Shell Chemicals

"Meeting the Global Sustainability Challenge through Chemistry"

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Bob Chouffot

Bob Chouffot was appointed General Manager, Higher Olefins and Derivatives on November 1st, 2006 and is based in Houston. Bob holds a BSc and MSc in Chemistry from the University of Kent at Canterbury, England, and an MBA from the University of Houston.

Bob brings over 25 years of experience in the Petrochemical Industry to this assignment. He joined Shell at the Martinez refinery in California in 1982 and has held positions in both Chemicals and Oil Products, including business, commercial, strategy, technical and operations management.

Bob currently serves on the Board of Directors of the Soap and Detergents Association and in January 2010 he was appointed Vice Chair.

In April 2010 Bob become the chairman of the International Council of Chemical Associations (ICCA) Energy and Climate Change Advocacy Task Force.

Bob is married with two teenage boys and enjoys reading non fiction, cycling, scuba diving and the occasional motorcycle ride.

Introduction

My aim today is to highlight some of the major issues facing the chemicals sector in the 21st century, and to offer some reasons why chemistry can play a pivotal role in meeting the world's sustainability challenges.

I also want to touch on the prospects for the US chemical industry, which are probably brighter than they have been for more than a decade.

As an advance warning, you will hear quite a bit about the three Es:

- Energy
- Environment

And…

- Economy

First, however, I want to say something about our industry.

In the 200 years or so since chemistry was "invented", it has burgeoned into an international community of chemists, engineers, technologists and businesses that is characterised both by it's scientific rigour and it's creativity.

We're a $3 trillion-plus global sector, that touches almost every area of human activity. From energy to health and personal care, chemistry helps transform our lives and enables the standard of living which we enjoy today.

However, too many people associate chemicals with the risks and hazards that our overall safety record suggests are very well understood and managed. Our problem is that not enough of the world's population knows what chemistry has achieved or what it enables.

Chemistry's challenge is to lose the "problem" tag, and to strengthen our public reputation as a problem-solving, progress-enabling centre of scientific and technological excellence.

In the coming decades, our industry will have the opportunity to do just that by putting itself at the heart of the process to meet the biggest challenge that humanity has yet faced - delivering global sustainability.

The Challenge of Sustainability

The world's population is now over 6.5 billion, and we are already generating levels of greenhouse gases that are causing climate change. This is due to our use of fossil fuels and changes in land use to power our economies and feed people.

By 2050, forecasts suggest there will be 9 billion people on Earth using two - or even three - times as much energy as we do today. Yet over the same period, the scientific consensus is that we will need to reduce greenhouse gas emissions - primarily CO2 - by 50% to keep climate change within sustainable levels.

The main drivers of future energy demand growth will be highly-populated countries such as China and India, which today account for almost 40% of the world's population. These countries are entering the most energy-intensive phase of economic development as they seek to achieve widespread increases in standards of living that will doubtless mirror those already enjoyed in North America and Western Europe.

Where will future energy come from? Primarily from fossil fuels, although renewables - wind, water, biofuels and solar power - are expected to contribute a growing but still small percentage of global energy resources.

According to the International Energy Agency's 2010 survey, traditional fossil fuels - coal, oil and gas - currently provide just over 80% of the world's energy, with nuclear and hydro meeting a further 10% of demand. Unless government policies drive change towards nuclear and renewables, the IEA forecasts little change in this supply balance through 2030.

"At Shell, we have developed scenarios that look at long-term challenges to sustainability based on energy, economic and environmental responses to the different scenarios."

It's not my intention to reprise in detail the theory of climate change, other than to say that Shell concurs with the view of the Intergovernmental Panel on Climate Change that at current rates of greenhouse gas emissions - primarily CO2 generated in the production and use of fossil fuels - mankind is on course to alter average annual global temperatures by more than 2°C by 2050.

At Shell, we have developed scenarios that look at long-term challenges to sustainability based on energy, economic and environmental responses to the different scenarios. Currently, and based on action or in-action to date, we see two ways forward, which we've called Scramble and Blueprints.

Scramble is a world driven by fears over energy security and short term reactions resulting in severe climate change as well as turbulence and volatility in the energy system.

Blueprints is a world where we see anticipation of challenges and critical choices being made early to respond to challenges, resulting in a more stable energy system and much better environmental outcomes.

For its part, Shell strongly prefers the better Blueprints results, and is urging policy decisions that will move the world towards these. However, we also recognise that at best, Blueprints is only likely to deliver GHG concentrations of 650ppm by 2100. That's well ahead of the maximum 450ppm that scientists say is necessary to restrict climate change to a manageable 2°C. In Shell's view, there is no question that urgent action is needed since the choices made in the next few years will be critical in determining the route we will take over the next half-century.

Sustainability: the chemicals sector's role and response

Having outlined our 21st century global challenges, I want to move into a discussion about the chemicals sector's role and responses. There's good news, and bad.

The bad news is that too often, and perhaps unfairly, we're seen as part of the sustainability problem. The good news is that plenty of highly-influential, responsible people also recognise that we are an essential component of any long-term, successful response.

As Professor Jeffrey Sachs, who is Director of Columbia University's Earth Institute, has bluntly remarked, the chemicals sector is "a big energy consumer and a big emitter of greenhouse gas." However, thanks to our scientific and technological creativity, "Chemicals is also at the heart of the [sustainability] solution." That's because our processes and products can make a very significant contribution to both reducing global energy use and reducing global GHG emissions.

Now lets look at these challenges facing the Chemicals sector through the lenses of the three Es: energy, environment and economy.

I will start with the energy.

Chemicals and the energy challenge

The chemicals sector, which is heavily reliant on oil and gas for feedstock and energy, is a significant generator of carbon dioxide. We will have to respond to the global competitive challenges and the development of regulatory regimes designed to enhance energy efficiency and cut greenhouse gas emissions. Our response to the energy and feedstock challenge will determine the future share of our industry.

The world's 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. We'll also need more coal, nuclear and renewable resources in the global energy and feedstock mix. But forecasts suggest fossil fuels will still account for up to 70% of global energy consumption well beyond 2050.

We will have to focus on developing new technology that will enable us to process and develop a broader range of oil and gas feedstock, as well as increasing our use of coal-based and renewable bio-based feeds.

These technologies - which are already in use and could become commercially viable within a decade - will enable us to capture and store the resulting CO2 emissions while increasing the scope of product reuse and recycling.

This also encompasses technology that will enable us to continue developing the kind of products that already help the world reduce energy consumption in power generation, transportation, construction, agriculture, industry and our homes. By some estimates, non-conventional feedstocks such as bio-based materials will be responsible for about 10-20% of chemical production by 2025.

Oil is set to remain the dominant resource, but natural gas - the cleanest burning of all fossil fuels generating 60-70% less CO2 emissions than coal - has enormous potential as an increasing source of feedstock. In addition to the unlocking of tight gas resources, there are vast reserves of natural gas "stranded" in remote locations, and the key to extensive utilisation lies in conversion to liquids for transportation and or processing.

Shell has 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 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 ongoing opportunities for alternative sources of chemical feedstocks and power generation. However, to be sustainable new generation coal-fuelled power and chemicals plants will need to have associated carbon capture and storage technology.

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Another alternative feedstock option is to produce a range of chemicals from plant-based bio-ethanol, made predominantly from corn, 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. It's a technology that Shell, which is already amongst the world's leading distributor of bio-fuels, is interested in developing.

Shell favours the development of advanced biofuels, which use wastes or residues or non-food biomass for bio-fuels and bio-feedstock generation as they will reduce pressure on land use, have improved CO2 performance, improve fuel properties and may not compete with the food chain.

Worldwide, promising development work is ongoing into biofuels and bio-feedstocks made from the non-edible parts of crops. The use of catalysts and process chemicals to speed biomass decomposition into raw materials is also being pursued.

While bio-fuels and bio-feedstock have significant potential, there are other issues relating to their production that also need to be addressed, such as social and environmental issues (including calculation of carbon footprints, land use and deforestation, and labour rights) and economic issues such as the use of subsidies to encourage development. Land use is currently the subject of increasing analysis.

The most obvious way to cut energy use and lower emissions is through energy efficiency measures. In North America, Europe and Japan the chemical industry has already taken big steps to reduce the energy intensity of production, largely as a response to increasing energy prices, and achieved significant reductions in greenhouse gas emissions.

For example, from 1974 to 2005 the US chemical industry's energy consumption per unit of production fell by almost 50%, while from 1990 to 2005 GHG emissions decreased 13%. In the European Union, the industry output rose by 60% while energy use remained flat and GHG emissions fell by nearly 30%.

Industry in other parts of the world is also responding. As Brazil's chemicals production jumped 30% between 2001 and 2007, energy consumption fell by a quarter and renewable energy resources accounted for 50% of energy consumed.

This focus on improved chemicals sector energy efficiency will remain for the foreseeable future. It's an imperative driven by the upward trend in energy prices, which is unlikely to be reversed, and wider efforts to reduce the industry's carbon footprint in response to a raft of national and international governmental measures including carbon trading and CO2 emissions regulations.

Chemicals and the environmental challenge

One of the charges levelled against the chemicals sector in the sustainability debate is that we use a lot of energy and generate a lot of GHG, primarily CO2. This is a fair assessment. However, as I have just demonstrated, we're making more while lowering both our energy usage per production unit and our output of GHGs.

There's more good news, too. In 2009, the International Council of Chemical Associations (ICCA) published a study demonstrating the chemical industry's positive role in reducing GHG emissions. Carried out by the consultant McKinsey and Company, the report provided a

ground-breaking carbon-lifecycle analysis showing that for every unit of greenhouse gases emitted by the global chemical sector, society saves more than two units through the use of chemistry products and technologies provided to other industries and consumers. Furthermore, the report contended that the GHG savings ratio would likely increase to at least 4:1 by 2030.

Where are the industry's products and technologies having the biggest beneficial impacts?: According to the ICCA report, primarily in energy-saving building insulation, agriculture, lighting, renewables and transportation.

For example, McKinsey calculated that building insulation supplied by the chemical industry made possible a net CO2 emissions abatement of 2.4 GtCO2e in 2005. Although energy is used and GHGs are emitted in production, over their lifetime these insulation materials can save over 230 times those emissions generated during manufacture of the products.

Just think about the energy-savings potential this could offer in the construction and refurbishment of the cities of the future that will house 75% of the population: smarter cities, smarter energy use and management - enabled in part by chemistry.

In agriculture, chemical fertilisers and pesticides have enabled us to grow more crops on less land. And with 30% more people living in 2050, we'll need to produce a lot more food, while avoiding further depletion of our forests, which is reckoned to account for around to 20% of GHGs.

According to ICCA calculations, the use of chemical products in farming increase crop yields by an average of 50% over organic methods and provide a net GHG emissions abatement of 1.6 GtCO2e, mainly through prevention of changes to land use.

Lighting is another great example of chemical industry products enabling savings in GHG emissions. Although we all need to pay far greater attention to the energy we use in lighting - at home, at work and in our communities - by hitting the off switch more often, the development and increasing use of compact fluorescent lamps is providing a 75% saving in the emission of GHGs from electricity generated by fossil fuels. We're also seeing the development of light-emitting chemicals-based wall covering and coatings, which also have significant energy and emissions saving potential.

"Insulation materials can save over 230 times those emissions generated during manufacture of the products."

The chemical sector is also having a beneficial impact helping to reduce GHG emissions from the transportation sector. For example, the use of anti-fouling compounds and friction-reducing hull coatings are estimated to be reducing shipping fuel consumption and GHG emissions by up to 29%. In aerospace, bigger, lighter planes are carrying more people longer distances, consuming less fuel and generating fewer emissions.

In the road transport sector, increased use of chemical products and plastics as replacements for steel, aluminum and glass is reckoned to have cut the global fleet weight by around 8 million tons, increased fuel efficiency, and saved around 5% of road transport GHG emissions. In addition to weight reduction-based emissions abatement, our industry's products are also delivering road transport emission benefits through lubricants and fuel additives, which are enhancing fuel economy and extending engine life. Low-friction tires made with chemicals and plastics are also part of the improved energy efficiency picture. Time and

technological development will deliver further benefits.

As you can see, there are many ways that the chemicals sector is helping to meet the sustainability challenge. But before I move on, I want to mention just two more great everyday examples: synthetic low-temperature and concentrated liquid detergents. ICCA life-cycle analysis indicates that combined production and end-of-life carbon footprints of these detergents are about one fifth of those for soap, and that energy saved in heating water to 37°C rather than 60°C, saves around 43 million tons of CO2 equivalent emissions. Compared to the traditional big-box powders, more concentrated, compact laundry detergents, reduce packaging, transport costs and shelf space as well as the detergent used per wash load.

As I'm talking life-cycle analysis, this is probably an appropriate point look at an example of the potential misunderstandings that can arise in the "natural" versus synthetic debate that often arises in relation to chemical products.

In recent years, manufacturing capacity for oleochemical- based surfactant alcohols has increased significantly. One of the reasons for this has been a perception that these products, which are derived from vegetable oils such as palm, palm kernel and coconut oil, enhance the environmental profile of laundry detergents when used instead of petrochemical-derived alcohols.

In fact, significant levels of chemical processing is required to transform vegetable oils into surfactant alcohols and life-cycle analysis by some of the major detergent manufacturers has shown that the origin of the surfactant is not a significant factor in environmental footprint.

That said there are successful models being developed for sustainable development of bio feedstocks and the overall conclusion is that both oleo chemical- and petrochemical-derived alcohols will remain important ingredients for future detergent production and in our own production plans.

While I'm on the subject of soaps and detergents, I'd like to give another plug for the health benefits deriving from our industry. On October 15 this year, it will be "Global hand washing day." Why? Because the coalition of scientific institutions, academies, charities and businesses that promote this initiative and sponsor research reckon hand washing with soap is the most effective and inexpensive way to prevent diarrhoea and acute respiratory infections, which take the lives of over 3.5 million children in developing countries every year. If the whole world can get the habit of hand washing with soap and detergents before eating and after using the toilet, the coalition estimates that the current level of 1.7 million child deaths from diarrhoea per year could be halved, and those from respiratory diseases - about 1.8 million - cut by 25%.

Having spent a few minutes on the environmental aspects of sustainability, I want to switch to the economic aspects and talk more about the outlook for the US chemical sector before offering my conclusion.

Chemicals and the economic challenge

Now the energy and environmental developments I have just been talking about also have clear economic implications for our industry. Here in the United States, as in Europe, the long-term viability of the chemicals sector has sometimes been questioned in light of the massive chemicals manufacturing investment undertaken in the low-cost, energy-abundant Middle East and in the growing demand centres of Asia, most notably in China.

It's certainly true that over the past two decades US chemical manufacturing and exports have

felt the increasing competitive pressures of these new production centres, particularly with the migration of certain chemicals-consuming industries such as textiles, appliances and white goods, and automotive to Asia-Pacific. There was also widespread concern that declining availability of advantaged gas feedstock in the US would force a switch to heavier, less competitive liquid feeds.

However, as these emerging economies enjoy increasing wealth and affluence, they are also witnessing a surge in domestic demand for products that in the past were primarily for export.

What's more, here in the US, the underlying profitability of the chemicals industry - albeit disrupted as a result of the financial storms of 2008 & 2009 and the subsequent recession - is being transformed by the availability of abundant, newly accessible shale gas - or "tight gas" - resources. According to the US Energy Information Administration, assessments of available shale gas resources more than doubled between 2009 and 2011, and it is now anticipated that the contribution of shale gas to total US dry gas production will increase from 14% in 2009 to 45% by 2035.

In fact, shale gas is being described as a "game changer" for our industry, because it is giving US petrochemical producers a competitive advantage after a period of volatile and relatively high energy and feedstock cost.

Today, the US cash cost of ethane-based ethylene production is about $600/ton, which compares very favourably with Asia's naphtha-based production at about $900/ton.

We expect that the crude/natural gas differential will continue for some time to come and thus provide US crackers with a competitive advantage over naphtha crackers in Europe and Asia. Middle East producers still enjoy significant cash cost advantages over the US Gulf. However, feedstock is now rather scarce in the Middle East and the large increase in ethane availability in North America positions the US very well to capture future global market growth

In turn, this increased competitiveness will create opportunities to re-energise the whole chemicals value chain, strengthen broader US manufacturing, boost economic output and exports, and create jobs— perhaps as many as 17,000 new knowledge-intensive, high-paying jobs in chemicals, with another 395,000 more jobs in related industries.

According to American Chemistry Council estimates, this new chemicals growth could generate around $4.4 billion a year in additional federal, state, and local tax revenue, and trigger over $16 billion in chemical industry capital investments, giving a major impetus to the US economy as it emerges from recession. So that's more good news from chemistry!

Conclusion

I want to end on a high note, because I believe there are great things to come from this industry. We'll likely see a swathe of new technologies in coming years, and a range of new chemicals and chemicals-based products that will help usher in a low-carbon age.

We have no choice but to respond to the challenges of sustainability. Our consumer-facing customers further down the value chain are already responding to societal and governmental pressures to reduce the carbon footprints of the products and services they supply. Increasingly, the leaders - big global retailers like WalMart and IKEA, and their home and healthcare product suppliers - want us to work with them to better understand, record and calculate life-cycle analyses and

carbon footprints - the measures against which we can set sustainability improvement goals.

For the chemicals industry, this is a great opportunity to raise our profile and foster better public understanding of both the way we do business and of the products and technologies that have transformed and will continue to transform for the better the lives of people the world over.

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