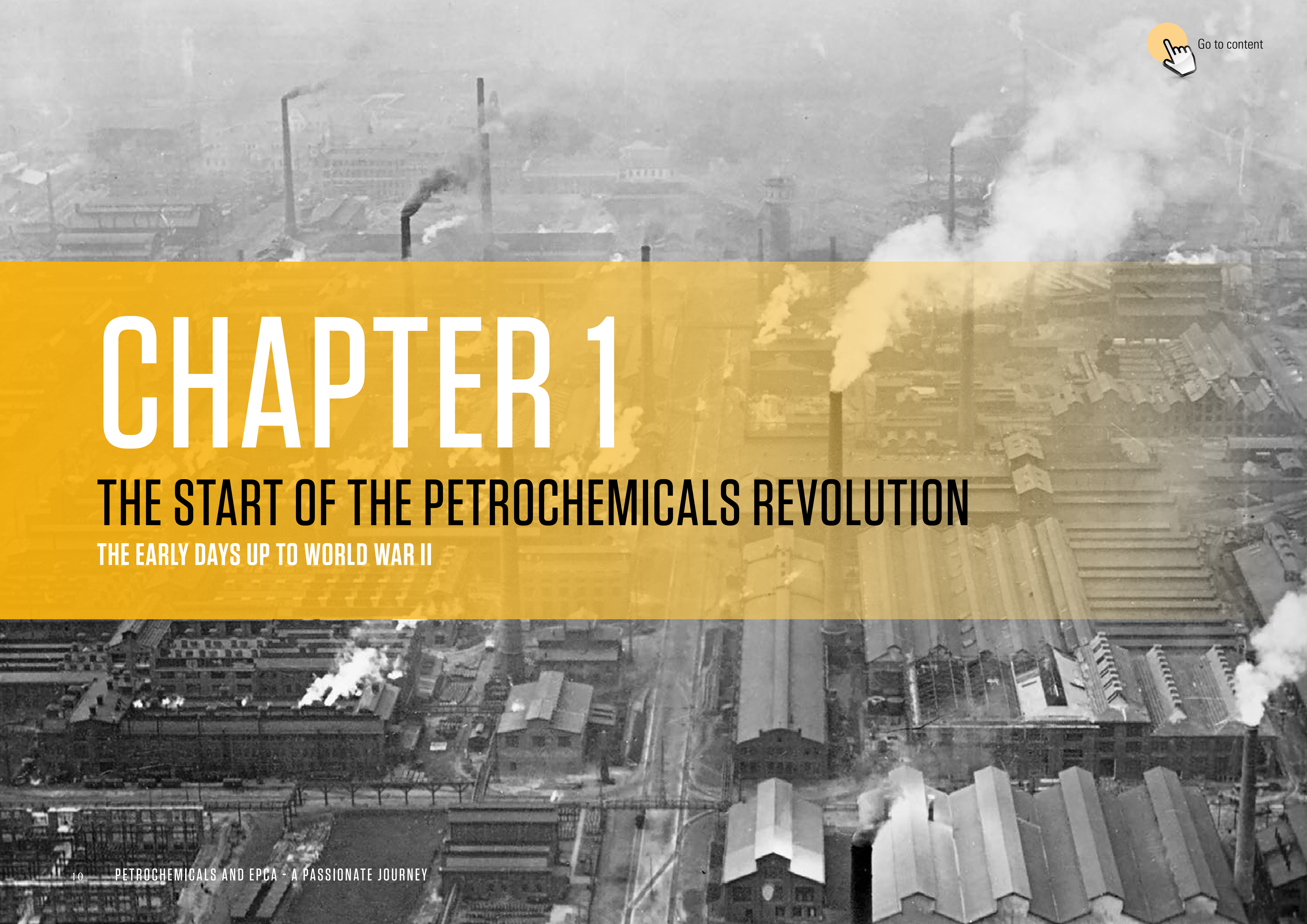

CHAPTER 1

THE START OF THE PETROCHEMICALS REVOLUTION

THE EARLY DAYS UP TO WORLD WAR II

EARLY TECHNOLOGIES AND PRODUCTS

The boom years for petrochemicals in the developed world of the 20th century — North America, Europe and Japan — were in the 1950s and 1960s. In fact, in the US **the golden age of petrochemicals started immediately after the end of World War II** in the second half of the 1940s. This was due to the innovations made in the 1920s and the 1930s and during the war as well as to the rapid reconstruction of Europe and the economic recovery after World War II.

Initially the petrochemical industry was able to rely on product and process technologies based on the conversion of coal, natural gas and alcohols into chemicals. Some of the discoveries of the science behind the technologies were mainly made in academia, particularly in Europe, in cooperation with visionary industrialists.

In Germany, before World War I, chemist Fritz Haber discovered the catalytic process for synthesising ammonia from hydrogen and atmospheric nitrogen under conditions of high temperature and pressure. To develop the process for large-scale production, Haber teamed up with Carl Bosch, a chemist and engineer at BASF. Both scientists received Nobel Prizes for the achievement.

The breakthrough was highly significant because it enabled abundant quantities of nitrogen-based fertilisers to be provided to grow the crops needed to **feed the world's increasing population**.

It was also important to the future petrochemical industry because its combination of catalysis and engineering was to become the basis of a series of innovations during the history of the sector. Ammonia tended to be produced on refinery/petrochemical sites because of the need for hydrogen while it was also an intermediate for petrochemical products. This however posed one of the first major health and safety challenges because of the potential danger of major accidents due to the high temperatures and pressures within its reactors.

POLYMERS REVOLUTIONISE THE MATERIALS WORLD

Meanwhile the foundations of polymer chemistry, a vital source for the development of petrochemicals, many of which are plastics, were being laid in the 1920s by Swedish scientist Theodor Svedberg and German chemist Hermann Staudinger. Earlier, Belgian chemist Leo Baekeland reacted phenol with formaldehyde to

CARL BOSCH
(1874-1940)
German chemist-engineer. *Nobel Prize for Chemistry in 1931. Developer of Fritz Haber's ammonia synthesis into a large-scale industrial process for commercial fertilisers which would transform modern agriculture.*

WALLACE CAROTHERS
(1896-1937)
US chemist, *who led a DuPont team, which discovered in the 1930s the synthetic rubber Neoprene and a polyamide fibre, later to be called Nylon as an alternative to silk stockings.*

FRITZ HABER
(1868-1934)
German chemist. *Nobel Prize for Chemistry in 1918. Inventor at laboratory scale of the catalytic synthesis of ammonia from hydrogen and atmospheric nitrogen at high temperatures and pressures.*

LEO BAEKELAND
(1863-1944)
Belgian-American chemist. *Inventor of Bakelite, a thermosetting resin made by reacting phenol and formaldehyde under high pressure. Dubbed the Father of Plastics due to Bakelite's processability.*

make the thermoset polymer Bakelite, which retained its shape after being heated. This is considered to mark **the beginning of the age of plastics**. In the 1920s, it was commercialised for the manufacture of radio and telephone housings and electric insulators.

The world's first commercial-scale ethylene cracker was built by Union Carbide in West Virginia in the early 1920s. At DuPont, in the late 1920s Wallace Carothers invented neoprene, a synthetic rubber with a similar chemistry to isoprene at the core of natural rubber. Then he discovered nylon, although a chemist at the German combine I.G. Farben soon afterwards developed a more efficient process for making the polyamide.

By the late 1930s most of the major polymers of the petrochemical revolution of the second half of the 20th century had been discovered. In addition to nylon and thermosets these included the leading thermoplastic polymers, which change their shape when heated — like polyethylene (PE), polypropylene (PP), polyesters, polystyrene (PS), or polyvinylchloride, commonly known as PVC. Many of these started to be made in commercial quantities from feedstocks from petroleum production in the US in the 1930s and then in much larger quantities during the war.

Production of polyisobutylene in Ludwigshafen, 1938.

CORPORATE LEADERS ESTABLISH THEMSELVES

The major companies behind the discovery and development of the carbon-based organic chemicals were destined to become the technological and market leaders in petrochemicals. For many it was a position they were to retain until the 1990s and 2000s and for a few until today.

In the US these pioneers included DuPont, The Dow Chemical Company (Dow), Union Carbide and 103 of New Jersey. In Europe they were led by BASF, Bayer and Hoechst, which were merged temporarily into I.G. Farben, ICI and BP of the UK, and the Anglo-Dutch Shell.

"THE FOUNDATIONS OF POLYMER CHEMISTRY WERE BEING LAID IN THE 1920s."

THE FOUNDATIONS OF PETROCHEMICALS LOGISTICS

With respect to logistics, the laying of the groundwork for what was to become the petrochemical era began even earlier than that for the chemical industry.
The basic concepts in transportation and communications which were to make up the core of petrochemicals distribution — rendering mass production of petrochemicals economically feasible — emerged first in the oil and petroleum sector in the mid-to-late 19th century.
Soon after commercial quantities of oil were first produced in Pennsylvania in the US in the 1860s and then refined mainly into kerosene for lighting, and into health care products for instance for disinfection or skin care, supply chains were being created from the oil well to the retail outlets for lamp fuel. Similar chains were being formed in eastern and central Europe where kerosene was becoming a thriving business because of the local availability of oil and refining units.
The key transportation and logistical components of these chains were barrels, tin cases, tanks, railway tank cars and pipelines for carrying the oil and kerosene from one distribution point to another.

A variety of containers were used to transport the oil and fuel by road, rail, inland waterways and marine shipping. Railways transported oil and fuels at first in vertical tanks on flat rail cars. By the late 1860s more efficient and safe boiler-type tank cars, with the tanks integrated with the wheel chassis, were introduced as the basis for a design which is still being used to transport refined products and other bulk liquids today.
Pipelines, initially made of wood and then wrought iron, provided a cheaper means of conveying oil from the Pennsylvanian fields to railroads. In 1879 the first long-distance pipeline was opened to deliver oil with the aid of pumps over 100 miles through mountainous countryside. Soon pipelines were to become the main means of transporting oil across land.
As the networks of pipelines and rail tank cars expanded, local hubs for the distribution of refined products by horse-drawn wagons were set up in the US with storage tanks with capacities from a few hundred to tens of thousands of barrels.
By the last decades of the 19th century the oil companies and traders had developed fuel tankers to serve international networks of storage depots and terminals for the distribution of kerosene in tin cases to

"RAILWAYS TRANSPORTED OIL AND FUELS AT FIRST IN VERTICAL TANKS ON FLAT RAIL CARS."

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Fuel-filling a tank truck.

inland retail outlets. These distribution systems extending across the Atlantic from the US to Western Europe and from Russia to the Far East caused a big increase in refining capacity, because of the size of the market which their products were able to supply.

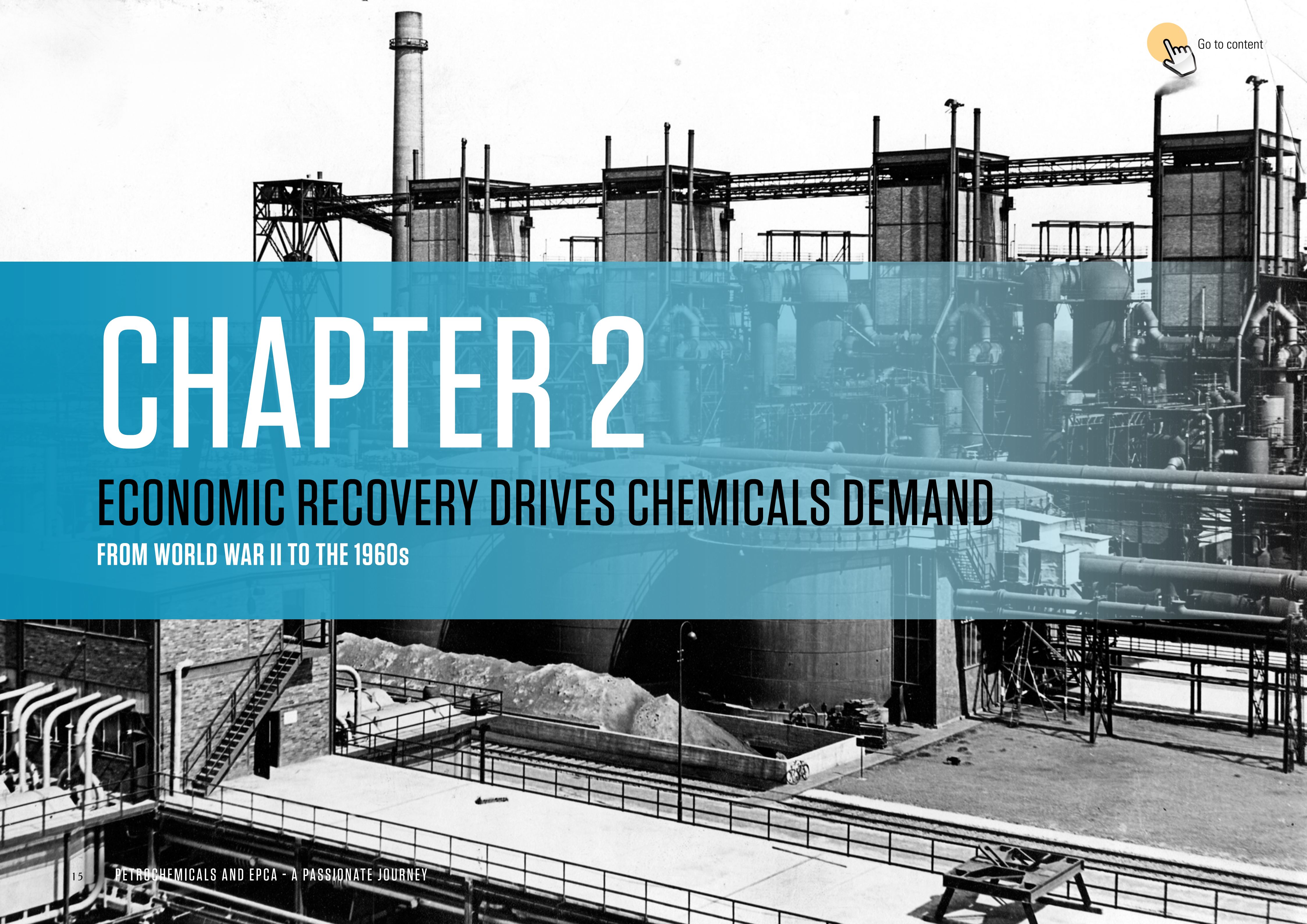
These ocean-going tankers posed big challenges for ship designers. Cargoes had to be well separated from engine rooms because of the danger of fires, while they had to have room to expand and contract, to be adequately ventilated and to be relatively stable so that liquids did not slosh from side to side. By the late 19th century tankers were being made with several compartments which could be filled directly by pumps.

During World War I, the capacity of the global tanker fleet was more than doubled. The additional ships were needed to meet **a big increase in demand for fuels** but also to replace tankers being sunk by submarine. But it meant that after WWI there were many surplus tankers which were sold cheaply on the open market. This led to the rise of independent tanker owners serving a fast expanding market for chartered vessels.

Throughout much of the first half of the 20th century the logistics of first kerosene and then gasoline distribution, for which the demand was much greater because of rapidly increasing sales of automobiles, were considerably improved by technological and organisational innovations.

One of the most important of these innovations was the motorised tank truck. They were first introduced in the 1900s in the UK and soon afterwards in the US where their numbers grew rapidly. In the 1910s there were over 20 vehicle manufacturers making tank trucks initially with solid rubber tires and wooden wheel spokes. In the 1920s when the US tank truck fleet reached over 100,000 these were replaced by pneumatic tires and steel spokes. ■

"THE MOTORISED TANK TRUCK WAS ONE OF THE MOST IMPORTANT INNOVATIONS OF THAT TIME."



CHAPTER 2

ECONOMIC RECOVERY DRIVES CHEMICALS DEMAND

FROM WORLD WAR II TO THE 1960s

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THE IMPACT OF WORLD WAR II

Two major forces — World War II and the post-war economic recovery — pulled the petrochemical sector into an era of large-scale technology-driven production and commercialisation, starting in the US and soon afterwards Western Europe.
WWII provided the government funds — and the urgency needed for the large-scale realisation of technologies discovered and developed in the 1920s and 1930s and in some cases even earlier.
Then, 2-3 decades after World War II, **fast economic growth in the developed world** was to provide the next impetus behind the petrochemical revolution.
The countries which were leaders in petrochemicals production tended to be the countries with the highest levels of GDP per capita — with the US being by far the world's richest country, followed by Japan, Germany, France and the UK.
Populations with high disposable income had the money to spend on consumer and other products with high petrochemicals content.
At the same time the technology was, on the whole, able to keep pace with rapidly increasing demand, in particular through the development of processes able to achieve the economies of scale necessary for ensuring petrochemicals were able to **meet the needs of rising living standards** at low cost.
However, initially only the US was able to scale up the processes for making petrochemicals in sufficient quantities to meet demand. The petrochemical industry in the country was growing so fast that it was soon one of the biggest contributors to the US gross domestic product.
In much of the rest of the developed world demand took several years longer to bounce up to the levels of that in the US. Then, even when it began to increase strongly, there was for a while a lack of know-how and financial resources to repair chemical plants damaged during the war and build state-of-the-art new ones.
Money was a major difficulty in Western Europe. First the region went through a period of austerity to rebuild basic infrastructure. But once that was over the banks were not geared up to channel funds into chemicals and other manufacturing capacity.

Much of the funds and engineering know-how had to come initially from US companies, especially oil producers with expertise in refinery processes.

ELIMINATING THE GAP BETWEEN SUPPLY AND DEMAND

The rapid rise in demand for chemicals stemmed from the rising incomes of consumers and from industries responding to their needs.

Economic planners in the 1940s in North America and Western Europe expected **soaring demand for consumer products, automobiles, electrical appliances and clothes**. But it turned out to be even higher than forecast. Manufacturers struggled to keep up.

Because of its potential for large-scale output and low cost products the petrochemical industry could provide the means for eliminating the gap between supply and demand.

In particular it could provide plastics for a wide range of materials from packaging to components for automobiles and electrical household appliances. Also it could supply man-made fibres to satisfy a fast growing demand for clothes and textiles.

In the US, consumption of synthetic fibres — polyester, polyamide, acrylics and polyolefins — rose from zero in the late 1940s to account for almost one third of the total domestic market for fibres in 1969. By the mid-1950s synthetics had close to a one-third share of the women's and children's wear market and over a third of textiles for industrial use. By the late 1960s close to a third of home furnishing fibres came from synthetics.

THE DIFFICULT TASK OF BUILDING PRODUCTION CAPACITY

The US was able to take advantage of the production and logistics infrastructure built in the country in the 1930s and 1940s to establish a petrochemical sector before other industrialised nations. The Europeans were slow off the mark in upgrading and constructing plants partly because of a lack of finance and a lack of a clear strategy for how to handle what were for most companies entirely new markets in plastics and man-made fibres.

Nonetheless the production capacity gap was gradually closed. The divide narrowed considerably in the 1960s with Western Europe having 6.3 million tonnes of ethylene capacity — almost an eightfold rise in ten years — while US capacity rose threefold to 9.3 million tonnes.

A platform for the **expansion of petrochemicals in Western Europe** came from the international oil companies, such as ExxonMobil (with its Esso brand in Europe), Shell and BP. ExxonMobil established a petrochemicals complex adjacent to its Esso refinery in Fawley, southern England, which was one of Europe's first petrochemical facilities.

Bayer, which with BASF and Hoechst was the main component of the former I.G. Farben, established a partnership with BP to set up a joint venture named Erdolchemie for the purpose initially of providing acrylonitrile for synthetic fibres production.

ExxonMobil built petrochemical facilities elsewhere in Germany, while in France it constructed the country's first ethylene cracker, a 30,000 ton-a-year unit on the Normandy coast.

BP created another partnership on mainland Europe with Kuhlman and Pechiney of France for the establishment of a petrochemicals complex called Naphtachimie in the south of the country.

Shell formed a joint venture with BASF in Germany — Rheinische Olefinwerke (ROW) — to produce polyethylene, which started operating in 1955. In fact demand for its output was so strong it soon boosted its annual capacity to 125,000 tonnes, making it at the time one of the world's largest polyethylene plants.

Hoechst decided to go it alone, building

KARL ZIEGLER (1898-1973) German chemist.
Nobel Prize for Chemistry in 1963 (with Giulio Natta). Discoverer of catalysts in the 1950s for the large-scale production of polyethylene opening the way to a mass thermoplastics market.

GIULIO NATTA (1903-1979) Italian chemist.
Nobel Prize for Chemistry in 1963 (with Karl Ziegler). Using Ziegler's catalysis work, Natta developed stereoregular polypropylene in 1954 and other catalyst systems for a range of polymers.

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two crackers in the 1950s near the city of Frankfurt. Caltex of the US soon afterwards built a nearby refinery which supplied feedstocks and ethylene to Hoechst.

Throughout most of Western Europe most petrochemicals in the post-war period were located adjacent or close to expanded or newly constructed refineries. It was not only the convenience of feedstocks being available close by. The proximity helped speed up the building of petrochemical units. Engineering contractors — most of them from the US — could transfer their expertise in the design and construction of refineries to doing the same with petrochemical facilities.

Eastern Europe took even longer to adjust to the new petrochemical technologies amidst the problems of centrally planned command economies and an intra-trade system run by COMECON.

The Japanese petrochemical industry also took a different direction from its Western counterparts mainly because of its system of dividing industry into conglomerate organisations of Keiretsu (a set of companies with interlocking business relationships and shareholdings) through cross-share holdings. Most of the country's main petrochemical operators — Mitsui, Mitsubishi, Sumitomo, Asahi, Showa Denko — were members of Keiretsu.

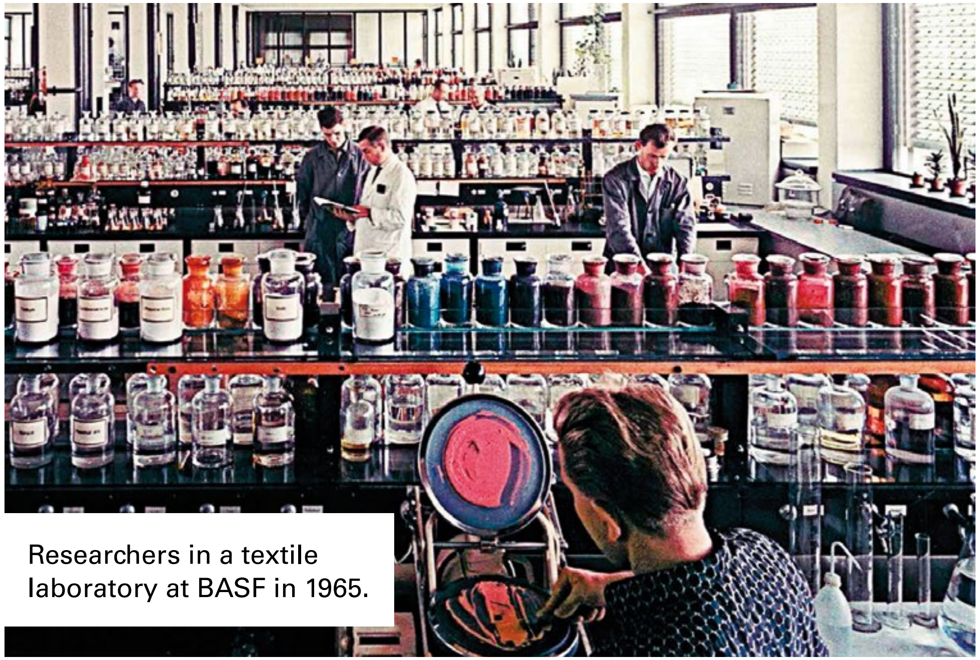
THE EMANCIPATION OF PETROCHEMICALS MANUFACTURERS

Much of the new petrochemicals capacity across the world was based on crude oil-derived feedstocks, because of their abundance, relatively low cost and ability to serve large-scale plants. **A high proportion of petrochemicals production was closely linked to feedstocks from refineries** so petrochemical plants would tend to be located adjacent to refineries or within refinery complexes. These would tend to be in coastal areas so that raw materials and output could be economically shipped in and out of terminals and ports, which would also be connected to rail networks.

In the US, petrochemicals production had already become concentrated in the Gulf of Mexico, the country's centre of oil and petroleum production.

In Western Europe, US oil companies, as well as European ones such as Shell and British Petroleum, were initially among the main builders of petrochemical plants, mostly adjacent to their refineries.

In the parts of the industry based on refinery-petrochemicals integration, petrochemicals production and marketing tended to be in the hands of the oil companies, with the larger ones, particularly in the US, looking to expand



Researchers in a textile laboratory at BASF in 1965.

their petrochemicals know-how overseas. However, these oil-based petrochemical players were coming under increasing competition from a group of dedicated petrochemicals producers — Dow, DuPont, ICI, DSM, BASF, Bayer and Hoechst. They were soon becoming much more powerful operators in the sector, not only nationally but internationally. ICI was active in using its position as the leading UK producer to expand across the world in British Commonwealth countries in many of which it used technology transfers to establish embryo petrochemical industries.

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Advertising poster for Dralon fibres.

In both North America and Europe, stand-alone units dedicated to chemicals production, rather than a combination of refinery products and chemicals, were emerging, with the larger ones being run by the dedicated petrochemical operators. The prevalent economies of scale made relatively small ethylene crackers and their derivatives unit commercially viable. In Western Europe in particular governments were anxious to establish national petrochemical industries so they encouraged the creation of relatively small petrochemical production centres, primarily serving domestic markets.
This trend towards small-scale operations was helped by the availability of a choice of process technologies from a variety of sources, including specialist engineering firms (SEFs). With process technologies available on the licensing market at a relative low cost, **petrochemicals capacity was able to match buoyant demand** which with some chemicals was growing at double-digit annual percentage rates.
In the 1950s through to the early 1970s the petrochemical sector began to spread beyond the industrialised world. It was the first sign of the **globalisation of the industry**. Much of the impetus came from foreign direct investment (FDI) by US companies in petrochemical projects in Latin America. Also the first petrochemical facilities were being built in the Middle and Far East, although on a small scale.

TECHNOLOGIES BECOME ABUNDANT

The petrochemical boom triggered a lot of research and development (R&D) into discovery of some new plastics but much of the research effort was directed at scaling up the production of already invented polymers with the help of new and existing catalysts. By the 1960s across the Western world the major plastics — low and high-density polyethylene (LDPE, HDPE), polypropylene (PP) and PVC — and the three main synthetic fibres — polyamides, polyesters and acrylics — had become major industrial products.
The mass-selling polymers were derived from ethylene, propylene and butadiene, all products or by-products from refinery processes or ethylene crackers. From ethylene came polyethylene, PVC, polystyrene and polyethers and polyesters. Propylene led to polypropylene, acrylics, urethanes, phenolic resins and polymethyl methacrylate (PMMA). Derivatives of butadiene included polybutadiene, styrene-butadiene rubber (SBR) and nylon 6,6.

Much of the impetus behind the demand for polymers and other petrochemicals was their relative cheapness, availability and their **ability to replace existing materials** because of their high performance. Soon petrochemicals were being used as building components and materials, automobile and other transport components, household products, parts of electrical appliances and as packaging materials. Initially, one of the markets in which they made the biggest inroads was textiles. By the mid-1960s synthetic fibres consumption exceeded the combined total of natural (dominated by cotton) and cellulosic (mainly rayon) fibres.

With low-density polyethylene (LDPE), the two main producers initially during and after World War II were ICI and DuPont using a high-pressure, high-temperature process based on the free-radical polymerisation of ethylene. In the 1950s German catalyst specialist Karl Ziegler discovered a process using alkyl aluminium compounds and titanium tetrachloride as a catalyst to make high-density polyethylene (HDPE) at atmospheric pressure and close to ambient temperature. Ziegler discovered a means of gaining chain reactions to produce unbranched, linear polymers. His research was used as a basis for the discovery by Giulio Natta at Ferrara, Italy, of a catalysis system for producing a polypropylene in which the location of the methyl groups on the polymer chain could be modified to control the stiffness or elasticity of the plastic. The discovery enabled the Italian company Montecatini to start the large-scale commercial production of crystalline isotactic polypropylene from the late 1950s using what came to be called a Ziegler-Natta catalyst. But lack of money prevented the company from exploiting other types of modified polypropylene developed by Natta.

Both scientists — Ziegler and Natta — were awarded the Nobel Prize for chemistry in 1963. By 2013 the family of catalysts centred on the Ziegler-Natta catalyst were estimated to be responsible for the production of around 100 million tonnes of plastics, elastomers and rubbers.

Such was the strength of demand for new or improved technologies that some of the more **talented scientists were able to make a good living** out of becoming highly independent inventors. One of these was Ziegler who despite being employed by the German Max Planck Society determined his own licensing policy and negotiated licensing agreements without lawyers, while benefiting personally from the licensing income.

Chairs made from plastics first appeared on the market in the late 1950s.

Polycarbonate was used during the Apollo 11 mission for the visors of the Astronauts' helmets.

The success of state-funded research into new product and process technologies during the war prompted governments to continue to be involved in R&D in the chemical and other industries. The result was the setting up of an increasing number of chemistry and chemical engineering departments in universities and research institutes financed by state money — with a significant proportion of them doing research into petrochemicals. This broadened the number of research networks in academia which petrochemical companies were able to rely on as a source of innovation.

Scientists were able to take advantage of relatively generous research funds to make **discoveries of long-lasting importance**. Also, chemical engineers and equipment manufacturers were able to streamline production processes to achieve much higher capacities. Many petrochemical plants, especially in Europe, had capacities languishing in the tens of thousands of tons per year, which in the longer term would prove to be uneconomic.

One important technological initiative in the 1960s and early 1970s was the development of flowsheets and equipment to allow the construction of very large single-train plants for the production of ethylene and ammonia. With ethylene, this included the design of "high severity" cracking furnaces, quench boilers for rapid cooling of the furnace effluent from naphtha and gas oil crackers, the use of big centrifugal compressors and flowsheets for the separation of low-boiling light hydrocarbons. Similar innovations were made in the production of ammonia. For both chemicals, these **breakthrough developments** greatly lowered production costs, increased run lengths and greatly influenced the flowsheets of other petrochemical processes.

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ADVANCES IN LOGISTICS

Big advances in logistics during World War II were to help meet the tremendous distribution requirements of the surge in demand for oil, fuels and petrochemicals during the post-war economic revival. Virtually every means of transport was pushed to its maximum performance while scientists and engineers were pressed to **achieve constant technological improvements**. With its large amount of petroleum refining capacity, most of the logistical and technological advances occurred in the US.

In response to the increase in the sinking of coastal tankers by submarines, in the early 1940s the US embarked on what has been described as "one of the extraordinary feats of engineering in World War II". The oil transportation and construction industries were mobilised to build a 1,254-mile oil pipeline from the oil producing south of the country to the northeast coast with a load five times bigger than existing pipelines. A second even-longer pipeline of 1,475 miles was also constructed from the south to the northeast to carry gasoline and other refined products. The projects required a great deal of newly designed and developed equipment.

Large quantities of fuel had to be shipped across the Atlantic, initially to Britain and the Soviet Union and then to support the Allied invasion of continental Europe. The solution was the development of a fast method of building a standard tanker called the T2 with its parts being welded rather than riveted together. Around 500 were constructed during the war with a similar design and a deadweight capacity of 16,613 long tonnes. After the war they were used commercially with some to be converted to carry petrochemicals.

Trucks, with and without tanks, became the essential mode on both sides of the Atlantic, for short-haul transportation. Convoys of trucks carrying drums of oil, gasoline and lubricants supplied the fronts in the last years of the war. Tank trucks delivered fuels to airfields and to depots close to the front but their main job was to distribute fuels to cities to prevent shortages. They freed up railway tank car capacity for long-haul transportation. It was a time when **road transportation worked 24 hours, seven days a week** and maintained the equivalent of a just-in-time schedule. To keep up with demand the manufacture of tank trucks in the US had to be increased by around 60 percent between 1942 and 1943. Despite the development of new technologies to

BASF-Dow production site in Freeport, Texas. Operation started in 1959.

make synthetic rubber as an alternative to natural rubber, there was, however, a constant shortage of tyres.

EVOLUTION OF PETROCHEMICALS SUPPLY CHAINS

The supply of feedstocks and raw materials to petrochemicals producers required the development of increasingly sophisticated logistics systems, including transportation and storage facilities. Downstream from petrochemicals production were a growing army of converters, some of whom were owned by the petrochemicals producers themselves who had forward integrated into plastic products manufacture. This downstream chain gradually needed to be served by dedicated logistics systems. Initially most petrochemical businesses ran these themselves with their own transport and storage operation. But it soon became more efficient and less costly to outsource this work to logistics specialists who developed their own expertise in the handling of petrochemicals-derived products.

Chemical companies and oil producers, particularly those with petrochemical activities, were able to take advantage of the availability of wartime transportation ships and vehicles and distribution networks to market their products, particularly abroad. US companies were quick to expand in Western Europe by transporting their products in wartime petroleum tankers, which could be modified to carry petrochemicals and their feedstocks.

If the Western European petrochemical industry was to take advantage of the economies of scale available from producing chemicals from petroleum it had to switch from coal to oil as the main upstream raw material.

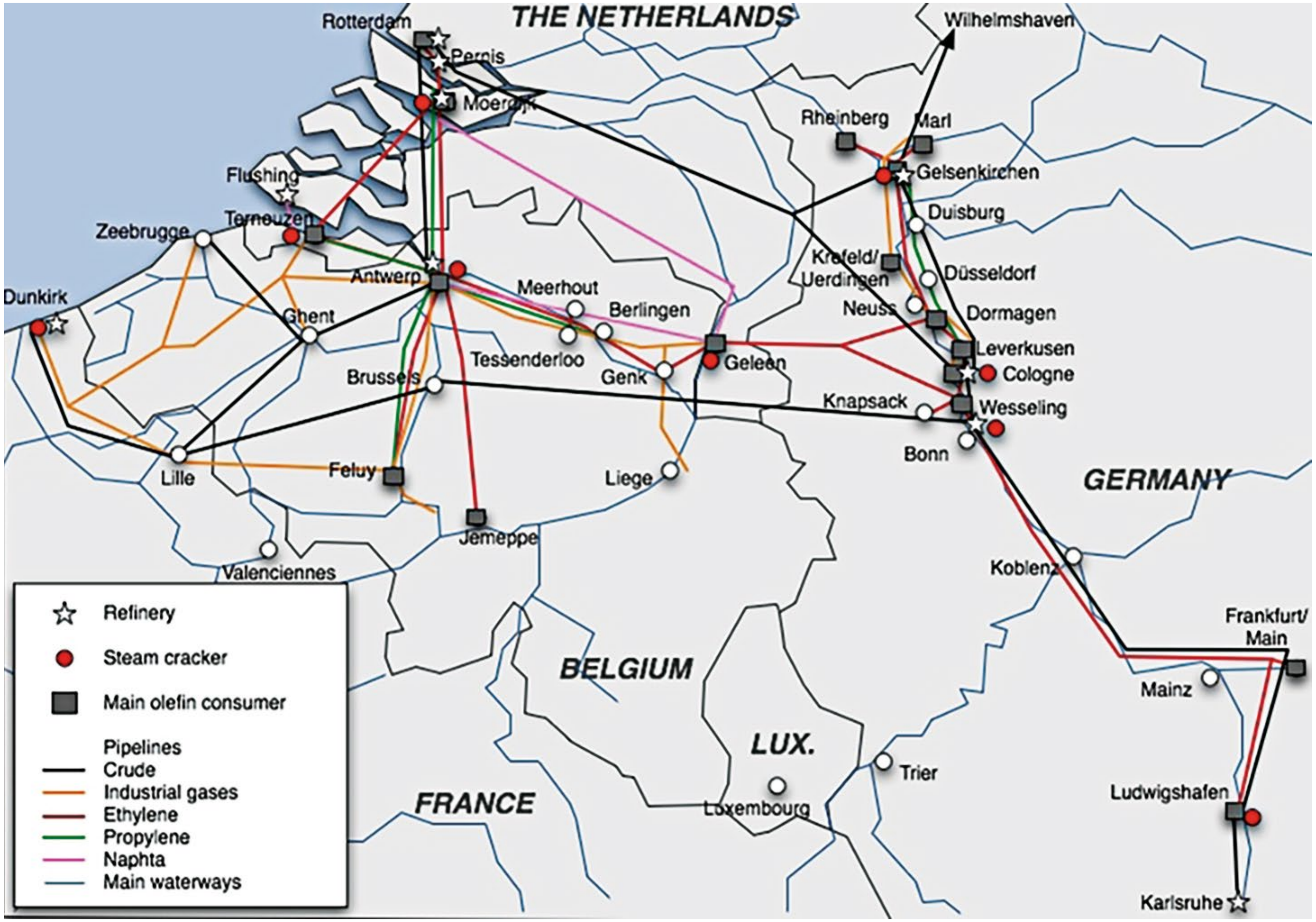
Because of the lack of abundant Western European oil and gas reserves (with the potential of North Sea hydrocarbon yet to be investigated), most of the region's needs for oil and gas and for much of the refinery products had to be imported. That required investment in port facilities for handling bulk liquid cargoes and then distribution networks inland. **Pipelines were to become a major means of transporting oil and gas and also petrochemical feedstocks** like ethylene. Germany, which was the most highly dependent on coal feedstocks of the major Western European countries, was by the early 1960s being supplied with oil by pipelines, mainly from Rotterdam. West Germany's three large chemical companies — BASF, Bayer and Hoechst — were able to move over to petroleum feedstocks with the help of connections to oil pipelines.

"THE BIGGEST ETHYLENE PIPELINE NETWORK IN EUROPE WAS SET UP IN 1968 AND STARTED OPERATIONS IN 1970."

Ship being loaded in a port in 1959.

Upstream feedstock pipelines in Europe were complemented by ethylene pipelines in the region's major petrochemical-producing areas. Similar in concept to a pipeline network already connecting petrochemicals sites in the US Gulf, the biggest ethylene pipeline network in Europe — named ARG after the company running it (Aethylen-Rohrleitungs-Gesellschaft) — was set up by a consortium of ethylene users and suppliers in 1968 and started operations in 1970 with the opening of its first section between the German towns of Gelsenkirchen and Dormagen. By 1974 it had been connected to nine other sites in northwest Germany, Belgium and the Netherlands. These included Wesseling where it was connected with an ethylene pipeline to Frankfurt and, in 1980, a BASF pipeline to the company's main site at Ludwigshafen. The pipeline grid was eventually to be 490 kilometres long with a 117 km spur linking the port of Rotterdam with Antwerp.

Other ethylene pipelines have been built in France connecting Marseilles with eastern France, which is also linked by pipeline to the country's north coast. In the UK an ethylene pipeline runs from Grangemouth in Scotland into northeast England where it provides feedstock to the Teesside chemicals cluster.



Overview of cluster interrelationships.

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Container ship pioneer Malcom McLean.

DEVELOPING SPECIALISED MEANS OF TRANSPORT

At the same time there were a lot of relatively small ethylene derivatives units located in stand-alone locations which had to be supplied with ethylene by tank trucks or rail tank cars. Ethylene, a colourless highly reactive, flammable gas, is difficult to transport so it required specialist vehicles. In the 1950s, ICI designed a high-pressure tank truck to supply its customers. An increasing proportion of **tank trucks and rail tank cars** were in fact manufactured to carry specific chemicals. In the US tank cars were developed to transport heat-sensitive chemicals with insulating urethane foam being used to maintain temperatures.
In the 1950s Dow pioneered the making of the first large tanker to exclusively carry commodity chemicals in multiple tanks separated by double bulkheads with individual pipe systems. The tanker had a carrying capacity of 16,000 long tonnes of chemicals.
This **trend towards specialist ships** gave birth to the parcel tanker which was considerably cheaper and more efficient for long-haul voyages than other chemical carriers. Its development was spearheaded by Stolt-Nielsen, an originally Norwegian shipping company. Parcel tankers, which were to comprise the majority of vessels classified as chemical tankers, consisted of around 30 to 40 tanks each of which had its own pump so that the purity of liquid load could be assured. But it also enabled the ship to bring back a similar load of chemicals on the return trip making the vessel highly economical.

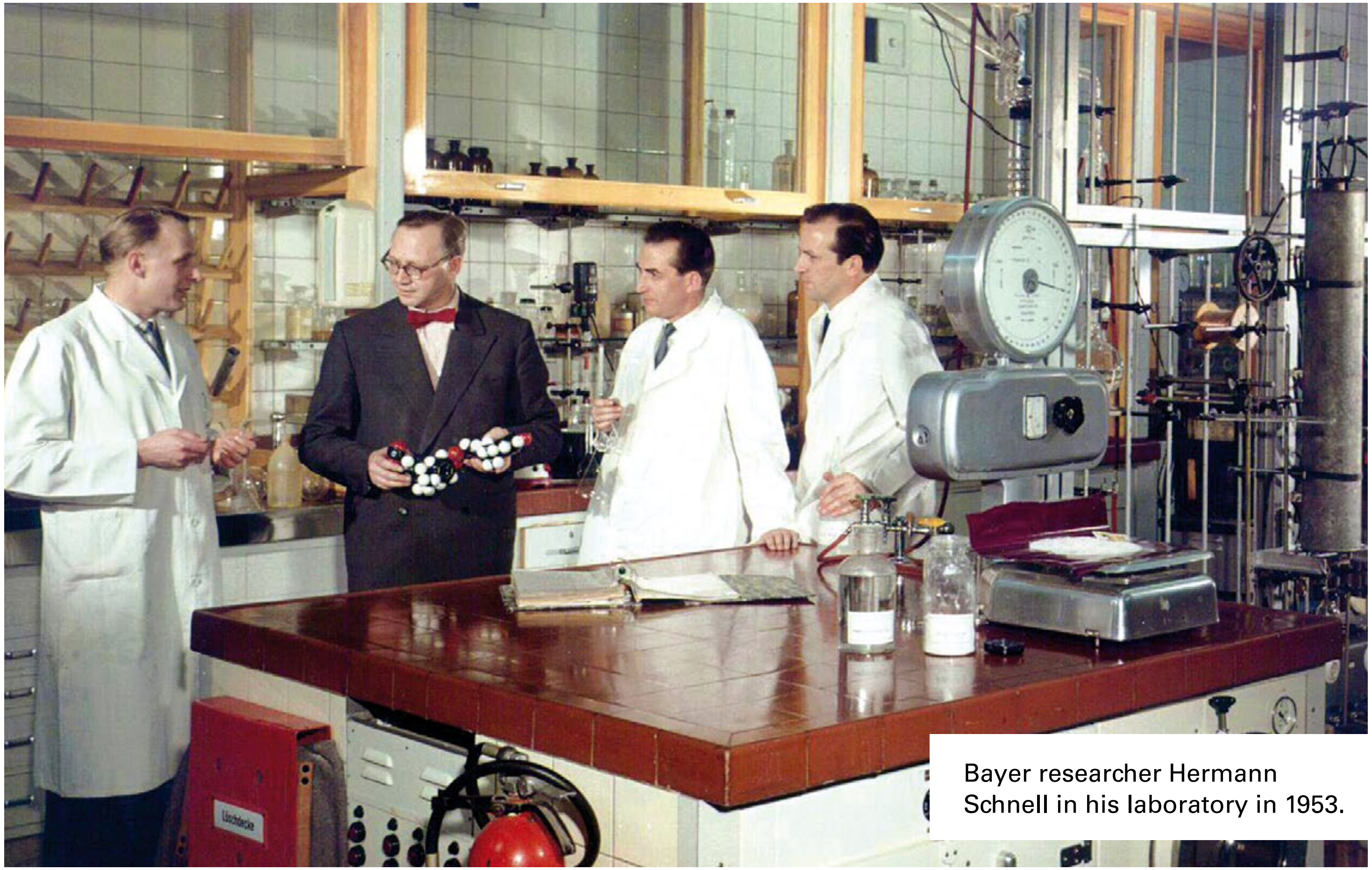
THE BEGINNING OF CONTAINERISATION

The fast growth in international trade in the 50s and 60s brought about such congestion in ports that ships were spending as much as half of their time waiting for a berth and being unloaded and loaded. The freight industry response to this dilemma was the introduction of containerisation which was a concept tested before the war but without success mainly because of a lack of standardisation. First came the box container. A North Carolina-based trucking company headed by Malcom McLean is considered to have made the **first ship voyage with containers** with a converted T2 tanker carrying on its deck from New Jersey to Texas 52 truck trailers detached from their wheel chassis. Once they were unloaded in Houston they were placed on fresh running gear to be delivered to their destinations.

Gradually other cargo shipping operators followed the example of McLean with a variety of containers. Then there were lengthy negotiations in the shipping sector not only on the setting of standards for the containers but also on the reconfiguring of port facilities around the world. Box containers offered chemical shippers the means of transporting relatively large quantities of liquids in drums, which could be loaded and unloaded relatively quickly with scope for intermodal transportation in the containers by truck or rail.

There was even **greater potential for intermodal transportation** in the tank container, comprising a vessel of stainless steel surrounded by an insulation layer of polyurethane and aluminium. It sits in a steel rectangular frame which enables it to be carried by ship, truck or rail. The first tank container was designed by a London-based engineer in the mid-1960s. But the first tank containers were not manufactured commercially until later when they complied with standards set by the Geneva-based International Organization for Standardization (ISO).

The tank container was gradually to become a leading means of transporting chemicals in international markets. But as an intermodal method of distribution in Europe it had to overcome the difficulties



Bayer researcher Hermann Schnell in his laboratory in 1953.

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First containers arrived in Bremen with "MS Fairland" in 1966.

"THE SOCIAL ELEMENTS OF EPCA MEETINGS HAVE ALWAYS BEEN PART OF THE WINNING DEAL."

of rail networks being controlled by numerous national rail companies with different freight systems or track gauge.

GROWING COMPLEXITY OF CHEMICALS TRANSPORTATION AND DISTRIBUTION

The **growing complexity of chemicals transportation and distribution** was requiring specialised knowledge and came at a cost. So an increasing number of chemical producers opted to outsource logistic services. Even oil companies with chemical businesses decided to concentrate on operating their own oil tanker and tank truck and trailer fleets but to contract out the transportation of their chemicals to independent hauliers. Certain logistics companies tended to cover a relatively wide range of chemicals and transport modes. But then many of them focused on specific types of chemicals, especially those needing expertise to ensure they were handled safely and efficiently.

As **international trade in chemicals expanded**, there were opportunities for freight forwarders to organise for petrochemical producers shipments from the plant to the final marketplace. The management of newly formed international supply chains was made easier by advances in communications both in terms of travel and in terms of transmission of messages and documentation.

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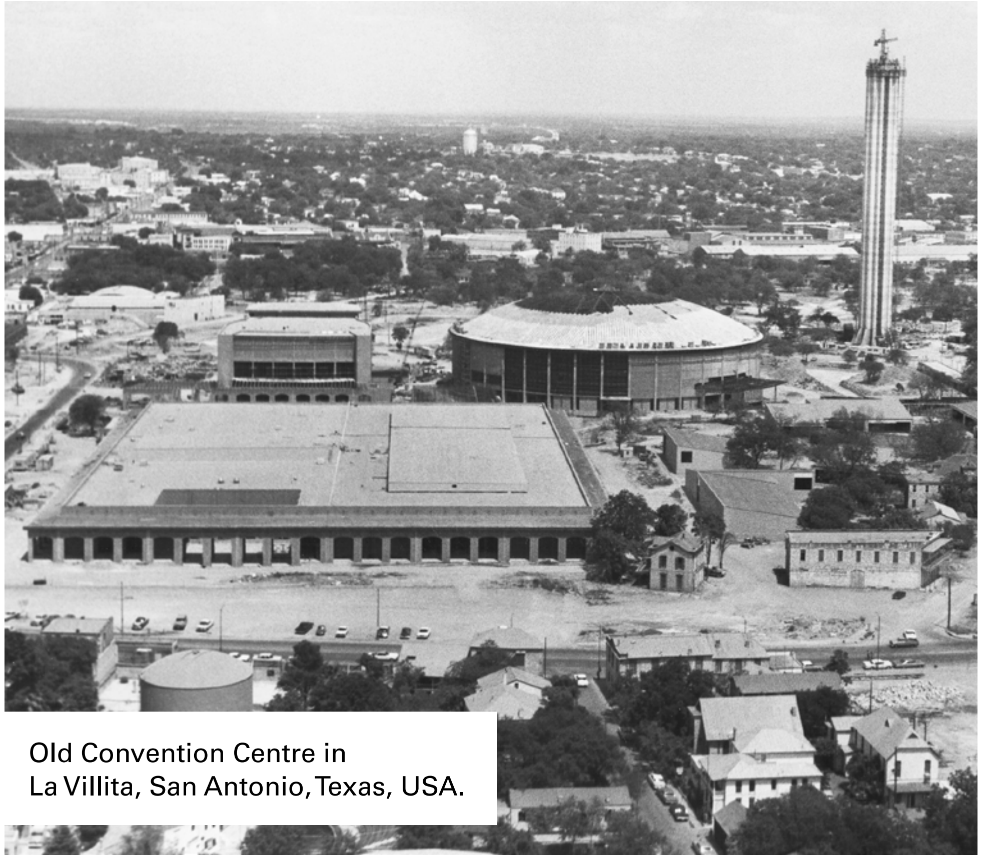

Old Convention Centre in
La Villita, San Antonio, Texas, USA.

THE BEGINNING OF EPCA

It is 1967, one year before the summer of love in California and the student upheavals in Paris, two years before Neil Armstrong takes that **historic first step on the moon**. The annual meeting of the US's venerable National Petroleum Refiners Association (NPRA), whose roots date back to the year 1902, is underway and in full swing at the old Convention Centre in La Villita, San Antonio, Texas. After a fulsome dinner a small group of European petrochemical executives (Richard Kuhn of BASF, Dewey Mark of Tenneco, Fred Plesman of Carbonit and Eric Yates of Monsanto) meet in a reflective mood. They contemplate the fact that excellent as they are, these NPRA meetings focus primarily on the concerns of refineries and not the petrochemical industry. In terms of industry size, this is to be expected; after all you can't have the tail wagging the dog. The discussion moves on to address the fact that the NPRA meeting, despite its global overtones, mainly deals with issues affecting the US industry, again to be expected. Yes, there is a place at the NPRA for the global petrochemical family to meet — but is this enough?

As the evening wears on a glimmer of an idea comes into focus. Isn't what is needed a particularly **unique meeting focused specifically on the petrochemical industry?** Would not Europe be an appropriate region to set that up? Those sitting around the table all nod enthusiastically; and it is in that moment that the seed of a distinctive petrochemical industry association based in Europe was sown. Before calling it a night the group agreed to meet once they were all back in Europe, in order to take this intriguing idea forward.

THE BIRTH OF EPCA

The scene shifts to Paris. It's the 9th of June, 1967, and in a meeting room of the Hotel Royal Monceau, the initial group are joined by Robert Lavoir of Antar, Huw Williams of ICI, Mario Tepsich of Ftalital and Robert Boulitrop of Elf. After a lengthy debate, this group agrees that they will provide a forum where petrochemical people could meet, hold a meeting in October 1967 in the French town of Deauville, and use that occasion to launch "The European Petrochemical Association".

Hardly four months after that fateful decision 217 delegates attended the first EPCA meeting in Deauville, France, at the Hotel Le Normandy from the 1st to the 3rd of October, 1967. The organisers had originally only expected 70 to 80 delegates to attend this **launch meeting of EPCA**. The representation at this meeting included nearly all of the major companies involved in the production of petrochemicals plus many of the service groups to the petrochemical industry. One of the founders of EPCA attending that first meeting later said that he 'had never seen so many decisions made in such a short period of time'.

Eric Yates, one of the founding fathers of EPCA delivered the keynote address at this initial meeting. He outlined some of the aims of the proposed association as follows:

"From its basic origin as a satellite of the petroleum, coal and chemical industry petrochemicals has emerged as an industry of its own. Petrochemicals, as an industry, is now only in its second decade. Its growth has been phenomenal in the 1960s and the forecasts for the future are such that we can still look at the industry as an infant.

Growth of this magnitude and the problems arising from such growth are now becoming apparent. Some of the specific problems can be identified. There is the problem of the recognition of the fact that petrochemicals is a distinct and unique industry, there is the problem of communication within the industry as well as communication with those outside the industry, and there is the problem of industry representation and posture before the rest of the business world. The scope of these business problems is such that it is the industry's responsibility to endeavour to find solutions. This, we suggest, is best accomplished by a truly petrochemical industry organisation.

The conclusion of the meeting was that there was a strong desire to form EPCA on a formal basis to provide, amongst other areas of activity, a **forum where petrochemical industry people could meet** and discuss common issues or concerns. The meeting included representatives of Logistics Service Provider companies, and from the start, EPCA has recognised the importance of the logistics segment in achieving business success.

Following the consensus view at the Deauville Meeting, work proceeded during 1968, and involved the drafting of the Articles of Association under Belgian law and consultation with a wide range of companies to ensure that the proposed Articles were acceptable to both European and American companies

Hotel Le Normandy, Deauville, France in 1950.

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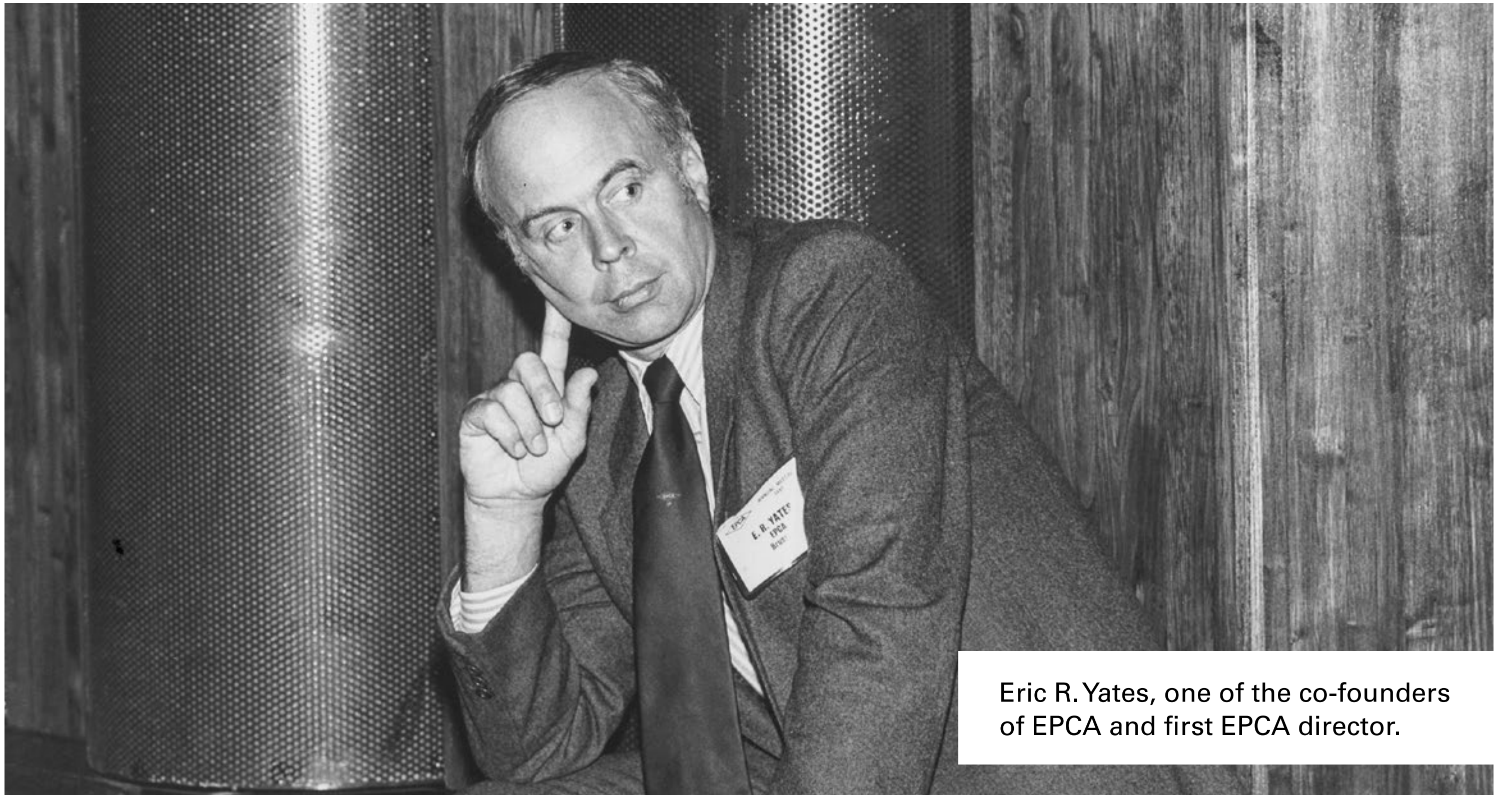

Eric R. Yates, one of the co-founders of EPCA and first EPCA director.

active in Europe. By the end of 1968, the Articles had been drafted, agreed by companies and accepted by the Belgian authorities. On December 27, 1968 the Articles were signed by the King of the Belgians, and EPCA became a formally established Association.

The EPCA Articles of Association indicate that EPCA has as its objective to provide for an efficient means of communication aiming at the **exchange of opinions and experiences** and the realisation of comparative studies in the scope of the petrochemical industry.

It is perhaps worth noting here that EPCA has always been, since its conception, financed by modest membership fees paid by member companies and by income from meetings and has never sought extraordinary financing. It was also clear that any representative or spokesman role for the Association could cause difficulties for national federations (when EPCA was founded, the European Chemical Industry Council (Cefic) in its present role did not exist), and it was therefore decided in 1969 and written in the bye-laws that EPCA would not have a representative role. This has been confirmed several times up to today.

The successful Deauville meeting set the scene for EPCA as a "platform" via the organisation of annual meetings allowing for networking and exchange of information. Following the original successful meeting in Deauville, meetings were held in Knokke, Belgium in 1968 with 290 present and in Wiesbaden, Germany in 1969 with 350 people present, each time with increasing attendance.

The **social elements of EPCA meetings have always been part of the winning cocktail** of what EPCA has been about. The social sessions such as events (tennis, golf, fun run, later to also include sailing), opening cocktail events, Committee luncheons and gala dinners offer ample opportunities for networking and informal conversations, both about the topics under discussion in the formal session and also around individual business discussions and deals.

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CHAPTER 3

OIL PRICE SHOCKS, EMERGING ECONOMIES AND ENVIRONMENTAL REGULATIONS

THE 1970s AND THE 1980s

MARKET TURBULENCE AND INDUSTRY REORGANISATION

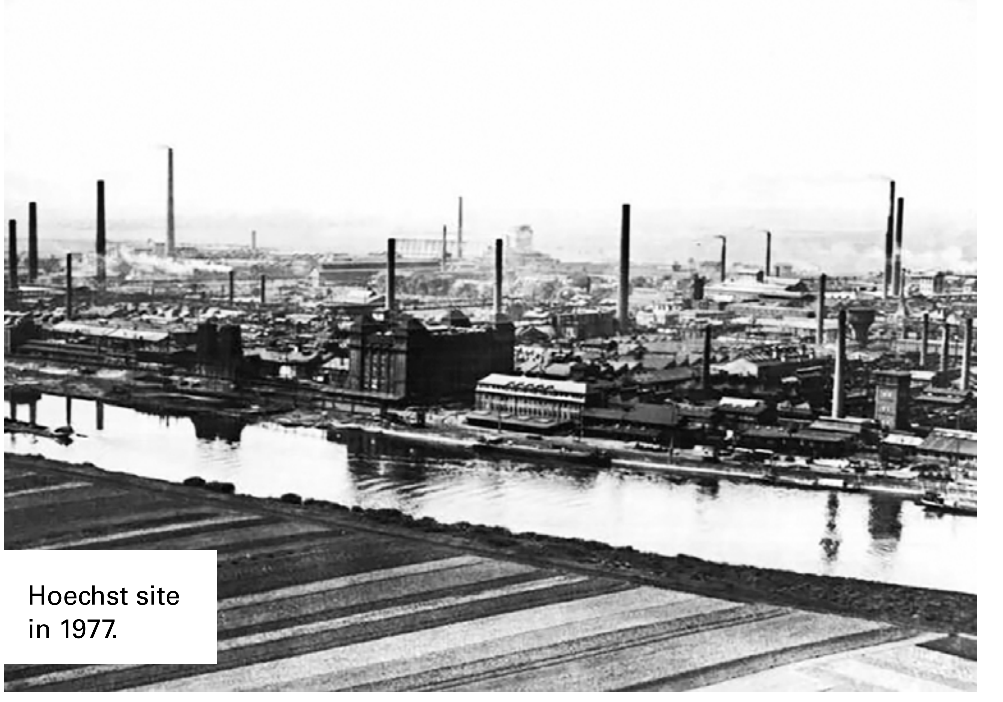
OIL PRICE SHOCKS

By the early 1970s some petrochemical producers in North America and Europe were almost convinced that the era of buoyant demand and relative economic stability would never end. But this optimism was battered by the effects of an Arab oil embargo in protest against US support for Israel in the Yom Kippur war. The Organization of the Petroleum Exporting Countries (OPEC), which after being formed in 1960 accounted for a third of world energy production by 1970, then first started to show its strength as a cartel. The result was **a steep rise in the oil price** from around $3 to $20 per barrel within a few weeks in October 1973.

At the time of the overthrow of the Shah in Iran in 1978/79 followed by the Iran-Iraq war in the 1980s which led to production cuts in two major oil exporting nations, the oil price had shot up again to $30 per barrel, a tenfold increase in seven years. The two shocks had a devastating impact on the economies of both developed and developing countries with a big drop in economic growth, high inflation and high interest rates. The underlying certainties of the last two decades of high economic growth and continuous strong demand disappeared. For petrochemical businesses, the dramatic change required new approaches and strategies.

Most petrochemical companies managed to go through the first bout of oil price increases without any severe damage to their level of sales or profitability. This was mainly because the first reaction of their customers was to raise their inventories in the expectation that the oil prices might go up to even higher levels. So, demand among converters and chemical industry customers went up. But trends further downstream among customers close to or providing products direct to consumer markets were indicating that difficult times lay ahead.

Soon lower consumer demand was beginning to impact manufacturing output. The economic outlook darkened as wages were squeezed and unemployment increased. Inflation also started rising. Even before the first oil price hikes, the industry was suffering from overcapacity due to a surge of investment in petrochemicals because of the optimism about future demand. With demand starting to weaken, the excess worsened.



Hoechst site in 1977.

Yet demand was strong enough to result in some petrochemical plants achieving above 90-percent utilisation rates. Petrochemicals output in Western Europe, although declining, remained well above the levels of overall industrial production. Consequently some producers were confident enough about the future to continue to invest in additional capacity. Yet at the same time they had to cut costs. This was a challenging task especially for those which had only recently switched

LyondellBasell polyolefins complex in Wesseling.

from coal to oil-derived feedstocks, which they had expected would give them more leeway with costs. One response was to reduce expenditure on research and development. Another was to make savings in logistics by stopping direct distribution to small volume customers. It was also a time when **companies had to decide what their core businesses were**. Some companies, particularly oil companies, focused more on base products by concentrating on their advantages in upstream integration. Others moved downstream by shifting their portfolios into added-value petrochemicals products. Some went further by investing in non-petrochemical speciality products. In Western Europe, in particular, petrochemical business focused more on forging closer links with their customers. This frequently involved **providing more technical and backup services**.

Price rises in the late 1970s which doubled the cost of crude oil had a much bigger impact on the petrochemical industry because they were not compensated for by higher demand from increases in inventories. The petrochemical industry now began to realise that volatile oil prices and fluctuating feedstock costs were becoming a permanent phenomenon which required radical adjustments in business strategies. The industry and its customer sector were being battered by an economic storm caused by a sharp global economic downturn and even higher inflation.

THE INDUSTRY REORGANISES ITSELF

Meanwhile the industry had to struggle with an even worse imbalance between supply and demand caused by excess capacity. Petrochemicals no longer enjoyed demand rates which put levels of output well above those of total industrial production. For the first time since the petrochemical revolution hit Western Europe in the early 1950s, petrochemicals production rates were around the same as overall industrial output. Western Europe also had to withstand the effects of overcapacity elsewhere. The US was exporting large amounts of excess polymers and man-made fibres. A substantial proportion of plants needed to be closed down, particularly among ethylene crackers and derivatives units. Some of them were, but from the view of the investors not enough of them. In newly liberalised financial markets financial institutions were exerting much more muscle and imposing new disciplines on manufacturing and other companies, often forcing them to take far reaching measures to improve profitability. The industry did try to reorganise itself, particularly through **mergers and acquisitions, joint ventures and portfolio swaps**.

In the European PVC sector, for example, BP moved its PVC interests to ICI, which in turn relinquished its polyethylene operations to BP. Later in 1985 ICI and Enichem of Italy merged all PVC activities into a single joint venture.

At one point such little progress was being made in closing uncompetitive plants that the industry, through Cefic, asked for help from the European Commission, the EU executive. The Commission and Cefic drew up a joint report recommending cutbacks based on volumes of output rather than low efficiencies. The report failed to gain enough support in the industry to be initiated.

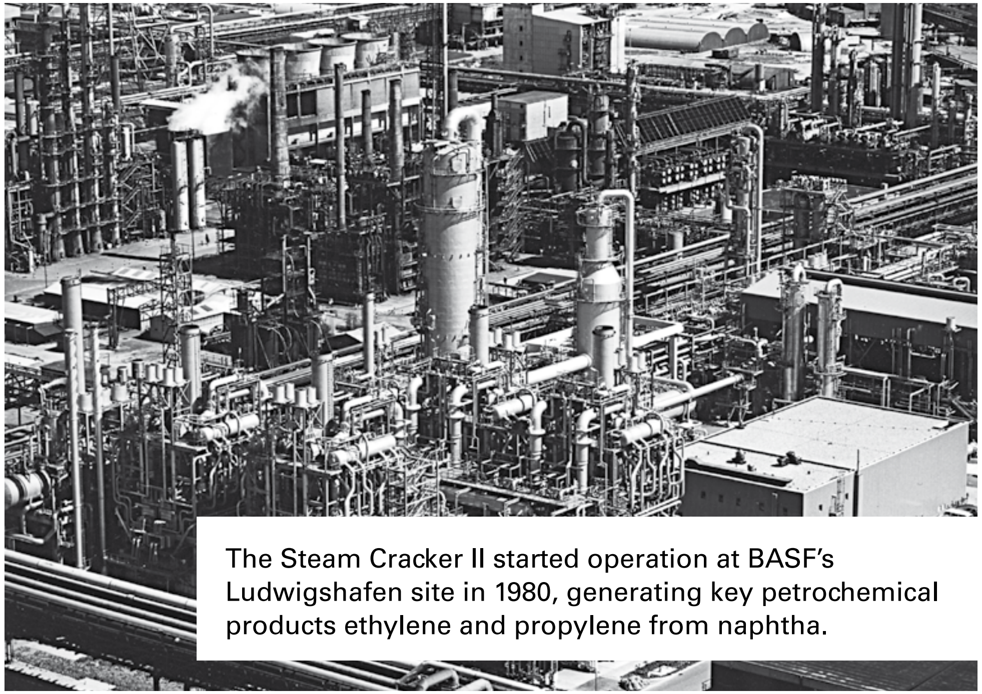
However there was more success with a rationalisation scheme to reduce excess capacity in man-made fibres, which was aided by a relaxation of competition rules by the European Commission. In polyester, both ICI, a pioneer in the development and commercialisation of the polymer, and Bayer withdrew from the sector with ICI instead concentrating on nylon and Bayer on acrylic.

In France the government intervened to help the chemical sector. Rhône-Poulenc, whose petrochemicals operations were mainly in bulk polymers and synthetic fibres, had to divest its commodity chemicals assets mostly to the state-owned Elf oil company with the objective of forming an operation which could compete internationally. Then in 1982 Rhône-Poulenc was itself nationalised after it recorded losses.

In the mature markets of the US and Western Europe the pressure to restructure began to ease considerably in the mid-1980s as oil prices declined steeply. Feedstocks became cheaper and demand picked up again. **Investment in new capacity rose**. Inevitably the issue of intensifying global competition and excess capacity would soon, however, return.

EMERGING ECONOMIES ENTER THE PETROCHEMICAL MAP

As the economies of the developed world — North America, Western Europe and Japan — were being hit by stagflation, the spread of petrochemicals production accelerated across the developing world. The oil producing countries were the pacesetters because of their plentiful oil-based feedstocks and abundant funds from rising oil revenues to allocate to petrochemical projects. Also they were able to attract investment money and vital technological support from US, Western European and Japanese petrochemical companies anxious at a time of high oil prices to gain access to cheap feedstocks. The most ambitious and fastest expanding of the new operators in petrochemicals were oil producers in the Middle East Gulf, who, with the exception of Iran, built plants mainly to export bulk polymers and intermediates, mainly to Asia. Since most of the petrochemical schemes were joint ventures with Western companies, the output of the plants was shared with their partners.



The Steam Cracker II started operation at BASF's Ludwigshafen site in 1980, generating key petrochemical products ethylene and propylene from naphtha.

In 1974 Saudi Arabia gained control of its main oil company, the US-owned Arabian American Oil Company (Aramco), which was renamed Saudi Aramco. After responsibility for petrochemicals was transferred from the oil ministry to a newly created industry and electricity ministry, the task of setting up the country's petrochemical industry was given to the majority state-owned Saudi Basic Industries Corporation (SABIC) founded in 1976.

The iconic "tower and bridge" at the Hoechst site in Frankfurt, Germany.

Within a few years SABIC was negotiating six joint venture projects with Shell, Dow, Exxon, Celanese and Texaco Eastern, Mobil and a Japanese consortium which were scheduled to come on stream in the early to mid-1980s in Jubail and Yanbu. By 1985 SABIC had a total output of 6.3 million tonnes.

For Middle East producers a large importer of their petrochemicals was China which from 1979 gradually switched to market principles and opened the country to foreign investment. China endeavoured to offset rising chemical imports by the production of its own petrochemicals and other chemicals. By the mid-1980s chemicals were accounting for 5 percent of its exports. By 1990 it had a total ethylene capacity of nearly 2 million tonnes, the largest in Asia outside of Japan.

Singapore was another country in Asia, although virtually a city state, to move quickly into petrochemicals to take advantage of its position as a hub for oil and downstream products in the region. Also it was able to exploit the feedstocks from several refineries on the island, which ranked it as the world's third largest refining centre after Houston and Rotterdam.

Petroleum Corporation of Singapore (PCS), a petrochemicals complex whose leading owners were Shell and a Japanese consortium led by Sumitomo Chemical, opened a 300,000 tonne-a-year cracker in 1984 for the production of a range of derivatives which were mainly exported to elsewhere in Southeast Asia.

In Latin America private enterprises, often backed by foreign investment, had instigated many of the region's first petrochemical projects. In the 1970s Latin American governments started to extend their reach into petrochemicals. In Mexico, Chile and Argentina production of base petrochemicals was reserved for state-owned schemes.

NEW CATALYSTS FOR CUSTOMISED PRODUCTS

The main focus in R&D was on the development of improved polyolefins. These were still the main product category in petrochemicals in terms of sales and profitability. A **major breakthrough** came in the late 1970s with the development of linear low-density polyethylene (LLDPE). In order to satisfy the relentless need to cut costs, the trend was towards the building of larger plants — crackers and polyethylene and polypropylene units.

TOWARDS A GREATER ENVIRONMENTAL AWARENESS

Together with the financial pressures of

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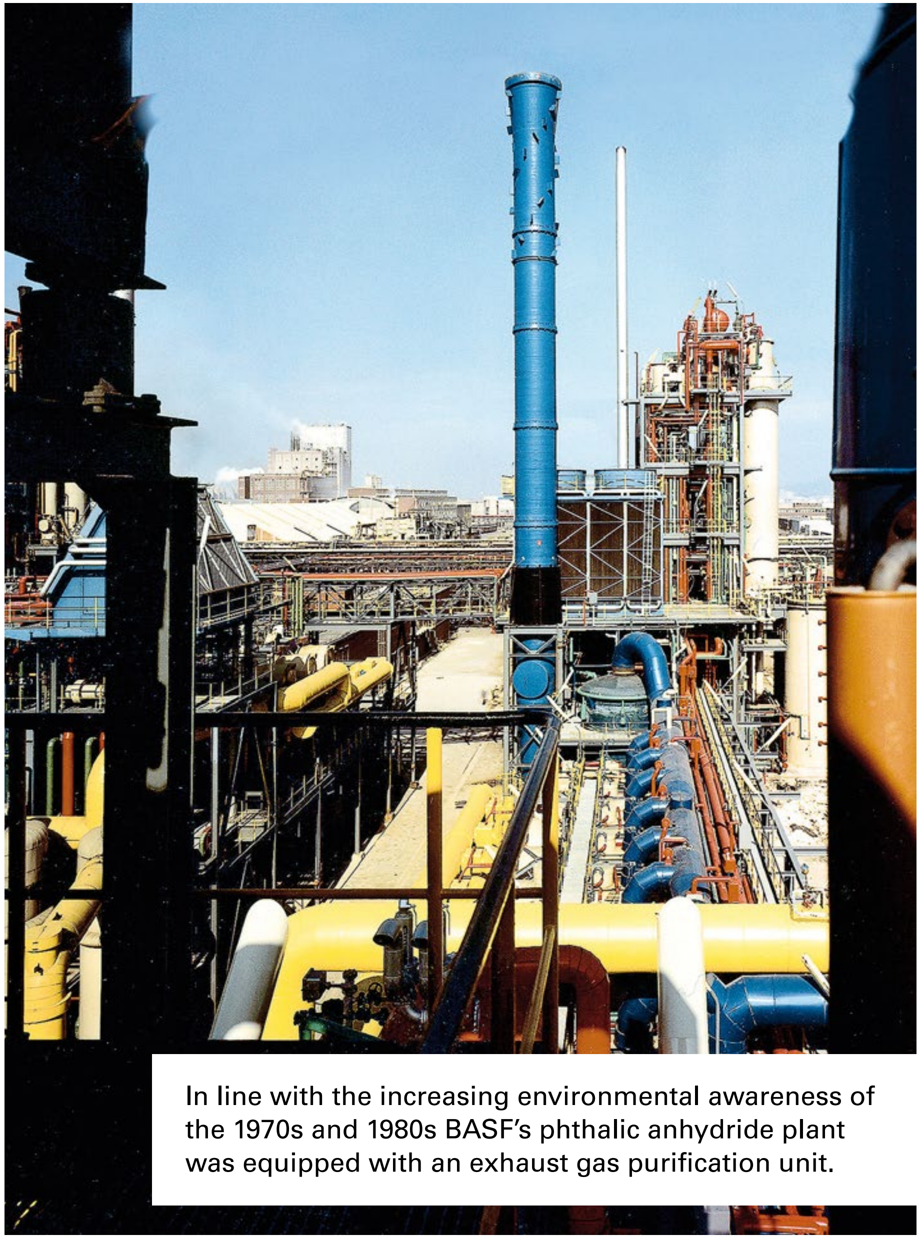
the economic turbulence of the 1970s and 1980s, petrochemical producers had to contend with the imposition of much tougher environmental regulations. In some cases these were prompted by the need for governments to take action in response to a growing public awareness about the importance of environmental protection. This led to the creation of political groups like the Greens in Europe and highly active environmental non-governmental organisations (NGOs) across much of the industrialised world. In 1983 the Green Party entered the German parliament (Bundestag) for the first time. Germany as a result took on a leadership role in environmental policy in Europe, similar to the position of California in the US.
In addition to pressure from economic downturns triggered by oil price increases, petrochemical producers had to more and more comply with environmental regulations, initially developed in North America, Western Europe and Japan. The driving force behind a series of regulations was a number of accidents and disasters involving chemicals from the mid-1970s to the mid-1980s. The industry took into account **the general public's expectations** and was willing to actively implement measures in order to avoid accidents and to adopt new regulations.

THE LAUNCH OF RESPONSIBLE CARE

The proliferation of regulations on both sides of the Atlantic prompted the chemical industry to be more pro-active in anticipating legislation and in reinvigorating the concept of self-regulation, particularly since the chemicals sector was now suffering from a dismal public image regarding protection of the environment and human health.
Regulatory compliance was being seen by many petrochemical companies as not being sufficient. Keeping ahead of possible legislation became part of their competitive strategy. It improved not only their reputation but also profitability because the development of new **safer technologies and processes**, for example, also led to greater production efficiencies.
A major boost to the chemical industry's image came with the introduction of Responsible Care, a self-regulatory programme initiated by the Canadian chemical industry in 1985. Its objective was to promote codes in areas like the safety of communities near chemical plants, pollution prevention, distribution



In line with the increasing environmental awareness of the 1970s and 1980s BASF's phthalic anhydride plant was equipped with an exhaust gas purification unit.

and process safety, employees' health and safety and product stewardship. Responsible Care was soon adopted as a condition of membership of chemical trade associations in the US and across Western Europe and eventually was being embraced by chemical industry organisations across the world. It became a big contributor to a gradual improvement in the image of the industry globally and is now a crucial part of the chemical industry's DNA.

ECONOMIC TURBULENCE SQUEEZES RESEARCH AND DEVELOPMENT FUNDS

In the 1970s the petrochemical sector entered a period in which there were few **big R&D breakthroughs** in the development of new products and processes. In the midst of the economic uncertainties triggered by the two oil shocks, research budgets were a victim of the priority given to saving money and cutting costs. Also most of the major technological advances based on the manufacture of petrochemicals from petroleum feedstocks had already been achieved.

Linear low-density polyethylene (LLDPE) — the last of the new major bulk polymers — was discovered by Union Carbide in the US in the late 1970s and commercialised in the mid-80s, as a stronger, more versatile and above all lower cost version of LDPE. Union Carbide opted for a licensing strategy for its Unipol LLDPE technology so that the new polymer became available relatively quickly throughout the world.

At a time of narrowing margins, the **efforts of researchers** were focused mainly on making improvements to processes to reduce energy consumption, increase yields, raise feedstock efficiencies, and find other ways of cutting costs.

Despite the poor economic conditions, additional petrochemicals capacity was continuing to be built, albeit at a slower rate. A major impetus was coming from **continued strong demand**. Even in the relatively mature market of Western Europe ethylene consumption tripled between 1970 and 1985. In the 1970s world output of non-cellulosic fibres also tripled.

With new plants, the emphasis was on increasing the size of the units to make them far more economical. The advances made previously in plant components and equipment and in flowsheets provided a basis for the design of much larger facilities, with some reaching annual capacities of 500,000 tons or even bigger. By 1975 a newly designed 200,000 ton-a-year facility had a manufacturing cost which was per ton two thirds cheaper than a much smaller unit in 1955.

The larger the plant the more 'shut-down' economics applied — in other words a new advanced process would not have sufficient economic benefits to justify closing big units which already had major advantages of scale.

PROCESS INNOVATIONS DESPITE TIGHT R&D BUDGETS

As a result, research teams found it increasingly difficult to obtain board backing for R&D projects into new processes. Nonetheless there were **a number of key process innovations** such as the development of ethylene oxychlorination for the processing of hydrogen chloride in the making of vinyl chloride and the production of acrylonitrile via fluid-bed oxidation of propylene.

Other process innovations were based on the modification of old knowledge to achieve new results. The Shell higher olefins process (SHOP) which was adopted throughout the world for the processing of alpha-olefins mainly for the production of surfactants involved the combination of four reactions, each of which was already known, at least as a concept.

Metathesis, a technology for interchanging olefins, was revived in the 1980s as a reverse process to react ethylene and 2-butene to make scarce propylene. The technology was discovered in World War II but only to convert what was then cheap propylene into ethylene. In 1984 Lyondell of the US built a unit to produce propylene in this way, with 2-butene being derived from ethylene so the whole process was actually ethylene based.

Processes were also being developed and whose significance was not fully realised at the time. Mobil Chemical, for example, developed aluminosilicate zeolite (ZSM) catalysts which it first used to make gasoline from methanol in New Zealand. This technique for converting methanol into hydrocarbons eventually led to the development of methanol–to-olefins (MTO) technologies. Aluminosilicate zeolite noble and non-noble catalysts are now also used in styrene production, other aromatics processing, catalytic dewaxing and other applications.

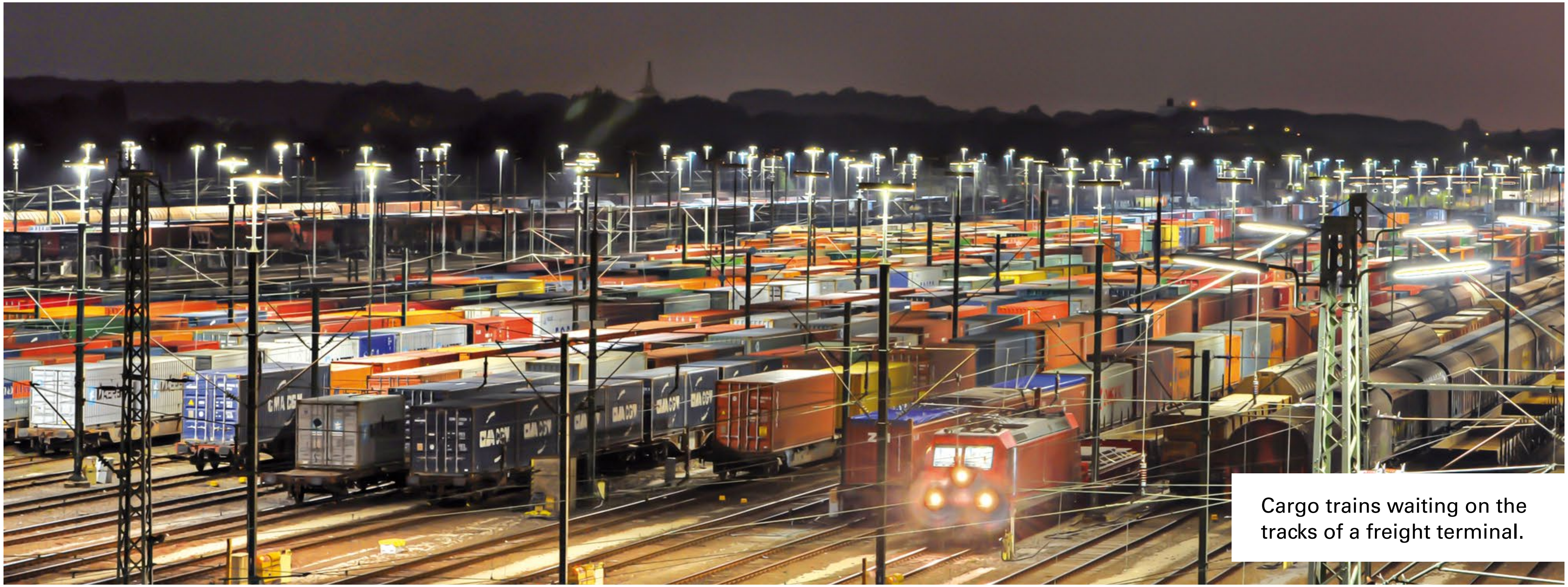
LOGISTICS BECOMES MORE SPECIALISED

The two oil shocks in the 1970s made business difficult for logistics companies in the chemicals sector. They had to cope with steep rises in fuel costs, high inflation and fluctuating demand for their services among both petrochemical producers and users. On the other hand they were able to benefit from **acceleration in outsourcing of logistics**. For producers, contracting out transportation services was a way of reducing their own costs. Also, it released them from the burden of having to invest in the improvements to the technologies and organisation of transport, storage and communications systems in the logistics chain.

One of the reasons for the need for these improvements was that safety and environmental regulations, introduced mainly in response to accidents, were starting to put pressure on the logistics sector. New regulations had a particularly strong impact on the shipping industry. In the early 1970s the United Nations' Inter-governmental Maritime Consultative Organization (IMCO), whose name was changed to International Maritime Organization (IMO) in 1982, introduced rules for the construction and equipment of ships carrying dangerous chemicals in bulk. The rules, which divided chemical carriers into three categories according to the degree of hazard of their cargoes, were extended to all chemical carriers in operation in the late 1970s. **Ships were inspected regularly** (e.g. by CDI Marine) to ensure they were complying with the obligatory standards which in addition to equipment also applied to the competence of crews.

Parcel tankers were developed further to provide safe transportation of chemicals and other bulk liquids.

The new parcel tankers segment was quick to invest in new ships and equipment because it provided an opportunity to take a majority share in the chemical tanker market. Because of a reluctance to invest in transportation, the tonnage of tankers owned by chemical producers steadily achieved an average age which made them uncompetitive with independent tanker operators. However, the result was a high level of concentration in the



Cargo trains waiting on the tracks of a freight terminal.

sector, which despite anti-trust court action in the US continues to the present day. In the mid-1970s the three main players were meanwhile US-headquartered Stolt-Nielsen, Norway-based Odfjell and UK-located Panocean, an Anglo-Norwegian joint venture. Despite low freight rates, all had been **investing in new up-to-date capacity**.

However, Panocean, which had become financially stretched as a result of takeovers and the buildings of new ships, halted any further investments while the other two continued to put money into new designs and technologies. In fact Stolt-Nielsen was so short of money that it had to borrow $50 million from British Petroleum (BP) in return for a share option in the shipping company.

After Panocean with its out-of-date fleet was unable to benefit from a shortage of tonnage after some tanker owners failed to meet the new IMCO rules, two major shareholders in Panocean, P&O shipping line and the UK sugar group Tate & Lyle, decided to pull out of the parcel tanker sector. In late 1982 Panocean agreed to merge its fleet with Stolt-Nielsen. But by 1986 Panocean had effectively withdrawn from the tanker market altogether to focus on its business in bulk liquids terminals. Stolt-Nielsen and Odfjell were left as the two leaders of the parcel tanker sector. But they became three when Odfjell was split between two branches of the Odfjell family with one setting up Jo Tankers to become the third leading player in the deep-sea parcel tanker market. Fast forward: In July 2016, Stolt-Nielsen announced to acquire Jo Tankers for $575 million.

The demise of Panocean caused by reluctance to invest in modernisation of assets was also one which threatened companies in other logistical sectors. In times of tight margins stemming from low average growth in sales, petrochemical shippers wanted to use logistical providers which were able to offer greater efficiency but at a lower cost.

LOGISTICS COMPANIES EXPAND INTO SERVICE AREAS

In the US rail tank car sector the leaders were **investing heavily in innovative rolling stock** designed to meet the needs of specific groups of customers. In both North America and Europe, operators of tank trucks, trailers and containers were offering more sophisticated equipment, often after merging with competitors. In Europe the haulage market started to fragment between large contractors and smaller operators who often acted as sub-contractors serving local markets.

But at the same time there were **opportunities in niche segments** and in providing a wider range of services. The logistics umbrella increased considerably in size to cover a wide range of activities — such as demand forecasting, packaging, labelling, blending, preparing mixtures, documentation flows, and customer management services.

Foreign markets were also providing another opening. There could be big difficulties, however, in dealing with low-standard infrastructure in the emerging economies which were endeavouring to create economic structures for the export and import of both petrochemicals and petrochemical derivatives.

Most had insufficient roads and bridges, sub-standard rail networks and inadequate port facilities. A US government survey of China's transportation system in the mid-1980s reported an inadequate road and rail network which could not meet the supply and distribution needs of the country's ports. There was also a lack of vehicles able to handle large loads, particularly of bulk liquids. China's rail operations had a shortage of freight rolling stock.

Even in the Middle East ports became quickly congested as transportation infrastructure failed to keep pace with the expansion of petrochemicals production capacity. There was a limited road network in the Arab countries in the Gulf and virtually no railways. ■

"EPCA'S HISTORY IS THE STORY OF A PASSIONATE JOURNEY."

THE STATE OF THE INDUSTRY

In 1970, the EPCA Meeting was held in Venice for the first time, and the Italian lagoon city that is famous for its canals and bridges was to become EPCA's prime "home" for a number of years.
The inimitable ICI Senior Executive John Harvey Jones, concluded his remarks during this Meeting with the statement: "I think there will be a shake-out in the petrochemical business, the like of which we have never seen before, and it really will be the mating of dinosaurs: it will be heard all over the world, and at the end of the day I think we will have a worse industry than we have now".
The first Venice meeting attracted close to 500 delegates and, for the first time, there was an indication of pressure if numbers increased, something that had been a dominating theme and a sign of EPCA's success until the end of the 1990s. It was becoming clear that the number of venues in Europe that could offer the space and the quality required was limited and it was not possible to rotate around all the major European countries. Therefore, in 1971, **the concept of the "host country" was developed** and implemented. In holding meetings in a limited number of venues, a different country would act as host to project an image of their culture and business approach. So, at the 1971 meeting, held in Venice for the second time, Great Britain was the first recorded host country. The 1972 meeting, for the first time in Monaco, was followed by two more years in Venice. EPCA had truly arrived as a significant business meeting on the petrochemical companies' calendar. For the following years and through the 1980s, Venice and Monaco would be EPCA's favourite venues for holding the Annual Meeting.

NEW CHALLENGES, ACTING RESPONSIBLY

As the 1980s drew to a close the issue of **environmental protection and responsibility** noticeably grabbed the attention of European societies, which was reflected in the rise of Green Parties, throughout the continent. Never one to be left behind EPCA recognised the importance of this debate to the petrochemical industry in general and to its members particularly, hence the 23rd EPCA Annual Meeting was held in Monte Carlo, at the end of September 1989 under the theme 'The Petrochemical Industry and the Environment'.

EPCA Annual Meetings have since their beginning been information and networking events.

The conclusion was that "safe and environmentally compatible production will be as decisive as equally environmental-friendly application and disposal. The environmental impact of a product throughout its full life cycle will become a factor in completion".
In addition to the Annual Meetings, in the 1980s EPCA held seminars on a wide range of topics, amongst others "Reducing Uncertainty (Information)" in Cannes in February 1989.

Speakers and committee dinner at the EPCA Distribution Meeting 1982.

THE BIRTH OF EPCA DISTRIBUTION

By 1974 it was clear that the logistics and distribution sections of the European petrochemical industry needed their own distinctive forum. A growing desire from the petrochemicals logistics sector to have a meeting which dealt specifically with distribution issues, plus the increasing pressure on numbers and space at the EPCA Annual Meeting, came together to create the environment for a specific EPCA Distribution Meeting.

In what has become a hallmark of the Association over the years EPCA leaders had the sensitivity and flexibility to organise **the first EPCA Distribution Annual Meeting** in Venice, in October 1974, approximately a month after the EPCA Annual Meeting, which also took place in Venice.

This timing gap of about one month remained a part of the petrochemical industry's calendar until 2006, when the two meetings would finally be merged into one.

That first EPCA Distribution Meeting dealt with crucial issues of the day, while showing the foresight to look ahead and grapple with key themes of the future. It focused on growing concerns regarding maritime safety and pollution regulations and the response of the different sectors of the petrochemical distribution supply chain to these issues. Many of the themes and debates tackled at this inaugural EPCA Distribution Meeting informed and fed the **sustainability and environmental agenda**, which would become a staple element of the petrochemical bulk distribution world in the years and decades to come.

COMMON SAFETY STANDARDS

From the outset delegates called on EPCA to broker a common set of safety standards that would be acceptable to both the producing and distributing arms of the petrochemical industry. Attendees alighted on a visual image of two arms working together, for the betterment of the industry as a whole. Corporate cultures, standardising safety language and different interpretations of safety regulations also came into focus.

There was a growing recognition that societal concerns regarding environmental issues can only rise rather than decrease in the coming years and so the petrochemical industry has to be seen to be acting responsibly.

On the 23rd of October 1974, D.R. Hunter of Cefic, commented, 'We don't conduct our business at the expense of safety', setting a tone which the EPCA Distribution Meeting would strive to uphold and promote in the coming years and decades.

STRAIGHT TALKING IN BRIGHTON

By the fourth EPCA Distribution Meeting, which took place in Brighton, England in 1977, EPCA showed a capacity to deftly respond to the demands of its members in offering both technical and detailed micro-industrial information while also addressing macro-societal issues, going beyond the direct production and distribution of petrochemical products to

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explore how the petrochemical industry is viewed in wider society.

The meeting agreed 'that the public image of chemical distribution can and must be improved'. It was also noted that the '**exceptional safety record of the industry** is practically unknown'. These sentiments expressed at this early EPCA Distribution Meeting sowed the seeds for what would become a massively proactive sustainability effort and a crucial part of the petrochemical distribution sector's contribution in Europe to **the development of Responsible Care**.

As a concluding statement in 1977 the EPCA General Committee Member F. J. Plesman said: 'The image of society and therefore the chemical industry, in my mind, is created within families, schools and universities. I feel there is a task for the industry to work in these areas.' This is what EPCA has actively taken up since and is continuing to this very day.

INCREASING TRAFFIC AND THE NEED FOR REGULATION

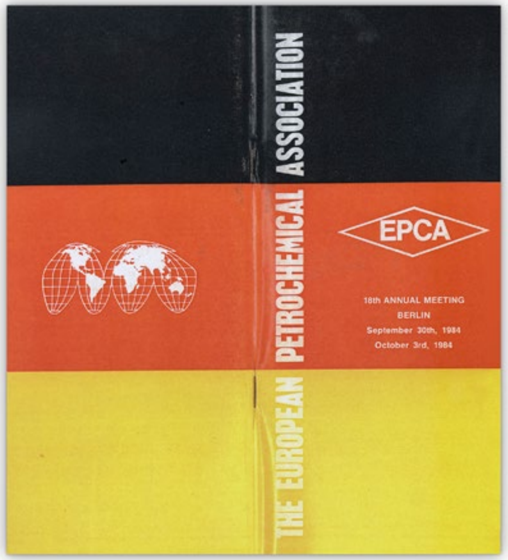
Meanwhile, in the early 1980s, the EPCA Distribution Meetings were dealing with the fact that the overall field of industrial product transport was reeling from a series of accidents and pollution incidents, such as the Torrey Canyon, the Amoco Cadiz, Flixborough and Seveso, being the most high profile incidents. Even though few of these incidents directly involved petrochemical distributors they still had an impact on how the sector was perceived. The EPCA Distribution Meeting was even more aware of its remit to provide a true, fair and balanced picture of its members' activities, in the teeth of this negative publicity.

The area of regulation continued to be a major concern for the EPCA Distribution Meeting, especially regarding the implementation of the MARPOL Convention, which came into force a couple of weeks before the 10th EPCA Distribution Meeting in October 1983.

The **rise in the volume of container traffic** was another key area, addressed by the EPCA Distribution community in the early 80s. In the 1984 Distribution Meeting it was noted that container traffic in the Port of Antwerp had grown from 2.3 million tonnes in 1972 to reach 7.3 million tonnes by 1982, which had significant consequences for the petrochemical distribution sector.

EPCA SETTLES INTO OFFICE

Until 1974, EPCA was organised by a group of willing volunteers working for major companies and prepared to



Cover of the Berlin 1984 EPCA Annual Meeting programme and a drawing of a tin of sardines with the EPCA logo.

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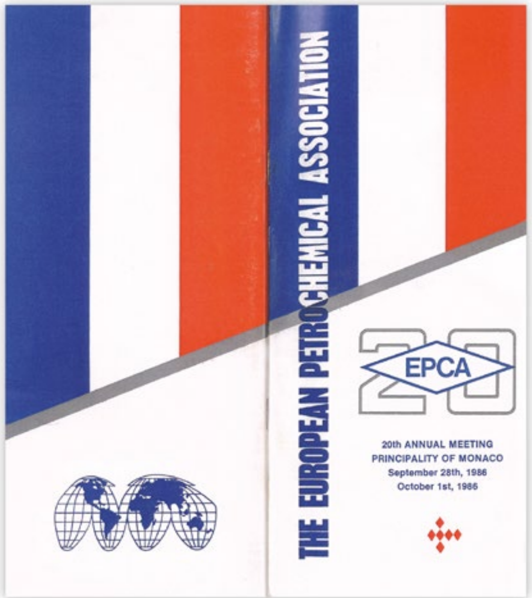

Cover of the 20th EPCA Annual Meeting programme 1986.

Fairmont Monte Carlo.

devote some of their company's (and much of their own) time to making EPCA happen. With the start of the Distribution Meeting and initiatives being taken in a number of other areas, it was becoming necessary to put the organisation on a professional basis.

In 1974, Eric Yates, who had worked in the petrochemical industry since 1956 with ICI at Wilton and in Frankfurt, and with Monsanto in Brussels, was appointed permanent Director, a post he held until 1998, and an office opened in Brussels.

In 1976, EPCA bye-laws were voted upon by the Ordinary General Meeting completing the EPCA Articles of Association. These bye-laws excluded EPCA from representing the petrochemical industry to third parties, making declarations binding the industry or expressing the opinion of the industry. They also provided for the formation of an Executive Committee as well as sub-committees. The **Distribution Committee, later called the Logistics Committee**, was established in that connection from 1974 on to propose programs and speakers for the EPCA Distribution Meetings and propose to the General Committee projects of interest to the chemical industry in the distribution segment. This Committee would prove to be very active over the years.

Since EPCA has, as members, all major producers and most of the major service groups to the industry, it was well placed to develop **a range of ideas** of benefit to the industry, but which did not conflict with the fact that EPCA could not represent the industry.

EPCA, with its conceptual origin in San Antonio, has always had close and friendly links with NPRA. To ensure close collaboration, the EPCA Director sits ex-officio on the NPRA Petrochemical Committee and the NPRA President sits on the EPCA General Committee.

With the Latin-American Petrochemical Association (APLA) being formed in 1976, a similar relationship was established and the EPCA Director sits on the APLA Executive Committee, and the APLA Secretary General is an ex-officio member of the EPCA General Committee.

Also, shortly after Cefic was formed in 1972, the Cefic Director General was invited to sit ex-officio on the EPCA General Committee, a practice that has continued to the present day with mutual benefit.

In 1975, EPCA commissioned a major study on price reporting in the petrochemical industry. In the introduction to the study, the consultants performing the study, Commodities Research Unit, said that "The Petrochemical Industry is the only

Brazilian football legend Pelè accepting a charity donation for children of Brazil given by S.A.S. Prince Albert II of Monaco.

Group picture of players participating in an EPCA tennis tournament.

Participants preparing for an EPCA fun run.

major raw material supplying industry that does not have a regular price reporting system." Since that time of course major price reporting systems have been set up and are widely used by the industry. EPCA can perhaps take a little credit for initiating a major discussion on the subject.

At the 1972 Annual Meeting in Monaco, a team led by John Tholen of ICI launched a proposal for a benzene futures market, and the presentation was the only time that there was standing room only at an EPCA Meeting. The proposal was not taken up by the industry, but the debate it started clarified much thinking in the industry on the subject.

The Chemical Cargo Inspection Association, a sub-association of EPCA, was formed in 1986 to provide a forum for discussion for inspection companies, and to work towards standardisation of inspection procedures.

EPCA PRESIDENTS

1970 – 1973
E. R. YATES
MONSANTO
Belgium

1973 – 1975
B. VERKAAIK
N.V.C.P.
The Netherlands

1975 – 1977
C. CAPITANI
ANIC
Italy

1977 – 1980
R. ROSE
RHÔNE-POULENC
France

1980 – 1982
M. E. ROBINSON
ICI
United Kingdom

1982 – 1984
J. T. QUANT
SHELL
The Netherlands

1984 – 1987
C. PAYA
ENFERSA/HISPANOIL
Spain

1987 – 1989
H. BJØNTEGÅRD
DYNO INDUSTRIER
Norway

EPCA VICE-PRESIDENTS

1975 – 1978
T. D. OVERTON
BP CHEMICALS
United Kingdom

1978 – 1981
G. VAN DER SCHUEREN
PETROCHIM
Belgium

1981 – 1982
H. U. FINTELMANN
HOECHST AG
Germany

1982 – 1984
C. PAYÁ
ENFERSA
Spain

1984 – 1987
H. BJØNTEGÅRD
DYNO INDUSTRIER
Norway

1987 – 1989
G. PORTA
MONTEDISON
Italy

EPCA TREASURERS

1970 – 1977
F. J. PLESMAN
CARBONIT
The Netherlands

1977 – 1980
A. J. METZLAR
NIEUWE MATEX
The Netherlands

1980 – 1983
M. J. COOPER
PANOCEAN-ANCO
United Kingdom

1983 – 1985
J. C. VERCHIN
ATOCHEM
France

1985 – 1988
T. LINAAE
STOLT NIELSEN SHIPPING
Norway

1988 – 1989
C. BOSMAN
CHEMGAS
The Netherlands

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CHAPTER 4

GLOBALISATION TRANSFORMS THE INDUSTRY

1990 TO 2009

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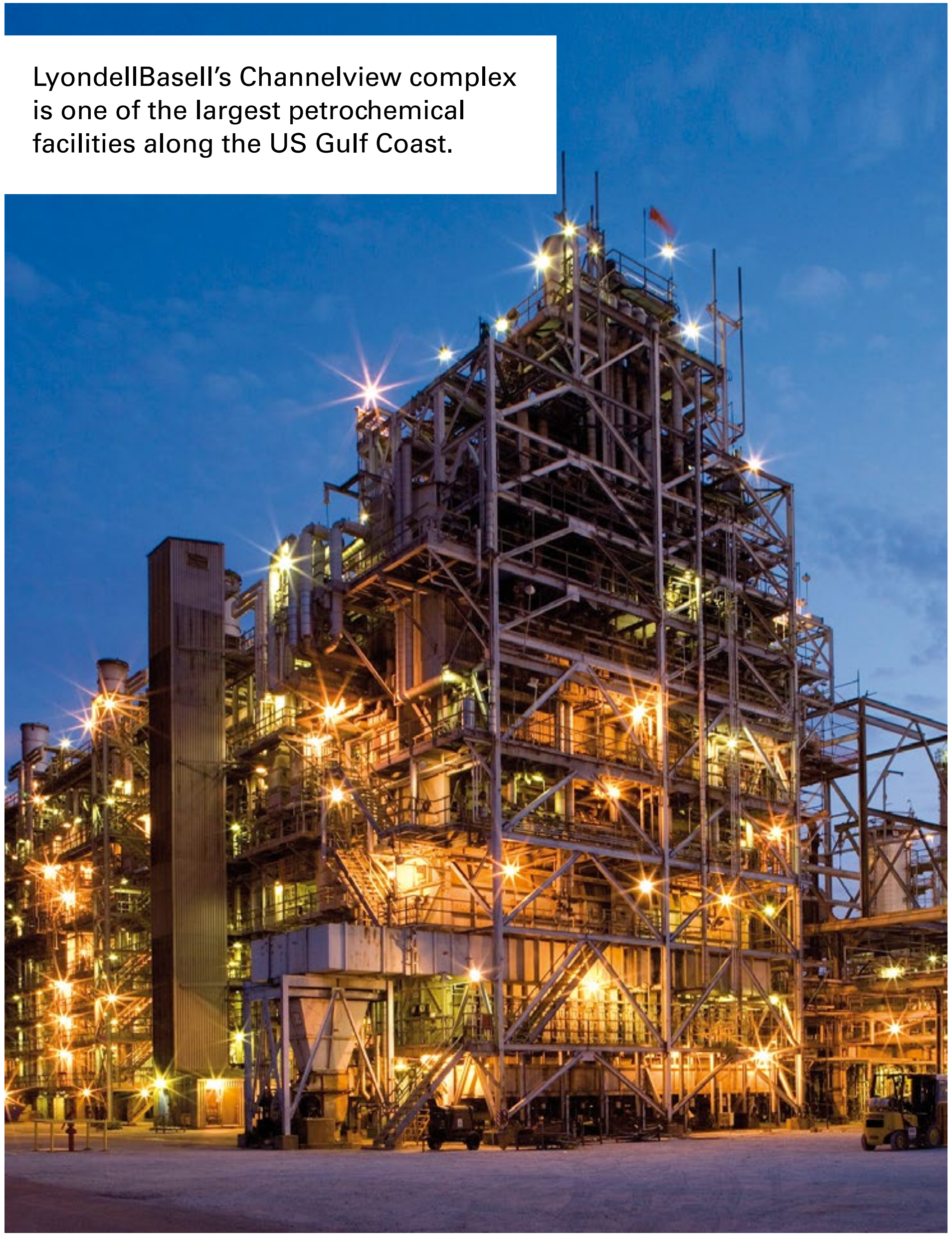
PETROCHEMICALS GROWTH IS BEING SPARKED

Globalisation was not a new phenomenon. In fact historians see it as a trend which has been repeated throughout the world's economic history. It tends to come in cycles. The globalisation which started in the second half of the 20th century is regarded as being a process which returned the world to the global economic integration which was interrupted by World War I, the depression and trade protectionism of the 1920s and 1930s and then World War II. What made the globalisation which became a predominant force in the 1990s different was its speed. This was mainly due to the opening up of previously closed markets like China. But it also would not have been possible without modern transport and communications.

International petrochemical companies have taken unprecedented opportunities to invest in bulk chemical capacity in emerging economies to take advantage of the rapid economic growth and the lower production costs of these countries. The objective was to use this capacity to serve thriving local markets, the needs of Western downstream manufacturers also investing in local production plants and to export chemicals back home. In Europe, in particular, the proportion of total capital expenditure being allocated to projects abroad, especially Asia, rose significantly. At the same time domestic petrochemical producers in **emerging economies were investing heavily** in their own capacity, often with the technological help of Western partners. These plants primarily aimed at import substitution but, in the Middle East especially, their objective was to serve export markets. With internal and international trade in petrochemicals increasing significantly, the logistics of the industry became even more important. **Global transportation and distribution networks** were required. Logistics were considered within a holistic approach embracing the whole supply chain — covering raw material suppliers, the producers, downstream customers and end-users.

PETROCHEMICALS GROWTH BOLSTERED BY INTERNATIONAL FLOWS OF CAPITAL

The pace of the building of plants and infrastructure in petrochemical sites and complexes across the world quickened considerably. A big driver behind this expansion was the Western petrochemicals



LyondellBasell's Channelview complex is one of the largest petrochemical facilities along the US Gulf Coast.

producers and SEFs who, like other Western manufacturing sectors, set up the basis for globalisation through big increases in levels of foreign direct investment (FDI).
A major impetus behind increased FDI was trade liberalisation. The World Trade Organization (WTO) came into operation in 1995, based on an agreement signed by 123 nations which replaced the General Agreement on Tariffs and Trade (GATT). The WTO's main remit was the elimination of protectionism and the promotion of fair trade.
Trade liberalisation was encouraged on a regional basis by a series of pacts and initiatives. The European Union's Single European Act (SEA) began to be implemented in the early 1990s with the aim of establishing a single market with harmonised laws on non-tariff issues like rules on safety and environmental protection.
The North American Free Trade Agreement (NAFTA) came into force in 1994 with the objective of creating a trilateral trading bloc comprising Canada, USA and Mexico. In South America, Mercosur, a bloc to **encourage free trade**, was set up in 1991 with five full members — Argentina, Brazil, Paraguay, Uruguay and Venezuela. In the Middle East the Gulf Cooperation Council (GCC), an alliance formed in 1981 between the six Arab Gulf states — Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates (UAE) — started the creation of a customs union in 2003. The Association of Southeast Asian Nations (ASEAN) with 10 member states with a total population of 625 million, agreed in 1992 to phase out tariffs to expand the "region's competitive advantage as a production base geared for the world market."
Most of the world's leading petrochemical producers stepped up their foreign investment, particularly in China and elsewhere in Asia and in the Middle East. The attraction was not only high growth rates but also the advantages of having local plants to supply the factories of Western manufacturers which had also been **investing in the emerging economies**.
A sign of how much the petrochemical industry was becoming globalised was the extent of investment by the leading petrochemical operators of the newly industrialised world investing in the old one — such as Taiwan's Formosa Plastics, Westlake in the US, and Saudi Arabia's SABIC in Europe.
North America and Europe rapidly lost share of the world's petrochemicals and chemicals market, especially in the 2000s.

FRANZ FISCHER
(1877-1947)
German chemist *who in 1925 together with Hans Tropsch developed a catalytic process for synthesizing carbon monoxide and hydrogen into liquid hydrocarbons. Still used today for converting gas to liquids.*

HANS TROPSCH
(1889-1935)
German chemist. *Responsible, along with Franz Fischer, for the development of the Fischer-Tropsch process that is being applied in large-scale gas-to-liquids and coal-to-liquid facilities.*

"THE PACE OF THE BUILDING OF PETROCHEMICAL PLANTS AND INFRASTRUCTURE QUICKENED CONSIDERABLY."

Growing demand in Asian economies led Western chemical manufacturers to invest heavily in the region. The photo shows the fully integrated Shell Eastern Petrochemicals Complex in Singapore.

The US' and the European Union's share of world chemicals sales, a high proportion of them petrochemicals, declined from around 60 percent in 1999 to 45 percent by 2009, while the share of Asia excluding Japan doubled to 38 percent. At the same time by the 2008 financial crisis the total ethylene capacities of the Middle East and Asia outside of Japan were poised to exceed those of the US and the EU combined.

SKYROCKETING DEMAND IN ASIAN ECONOMIES

China was one of the fastest expanding producers in line with the rapid growth of its economy whose share of the global GDP increased fivefold between 1979 and 2010 when it opened up the country to trade and investment. Its ethylene capacity also went up fivefold from around 2 million tonnes in the early 1990s to over 10 million tonnes by 2007. After, a reorganisation of the country's state-owned petroleum companies China Petroleum and Chemical Corp (Sinopec) was given the main responsibility for expanding petrochemicals output. By 2008 Sinopec had 8 million tonnes a year of ethylene capacity while PetroChina, part of the main NOC China National Petroleum Corp (CNPC) had 2 million tonnes.

The country nonetheless remained a substantial importer of petrochemicals, mainly from the Middle East and to a lesser extent Europe and North America. Most of the importers tended to be of a larger size than their domestic competitors. By the early 2000s China had around 85 PVC producers and over 80 polypropylene makers while numbers of polyethylene and polystyrene producers were 20 to 30. China's joining of the WTO in 2001 was likely to boost imports with tariff barriers on styrene coming down by 85 percent and on polypropylene by two thirds. But the country also continued to be a big exporter of chemicals. These account for around 5 percent of total exports in 2009, the same proportion as in the 1980s.

In the rest of Asia, outside of Japan, the priority for many countries was to speed up the establishment of their petrochemical industries both as a means of import substitution and to satisfy growing domestic consumer demand. So many petrochemical plants were being built that there was a danger of overcapacity. But on the other hand there was plenty of demand. Even in the late 1990s the median level of consumption of plastics products in Asia was four times lower than the world average and of fibres almost half the global average. Annual ethylene capacity in the 1990s rose almost fourfold in South Korea to 4.5 million tonnes while that in Taiwan went up almost three times to 3.4 million. In the ASEAN countries, mainly Thailand, Malaysia and Singapore, it soared nearly fifteenfold to 2.5 million tonnes in 2000. With Malaysia and Thailand the impetus was local oil and gas reserves while with

Singapore it was the availability of feedstocks from the country's large refineries.

In Thailand, Thai Olefins Company, part of state-run Petroleum Authority of Thailand (PTT), built the country's second cracker with a capacity of 385,000 tonnes a year. This was followed in 1999 by a third cracker of 600,000 tonnes a year constructed by the privately owned Siam Cement.

Malaysia's move into petrochemicals started with the opening of a polypropylene plant in the south of the country in 1993. Soon the country's NOC Petronas became the main player, backed by Western multinationals such as BASF, Dow and Shell, in a fast expanding sector which was centred on an integrated oil, gas and petrochemical cluster in Kertih and Gebeng in the east.

In Singapore, ExxonMobil started work on a steam cracker and an aromatics unit. The project adjacent to ExxonMobil's large refinery in Singapore was to become ExxonMobil Chemical's largest integrated petrochemicals complex at the time.

A SURGE OF NEW PETROCHEMICALS PLANTS IN THE MIDDLE EAST

In India, Reliance Industries was now emerging as a leading petrochemical operator with total ethylene capacity of 2 million tonnes a year by 2008. Work on Reliance's giant refinery and petrochemicals complex at Jamnagar, Gujarat, began in 2005.

The Middle East Gulf continued to be a major growth area for petrochemicals, helped by a surge in oil prices in the 2000s which provided plenty of additional revenue to be channelled into **increasing production capacity**. Its share of world ethylene capacity at the turn of the century of around 7 percent had more than doubled by the 2008 financial crisis and its immediate aftermath.

Much of the increase in capacity of ethylene and its derivatives was in Saudi Arabia which accounted for 60 percent of the petrochemicals output of the Gulf Arab states. In neighbouring Abu Dhabi of the United Arab Emirates (UAE), Borouge, a joint venture between the Abu Dhabi National Oil Company (ADNOC) and Austria-based Borealis, announced plans for a tripling of its annual polyolefins capacity to 2 million tonnes, including a 1.5 million ton-a-year ethane cracker.

In Qatar, a joint venture between Qatar Petroleum, Total Petrochemicals of France and Chevron Phillips Chemical of the US was planning to build a 1.3 million tonnes-a-year cracker scheduled to come on stream in 2010.

Despite US sanctions which blocked its access to Western technology, Iran had ambitions to more than triple its petrochemicals output to 100 million tonnes a year as part of an industrialisation programme to provide employment for its 74 million population.

In the 2000s so many petrochemical plants were being built in the Gulf region that an acute shortage of **qualified engineering and construction personnel** substantially increased the cost of projects.

A major attraction for Western petrochemical companies investing in the joint ventures behind most of the ethane-based schemes was the availability of cheap feedstock. The price for ethane in Arab Gulf countries was 4-5 times cheaper than the average price of ethane for an ethylene cracker in the US. In times of unusually high gas demand in the US the difference was far greater.

However, Gulf ethane suppliers were increasingly coming under pressure from shortages of ethane in the region while having to base more of their petrochemicals on naphtha which had to be costed at world prices.

Greater competition in petrochemicals was also introduced into the region by **the entry of new players** into the sectors. By far the biggest of these was Saudi Aramco which aimed to exploit the synergies between its refineries and petrochemical production. In 2005 it announced a partnership with Japan's Sumitomo Chemical to upgrade an existing refinery at Rabigh on the country's west coast into a refining and petrochemical complex. Then in 2007 Saudi Aramco and Dow Chemical started planning a joint venture petrochemicals complex adjacent to a refinery at Ras Tanura on the east coast, which evolved to Sadara Chemical Company (Sadara) in Jubail.

Another change in the Middle East was for the private sector to be encouraged to become more involved in petrochemicals. In Saudi Arabia, Saudi Kayan, a joint petrochemical project between the state-controlled SABIC and private investors, was launched with plans for capacity of 6 million tonnes a year. In Iran the government tried to attract commercial funds into petrochemicals by privatizing the National Petrochemical Company (NPC).

LIBERALISATION SPARKS PETROCHEMICALS GROWTH

Liberalisation became a major factor in the further expansion of petrochemicals in Latin America led by Pacific coast countries where tariffs were lifted, particularly after the creation of the Mercosur trading bloc. Argentina and Brazil still have import duties protection for most of the petrochemical products manufactured in those countries. In most countries pricing controls were eliminated (major exception Venezuela). Some governments loosened their grip on chemicals production by privatizing state-owned producers, which helped to **boost foreign investment** by leading petrochemical multinationals. Dow took over the Bahia Blanca petrochemicals complex in Argentina in 1996.

In Brazil Petrobras divested most of its stakes in around 40 petrochemical and derivatives companies to private companies.

In the industrialised world **large new centres of petrochemical production** were emerging. The petrochemicals investment programme of the natural gas-producing province of Alberta initiated a new phase, with Nova Chemicals and Union Carbide — prior to its merger with Dow — building a joint-venture ethylene cracker. Other foreign investors in petrochemicals in Alberta included Shell and BP.

After the collapse of the Communist trading bloc Soviet Union-led COMECON following the demolition of the Berlin Wall in 1989, followed by the disintegration of the Soviet Union itself, petrochemical production was modernised and expanded with the help of Western investment. In eastern Germany, Dow took over Buna which was the largest production site for plastics within the German Democratic Republic (GDR), while Elf Aquitaine later acquired an adjacent refinery. A large polyolefin complex was established on the basis of a pre-existing petrochemical plant, at Plock, Poland, by a partnership between PKN ORLEN, the country's leading petrochemicals producer, and Basell Polyolefins, a Shell/BASF joint venture, to become LyondellBasell after a merger with Lyondell Chemical of the US in 2007.

In the former countries of the so-called "Soviet Block" both production and investment in chemicals declined sharply from 1990 to 1995 when it levelled out but only began to climb back to the pre-1989 levels in the latter part of the next decade.

RADICAL RESTRUCTURING AFTER THE FINANCIAL CRISIS

The pressures of the new international order and high expectations in the financial markets of greater profitability were too much for some major petrochemical players, some of whom had been leaders in the sector since its beginning. By the time of the 2008 financial crisis, the corporate structure of the petrochemical industry had been transformed. This was especially the case in the US and Western Europe which had provided the **scientific and commercial foundations** of the industry in the first half of the 20th century.

Even in the 1990 ranking of the world's leading chemical companies most of the original pioneers of petrochemicals, made from coal, biomaterials or mineral oil or natural gas, were still among the top 10. But by 2007 a significant proportion of them had disappeared, mainly as a result of being broken up with their parts being acquired by other players.

Among those that passed into history were ICI, Hoechst, and Union Carbide. The latter has been taken over by Dow. ICI and Hoechst were broken up in similar circumstances. Under pressure from the financial markets for improvements in profitability and returns on investment in their shares, parts of both companies were divested or floated on the stock market or merged in joint ventures. In 1998 Hoechst moved its industrial chemicals operations, including petrochemical activities, to a new subsidiary Celanese, which was spun off in an IPO a year later. Also in 1998, Hoechst and Rhône-Poulenc of France announced they were merging their life sciences operations into the Aventis joint venture. In the first half of the 1990s ICI sold its nylon business to DuPont and spun off its pharmaceutical, agrochemicals and speciality activities into an independent company called Zeneca. The rest of the bulk chemicals operations was sold off in a series of deals, among the biggest of which was DuPont's takeover of the polyester chemicals business for $3 billion in 1997. ICI disappeared completely when AkzoNobel acquired its paints operation and remaining speciality activities in 2007. The main survivors were BASF, Bayer, Dow, DuPont and the long-established petrochemical players among the international oil companies, such as Shell, BP and ExxonMobil. Most of the **newcomers to the top league** were relatively young but fast growing producers from outside the US and Western Europe, indicating how much the balance of power within

Like many locations of Western chemical companies, Bayer's Leverkusen site underwent some restructuring and has turned into a chemical park that today accommodates several different chemical, logistics and service companies.

the industry was changing. These included Sinopec of China, SABIC of Saudi Arabia, Formosa of Taiwan and LG Chemicals of South Korea.

The exceptions were the Anglo-Swiss Ineos and US Huntsman Corporation which used debt finance to acquire struggling petrochemical businesses to build strong positions in the North American and European petrochemicals markets. Ineos, founded by the former equity fund executive Jim Ratcliffe, became the world's biggest privately owned petrochemicals producer mainly through acquisitions of assets from BP and ICI.

Some of the international oil companies like Shell, BP and Chevron — the latter through its joint venture with Phillips, Chevron Phillips Chemical — cut back their activities in petrochemicals, in the case of BP substantially. Other oil companies were expanding their petrochemical activities. In France, Total, the country's main oil company, created a large petrochemical operation initially called Atofina after acquiring Petrofina of Belgium in 1998 and the other main French oil company Elf-Aquitaine. Exxon and Mobil considerably strengthened their position in the global petrochemicals market after they agreed to merge to ExxonMobil in 1999.

Even the players from the newly industrialised countries and emerging economies had to reorganise in the face of intensive global competition and the continued surge of excess capacity.

AGGLOMERATION IN THE OLD AND NEW HEARTLANDS

The tendency to geographical agglomeration in the industry strengthened considerably for the sake of lowering costs and greater infrastructure and logistical efficiencies. In the US by 1990, petrochemicals production was already highly concentrated with close to 70 percent of it taking place in Texas and much of the rest in neighbouring Louisiana. In Europe a super-cluster was emerging, linking petrochemical activities in and around Rotterdam and Antwerp and Northwest Germany.

Among the new petrochemical producers outside the US and Western Europe, agglomeration became a more immediate trend. Saudi Arabia congregated its new plants in two main centres — Al Jubail on its west coast and Yanbu in the east. Singapore started building an integrated concentration of refineries and petrochemical facilities to make it a major hub in Southeast Asia. China began establishing **a large chemicals cluster in and around Shanghai**.

In Europe and to a lesser extent in North America the departure of the weaker producers led to greater agglomeration within the industry. The result was that clusters of producers became even more prevalent, especially in Europe.

In the US by the 1960s, a large proportion of petrochemicals production was taking place in Texas. That increased to around 40 to 50 percent by the 1990s. The wider region of the US coast of the Gulf of Mexico accounted for the vast majority of US petrochemicals production. The US Gulf had the infrastructure from the early days of petrochemicals because most of the refineries were built there and it was the centre of the logistics and distribution network. This pattern of petrochemicals production has tended to be repeated in the locations of petrochemicals production in the developing world.

SEARCH FOR SECOND-GENERATION POLYOLEFINS

Advances in catalysis boosted the number of grades of polymers, for example, because new catalysts could provide more tailored properties. The biggest advance was the introduction of single-site catalysts mainly based on a combination of metallocene and the co-catalyst methylaluminoxane.

Huge sums were poured into R&D

projects. In the 1990s alone over $3.5 billion was spent on the technical and commercial R&D for second-generation polyolefin technologies, according to estimates. But overall the technology for the production of mainstream petrochemicals using traditional processing routes was maturing. Catalystsimprovements and innovation were unable to provide significant increases in yields.

In order to gain substantial cost savings petrochemical companies had to continue to rely on the ability to build plants of larger scale as a result of advances in engineering.

But this became less of a viable option as prices of bulk polymers and other base chemicals, mostly petrochemicals, dropped across the world because of production overcapacity. This overcapacity was due mainly to the growing share in the global market being taken by producers located in countries with low feedstock and/or labour costs.

Instead some of the R&D likely to have the greatest potential was being directed at **radical changes** in the way petrochemicals were made. These involved moving away from ethylene and, in some cases, going back to some of the technologies prevalent before the start of petrochemical revolution of the 1930s and 1940s. These were producing the equivalent of petrochemicals from coal, gases and renewables.

WAYS TO DIFFERENTIATE POLYOLEFIN PRODUCTS

Globalisation boosted total R&D expenditure on petrochemicals. This was due to the rapid growth in demand for petrochemicals, particularly polymers, in the emerging economies and elsewhere in the developing world. Also, producers and state-backed research institutes in newly industrialised countries were beginning to put money into petrochemical research. Some of the larger research projects were aimed at finding ways of fending off commoditisation through technologies which differentiate products within the same polymer class.

Much of the research work was on new types of catalysts, many of which were developed with the aid of new electronic imaging instruments. Advances in catalysis boosted the number of polymer grades because new catalysts could provide more tailored properties. One of the biggest advances was the introduction of single-site catalysts. The most prominent of these were metallocene catalysts which differed from heterogeneous Ziegler-Natta catalysts with many active sites. Metallocene catalysts were homogeneous with a single active polymerisation site which gave polymers a lower level of crystallinity, greater clarity and lower heat-seal temperatures. Catalyst improvements and innovation were unable, however, to provide significant increases in yields. Instead they were targeted at improvements to performance.

To gain substantial cost savings petrochemical companies had to continue to rely on the ability to build plants of larger scale as a result of advances in engineering. But this became less of a viable option as prices of bulk polymers and other base chemicals, mostly petrochemicals, dropped across the world because of production overcapacity. One factor behind this trend was the increased share in global markets being taken by producers with low feedstock and/or labour costs.

There were **significant advances in the making of petrochemicals** direct from the basic feedstocks. Cooperative work between UOP of the US and Norsk Hydro of Norway, with parallel research by the Dalian Institute of Chemical Physics in China, led to the development of methanol-to-olefins (MTO) technologies. UOP, with silica aluminium phosphate catalysts, and Dalian, with aluminosilicate zeolite (ZSM)-type catalysts, separately developed processes to make both ethylene and propylene from methanol. In China, this was coupled with the production of methanol from coal-based synthesis gas. This led to the construction of many MTO plants, primarily in China.

The drive to develop new sources of feedstock led to the re-emergence of the Fischer-Tropsch process, discovered in Germany in the 1920s and then used by the country during World War II to make gasoline from coal via the production of synthesis gas. In South Africa, Sasol, the country's main energy and chemical company, installed and continued to develop this technology to make fuels and petrochemicals, including higher alpha olefins used as co-monomers in the production of polyethylene.

Shell separately developed its own Fischer-Tropsch-based gas-to-liquids (GTL) process to make liquid fuels from "stranded" natural gas: first in a small plant in Bintuli, Malaysia, in 1993. This acted like a pilot plant for a giant GTL plant in Qatar which Shell opened in 2012. It was an example of chemical engineering at its highest level with thousands of catalysts set in numerous looped tubes. But GTL also offered prospects for process intensification because recent innovations with the Fischer-Tropsch technology have demonstrated how it can be applied on a micro scale.

Great use of automation applying newly developed sensor technologies in petrochemical plants was raising production efficiencies but also helping to deal with **shortages of skilled workers, particularly operators**.

A NEW LEVEL OF CHEMICALS REGULATION

As a result of the passing of the Single European Act, which set the European Community an objective of establishing a single market by the end of 1992, harmonisation of environmental standards became an EU responsibility. One of the first initiatives of the European Commission was to introduce in the early 1990s environmental controls on chemicals on the basis of the **risk assessment of chemical substances**.

In the US the Chemical Manufacturers' Association (CMA), now the American Chemistry Council (ACC), teamed up with the Environmental Protection Agency (EPA) to launch in 1998 a testing programme for individual high production volume (HPV) chemicals, most of them petrochemicals. This initiative was an example of how much relations between regulators and industry had improved since the surge of regulations targeting chemicals in the previous two decades.

In the late 1990s the European Commission, the EU's Brussels-based executive, started to work on what was to be the largest piece of legislation ever on the chemicals sector. It was called **REACH** for the Registration, Evaluation and Authorisation of around 30,000 Chemicals with an annual output of 1 tonne or more. It was finally approved in 2007 with petrochemicals being one of the first industries to have to provide safety dossiers on all its high volume products. The legislation which was issued in the form of a regulation so that it would be directly applicable in the different member states, required chemical producers and distributors to provide evidence that the substances they were marketing were safe for humans, animals and the environment. Cefic and other groups representing the chemical industry contributed their expertise and knowledge to six working parties set up by the Commission on the areas of the new legislation.

GLOBAL WARMING

Usually environmental and safety policy is concentrated on human health and air, water and land pollution. In the 1990s a new element was introduced with concerns about global warming. The priority with governments became the use of regulations and other initiatives to cut CO_2 emissions, particularly in energy intensive industries like petrochemicals. The EU was a signatory to the 1997 Kyoto Protocol to the UN Framework Convention for Climate Change (UNFCCC) such that it became committed to meeting legally-binding targets for reductions of greenhouse gas (GHG) emissions. The EU pledged to cut GHG emission levels by 20 percent by 2020. It decided to introduce the first international emissions trading system (ETS) to cover power and energy-intensive units like petrochemicals-producing plants. Emission allowances would be allocated to the plants. Owners of plants emitting more than permitted emissions would have to buy allowances to cover the excess or otherwise face the payment of heavy fines. The scheme was started as a three-year pilot scheme in 2007.

The industry indicated that it supported the objectives behind some key regulations. In particular it wanted to help in **the fight against climate change**.

At the same time increasing numbers of national associations were now signing up to the rules of Responsible Care. The petrochemical industry was seen to be **serious about environmental protection**.

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DIVERSITY

The chemical industry is a very diverse industry. The EPCA Talent and Diversity Inclusion Council (TDIC) was established in 2015 as an advisory body to the EPCA Board with the aim of making the business case of the need for diversity inclusion within the chemical business community.

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DIVERSITY

"EPCA ENCOURAGES THE INDUSTRY TO BENEFIT FROM DIVERSITY IN THE WORKFORCE."

SUPPLY CHAINS ARE BEING GLOBALISED

As petrochemical producers expanded across the world, their logistics service providers had to do the same. Furthermore the producers were outsourcing even more logistical services, especially in areas where the transportation, storage and distribution became highly specialised. Leading logistics service providers (LSPs) had to offer integrated solutions. These included international networks of intermodal transport, with tank storage units, warehouse facilities, freight forwarding services and some forms of supply chain management. Often these services were provided in emerging economies through joint ventures and alliances. The higher the complexity of the supply chain due to sub-standard infrastructure the more important local partnerships were in preventing disruptions. As **containerisation became more sophisticated and reliable**, increasing numbers of petrochemical producers and their customers were wanting to transport chemical products in containers. This helped to streamline key stages within the chain. While in North America a high proportion of bulk chemicals were transported by rail, in Europe it was the reverse with most loads being distributed by road. But with increasing opportunities for intermodal distribution with standardised tankers, a growing proportion of transportation was done by **combinations of road, rail and barges**. The creation of large-scale bulk terminals across the world helped increase the efficiency of local distribution. In Europe ports like Rotterdam and Antwerp operated hub systems with some hubs linking road, rail and waterways being located within their hinterland transport systems. The challenges LSPs were facing at the end of the 20th century also led to further consolidation activities in the sector. In 1999, Rotterdam-based Royal Vopak, was created by the merger of Dutch logistics companies Van Ommeren and Pakhoed, building on a history of almost 400 years. That was the start of a substantial expansion program in independent storage to serve the globalisation in the industry.

THE INFORMATION TECHNOLOGY REVOLUTION

Logistics companies expanded into being supply chain specialists, coordinating a series of distribution networks based on well-established relationships and partnerships. The radical changes in communication and data flows as a result

The turn of the millennium saw increasing investments in chemical production plants around the world.

"LOGISTICS COMPANIES EXPANDED INTO BEING SUPPLY CHAIN SPECIALISTS."

Ocean-going bulk carriers grew in size as containerisation became more sophisticated.

"BY 2008, THE CORPORATE STRUCTURE OF THE PETRO-CHEMICAL INDUSTRY HAD BEEN TRANSFORMED."

of **new IT technologies**, particularly those that brought in the internet and data processing and storage, made integration of logistics much easier than in previous years.Fifty years ago customers telephoned orders which were processed through locally devised systems. Shipping documents were put together manually. Only critical information was faxed. Now emails and the internet enable information to be transmitted instantaneously while data is processed and analysed rapidly by computer. IT also allowed activities along the logistics chain to be monitored electronically with the data being sent back to the computers of shippers and transportation companies. The efficiency of Vendor Managed Inventory (VMI) systems, for example, was considerably improved by electronic monitoring. Sensors or scanners could measure the levels of products in a customer's storage tank with the information being transmitted back to the supplier to ensure stocks would be replenished at the right time. These monitoring systems could be linked with the software controlling computerised manufacturing planning tools (MRP) which helped schedule the volume and range of outputs in production plants. MRP had been slow to penetrate the chemical industry until it was extended to enterprise resource planning (ERP) in the 1990s to cover not just manufacturing planning but all the departments of a company as well as its customers and suppliers. Among the software specialists creating ERP packages, SAP of Germany was the most successful in the chemicals sector because it ensured its programmes covered requirements unique to the chemical industry.

These included regulatory and environmental compliance but also aspects typical of a chemicals logistical chain. ERP opened the way for the chemicals sector to make much greater use of IT. By the late 1990s the vast majority of the largest chemical companies, including leading petrochemical producers, were using SAP's latest ERP software. One major effect of ERP was that it enabled petrochemical and other chemical producers to participate in the **surge in e-commerce** from the late 1990s to the early 2000s, after which its popularity as a means of doing business started to wane rapidly.

THE E-COMMERCE BOOM AND WHAT'S LEFT OF IT

E-commerce was seen by its pioneers as being an ideal solution for the commodities-dominated chemicals industry by offering a means of buying and selling of products online, particularly on the spot market. It would speed up considerably the process of finding and then doing deals online with potential buyers or sellers. Entrepreneurs rushed into the rapidly expanding sector so that by 2000 there were 45 e-commerce exchanges. Among the biggest and the first into the market was the San Francisco-based ChemConnect, which was founded in 1995 and raised over $100 million from investors, including chemical companies. Its exchange had a volume of close to $9 billion in 2002. However, e-commerce volumes soon began to quickly subside as chemical companies and traders realised it was just one way of doing business, not necessarily the most efficient. By 2004 ChemConnect's staff had fallen by two thirds to 60. Three years later it was taken over by Intercontinental Exchange (ICE), an Atlanta-based futures exchange. Although most of the chemicals exchanges founded at the time of the e-commerce craze were failures, a few were successful in developing IT infrastructures for the selling, marketing and distribution of chemicals and providing a platform for **IT-based supply chain management**. One of these was Elemica, which was set up by a consortium of leading chemical companies such as BASF and Dow. It went on to become a leading provider of supply chain integration systems.

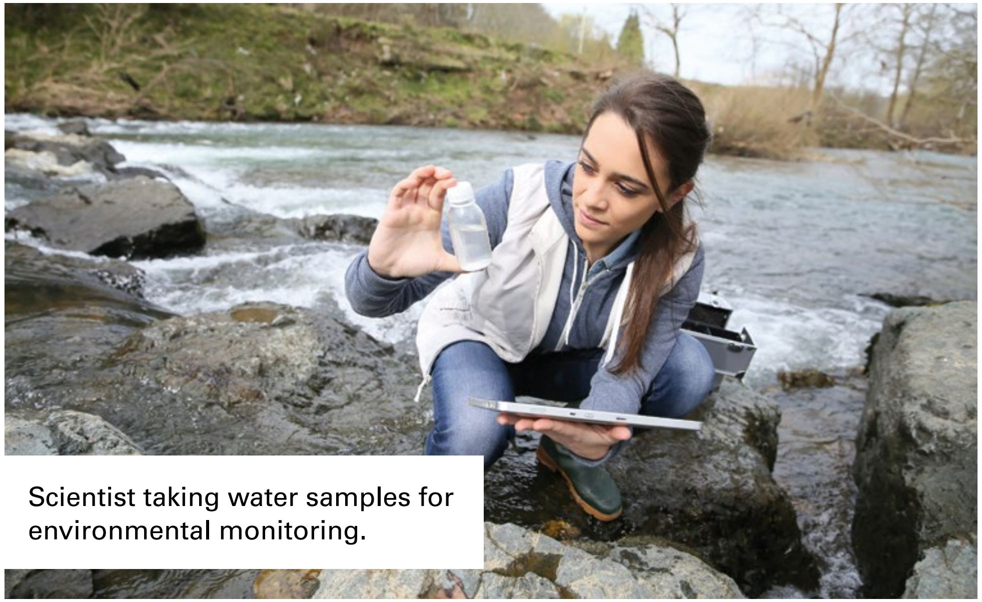
SABIC scientist running experiments in the research lab.

INVESTING IN SAFETY AND ENVIRONMENTAL PROTECTION

The arrival of the internet compelled chemical companies to invest more in IT, especially to improve the efficiency of logistical operations. Another factor pushing up investment was the increasing toughness of regulations on safety and environmental protection.

"SOME OF THE INTERNATIONAL OIL COMPANIES CUT BACK THEIR ACTIVITIES IN PETROCHEMICALS."

The chemical industry has been investing significantly in water treatment technology at its sites around the world.



Scientist taking water samples for environmental monitoring.

In shipping one of the most expensive new rules was the requirement that chemical and other tankers be fitted with double hulls to lessen the environmental damage from accidents at sea. The obligation which was part of the International Convention for the Prevention of Pollution from Ships (MARPOL) drawn up by IMO, applied to new tankers of 5,000 deadweight tonnes or more from July, 1993 and to existing tankers from 2007.

Health, Safety, Security & Environment (HSSE) standards were being introduced on a wider scale in the tanker sectors but also along the logistics chains in storage and pipeline systems. There were a number of other initiatives in the chemicals sector to draw up voluntary codes and processes for improving safety and environmental protection. Europe had the Safety and Quality Assessment System (SQAS) for evaluating the quality, safety, security and environmental performance of logistics providers and distributors.

The **issue of global warming** also began to gain greater prominence in logistics. An impetus behind the growing popularity of tank containers was their ability to increase efficiencies and also to reduce energy consumption along the logistics chain and hence CO_2 emissions.

"THERE WERE SIGNIFICANT ADVANCES IN THE MAKING OF PETROCHEMICALS DIRECT FROM THE BASIC FEEDSTOCKS."

EXAMPLES OF EPCA COMMUNICATION AND BRANDING ACTIVITIES

Berlin mini-MARATHON 2013 sponsored by EPCA.

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EPCA
THE EUROPEAN PETROCHEMICAL ASSOCIATION

THE TURN OF THE CENTURY

CALLING IT A MILLENNIUM

1990 TO 1998

During the period of globalisation and increasing legislative as well as general public environmental pressure in the 1990s, EPCA reflected on how to adapt its own role to the ongoing globalisation of its member companies and on its relationship with other regions and associations.

EPCA's Director, Eric Yates, supported in his efforts by the General and Distribution Committees put EPCA meetings at the forefront as "the place to see and be seen" by industry peers and the "who's who" in petrochemicals for newcomers, suppliers as well as customers of the petrochemical industry. Under his guidance **EPCA meetings became a "must attend" for** people active in the petrochemical industry in Europe and even from non European countries. One had to be "invited" to join EPCA meetings for which strict limitation rules on segregation per activity segment were applied. Yates also was very active in the logistics field trying to develop measures that would improve health & safety.

Under the guidance of Jan Hessel Kruit, who joined the General Committee from 1993 to June 2002, governance principles were introduced in the EPCA structures, completing what was provided for in the EPCA Articles of Association and bye-laws. Under Kruit's EPCA Presidency from 1995 to 1997 an EPCA Mission Statement was introduced and indicated that EPCA was to provide to its members an efficient means of communication of matters of interest and relevance within and to promote activities of potential benefit to the petrochemical industry in Europe.

In this period, the General Committee also established the EPCA Strategy by which EPCA's main function was to **organize an Annual and a Logistics Meeting each year** as well as seminars on specific topics. Also, the excellent relationship developed with other associations like NPRA and APLA should be continued and a relationship with Asia should be examined to encourage regional meetings. Finally, EPCA was to continue to develop ideas that were in the interest of the industry.

J. H. Kruit, EPCA President 1995-1997.

What was in particular addressed in the EPCA Strategy were the many logistics projects in which EPCA got involved, following up on discussions with delegates at the **EPCA Distribution meetings that changed name** in 1996 into Logistics Meeting. For instance, in the field of European land logistics, one of the most important projects developed during this period was the International Chemical Environment (ICE) program aimed at

reducing health, safety and environmental risks in the supply chain. The steering group chairman was Eric Yates. The Cefic Board approved the ICE program in 1992 and the management of ICE was transferred from EPCA to Cefic in 1998 under the chairmanship of Phil Browitt, ex ICI, founder of Agility Logistics. In the field of marine logistics, the Chemical Distribution Institute (CDI) was created. It provides inspection systems for marine and terminal operations.
In its move to open EPCA to the Eastern European market, in 1992, a first seminar in Budapest was organised on the logistics challenges facing Eastern Europe.

DEVELOPING THINK TANK CAPABILITIES IN LOGISTICS

Think tank capabilities were undertaken for the first time during the 1995 EPCA Distribution meeting when a "strategy breakfast" was organised amongst selected EPCA delegates serving as a **think tank for generating new ideas**. Further development came via the organisation of a formal EPCA Logistics Think Tank. The first one was held in 1996 in Limelette, Belgium. The need for standardisation of equipment between service provider companies and producers' loading/unloading facilities was highlighted, as was night driving for hauliers to reduce traffic congestion during the day and avoiding return trips of trucks running empty after unloading.

THE BIRTH OF THE EUROPEAN CHEMICAL TRANSPORT ASSOCIATION (ECTA)

The 25th anniversary of the EPCA Logistics Meeting in Barcelona in 1997 was at the origin of the creation of the European Chemical Road Transportation Association (ECRTA) in 1998, which had its inaugural meeting in Amsterdam a year later. During this inaugural meeting the name of the association was changed to the European Chemical Transport Association (ECTA). This name change marks the inclusion of rail, short sea shipping, inland terminals and barges in the land logistics segments covered by the ECTA scope as a representative body of land chemical transport companies and platform for meetings between producers and service provider companies on European land logistics issues.
The development of contacts with other associations in the logistics field like Marichem, ITCO, INTERTANKO, and CCIA was debated frequently between 1996 and 1998.

BIG SHOES TO FILL 1999 TO 2008

THE CHANGING OF THE GUARD IN 1998

In September 1998 a new Director, Cathy Demeestere, was appointed to succeed to Eric Yates who retired in November 1998 and tragically passed away only three months after his retirement. Eric Yates left an impressive heritage and "big shoes to fill". Such was the challenge put to the new Director.

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EPCA Committee of the Annual Meeting 2000 in front of the Hotel Hermitage, Monaco.

GOVERNANCE

Through a series of changes to the Articles of Association, the organisation was modernised and aligned with changed legal requirements and governance best practices. The objective of the association was clearly defined, inclusive of the obligation to build up reserves to safeguard the perpetuity of the organisation, and a set of written policies were decided upon.

OPTIMIZING RESOURCES AND COMMUNICATION

The relationship with Cefic, APPE (now Petrochemicals Europe) and APME (now PlasticsEurope) was clarified in the sense that EPCA is defined as a network bringing companies together from all over the world, regardless of the fact that they are producers, suppliers or customers of the petrochemical industry. It was also made explicit that, contrary to the aforesaid lobby bodies for European chemical producers, advocacy is excluded from EPCA's activity field and that EPCA does not represent its member companies.

To avoid overlap and optimize resources and communication in an informal way between Cefic, Petrochemicals Europe and PlasticsEurope several members of the EPCA Board and Supply Chain Program Committee are active with the Board or the SIG Logistics of Cefic and with the Board of Petrochemicals Europe or PlasticsEurope.

INCREASING THE UNIQUENESS OF EPCA MEETINGS

The strategy was developed to increase the "uniqueness" of EPCA meetings and differentiate EPCA from other meeting organizers in the chemical segment, via limiting access to EPCA members.

In 2001, for the 35th Annual Meeting in Monaco themed "Concentration: Fashion or Necessity", the host country approach was abandoned and an **"all in one"** approach was adapted for content, form, entertainment, visuals, and decoration aligned with the main theme.

EPCA also decided to keep the meeting going in the aftermath of the September 11, 2001 terrorist attacks in the US. 1,100 delegates from all over the world gathered together in Monaco with 11 persons coming from New York City. Notwithstanding the sad and difficult circumstances of September 11, the fact that EPCA went on with its meeting had a positive impact on the development of building trust and reliability in EPCA's contractual relationships with the hotels and local authorities.

COMMUNICATION IMPROVEMENT: REPORT — BRAND — EMBRACE DEVELOPMENT

From 1999 on, all activities undertaken by EPCA resulted in a written report shared in the EPCA network and with external stakeholders. Quite often the conclusions of such a report served as a source of inspiration for the organisation of further EPCA activities deepening topics which the Board agreed to be important for the industry or the EPCA organisation.

Ice sculpture at the 40th Anniversary Meeting in 2006.

A **new EPCA website** became operational in mid-1999. In 2000 EPCA adopted a new logo reflecting its openness to the outside world and new ideas and started to develop a fresh corporate identity to make it more attractive to the public and youngsters as well as to align it with its mission statement.
From 1999 on, EPCA Annual and Logistics Meetings as well as seminars, working groups, workshops and think tanks were given a specific theme to allow topics of relevance to the industry to be debated on the EPCA platform from different angles and allow transfer of learning from leaders in other industry segments or from recognized opinion leaders or experts with global reach. The aim was to confront vested opinions from inside and outside the industry and **challenge 'business-as-usual' approaches**, making the audience aware and supporting them to get ready for the changes occurring around them.

COOPERATION WITH OTHER GEOGRAPHICAL AREAS CONTINUES

To bridge the gap of a lack of industry-driven meetings in Asia, EPCA supported such a local Asia meeting inspired by the NPRA, APLA and EPCA practice in 1999. The Gulf Petrochemical Association (GPCA) was created in 2006, and represented the downstream hydrocarbons industry in the Arabian Gulf. A lot of support was given by EPCA to GPCA in the early days.

RINGING IN THE CHANGES

At its 40th Anniversary Annual Meeting, which took place in Monaco in 2006, EPCA introduced a major initiative: holding again joint meetings of the general business and the supply chain sectors that were split from 1974 up to and inclusive of 2005. EPCA registered an all-time record attendance of more than 2000 delegates. Then-EPCA President Boy Litjens stated, 'the main reason for holding a joint meeting is that **logistics and supply chain management** are becoming an increasingly integral part of the petrochemical business and we also think it is important that service providers and chemical business people be able to meet and discuss common topics'.

ECTA IMPLEMENTATION

Intensive efforts were dedicated to drafting the ECTA Articles of Association and obtain approval from the Belgian authorities by Royal Decree in 1999, whilst reports were issued on standardisation of equipment and standard performance measurement that were endorsed by the Cefic/EPCA/ECTA working groups on best practices. The number of working groups increased steadily in good cooperation between ECTA and Cefic whereas EPCA acted as a neutral platform as well as a manager and facilitator/sponsor of ECTA.
Milestones for ECTA were the signing of the European Road Safety Charter in 2005 in the presence of the European Commission and the signing of the agreement with Cefic in October 2008 as the first transport association to launch a pan-European Responsible Care program in Europe. Having gained recognition and acceptance of its advocacy role, ECTA

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became independent from EPCA at the end of 2010.

EASTERN EUROPEAN SEMINARS ON EU ENLARGEMENT IMPACT

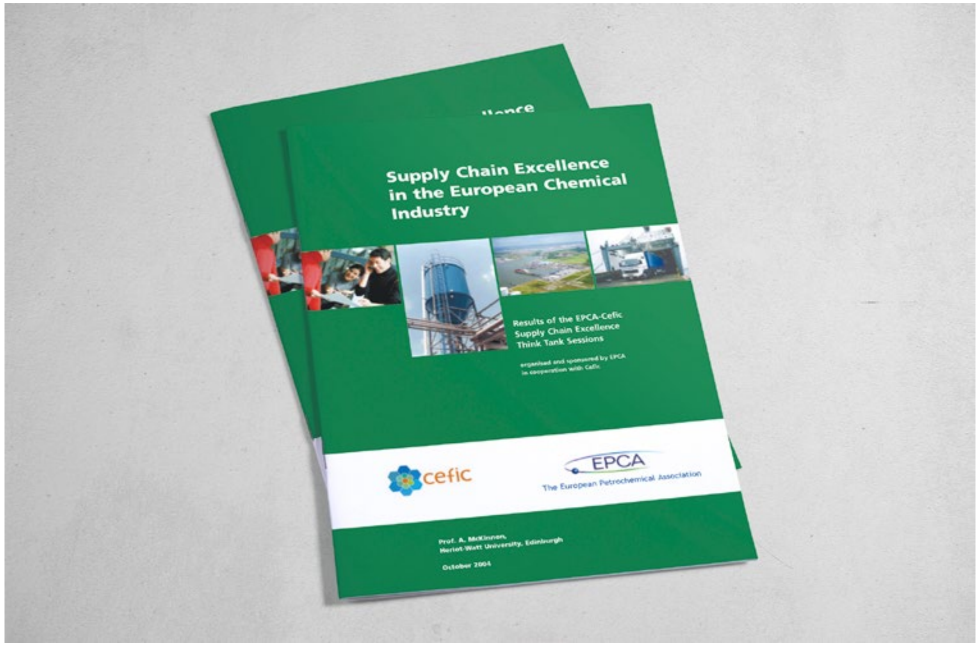
To promote the **implementation of Responsible Care** out of the factory gate into the supply chain, EPCA, in cooperation with Cefic and ECTA as well as with local industry and transport associations, organised three European Logistics and Transport seminars in Prague in 1999, Krakow in 2001 and Budapest in 2003. These seminars brought together delegates from Eastern and Western Europe from producing and service provider companies with the participation of the European Commission to discuss the **impact of the EU enlargement** on logistics in Eastern Europe as well as to promote the best practices of ICE and Responsible Care. The need for more implementation of principles and guidelines developed in this connection were frequently underscored.

SCHOLARSHIPS: SUPPORT, APPRECIATION AND ENCOURAGEMENT

In 2000 EPCA and the Heriot Watt University in Edinburgh, Scotland, selected an EPCA sponsored scholar in the scope of his Masters in Logistics and Supply Chain Management.
Being offered a job by BP whom he interviewed as EPCA member company for the writing of his thesis, this scholarship met many objectives: make EPCA and the chemical industry known and appreciated in universities, encourage scholars to work for the chemical industry and in logistics, and support member companies in their efforts to attract young talents. EPCA has continued these efforts ever since in its **educational projects**.
In 2002 EPCA funded a thesis by a group of students, dedicated to "Bulk Chemical Supply Chains: Moving Feedstock to Flow" in collaboration with the Technical University Eindhoven, The Netherlands and Stanford University, USA. In 2006, EPCA sponsored the thesis of an MSc in Logistics and Supply Chain Management at Cranfield University offering a well-documented case study on Vertical Collaboration.

DEVELOPING THINK TANK CAPABILITIES IN LOGISTICS & IN CHALLENGING "BUSINESS AS USUAL"

In the period 2004 to 2009 three think tank exercises took place, resulting in the production of reports that have been



shared with the delegates in the Logistics Meetings of 2004, 2005 and 2007 and distributed in the EPCA network and in other conferences.
The first of three reports called "**Supply Chain Excellence in the European Chemical Industry**" was a joint EPCA and Cefic initiative dedicated to the competitive threats the European petrochemical industry was facing from the Middle East and Asia, whilst being confronted with higher chemical transport costs in Europe. The think tank identified a series of measures that could transform European chemical supply chains.

The vast majority of these measures would require inter-company collaboration, a real mindset shift. The chemical industry was indeed seen to lag rather than lead the development and implementation of **new logistics practices** and tendencies. The report concluded with a call for action to adopt, for example, swap arrangements, shift from packaged to bulk distribution and transfer traffic from road to rail and waterways.

A second EPCA/Cefic think tank resulted in a report published in 2005 called "**Maximising Performance Management: the Power of Supply Chain Collaboration**" and proposed benefit forecasts that could be realised if the proposed measures were implemented. The third EPCA report was drafted by a team of researchers at the international INSEAD Business School created in 1957 in Fontainebleau, France. It was themed "**A Paradigm Shift: Supply Chain Collaboration and Competition in and between Europe's Chemical Clusters**" and summarized the conclusions of two think tanks.

One was dedicated to the Antwerp/Rotterdam/Rhine-Ruhr cluster, spread over The Netherlands, Belgium and Germany, and another one was examining the Tarragona cluster in Spain.

Four recommendations were made for companies acting in clusters in order to get more value out of the cluster. The report indicated that the paradigm shift on collaboration had anything but taken place. However, this cluster report was taken on board upon its publication by the **High Level Group on the competitiveness of the chemical industry** in the European Union that was organized in June 2007 by the European Commission with the participation of industry leaders.

Each of these publications constitutes an interesting source of learning one can still draw from that was generated by the efforts of EPCA member company representatives, top level academics and EPCA.

YOUNG EPCA THINK TANK (YETT)

In 2002, the Young EPCA Think Tank (YETT) was established as an advisory body that is to regularly challenge EPCA's mission and strategic development, assist in the selection of themes for the Annual Meeting, support EPCA's education and communication efforts and act as ambassador of EPCA in their respective organizations for cooperation on EPCA education and communication projects. It can also suggest to the Board new projects which could be of interest to the industry and are different from the ones EPCA is already involved in. The YETT has had regular meetings since 2004 and has since its creation contributed substantially to the debate on EPCA's strategic focus, communication and adapting EPCA's meetings to the **changing needs and expectations** of EPCA delegates.

LEARNING FROM BUSINESS SESSIONS

Since 2000, EPCA has put at the forefront of the business session programs of its Annual and Logistics Meetings a theme showing how the chemical industry contributed to sustainable development in one or the other aspect of sustainability. **Sustainable development and corporate social responsibility** as a whole were addressed in the meetings of 2000 and 2002, whilst in 2005 EPCA promoted and demonstrated that chemical products improve our daily life and human well-being. The economic dimension of sustainability was challenged in 2001 by examining the competitive advantage of concentrations in the chemical industry and in 2003 by looking at the global competitiveness of the European chemical industry.

In 2004, the focus was laid on the human aspect of sustainability by promoting how the chemical industry recognises the value of people and the need to constantly develop them, and in 2007 EPCA showed that the industry takes advantage of the diversity in the workforce and of the different, complementary skills of the people employed by the many international companies that form part of its membership.

In 2008, Kofi Annan, United Nations Secretary General from 1997 to 2006, underscored the geopolitical impact of climate change as well as the lack of leadership and of poverty inclusion.

Energy and hydrocarbons were at the heart of the debate in 2006 and 2008, with attention focused on hydrocarbons as building blocks for the chemical industry. In 2008 François Cornélis, then President of Cefic and Vice-Chairman of the Executive Committee of Total, expressed the belief of continued dominance of fossil fuels in giving access to carbon as a building block for the chemical industry, as well as the fact that the chemical industry is at the centre of all industries and an important source of innovation.

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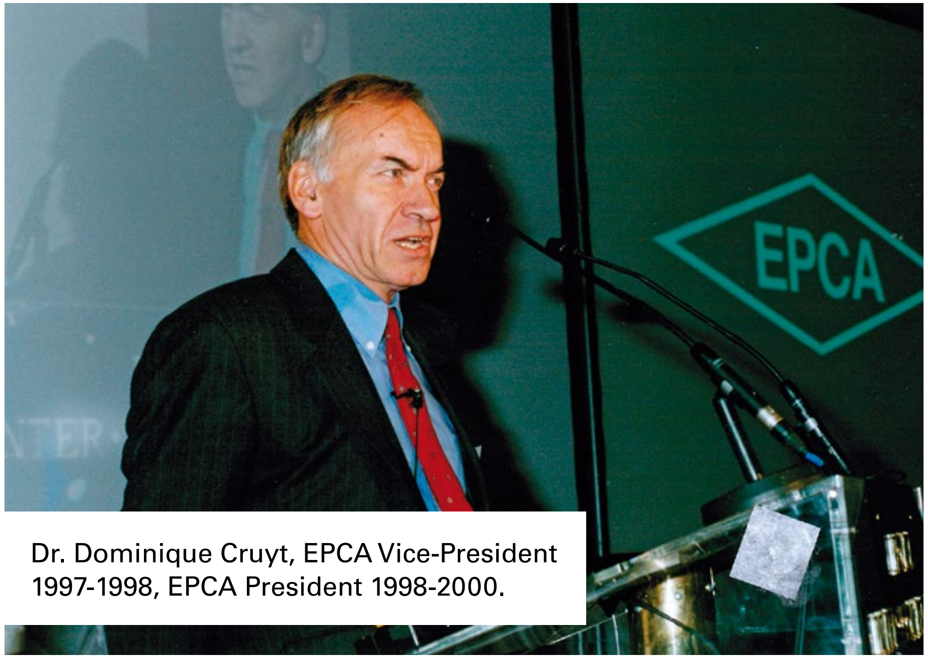
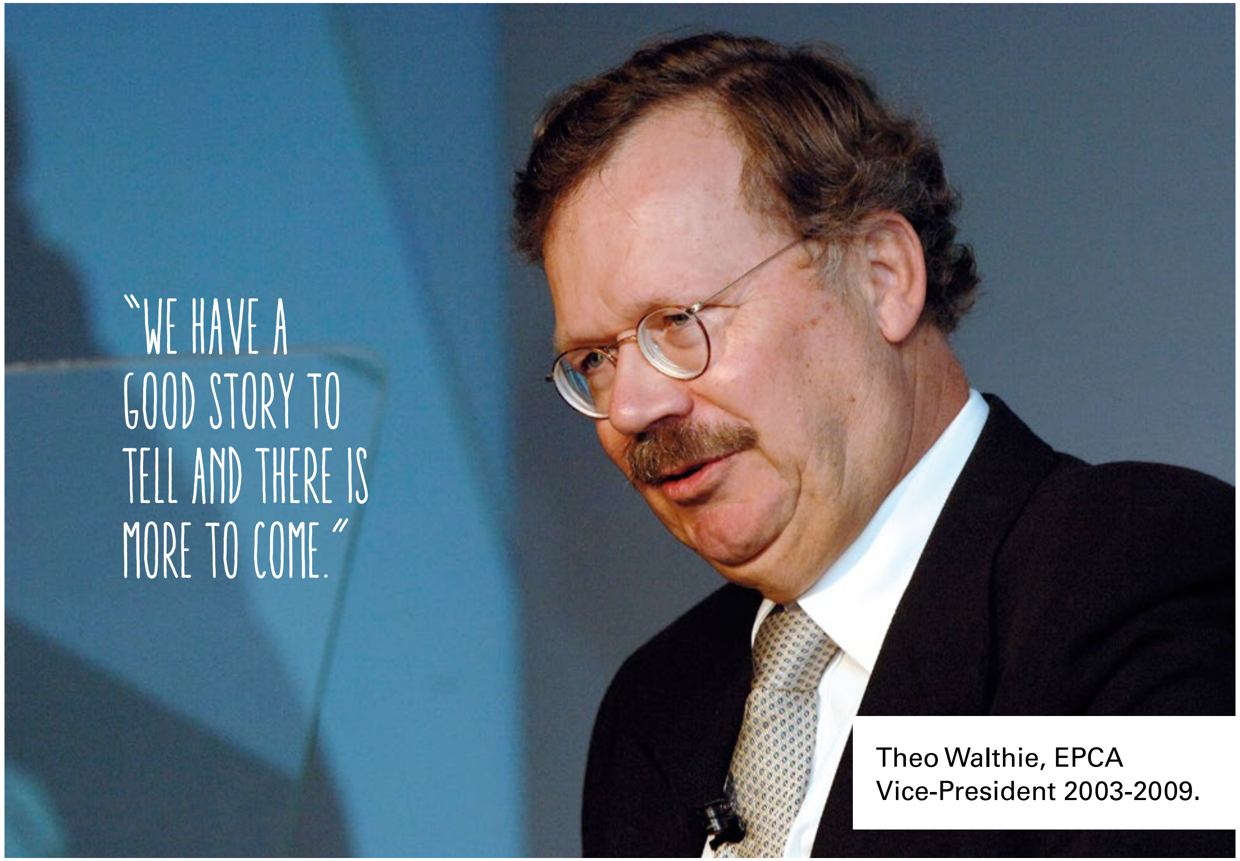


Dr. Dominique Cruyt, EPCA Vice-President 1997-1998, EPCA President 1998-2000.

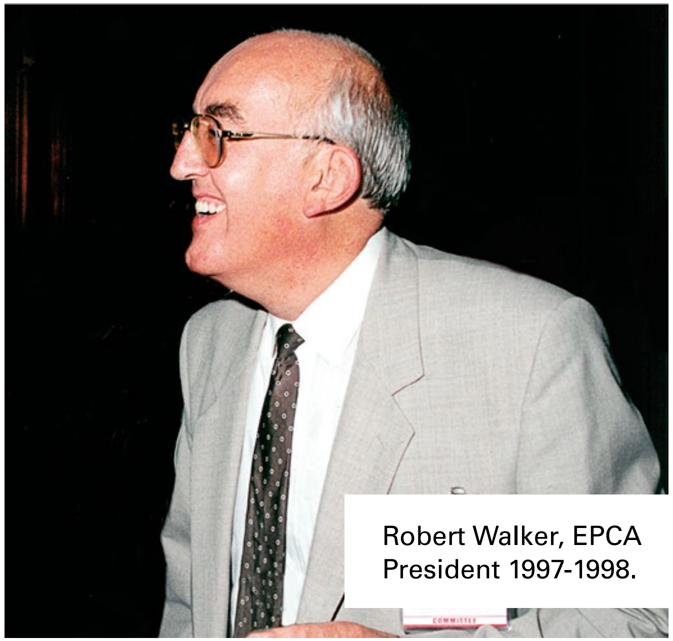
Dr. Albert Heuser,
EPCA President 2009-2010.

Boy Litjens, EPCA President 2006-2009.



Theo Walthie, EPCA Vice-President 2003-2009.

Dr. Walter Thuenker, EPCA President 2003-2006.



Robert Walker, EPCA President 1997-1998.

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EPCA speakers and panelists at the Logistics Committee lunch in October 2004, in front of the Hotel Hermitage in Monaco.

Paul Gooch, Member of the EPCA Logistics and Supply Chain Program Committee (SCPC).

EPCA PRESIDENTS

1989 - 1990
H. BJØNTEGÅRD
DYNO INDUSTRIER
Norway

1990 - 1995
DR. G. PORTA
ENI
Italy

1995 - 1997
J.H. KRUIT
DSM HYDROCARBONS
The Netherlands

1997 - 1998
DR. R.B.WALKER
ICI CHEMICALS & POLYMERS
United Kingdom

1998 - 2000
DR. W.D. CRUYT
PETROFINA
Belgium

2000 - 2003
R. WILLEMS
SHELL CHEMICALS
United Kingdom

2003 - 2006
DR. W. THÜNKER
DEUTSCHE BP/BP REFINING & PETROCHEMICALS
Germany

2006 - 2008
B. LITJENS
SABIC EUROPE
The Netherlands

EPCA VICE-PRESIDENTS

1989 - 1990
DR. G. PORTA
MONTEDISON
Italy

1990 - 1991
D. KEMPERMANN
CONDEA CHEMIE
Germany

1991 - 1992
F.A.G. COLLOT D'ESCURY
AKZO CHEMICALS
The Netherlands

1992 - 1993
DR. F. WEHMEIER
VEBA OEL
Germany

1992 - 1995
B. WILTZ
ELF ATOCHEM
France

1993 - 1995
J.H. KRUIT
DSM HYDROCARBONS
The Netherlands

1995 - 1997
DR. R.B. WALKER
ICI CHEMICALS & POLYMERS
United Kingdom

1997 - 1998
DR. W.D. CRUYT
PETROFINA
Belgium

1998 - 2000
J.-P. VETTIER
TOTALFINA
France

2000 - 2003
DR. W. THÜNKER
VEBA OEL
Germany

2003 - 2008
T. WALTHIE
THE DOW CHEMICAL CO.
Switzerland

EPCA TREASURERS

1990 - 1992
C. BOSMAN
CHEMGAS
The Netherlands

1992 - 1997
M. GISIGER
SGS
Switzerland

1997 - 2004
O. TANGERAAS
ODFJELL
Norway

2004 - 2008
J.A. HAMMER
ODFJELL
Norway

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CHAPTER 5

RECOVERY FROM RECESSION AND CONTINUED GLOBAL EXPANSION

2009 TO PRESENT

MARKET SHAKE-UPS AND A CHANGING INDUSTRY LANDSCAPE

The developed world, particularly in Europe, was the worst affected by the 2008 financial crash. Petrochemicals production dived in Western Europe. By 2015 it had still not recovered to its pre-2008 levels. But output recovered relatively quickly in the emerging economies, especially in China where the government introduced a number of measures to stimulate the economy. While demand fell in Europe, North America and Japan, it continued to surge ahead strongly elsewhere. Europe's share of the global chemicals market shrank further.

However, worldwide investment in petrochemical capacity was buoyant. In 2015 global investment in petrochemical projects in the planning through to construction stages was estimated to total around $500 billion, well above the historical average. The global petrochemical industry was confident that demand for its products in high growth regions like Asia would remain high as a result of relatively strong growth in GDP and a steady increase in the living standards of hundreds of thousands, possibly billions, of people.

A dramatic drop in crude oil prices which started in mid-2014 leading to prices below $40 per barrel by early 2016 helped to boost demand because of cheaper petrochemical prices. This was mainly due to a 30 percent drop in a year in feedstock costs. However, uncertainties about the future level of oil prices, especially fears that they might return to the highs of over $100 per barrel triggered a sudden drop in announcements of petrochemicals projects in the pre-planning phase, indicating there could be a lull in new capacity in the early 2020s.

Nonetheless the curbs on investment looked likely to be temporary with the petrochemical sector returning to its relentless growth in capacity once there were fewer doubts about the future direction of oil prices.

In the early 2010s, the development of the **US shale gas and shale oil boom** due to the successful combination of the technologies of horizontal drilling and hydraulic fracking has triggered one of the biggest seismic shifts in the whole history of the petrochemical industry. Not only has it rejuvenated US petrochemicals but it has also changed the whole balance of competitiveness in the global petrochemicals market.

Jan Van den Bergh, EPCA President 2013 – 2014.

CHINA, INDIA PRESS AHEAD WITH PETROCHEMICAL EXPANSIONS

The big drivers of expansion in the sector remained the two major engines of **demand growth in Asia** – China and India — with much of the supplies to meet demand coming from petrochemical imports. Even when China suffered the slowdown in GDP in early 2016 it dipped just below an annual rate of 7 percent while the economy of India was increasing by just over 7 percent.

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Lord Sebastian Coe presents an award to a participant of the EPCA-sponsored mini-marathon in Budapest in 2012.

China was pursuing ambitious plans for an almost doubling of ethylene capacity to 33 million tonnes a year by 2020 rising to 50 million tonnes by 2025. India also aimed to invest heavily in new petrochemical plants with some of the feedstock possibly from gasification of coal.

In the Middle East Gulf, Saudi Arabia continued with its plans for more petrochemicals capacity. But like its fellow member states in the GCC, such as the United Arab Emirates (UAE), Oman and Kuwait, a new priority was diversification to reduce dependence on oil revenues. The idea was that the GCC economies would consist more of manufacturing plants using petrochemical derivatives. A lower proportion of the GCC petrochemicals output would go into export markets, mainly of Asia, and more into local embryo industries like the making of electrical and electronic appliances, automobiles and car parts and healthcare products and equipment. Neighbouring Iran, however, which is not a GCC member, had in 2015 embarked on a massive programme of petrochemical expansion after the lifting of sanctions. Iran's state-owned National Petrochemical Company (NPC) announced plans to more than double petrochemicals capacity to 138 million tonnes a year by 2020 and to 180 million tonnes by 2025.

EUROPEAN PETROCHEMICALS COME UNDER NEW PRESSURE

The 2008 financial crisis left the European chemicals sector suffering an even greater loss in its share of the global chemicals market, particularly that of petrochemicals. Despite a recovery in sales, Europe's share of global chemicals production by value had fallen to just under 17 percent in 2013, compared with 32 percent in 1993. By 2030 the share was projected to go down further to 12 percent, according to a study by Cefic. EU chemical producers were even losing business to importers with its share of the domestic market going down from almost 87 percent in 2003 to 81 percent in 2013.

The **restructuring of the European petrochemical industry continued** with more long-established players withdrawing from the sector. In 2011, Belgian chemical company Solvay acquired French competitor Rhodia (the chemicals, fibers and polymers activities spun off from Rhône-Poulenc in 1998). Bayer in 2015 moved to spin off the last of its petrochemical-based businesses into a new independent company Covestro. In late 2015, DuPont and Dow announced plans to merge their

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Royal Vopak built many industrial tank terminals to facilitate flows in and out of petrochemical complexes.

"NEW RISING STARS WERE TAKING THEIR PLACE AMONG THE LEADERS OF A THRIVING GLOBAL PETROCHEMICAL SECTOR."

operations, and subsequently spin into three independent companies creating industry leaders in agriculture, material sciences and specialty products. With that, BASF is the only company from the petrochemical industry's early days to remain a leading operator in the sector today.

However, there were plenty of rising stars outside Europe and North America already taking their place among the leaders of a thriving global petrochemical sector. These included SABIC, Sinopec, Braskem and Reliance.

BASF's continued prominence in the sector was built on integration — in production and in know-how. This integration was also the major strength of the European chemical industry as a whole, particularly with petrochemicals, the production becoming even more deeply embedded into a series of clusters across Europe. The biggest of these were in the ports and hinterlands of Rotterdam and Antwerp. In fact these two clusters linked to the petrochemicals producing centres of North-Rhine-Westphalia in Germany accounted for around 40 percent of Europe's petrochemicals production. Europe's clusters provided a platform for distribution and marketing networks in the region which brought petrochemical producers into closer relationship with their customers than most other areas of the world.

US JOINS THE RANKS OF THE MAJOR PETROCHEMICALS EXPORTERS

The boom in the production of US shale oil and gas triggered a remarkable revival of the country's petrochemical sector. It went through a period in the early 2000s during which the country's trade surplus virtually disappeared. But it was faced with the prospect of an enormous trade surplus by the 2030s mostly stemming from the potential for a big rise in exports of bulk polymers and other petrochemicals.

In 2015 around 20 companies, many of them foreign, were planning to build new or expanded ethylene crackers based on low-cost shale ethane which would increase US capacity by two thirds in 2020 when they were scheduled to come on stream. Even if only half of the projects went ahead, a considerable proportion of the additional output — perhaps as much as 10 million tonnes a year in ethylene derivatives — would be exported to Asia, Latin America and Europe.

The major market would be Asia where they would compete with the region's naphtha-based crackers with a considerable advantage in feedstock costs. However in these markets their main rivals would be petrochemicals exporters from the Middle East Gulf. Their products would also be derived from ethane, but they would have little, if any, cost advantage over the US products.

In Europe, the first petrochemicals manufacturers that have planned to import ethane from the US have been Ineos, Borealis and Shell, while Reliance Industries in India is also planning to become an importer of US ethane.

The US and Middle East exporters would be confronting not only competition from domestic chemical producers but also a relatively new phenomenon of government policies aimed at making their countries self-sufficient in petrochemicals. Ironically, this would be a similar tendency to what prevailed in Europe in the 1950s and to a lesser extent 1960s with governments anxious to help their domestic petrochemicals producers gain the most benefits out of rapidly growing consumer demand.

China has been the most notable in Asia to be supporting moves to self-sufficiency. Others include Indonesia while Malaysia is aiming to considerably reduce its inflow of petrochemical imports. India has a long-term objective of self-sufficiency but analysts reckon this is unlikely to be achieved until well beyond the 2020s.

MORE DIRECT ROUTES FROM FEEDSTOCKS TO PETROCHEMICALS

Many of the new areas of R&D in petrochemicals were now focused on the **development of innovative processes** which shorten the routes between feedstocks and the final petrochemical products. These include further refinements to GTL, coal to olefins (CTO), methanol to olefins (MTO) and propane dehydration (PDH). But just how successful development work in these areas is will depend on the future level of oil prices. The production of petrochemicals from coal — which is an important part of the future industrialisation strategies of China and India — will benefit from a high oil price. Also, the production of derivatives from oil could depend on progress with carbon capture and sequestration (CCS) technologies.

One option is being moved forward by SABIC in Saudi Arabia with plans for a $30 billion oil-to-chemicals (OTC) scheme in Yanbu due to come on stream in late 2020. It would use technology for the direct production of chemicals from crude oil without the necessity for the traditional processing in refinery units.

One advantage of these technologies for emerging economies, particularly large ones like China and India, is that it helps them be more technologically independent without having to buy process licenses and engineering expertise from Western companies.

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EPCA EDUCATION PROJECTS –
EDUCATIONAL EVENTS AT EPCA MEETINGS

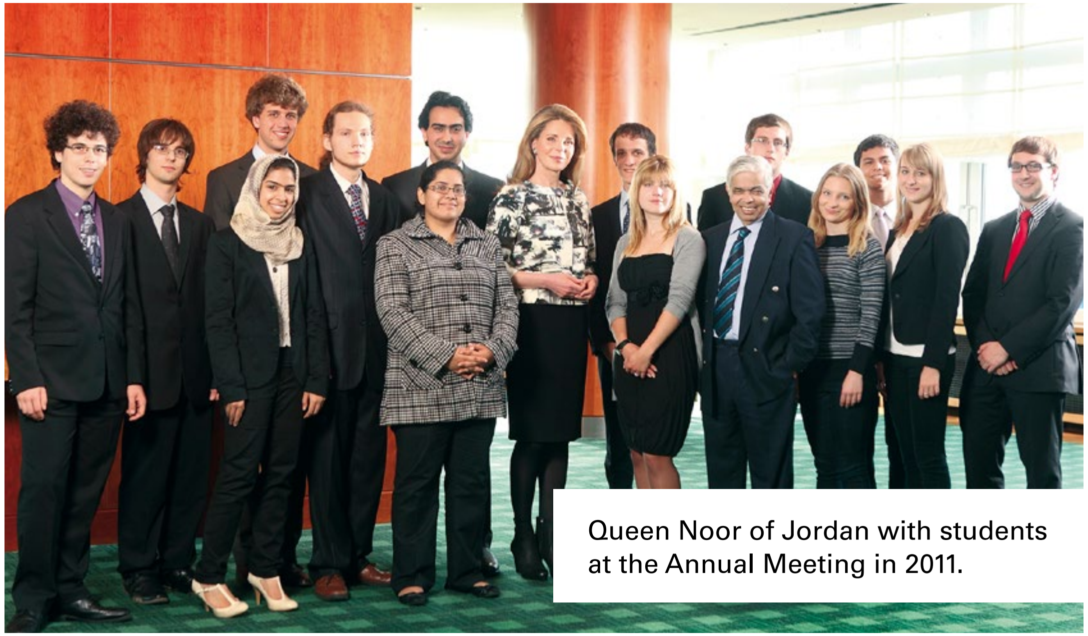
EPCA EDUCATION PROJECTS – EDUCATIONAL EVENTS AT EPCA MEETINGS

LOGISTICS RESHAPED TO SERVE NEW TRADING NETWORKS

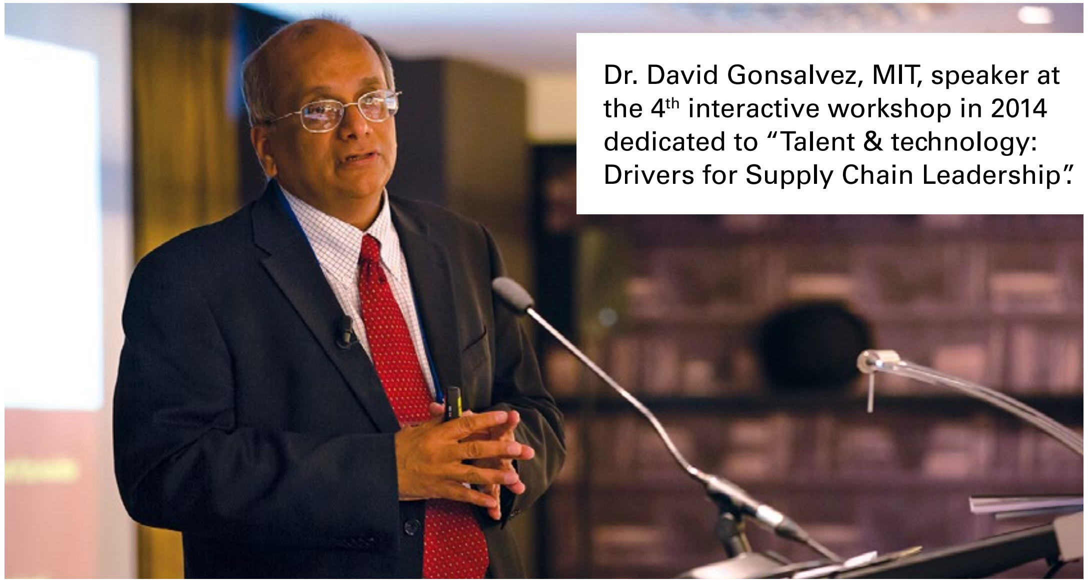
The big challenge in logistics and supply chain management has been to find ways of reducing costs with a choice of a wide range of IT tools while ensuring that supply chains do not become too complex. One major difficulty is matching supply systems based on bulk products to a growing trend downstream for a need for flexible production processes which can switch quickly between different grades with minimal downtimes. This is particularly happening among packaging converters, who have to respond to demands from retail chains for frequent changes in packaging design in line with their in-store marketing activities.
Also, online supply chain-tracking systems are generating large amounts of data which put pressure on petrochemical companies to speed up logistics and to reduce lead times for fulfilment of orders. This is often not easy in a sector with large production plants. Production lead times after the 2008 financial crisis lengthened, particularly in Europe, as a result of closures of plants which left scarcities in the supplies of some chemicals, making procurement more complicated.

Balancing inventory efficiency and the need to reduce costs has become a problem during a time of falling oil prices and with it fluctuating petrochemical prices. Often it has become necessary to hold back stock in order to take advantage of price changes. Thus, the extra cost involved in increasing the inventory times has to be offset against its financial price-related benefits.
At the same time production and inventory level planning has been made more difficult by sharp contrasts in growth rates in demand between the world's mature markets and the faster expanding emerging markets. Demand forecasting has become more complicated.
Other issues include the extension of IT activities from ERP systems to more web-based operations, like greater use of cloud facilities, and the extension of outsourcing to the handling of documentation. **Supply-chain-management (SCM) specialists** are expanding their activities to cover procurement, order capture and fulfilment, transportation, invoicing and payment, vendor inventory management (VIM), and terminals flow monitoring. The result is an opportunity for producers to have the advantages of more integrated supply chains.

Dr. Kurt Bock, Chairman of the Board of Executive Directors, BASF at the Annual Meeting in 2013.



Queen Noor of Jordan with students at the Annual Meeting in 2011.



Dr. David Gonsalvez, MIT, speaker at the 4th interactive workshop in 2014 dedicated to "Talent & technology: Drivers for Supply Chain Leadership".

Phil Browitt, Chairman EPCA Supply Chain Program Committee, EPCA Treasurer 2010 - 2011.

Data management has become a key element of these outsourced services. It can provide opportunities to expand sales from existing customers and to find new ones. Automation of as many processes as possible along the supply chain has become an important objective. And then there is the challenge of integrating them all in a single system and, with data, a single source of information.

Non-IT issues include the rapid rise in the growth of tank containers, particularly in China, now the world centre of container manufacturing. **Responsible Care is adopted more widely in chemical logistics**. Levels of CO_2 emissions in logistics chains become an even bigger challenge so that chains are beginning to compete on the basis of their carbon footprints.

ADJUSTING TO NEW INTERNATIONAL SUPPLY PATTERNS

Logistics service providers have had to adjust to new patterns of international supplies, particularly between Europe and Asia and to a lesser extent with the Middle East. More radical changes will be necessary once the US establishes itself as a major petrochemicals exporter. In the Middle East the petrochemical clusters have been getting even bigger. But at the same time there has been a massive programme in building **new roads and rail systems** so that there is more transportation of products between clusters. Also, as a result of economic diversification more petrochemicals need to be distributed to relatively small downstream manufacturers. In China there have also been big efforts to improve its transport infrastructure.

Globally the ports themselves have been developing international alliances which are forming the basis for global networks with the larger ports acting as hubs for other smaller ports and for inland logistics centres.

Changes in trading patterns have not just been confined to petrochemical products but have been embracing feedstocks as well. Ineos has been investing over $2 billion in a scheme to import low-cost US shale ethane to terminals in Scotland serving two ethane-based crackers at Grangemouth and nearby Mosmorran and another one in Rafnes, Norway.

More changes are expected with regard to feedstock supply chains. This will also lead to increasing volatility. Petrochemical supply chains will have to be capable to deal with this situation.

THE FINANCIAL CRISIS AND ITS AFTERMATH

GOVERNANCE

In the scope of its continuous improvement efforts and in order to create added value for its member companies, EPCA revisited its mission and strategy definition in 2008 and 2009 and in 2014 introduced a new Mission, Vision, Ambition, Values and Strategic Theme Definition.

In 2015 the EPCA Board issued a governance charter for EPCA explaining all EPCA governance topics, as completed by a risk-assessment tool and a manual book comprising 200 policies, all of which were approved by the Board.

After the merger of the Annual and Logistics Meetings in 2006 and the introduction of more service provider companies into the EPCA Board, the Logistics Committee as a statutory body was replaced in 2008 by the advisory **SUPPLY CHAIN PROGRAM COMMITTEE (SCPC)** at the same level as the Young EPCA Think Tank (YETT). The SCPC continues to develop the supply chain and logistics part of the Annual Meeting and to propose to the Board thought-provoking projects supporting the improvement in chemical supply chain management.

TALENT AND DIVERSITY INCLUSION COUNCIL (TDIC)

In 2015 the EPCA Talent and Diversity Inclusion Council (TDIC) was created as an advisory body to the Board to identify and promote diversity inclusion best practices developed in- and outside the chemical segment and make the business case for **diversity inclusion** in the chemical business community. Diversity is defined as difference in gender, age, nationality and culture/ethnicity.

EPCA AND DIVERSITY PROJECTS

Under the guidance of the TDIC, EPCA asked McKinsey to make on behalf of the EPCA Board a survey amongst leading EPCA member companies active in diversity inclusion initiatives in their respective organizations. The results of this enquiry were shared in the 2015 Diversity Inclusion session of the Annual Meeting and summarized in an EPCA article on "diversity matters" that can be downloaded from the website.

In 2016, EPCA takes this initiative one step further with Accenture delivering a speech during the diversity session of the 50th Annual Meeting. An article on the subject will be shared in- and outside the EPCA network.

LEARNINGS FROM ANNUAL MEETINGS 2009 - 2015

Two EPCA Annual Meetings were specifically **dedicated to the future**: in 2008, the Monaco meeting addressed "Chemicals on the Horizon 2030 and Beyond", and the Annual Meeting 2010 in Budapest looked at "Nine Billion People in 2050, the Chemical Industry as an Enabler of Sustainable Solutions".

However, the majority of the meetings during that period looked at the future, whilst underscoring the important link between energy, hydrocarbons and the industry that was positioned as contributing to sustainable solutions for all.

ENERGY, HYDROCARBONS, RENEWABLES AND THE CHEMICAL INDUSTRY

The important link between hydrocarbons, energy and the industry was brought up in the meetings of 2009, 2013 and 2014. Ample and affordable supplies of oil and gas were mentioned as a good reason to be positive about the future of the petrochemical industry in 2009 and 2013 respectively by then ExxonMobil Chemical President Steve Pryor and Dr. Kurt Bock, CEO of BASF.

They underlined the sustainable effect of renewables but agreed, with Prof. Niall Ferguson and Laurence A. Tisch Professor of History at Harvard University, that renewables are not a viable substitute for carbon-based fuels – coal, oil and gas – in a world where future energy demand will be escalating. In 2015, this was confirmed by Philippe Sauquet, President Refining & Chemicals and Member of the Executive Committee of Total who stressed that renewable energy has a bright future but will only represent 5 percent of the supply in 2040. However, the petrochemical and plastics value chain plays a crucial role for enabling solar energy generation.

The importance of oil and gas for global geopolitics and economics was highlighted by Pulitzer Prize winner Daniel Yergin, one of the world's most notorious experts on energy. Dr. Bock warned all people in the world to drastically change their lifestyle if emissions reduction targets are to be met on a global scale. He also called upon the industry to manage the risk of volatility of agricultural commodities.

SUSTAINABILITY

In 2009, a very "diverse" panel composed of, amongst others, Gerd Leipold, Executive Director of Greenpeace, and Joschka Fischer, Foreign Affairs Minister of Germany (1998-2005) and activist/ leader of the Green Party in Germany debated the double challenge of coping with the severe effects of the economic downturn whilst continuing to **embrace sustainability to fight climate change**. The conclusion was that the chemical industry provides sustainable solutions but should endeavour to be more pro-active rather than reactive when it comes to supporting access to alternative sources of energy and emission reductions.

In 2010 Columbia University Professor Jeffrey Sachs, Director of the Earth Institute, special advisor to the United Nations Secretary General and author of the "**Millennium Goals**" called upon the chemical industry to play a big role in the **transition to a low-carbon economy**, development of renewable energy, carbon capture and storage, electric vehicles and green buildings.

He furthermore asked the industry to bring about sustainable agriculture and clean water supplies, increase recycling and use technology to eliminate toxic pollutants. With the **signing of the COP 21 agreement** in Paris at the end of 2015, these recommendations remain valid and should be addressed in the debate about the future of the chemical industry.

In 2014, Prof. Joseph Stiglitz, winner of the 2001 Nobel Prize for Economics, highlighted that the growing income inequality in societies undermines economic performance and that a robust recovery is possible only when ordinary citizens have money to spend.

REPUTATION ENHANCEMENT, TALENT, TECHNOLOGY & INNOVATION

2011 marked the International Year of Chemistry (IYC) as well as the 45th anniversary of EPCA. On this occasion, Jeroen van der Veer, former CEO of Royal Dutch Shell, delivered a six-point focus for improving the reputation of the industry: achieve zero accidents, address public concern that fracking will contaminate drinking water, inform everyone that **the chemical industry is the innovator of bio-based feedstocks** and can develop modern materials from these feeds, continue the dialogue with governments to develop activities coping with societies' needs, and attract new talent by showing the big contribution the industry makes to society.

THE CLEAR LINK BETWEEN PEOPLE, COMPETITIVENESS AND INNOVATION

In 2012, the key role of leadership and people for innovation and business success was highlighted by the inspiring messages of, amongst others, Dr. Ajit Baron Shetty, former Janssen Pharmaceutica and Johnson & Johnson, Soumitra Dutta, Dean Samuel Curtis Johnson Graduale School of Management, Cornell University and John Kao, Past Chair of the World Economic Forum's Global Advisory Council on Innovation. To spur innovation, they recommend to use open communication platforms with input of customers, going digital and that "**creativity is a skill, not a wish**". In 2014, Graham van't Hoff, Executive Vice President of Shell Chemicals and Daniele Ferrari, CEO of Versalis and Matrica, gave recommendations on how to keep European petrochemicals competitive. Professor Xavier Sala i Martin, Chief Economist and Senior Director of the World Economic Forum (WEF), editor of the WEF Competitiveness Report, and Professor of Economics at Columbia University, mentioned the clear **link between competitiveness and innovation**. Recognizing there are many ideas that are generated by R&D, a lot are not implemented due to an overcautious approach to failure. His advice is that "**diversity generates innovation** and we should "learn from failure and embrace innovation".

Also, NATO Secretary General and former Prime Minister of Denmark (2001-2009) Anders Fogh Rasmussen marked in 2015 the importance of the digital transformation to bring economic value around the world.

EPCA EDUCATION PROJECTS

CARS AND CHEMISTRY – BERTHA BENZ, FIRST TEST PILOT

During the 2009 meeting, the opening event in the Mercedes World featured a joint EPCA-Cefic exhibition showing twelve Mercedes cars, each of them representing a milestone during the 125 years (1885-2010) evolution of the car industry and showing the **connection between the chemical and the automotive industry**.

As pedagogical support a brochure was developed and a comic strip published for youngsters and the general public. The brochure is based on the history of cars and petrochemicals and tells the story of Bertha Benz, wife of Carl Benz, inventor and maker of the **first gasoline-powered automobile**. Carl Benz, founder of Mercedes-Benz, indeed openly attributed his business success to his wife. We owe this comic strip and brochure to the contribution of past EPCA President Dr. Dominique Cruyt, former Total executive.

Prof. Condoleeza Rice, former US Secretary of State, promoted in 2009 education for all regardless of gender. Her Majesty Queen Noor of Jordan delivered a similar recommendation in 2011, as a means to combat poverty and protect the environment.

EPCA FILMS

The involvement of EPCA in the making of educational films and becoming a "global partner of the UNESCO", as well as a partner of European Schoolnet in Europe for the promotion of **STEM education (Science, Technology, Engineering and Mathematics)** started in 2011, International Year of Chemistry (IYC).
These educational activities in addition promote gender and cultural diversity inclusion and the chemical industry as a good industry to work for.
Three films have been made in this connection: **"Chemistry All about You"** (2011), **"Science: Where Can It Take You?"** (2013) and **"Petro and Chemistry: Partnership for a Better Life"** (2015) and were completed by 6 role model films, featuring young, talented men and women working for EPCA member companies and being active in EPCA advisory bodies (YETT and TDIC).

EDUCATION EVENTS AT ANNUAL MEETINGS

Since October 2011, each EPCA Annual Meeting has hosted an education event with students or teachers, and promoted one or more educational films made by EPCA for youngsters, their teachers and parents.
In 2011, **a students' workshop** with winners of the 2009 **UNESCO Chemistry Olympiad** contest was organized at the Annual Meeting in Berlin bringing together 14 students from all over the world and giving them the opportunity to learn about the chemical industry and bridge the gap between academia and the industry. The students met with the EPCA Past Presidents and Supply Chain Program Committee representatives to learn "from within" about the many different career opportunities.
On Sunday 7 October 2012, EPCA sponsored for the first time a **kids' marathon** (Budapest) reaching 93 schools and 4,300 youngsters in Hungary. Lord Sebastian Coe, Chair of the 2012 London Organizing Committee for the Olympic and Paralympic games, awarded the winning team of young runners. During the closing lunch, he explained how the chemical sector helped put sustainability at the heart of the 2012 games and urged the audience to **connect and engage with youngsters** using language and technology they understand.
In 2013, EPCA sponsored the kids' marathon of the world renowned Berlin marathon allowing a YETT member, who is also an athlete, to make the link between sports and chemistry. This event was widely covered in the local press together with the fact that the closing lunch was addressed by Bill Clinton, 42nd President of the United States and Founder of the Clinton Foundation. In 2014 EPCA brought the Belgian **learning vehicle XperiLAB.be®** to Vienna and put it at the entrance of the EPCA conference hotel. XperiLAB.be® is a learning laboratory on wheels that goes to schools and public places in order to give youth aged 10 to 14 the opportunity to visit the lab and understand the role science plays in everyday life. 729 pupils from 27 Austrian schools accompanied by 59 teachers were enthusiastic about their experience. An EPCA teachers' workshop was also organized.
In 2015, an education event was integrated in the program of the meeting in which youngsters aged 16 to 21 were present. Bertrand Piccard, Initiator and President of the **Solar Impulse** project, shared with the audience his passion for the airplane that flies only with solar energy, making clear links between solar and the petrochemical industry. This supported the message of EPCA's third educational film "Petro and Chemistry: Partnership for a Better Life" launched on the occasion of the Berlin 2015 mini-marathon, as well as the topics covered in the 49th Annual Meeting.
On the occasion of the 50th Annual Meeting in Budapest, the finals of the **European Youth Debating Competition** takes place in the main hotel and winners are awarded during the closing lunch.
This competition in 9 European countries aimed at boys and girls aged 16 to 19 years old is a joint project co-organized between EPCA, Plastics Europe and Young Leaders GmbH, and sponsored by EPCA.

EPCA AND SUPPLY CHAIN

FOUR INTERACTIVE SUPPLY CHAIN WORKSHOPS

Four **interactive supply chain workshops** took place during the period 2008 – 2016. These workshops broadened the previous EPCA workshop focus of promoting Responsible Care and European Land

Logistics "best practices", to addressing the improvement of supply chain management.

The first interactive workshop took place in Frankfurt on 2 and 3 March 2010 and was dedicated to **"Coming Out of the Economic Downturn"**, linked with managing "green" supply chains, echoing the theme of the 2009 Annual Meeting.

Delegates were advised to prepare for a volatile and unpredictable future and to look at the whole supply chain, from suppliers of products and logistics services, to producers, customers and even end-consumers. The fact that the chemical industry is at the center of all other industries was confirmed at this workshop. For **the "greening" of supply chains** the audience learned the importance of integrating environmental and corporate social responsibility reporting in production, procurement and customer delivery activities and that the industry needed to prepare for carbon reduction labelling and standards as well as auditing tools. On 15 and 16 March 2011 in Brussels during the workshop themed **"21st Century Supply Chains for the Chemical Industry"**, the audience was confronted with the increasing impact of the "Internet of Things" on logistics and supply chain management. Emeritus Professor Martin Christopher of Cranfield University in the UK mentioned the importance of managing resources sustainably and the need for the chemical industry to hire a workforce specialized in one discipline but with cross-functional skills. He translated Darwin's "survival of the fittest", into **"survival of the one who is most responsive to change".** An Ikea representative indicated the need for supply chain managers to develop sustainable products, gain carbon neutrality, turn waste into a resource and design a supply chain from **"cradle to cradle"** warning "chemical footprint" labeling requirements were to be expected from retailers and end-consumers.

In Frankfurt on 12 and 13 May 2012 the workshop on **"building resilient supply chains"**, proposed practical ways to implement the recommendations of the first two workshops. The use of scenarios for demand planning, especially unlikely events, was suggested. Examples were given on how to build resilience through partnerships, with due regard to competition law compliance. Differentiating service offerings by segmentation of customers without compromising scale benefits and complexity management was also recommended.

The fourth interactive workshop organized in Brussels on 2 and 3 June 2014 was dedicated to **"Talent & technology: Drivers for Supply Chain Leadership"**, based on the learning from the 46th Annual Meeting in Budapest of 2012. The audience was informed by representatives of EPCA member companies Dow and DAMCO about their respective company experience in developing the right talent for the different jobs and reaching corporate goals, with a specific **focus on diversity inclusion**.
The founding partner of Borderless Research shared with the audience the results of the 2014 EPCA/Borderless survey, which was conducted in the EPCA supply chain and logistics leaders' community on the topics of leadership, people and organizations. A key take away of his talk was the reluctance of the chemical industry to look for fresh ideas outside the industry.

Professor Marc Buelens of Vlerick Business School, quoting Sumantra Goshal, indicated "You cannot manage third generation strategies with second generation organizations and first generation managers". **The importance of people** in achieving revenue growth, improving performance and delivering results was highlighted and the Professor concluded that a third generation organization favors collaborative networks, transfer of **effective knowledge and game-changing innovation**. "If real progress is to be made on diversity inclusion, there is a need to put actionable policies in place".

The content of this workshop was much broader than supply chain and logistics issues and inspired the organization of the first "diversity matters" workshop during the 48th Annual Meeting in Vienna in October 2014 which resulted in the creation of the EPCA Talent and Diversity Inclusion Council (TDIC) on 10 June 2015.

2013 EPCA REPORT ON "SUSTAINABLE CHEMICAL SUPPLY AND LOGISTICS CHAINS, THE PATH FORWARD"

Following a leader's breakfast at the Annual Meeting of 2011 three "think tank" working groups were established in 2012. The selected issues were how to manage complexity and uncertainty in the supply chain, examine collaborative approaches and possible barriers against same, look at technological innovations coming from IT development as well as equipment improvement. Thirty-four practical cases coming from "real life" experience were brought to the working groups by participants; the cases were from in-and outside the chemical industry. The learning from these cases can easily be applied by supply chain practitioners in their daily operations and facilitate implementation of sustainability principles in chemical supply chain management and logistics.

The findings of the working groups were summarized in a single summary report containing a special section promoting the trailblazing work of the global chemical industry under the Responsible Care initiative and linking, under the ICCA Charter, this initiative with reaching the United Nations' sustainability goals.

This Charter was launched in 2006 at the first UN International Conference on Chemical Management and pushed the adherence to the Responsible Care and sustainability principles out of the chemical factory gate into the whole chemical supply chain. Worthwhile to note is that, as has been described in the period 1990-2008, with the input and support of EPCA, Cefic and ECTA, European chemical producers and logistics service providers already applied this approach 10 years before the launch of the ICCA Charter. In that perspective CDI and ICE have been integrated in the 2013 EPCA report as "best practice" cases.

It is widely accepted that the report proved to be a success. According to Paul Gooch, member of the **Supply Chain Program Committee** (SCPC), 'clients continue to eat up the findings of these reports. The case studies within the sustainability report are proving to have a long shelf-life, they are still being referenced and used as templates, three years after the report was published'.

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EPCA SPEAKERS

Anders Fogh Rasmussen, 12th Secretary General of NATO, 2009 - 2014.

Jeroen van der Veer, CEO Royal Dutch Shell, 2004 - 2009.

Gillian Tett, editor, author and columnist.

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EPCA SPEAKERS

Professor Xavier Sala i Martin, Chief Economist and Senior Director of the World Economic Forum.

Professor Condoleezza Rice, US Secretary of State, 2005 - 2009.

EPCA PRESIDENTS

2009 - 2010
DR. A. HEUSER
BASF
Germany

2010 - 2012
T. CROTTY
INEOS GROUP
United Kingdom

2013 - 2014
J. VAN DEN BERGH
EVONIK INDUSTRIES
Germany

2014 - present
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INEOS GROUP
United Kingdom

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THE DOW CHEMICAL CO.
Switzerland

2009 - 2010
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United Kingdom

2009 - 2010
J. P. BROEDERS
ROYAL VOPAK
The Netherlands

2010
O. GREINER
TOTAL PETROCHEMICALS & REFINING
Belgium

2009 - 2011
G. VAN'T HOFF
SHELL CHEMICALS
United Kingdom

2010 - 2013
J. A. HAMMER
ODFJELL
Norway

2012
J. VAN DEN BERGH
EVONIK INDUSTRIES
Germany

2011 - 2013
P. HOLICKI
DOW EUROPE
The Netherlands

2013 - 2014
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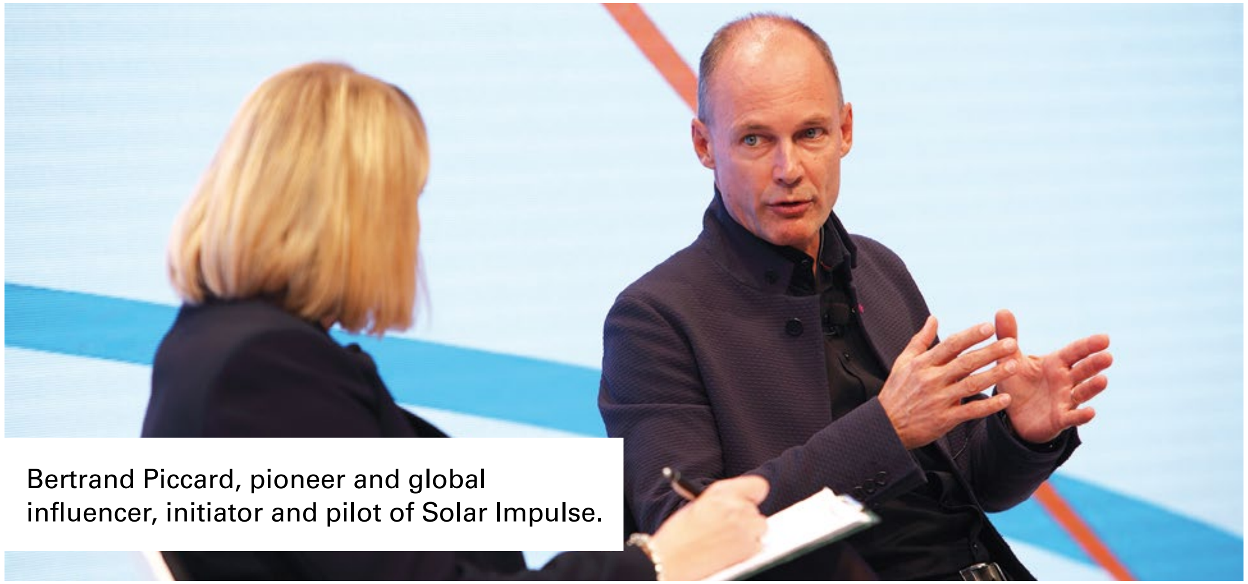
INEOS
United Kingdom

2014 - 2016
O. GREINER
TOTAL PETROCHEMICALS & REFIN-ING
Belgium

2014 - present
PROF. DR. R. DIERCKS
BASF
Germany

2016 - present
M. SCHULLER
ARKEMA
France

Solar Impulse, the first zero-fuel airplane, flying over Abu Dhabi (UAE).



Bertrand Piccard, pioneer and global influencer, initiator and pilot of Solar Impulse.

"THE SOLAR IMPULSE PROJECT WOULD NOT BE POSSIBLE WITHOUT THE SOLUTIONS PROVIDED BY THE PETROCHEMICAL INDUSTRY."

Bertrand Piccard

CONCLUSIONS OF 50 YEARS OF EPCA

Looking at the evolution of EPCA from its inception up to now, one can see the organization has become truly global and adapted to its customers' and stakeholders' requirements, led by a group of leaders who are members of the Board and advisory bodies which the Board has created. EPCA member companies are from all over the world and currently cover almost all segments in the chemical industry, inclusive of traders/distributors, logistics service provider companies and other service providers in the value chain, inclusive of ports and organizations which promote the chemical industry investments in their region.

Facts and figures are the best performance indicators. 50 years after the foundation of EPCA, the association has more than 730 member companies and nearly 3,000 annual meeting attendants, who "physically" join the EPCA network at least once a year. They come from all continents, literally "moving their offices" during the EPCA Annual Meeting. The organisation's financial situation is healthy and under control.

In the past two decades EPCA has clearly positioned itself as a service provider for its member companies and delegates, using total quality management methods of getting feedback from its customers. Such feedback is leveraged as a tool for continuous improvement delivering to individual delegates — wherever possible — customized solutions, within the scope of EPCA's meeting terms and conditions. In-sourcing of meeting administration was part of this exercise.

Though **one-to-one business meetings** are the driving force of EPCA's success, delegates who take the time to attend the business sessions appreciate the quality of speakers and content and the learning that can be gained from the discussions. Panel debates bringing together speakers with global reach from diverse backgrounds and who jointly analyse a central theme from different angles contribute to the development of EPCA's think-tank and transfer-of-learning capabilities.

EPCA's continuous communication and publication efforts make sure the **learning from key messages** is kept and delivered in a written report or other form that can be used as a source of inspiration for further study or reflection. Encouraging youngsters to embrace STEM education and to work for our industry is part of these efforts.

In the **Diversity Inclusion, Education and Supply Chain projects** selected by the EPCA Board the association endeavours to identify and promote best practices from inside and outside its network. These projects aim at supporting member companies in their continuous improvement initiatives, all of which are inspired by the principles of the **United Nations' Global Compact** and the Global **Chemical Industry's Responsible Care Program**.

The members of the the EPCA Board and advisory bodies act as ambassadors of EPCA initiatives in their respective organizations and help EPCA in evolving from exchanging views to delivering useful implementation examples for our member companies.

The continued professionalization of the organisation is in line with legal, governance, risk management and sound economic best practices. This contributes to the perpetuity of the association, supported by competent Board and advisory body members. All of the above team efforts help EPCA in promoting **the chemical industry as a good industry to work** for and as an innovative solution provider, responding, in a sustainable way, to the planet and its global population's evolving needs.

This is the **story of a passionate journey** with an innovative industry segment that supports the building of a better future for all.

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OUTLOOK

OPENING NEW HORIZONS

THE FUTURE OF THE PETROCHEMICAL INDUSTRY

WHAT IS NEXT?

What's ahead for the petrochemical industry? In order to paint a substantiated image of the future of the petrochemical industry and its service sectors an evaluation of several influencing factors is necessary. To get a broad overview considering economic, social, scientific, and other developments we interviewed a leading consultant, an academic, a former head of a major player's petrochemical operations and a chief executive of a leading logistics company. Here are their projections of the future global outlook for petrochemicals over the next 25 years.

PETER SPITZ, SENIOR ADVISOR TO ARTHUR D. LITTLE'S CHEMICAL PRACTICE, FOUNDER OF INTERNATIONAL CHEMICAL CONSULTANCY CHEMSYSTEMS, USA, AND AUTHOR OF THE BOOK "PETROCHEMICALS – THE RISE OF AN INDUSTRY" (1988).

Let me present a base case scenario, while recognizing that conventional wisdom and knowledge used for forecasting can be fallible (viz. the US shale gas boom which nobody foresaw).

The easiest part of my 25-year projection is to predict that, regardless of all future research in hydrocarbon conversion to petrochemicals, no new technology discovered during the forthcoming years will dramatically affect the structure of the global industry. There will be so much installed conventional capacity that no new process can obsolesce most of the existing players in the industry.

Direct methane coupling to ethylene, as currently being researched at Massachusetts Institute of Technology (MIT) and elsewhere, could conceivably lead to the construction of a number of new ethylene plants with somewhat better economics than current

The petrochemical industry is an enabler of sustainable solutions in the field of renewable energy.

Products of the petrochemical industry play a crucial role in innovative mobility concepts.

ethane crackers. That will put these new producers at the bottom of the "cost curve", with shale-based and other ethane crackers also still very competitive. But this will lead to some shutdowns of expensive liquid crackers.

However, the need for propylene, butenes and other liquid cracker by-products will keep many of these plants in operation. The same general argument about obsolescence can be made for possible new lower cost (e.g. one-step) technologies for styrene, phenol, and methanol-to-aromatics.

There will be more good news for existing petrochemicals in respect of possible competition from renewable feedstock-based key "petrochemicals". It is hard to see how these will displace hydrocarbon-based lower olefins and BTX aromatics — benzene, toluene, xylenes — for three important reasons:

Firstly, the economics of the two biomass conversion options — via fermentation and synthesis gas — are and will remain too expensive unless crude oil and natural gas prices permanently spike to very high levels. Secondly, rapidly increasing global demand for food will make it unlikely that corn, soybeans, and cane sugar will be diverted to chemical uses in quantities to displace current petrochemicals. Moreover, there will be increasing resistance by various groups to the use of food to make chemicals. Waste from crops is a less desirable feedstock in any case, which brings me to the third reason. It is difficult logistically and expensive to harvest and transport many thousands of tons of waste crops to a central plant (or more likely many plants) that would produce "petrochemicals" made the old fashioned way.

Finally, there is the question of shale gas in China, which has even larger shale resources than the US. It will start shale production at some point in the next few years. Little is known about the liquids content of Chinese shale gas. Many of the reserves are very deep. And there is the issue of water shortages. So, there are a number of imponderables. In my base case, some Chinese shale gas-based ethylene will reduce Chinese ethylene derivative imports into the country over the next 25 years.

"NO NEW TECHNOLOGY WILL DRAMATICALLY AFFECT THE STRUCTURE OF THE GLOBAL INDUSTRY."

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VERA ZAMAGNI, PROFESSOR OF ECONOMIC HISTORY, BOLOGNA UNIVERSITY, ITALY

Over the next 25 years there will be changes in the location of bulk chemicals plants, like those for petrochemicals. In my opinion, Europe and the USA will maintain a few commodity chemical plants owned by a few giant companies. But most of the commodities, such as petrochemicals, will be produced elsewhere. Demand will be growing mostly outside Europe and the USA — in Asia in particular. In specialties Europe and the US will continue to be global leaders, but not necessarily through huge corporations. There will also be an increase in diversification of feedstocks away from crude oil derivatives. European and American producers will increasingly have to take into account environmental issues.

"DEMAND WILL BE GROWING MOSTLY OUTSIDE EUROPE AND THE USA – IN ASIA IN PARTICULAR."

WERNER PRAETORIUS, FORMER PRESIDENT BASF GLOBAL PETROCHEMICALS, MEMBER OF THE BOARD OF EPCA AND THE ASSOCIATION OF PETROCHEMICAL PRODUCERS EUROPE (APPE).

Petrochemicals are and will remain essential for modern life and prosperity in developed societies. We are surrounded by innovative products and life style solutions which are only made possible through petrochemical products and building blocks. For good reasons, petrochemicals are called the "immortal products" as they are the enablers for a vast variety of industrial and consumer goods.

While the technologies and processes for petrochemicals have matured with only limited potential for further raw materials and energy savings, the industry will continue to be highly flexible and innovative in terms of adapting these technologies and processes to changing feedstock and energy situations.

From a consumption point of view, growth will remain limited in the developed economies of North America and Western Europe. However, there is still huge growth potential in many parts of Asia, Eastern Europe, South America and even Africa. China's economic development has shown what can be done in realising this potential. But it will not be an easy task.

"PETROCHEMICALS ARE AND WILL REMAIN ESSENTIAL FOR MODERN LIFE AND PROSPERITY."

Supply Chain Program Committee (SCPC) meeting.

TOM CROTTY, DIRECTOR CORPORATE AFFAIRS, COMMUNICATIONS AND BUSINESS DEVELOPMENT NEW TERRITORIES OF INEOS, EPCA PRESIDENT 2010 - 2012 AND 2014 - PRESENT

The big change in the global petrochemical sector in the 4-5 years in which I have been EPCA President has been the shale gas boom in the US and its impact on US industry. It has meant that the Middle East will no longer be the world's only petrochemicals production centre with low-cost feedstocks. Low-cost petrochemicals will be imported into Asia, the world's main regional petrochemicals market, from both the Middle East and the US. It will be a big challenge for Europe's petrochemical industry as well because Europe will also be seen by both Middle East and US petrochemical exporters as a market for their products.

US shale will also have other repercussions. Shale ethane is already being shipped across the Atlantic to the UK to be used as a petrochemical feedstock, cheaper than any available in Europe. Reliance, the big Indian petrochemicals producer, is also planning to ship shale ethane into India. Shale gas will also soon be produced outside the US. At Ineos we believe that will happen in the UK. There's still public resistance in the country but we hope that will change after Brexit. There could be opportunities in other European countries like Germany and France. The extent of production outside the US will depend on extraction costs which will be influenced by technology developments.

The availability of shale gas will put a cap on crude oil prices and as a result petrochemical feedstock costs. We won't see a return to high oil prices in the near future. One big advantage of shale is that its production levels are very responsive to market conditions. Output can be subtly tuned to current demand. There will be no big changes in sources of feedstocks, e.g. between fossil fuels and bio sources. Biomass won't be able to compete on costs. But petrochemicals will help combat climate change by providing the plastics and materials needed for light-weighting of low energy-consuming vehicles and for wind turbine and solar panels to provide renewable energy.

The petrochemical sector in the developed world will continue to be dominated by large companies able to operate on a big scale and carry out consolidations of parts of the petrochemical sector like those done successfully by Ineos and Huntsman Corporation. The other end of the spectrum will be occupied by small companies supplying niche markets with specialty petrochemical derivatives. There will be few opportunities for medium-sized players. Most of the big international oil companies will continue to pull back from petrochemicals production because they don't see much long-term potential in it. But in the Middle East and Asia the corporate trends will be much the same as they were in the 1960s and 1970s in North America and Western Europe, where oil companies had a major role in the petrochemical sector. We're likely to see companies like Saudi Arabia's state oil company Saudi Aramco become a major players in petrochemicals. In China Sinopec could emerge as a strong global force in petrochemicals.

Overall the future is looking very bright for the industry. There will be plenty of demand, especially in the developing world with petrochemicals helping to improve people's standard of living. But the industry will have to do more to explain to people the extent to which petrochemicals have a positive impact on their lives and that, above all, they can make a huge contribution to the fight against climate change.

"PETROCHEMICALS CAN MAKE A HUGE CONTRIBUTION TO THE FIGHT AGAINST CLIMATE CHANGE."

Tom Crotty

REIN WILLEMS, FORMER PRESIDENT OF SHELL NEDERLAND, FORMER LEAD OF NETHERLANDS' TOP SECTOR CHEMISTRY AND FORMER CHAIRMAN OF THE ASSOCIATION OF DUTCH CHEMICAL INDUSTRY (VNCI), EPCA PRESIDENT 2000 - 2003

The chemical industry will undergo big changes in the future, essentially because of the pressing need to reduce CO_2 emissions and the changes taking place in the energy industry.

Natural gas will take a growing share of fossil fuel consumption to become an increasingly important part of the fossil-fuel energy mix. Coal's share will not rise, while the share of gas will possibly overtake that of oil.

Nonetheless demand for energy will still grow so that in 2100 it will be double the present level. Hence the transition to non-fossil fuels will not immediately result in weakening demand for fossil fuels. According to figures from organizations like the International Energy Agency, total fossil fuel will drop from 80 percent of the energy mix in 2010 to 65 - 67 percent in 2050 with total energy demand growing by more than 50 percent over that period.

As petrochemicals demand will continue to grow, the share of fossil fuel processing going into petrochemical feedstocks will rise at the expense of that for producing transport fuel. However the petrochemical industry will have to face pressures to reduce CO_2 emissions. The industry will have to cooperate much more strongly in aspects such as eliminating heat waste in petrochemical sites, CO_2 capture, process intensification technologies and the need to use renewable energy in chemical processes.

We will see in the next 10 to 20 years a growth in biobased chemical products but these will not be developed by the large petrochemical firms. Instead new companies — and some existing chemical players — will expand the biobased sector. Petrochemical players will continue to play a big role basically with ethane and propylene and the aromatic-based chemicals — benzene, toluene, xylene (BTX). The newcomers will challenge the global players by being more cost conscious and focused.

However dramatic changes are unlikely. Global crude prices will not return to the $100-per-barrel levels. They will be capped by the relatively low cost of shale oil and gas.

Current patterns in the trading and distribution of petrochemicals will be maintained but there will be increasing use of IT technologies. There may even be a revival of e-commerce in petrochemicals.

In other words petrochemicals have a bright and challenging future. EPCA will continue to play its contributing role with the help of chief executives like Cathy Demeestere. They will have to stand on the shoulders of a giant lady. Thanks Cathy!

"THE CHEMICAL INDUSTRY WILL UNDERGO BIG CHANGES IN THE FUTURE."

HANS-JÖRG BERTSCHI, CHIEF EXECUTIVE AND CHAIRMAN, GLOBAL LOGISTICS COMPANY BERTSCHI GROUP, SWITZERLAND

The future of logistics in the chemical industry will be very dynamic and fascinating. Several trends will shape this future. 3-D printers might reduce the need for some transportation of finished products. However, for a chemicals industry which is based on intermediate products, globalisation will be the trendsetter. The industry is a regional industry currently developing into a global industry. In 2000, only 5 percent of chemical products were exchanged between the regions. Today it is about 10 percent. Experts estimate that by the year 2020 it will be 20 percent. What a great challenge for our industry!

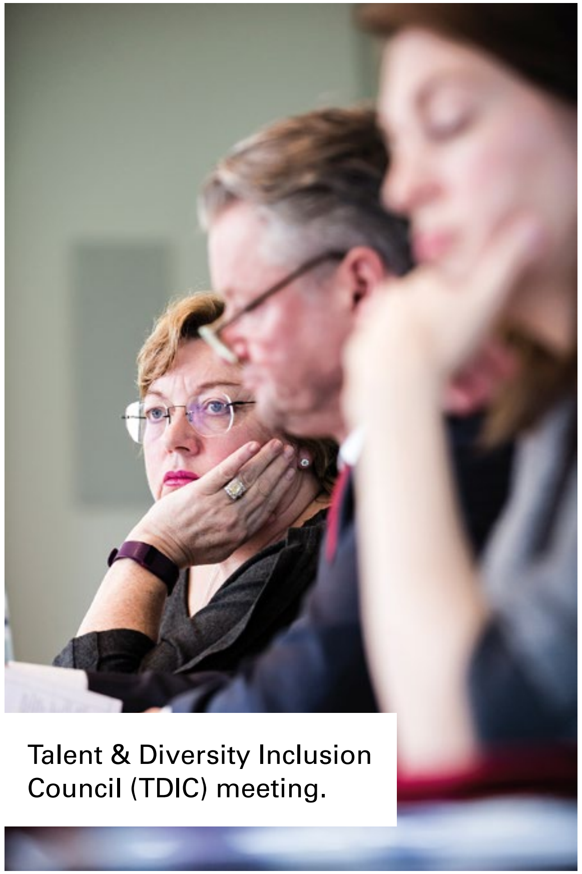
Global chemical supply chains are by their nature very complex given the characteristics of what are often hazardous products. In emerging economies, operational safety and environmental problems are a very major issue in chemical supply chains. A lot of management attention, training and investments will be required to overcome these huge challenges over the next two decades.

The Internet of Things (IoT) — the network connectivity allowing exchange of data between objects — will make transport equipment, infrastructure and also the products themselves smart and communicative. New supply chain management concepts and solutions will emerge based on distributed and mobile intelligence.

Whilst some older petrochemical plants in Europe might disappear in the coming decades, our continent has a tremendous opportunity to be the future powerhouse for the development and production of sophisticated speciality chemicals. Innovation, global market orientation and strong cultural influences, as well as an experienced chemicals workforce, will play an important role here. The same ingredients will probably be the key for the future success of the European chemical logistics sector in the world. I do see a bright future for our sector — we have the best opportunities to be leading global players in even more globalised markets in two decades. What a great sector to work for!

"OPERATIONAL SAFETY AND ENVIRONMENTAL PROBLEMS ARE A MAJOR ISSUE IN CHEMICAL SUPPLY CHAINS."

"WHAT A GREAT SECTOR TO WORK FOR!"



Talent & Diversity Inclusion Council (TDIC) meeting.

EPCA AND THE FUTURE

CATHY DEMEESTERE, CEO, EUROPEAN PETROCHEMICAL ASSOCIATION (EPCA), BRUSSELS, BELGIUM

The continued success of EPCA meetings, seminars, working groups and workshops demonstrates the need for people to "physically" meet in order to know and appreciate each other better and to build trustworthy and respectful business relationships. The events also offer delegates the opportunity to get access to speakers and content they normally would not come across in their day-to-day business, thus, opening new horizons of thought and providing timely information about the next "big thing" that may impact their operations and business success.

Whatever the current and future technological (r)evolution, opinion makers and leaders from all horizons, whether these are academics, politicians, artists or captains of industry, recommend building empathy and collaborative approaches between all stakeholders to achieve lasting results.

Therefore, networking organizations like EPCA that facilitate these "physical" encounters and deliver "food for thought" have a bright future, provided they are managed with the same governance principles as companies quoted on the stock exchange and there is a fruitful cooperation between the association and its member companies. By embracing diversity and innovation, challenging "business as usual" for continuous improvement and aligning with customers' requirements, they add value for their members and stakeholders.

As President Bill Clinton told the audience at the EPCA Annual Meeting in 2013: "we are all in this together".

"NETWORKING ORGANIZATIONS LIKE EPCA HAVE A BRIGHT FUTURE."

Young EPCA Think Tank (YETT) meeting.

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GLOSSARY

ACC	American Chemistry Council
APLA	Latin-American Petrochemical Association
ARG	Aethylen-Rohrleitungs-Gesellschaft
ASEAN	Association of Southeast Asian Nations
BP	British Petroleum
BTX	Benzene, Toluene, Xylene
CCS	Carbon Capture and Sequestration
Cefic	European Chemical Industry Council
CMA	Chemical Manufacturers' Association (USA)
COMECON	Council for Mutual Economic Assistance
CTO	Coal-To-Olefins
ECRTA	European Chemical Road Transportation Association
ECTA	European Chemical Transport Association
EPA	Environmental Protection Agency
EPCA	European Petrochemical Association
ERP	Enterprise Resource Planning
ETS	Emissions Trading System
FDI	Foreign Direct Investment
GCC	Gulf Cooperation Council
GPCA	Gulf Petrochemical Association
GTL	Gas-To-Liquids
HDPE	High-Density Polyethylene
HSE	Health, Safety and Environment
IMCO	Inter-Governmental Maritime Consultative Organisation
IMO	International Maritime Organisation
LDPE	Low-Density Polyethylene
MARPOL	International Convention for the Prevention of Pollution from Ships
MRP	Manufacturing Planning Tools
MTO	Methanol-To-Olefins
NAFTA	North American Free Trade Agreement
NGO	Non-Governmental Organisation
NPRA	National Petroleum Refiners Association
OPEC	Organisation of Petroleum Exporting Countries
OTC	Oil-To-Chemicals
PMMA	Polymethyl methacrylate
PVC	Polyvinyl Chloride
R&D	Research and Development
REACH	Registration, Evaluation, Authorisation and restriction of Chemicals
SBR	Styrene-Butadiene Rubber
SCPC	Supply Chain Program Committee
SEF	Specialist Engineering Firms
SQAS	Safety and Quality Assessment System
STEM	Science, Technology, Engineering and Mathematics
TDIC	Talent and Diversity Inclusion Council
UAE	United Arab Emirates
YETT	Young EPCA Think Tank

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EPCA The European Petrochemical Association A.I.S.B.L./I.V.Z.W.
Avenue de Tervueren 270 Tervurenlaan
1150 Brussels /Belgium
T +32 2 741 86 60 / F +32 2 741 86 80
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