Business and Industry Advisory Committee to the OECD

Comité Consultatif Economique et Industriel Auprès de l' OCDE

BIAC is pleased to submit this paper on Innovation and Environment to the Meeting of the Environment Policy Committee at Ministerial Level. While the various issues raised in the Environmental Strategy have been addressed in the comments we submitted previously, we have chosen to focus this discussion paper on a particular aspect, where business makes an important contribution to the sustainability of growth through environmentally effective management. This paper is also part of the BIAC discussion paper on "Innovation and Global Sustainable Growth", which has been submitted to the OECD Council Ministerial.

Meeting of the OECD Environment Policy Committee at Ministerial Level Paris, 16 May 2001

Innovation and the Environment: Learning from Our Successes

Working toward sustainable growth is a key challenge for the new century. Business and industry is fully committed to advancing the complementary themes of economic growth, environmental health and social development, which benefit all sectors of society, which are, broadly speaking, our markets. Contributing to these objectives should be considered in the context of business opportunities, which requires researching and harnessing innovations in product design and manufacture, management systems, and their nexus with public policy. Increasingly complex environmental challenges will require continuous innovation in science, technology and management systems to find environmentally sustainable solutions that spur, not impede, economic growth.

- ***Continuous improvements in environmental performance through innovation***

  Experience indicates that innovation can contribute to breaking the links between economic growth and environmental degradation. Upgrading technology is a prerequisite for more effective use of resources and thus improving environmental performance, which becomes all the more important in view of a rapidly growing world population. In most cases, newer technologies and processes are both more efficient and less polluting than the technology they replace, allowing increased production using less material and causing less pollution. At the same time, environmental performance often presents business opportunities that enhance firm-level efficiency.

  Technology development depends on the effectiveness of the R&D efforts both in the public and private sectors. While government efforts are key, most non-defence R&D takes place in the private sector. There are continuous, robust industry research programmes under way in

the areas of materials, materials management, process engineering, etc., which are focused on the efficient and cost-effective use of product inputs and natural resources. Public policies need to take into account both the potential and the complexity of these environmental innovations, as well as of the flexibility, support and incentive structure that encourages firms to innovate and diffuse new technology, bearing in mind that commercial success depends upon carrying out business in value-creating ways.

- ***Business opportunities through better environmental performance***

  Firms that give priority to resource productivity, process change and product innovation can achieve significant performance gains at lower cost. A competitive firm must have as robust a programme of cost reduction as it does in the pursuit of market share. Strategies to improve performance often also reduce negative environmental impacts. The first point of departure is to search for ways to reduce the use of inputs or materials and natural resources. Another focus is on the reduction of energy use. Lower costs, driven by competition, bring prices down and can in many cases improve environmental performance. More efficient production processes and products through innovation and a reduction in resource use and pollution can be mutually reinforcing objectives.

- ***Offer a sound regulatory framework for innovation***

  The market depends on a stable and supportive framework of public policy. Business benefits from regulation that is predictable and consistent, but not overly prescriptive. It is critical that the regulatory framework encourages innovation and fosters beneficial technological change. Given the economic, environmental and social importance of innovation, regulatory programmes need to fully take into account the effects of regulations on the development of new technologies. This can involve the revision of a single regulation, a regulatory regime, or the improvement of processes for managing reform. Regulatory reform to increase competition and encourage new market entrants is key to innovation. Policies need to be flexible and incentive-based and be designed to stimulate dynamic efficiency. Innovation policy approaches need to look for creative ways to enhance co-operation across sectors, from R&D to commercialisation, as well as public-private partnerships to meet particular research challenges.

- ***Use market-based incentives as a tool for environmental improvement***

  Regulatory programmes that take advantage of market forces can achieve impressive environmental results with lower transaction costs and fewer prescriptive requirements than traditional approaches. These tools – which rely on marketplace incentives rather than direct, command-and-control requirements to achieve environmental performance – need to be extended to a wider range of pollution control and prevention programmes. Innovations in product design, pollution prevention and resource management will work best in a regulatory system that builds on business's proven success in meeting requirements through investments in science, technology and process innovation. Fiscal policies need to provide incentives, e.g. lower statutory rates, R&D credits, for firms to invest and innovate, thereby improving environmental performance.

- ***Develop policies and strategies that focus on performance***

  Drawing on many recent innovations in environmental stewardship that have emerged from government and the private sector, public policies should foster a culture of performance-

based management. This culture would focus on defining, measuring and rewarding environmental results and reorienting core regulatory functions so they are driven primarily by performance goals. Policies need to set clear, transparent goals that establish desired environmental outcomes and give business greater flexibility in determining how to achieve these outcomes. Regulatory renewal and a performance focus by industry to effectively track and communicate progress should also be encouraged.

- ***Support voluntary actions in environmental policy***

  Industry relies on innovation to improve production efficiency and reduce environmental impacts. Voluntary actions represent a promising approach with respect to many environmental problems. They are based on a comprehensive consideration of technical trends and other management-related issues and allow those with the best knowledge about their own business to propose and execute measures that are effective from a cost-benefit standpoint. Especially compared to other more prescriptive policy tools, they provide a flexible framework for innovation and creativity that allows for new approaches, the opportunity to improve environmental competitiveness and more rapid changes than would be possible under mandatory programmes. In addition, they promote awareness of existing and new technical management practices and encourage the dissemination and implementation of effective technologies. Improvement in actual performance will more easily occur through private sector initiative and invention than through imposed government constraints, which do not allow the flexibility needed for ongoing progress. Business should be encouraged to play its part.

- ***Promote environmental innovation world-wide***

  The advance of democratic governments, the rule of law, market liberalisation, and international communication have made more vivid the linkages between environmental, social, and economic values. These trends have created significant benefits for society through greater wealth, freedom and mobility, increased opportunity, and improved access to products and services. Economic growth permits higher environmental and living standards world-wide. The global diffusion of the market-based economy has brought with it an algorithm of value that has led to serious efforts to combat domestic corruption and improve the implementation of existing regulations, both of which have had significant benefits for the environment and society at large. As national regulations are further developed, policies should be designed that promote innovation and the absorption of technology and thereby reinforce improved environmental performance.

- ***Encourage the transfer of environmentally friendly technologies***

  The development and application of environmentally friendly technologies and know-how are already making a significant contribution to reducing the environmental impact of economic activities. The spread of innovative approaches to non-OECD countries will be crucial for environmental improvements. The main vehicle for this form of co-operation between industrial and developing countries has been and will continue to be the private sector, through its day-to-day business activities of technology development, foreign direct investment and technology sales and dissemination. The development impact of foreign direct investment goes beyond its monetary value and includes positive side-effects such as the transfer of environmentally-friendly technology and know-how and the spread of efficient management practices. This is due to the managerial links between parent and subsidiary and the advantages of employing comparable environmental procedures throughout a multinational firm's operations. Trade and investment liberalisation is therefore essential to speed the transfer and diffusion of clean

technologies. Governments should set enabling legal, fiscal, economic and social framework conditions for private investment and technology co-operation to take place.

- ***Develop new forms of dialogue and partnerships***

  Establishing a sound dialogue with those who have a stake in these issues will become increasingly important. Efforts should be made to create public/private partnerships to meet particularly difficult research challenges and stimulate investment in environmentally beneficial technologies. These should include processes for business and government collaboration and supportive incentives for private sector R&D in environmental technology. Dialogues that follow the “life chain” of products, from producer to consumer, may create a better understanding of the range of possibilities and consequences. Dialogue and partnership can also help to increase public understanding of complex subjects, such as technological change, and raise awareness of the fact that a broad base of action is needed to involve all parts of society to work towards sustainable development.

ANNEX

Business Practises Contributing to Success

Companies have begun to take a pro-active stance towards the environment, recognising the value proposition that this implies and the potential economic reward in efficiency. The following examples illustrate the contribution that specific sectors and companies have made, for example, in the area of greenhouse gas emission reduction and the reduction of resources used per output unit. All of these industries rely on innovation to improve production efficiency while at the same time reducing environmental impact.

Voluntary reduction of Perfluorocarbon by-products from the Aluminium sector (IAI)

The Aluminium industry plays its part in responding to the challenge of climate change by reducing its own energy consumption and emissions through more efficient production and recycling. It also contributes to energy saving and emission reduction in key sectors of the global economy such as transport, packaging and construction. It has been one of the first industrial sectors to reduce voluntarily significant amounts of greenhouse gas emissions from its internal operations. PFCs are one of the few greenhouse gases which are actually in decline. A recent IAI Survey of PFC emissions covering over 60% of the world's primary aluminium production, excluding Russia and China, showed that in the seven years between 1990 and 1997, there was an overall reduction of 47% in the specific emission rate of CF4 (kg per tonne of aluminium production).

Reduced mass weight of vehicles by material substitution (IAI)

The Aluminium sector assists its customers in the transportation sector to achieve their goals of producing vehicles that will emit lower greenhouse gas emissions. Aluminium's contribution to reducing vehicle weight and therefore fuel consumption means that every tonne of aluminium, which replaces 2 tonnes of conventional heavier materials used in automobiles saves the equivalent of 20 tonnes of CO2 emissions over the lifetime of the average automobile. Other applications such as trucks, buses, railroad cars, aircrafts and ships contribute even larger GHG savings. The global use of aluminium in transport has increased from 2.5 million tonnes in 1991 to nearly 4.5 million tonnes in 1999. This use of aluminium for 1999 would have the potential over the lifetime of the vehicles to reduce GHG emissions by 90 million tonnes per year assuming that all this aluminium was used to replace denser materials.

GHG emissions reduction and energy saving through the recycling of materials (IAI)

At the end of their useful life, aluminium products can be recycled again and again to produce new products without any loss of value. The increasing use of recycled metal saves on energy and the mineral resources needed for primary production. It can therefore over time make a major contribution towards the goal of sustainable development through the reduction in the use of energy and raw materials and by cutting down on greenhouse gas emissions. Recycled aluminium saves up to 95% of the energy required to produce primary aluminium. Greenhouse gas emissions from secondary production are only 5% of those from primary production. Just over 7 million tonnes were recycled in 1998 worldwide, which fulfilled 20-30% of the global demand. The aluminium industry is working with the automobile manufacturers to enable easier dismantling of aluminium components from cars to improve still further the sorting and recovery of aluminium.

Shell's greenhouse gas emission reduction

Shell's greenhouse gas emission strategy is best understood in the context of fundamental changes in the company's approach to its world-wide operations, which took place in the mid 1990's. Two main changes include:

- *the view that sustainable development encompasses all of financial, social and environmental aspects, and is an integral part of all business decisions*

- *a revision in business principles towards openness and transparency. This included a decision in 1997 to monitor and report 24 key health, safety and environment parameters, and to have 12 of these verified by an independent agency*

For GHG emissions we have set ourselves an absolute emission reduction target of 10% over 1990 emission levels by 2002. We have also developed an internal emissions trading system, the Shell Tradeable Emission Permit System (STEPS) and have developed a CDM demonstration programme. In 2000, Shell's GHG emissions increased slightly, mainly as a result of higher production. GHG emissions are now 11% below 1990 levels in line with the reduction target. Shell is achieving its emission reductions primarily through the reduction of venting and flaring of natural gas associated with oil production, and energy efficiency in refineries and chemical plants. Continuous venting will be phased out by 2003, while continuous flaring will cease by 2008.

EnviroEngine technology makes seafaring environmentally friendly (Wärtsilä)

The Finnish company Wärtsilä has developed a totally smoke-free EnviroEngine marine power plant based on its $_9L_4$6D engine. The technology employed in the engine makes it smoke-free even at low revolutions or when used in port for lighting, air conditioning or other crew quarters systems. EnviroEngine diesel engines go well beyond international emissions standards.

Wärtsilä will deliver the first engine for the Carnival Spirit cruise liner about to be completed in the spring of 2001 at the Kvaerner Masa-Yards Helsinki shipyard. Engine orders have also come in from Portugal and Italy. Wärtsilä developed the engine in cooperation with the U.S.-based Carnival Corporation. Wärtsilä is the world's leading maker of ship propulsion systems and a significant provider of power plants for dispersed energy production and of maintenance and operating services. The consolidated group also includes a Nordic specialty steel producer. Wärtsilä employs 10,500 persons, 3,500 of whom work in Finland. Consolidated net sales totalled EUR 2.7 billion last year.

From Vision to Reality: The "Three-Litre Car" (Volkswagen)

The vision of sustainable development and sustainable mobility has increasingly developed into an important global challenge for international auto-manufacturers. As a global player, the Volkswagen Group accepts its responsibility in achieving this vision. The VW Lupo 3 L TDI, the world´s first serial production made cars capable of consuming only three litres of fuel per hundred kilometres, stands for the Volkswagen Group's determination to make a direct contribution towards sustainable mobility. The launch of the "three-litre car"[1] *in summer 1999 has been a major step in fulfilling Volkswagen´s voluntary commitment to reducing the volume of CO2 emissions. It also contributes to the German automobile industry's joint voluntary undertaking to reduce the average fuel consumption of new cars by 25 percent between1990 and 2005. The "three-litre" Lupo is the first passenger car that easily outperforms the target of 90 grams per kilometre for carbon dioxide emissions.*

Volkswagen has developed the "three-litre" Lupo with the aim of creating a passenger car that uses as little fuel as possible but still has a full equipment specification and also complies with the company's own high standards of safety. Numerous innovations have been introduced in the Lupo's engine, transmission, running-gear, body and aerodynamics areas. Features include systematic weight-saving design and construction, an optimised aerodynamic drag coefficient of only CD =0.29, tyres with reduced rolling resistance and an extremely economical power train. When the engine was developed, the main objective was to create not only an exceptionally economical unit but also one with adequate power for this class of vehicle, and in this way to ensure that fuel consumption in the MVEG cycle did not exceed 2.99 litres per 100 kilometres. The "three-litre" Lupo is powered by a three-cylinder turbocharged diesel engine with charge-air intercooler, using the pump/ injector mixture formation principle.

The engine has a start-stop circuit, meaning that it shuts down automatically after the car has come to a halt, and restarts when the accelerator pedal is pressed. It enables the engine to run for longer periods in the most favourable fuel consumption and emission speed ranges. The 5-speed direct-shift gearbox is one of the principal components used in the "three-litre" Lupo. Its simplicity compared with a conventional automatic transmission, the measures taken to reduce weight and the improved efficiency obtained with freely selectable shift points all lead to a definite reduction in fuel consumption. The market as well as press

[1] This figure does not of course refer to its engine size but to the amount of fuel the car needs to cover 100 kilometres, according to the European method of measuring fuel consumption.

and environmental organisations have paid significant attention to the Lupo: The German Association for Transport and the Environment (VCD), an environmentally committed NGO, evaluated the performance of the Lupo 3L TDI. This organisation compares the environmental performance of all production models available on the German market every year, awarding points for the environmental and health impact of vehicle emissions. The Lupo 3L TDI is top of the current 2000 "Cars and the Environment" table, as it was in 1999.

Diesel Technology Innovations: The Diesel High Direct Injection (Hdi) (PSA)

The Hdi is a high pressure direct injection engine combining common rail technology with state-of-the art engine architecture and electronics . It is one of the "cleanest" engines on the market today. The combustion system of the Hdi engine is one of its strong points. It comprises two key components :
- The high pressure injection system, comprising the high pressure pump, the common feed rail and an electronic control unit. Electronic management of the injectors makes it possible to inject fuel at very high pressure.
- The combustion chamber, designed specifically to optimise the air-fuel mixture. This system ensures extremely fine atomisation of the fuel in the cylinder for clean, complete combustion.

The common rail technology, combined with completely new engine architecture, reduces consumption by around 20 % compared with a standard indirect injection diesel engine with pre-combustion chamber and by 40 % compared with a petrol engine. Exhaust emissions are also substantially reduced, since high-pressure injection ensures more "complete" combustion whatever the engine speed. In comparison with a conventional diesel engine with a pre-combustion chamber, The Hdi engine offers a reduction of :
- *40 % of carbon monoxide emissions,*
- *40 % of unburned hydrocarbons emissions,*
- *60 % of particulate emissions.*

The high-performance Hdi engine also enhances driving pleasure, with more torque at low engine speed, less noise and less vibration.

Diesel Technology Innovations: The Particulate Filter (PSA)

Designed for use with the Hdi engine, the particulate filter works with the electronic system managing the engine's fuel supply. A major technological breakthrough, the filter sweeps away any hesitations concerning the use of diesel engines by reducing particulate emissions to the detection threshold. The filtering process is simple. It relies on a porous silicon substrate comprising a number of channels to force exhaust gases through the walls. The most significant technical obstacle to be overcome during the development phase was the problem of filter regeneration, since particles must be burned at a temperature of roughly 550°C. A cerine-based product was added to lower the combustion temperature to 450 °C, but even this is not sufficient, particularly in city driving, as the temperature of diesel exhaust gases is around 150 to 200 °C. This is where the Hdi engine comes into play : the electronic management system injects fuel during the expansion phase. The resulting post-combustion boosts the exhaust gas temperature to about 450 °C, thereby allowing the filter to be regenerated. This post-injection also produces additional unburned hydrocarbons, which are treated by the oxidizing catalyst located upstream of the particulate filter.
The particulate emissions of a 607 with a particulate filter are around the measurable limit : 0.004 g/km (the particulate emission limit in the European legislation is at the moment : 0.05 g/km). Several independent European laboratories verified this performance.

Eco-Design Contributes to Sustainable Development (ATOFINA)

The inherent properties of Orgalloy® (polyamide-polyolefin alloy) make it suitable for the manufacture of lubricating oil and air supply lines. In the latter case, Orgalloy® is processed by sequenced extrusion blow-moulding into a single component combining flexible and rigid parts. Air lines for turbo-diesel engines have traditionally consisted of some 20 different parts made from metal, rubber or plastic and joined together by mounting rings and clamping screws. They are now being replaced by a single component made of just 3 parts produced from two Orgalloy® grades. As a result, the weight of the pipe has fallen from 2.5 kg to 1 kg, which compounds the weight reduction afforded by the use of plastics in many automative components, and therefore further contributes to fuel savings throughout the car's life.

Electro technologies (EDF)

The utilization of electro-technologies is a means of reducing energy consumption, pollutant emissions and wastes. Therefore, it greatly contributes to sustainable development. As an example, in the cast iron industry, two processes are in competition: the cupola furnace uses 150 kg of coke per ton of scrap and therefore emits 520 kg of CO2/t. The induction furnace needs no coke but 600 kWh of electricity per ton of scrap. The corresponding CO2 emission would be 264 kg/t if an average European kWh were used and is only 60 kg/t in the French case (because of the very low CO2 content of electricity). In France, the CO2 savings due to the 40% market share of induction furnace are currently about 350 000 tons of CO2 per year. If a market share of 75% is reached, the additional savings of CO2 emissions will be 300 000 tons per year. EDF has made a large R&D effort in this field with vendors and has participated in several pilot projects.

Designing an environmentally sensible chlorine alternative to imitate naturally occurring antimicrobials

STABREX™ Microorganism Control Chemical2 is the first biomimetic industrial biocide, having been designed to imitate the stabilized bromine antimicrobials produced in mammalian immune systems. STABREX is original and unique: It is the first biomimetic industrial biocide and it is the first stabilized liquid bromine product ever developed. Scientific validity and commercial significance have been recognized by industry observers and featured in the press. Competitive imitations of the product in development further confirm the importance of the innovation.

Far more chlorine is used to control microbial fouling in industrial water compared to any other chemical. An environmentally sensible chlorine alternative is needed because handling the gas is hazardous, the liquid is not stable, combined residuals are not effective, free residuals do not control biofilms, and disinfection by-products are toxic. STABREX is an order of magnitude that is less toxic, less volatile, easier to handle, more compatible with other water treatment chemicals, more effective against biofilms, and generates less than half the disinfection by-products compared to chlorine or other alternatives. Replacing seventy million pounds of chlorine from use in the field with STABREX since commercial introduction in 1997 has reduced environmental and human health risks. Four hundred billion gallons of industrial water have been successfully treated worldwide.

New-generation fluorine-containing compounds with low environmental burden

Nippon Zeon Co., Ltd. and National Institute of Materials and Chemical Research (NIMC) have recently developed jointly ozone non-depleting fluorine-containing compounds, i.e., heptafluorocyclopentane useful for cleaning solvents and octafluorocyclopentene for dry etching gas in semiconductor manufacturing. Both compounds show zero ozone depletion coeff., and Nippon Zeon/NIMC were awarded with the Stratospheric Ozone Protection Award from the US EPA in 1998 for the development of the former material.

Re-use of recycled PET for raw materials of alkyd resin coatings

Kansai Paint Co., Ltd. has recently developed the technology to manufacture alkyd resin coating materials from recycled PET resin. Kansai is operating the plant since October 2000, with the capacity to process 100 ton/month of recycled PET resin, expecting 500 ton/month soon.

Thermal decomposition of nitrous oxide gas

Asahi Kasei Corp. implemented the new technology in 1999 to thermally decompose nitrous oxide gas, which is produced in the process of manufacturing adipic acid from cyclohexanol by using nitric acid. Nitrous oxide has 310-folds of greenhouse effects vs. carbon dioxide and is produced 0.25 ton per 1 ton of adipic acid production. The technology contributes to 1/20 of the national target of greenhouse gases reduction which was set by the Kyoto Protocol.

[2] STABREX™ is a trademark of Nalco Chemical Co., Naperville, IL

Bio-based materials for industrial processes

DuPont is working to meet the needs of more people with fewer materials and less energy, and has set an important goal of gaining 10 percent of energy needs and 25 percent of its revenues from renewable resources by 2010. Biotechnology has allowed the development of polymers from corn starch. DuPont is now looking for a number of industrial applications to use specialty corn starch developed through this new process. DuPont Sorona(tm), a bio-based polymer used to create fully recyclable fibers from renewable resources, will be available by 2003. A pilot plant test to produce the key raw material from corn starch is now underway in Decatur, Illinois. Other bio-based materials for industrial applications are down the road : Bio-based clothes and plastics : New processes that make fully recyclable fibers, clothes, and plastics from renewable resources such as corn. New consumer-friendly products : New building blocks for polymers from fermentation processes, thereby creating materials with enhanced performance (lighter weight, stronger).

Réduction des émissions de SO_2 (Lafarge)

La cimenterie de Retznei est située dans le sud de la Styrie. Les matières premières qui l'alimentent proviennent des carrières voisines de Rosenberg et de Haupstock. En raison de la forte teneur en sulfure de fer de ces matières premières, la cimenterie de Retznei présentait un niveau de SO_2 relativement élevé. En 1997, celles-ci dépassaient 400 mg/Nm^3. Elles pouvaient donc, dans cette région touristique, avoir des effets néfastes sur les forêts et les vignobles environnants.

Après avoir étudié plusieurs solutions possibles, Lafarge Perlmooser a opté pour le traitement des fumées du four au moyen d'un laveur humide. Ce procédé, en utilisant les poussières du four comme réactif pour capter les vapeurs soufrées, représente une innovation. De plus, il génère comme sous-produit de la désulfuration des fumées du gypse qui est intégralement valorisé dans le procédé comme ajout lors du broyage du ciment. La mise au point de cette technologie a bénéficié des compétences et de l'expertise du Centre Technique pour l'Europe Centrale (CTEC) du Groupe, basé à Vienne. Depuis la mise en service du nouveau filtre en mars 1998, le taux d'émission a été réduit de moitié. Avec moins de 200 mg/Nm^3, les émissions sont d'ores et déjà très inférieures à la future norme autrichienne. Cette performance traduit la volonté de Lafarge Perlmooser de jouer un rôle moteur au sein de la profession en terme de protection de l'environnement en Autriche.

Application of cogeneration in the milk produce transformation industry
(example provided by Gaz de France)

Description: Cogeneration enables heat and mechanical energy to be produced simultaneously from a single fuel. The mechanical energy generated by a gas engine or a gas turbine is used in the majority of cases to drive alternators generating electricity. Thermal energy is recovered by captation of a large part of the heat release which is normally lost when producing mechanical energy, and which produces process steam into recovery boilers. Heat and mechanical energy are provided by cogeneration at an overall efficiency distinctly higher than that achieved through two separate production streams. The main environmental advantages of cogeneration are fewer releases of greenhouse gases (CO2) due to, both, lower emission factor of natural gas and improved efficiency compared to traditional generating facilities and in situ generation of electricity avoiding need for power transmission lines impairing landscape and generating problems in the event of severe tempests .

The milk transformation plant whose cogeneration system is described here processes 800,000 litres of milk per day, to produce fresh cheeses, yoghurts, etc. using specific processes such as pasteurisation, fasts skimming, homogenisation, maturing, additives, all requiring electric and/or thermal energy. As their former oil-fired boiler system had become obsolete, the plant managers decided to replace it with a cogeneration facility comprising two 1.1 Mwe unit gas turbines and one 6 t/h steam recovery boiler for the November-March period, and with a steam generation plant comprising two high efficiency, low Nox emission 5 t/h steam gas-fired boilers for the April-October period .

Characteristics and Results: Installation efficiency: overall 67 %
Cogeneration part: 72 % (of which electricity: 40%, steam 32%)
Mean gas consumption of turbines: 265,000 kWh/day
Gas consumption during summer season (excluding cogeneration):about 32 GWh
Lower CO2 emissions

Improved energy efficiency, easier control of the boiler installation, less maintenance and disappearance of dust and other sources of pollution
Low cost electricity production during the winter: source of savings

Improvement of thermal efficiency of thermal power generation

TEPCO has introduced an advanced combined cycle power generation system to improve the thermal efficiency of thermal power stations in pursuit of economic efficiency, a reduction of CO2 emissions and effective use of resources.

The combined cycle power generation system that makes use of the merits of both gas and steam turbines is the mainstay of the operation at LNG-fired thermal power stations. Since 1996 they have operated the advanced combined cycle technology that allows the combustion temperature in a gas turbine to be raised from 1,100C to 1,300C, and its thermal efficiency has reached a world record of some 54% on Low Heat Value basis (LHV). Moreover, they are planning to introduce the more advanced combined cycle (MACC) technology in their thermal power stations that envisages a further improvement in the thermal efficiency to 58% (LHV).

Compared with the case whereby the thermal efficiency in fiscal year 1999 remained unchanged from fiscal 1970, a rise in the efficiency from nearly 42% to 44% (LHV) has resulted in CO2 emissions reduction by 3.1 million t CO2 (equivalent to a reduction of 1.1 million kl of oil).

CO2 Underground Storage – The Sleipner Case

Storage of CO2 in underground geological formations has the potential of avoiding emission of huge quantities of CO2 from fossil fuels to the atmosphere, and thus possibly reducing adverse climatic effects. Beginning in 1996, l million tons of CO2 per year has been stored at the Statoil operated Sleipner field in the North Sea. The capacity to store CO2 underground within Europe is probably more than 800 billion tones of CO2, particularly under the North Sea. This is the first case of industrial scale CO2 storage in the world. It is being injected into the "Utsira" formation – a thick saltwater-bearing sandstone at a depth of approximately 1000 meters under the seabed. Being the first case, the behaviour of the CO2 injected has been carefully monitored by an international R&D project "SACS – Saline Aquifer CO2 Storage".

INNOVATION - In addition to demonstrating the long-term feasibility of storage of CO2 in the Steipner field case, it is a particular aim also to provide solid scientific documentation of underground CO2 storage as a method. It may be applied in other geographical areas and by other industries such as power generation.

INTERNATIONAL CO-OPERATION - Statoil, BP, ExxonMobil, Norsk Hydro, BGS, BRGM, GEUS, IFP, NITG-TNO, SINTEF, NERSC, GECO and IEA GHG and ministries/research councils in NO, DK, NL, UK and FR. Inter-continental co-operation with similar projects in Canada, USA and Australia is under development, co-ordinated through the IEA Greenhouse Gas R&D Programme.

EXPECTED RESULTS - The project will generate a working methodology for evaluation of subsurface CO2 storage from a technical and an environmental point of view, in order to satisfy authorities and the general public as to the feasibility, safety and reliability of the saline aquifer CO2 storage process.

REFERENCE - Statoil – Den Norske Stats Oljeselskap AS, www.jeagreen.org.uk and look for "Practical Research"

Increasing efficiency in fertilizer production through technical innovation (IFA)

As regards the production of fertilizers, there has been considerable environmental progress during the past thirty years. One expert calculated that energy consumption using best available production techniques was about half in 1998 what it was in 1968 (2743 Gigajoules (GJ) versus 5040 GJ for 134 million tonnes total nutrients). This improvement can be directly attributed to improved production technology.

A reduction in energy consumption in the fertilizer industry is accompanied by an even greater reduction in greenhouse gases. Because of increasing energy efficiency, some estimate that the fertilizer industry's carbon dioxide emissions will remain near 1990 levels in absolute terms. In 1995, the European Fertilizer Manufacturers Association (EFMA), published a series of booklets on best available techniques (BAT) for the

production of fertilizers. According to these, achievable emissions levels for plants built after 1990 are often 25-30% of those for older, less innovative facilities. EFMA carries out a benchmarking exercise to help member companies see how their performances compare with these goals; benchmarking against BATs is currently being put in place at the global level. Improved technology, proper operation, maintenance and housekeeping are all important in reducing emissions to a minimum. Further significant limitations of emissions will largely depend on the continuing replacement of old, inefficient factories by new ones.

Coal – providing solutions through the deployment of technology and innovation
(contribution provided by the World Coal Institute)

Coal is getting cleaner – clean coal technologies increase energy efficiency and reduce coal-related greenhouse gas (GHG) emissions. The deployment of higher efficiency technology in new and replacement combustion facilities and the introduction of efficiency management programmes improves the performance of coal. All stages of the coal cycle should be recognised as potential contributors to improved efficiency and emission reductions via innovation and technical enhancement. Improved coal technology and efficiency can provide significant benefits, in both developed and developing countries. It is not the use of coal, but rather how coal is used that must be the focus for action. The following examples demonstrate some of these opportunities.

- ***Belle Vue Coal and Bagasse Dual-Fired Power Plant in Mauritius***

Dual fuel bagasse-coal electric power plants, such as Belle Vue in Mauritius, create significant opportunities to optimise use of locally available renewable bagasse resources. The bagasse partnership with coal at Belle Vue reduces the amount of coal (or other fossil fuel) inputs to supply the community's electricity demand by over one-third and saves foreign exchange exposure for Mauritius by reducing fuel import requirements. The new Belle Vue facility, a 70 MWe power plant, comprising two 35 MW units, is projected to burn around 280,000 tonnes of bagasse per year and 130,000 tonnes of coal. The bagasse component is equivalent to around 100,000 tonnes of coal. Over the six months from July to December the Belle Vue plant will mainly burn bagasse. During this period, coal is available (and used) as the standby fuel to cover any disruption in the delivery of the bagasse to the boilers to ensure the integrity of the operation. The Belle Vue plant is the fourth one of its type to be built in the world, with two similar plants (Bois Rouge and Le Gol) on the nearby island of Réunion and a plant (Le Moule) recently commissioned in Guadeloupe. Harnessing the full value of the available bagasse into the production of energy for both the supply of process steam and the generation of electricity brings major fuel savings – and creates the opportunity for win-win solutions for efficiency and reduced GHG emissions per unit of energy produced.

- ***Schwarze Pumpe Power Station – New Generation of Advanced Lignite-Fired Electricity Generating Plants***

One of a new generation of lignite-fired power plants, Schwarze Pumpe in Germany has two 800 MW generating units achieving 41% overall operating efficiency. The new facility replaces an old power station, which had an operating efficiency of 32%. The efficiency level at the new plant is further enhanced to 55% fuel utilisation through the cogeneration of heat and steam. Compared with the results from the old power station previously operated at the site, the new Schwarze Pumpe plant has reduced SO_2 emissions by 91%, NOx emissions by 61% and dust/particulate emissions by over 98%. CO_2 emissions have fallen by 31% per unit of energy produced over the previous plant levels. This modern plant requires around one third less lignite to generate the same amount of electricity –not only reducing emission levels, but also conserving valuable natural resources. Equipped with the latest in power generation technology, Schwarze Pumpe has achieved improvements in performance, efficiency, availability and reliability.

- ***Methane Recovery and Utilisation at Moura Coal Mine***

Located in Australia's Bowen Basin coalfields, Moura is a typically gassy mine with major methane gas (CH_4) deposits co-located with the coal resource. Traditional mining practices involved the release of this CH_4 to the atmosphere as a safety measure. However, in more recent times, concern over the loss of this potential energy source – together with the effect that CH_4, as a GHG, may have on the global climate has initiated the collection of this gas for commercial use. The drainage and capture of gas from the Moura Mine coal seams has a two-fold benefit: reduced CH_4 emissions to atmosphere from the mine contributes towards Australia's GHG reduction programme; drainage of the CH_4 from coal seams over several years in advance

of mining reduces the cost of gas drainage compared to the current 'just in time' gas drainage employed at many coal mines.
At design capacity the CH_4 drainage will represent a significant reduction in on-site GHG emissions. Based on an expected production of 18,000 GJ/day and an assumed energy content of Queensland gas of 37.3 MJ/m^3, density of 0.68 kg/m^3 and CH_4 content of 98.5%, this represents an annual utilisation of 119,000 t CH_4. GHG emissions associated with this level of CH_4 were it to be vented or otherwise released into the atmosphere are more than 2.5 Mtpa CO_2 equivalent, based on a GWP for CH_4 of 21. The Moura Mine Seamgas Operation is a positive outcome for coal, coal safety and for the environment via the significant GHG emission reductions achievable.

- ***Mlada Boleslav's New Coal-Fired Cogeneration Plant in the Czech Republic***

Following a major upgrade, Volkswagen's Mladá Boleslav Power Plant in the Czech Republic is now one of the most advanced coal-fired cogeneration district heating plants providing 70 MW of electricity to the Skoda automobilova sa car factory as well as 140 MW of district heat for Skoda and around 10,000 households in the town of Mladá Boleslav. Fuel conversion and use of state-of-the-art energy-efficient technology during modernisation of the plant has led to significant energy savings and emissions reductions. The old Mladá Boleslav plant based in North Bohemia was built over 40 years ago and until 1998 was primarily fired on local high-sulphur lignite. The new Mladá Boleslav coal-fired cogeneration plant utilises local hard coal to fuel two base load circulating fluidised bed boilers. The new plant has an electrical output of 70 MW and an overall thermal capacity of 300 MWt. As a result of cogeneration overall fuel utilisation efficiency is approaching 80%, which means the energy content of the fuel is being utilised to a far greater extent than in normal condensing power plants. Mladá Boleslav Plant is now operating well within Czech Republic emission levels for SO_2, NOx, CO and dust and is also complying with the more stringent German standards. Through increased fuel and plant efficiency, CO_2 emissions have been significantly reduced by over 60% compared with the old plant. The whole modernisation of the CHP plant is estimated to have reduced GHG emissions by some 280,000 t CO_2 per annum.

German Cement Industry*

Specific fuel consumption has fallen consistently since 1987. In 1998 it was 2,905 kJ per kilogram of cement, which was 70 kJ down on the foregoing year. Taking the average of all cement plants in Germany, this level of consumption represents an efficiency of approx. 77.5% (2,250 kJ per kilogram of cement). According to the cement industry, this is above all a result of the following actions:

-Utilisation of the hot waste air from the clinker cooler to generate electricity in the Organic Rankine Cycle process - a new ORC power plant was commissioned at Lengfurt cement plant. The ORC process involves a conventional steam turbine configuration with an added expansion turbine that utilises industrial waste heat. Developed specially to exploit low temperature media for power generation, this innovative concept is being used for the first time in a cement plant. The new power plant has a net capacity of 1.13 MW which is used entirely in cement production and covers 12% of the cement plant's total power demand. The remaining process stages account for approx. 16% of the electricity consumption.
- Installation of the expert system "LINKman" to harmonise kiln operation in two units at Göllheim cement plant.
- Substitution of kiln flue gas for natural gas in the clay dryers at Karsdorf cement plant. A new kind of dryer which went into service there in 1998 employs a granulation process for chemical dehydration. Under exactly defined conditions the clay is mixed with an additive which absorbs part of the water contained in it. The result is dried in a stream of hot flue gas that was previously released unused. This measure has enabled the cement industry to save 2 million m³ of natural gas by exploiting waste heat and the new drying process also reduces the CO_2 emissions of the cement plant by 3,550 tonnes a year.
- Better thermal energy recovery through improvements to pre-heater cyclones and clinker coolers.
- Substitution of granulated blast furnace slag cement for conventional Portland cement (Amoeneburg cement plant).

German Iron and Steel Industry*

The iron and steel industry implemented numerous technical innovations affecting energy consumption. Efforts to increase the efficiency of energy use were directed at nearly all stages of the production process.

The investment and modernisation programme was particularly aimed at coking plants, sintering plants, blast furnaces, combined energy cycles, oxygen refining and electric furnace processes. In 1998 CO_2 reductions due to modernisation and new construction measures amounted to at least 315,000 tonnes. Reductions achieved by the steel industry are especially attributable to the concentration of pig iron production facilities. For example, at the Dillingen steelplant Blast Furnace 3 (design capacity 660,000 tonnes p.a.) was shut down and pig iron production concentrated in Blast Furnaces 4 and 5 dating from 1974 and 1985. A prerequisite for this measure was the relining of Blast Furnace 4 which appreciably boosted its productivity. The relining operation, which required capital expenditure of DM 150 million, principally involved enlargement of the frame to increase useful volume, modernisation of the technology to state-of-the-art and reinforcement to prolong service life. Increasing the efficiency of the wind heaters by 5% was in itself sufficient to achieve an annual reduction in CO_2 emissions of 69,100 tonnes.

Trials were carried out on a new kind of heating system for use in arc furnaces. This innovative system works on the rotary generator principle, transferring heat from a waste gas stream to the surface of a rotor which subsequently pre-heats a stream of primary furnace air to temperatures in excess of 1,000°C. By comparison with conventional systems this means fuel savings of up to 50%. The trials performed at a steelplant demonstrated that using the rotary generator burner system (DREBS) would reduce natural gas consumption by 460,000 m³ or 38% under identical load conditions. The resultant reduction of CO_2 emissions amounted to 846 tonnes p.a. Specific reducing agent and energy consumption fell by 12.8% in the period 1990–1997 and by another 1% in 1998. Accordingly, the production of one tonne of rolled steel in Germany requires around 21.2 GJ of electrical and thermal energy. This corresponds to a drop in specific CO_2 emissions from 2,089 kg to 1,794 kg per tonne of rolled steel.

German Chemicals Industry*

Sizeable savings were achieved in Ludwigshafen, a major location of the chemicals industry, as a result of the commissioning of a natural gas fuelled combined cycle power plant. The plant is fitted with waste heat boilers utilising the exhaust from the gas turbine (500°C) in an optimised double pass system. The high-pressure steam generated in the boilers is expanded in a tapping turbine and fed into the plant's service circuit at 6 bar. In the year it was commissioned this combined cycle power plant generated 4 million tonnes of steam and 2,800 GWh of electricity. By comparison with the coal fired cogeneration plant at BASF, which was 70% decommissioned in 1998, the new plant results in a reduction of CO_2 emissions in the order of 1.2 million tonnes. As the coal fired cogeneration plant was taken out of service entirely in 1999, the contribution of the combined cycle plant to the reduction of CO_2 emissions has gone up to 2 million tonnes.
According to the information provided by the chemicals industry the greatest reductions resulting from process oriented measures in 1998 were attributable to the deployment of more efficient chlorine production techniques. Conversion of conventional electrolysis plants with an annual capacity of 500,000 tonnes to the energy saving membrane process resulted in a reduction of the chemicals industry's electricity consumption in the order of 110 GWh, which is reported to represent a reduction of CO_2 emissions of at least 60,000 tonnes.

German Glass Industry*

The replacement of old plants and equipment with new furnaces burning an oxygen / gas mixture instead of an air / gas mixture, the ongoing improvement of energy use whenever regular repairs and overhauls take place and the increased use of waste glass as a secondary raw material have all resulted in appreciable energy savings. Up to 98% of production waste is recycled, as a result of highly efficient sorting procedures. Despite the level of glass recycling being already very high, the glass industry was able to improve the recycling quota still further in the period 1995 to 1998 (to 80.7%): Of the annual 3.4 million tonnes of container glass sold in Germany the glass industry recycles 2.8 million tonnes in its production processes. Increasing the broken waste glass content in the melt by 10% results in energy savings of up to 5%.

**Third Monitoring Report: CO_2 -Emissions in German Industry 1997–1998; By Hans Georg Buttermann and Bernhard Hillebrand; RWI-Papiere, Nr. 70 - Available as pdf-download at www.rwi-essen.de, publications*