Shell Chemicals

What does the future hold for the C6 aromatics chain?

A global perspective from a global benzene and styrene producer

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Alexander Farina

Alexander Farina joined Shell in 1990 with a Masters degree in chemical engineering from Munich's University of Technology to take up the role of Quality Manager and later Manufacturing Manager in Shell's automotive supply venture in Germany.

Between 1994 and 2000 he worked in Shell's elastomers business covering roles from research and development to marketing, including Global Business Manager for the Isoprene Rubbers Business. During this time he had postings in Brussels, London and Paris.

In 2000, Alexander was appointed venture manager of Shell's e-business and technology venture capital fund before returning in 2003 to the chemicals business as Strategy Manager for the Phenol and Solvents business.

In 2006, he was appointed as Strategy Manager for Base Chemicals with the focus on restructuring the North American Base Chemicals Business.

Alexander was appointed General Manager Chemicals strategy in June 2009 and joined the Chemicals Leadership Team. He is also responsible for Chemicals technology activities.

Alexander is married with two daughters. He lives in The Hague and his hobbies include horse riding and skiing.

Introduction

After two-and-a-half tough years for the C6 aromatics value chain, my intention today is to offer some optimism for the long-term future of this business. And while for many of us business conditions remain difficult, throughout the industry there is a feeling that better times are coming.

As most of you know, Shell is a global producer and supplier of benzene, styrene and phenol-acetone, the key building blocks for the C6 chain. Having over many years built a world-scale, world-class manufacturing network, our strategy is focused on sustaining and strengthening our position as a global industry leader.

So why are we optimistic?

Mainly because further along the C6 chain our major customers and their customers are confident that the materials and products made from or with aromatics will continue to be in demand, with new applications driving growth in a number of markets.

There are numerous and complex challenges to be met, some relating to competition, others to supply, cost or sustainability issues. But, there are also significant opportunities for future growth if the supply chain remains flexible, competitive and creative.

Using a broad brush, I am going to paint an impressionistic overview of the outlook for the C6 aromatics chain through 2011 and beyond. I will be looking at demand drivers, reviewing some industry-wide issues and challenges, then offering a brief summary of Shell's response to market developments and our strategy for staying competitive before concluding.

Demand drivers

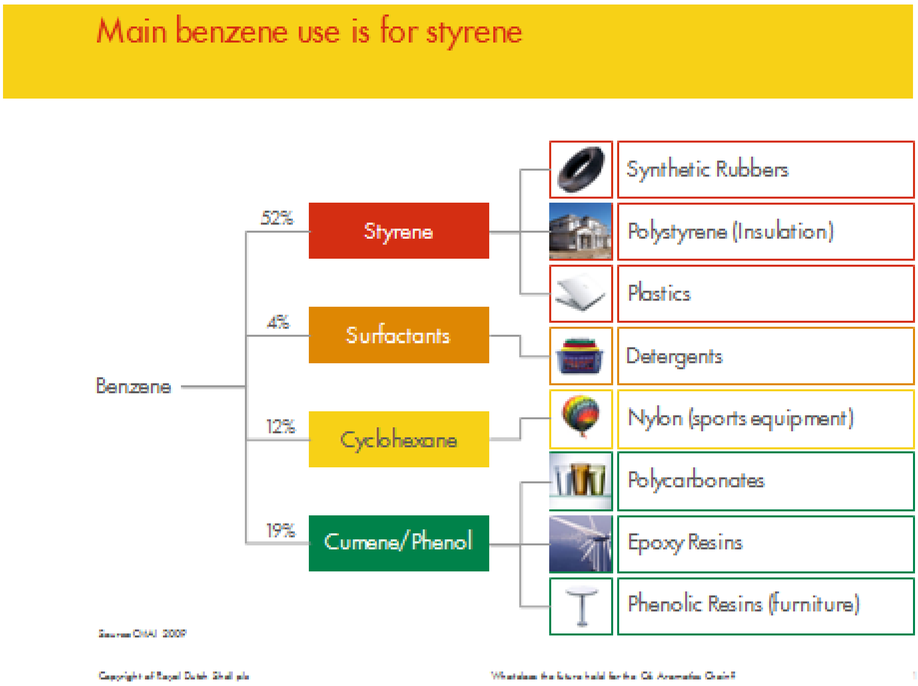
Today, aromatics are the precursors for an incredibly diverse range of everyday and essential plastics, fibres, foams and resins that are used in automotive manufacturing, construction, clothing, appliances, IT equipment, cleaning products and pharmaceuticals. New uses and applications continue to be developed. What's more, many of these products can enhance energy economy – by providing insulation or weight reduction, or both – and help to reduce CO_2 emissions.

Like most petrochemicals, aromatics suffered major demand disruptions in the wake of the global financial and economic meltdown, which occurred in late 2008. Global styrene producers, for example, are still grappling with average industry operating rates around 85 per cent, happily up from a post-1990 low in 2009 of 82 per cent. And while phenol operating rates perked up to an estimated 85 per cent in 2010, back in 2009 they averaged around 75 per cent.

Thankfully, industry indicators continue to suggest strengthening demand.

Let's take a closer look at current and future demand for benzene and its derivatives.

In 2010, estimated global benzene demand was around 41 million tonnes, of which 4.5 million tonnes were traded between regions.



Currently, styrene production accounts for 52 per cent of this, with main downstream uses in polystyrene, synthetic rubbers and plastics for applications ranging from household appliances and white goods, to IT products, automotive parts and insulation products for the construction sector.

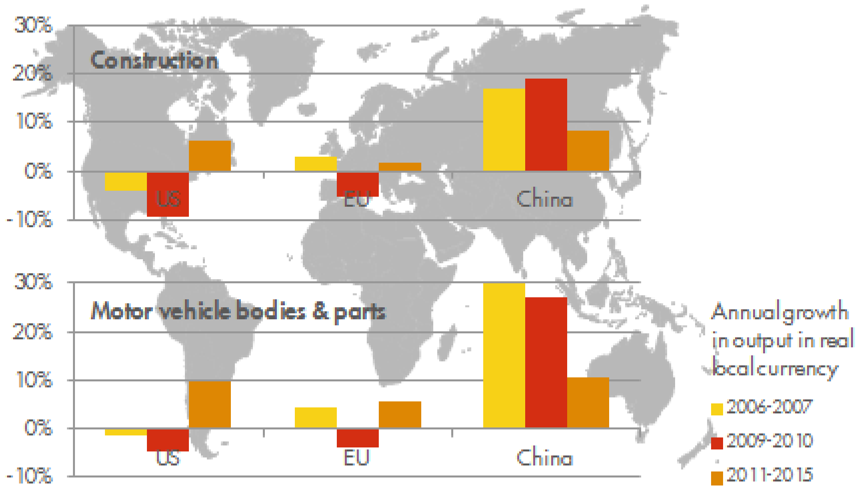
Around 20 per cent of benzene is used – via cumene and phenol – to produce both phenolic resins, used to make furniture and construction boards, and polycarbonates, which have wide industrial applications and considerable growth potential.

Another 12 per cent is used for cyclohexane to make nylon, primarily for sports and leisure products. About 3 per cent is used in detergent surfactants.

Since late 2008, two key C6 end-use markets – automotive manufacturing and construction – have been in a deep trough. But it is in these two key end-use markets, which are now slowly recovering, where much of the future growth in C6 value chain demand is likely to emerge.

In large part, this will be because C6-derived products have the properties to meet the needs of a low-carbon and high energy cost world. Their low-weight and insulating properties can deliver significant reductions in energy consumption, which in turn lowers CO_2 emissions.

Chinese automotive and construction industry recovered quickly to pre-crisis levels



Meanwhile, the "processibility" properties of C6 products are enabling designers to engineer a variety of stronger, more flexible parts and products that meet the needs of a wide range of manufacturing industries.

Given the importance of the styrenics chain for benzene, let us take a closer look at what is likely to drive future demand.

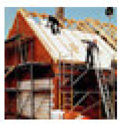
We see good long-term prospects for EPS due to its excellent insulating properties. In a world seeking a major reduction in its carbon footprint, we expect renewed demand growth in the construction sector – in both new builds and refurbishments.

Excellent insulation properties of EPS drive strong demand growth in construction

Use of EPS in CONSTRUCTION
(8% AAGR NE Asia 2010-2015)

Insulation:
- Floor, ceiling and wall insulation
- Mobile homes

Other:
- Floatation Devices
- Road Construction



Use of EPS in PACKAGING
(3% AAGR NE Asia 2010-2015)

Transportation protection:
- Consumer goods, electronic items
- Plant trays, toys

Thermal protection:
- Fish and dairy products
- Pharmaceutical goods

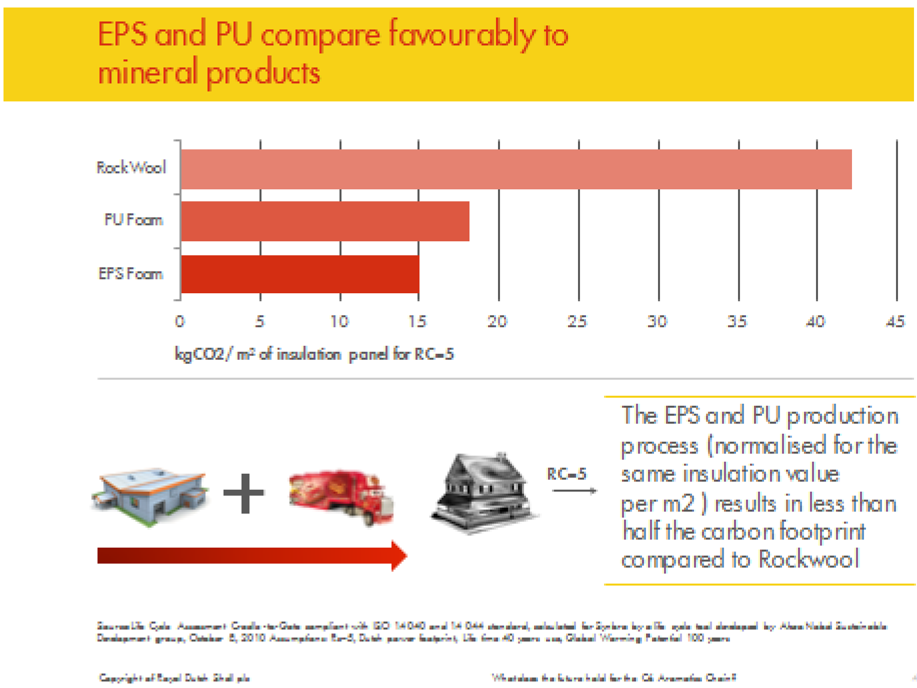
Not only does EPS insulation significantly reduce heat lost by buildings in cold climates, lowering energy demand for heating, in hot climates it can help keep buildings cool, reducing energy usage for air-conditioning.

It is estimated that the energy used to produce polystyrene foam insulation for a typical house is recovered after only one year through energy savings.

With buildings accounting for up to 40 per cent of energy use globally, the potential contribution of insulation to energy efficiency, and therefore lower CO2 emissions, is significant. Some estimates suggest that 20 per cent of current world energy consumption could be saved if all new buildings were energy efficient.

At this point, I should also mention polyurethane (PU) foams, which are widely used for insulation in both construction and domestic appliances, such as refrigerators. Benzene is used in the production of polyols, an essential ingredient in PU manufacturing, of which Shell is a major producer.

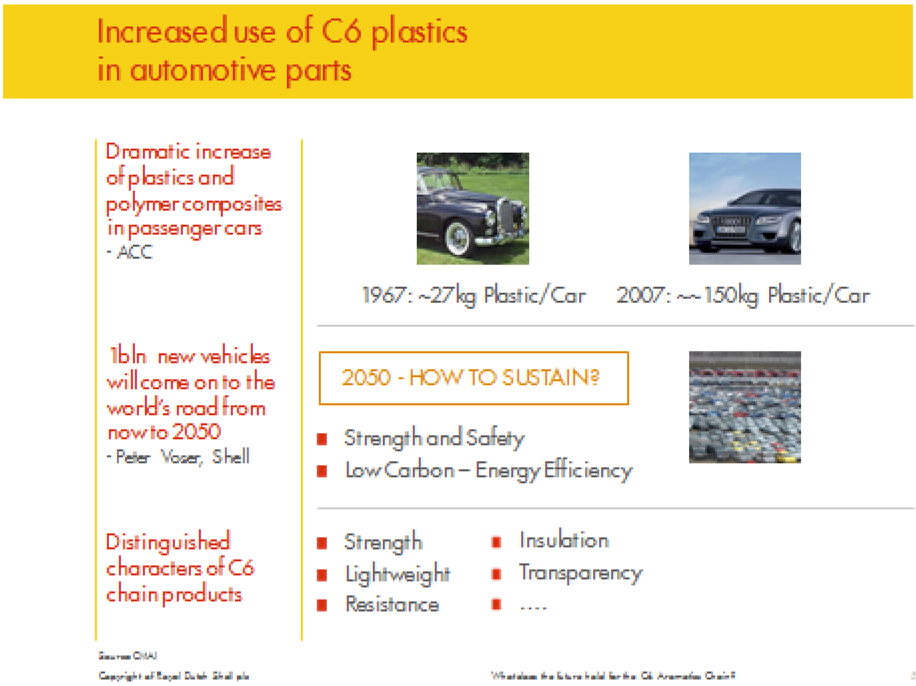
The performance of these chemical insulation products compares favourably to mineral products like Rockwool. Carbon intensity data for insulation panels made from EPS, standard polyurethane and Rockwool, calculated for Synbra by a life-cycle tool developed by Akzo Nobel, show that both EPS and polyurethane production results in less than half the carbon footprint (expressed as CO2-equivalent per m2 of insulation panel with Rc 5) compared to Rockwool.



According to the July 2009 International Chemicals Councils Association report, Innovations for Greenhouse Gas Reduction, insulation of buildings using chemicals industry products – primarily

EPS, extruded polystyrene and polyurethane – was almost 2.1 Gigatons of CO2-equivalent in 2005. This equates to 40 per cent of the total CO2 emissions savings enabled by chemical industry products.

Staying on the low-carbon track, another source of optimism is the fact that the automotive industry's use of polymers and composite materials has been rising steadily for over 40 years. A wide variety of styrenic polymers and polyurethanes are all widely used in automotive applications.



In 2009, an American Chemistry Council (ACC) report estimated that the use of plastics and polymer composites in a typical passenger car rose from 27kg to over 150kg in the 40-year period to 2007.

Just 15 years ago, a leading automotive OEM executive was telling his and our industry that steel is for cars, aluminium is for aeroplanes, and plastics are for toys.

Yet the ACC now reckons that by the end of this decade it is quite possible "the automotive industry and society will recognise plastics as a preferred material solution that meets, and in many cases, is the benchmark for automotive performance and sustainability requirements".

Why? Because these products – many of them from the C6 value chain – offer a wide range of desirable characteristics, including strength; processability; light weight; resistance to chemicals, corrosion and harsh environments; thermal and electrical insulation; thermal and electrical conductivity; transparency; translucence; opacity; size and shape; and cost-effectiveness.

According to the ACC, over 50 per cent of a typical car's volume comprises polymers and composites, but only 10 per cent of the weight. What's more, they estimate that plastics – through "light-weighting" – help reduce energy consumption in the US passenger vehicle fleet by 88 million barrels of oil-equivalent (BOE) each year, preventing 30 million tons of CO_2 emissions.

Last year, Shell CEO Peter Voser suggested that "between now and 2050, one billion new vehicles will come on to the world's roads, mostly in Asia, more than doubling today's total." That is a lot of cars needing a lot of plastics.

There is also increasing interest in the strength and safety qualities of automotive plastics, highlighted by the development of heavily plastics- and composite-reliant aeroplanes. Plastics also offer significantly increased design and engineering flexibility over metals and glass, while impact-resistant and lighter weight plastics or composite materials offer better passenger protection and safety.

But what, you may ask, does this mean for the C6 chain specifically?

Well, at Shell we estimate that the proportion of C6 value chain products going into the automotive sector is currently around 15 per cent globally, with virtually no difference between the regions.

A good example of a benzene-derived product that is winning a bigger share of the weight and performance market is polycarbonate.

Already the largest volume engineering plastic, polycarbonate has enjoyed strong demand growth due to its combination of strength, low weight, thermal stability and – for some applications – excellent polymer clarity.

Annual global polycarbonate demand climbed above 3 million tonnes in 2010, and is growing at 6 per cent per year.

Although demand growth in CDs and optical media has slowed, applications in automotive components, electronics and sheeting or film are increasing rapidly.

Automotive glazing demand is growing particularly fast. Polycarbonate is already used in headlamp, fog lamp and tailgate lenses, roof modules and fixed side windows in cars and trucks.

Development of scratch-resistant multi-layer polycarbonates is expected to drive wider use in both automotive and construction sector applications. Polycarbonate offers weight savings over glass, more design options and much easier handling. Some manufacturers are using polycarbonate rear windows, and are optimistic that it may soon be used in windscreens. It is already widely used in motorcycle windshields due to its weight and safety benefits.

I will come back to polycarbonate later on when I talk about Shell's strategy for aromatics. For now, the message is that there are good ongoing demand prospects for the C6 value chain, but the players along the value chain will need to work together to develop the products that take advantage of the performance and design properties of C6-based products, and particularly those addressing solutions for a low-carbon future.

For the period 2011-2015, Shell and CMAI estimate potential annual benzene demand growth of 3.8 per cent, which is underpinned by derivates demand growth, including 3.7 per cent for styrene, 3.7 per cent for cumene/phenol and aniline (2.1 per cent).

Challenges

Now, having offered reasons for optimism in the long-term demand outlook for the C6 value chain, there are also some challenges.

Let us start with benzene. My message today is that while benzene will be characterised by supply and price volatility, nevertheless, for reasons that will become clear, it remains competitive.

From a 1990s market awash with benzene, supply tightened significantly during the first decade of this century.

Why was that? Well, in response to tightening mogas regulations, supply had been heavily impacted by the steady closure or mothballing of many of the toluene hydrodealkylation units that once provided "on purpose" production and "swing capacity". Since then, benzene output has been mainly determined by gasoline manufacture and naphtha cracking, both of which generate benzene as a by-product.

Before 2005, on-purpose swing capacity could add 20 per cent to other benzene production. Today, it is nominally about four per cent, but practically non-existent.

Back in 2005, a Shell colleague speculated on whether the severe reduction in swing capacity would – at some point – create the need for new, on-purpose benzene supply if incremental fatal supply remained unavailable. Well, to-date, it has not, and the jury is still out on if and when that may happen.

New benzene capacity has come on-stream, but only as by-product of other manufacturing processes. In Asia-Pacific, new steam crackers and aromatics plants will have added around 4.5 million tonnes of benzene capacity by 2015, while in the same period the Middle East is expected to have added 1.2 million tonnes, three quarters of which will be refinery-derived.

In both North America and Europe, benzene capacity expansion has been limited by the lack of demand growth for ethylene and paraxylene, although some 600,000 tons per year of additional benzene has been released in response to the MSAT regulations, stipulating a reduction in benzene levels in gasoline.

In Central and Eastern Europe, capacity addition is limited as both regions currently have surplus benzene.

Supply of aromatics feed has also been impacted by a number of factors including the shift towards lighter cracker diets, the relatively poor demand for polyolefins through late 2008 and 2009, and falls in gasoline demand. All of these have reduced supply of pygas and reformate.

Current estimates suggest that benzene capacity may rise by just over two per cent a year, but annual demand growth will be about three per cent.

One of the consequences of the loss of swing capacity is that benzene supply has shown a tendency to very quickly move from short to long or vice versa, depending on demand for olefins and transport fuels.

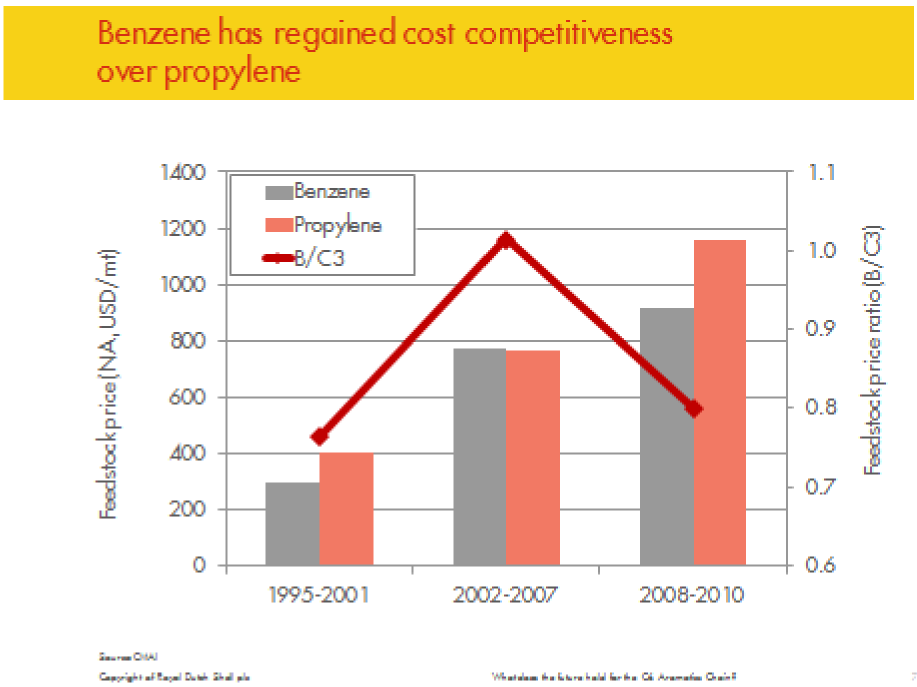
In combination with high and fluctuating crude prices, the knock-on effect has been to make benzene prices much more volatile.

Current estimates suggest that benzene capacity may rise by just over two per cent a year, but annual demand growth will be about three per cent.

Price volatility has made life very difficult for all of us throughout the value chain as we try to plan ahead and stay competitive while managing key materials costs that can vary by up to 30 per cent month to month.

One of the ways the industry has dealt with this volatility is by moving away from quarterly pricing to monthly adjustments. While monthly pricing does not fully mitigate price volatility, it does afford more rapid correction to upstream cost drivers, such as crude and naphtha prices, and enables much more rapid adjustments in cash management.

However, there is more good news on the price front. Having seen a five-year cost advantage over propylene slowly slip away about 10 years ago, the post recession period has seen benzene regain this competitive edge, which has strengthened the cost position of PS against PP.



Equally encouraging is that fact substitution of PS by PP seems to have reached a plateau, and estimates suggest global styrene demand will grow around three per cent per annum to 2020.

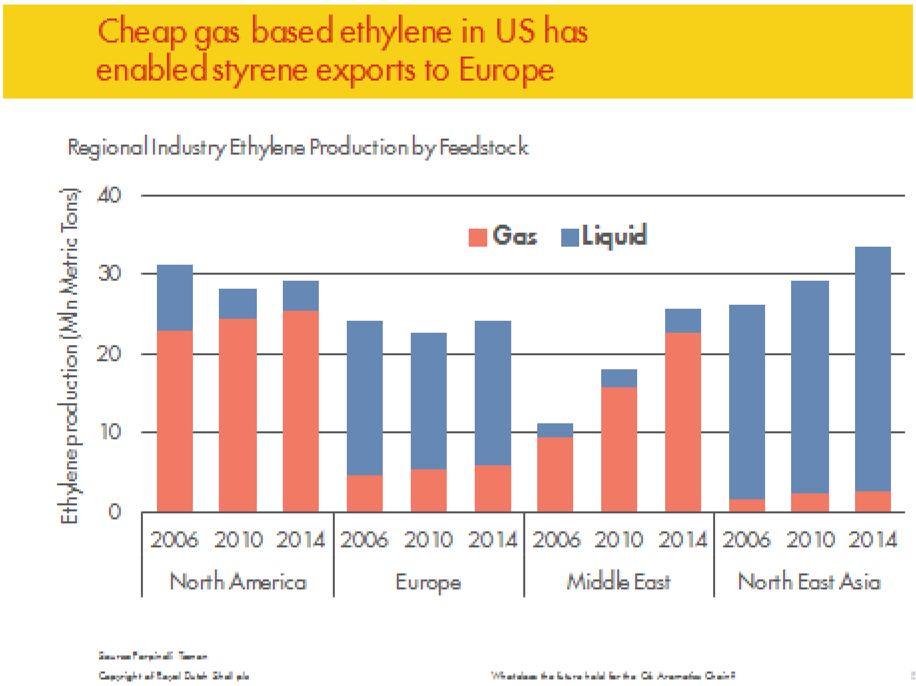
Reports from Asia confirm that further PS substitution is no longer an issue. There are ongoing challenges for PS in North America and Europe, where perhaps up to one-third of each market could be vulnerable to PP, but only with increased investment in production capacity for the latter. Substitution is not a threat to construction market-focused PS products – particularly insulation – where long-term demand outlook is good in both new build and refurbishment. There are other uses – such as snap-off multipacks for foods like yoghurts – where PS is clearly the material of choice.

Another consequence of the trend towards lighter cracker feed-slates is less C4 production, which has impacted butadiene costs for ABS producers.

In 2010, European butadiene prices rose higher than ethylene for the first time ever, and US prices jumped by nearly 50 per cent between January and July last year. In large part, this is due to liquids cracking struggling to compete with ethane-based US and Middle Eastern crackers, thereby cutting availability of butadiene, which is dependent on heavy liquid feedstock. As a result, butadiene is very tight in the US.

To-date, increased butadiene prices has however not impacted ABS/SBR demand. There are several reasons for this. Due to its performance and processing properties ABS is not easily substitutable – by alternatives such as PP or high-impact PS – and it still has a cost advantage over polycarbonate. Butadiene is also a relatively small cost component of ABS – at about 15 per cent. And finally, ABS end-uses tend to be in high-price products – ranging from automotive parts to musical instruments, golf club heads to luggage – where materials are only a small proportion of total costs.

Another issue impacting the C6 chain is differences in regional ethylene pricing.

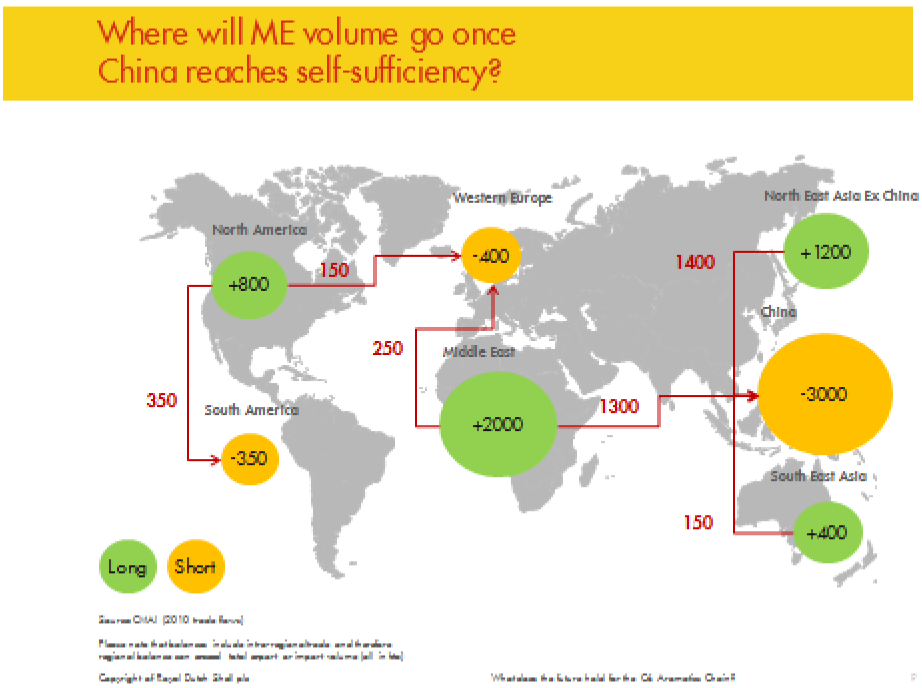


Until about three years ago, relatively high ethane prices were seriously undermining the competitiveness of US styrene production. However, with a significant fall in ethane costs, US competitiveness has completely turned around, enabling US styrene producers to revitalise some underused capacity and to export significant tonnages to Europe.

Globally, styrene is currently long. With CMAI calculating average industry operating rates at about 86 per cent, I am sure we all long for the golden days of 2004, when they were close to 95 per cent.

The good news for styrene is that only between 1-1.5 million tonnes of new capacity is announced to come on-stream after 2010, which is equivalent to demand growth for just one year. Operating rates are expected to recover steadily through 2011 and beyond.

Currently, virtually all Middle Eastern styrene is absorbed by Asia-Pacific, primarily China, while some European demand is being met by US imports. However, should China ever reach its self-sufficiency target, then low-cost Middle East production could heap pressures on European manufacturers.



Like styrene, phenol has also taken a hammering since 2008. At one point, global industry average operating rates fell close to 75 per cent, but through 2010 and into this year demand has been more buoyant. Over the longer term, phenol demand is expected to grow by around five per cent a year, mainly on increased demand for BPA for polycarbonate and epoxy resins. But new capacity coming on stream will mean fierce competition.

Industry developments and competition are constantly driving structural changes in our industry, and we are witnessing widespread and ongoing industry restructuring as some plants – mainly older, small-scale units – are closed, while some long-established players like Dow have sold their businesses, or – like BASF – are putting them into new, stand-alone structures. Overall, the balance of manufacturing is shifting from the West to Asia-Pacific.

Shell, too, has been reducing its refining footprint worldwide and we have recently announced plans to rationalise assets, which will impact aromatics production in Europe. However, with the opening of our new complex in Singapore, we have increased benzene production in Asia-Pacific, reflecting demand growth in that region. I will offer a few more Shell-specific examples of how we are responding to industry changes and competition in a moment. But I want to finish this section with a brief look at health, safety and environment.

Health, safety and environment (HSE)-related challenges will require close monitoring. The potential hazards of benzene and its derivatives are known and recognised by industry and regulators alike, but our record of safety and stewardship through production and distribution to downstream manufacturing, and end-use utility, means broad acceptance for the risk management of C6 derivatives.

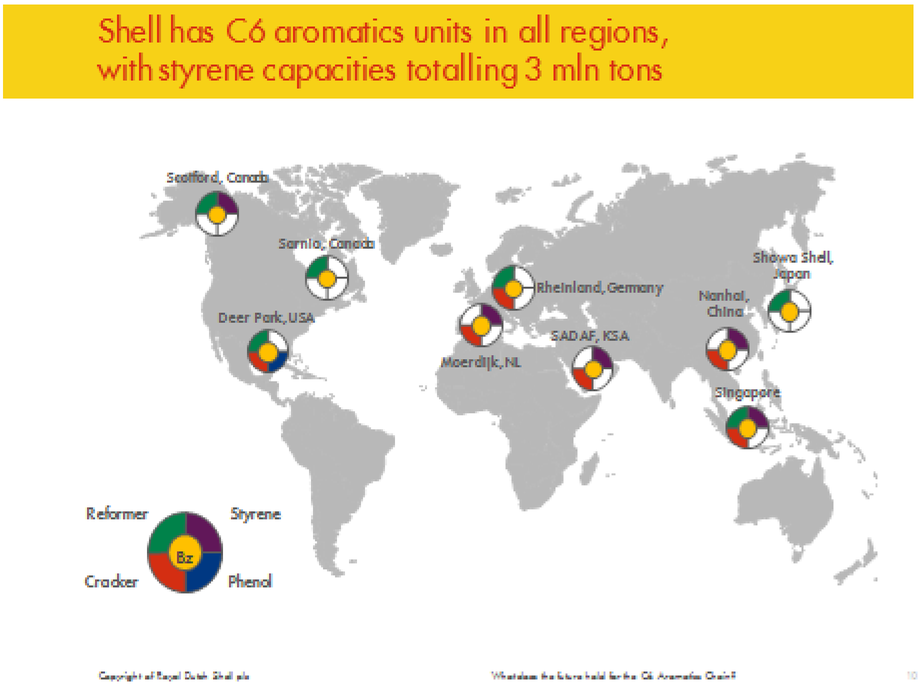
For the industry, the best response to HSE concerns is to continue our close engagement with ongoing and long-term research into the potential hazards and risks relating to our products. Industry organisations like CEFIC in Europe and ACC in the US play a key role in developing a sound understanding of these hazards and risks and advising on responses the industry should take. Shell fully subscribes to the positions that these organisations have taken in terms of the potential issues related to styrene and other products of the C6 chain. It is essential that we continue to press the case for a science-based response to regulation, and to promote the beneficial societal impacts of our products.

Having looked at some of the broader opportunities and challenges facing the C6 chain, I want to provide a brief outline of Shell's aromatics operations to illustrate how we are responding to the challenges the industry faces and endeavouring to remain competitive from our location at the start of the C6 value chain. I don't want to suggest what we are doing is unique, but rather to offer some concrete examples of the approaches Shell and others are taking to remain competitive.

It is essential that we continue to press the case for a science-based response to regulation, and to promote the beneficial societal impacts of our products.

Shell: staying competitive in the C6 chain

As you can see from this chart, Shell's global C6 manufacturing network is closely aligned with refining to maximise the oil-chemical advantage.



Our chemicals businesses are focused on upgrading hydrocarbons in close integration with upstream and refining, but we are not involved further down the value chain.

For aromatics, our strategy is quite simple:

Optimise the integration advantages of being a member of a global energy major.

Remain a low-cost global producer with world-scale world-class manufacturing assets, and a leading reliable supplier strengthening long-term relationships with our customers.

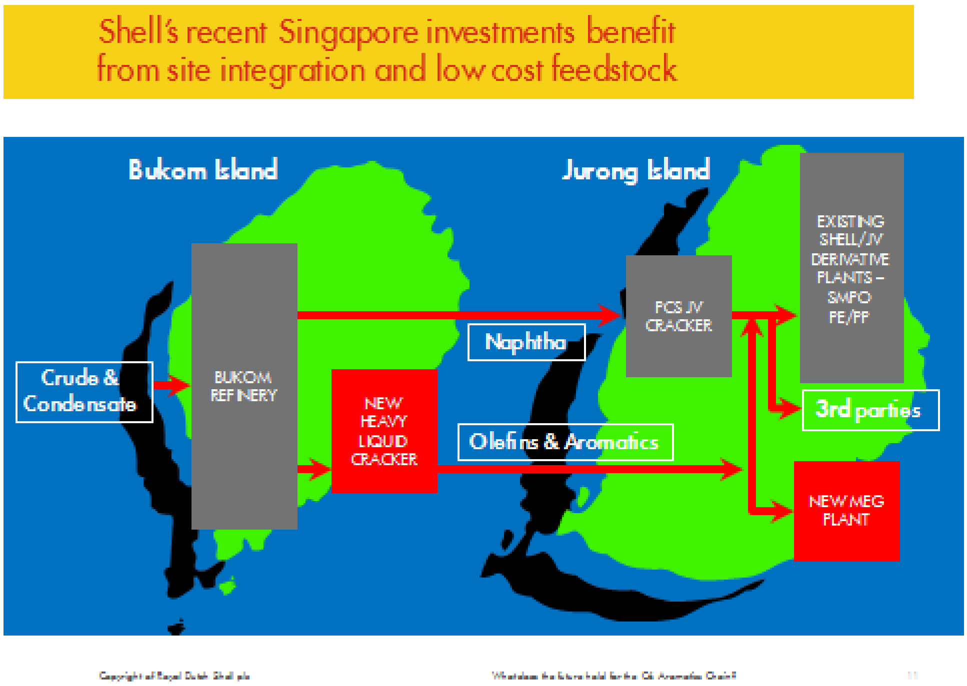
And finally to continue to target outstanding HSSE performance, including product stewardship, in all our activities.

We all know remaining competitive is essential to sustainable success, so I want to finish by looking at three areas of activity within Shell, because I think they will mirror the industry-wide pursuit of competitiveness.

As I mentioned earlier, Shell has for many years pursued a manufacturing strategy based on low-cost feedstock and close integration with upstream and refining activities to optimise both upstream-chemicals and oil-chemicals advantage.

This means concentrating our asset base in major regional hubs to ensure we can optimise feedstock through hydrocarbon upgrading and benefit from on-site integration.

In May last year, Shell completed its largest-ever petrochemicals investment in Singapore – a new world-scale cracker located on Singapore's Bukom Island and one of the world's largest MEG plants on Jurong Island. The new plants are strategically located to take advantage of existing infrastructure and to ensure that maximum benefits are achieved by integrating the petrochemical site with Shell's largest global refinery on Bukom Island.



Within Shell, we think we have combined most of these advantages at the Moerdijk facility in the Netherlands and at Deer Park, in the USA.

At Moerdijk, the new benzene unit is world-scale, integrated with the cracker, and almost all of the output is consumed on-site in the styrene unit.

At our Deer Park manufacturing hub in the US, we have world-scale phenol production supplied from on-site propylene and benzene feeds. Cumene and phenol-acetone production are also co-located, and we have extensive pipeline distribution to customers.

Finding smarter, more efficient routes to existing products drives innovation and technology across the industry. Within Shell, we always seek to enhance production process efficiency, and wherever possible focus development on "game-changing" technologies.

Since introducing our proprietary SMPO production process, Shell has maintained its technology leadership, and we are constantly seeking to boost its competitiveness.

More recently, while pursuing this agenda Shell technologists in the US and The Netherlands have developed advantaged, phosgene-free process chemistry with the potential to create a more sustainable route to producing diphenyl carbonate (DPC), a key raw material for polycarbonates used in everything from space helmets and laptop computers to car headlights and mobile phones. We are currently evaluating the technology with our customers, and the early indications are very positive.

As you may know, Shell is a global leader in natural gas. As one of the leading global benzene marketers, we are developing promising technologies to convert gas streams to aromatics, which will give us a competitive edge and support our growth. Although in early stages of development, these technologies are expected to mature by decade's end, providing Shell with advantaged gas-based technologies to produce aromatics.

Leadership in HSSE

Leadership in HSSE is important to both Shell and to our customers, particularly when transporting and processing potentially hazardous products. Like most of you, Shell is constantly looking to raise performance, reduce our environmental footprint and to co-operate with customers along the supply chain to enhance our overall stewardship of aromatics.

As individual companies and members of the chemical industry, it is essential that we all retain the trust of regulators and society at large. That's why Shell has maintained a high profile and leadership position in response to the EU's REACH initiative. While accepting that the registration process has been a challenge, I think co-operation within products groups such as aromatics has been exceptional and provides testimony to how seriously we take our responsibilities.

You may also have heard about Shell's efforts to provide better metrics for our own carbon footprint, which we are also sharing with customers on request. There is no doubt that consumers are increasingly interested in the life-cycle carbon footprint of the products they use, and certainly some of the major retail chains are indicating that their purchasing choices are likely to favour suppliers who can track these metrics. Similar trends are also emerging in the automotive sector.

Conclusion

So, as I draw to a close, I hope I have offered a plausible and reasonably upbeat outlook for the C6 value chain.

As the western world emerges from the ravages of recession, we expect to see a sustained upturn in overall demand and an increase in demand for products such as insulating materials and low-weight, high-strength products for the automotive sector that I outlined earlier.

Another feature will be the continuing shift in the production balance away from Europe towards the demand centres of Asia-Pacific. However US producers have seen a rapid reversal of fortunes since 2008 as low-cost feedstock availability has transformed their competitive position. The "Closing down Sale" signs have been removed, facilities spruced up, and new investment is being considered.

To remain competitive, new and existing capacity will fare best if they have some inherent advantages, such as access to low-cost feedstock, safe and reliable assets, economies of scale, site integration with upstream and downstream plants, and technology and customer linkages.

Shell sees its future as a leading global merchant supplier of benzene, styrene and phenol.

In the long run, the C6 value chain will only survive if our customers thrive. So it is imperative that producers' strategies are aligned with the growth plans of their customers. This could take the form of growing in new markets, assisting in new formulations of products, being proactive in the management of inventories, etc. In short, the value chain needs to be customer-focused.

Technology has a big role to play in this regard. For Shell, as an upstream player, we are looking at DPC and gas-to-aromatics technology. But for those further along the value chain, it will be exploiting properties with new properties that meet the challenges of a high-cost energy and low-carbon world.

As far as Shell is concerned, being at the start of the C6 value is a logical location for an integrated energy group. Having long since withdrawn from the downstream sector of the C6 value chain, we have no intention of returning. For our joint venture partners and customers who do have downstream businesses, our message is clear: Shell sees its future as a leading global merchant supplier of benzene, styrene and phenol.

As for future C6 investments, well, wherever there is an integrated refinery and petrochemicals complex, there is always an option for more aromatics.

Thank you.

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