In support of the G8 Plan of Action

The International Energy Agency in collaboration with CEFIC

Feedstock Substitutes, Energy Efficient Technology and CO_2 Reduction for Petrochemical Products

- A Workshop in the Framework of the G8 Dialogue on Climate Change, Clean Energy and Sustainable Development-

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This document contains the proceedings of the workshop on Feedstock Substitutes, Energy Efficient Technology and CO_2 Reduction for Petrochemical Products, which took place on 12-13 December 2006, at the International Energy Agency in Paris. This workshop was organised in collaboration with CEFIC and is part of a series of industrial sector activities in the framework of the G8 Plan of Action on Climate Change, Clean Energy and Sustainable Development .

The goal of the workshop was to explore possibilities to compare energy efficiency and CO2 emissions and to identify improvement potentials. Wider application of existing energy efficient technologies, development of new technologies, the use of biomass feedstocks and recycling of plastic waste were discussed. This document reflects the presentations and discussions of the participants at the workshop. The views expressed in this paper do not necessarily represent those of the IEA, or its member governments, or CEFIC. A CD-ROM with the workshop presentations is available from the IEA Secretariat in Paris.

Summary

The chemical and petrochemical industry accounts for 30% of total global industrial final energy use. More than half of the energy used by the chemical industry is stored as feedstock in products.

The petrochemical industry accounts for about 8% of world oil consumption. The industry produces materials such as plastics, synthetic rubbers, fibres and solvents which are indispensable to our everyday life products (in the form of packaging, clothes, medicines, computers, furniture, etc.). Often these products generate energy savings during their use which by far outweigh the energy used to produce them. Because of the high share of feedstock energy, the process energy efficiency potential is limited. Optimising recycling of materials and recovering of the contained

feedstock energy at the end of the product life increases the overall petrochemicals lifecycle energy profile. Biomass feedstocks can help to reduce CO_2 emissions and fossil fuel dependence, but this seems an option for the longer term. On the short and medium term, CHP and better process integration deserve more attention.

Energy costs represent a significant portion of the production costs (up to to 60%) of the chemical sector. In an effort to reduce these costs, energy use per unit of product has been substantially reduced. For example in Europe, greenhouse gas emissions have been cut by more than 20% since 1990, although overall chemicals production in Europe has increased by more than 50%. The industry calls on policy makers to encourage such efforts and provide incentives for R&D and investments in order to offer the best possible conditions for the development and deployment of technologies which mitigate global warming by reducing energy use and environmental impacts to achieve a more sustainable development. This includes credible long-term policy targets and policy frameworks with a broad regional scope. The industry is not opposed to CO_2 emissions reduction, but it should not distort competition and benefit certain industries at the expense of others. The industry feels that the current EU ETS is flawed and needs improvement.

A number of Consultants are carrying out benchmarking studies i.e. Solomon Associates is benchmarking steam crackers, Phillip Townsend Associates is benchmarking various Polymers, Elastomers etc, Plant Services International is benchmarking Ammonia & Urea and Process Design Center (PDC) is benchmarking various processes. Together they cover a significant share of petrochemical energy use worldwide. However these benchmarks are confidential and they do not cover all energy use. Even industry is not allowed to see the data for individual plants because of antitrust legislation. The energy data in the IEA statistics are aggregates on the level of the chemical and petrochemical industry as a whole. It is not possible to do an accurate analysis of efficiency potentials based on these data. If governments want a better insight into efficiency potentials they could develop their own benchmarking activities, similar to the ones in Flanders and the Netherlands. Benchmarks used in these two countries are based on both direct and indirect energy consumption. Indicators on a country level are complementary to benchmarks.

Various participants expressed the opinion that South Korea, Belgium and the Netherlands have high energy efficiency in their petrochemical industry. However within countries big differences exist from plant to plant. The age of the capital stock, the plant size, the plant heat integration within petrochemical and refinery complexes and fuel prices affect the energy efficiency. New plants are usually built with high energy efficiency. More robust coherent datasets and indicators are needed to evaluate the energy efficiency of the sector.

Maximising energy efficiency could help enhance the long-term business perspectives in a world with a challenging prospect of high price levels and increased price volatility. It also reduces fossil fuel import dependency, an important government concern. Moreover, with the move towards a carbon constraint economy, emissions may have to be reduced significantly in the coming decades. A fundamental change of the production structure is a slow process that may require decades, which would favour timely action.

Countries are making good progress in terms of energy recovery and plastic waste recycling. Japan and Germany are leading the way. Also Combined Heat and Power (CHP) is already widely applied by the major petrochemical companies that were present at the workshop. Still further expansion would be feasible. Process integration is in certain cases a viable strategy but quantitative estimates of the remaining potentials are lacking.

A refined analysis on country comparisons of energy use in the chemical and petrochemical industry will be included in the April 2007 IEA publication *Indicators for Industrial Energy Efficiency and CO_2 Emissions.* This publication will be an input for the G8 2007 summit in Germany. IEA aims to work together with industry on a more detailed analysis on energy efficiency and CO_2 emissions and to improve and refine existing data. The proposed IEA country level indicators will be further refined, drawing on the advice and data resources of the workshop participants. The next step following this publication will then be to make a detailed analysis of future technology potentials to increase energy efficiency and reduce CO_2 emissions. The IEA intends to work with governments and industry to advance this project in 2007.

Summary of presentations

G8 Programme – Rick Bradley, IEA
IEA activities under the Plan of Action for the G8 Dialogue on Climate Change, Clean Energy and Sustainable Development were presented. Goal is to deliver a final report to the G8 summit in Japan in 2008, with an update at the June 2007 G8 summit in Germany. The analysis of industrial energy efficiency and CO_2 emissions reduction potentials is part of this body of work.

G8 industry task – Dolf Gielen, IEA
The short-term goal of the IEA G8 industry task is to publish an analysis of Indicators for Industrial Energy Efficiency and CO_2 Emissions in April 2007 that builds on the outcome of sector workshops. This publication will be submitted to the G8 summit in Germany. The goal is to analyse country trends, to compare countries in terms of industrial energy intensity and CO2 emissions, in order to identify areas where further analysis would be warranted. This is followed by an analysis of the potential of new technologies to reduce energy use and CO_2 emissions in the second half of 2007. This will feed into a scenario analysis of industrial emission reduction potentials. A dialogue with industry is a key part of this process.

Status and Global Trends

Oil & gas price projections: IEA insights (WEO) - Olivier Rech, IEA

The 2006 World Energy Outlook forecasts that oil prices could ease in the near term as spare capacity rises, but geopolitical tensions or supply disruptions could push prices back up. Today there is limited spare refining capacity, but investments in refining are being made to increase capacity. Oil price assumptions have been revised upwards to 60$ per barrel with prices falling over the next 3-5 years to about 45$ per barrel. In the long term oil prices will increase again to 55$ in real terms by 2030. This is equivalent to a nominal price of 100$ in 2030.

As more that half of the global investment in oil-supply infrastructure is needed in developing countries, with much of the spending on refining and Gas-to-Liquids (GTL) going to the Middle East as well as accounting for increase in material and labor supply costs in the upstream sector, there exists uncertainty on whether and when these investments will be made. The impact of deferred investment will lower OPEC production and push prices up, curbing demand and cutting OPEC’s market share. Higher prices will stimulate higher investment in non-OPEC countries, driving up their conventional and non-conventional oil production.

Benchmarking of energy efficiency and CO_2 emissions in the Petrochemicals sector - Mr. Hans Keuken, Process Design Center

Process Design Center has set up 50 energy benchmarks around world and is a leading energy benchmarker for the petrochemical industry. The Petrochemical industry is very diverse and as a result needs a wider range of benchmarks. For a fair comparison one has to address: system boundaries, feed and products specifications, site integration and environmental issues. Benchmarking must be done independently of government and industry. Short questionnaires are best and only disclosure of anonymous overall energy efficiency performances should be made. Benchmarking for certain Petrochemical products is difficult as often only few producers exist and each has its own process design. Information for these products is very difficult to obtain and generally confidential. Benchmarking of steamcrackers for ethylene production is done by Solomon Associates. PDC focuses on downstream petrochemical processes.

Aggregated results were shown of PDC's 50 benchmarks. This showed significant room for energy efficiency improvements worldwide. The best country in Western Europe is Belgium followed by the Netherlands. Germany is roughly in line with North America. The US is a relatively high energy user with Canada performing slightly better. With the exception of Korea, Asian plants were seen to be relatively inefficient. This is explained by relatively small scale plants, the way they are operated, and the fact that the site heat integration is limited.

An analysis of the year of construction showed that plants built in the 1970s were the least efficient with the most recently built plants showing the best performance in terms of energy efficiency. After the oil crisis of 1974 it took about 5-6 years before better designs were implemented. PDC believes that many of the plants built in the 1970s will be phased out in the future. A few older plants from the 1950s and 1960s, which have benefited from upgrades, also showed relatively good performance.

IEA petrochemical scenarios for 2030-2050: Energy Technology Perspectives - Kamel Bennaceur, IEA

The 2050 outlook for energy demand and the challenges it creates from a supply side CO_2 emissions are mandating a thorough review of the technology alternatives to achieve a sustainable path. From an energy use and emissions management standpoint, the petrochemical industry has challenges, as several thousands of products are generated in variable amounts. Part is accounted for by feedstocks (naphtha, ethane). Generated products (plastics, solvents) lock-in the carbon from those feedstocks; additionally, this locked-in energy can be recovered when the product (plastic) waste is incinerated, with generation of additional emissions. Due to the increase in energy costs, and the industrial growth patterns in the Asia Pacific and Middle East, the petrochemical sector is undergoing radical changes from a supply and feedstock standpoint. Projections of technology impact on energy use need to account for such a shift.

The ETP model has been used to assess future energy use for petrochemicals production and the related CO_2 emissions from production and waste treatment of synthetic organic products. The demand has been calculated as a combination of demand for seven types of plastics, olefins and aromatics derivatives. The comparison between the 2050 projections for energy usage and CO_2 emissions in the Baseline scenario and the Accelerated Technology indicates a significant potential for reduction in the petrochemical life cycle. The key contributing factors are biomass feedstock usage, biopolymer production, gas-based CHP and changes in waste treatment (increased recycling and energy recovery). Energy efficiency in production processes and CCS in production processes would contribute 27%. The CO_2 emission intensity can be more than halved with a combination of such technologies. This would result in a decline of 3% in absolute terms in 2050, compared to the 2005 level.

Worldwide energy and carbon efficiency potentials for the Petrochemical industry - Maarten Neelis, Ecofys/Utrecht University

A systems approach was applied to identify theoretical saving potentials. The carbon and energy content is quantified for all process streams, including losses. This approach looks at individual process features: i) losses due to non-selectivity; ii) excess final energy use (the difference between ideal and actual); and iii) energy conversion losses (from steam and electricity production). Total energy losses worldwide amount approximately to 10 EJ per year in primary terms.

The practical energy efficiency potential is difficult to determine due to poor data quality, regional efficiencies not being well documented. A distinction is required for current best practice and best available technology, BAT. BAT figures are difficult to determine as most of the information is secret. For processes where analysis is possible the potential seems to be substantial. For example analysis, suggest a 40% improvement potential when comparing current practice to best available technology.

There is substantial potential for savings. In the short term (next 15 years), energy efficiency improvement are expected from current best practices, while in the long term (25-50 years), emerging technologies and going toward a thermodynamic minimum will be essential. It is crucial that new construction projects be based on BAT. Better information flow is needed. Data availability is a major issue in this sector. There is a need to improve information flow from industry. To yield better results it maybe necessary to think broader. For example the heat integration of a paper and chemical plant is one possibility to benefit from the use of waste heat.

Energy Efficiency Indicators

Methodological insights from the Flemish Benchmarking program - Hubert Van den Bergh, Flemish Verification Bureau for Benchmarking

The energy efficiency benchmarking covenant is an agreement between the Flemish government and large energy intensive industrial users. The goal is to realise the best international standards of energy efficiency. It is based on international benchmarking, with a standard from an approved benchmarking consultant, and all measures until 2012 have been fixed in a plan which is updated every four years and monitored annually. The methodology and terms of the Flemish benchmarking covenant were presented. Full benchmarking is seen as the best and most reliable method. All companies and plants must be included so results do not end up being a tailor made approach for one company.

Benchmarking studies, distribution curves and individual standards are confidential. The summary of individual energy plans are made public. Aggregated results are reported in a way that individual companies cannot be recognised. Belgium's industrial energy consumption and CO_2 emissions are well placed compared to best international standards.

What can be covered by benchmarking are energy consumption, cogeneration, renewable energy and recovered feedstock. If the goal is international results, a consistent approach must be used. Benchmarking could be enhanced through enhanced participation and scope, and distribution curves should be made public for national/international policy programs.

From energy-efficiency to CO_2 Benchmarking - Jan Janssen, VBE, Verificatiebureau Benchmarking Energie-efficiency

This presentation focused on the connection between energy efficiency and CO_2 benchmarking and how this can be used in the National Allocation Plans (NAPs). The 1999 Dutch Benchmarking covenant on energy efficiency covers large industrial sites with energy consumption greater than 0.5 PJ (circa 150 sites) and comprises 80% of total industrial energy use.

The benchmarking is done based on a worldwide benchmark and every four years a worldwide benchmarking study is completed. Companies are required to prepare an energy efficiency plan in case they want to bridge the gap to the world's top and this progress is monitored by the VBE. By 2012 companies are expected to fall within the top 10% of energy efficiency in the world.

A graph where individual plant energy intensities are listed in increasing order is called a benchmarking curve. A steep benchmarking curve suggests that there is a lot of scope for improvement through investments in new or more efficient technology. A more horizontal curve indicates that technology is more mature and indicates that there is limited room for improvement as most plants are already based on the latest technology. Results of latest benchmarking round show that 54% of the industrial sites in the Netherlands belong to the top 10% in the world in terms of energy efficiency. Also, the Energy Efficiency Index has improved by 4 percentage points in the last 6 years, and is expected to follow a similar trend until 2012.

It was recommended that the way forward for a European CO_2 benchmarking approach should include the following elements: i) cost effective and economically efficient; ii) simplicity; iii) predictability; iv) regulatory stability; v) equal treatment for new entrants; and vi) a link to the rest of the world. It was recommended that the NAPs be set based on a benchmark that would encourage companies to invest in more energy efficient equipment or better operations. European CO_2 benchmarking can be used to achieve a fair and transparent way to allocate emission rights in line with key criteria from the EU-ETS directive and provide a basis for a global system. The system should use a Pareto / 80-20 rule, and include direct and indirect CO_2 emissions.

Greenhouse Gas Emission Estimation & Inventories - Brigitte Poot, IPIECA / TOTAL

The International Petroleum Industry Environmental Conservation Association (IPIECA) is an NGO created in 1974. IPIECA's GHG emission estimation and inventories are based more on refining than petrochemicals as the main business. The intention is to develop a voluntary guideline for the oil and gas industry to measure and report GHG emissions. The focus is on operational emissions. These guidelines are based on already existing protocol. The main issues which arose when designing this guideline were: i) operational control versus equity reporting; ii) direct versus indirect emissions; and iii) tiered approach.

The boundaries for GHG emissions reporting are very important. Operational control based on industry practice is preferred over equity share. A tiered approach to the entire facility emissions was required for different quality objectives. A linkage to the API GHG compendium is also provided. The goal of this guideline was not benchmarking, but a methodology that would be consistent globally.

Greenhouse Gases Handbook - Eric Johnson and Russell Heinen, SRI Consulting

SRI has recently published a Greenhouse Gases (electronic) Handbook that allows an estimation of CO2 emissions for different feedstocks and operating conditions. The presentation focused on CO_2 emissions in German ethylene production. Historical and future capacity and production by feedstock were analysed. These factors are adjusted for local circumstances to determine emission factors for over 100 processes.

This approach is based on SRI's Process Economics Program and Chemical Economics Handbook. SRI has developed a number of different benchmarks, with a focus on major product chains (ethylene, propylene, butadiene, and methanol). These benchmarks are disaggregated and based on process on site. The benchmarks are calculated based on engineering estimates and can thus be used in smaller chemical sectors where it is difficult to get operating data. This approach is seen to be inline with the Non-Energy use Emission Accounting Tables (NEAT) model.

Technologies to Improve Energy Efficiency and Reduce CO_2 Emissions

Development trends for ethylene crackers: existing technologies and RD&D - Colin P. Bowen, Stone & Webster

The ethylene production process has been one of the most energy intensive due to its high heat of reaction (25 % of energy consumption) and complicated product recovery scheme. Early units were relatively small, unselective and inefficient. However when both feedstocks and fuels were low-cost, overall ethylene production cost was not significantly impacted by design efficiency. That situation changed significantly in 1973 with the first energy crisis and costs increased four-fold. Ethylene designs eventually reacted to this energy cost impact and in this same era plant sizes increased significantly up to 600 kta capacity. Following our recent fuel price hike we can anticipate another round of developments focusing on efficiency and lower cost feedstocks.

Today's specific energy consumptions (SEC) are in the range of 3500-4500 kcal/kg C_2H_4 for ethane crackers (compared to 6600 in the 70-s) and 4500-6500 kcal/kg C_2H_4 for naphtha crackers (compared to 10,000 in the 70-s). Feedstock cost increased respectively 25 and 8 fold in the same period. SEC is a function of the selected technology feedstock characteristics, its cracking conversion/selectivity, related ambient conditions and degree of upstream/downstream integration.

Key design changes which have been introduced include the following:

- Upgrade natural draft cracking furnaces to induced draft.
- Integral SHP steam super heater
- Gas turbine integration
- Higher temperature quench oil tower for higher level heat recovery
- Higher efficiency rotating equipment
- More extensive process-process heat recovery schemes
- Simultaneous cryogenic heat and mass transfer schemes
- Multi-stage refrigeration schemes
- Isentropic rather than isenthalpic expansion
- Integrated heat pump systems for several fractionation services
- Front end rather than back end hydrogenation
- Utility system integration with OSBL and associated units.

While most new mega-sized units incorporate a large number of the above features, several of the existing older units still operate with only a few such schemes. European and Japanese plants with an average age of over 20 years have generally been revamped and upgraded to a much greater extent than have US units. As a consequence the specific energy consumptions of the average US Gulf Coast unit are approximately 20% higher than their overseas counterparts. In the US improved operations have claimed up to 20% net energy reduction since 2000. The plan is to achieve a similar improvement during the next decade principally by upgrading design features. Current efficiency options include furnace upgrade, gas-turbine integration, combustion air preheat, catalytic distillation, while emission reduction are obtained by pre-treat of quench water, Lo-NOx multi-stage burners, and optimization of start-up/shutdowns.

Future feedstock options include methanol to olefins, catalytic conversion of olefin co-products, ethane dehydrogenation, and gasification technologies (F-T). Future cracking furnaces could use ceramic coil, coated radiant coils, refractory coatings and O2 enhanced firing. Efficiency improvement could also come from energy integration with upstream/downstream facilities.

CHP - Rick Meidel, ExxonMobil

Since 2000, ExxonMobil's energy efficiency teams have identified initiatives supporting a 15% reduction in energy use and have already captured about 50% of those savings in the 2000-2005 period. This translates into energy savings of over $500M / year and a savings of greenhouse gas emissions of about 7 million metric tones per year.

In addition to these energy efficiency initiatives, cogeneration has become a standard feature in many petrochemical production facilities. This further improves the energy efficiency and environmental performance story for ExxonMobil and for the regions in which they operate. Drivers for cogeneration are energy efficiency, emission reduction, economics and security of supply. ExxonMobil installed its first cogeneration facility in the 1950's and today, the company self-generates significantly more than 50% of its electricity needs. The company's cogeneration capacity has had the effect of reducing regional CO2 emissions by more than 9 million metric tones per year. This is equivalent to 35% of the wind capacity in Germany and 65% of the wind capacity in Spain, the #1 and #2 wind markets in the world respectively.

ExxonMobil aims to find additional heat requirements in operations that can be made more efficiently with cogeneration. One of the ways this is done is to leverage a technique called direct process heat integration. At the Antwerp refinery in Belgium, where a project is under construction, ExxonMobil is taking a portion of the waste heat to make steam and another portion of the waste heat and integrating it directly into the crude pre-heat process within the refinery. This is believed to be the largest direct process heat application in the world and results in a facility that's more than 85% efficient when including the refinery's net efficiency gains.

ExxonMobil applauds certain countries in the EU that are working to support cogen investments through a variety of mechanisms. But as they learned with the recent EU CHP Directive, active involvement is required to ensure that mechanisms designed to support cogen, actually will support these investments. ExxonMobil supports mechanisms that benefit facilities that enhance the overall efficiency of the grid. The same flexibility given to other generators is needed in terms of how to participate in the market and in terms of how market compliance costs are met. Going forward, rather than government policies and support mechanisms that incentivize renewables, these policies and mechanisms should aim to incentivize 'low carbon' technologies which include not only renewables but other high efficiency, low cost generation like cogeneration. This forward thinking approach is a triple win, benefiting industry, the public and the environment and on a scale perspective, would dwarf the impact of many well intentioned renewable projects.

New trends in process integration for better energy management considering the environment - Toshko Zhelev, University of Limerick

Combined resources management is seen as the way forward. The objective is to save both water and energy simultaneously. It is believe that fresh water can be saved through better energy management. Process integration through process decomposition was recommended. Energy pinch analysis allows an integrated energy –waste analysis.

Emergy, a resource management methodology developed by environmentalist, was seen to be an interesting alterative to pinch technology. A combined Emergy and Pinch Analysis were recommended. Integration between different players was suggested as well as integration on a regional scale.

Alternative Feedstocks

Biobased chemicals production and its competition from coal - Martin Patel, Utrecht University

This presentation focused on the results of the BREW Project. This project looked at medium and long-term opportunities and risks of the biotechnological production of bulk chemicals from renewable resources. A life cycle approach was taken and included the waste stage. The results of the study showed that biobased technologies require less energy than those for petrochemicals. The production of biobased chemicals from starch represented an energy savings potential of approximately 30%. Other fermentable sugar feedstocks such as lignocellulosic and sugar cane provide even greater energy savings potential. For sugar cane, if begasse is also burned for electricity overall benefit for sugar cane is even greater.

Under the scenario analysis the projected non renewable energy use savings for selected organic chemicals in 2050 was 7-10% in the low case, 19-29% in the medium case, and 37-66% in the high case. The results for the total production of all organic chemicals in 2050 showed non renewable energy use savings of 3 – 5% for the low case, 9 – 13% for the medium case, and 17 – 31% for the high case. Under today's environment the high scenario case seems unlikely.

It was also shown that biobased chemicals may face tough competition from coal, especially in China. The situation in Europe is unclear. When the BREW project was underway there was a lot of interest from stakeholders, but the impression now is that the primary interest today is in biofuels. Biomass feedstocks for bulk chemicals seem to be secondary. There is a need to try to exploit additional synergies. Substantial technological breakthroughs in bio-process and bio-separation are required.

Current Status of Plastics Recycling in Japan - Hisao Ida, Plastic Waste Management Institute

This presentation showed that plastic waste is a valuable resource when it is properly collected and used. In 2000, Japan began its development of a recycling orientated society with the introduction of the recycling law, part of the legislative framework for formation of a sustainable development society. The Three Rs were advocated: Reduction, Reuse and Recycling. Plastics waste is seen as a valuable resource with high caloric value. In 2004 there was a total of 10 Mt of plastics waste. Of this total 60% was utilized and 40% was either incinerated or land filled. Of the total utilized 1.8 Mt (18%) went to mechanical recycling, 0.3 Mt (3%) to chemical recycling, and the remaining 4.0 Mt (39%) was used in energy recovery. Japan is one of the world leaders in plastics recycling.

The plastics waste industry in Japan is facing two important challenges: rising costs and rising demand for plastic waste exports. The government's guideline places greater priority on mechanical recycling over chemical recycling and as a result leads to rising recycling and sorting costs. China is a large importer of Japan's plastic waste for use in fibres and is making procuring recycled waste difficult. End of life plastics after use should be collected and utilized by appropriate methods including energy recovery without land filling. The most suitable method should be selected for collection and utilization of waste plastics by taking into account Life Cycle Analysis (LCA), economic evaluation, local conditions and voluntary approaches. Developing Asian countries should be included in future discussions as their influence on the environment and resource consumption are growing rapidly.

Plastics recovery - Aafko Schanssema, Plastics Europe

The Plastics Europe presentation advocated a life cycle approach when considering the sustainability of plastics. Under this analysis plastics are seen to be sustainable. A cradle to grave analysis is required when looking at the plastics sector. Plastics contribute to resource efficiency during the use phase as replacement by other materials would require significantly greater amounts of energy. When plastics are used in insulation applications savings equalling the energy needed to produce the material are achieved after only 4 month of use, while total use phase is estimated at 50 years.

Three key recovery options exist for plastics: i) mechanical recycling; ii) feedstock recycling; and iii) energy recovery. As only 20-30% of plastic waste can be mechanically recycled the remainder can be used for energy recovery. The promotion of plastics recovery is important to enhancing the products sustainability. The industry sees a large potential for energy gains with increased plastics waste use for energy recovery. New advanced recovery technologies could help boost this performance.

Energy in Petrochemicals: Situation and Perspective

DOW Chemicals–Russel Mills, Director Technology and Innovation Mills – Dow Chemicals

This presentation focused on Dow Chemicals European operations, which account for approximately 1/3 of its global business. The company believes that Integration, Efficiency and Global Impact are key to closing the carbon cycle in the Petrochemicals industry. Energy costs represented over half of the company's total costs in 1995. The value of integration and importance of petrochemicals as building blocks was stressed.

Cogeneration, waste and by-product use are important aspects for Dow Chemicals. The company has a long term commitment to CHP, which relies on the effective us of the "by product" heat. Approximately 75% of all of Dow's electricity is supplied from cogeneration. In the short term key energy savings will come from energy efficiency and this will continue to dominate into the next decade. In the medium term, the speaker sees the arrival of biobased alternatives and C1 chemistry and other breakthroughs. Only in the long term (2030-2050), in line with IEA projection, will these alternatives represent a larger volume. The Biorefinery concept will be important and there is a need to demonstrate that 2nd generation biomass can be done efficiently without need for subsidies. In the long term biomass can selectively replace petroleum feedstocks.

Dow's 2015 commitment is to take aggressive action to mitigate climate change and has committed to a further 2.5% reduction per year for the next 10 years. This effectively represents a 20 year programme to cut energy use by half with an even larger reduction in GHG emissions. From 1994-2004 DOW already reduced energy consumption by 21%. Resource efficiency dominates savings in the short and medium term, but there is a critical need to keep all options open. Intelligent site integration plays an important role for efficiency; full life cycle thinking is needed to benchmark new policy measures.

Shell Chemicals – Johan Breukelaar, Global Sustainable Development Manager

Shell is taking action now to commit to combating climate change and is an active member of the World Business Council for Sustainable Development, WBCSD. The company is actively managing greenhouse gas emissions in their worldwide operations and helping customers reduce their emission. Shell's scenarios work is key to its business strategy.

One of Shell Chemicals key 5 year Sustainable Development Goals is to improve overall energy efficiency by 7.5% by 2007, relative to 2002. This represents a reduction of 750,000 t of CO2. Shell Chemicals is on track to achieving this goal. The company sees 3 key options to reducing CO_2 emissions: 1) further energy efficiency gains; 2) alternative energy sources and / or feedstocks with a lower carbon footprint; and 3) integrate "tail pipe" solutions such as CCS. In regards to emissions trading there is a need for clear and simple allocations.

Closing the carbon cycle will take many decades and energy efficiency is one of main vehicles to deliver this closure, CCS is another. Policies are needed that do not distort the market. Governments and other stakeholders need to work together.

TOTAL – Daniel Leuckx

Total believes that the announced growth rates will double the need for Petrochemical products in the next 15 years. The feedstock needs for steam crackers will reach nearly 10% of all hydrocarbons produced as a result of this strong increase in demand. There is a need to optimise the use of hydrocarbons and the Petrochemicals sector will need to adapt to changing feedstocks. Total's petrochemicals sustainable development plans include renewable resources, energy efficiency improvement and emissions reduction, waste reduction, and end of life improved products.
Total believes that energy efficiency will be driven by integration. Autoconsumption and heat integration is important to improving energy efficiency. The key question for the sector in the future will be how to get adequate feedstock and also solve environmental issues. There are no answers today. Biomass is one possible option. The economical sustainability of energy improvements is vital. If the cost of investment is not justified it will not be done. Total is actively looking at alternatives and continues to work on technological advances in petrochemicals.

SABIC – Vianney Schyns

SABIC is a large player in the Petrochemicals sector (43 Mt production in 2004) and wants to grow even further. The company sees a long term potential for improvement in energy efficiency and CO_2 emissions. To achieve these benefits a predictable business and policy environment is needed. The speaker believes that there exists a remaining potential of 80-90% in terms of exergy efficiency. Biofeeds, CCS and further improvements in energy efficiency are the key solutions to achieving this potential.

Shortcomings in the present implementation of the EU ETS Directive were also covered by the speaker. It was stressed that structural improvements are urgently needed. The key shortcomings are its effectiveness as an incentive for low carbon technologies; its ability to provide a level playing field across Europe; lack of competitiveness as electricity sector enjoy windfall profits and threat carbon leakage; and need for fair and free competition in both the energy and industrial markets. One possible solution presented was benchmarks with ex-post adjustment to actual production, or Performance Standard Rate (PSR) as an alternative to auctioning. Under this mechanism, action to reduce emissions is rewarded immediately.

ExxonMobil - Rick Meidel

ExxonMobil is taking actions on a global basis to improve efficiency and reduce emissions and develop technologies that offer long-term solutions. Since 1980, the company has conducted and supported peer-reviewed research to advance climate science. Energy is by far the single-largest operating expense at the company's refining and chemicals facilities, accounting for about one-half of total cash costs. Energy efficiency is seen as a triple winner that benefits industry, consumers, and the environment alike. And unlike many options, which may require billions of dollars and many years to develop, there is much being done to improve energy efficiency in operations right now and sometimes at low or no cost.

One important initiative that is having a positive impact is implementation of the Global Energy Management System – or GEMS – which utilizes international best practices and benchmarking to identify energy efficiency opportunities. The path forward for ExxonMobil includes Actions Now, Technology Extensions and Breakthrough Research. In the nearer term – a number of efficiency and conservation initiatives are underway. Over the medium term – work is being done to expand the sources and uses of clean-burning natural gas. These include fuel switching opportunities as well as LNG and GTL technologies. Longer term – ExxonMobil continues to support and participate in innovative and far-reaching climate-related research.

In order to stimulate innovation and the generation of research leads across a wide spectrum of technologies, Exxon Mobil worked to create the global climate and energy project at Stanford University. GCEP is a $ 225 million project that aims to create innovative, commercially viable technologies with low greenhouse gas emissions that can work across the globe. XOM is also participation at the EU-funded CO2ReMoVe project which aims at providing guidelines for monitoring CO2 injection.

No response to climate change can be effective without the involvement of important countries such as the United States, China, India and Brazil, among others. There is a tremendous opportunity to reduce emissions by encouraging the more rapid use of existing efficient technologies in both developed and developing countries. It will only be possible to involve developing countries if climate risk is addressed in the context of their priorities: development, poverty eradication, and access to energy.

BASF – Wolfgang Weber

The Verbund site concept is the most important measure being used by BASF to improve energy efficiency and reduce CO_2 emissions. The Verbund site aims to integrate the use of energy at its industrial sites. The Ludwigshafen site is the world's largest integrated chemical complex. BASF estimates that this Verbund site saves 500 million € per year, from which 150 million € can be attributed to energy savings. There is significant energy and CO_2 savings compared to a stand alone cracker.

BASF also stressed the need to use a Life Cycle Assessment when looking at energy efficiency and CO_2 emissions in the Petrochemical sector. For example the CO_2 savings from the use of insulation materials which is produced from BASF sites in one year is greater than 140 Mt CO_2 over its full life time and the use of BASF fuel additives saves more than another 12 Mt of CO_2 per year.

Alternative feedstocks such as biomass feedstocks and coal alternatives are also being researched by BASF. The option of biomass feedstocks suffers from competition from subsidized biomass use for electricity and biofuels. Biomass is currently being touted by politicians as an option for too many items and given that there is a limited supply of biomass cannot be used for everything. For the industry, other raw material such as coal maybe a better alternative as there is less price volatility than in the case of biomass.

Innovation, Research and Development - Marian Mours, CEFIC

An overview of the European Technology Platform for Sustainable Chemistry – SusChem was given. SusChem seeks to boost chemistry and chemical engineering research, development and innovation in Europe. SusChem is a multi-stakeholder platform that bridges academia, industry, SMEs, NGOs and other relevant stakeholders. It was jointly initiated by CEFIC and Europabio in 2004.

There are three technology working groups: 1) Industrial Biotechnology; 2) Materials Technology; and 3) Reaction and Process Design and all three have an important focus on energy. Industrial Biotechnology looks at fermentation and biomass; Materials Technology focuses on new materials used in new products which would increase energy efficiency; and Reaction & Process Design covers processes within the industry that can improve energy efficiency.

A description of how plastics and chemistry research were used in a smart energy home was given to demonstrate the impact of chemistry research and innovation on our daily life in the future. It was stressed that innovation requires a framework condition that enabled the uptake of new products and processes in the market.

The Legislative Context: Opportunities and Challenges

Opportunities and challenges in the regulatory environment in Europe - Peter Botschek, Director Energy Policy, CEFIC

Energy costs in the European Petrochemicals sector have risen 80% over the last 5-10 years, with energy consumption representing 12 % of EU demand. This has placed huge pressure on the sector and acted as a motivation for further optimisation of energy use. In Europe, energy consumption in the sector has remained relatively stable despite a sharp increase in production volumes, signalling a decrease in energy intensity. The industry confirms EU authorities' findings that the EU energy market suffers from serious failures which have contributed to high energy prices and under investment in the sector.

CEFIC believes that the EU energy market (gas and electricity) has suffered from vertical foreclosure that has led to market concentration. There are concentration and dominant positions at the wholesale level and incumbents not only control domestic production, but also imports. There is little room for new entrants and new players. The lack of competition in the energy sector is the result of insufficient unbundling during privatisation. This has also made investments in CHP more difficult.

It was suggested that an improved form of emissions trading could be used on a global scale and that the IEA could advocate a more global approach as climate change is a global issue. Many structural issues were raised with the EU ETS and with the setting of the NAPs. CEFIC feels that at times the EU ETS distorts incentives for more efficient energy installations. For example, a more efficient installation in one country could be required to buy credits from a less efficient installation in another country. Instead, the ETS should be improved by rewarding the efficient in comparison to the inefficient producer. Emission allocations should be based on performance and measures should be taken to prevent production shift from the EU (relatively CO2 efficient) to other regions without emission constraints (carbon leakage). Regulation and market conditions should enhance, not penalise efficient industries. Cefic has offered to be contribute to the official EU Emissions Trading System Review process to be launched in the first half of 2007 which aims at improving the scheme's effectiveness and global attractiveness i.e. for the time after 2012 (post Kyoto).

Sectoral approaches - Richard Baron, IEA

Sectoral approach is a new and upcoming topic on climate change mitigation. It is believed that a country by country approach lacks coordination and fairness and thus a sectoral approach maybe required. .This approach is used to try and maximise GHG reductions and can be applied in sectors that have homogeneous products or processes. Highly concentrated sectors would facilitate these negotiations. Governments must be involved in a sectoral approach as they are needed to endorse and even negotiate with industry. The underlying assumption for a sector approach is that a policy driving a single price of carbon that can affect all fuel use is not yet here.

The question was raised as to whether the Petrochemicals sector could benefit from taking a sectoral approach to climate change. A series of questions were raised to see if this would be a suitable approach for the Petrochemical industry. Some of these questions include: Is progress on CO_2 reductions in the sector hampered by competitiveness concerns? Where are CO_2 reduction options in the sector? Can these barriers be better handled through some international coordination?

7th Framework Programme - Pierre Dechamps, European Commission, DG Research

This presentation gave an overview of the European Commissions historical Framework Programmes and outlined the future activities of the latest 7th Framework Programme. Carbon capture and storage activities were given particular attention, including the Technology Platform for Zero-Emissions (ZE) Fossil Fuel Power Plants initiative. The EU is currently promoting zero emissions power plants, with an objective of capture-ready plants by 2010, and all new power plants to be using ZE Technologies by 2020. Approximately twelve large scale projects have been announced by the private sector recently.

In the past the EC feared that zero emissions research was diverting funds from renewables research, but now have refocused on zero emissions research as it is clear that renewables will not provide a sufficient solution to combat climate change and fossil fuel plants with CCS is preferred over nuclear. Both NGOs and the EC see CCS and zero emissions in power generation as a way to reach their objectives on mitigating climate change.

The EC energy theme objective is "adapting the current fossil-fuel based energy system into a more sustainable one, less dependent of imported fuels, based on a diverse mix of energy sources and carriers, with particular attention begin paid to lower and non-CO2 emission energy technologies, combined with enhanced energy efficiency and conservation, to address the pressing challenges of security of supply and climate change, whilst increasing the competitiveness of Europe's industries".

Energy and CO_2 Indicators for the Petrochemical Sector – Cecilia Tam, IEA

A paper was presented that outlines the proposed methodology for energy and CO_2 indicators in the Chemical sector. Indicators for petrochemicals are different than for other sectors because most carbon and a large share of the feedstock energy content are stored in the products. Therefore indicators should not only cover the production processes, but also the waste treatment stage that is critical to the overall energy and CO2 balance. We propose four indicators: 1) an energy efficiency index based on final energy use which looks at efficiency in the production process; 2) a primary energy equivalent index based on the first indicator; 3) a full life cycle energy efficiency index which credits the use of renewable feedstock and recycling / energy recovery; and 4) a CO_2 emissions index.

The lack of energy use data on the level of individual processes and products makes individual process indicators infeasible and thus we propose an aggregate product indicator. Ideally these indicators would only cover petrochemical products, but as IEA energy statistics also include inorganic chemicals our analysis includes all products in the chemical and petrochemical sector. We have identified 57 products to be included in this aggregate indicator. These products represent more than 95% of all energy used in the Chemical and Petrochemicals sector. An application to the Japanese Chemical and Petrochemical sector was then presented to give an example of how these indicators could be applied. The validation of the results is an issue. Application for more countries is sought in order to assess if the outcome is in line with ideas about country rankings that were expressed at the workshop. These indicators are not intended for comparisons across different materials categories, LCA methods are better suited for such comparisons. The following discussion focused on the BAT energy values and the data availability. Several participants offered additional data to improve the analysis.