Rising to the energy challenge: the chemicals industry response to carbon and feedstock constraints

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The expression "Shell Chemicals" refers to the companies of the Shell Group of companies engaged in the chemicals business. Each of the companies which make up the Shell Group of companies is an independent entity and has its own separate identity.

Within Shell, we use five words to sum up the energy challenge: more energy, less carbon dioxide.

That's because there is now broad international agreement that by 2050, our world will require double the energy we use today, but also need to halve its greenhouse gas emissions to prevent catastrophic climate change.

That's quite a challenge.

Conventional oil and gas stocks are predicted to decline from 2015 onwards, which means we'll need to access oil and gas reserves that are harder-to-reach and more expensive to exploit. And we'll also need more coal and nuclear energy.

Renewable energy resources such as wind, solar, wave, hydrogen and biofuel and bio-feedstock will play an increasing role in the global energy mix. But forecasts suggest fossil fuels will still account for up to 70% of global energy consumption through to and well beyond 2050.

And if industry uses more fossil fuels, then CO_2 emissions will rise unless we develop and implement technological solutions to lower mitigate and manage their output.

For the chemicals sector, which is both heavily reliant on oil and gas for feedstock and energy and, for base chemicals, a significant generator of carbon dioxide, our response to the energy challenge will determine the future shape of our industry.

We will need to access and develop a wider range of feedstock and energy resources, from fossil fuels to renewables including bio-based feedstock, while responding to global competitive challenges and the development of regulatory regimes designed to enhance energy efficiency and cut greenhouse gas emissions.

Three hard truths...

The global demand for energy is growing, both in the developed and developing world.

Supplies of "easy oil" - accessible, conventional oil and gas - cannot keep up with the growth in energy demand.

More energy means more CO_2 emitted at a time when climate change looms as a critical global issue

In Europe, we have already made great progress in reducing the energy intensity of our production, and achieved significant reductions in greenhouse gas emissions. We have also made progress in widening our feedstock pallet, but there is much more work to be done.

Because we are likely to remain heavily dependent on fossil-based hydrocarbons for many years to come, we must focus on developing new technology.

This includes technology that will enable us to process and develop a broader range of oil and gas feedstock, and also allow us to increase the use of coal-based and renewable bio-based feeds.

It includes technology that will enable us to capture and store the resulting CO2 emissions and also to increase the scope of product reuse and recycling.
And it also encompasses technology that will enable us to continue to develop the products - from engineering plastics through insulation materials to fuel cells - that are already helping the world reduce energy consumption in power generation, transportation, construction, agriculture, industry and our homes.

While much of our efforts to develop new feedstock and technology are focused on the energy challenge over the medium and long term, all of us are dealing with the energy challenge of the present.

As we all know, this sector was already heading into a downturn and struggling with oil and gas price volatility when the global economic crisis blew up and created what might be termed “the perfect storm”.

Cefic, the European Chemical Industry Council, recently noted that January 2009 chemicals output in the European Union was 22% down from a year ago, with base chemicals taking the biggest hit. Last month, having surveyed business confidence among chemical industry managers, Cefic reported more gloom, with orders expected to continue to fall, although chemical product prices were said to be “largely stable.”

Having risen to $150/barrel last summer, today oil prices are back where they were in 2004 at around $50/barrel and global oil demand is 3% lower than last year. Some may view this as good news.

The bad news is that the economic recession could amplify short-term volatility in the oil and gas sector by causing a slow-down in investments and thereby sowing the seeds for the next supply shortfall.

We also face considerable uncertainty relating to the development and implementation of climate change policies and the scope and costs of attendant regulations and tax regimes.

In the final analysis, all of these issues add to the complexity of the task the chemical industry faces in remaining competitive in an increasingly global market place against the backdrop of a stiffening energy challenge.

In the next few minutes, I will look at the chemicals response to the feedstock and CO2 challenges in both the near and longer term. I will try to address some of the competitive and technological challenges facing us, which are closely related.

As an integral part of a global energy group, and one of the world’s leading suppliers of olefins, aromatics and intermediates, Shell’s petrochemicals businesses provide the link in the supply chain between oil and gas and the downstream chemicals sector.

For this reason, my discussion will partly focus on the implications of the energy challenge from a Shell standpoint. But I will talk about some of the challenges facing our customers further along the supply chain. Ultimately, the energy challenge is something we have to meet together.

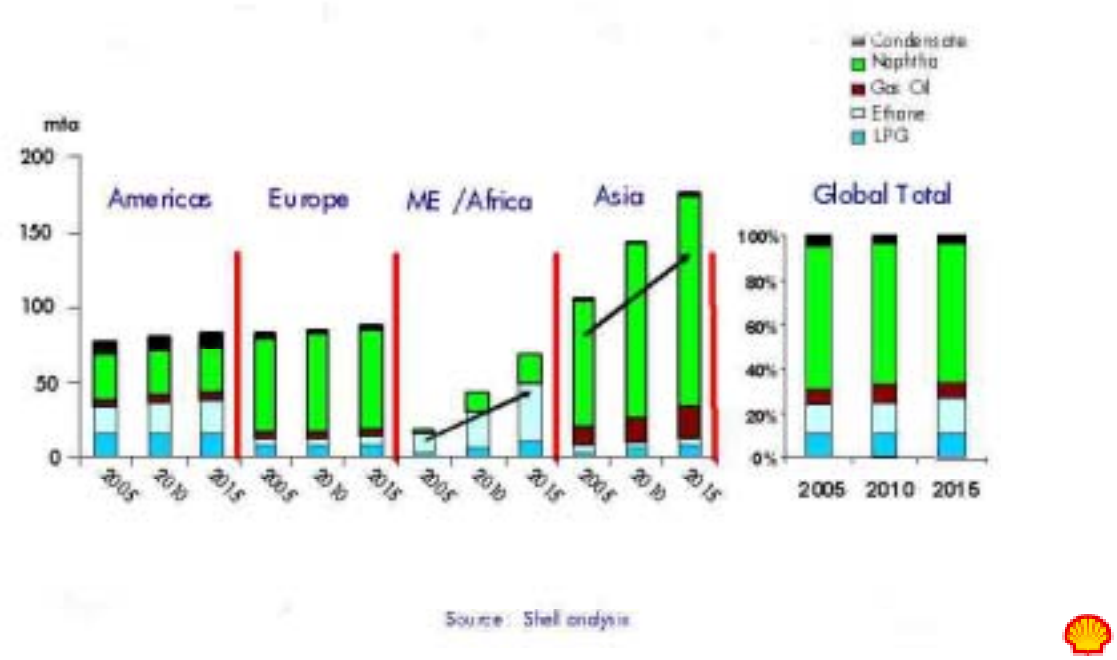
Let’s look at some of the feedstock issues facing the industry.

Chemicals, energy and feedstock constraints

Across the chemicals sector, hydrocarbons - used for power and feedstock - account for up to 80 per cent of our production costs. So the price of energy, which is linked to the price of key petrochemical feedstock, is a very significant factor in terms of both competitiveness and profitability.

Earlier, I mentioned that from 2015 it is widely expected that conventional oil and gas supplies will not match projected demand growth. Until then, however, we have a good picture of which feedstock will predominantly supply global ethylene and related production. We all know that there is a lot of Middle East capacity coming on stream and we know of the advantaged gas feedstock. But this will not alter the position of naphtha as the major petrochemical feedstock globally.

Ethylene Cracker Feed Evolution by Region



In Europe, chemicals producers have long recognised the potential competitive threat from low-cost Middle East production. Until recently, almost all Middle Eastern output has flowed into Asia Pacific. With a swathe of new and significant petrochemicals capacity coming on stream in both the Middle East and Asia Pacific - as seen on this chart by the example of ethylene cracker capacity - a surplus of production has been long anticipated, which, more recently, has become a concern for producers in the US and Canada, too.

However, Shell's view is that constrained availability of low-cost ethane feedstock in the Middle East and the emergence of a global gas market have led to a change in the supply/demand balance for ethane.

With construction and logistics costs also rising, Middle East producers have seen their export competitiveness reduced when compared with the most efficient producers in Europe and North America. Nevertheless, European producers need to remain focused on costs and on exploiting opportunities for integration, when competing with the modern and world-scale plants in the Middle East and Asia.

In the medium and longer term, post 2015, we are likely to face significant challenges in terms of accessing traditional sources of feedstock, and in developing new ones. For example, some concerns are being raised about future naphtha availability in Asia Pacific, and it is likely there will be increased competition for resources between fuels and petrochemicals.

From 2015 onwards, the chemicals sector will certainly need to increase access to unconventional sources of feedstock. But the recent high levels and severe volatility seen in key feedstock prices have also added impetus to the efforts of the industry to broaden its feedstock portfolio.

Feedstocks of the future?

Stranded natural gas

Bio feeds

Gas to liquids

Coal gasification

Many of the international energy companies, such as Shell, increasingly working in joint ventures with major resource holders and national oil companies, have already made great strides towards tapping harder-to-reach oil and gas reserves. There is also hope that these new and growing alliances - long term, value-driven partnerships - will help stabilise investment and the effective recovery and supply of hydrocarbons over the long term as the interests of the national and international energy companies become more closely aligned.

With only 30%-40% of reserves being recovered from conventional oil extraction, energy groups such as Shell are also stepping up efforts to enhance oil recovery by injecting water or CO_2 into wells and using detergents - a technique pioneered by Shell - to help “wash” out hard-to-extract oil resources.

Energy and chemical groups are already broadening the range of hydrocarbon feedstock that they can process while also undertaking development work on some of the potential alternative feedstock sources, such as coal, syngas, methane and plant-based bio-feeds. Commercially-viable technology is the key to unlocking these alternative resources.

For the near and medium terms, the contribution of these alternatives is likely to remain a minor albeit growing proportion of total feedstock consumption. Government intervention via policy and or financial incentives may help, but the technology and costs remain challenging.

Last year, oil soared to around $150/barrel, and price volatility wiped out chemical industry margins. As several senior chemicals executives noted in a recent issue of *Chemical Week*, investment and margin planning is tough when oil prices vary by $5/barrel a month or even a year; but it’s virtually impossible when prices vary by $5/barrel a day. At that time, alternative feedstock development looked a very attractive proposition. Is that still the case with oil prices now around $50/barrel? Recently, the International Energy Agency has warned that oil prices are likely to begin climbing steadily again as and when the world recovers from the current economic downturn and demand picks up. For this reason, many chemicals companies are determined to invest in new feedstock routes based on longer term considerations.

Natural gas has enormous potential as a source of chemicals feedstock. But with vast reserves of liquefied natural gas - LNG - “stranded” in remote locations, the key to extensive utilisation lies in conversion to liquids for transportation and or processing. Shell has also pioneered gas-to-liquids (GTL) technology for over 30 years, and we’re now engaged in developing the world’s largest GTL plant in Qatar. While GTL will help unlock the potential of the world’s gas reserves, primarily for transport fuels, the core process offers many potential routes - via synthesis gas processing - to chemicals ranging from solvents to olefins and aromatics. A number of companies are also developing technologies that offer routes from natural gas to chemicals, such as methane to methanol to olefins and aromatics.

In the face of high oil prices and long-term energy supply concerns, we are also witnessing the reinvention of the coal-to-chemicals industry that played such an important role in the development of Europe's chemical industry in the late 19th and early 20th Centuries.

The world has vast untapped coal reserves, which - with the prospect of high long-term oil prices and the development of new conversion technology - offer an alternative source of chemicals feedstock.

In China, which is expected to account for a significant proportion of future global energy demand growth, we have seen a major government commitment to the expansion of coal-to-chemicals production and a swathe of new projects announced.

India, which like China has little oil but lots of coal, may also eventually exploit its reserves for chemicals production. And in North America, which is reckoned to have up to 25% of global coal reserves, there is strong interest but as yet little concrete investment. Europe, too, has significant reserves.

Coal gasification technology holds considerable potential for chemicals production. Along with several other companies, Shell has been at the forefront of developing coal gasification technology and we have licensed our process to several projects to produce syngas for transport fuel in China. However, there is potential to further develop the process for chemicals production.

Coal gasification is a very clean technology. But it generates significant CO_2 and, like additional coal-fuelled power generation, will need to have associated carbon capture and storage technology if global CO_2 emissions are to be reduced by 50%. I'll come back to this in a moment when I look at carbon constraints.

Some companies are developing process technology designed to shorten the coal-to-chemicals route, which traditionally sees methanol transformed to syngas then to other products such as ammonia, olefins, aromatics and other intermediates. New methanol-to-olefins technologies can shorten this route and may offer potential cost advantages.

There is also some interest in developing routes from the refinery by-product petroleum coke - or pet-coke - to chemicals. These technologies will be closely associated with coal-to-chemicals processes.

Another alternative feedstock option is to produce a range of chemicals from plant-based bio-ethanol, made predominantly from corn or sugar cane, or bio-mass from agricultural and wood waste.

Given that bio-fuels are already big business, it is no surprise that several companies are investing heavily in bio-feed routes to chemicals including olefins, aromatics and plastics. In fact, it is a technology that Shell, which is already a leading buyer and blender of bio-fuels, is interested in developing.

While bio-feedstocks have significant potential, there are issues relating to their production that need to be addressed, such as the calculation of carbon footprints and the use of subsidies to encourage development.

Having mentioned carbon footprints, this is probably a good point to review the chemical industry response to carbon constraints.

Chemicals, energy and carbon constraints

What are the carbon constraints we are facing?

Since the United Nation's 1992 "Earth Summit" held in Brazil, the recognition that the world has to reduce its greenhouse gas emissions to prevent catastrophic climate change has gained momentum.

Today, there is broad scientific consensus that if catastrophic climate change is to be avoided, global greenhouse gas emissions must be stabilised by 2020 and reduced to at least 50% of 1990 levels by 2050. According to the Intergovernmental Panel on Climate Change, meeting this target will require developed countries to reduce emissions by 25%-40% by 2020 and 80%-95% by 2050.

With the Kyoto Protocol of 1997, most UN member countries agreed to meet formal GHG emissions reduction or stabilisation goals by 2012, which for the European Union amounted to an 8% cut in emissions compared to 1990 levels.

Having signed up to "Kyoto", the European Union subsequently committed its members to what's known as the *20-20-20 Initiative*, a three-pronged policy to combat climate change which says that by 2020 the Community will:

- Cut its greenhouse gas emissions by 20% compared to 1990 levels

- Increase renewable energy from 8% to 20% of the EU's total energy mix

- Improve energy efficiency by 20%, which involves a reduction of energy consumption by 13% from 2006 levels.

To date, the EU greenhouse gas emissions reduction target is the most ambitious commitment made by any single country group of countries for the post-2012 period. And the EU has indicated a willingness to agree a 30% greenhouse gas emissions reduction target as part of a comprehensive international deal, but only if other developed countries agree similar targets while the fast-growing developing countries make "appropriate" efforts by reducing the emissions intensity of their economic development.

The cornerstone of the EU's current efforts to cut greenhouse gas emissions is the Emissions Trading Scheme (ETS), which was introduced in 2005 and is the world's first international trading system for CO_2 emissions. Australia is also looking at emissions trading, and several US states are collaborating on regional systems. And just two weeks ago, the US government signaled its intent to target significant CO_2 emission reductions as a key plank of its climate change policy.

The EU's view is that a global carbon market, based on the ETS "cap and trade" system, can and should be established to promote cost-effective, worldwide emission reductions by linking comparable emissions trading systems. The EU's idea is to establish an OECD-wide market by 2015 and a much broader world market by 2020. The EU is also very keen to promote the development of carbon capture and storage technologies as a longer-term emissions solution.

We'll find out how far the countries of the world are prepared to go when they meet at the UN Climate Change Conference in Copenhagen at the end of this year.

Shell's view is that Copenhagen should result in the adoption of strong incentives to cut greenhouse-gas emissions, which could promote both investment and economic recovery.

A global "cap-and-trade" system would channel resources toward the most cost-effective reduction measures, while broad agreement on efficiency standards for

appliances, vehicles, and buildings would help companies and individuals use less energy.

Some other specific policy initiatives could help government and society better harness companies' agility and innovative power in the quest to control greenhouse-gas emissions:

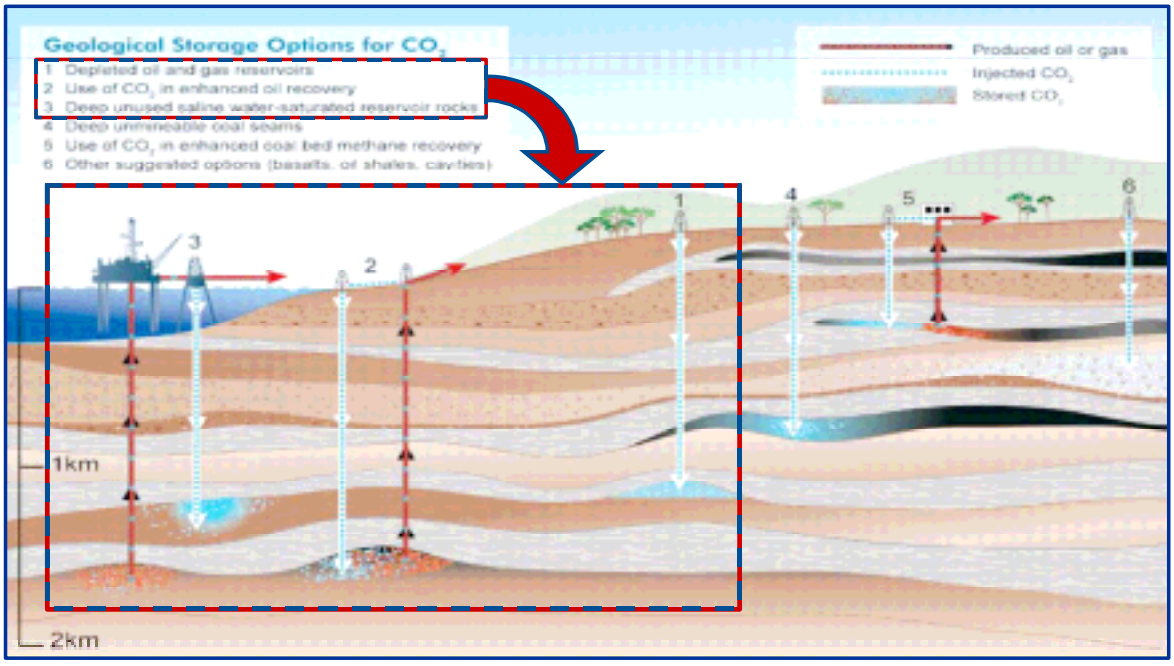
- Agreements among groups of key countries to reduce emissions in specific industrial sectors, such as power - which accounts for 35% of global CO_2 emissions - cement, chemicals and steel

- Incentives for companies to capture CO_2 and store it safely underground, accelerating the deployment of this promising technology.

- Technology funds to support the development and commercial demonstration of new technologies with high potential for lowering CO_2 emissions.

Agreement based on these initiatives would ease concern in competitive global industries that strict emission rules in one region would put companies at a disadvantage relative to rivals in countries with less strict policies. Certainly, that's been the concern here across the EU chemicals industry with regard to ETS.

According to the UN Intergovernmental Panel on Climate Change, carbon capture and storage - CCS - may contribute up to 55% of the emission reductions that scientists believe are necessary during this century to address global warming. So our view is that Copenhagen negotiators should also give CO_2 capture and storage high priority.



However, CCS adds substantial cost and generates no revenue. If CCS is to fulfill its potential, companies need incentives to invest and a way to make money. Policymakers should promote CCS in several ways.

First, they must put a price on CO_2 emissions. They could do so by capping emissions and creating a market where companies can buy and sell emission allowances, as in the European Emissions Trading Scheme.

Second, CCS needs to be recognised within the Kyoto Protocol's Clean Development Mechanism, through which developed countries can invest in emission-reduction projects in developing countries.

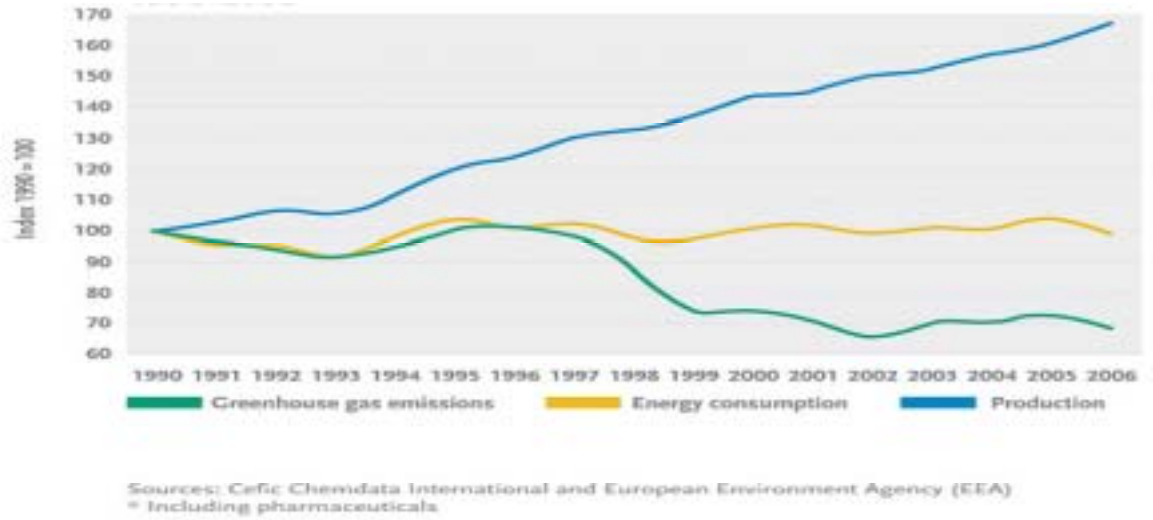
Finally, governments should stimulate the development and commercial demonstration of technologies that hold promise for a low-carbon energy future. The dramatic drop in energy prices in recent months makes it less likely that private investors will gamble on unproven technologies.

Shell also believes that cap-and-trade systems could provide a potential source of funds through the auctioning of emission allowances.

While the world's policymakers negotiate their way through the climate change challenge, the chemical industry here - and also in North America and some other countries in Asia-Pacific and Latin America - has worked hard to meet the energy challenge.

EU Chemicals industry greenhouse gas emissions, energy consumption & production

1990 - 2006



(Visual reproduced from CEFIC materials)

For example, data published this year by Cefic estimates total EU chemical industry energy consumption in 2006 was around 137 million tonnes, including about 74 million tonnes of oil and roughly 35 million tonnes of gas. About 90% of the oil and 40% of the gas consumed was used for feedstock.

Cefic calculates that between 1990 and 2006, EU chemical industry output has increased by around 70%, while energy consumption has remained stable and Greenhouse gas emissions are over 30% lower. Overall industry energy intensity - energy consumption per unit of production - was 53% lower in 2006 than in 1990.

Cefic also calculates that the chemical industry alone has achieved nearly one third of the EU's Kyoto Protocol commitment to reduce greenhouse gas emissions by 8% between 1990 and 2012 - amounting to a reduction of 96 million tonnes of carbon dioxide equivalents since 1990.

At the heart of these achievements is the chemicals industry's facility for technology development and refinement, and our focus on doing more with less. This focus has characterised our industry from its inception, and will remain the platform for our future success.

And while some of our technology is truly groundbreaking, an equally important part is played by incremental improvements that increase process efficiency and product performance. It is the combined application of breakthrough and incremental technology that can help us meet the energy challenge.

Before I look at some industry-wide examples, let me give you a snapshot of what Shell has been doing to improve the competitive efficiency and flexibility of our chemicals production to meet the challenges of feedstock and carbon constraints.

Shell's response to feedstock and carbon constraints

A key element of Shell's strategy for chemicals has been to achieve a better geographical balance in our global manufacturing network by focusing recent and new investments in world-scale, integrated facilities in the Middle East and Asia Pacific and upgrading facilities in our historical heartlands of Europe and North America.

Today, close to 30% of our chemicals production capacity is in Middle East and Asia Pacific, which gives us both regional feedstock and market access. And we are continuing to build partnerships with national oil and chemicals producers to strengthen our overall portfolio.

Oil-chemical integration is a key tenet of Shell's downstream strategy, which we believe gives us a competitive edge. Most integration value comes from directing hydrocarbons to the highest-value application, irrespective of traditional refining - chemical boundaries. Secondary or by-product streams from refining units can have their highest value as feedstock for chemical units. Likewise, by-products from chemical units can be most cost-effective as refinery feeds or fuel blending components.

Investing in hydrocarbon integration has also improved our operational flexibility, helping us to maximise returns as feedstock economics shift. We continue to develop and deploy more advanced optimisation tools for making day-to-day decisions for maximising the mutual hydrocarbon value in a coordinated way across our integrated refining-chemical locations. This flexibility to optimise various feedstocks can also bring our customers benefits in terms of security of product supply.

We are certainly seeing the oil/chemical advantage in regard to our refinery-integrated ethylene position in Europe, where Shell has three ethylene units. Due to a high level of oil/chemical advantage they are among our most cost competitive assets, which consistently achieve 1st quartile cost performance.

Extensive process design work at the Shell Global Solutions laboratories in Amsterdam and Houston has paved the way for innovation in heavy feed cracking, which is crucial to facilitating enhanced production. In Singapore, our Shell Eastern Petrochemicals Complex will use a higher percentage of heavier feeds compared to other liquid crackers. And nearer to home in The Netherlands, our Moerdijk cracker is being reconfigured to enable it to crack hydrowax from the Pernis refinery.

Heavy feed cracking of this nature will bring economic advantages, particularly in terms of producing more valuable byproducts such as propylene and butylenes. It will also increase cracker capacity by 40%. However the trade-off is that heavy feeds are more energy-intensive to process, so the challenge is to focus on process efficiencies to reduce CO_2 impacts.

Given that easy oil is no longer available, we all need to focus on new challenges of unlocking alternative hydrocarbon resources and utilising more unconventional petrochemical feedstock. Shell has already made significant progress in the use of hydrowax and butane in ethylene production, and we are also at the forefront of some fundamental new processes, such as gas to liquids and coal to liquids, which I mentioned earlier.

As the need to reduce energy and other resources associated with chemicals processing increases, finding more efficient routes to products is critical. Catalyst technology can play a significant role here. Using new catalysts developed by Shell in our ethylene oxide/glycols technology, for example, enables us to convert up to 90% of ethylene into EO. That’s a 10% improvement over the previous generation of catalysts, and it also saves hundreds of millions of dollars and lowers carbon emissions.

We’ve used Shell technology and acquired technology to commercialise and license the world’s most efficient process for MEG production. And our latest SMPO plants use 35% less energy for every tonne of chemicals produced while emissions to the atmosphere have been cut by 90%, and liquid and solid waste is almost 100% recycled.

Shell and other players have been developing carbon capture and storage technology for many years. We've been using these techniques in oilfields for over 20 years, and are currently involved in several CCS demonstration projects.

At Ketzin, in Eastern Germany, Shell is part of a consortium - including the German government and other industry partners and supported by the EU - which began work on a CCS project in 2004 and started CO_2 injection and monitoring in June 2008. We believe this is an important step towards developing CO_2 capture and storage on a commercial industrial scale.

We certainly believe effective technology will be available, and foresee development where individual companies will implement systems or where regional petrochemical clusters would collaborate to provide cross-company CCS.

Shell is by no means the only company working to extend feedstock flexibility, process efficiency and to lower the carbon intensity. I know that companies represented by other speakers and delegates at this conference are investing in feedstock flexibility and alternatives, and a range of technologies that will help meet the energy challenge.

Chemicals: part of the climate change solution

A role in tackling climate change through downstream application of end products, such as insulation, lighter vehicles and lower temperature detergents.

Across the industry, as we have already heard, we have seen the development of lighter, stronger, more hardwearing or more concentrated products that are transforming the energy performance of transportation, buildings, industry, agriculture, and our daily lives from appliances, clothing and furniture to food, health and hygiene. They range from engineering plastics and insulation products to detergents, lubricants and packaging.

The chemicals sector is also playing a vital role in the provision of products that will enable the development of renewables such as wind, wave and geothermal energy resources. Nanotechnology and biotechnology allied with the drive towards Green Chemistry will also play increasingly important roles in this new technological evolution and revolution.

Here in Europe, working with industry and using existing Technology Platforms, the Commission is establishing regional energy research governance and six industrial energy initiatives that include wind, solar, bio-energy, carbon capture and storage, smart electricity grids and sustainable nuclear fission.

The EU recognises that the chemicals sector - from universities and research organisations to the private sector - has a key role to play in this effort. That's why - as most of you know - the EU is working with us through the European Technology Platform for Sustainable Chemistry - or *Suschem* - to promote sustainable chemistry, industrial biotechnology and chemical engineering research, development and innovation in Europe.

Suschem targets key areas that address major energy- and climate change-related issues facing Europe, building on its expertise and technical potential. With three technology sections working to coordinate activities in industrial biotechnology, materials technology, and reaction and process design, *Suschem* can have a critical role in strengthening competitiveness across Europe's industrial sectors and in addressing and achieving sustainability in energy use, transport, health, and communication technology.

By way of conclusion, I want to offer a quick review and reminder of what the EU High Level Group (HLG) on Chemicals competitiveness reported after its recent final meeting.

Conclusion

In summary, this group - which included both industry leaders and leading policy makers from across the European Union - concluded that Europe's chemicals industry is a solution provider for the problem of global climate change and a major contributor to the world's greenhouse gas emissions reduction effort.

It recognised that access to sufficient high quality renewable raw materials at world market prices is essential for a competitive chemicals industry in Europe. Longer term, the group foresees an increase in ethylene production based on a new and growing slate of feedstock ranging from biological sources such as ethanol and agricultural biomass to coal.

The High Level Group also expects the chemicals sector to meet the energy and climate change challenge with responses ranging from production improvements and carbon sequestration to a growing slate of products made from CO_2, which Shell among others is already developing.

To achieve better regulation, the group recognises the need for full and proper stakeholder consultation, impact assessments, improved communication by the authorities and more full and even-handed application of agreed rules.

Given that current economic challenges could undermine the group's overall vision, it is viewed as essential that the industry collaborates with the European Commission and member states to overcome short-term difficulties and to establish right conditions for investment that will secure the chemicals sector's role as an indispensable enabler for a sustainable future.

Our industry is based on integrated chemical clusters, which require a comprehensive and complex infrastructure of logistics and production facilities. As a result of the HLG's work, there is now wider EU acceptance that global competition is stiffening as players in other regions with increasing numbers of skilled workers take advantage of lower feedstock and energy prices.

The strategy for European chemicals has to build on better legislation, competitive and reliable energy sources, fair and open trade conditions and increased skills and innovation capacities. If these are in place, then we will meet the challenge of feedstock and carbon constraints.